Coastal Engineering
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Module - 6
Forces on Coastal Structures
Lecture - 2
Forces on Coastal Structures – II

Now, the next problem would be water on both sides with same depth, but when we say same depth you remove your static head and then consider only the that due to the waves, that is the dynamic part. So, when the crest is on one side and the trough on the other side of a wall, then we have already calculated the force due to crest.

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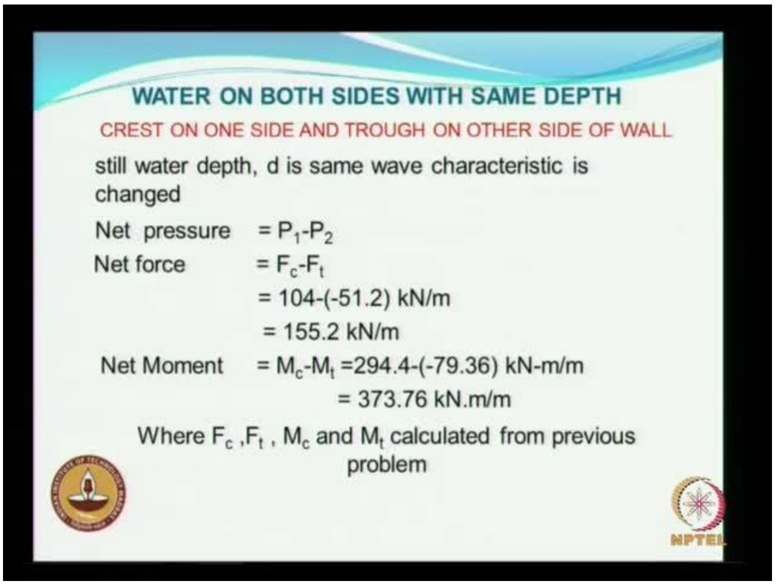

Due force when the crust is on the wall, that is equal to F c which we have already seen as 104 and that plus the trough is below the still water line. So that will be minus of this, so then the total force the net force will be this much, is that clear? So, then of course, this will be towards the direction of the crest. So similarly, the net moment will be M c that is the moment when the crest is on the wall minus the moment when the trough is on the wall; of course minus of minus becomes plus. So, you have 375 kilo Newton meter per meter and so all this F c, F t, M c, M t are all calculated from the previous problem, that is the first problem. So, that whatever it is, you need to evaluate the forces for the non breaking structure. Non breaking means on a structure which is non over topping. So, that has formed the base for all other cases or conditions.

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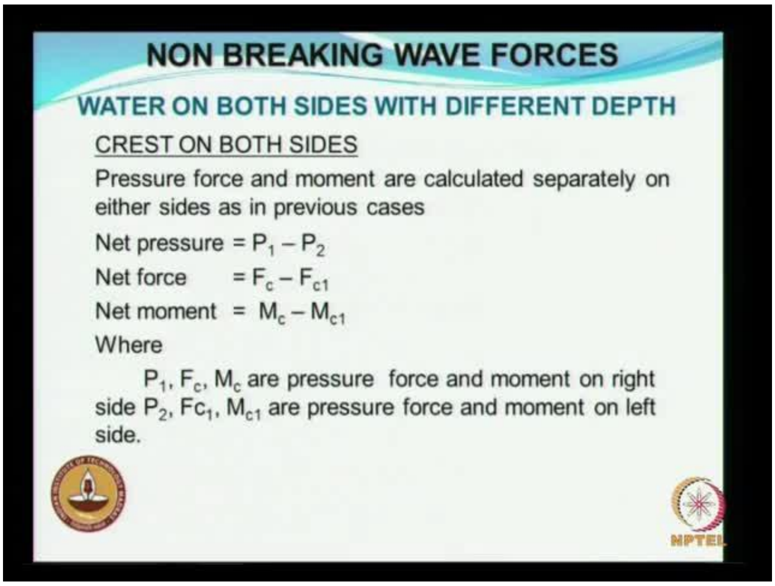

Now again, the same thing when you have water on both sides, but with different depth, so the pressure and moment are calculated by in the usual fashion P 1 minus P 2, P 2 then F c minus F c 1 and M c minus M c 1, that is you have this side water water depth is different. Now, in this case where because you have the different water depth, so you have to consider both your static as well as the dynamic part, is that clear? So, the same way whatever we have done only thing is make sure that you are taking the correct values and correct conditions.

