Port and Harbour Structures
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Module 8, Lecture 18
LOADS

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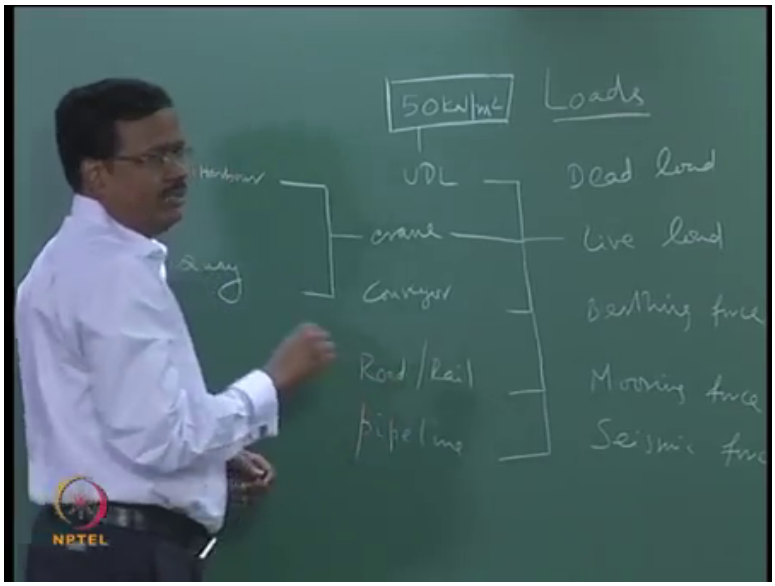

So in this class we will discuss the loads that are to be considered for design of berthing structures, you have to consider the dead load, live load, berthing force, mooring force, seismic force, active air pressure, differential water pressure, so these are the various loads that are to be considered, the optimum design will take place only if you find out the forces properly, the failure also takes place if you don't estimate the forces accurately.

Come to these loads for certain type of structures some loads will be governing the design for example for the berthing structure in seismic zone 5 near Kandla and Andaman group of islands seismic force will control the design whereas at other locations berthing force may control the design out of all the forces that have been listed here there are certain forces which are permanently present, these forces are dead load, active air pressure.

And differential water pressure always present, so you have to give importance to this whereas the seismic force will take place only there is an earthquake; the berthing force will take place when there is a berthing of vessel, the mooring force will take place when the vessel moves away

from the berth, when the vessel is subjected to wind and current which makes the vessel to displace from its position since it is connected to the bollards there will be mooring forces.

The live load, there are various categories of live load, one of them is uniformly distributed live load, another is crane load, the third one is conveyor load, if you are having railway line and road we have to considered this if we have pipeline we have to consider this, this cranes we have two types of cranes one is Mobile Harbour crane and another is rail key crane, so these are the loads live loads, so what is the difference between the structure.

What you will be building in the land for example this structure and the berthing structure is the live load what is normally used in buildings is only 5 kilo Newton per meter square whereas our berthing structures it can go up to 50 kilo Newton per meter square this is a heavy load 50 so for this place where we are sitting and listening to the lecture, live load is 5 kilo Newton per meter square, 5 kilo Newton is how many kg.

500 kg in 1 meter by 1 meter how many people can stand, you have come through the lift right, when you come through the lift they would have written what is the load the lift can carry, size of the lift is more, in a 1 meter by 1 meter space how many people can stand 9 depending on the bulkiness of a person, so if you take it as 9 average weight is, what is the average weight of the Indians, 60 kg ok 9 into 60 is 540 kg just to give an example only.

I told that 50 kilo Newton per meter square is coming because if you stack for 5 meter height coal, coal bulk density is very close to 10 kilo Newton per meter square (your sack) 10 kilo Newton per meter cube, if you stack it for 5 meters 5 into 10 it will become 50 kilo Newton per meter square, suppose you are using finished steel products, density of steel is very high then the load will be large, the problem is not with the large in intensity there is design issue.But the major problem is with seismic force,

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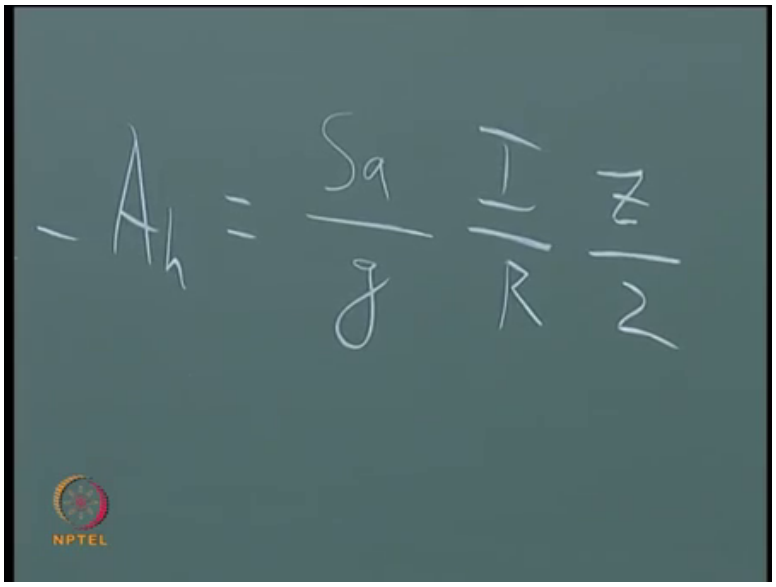

Seismic force is a horizontal force, this horizontal force can be calculated by using a formula where ah comes into picture so this is the formula that is used to get the horizontal force

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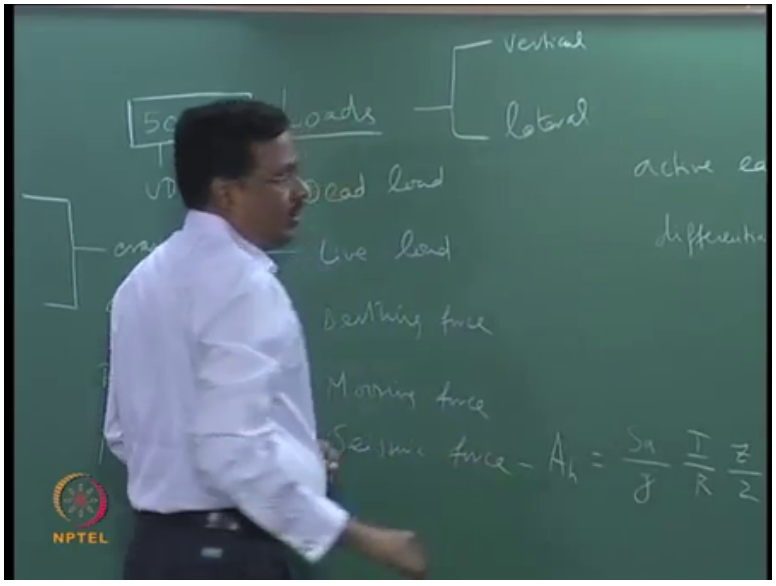

When you talk about the loads we also have to see how the loads are acting the loads can be vertical or lateral, vertical means the self weight of the structure is going down that is vertical, when the wind is blowing on a multi storied building.

There is a load which is going in the lateral direction, for a design of structure lateral loads are very important, very difficult generally lateral load capacity of any structure will be about 10 percent of the capacity in the vertical direction ok, for example you can take some weight on top of your head, weight lifters or somebody can take up to 30 kg 40 kg and all, but if someone wants to pull you or push you, what is the force required very negligible.

Maybe 2 kgs is sufficient to pull you, same case with the structure also the lateral load capacity will be very less,

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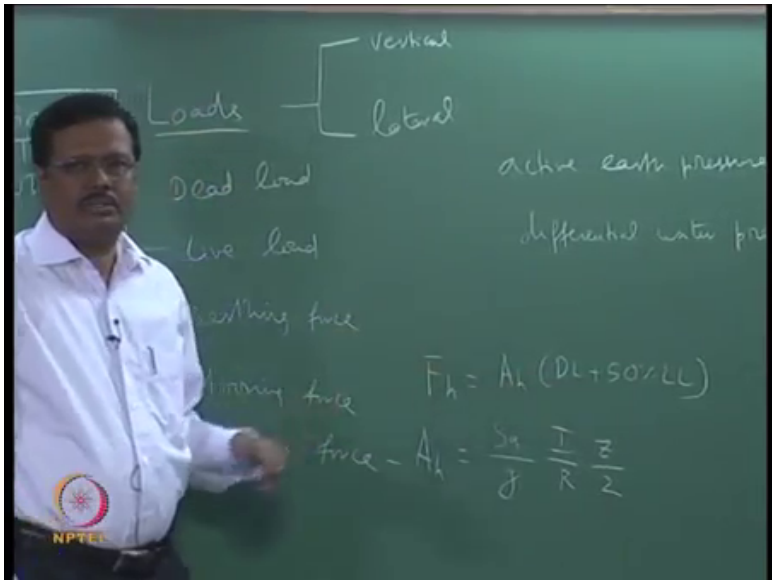

The seismic force is a lateral load ah is horizontal coefficient you want to calculate the seismic force in the horizontal direction that will be ah multiplied by dead load plus 50 percent of live load, so when it achieved 50 kilo Newton per meter square, the 50 percent of the live load and ah comes into picture.

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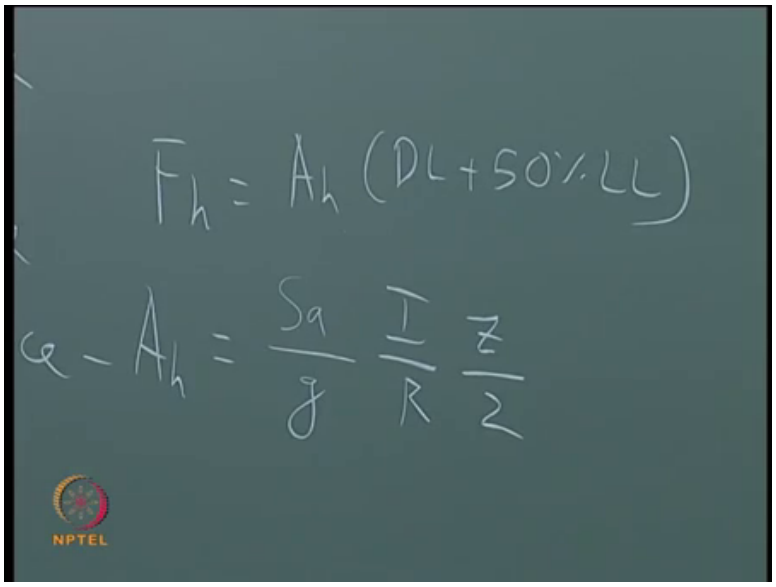

We will study these parameters separately in one of the classes.So the loads when you classify you can also classify whether loads are coming from the sea side or from the land side ok, this active air pressure, differential water pressure and all coming from the land side whereas the berthing force and mooring force are coming from the sea side that is from the ship the loads are transferred whereas from the soil which is back.