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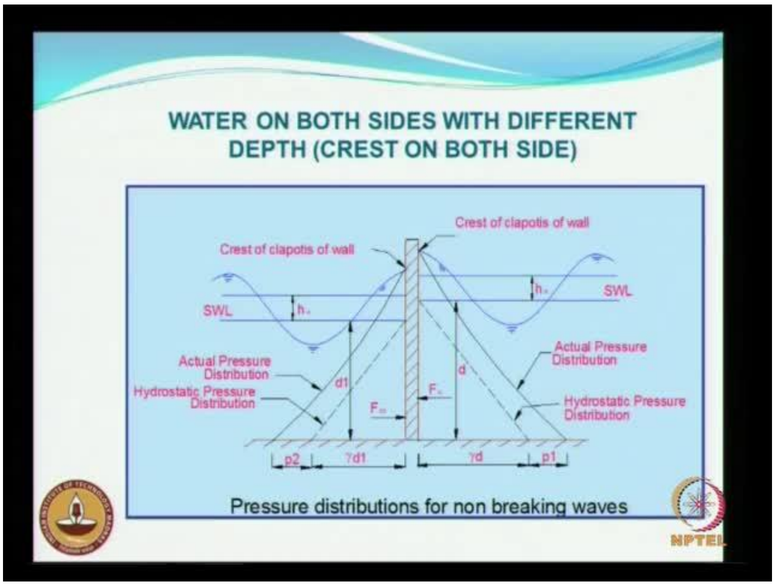

So, water depth on, water on both sides with different depths, so the condition will be crest on this side. So, maybe you have a higher water depth and then there is water in this depth in this this side is less than this, so you have a differential water depth and different differential pressures and forces acting on the wall. This condition may be a bit rare, but still you need to consider when you face such a situation, are you clear with this picture? I I would just leave some time for you to look at the pressure distributions as indicated in this picture, when the crest is on the wall and when the trough is on the wall.

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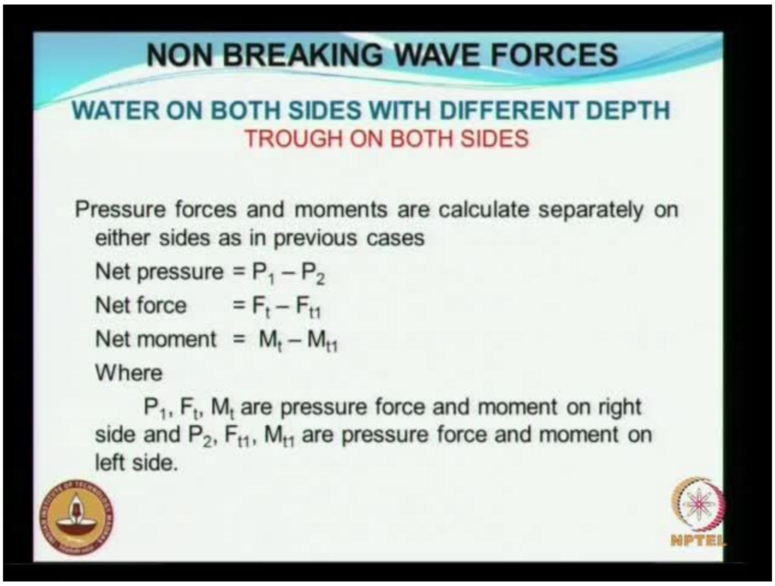

So, you use the same procedures as we have seen on the as in the case of trough.

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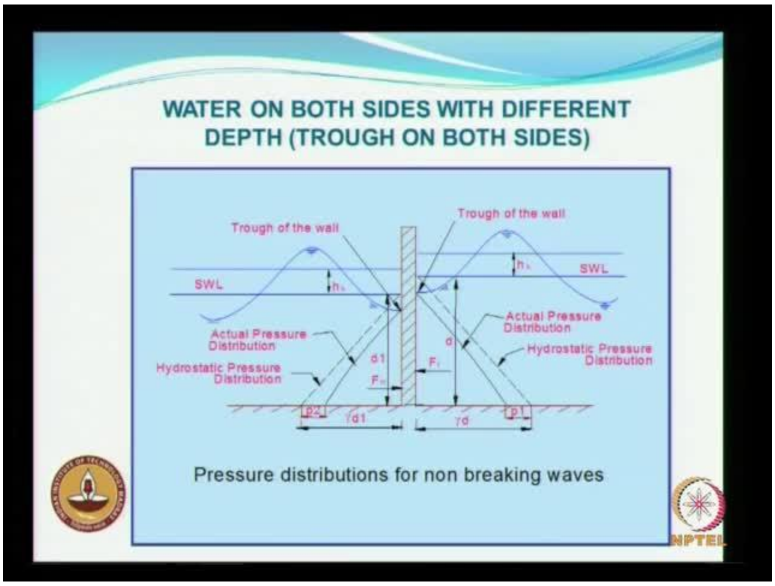

As in the case of crest, you have a condition when a trough is trough is hitting the wall on either side in different water depths. So, this pictures show the kind of pressure distribution, you can anticipate when you have the wall and with different water depths.