And variation water level you get this pressure, the seismic force which direction it will act, what is the direction of the seismic force, I told it is lateral, will act from the sea side to land side or land side to sea side, you tell wrong answer no problem, which direction the seismic force acts, what is it, it can act any side, it can act in the vertical direction lateral direction, left to right, right to left, diagonal it depends on the direction in which the seismic acceleration travels.

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So for example if you take a structure like this what is shown in this slide it can act from this side to this side, this side to this side, can go like this also any direction it can act, it can go up and down also, the seismic acceleration ah is high if you want to take a vertical it is some percentage of ah maybe I don't remember it maybe 50 percent or two third of ah that is a coefficient.

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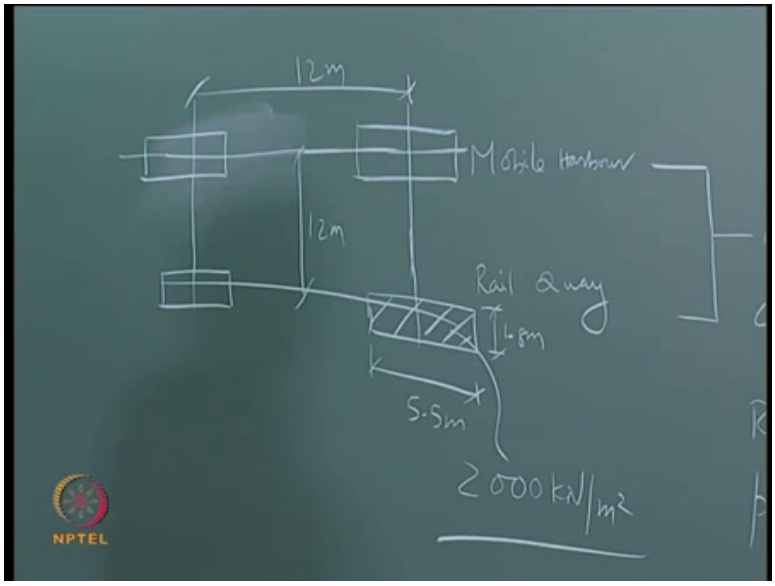

This Mobile Harbour crane generally consists of four pads.I will show the photograph in another class but typically this dimension is about 12 meter by 12 meter and this dimension is about 5.5 meter by 1.8 meters and the intensity of the load on the pad is about 2000 kilo Newton per meter square,

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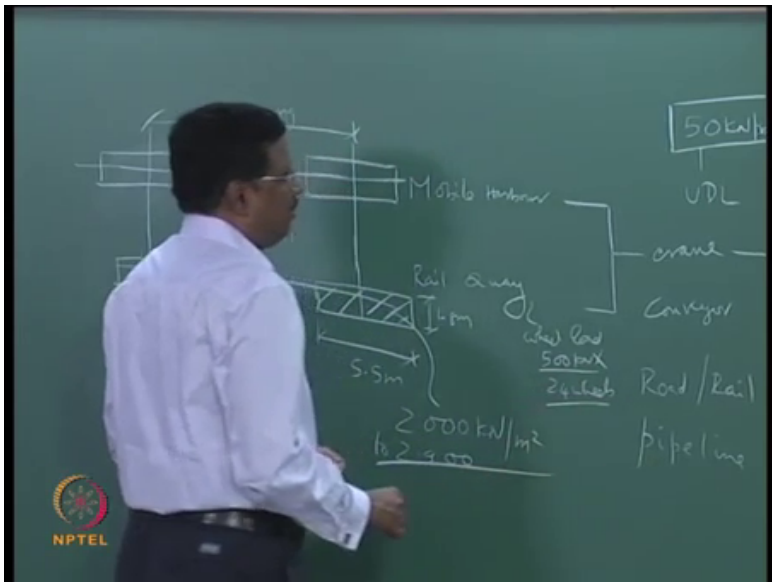

Sometime it is more also within 2000 to 2900, so you know what is a load udl this is 50 kilo Newton per meter square, this is throughout the structure, whereas when the Mobile Harbour crane is moving.

For lifting the cargo from the vessel, there will be four pads and each pad will have a load of about 2000 kilo Newton per meter square to 2900 kilo Newton per meter square it is only a patch load, it is not a continuous load but rail key crane there will be wheels typically there will be 16 wheels and each wheel load will be about 500 kilo Newtons, it can have about 24 wheels also, so this is the order of the load.

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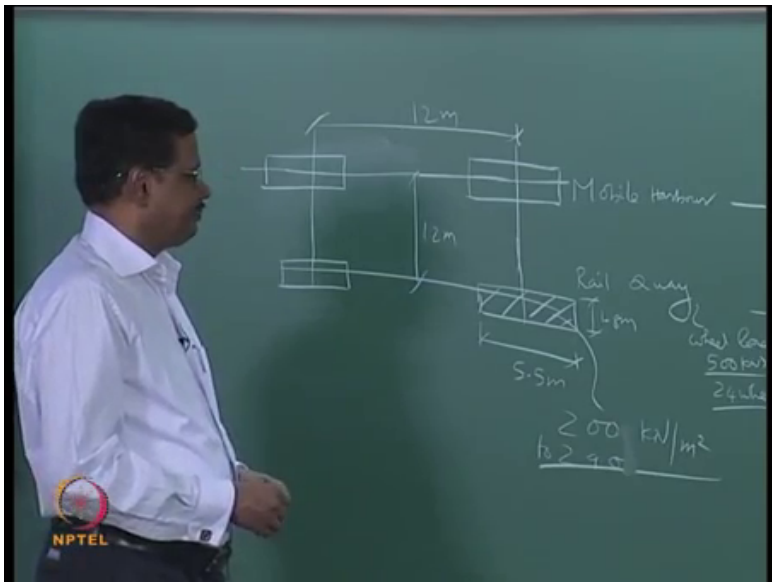

I think this is wrong I think it is about (2000) 200 to 2900, it is 200 to 290 not 2000. So this class we will see active air pressure and differential water pressure,

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I have written in this active passive we will discuss that,

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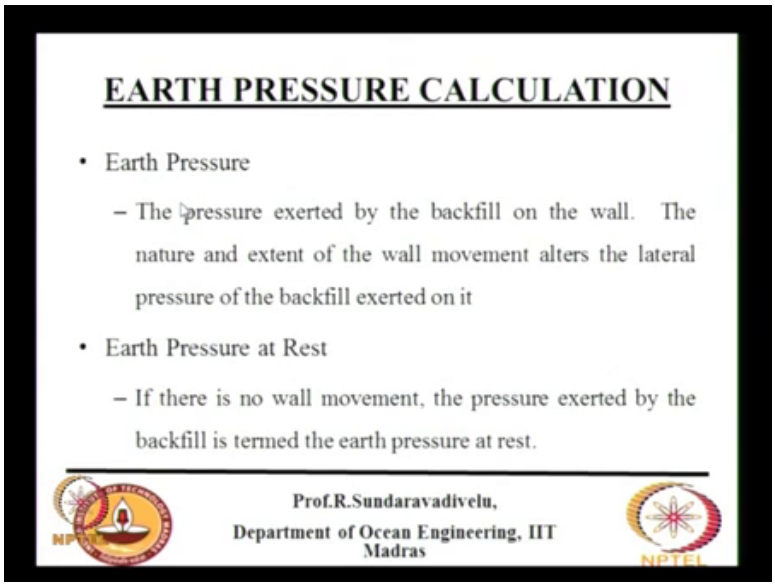

What is earth pressure the earth pressure is exerted by the backfill on the wall, the nature and accent of the wall movement alters the lateral earth pressure on the backfill extended on it,

See one example you are having a diaphragm wall and there is a fill behind the diaphragm wall, suppose the wall is removed the soil will collapse.

That means the wall is retaining the soil and there is pressure exerted by the wall, there is for example if there is a water tank filled with water, (water benk) the water will exert pressure on the wall, same way earth also exert pressure on the wall, there are three earth pressure one is earth pressure at rest, another is active earth pressure, the third one is passive earth pressure,

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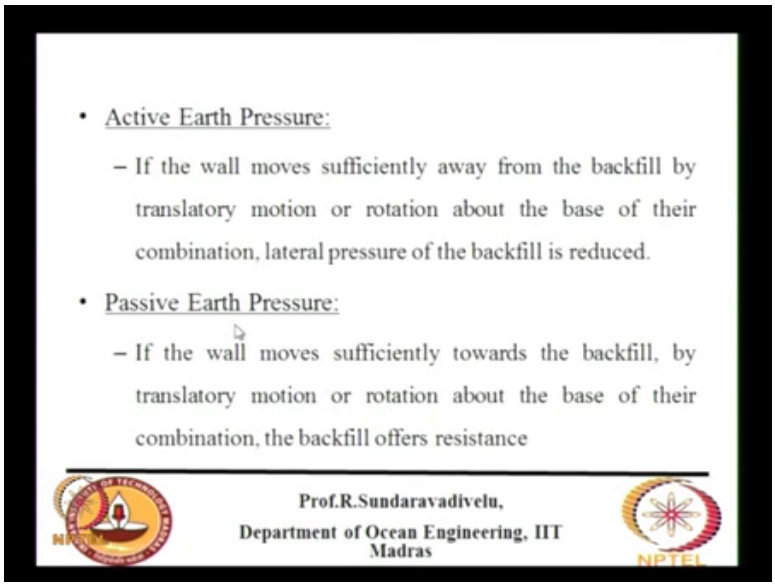

So the wall moves (so) whenever there is a pressure exerted on the wall. The wall is trying to move when the wall moves sufficiently away from the back field either by translate renovation or by rotation about the base or the combination lateral earth pressure of the backfill is reduced, reduced means it is reduced from earth pressure at rest to active earth pressure, suppose the wall moves sufficiently towards the backfill by translate renovation or rotation about the base (he) it should be or other combination the backfill offers resistance.