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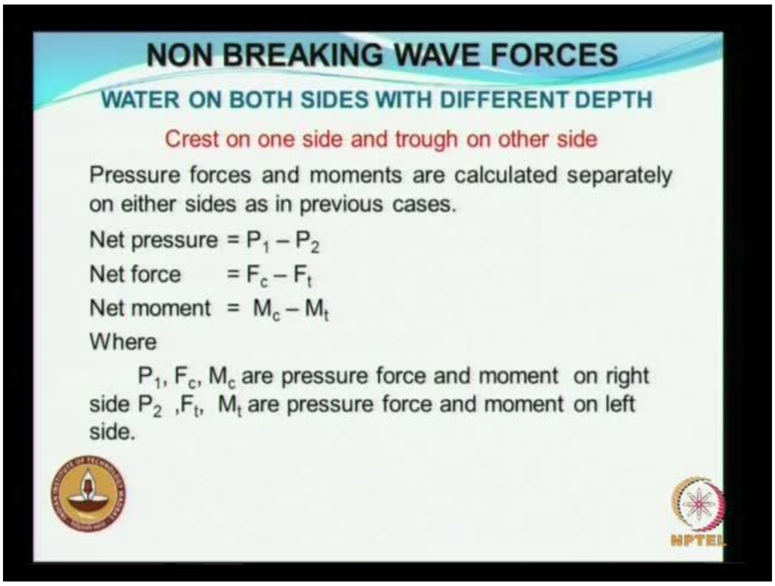

So, the same criteria is be has to be followed for all the conditions.

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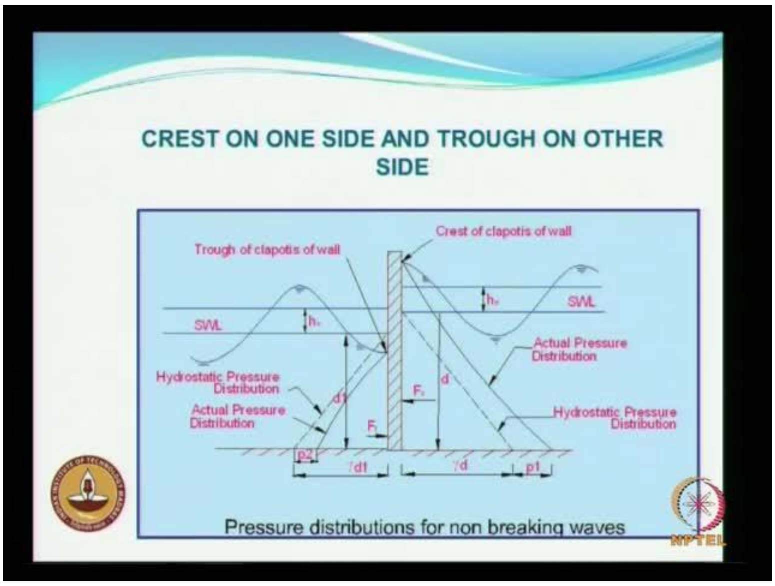

And crest on one side and the trough on another side and different water depths. So, these are all the different situations you can come across.

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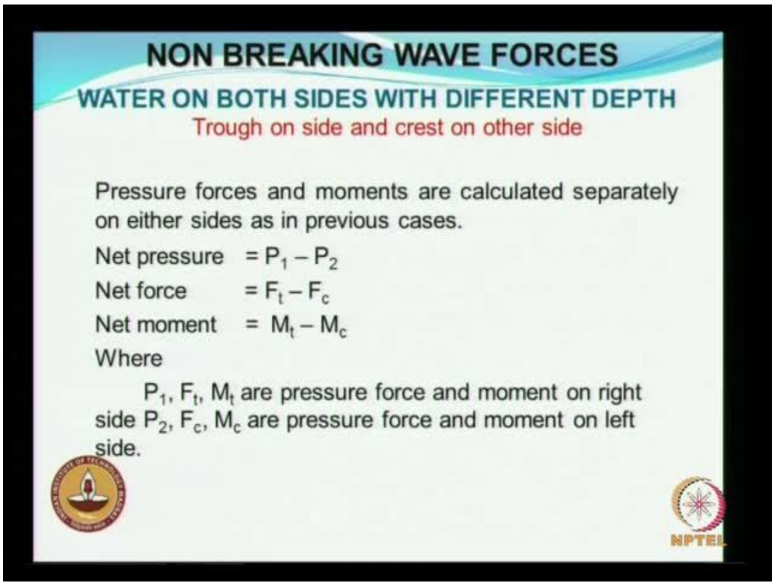

And the procedure remain remains the same, there is no difference in the procedures

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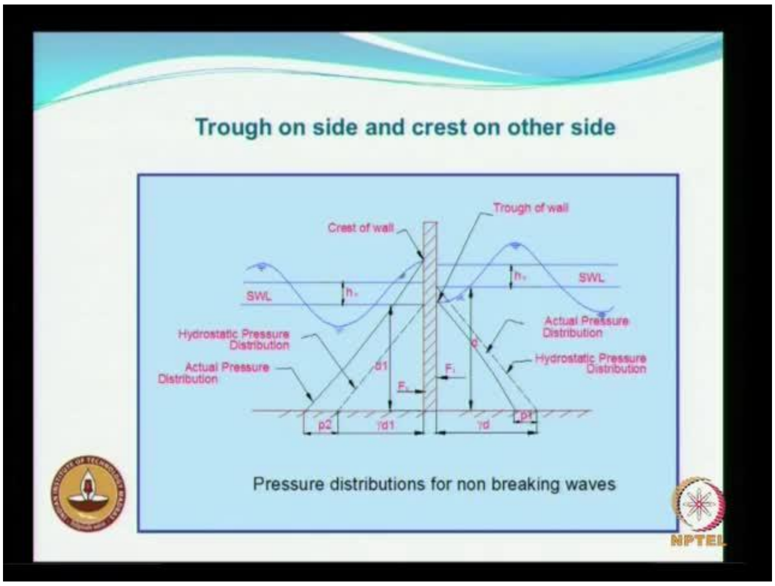

Trough on one side and crest on another side, so this is just the reverse.

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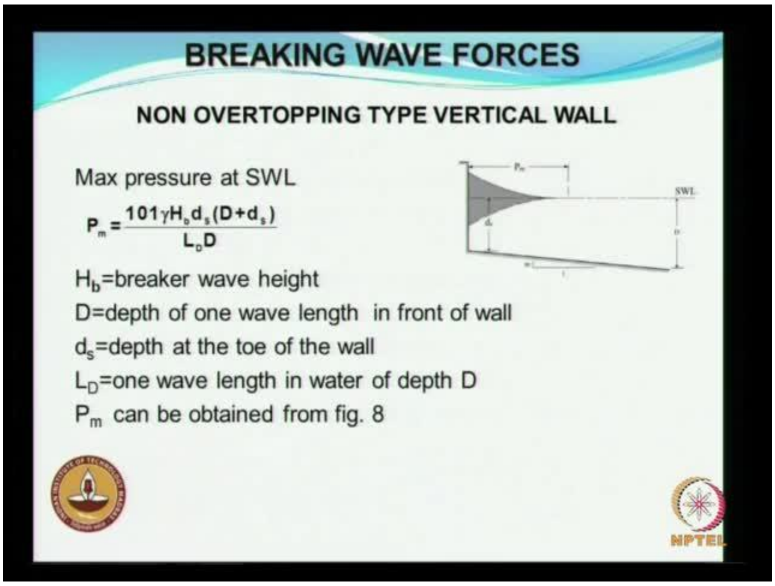

So, I am sure that all of you have understood, how to deal with the crest, when the of, on the forces due to non breaking waves on a vertical wall. So, what we have done is we looked at the non breaking waves.