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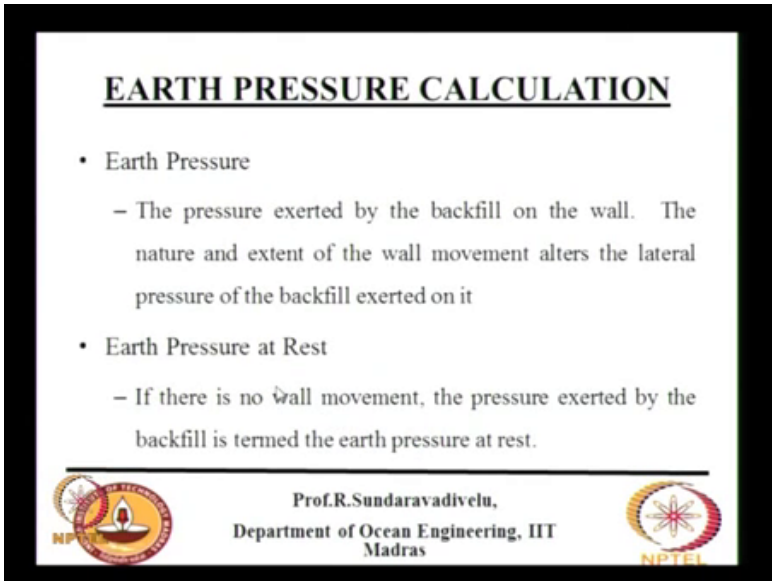

What is earth pressure at rest? There is no wall movement the pressure exerted by the backfill is termed as a earth pressure at rest, these are the three definitions,

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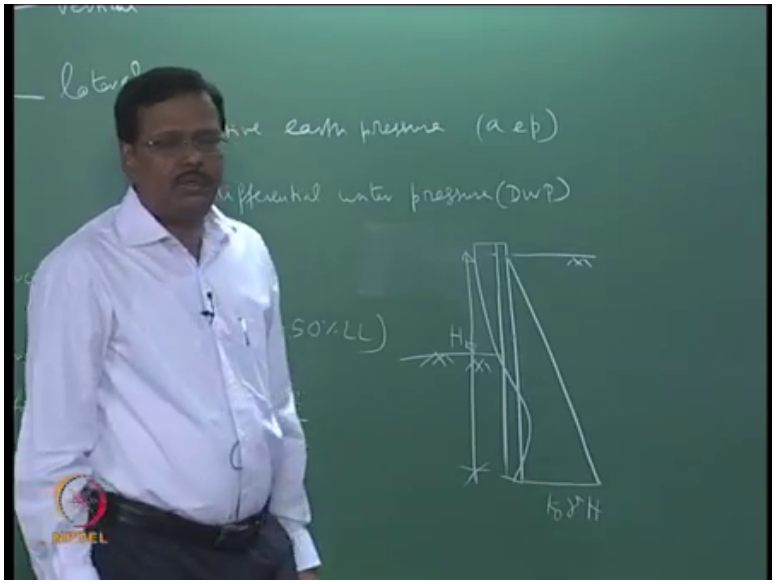

I will explain with a figure suppose you are diaphragm wall there is soil on both the sides afterwards you are going to dredge this case is earth pressure at rest, you will have pressure from this side as well as from the other side so this is k not koma h, koma is the density of the soil h is the height.

Suppose this is the h height Gama into h at every point here there is no over burden pressure, over burden pressure means the weight of the soil above here there is over burden pressure that is equal to the site into the density, (we) here you have over burden pressure that is equal to k not into x as you go down the over burden pressure increases and this is called as a coefficient k not it can be less than 1 or greater than 1 suppose it is 1 whatever is the vertical pressure.

Same thing is update on the horizontal direction, suppose you remove the soil on this side so much portion of the soil you removed, so we remove about h1 quantity of soil, what will happen to the wall one of the main thing you have to understand is whenever there is a force in the structure there is always a displacement both are together so when there is a pressure the wall is trying to displace the wall will try to move and you will have a displacement of the wall.

The wall may move something like this, so whenever you do the Straad pro analysis or any analysis you have to look for two things one is the force another is the displacement, force is three transnational force and (mat) movements three movements displacement, generally displacement is three displacements trans stationary and three rotations, so what will happen to the earth pressure now k not Gama h will it increase or decrease?

Will it increase or it will decrease, no idea, this is the soil the relation to the soil, this is the point where the deflection is zero above this point whether the wall is moving away from the soil or moving towards the soil? Moving away from the soil, what happen below this, wall is moving towards the soil, so you know this boxing and somebody wants to kick to you what you are trying to do, you are trying to dodge away.