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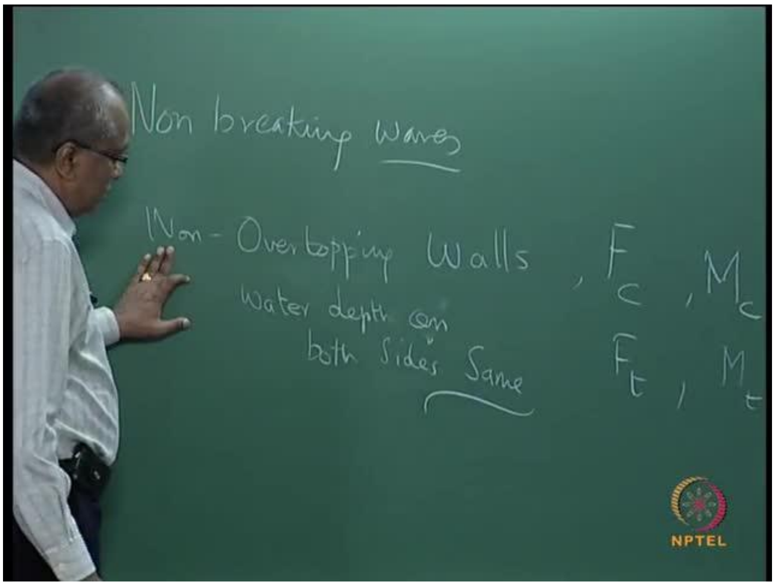

We looked at only the non breaking waves, under this condition what did we see? We saw the non overtopping condition. For non breaking non breaking waves acting on non overtopping walls you estimated F c, M c, F t and M t. So, far this is and all our results initially considered water depths, water depth on both sides same, on both sides it is same. Now, after this what did we do? We simply added the static head, I mean static forces and moments and then said that is the total, which need not have to be done if you are very sure that both sides it is the same water water depth.

What would matter you will be, if you have both sides same water depth it will matter what is the position of crest on one side what is the position on position of the trough on the other side. The worst situation will be, when the crest is on this side and when the trough is on this side. That is a condition for which you have to evaluate the wave force. So, all these things we were looking at for the condition, when the water depth is a constant on both the sides of the wall. Then what did we do? We inducted a submerged base of height some of some value, and then what did we do? We tried to find out how much of the forces are reduced due to the presence of this submerged obstacle or may be near at the at toe of the Structure.

This is what we did, this is the wave and when you have a submerged structure how much is the force reducing? And the con, next condition is when you have the wall and when you have the waves overtopping, what is the force? For all this situations we consider only constant water depth on both sides. So, that as given as clearly how do we deal with such kind of a problem for evaluation of the forces, and is there any doubt in that? So, once we considered once we took the non non breaking waves we we all these things pertaining to the action of non breaking waves.

Then finally, what did we do? We took a vertical wall, where in on one side you have a a particular water depth and another side may be lesser water depth, and then we looked at how the forces can vary and also the moments. So, I think we have competed most most of the scenarios that you can come across, in dealing with wave forces on vertical wall structures. Now, the next one is, so what you should try to do is I am not going to work out the problem here. So, you look at, so I want some values from you people. So, give me some data for which you need to work out the problem on your own.

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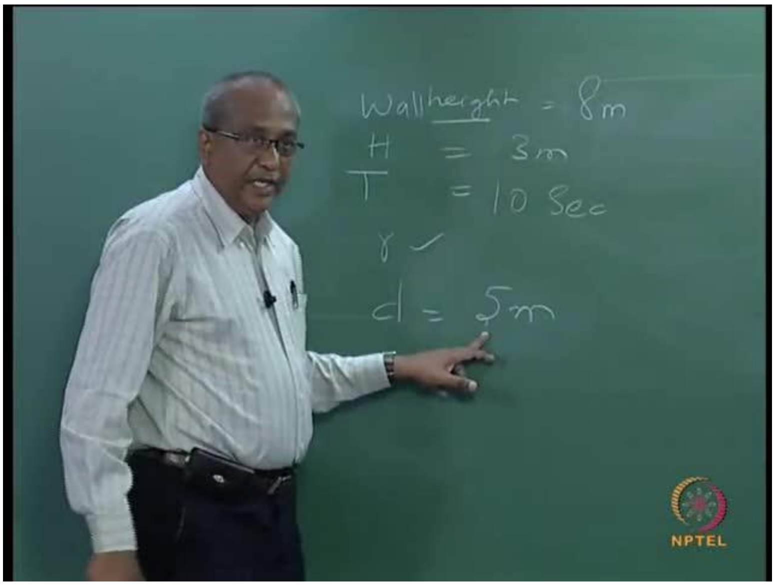

So, what is the wall height? Do you need the wall height or you fix the wall height after the forces are evaluated? It can be either case, you have a wall you need to evaluate the force. The other case is you evaluate the forces and then calculate your vice and then fix your top level of the wall, is that clear? So, I want you to give some of the data, I, based on the lecture whatever you have under gone now, what are all the data you need? And what are all the different condition you can think of? So, you you can say because I do not want to tell anything. Now, you come up give some values for wave height. Tell some value know.