Somebody wants to hit will you stand just like this straight, you will go and if somebody is trying to hit you and if you go away the impact will be less, but if you stand like this stubbornly then the impact is more,

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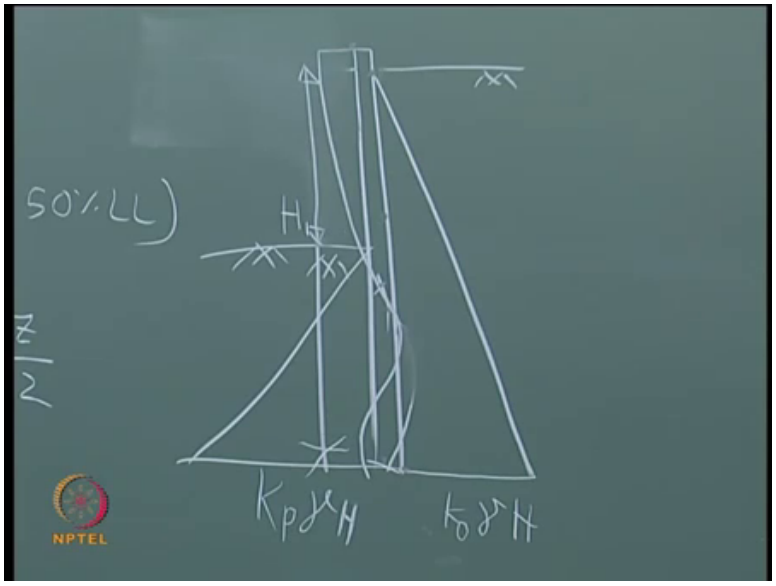

So by the same hypothesis when the wall is moving away the active earth pressure will take place and it will reduce from k not to ka and passive earth pressure will take place on the other side because there is a soil here.

This diagram is not correct exactly actually it will go like this and it may come down like this also we will have kp Gama h, this is only schematic it depends on which place you are having, so now we will read this sentence very carefully (berry) there is, this is not a literature this is a technical documentation.

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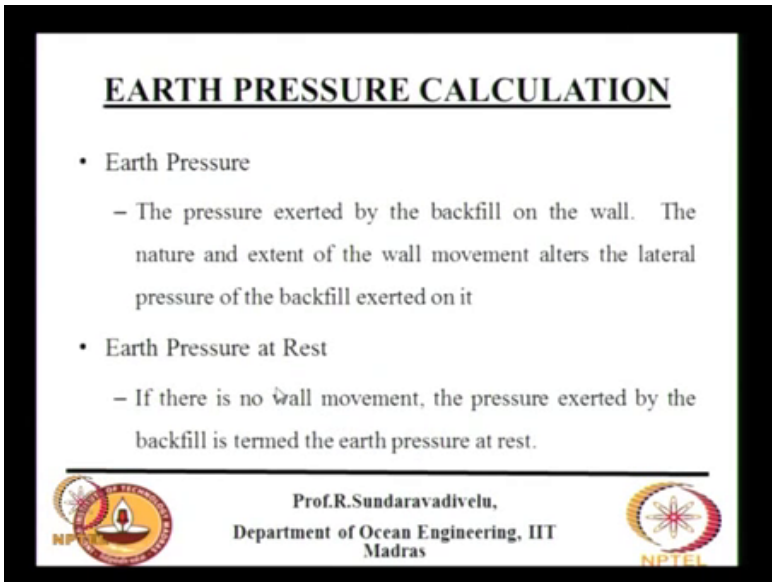

(So we have) every word has a meaning if there is no wall movement the pressure exerted by the backfill is termed the earth pressure at rest, that is the first case.

Second case if the wall moves sufficiently away I will explain in the next slide what is a sufficiently away there is a reason for putting sufficiently away from the backfill by translatory or rotation about the base or other combination, lateral pressure of the backfill is reduced from k not to ka the wall moves sufficiently towards the backfill, the translatory motion or rotation about the base or other combination the backfill offers resistance.

We have used the word resistance because the mobilization of passive earth pressure is equal to the load that is applied to the wall it will have the capacity, passive earth pressure capacity but it will not be the mobilized, whatever active earth pressure is coming based on that only the mobilization will take place.

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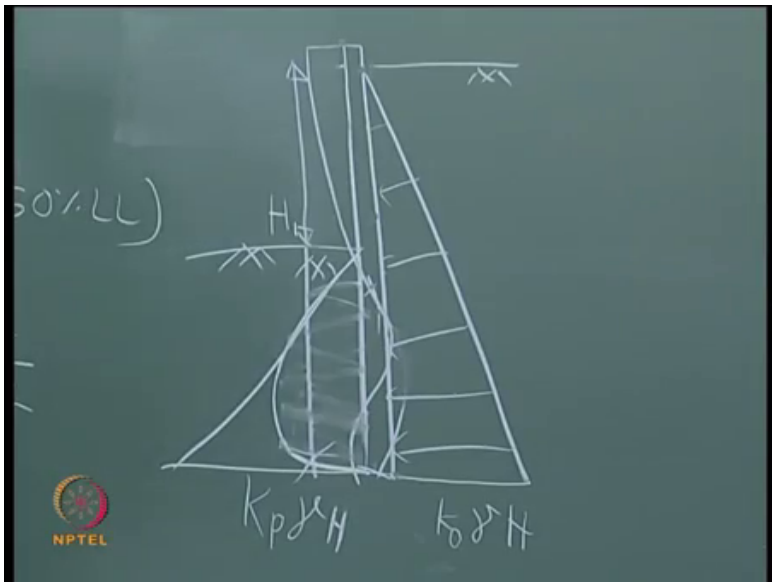

For example the capacity of the structure passive earth pressure is like this but the mobilization will go something like this. A concept is whatever force you are getting this side will be equal to the force on this side force equilibrium you cannot equate the pressure.

Please remember you can never equate pressure you have to equate only the force but to calculate the force and equate so we have sigma of all the forces to be equal to zero, sigma of all the moment to be equal to zero, the condition is to be realized so the active earth pressure is the pressure that is acting on the structure.

You can calculate the force due to active earth pressure same amount only will be mobilized on the other side same force; though it has a capacity the soil at the top will get fully mobilized as a go down it won't get mobilized.

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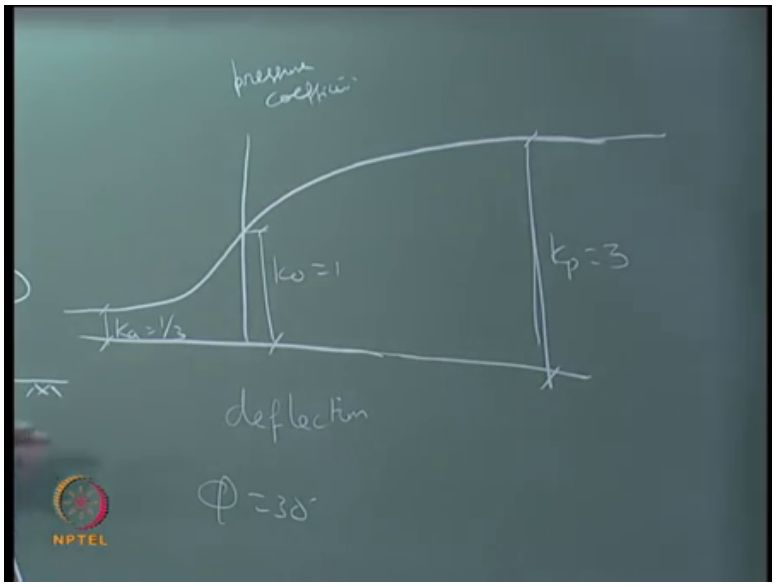

There is another statement that is made, that is what is the earth pressure coefficient so let us say the deflection of the wall or rotation of the wall or displacement and the x axis and pressure coefficient on the y axis?

So (you w) we will have the car going something like this, this is called as k not (this is) this remains constant after sometime it doesn't increase further, this is called as kp this remains constant here this is called as k here, I will be asking this question in the exam it is not there in the power point.

So those who have not come to the class you tell them to read this figure, it may not be available in many text books also soil mechanics text books.

It is a very important curve so typically for a sandy soil phi is equal to 30 degrees k not equal to 1 ka is equal to 1 by 3, kp is equal to 3

So from k not it reduces to ka after sufficient movement, the movement is not sufficient you won't get ka it will be more than ka, similarly full passive pressure will mobilized only if it moves from here for example if you are getting somewhere here the (curve) pressure coefficient is between 1 and 3 (if we) the movement is here.

The pressure coefficient (bitee) is between 1 and 1 by 3, so the force which is exerted depends on the wall movement that means the stiffness of the structure comes into picture, the movement of the structure is depends on the stiffness of the structure, stiffness means x modulus (24:28 mount of inertia) so the earth pressure at rest we have a code call is4651 part 2.

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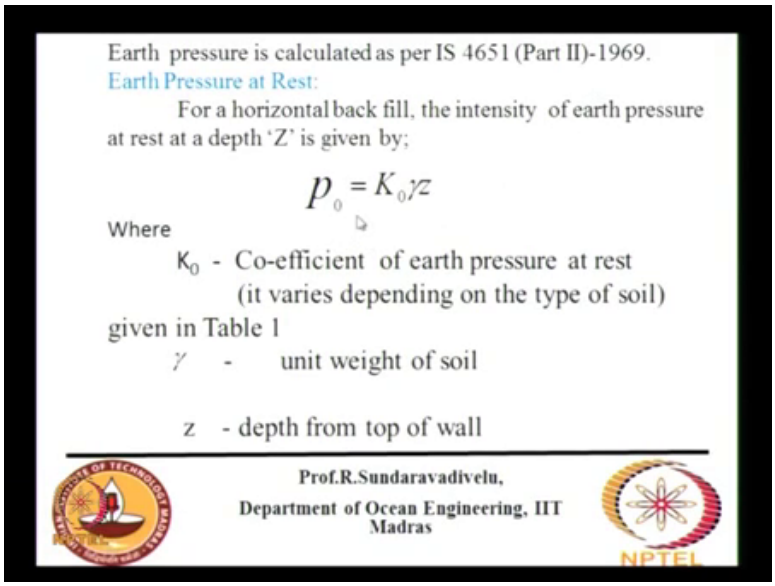

Then calculate using p not pressure is equal to k not at Gama is at, what is the unit of Gama. What is the unit of p not then, meter square so we are multiplying by yz that is the depth so kilo Newton per meter cube into meter is kilo Newton per meter square k not is the earth pressure coefficient no units, this k not varies depending on the type of soil there is a table that is not shown here when I discuss this code I will show that to you, how to calculate the active earth pressure this is the formula.