3 meters

Wave height is 1 meter. This is sorry wall height how much? Wall height is how you want to give the wall height? You do not want to give the wall height because you are comfortable with non breaking waves or you are comfortable with breaking? I mean overtopping it does not matter know. If it is over topping you need to calculate only the reduction factor, how does it matter know? So, can you fix the wall height? How much?

8 meters

What is the wave height you can think of?

3 meters.

3 meters, wave period?

10 seconds

10 seconds, then what other information you need? You need the unit weight of sea water, yes.

Okay, consider unit weight of sea water and then what are what other things you need? Water depth is 5 meters? 5 maters water depth you want to have a wave height of 3 meters? It is possible what is the 0.78 times water depth? 3.9. So, this is the reason why I am asking you to give the data. If someone says, sir please consider this water depth as 2 meters, it has happened, so you need to have a feeling for all the magnitudes and also whether this is possible or that is possible. So, as per your statement it it should be 5 meters here and you do have a wave height of 3 meters that can sustain in 0.5 meters because the maximum break the maximum breaking wave height can be 3.8 meters because of this condition.

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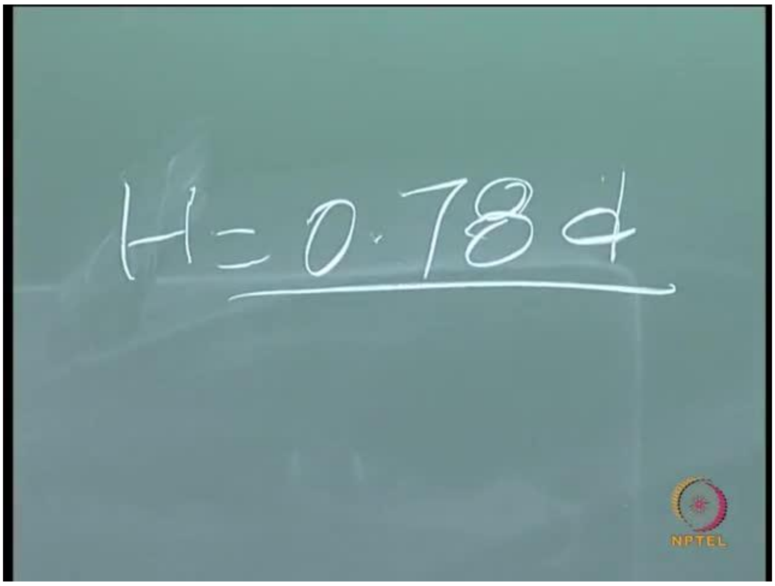

0.78 times water depth. Now, are these data enough? No, but reflect coefficient, but we have already said it is a vertical wall, the moment I say vertical wall reflection coefficient is 1, so you use all those relevant nomograms already available. So, I want you people to work out for this condition, what are the other conditions?

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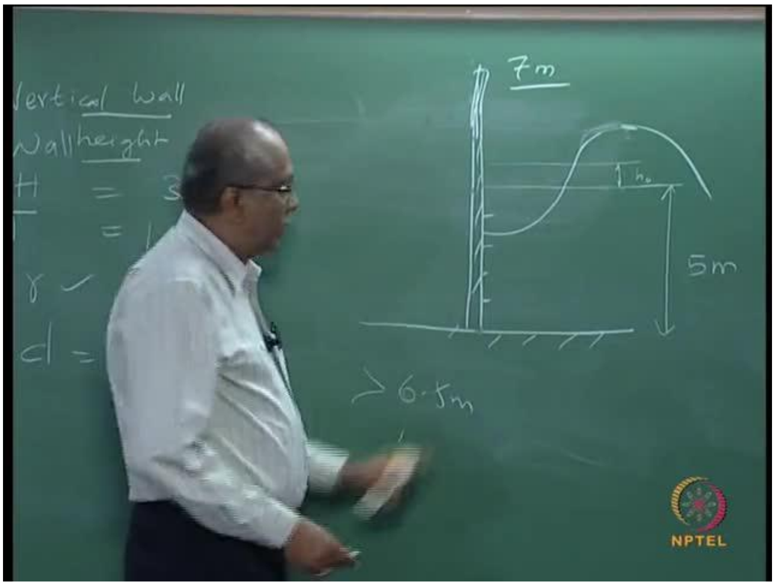

So, now according to so you have a water depth of 5 meters and let me say 1, 2, 3, 4 may be I will take here. 1, 2, 3, 4, 5 now you are going to have a wave height of 3 meters that is the dra, trough can come up to this. So, this is the, this is the wave height. So, naturally you, if you want to design it for you are as a non overtopping wall then it has to be at least say how much? May be add another 2 meters. So, this is the 0.5 meters water depth and you have 1.5 meters, so that means this height will be 6.5, so for sure it has to be certainly more than 6.5 meters.