Active earth pressure is ka Gama h minus 2c root of ka plus ka into q where ka is equal to 1 minus sin phi divided by 1 plus sin phi

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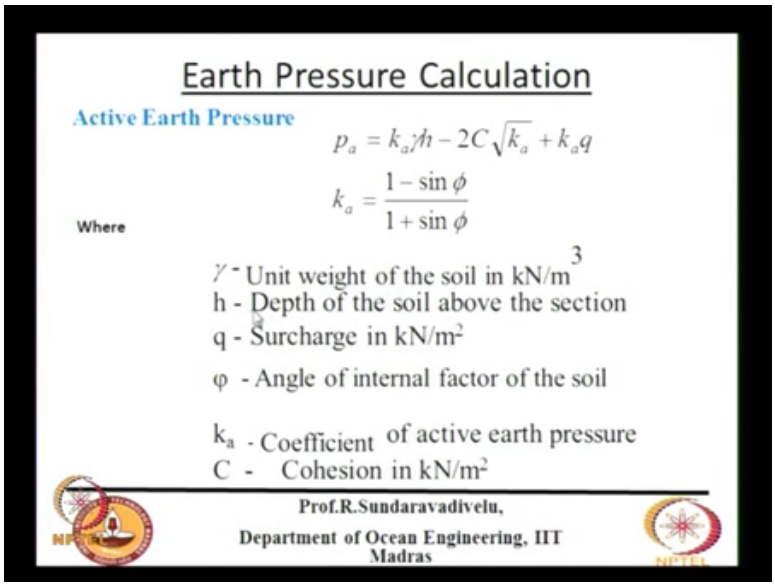

Gama is the unit weight of soil h is the depth of soil above the section they shown here k is the surcharge in kilo Newton per meter square, phi is the angle of internal friction internal friction and ka is the coefficient of active earth pressure and c is the cohesion, there are two properties that are required for a soil.

One is called as angle of internal friction another is called as cohesion, cohesion is for clay soil for sandy soil there is no cohesion c will be equal to zero but you have sandy clay where you will have both phi as well as c then you have to use this equation, so if you don't have if you have c is equal to zero then we will have surcharge ka Gama h only but if we have then you will have ka Gama h plus ka q for cohesive soils phi will be zero.

When phi is zero what is the value of ka 1 minus sin phi by 1 plus sin phi what is the value, 1 so you will have Gama h minus 2c plus kaq that is the formula (27:08 will disorder to) whenever you read a formula you substitute some limit values you can substitute phi is equal to zero, you can substitute c is equal to zero, you can substitute q is equal to zero, don't substitute Gama is equal to zero, Gama is equal to zero means nothing is there, these are the independent variables.

H can be made as zero, h zero means there is no soil above, c can be made as zero and q can be made as zero,

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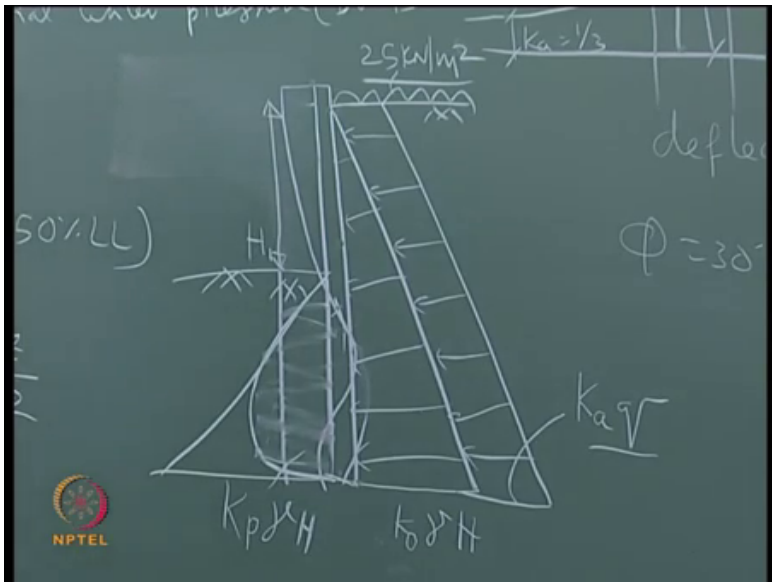

What is this q suppose there is some load on this, this load is typically about 25 kilo Newton per meter cube that is whatever live load you are assuming generally the surcharge load is taken as 50 percent but 50 also can happen, so I told you over burden pressure, over burden pressure is Gama into x, when there is no surcharge the over burden pressure here is zero.

But when there is a surcharge what is over burden pressure 50 kilo Newton per meter square, so what happens is you have the earth pressure due to surcharge which goes like this so this value is ka into q, unit for q is kilo Newton per meter square, and the (surcha) the surcharge pressure is equal to ka into q, any doubts in this

But this is a simple calculation under graduate level, how many civil engineering students are there b tek, all of you have studied this.

What it in the new today, already studied know what is that you have learned today compare to what you know already, nothing you please tell you already studied earth pressure, do you know what is the effect of movement of the wall on earth pressure coefficient that curve is known to you yes or no, yes who have start to you, you have start this in civil engineering Raj gopal, he has shown this curve, he has done this curve, but that lady was telling she knows.

That person also was telling, who is your sir, you don’t know his name, what is it ok, what about you, he has done this curve, we will continue with the differential water pressure in the next class.