But then what did you understand? When this wall is there you have to calculate this also, which means it has to definitely be greater than, for sure it has to be greater that 6.5 meters. So, maybe we can treat as 0.5 meters as a buffer, so maybe we can have this as at 7 meters. We do not know after the calculations only you will get, is that clear? Now, with this what other conditions you you would look for? In an open ocean you will consider crest trough all those things. Now, initially you have considered 5 meters.

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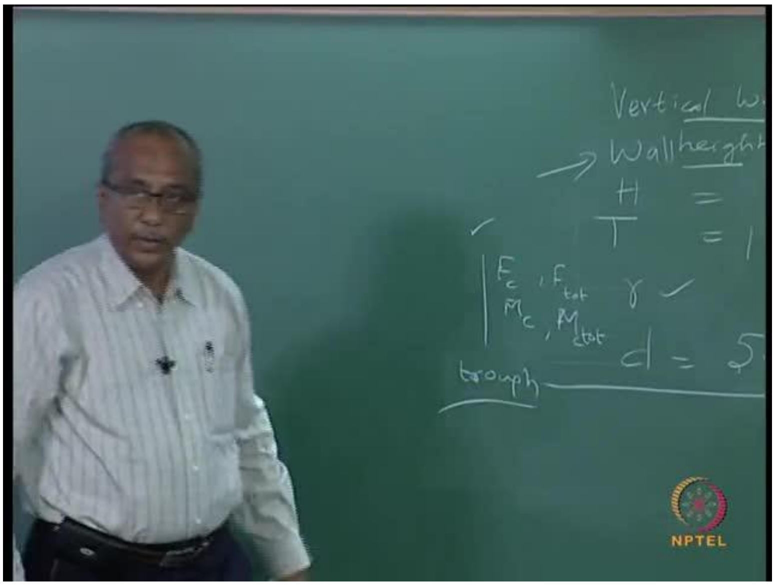

So, try to get the F c, M c, F total M c total and similarly, all these things for trough, when the trough is there. I am not going to give the answer for all this problems, for this problem but you need to do it on your own and then submit it to me later, is that clear? So, this is the first condition where in you you have to look in to the total because I may consider this height as earth filling. If this is the case, when there is earth on one side which quite common, then you have to consider the pressures exerted by the earth on the wall, which need to be resisted by a forces. And this condition I am not covering in this, but this has to be considered when you are dealing with such problems. Now, I am removing this.

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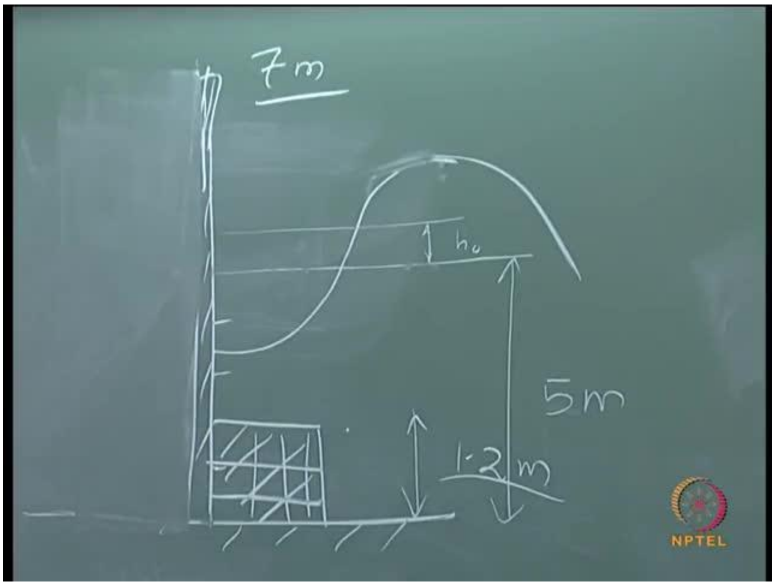

I want to have a, what could be the height? What does the scour protection say, Minimum height for scour could be around… What is the thumb rule for scour to take place thumb rule is twice the water depth, so the maximum scour can go even up to 10 meters, this is only a thumb rule based on a thumb rule. Now, I want to have some kind of a protection for scour. What was the kind of guidelines we have, height of the toe should be 1 to one and a half meters and the width of the toe should be around 3 meters. Now, I put a height of 1.2 meters maybe to be on safe side. So, my submerged height is 1.2 meters. Assume that that it is a non overtopping, again we are dealing only with a non overtopping. So, non overtopping with a base repeat the calculations from whatever you have studied. Then?

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No, can we just change the wave height, so that we are dealing with more realistic situation because if you have this, this 3 meter wave height is going to break. So, in that case we change this to 1 meter and when we change this 1 meter wave height, then again the height of the wall need not be 7 meters, it can be reduced, that is the reason why I am asking you to look at the problem with magnitudes that is the best way of understanding. Now, you see that suppose if 3 meters wave height comes, it is likely to break before it reaches the wall, provided the height of the clapot is it is not going to increase significantly.

When you mention 3 meters 3 meters wave height that time you consider only 5 meters, but you need to also take care of H naught. How is H naught calculated? Now, you you you look at this value know, so you look at this problem, you have to calculate your H i by g t square. So, h i by g t square suppose assume that H is equal to 3 meters H i by g t square is how much?

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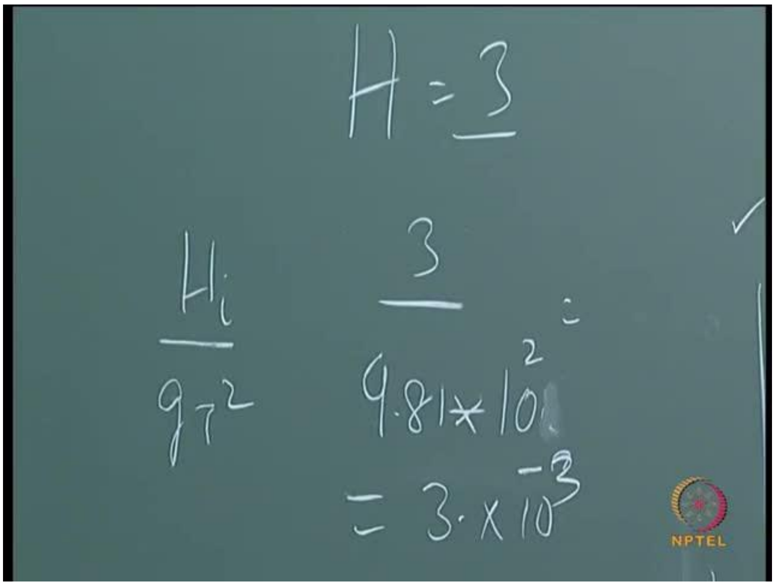

3 H i and you are considering 100 that is 10 square. How much is this? How much?

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3 into… Then go into this it should be somewhere here right?

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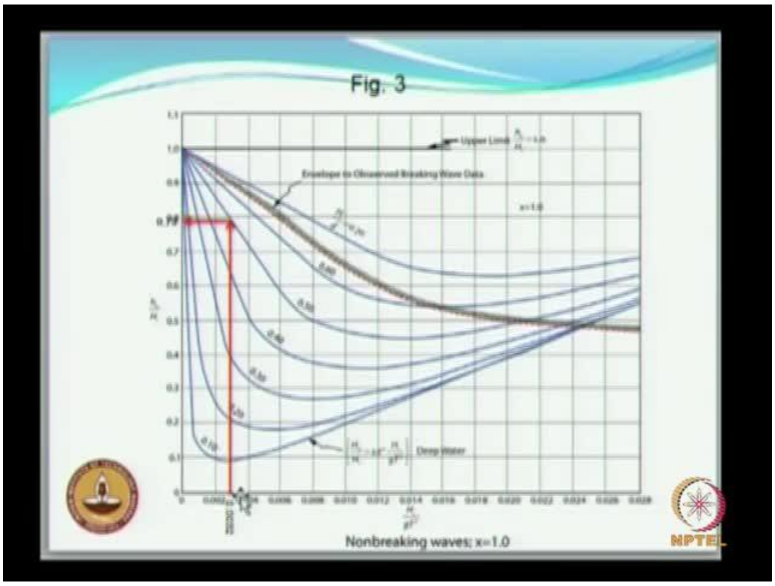

Now, this is point this is point 0.002, this is point 0.006, 0.003 it is approximately 0.003, right?

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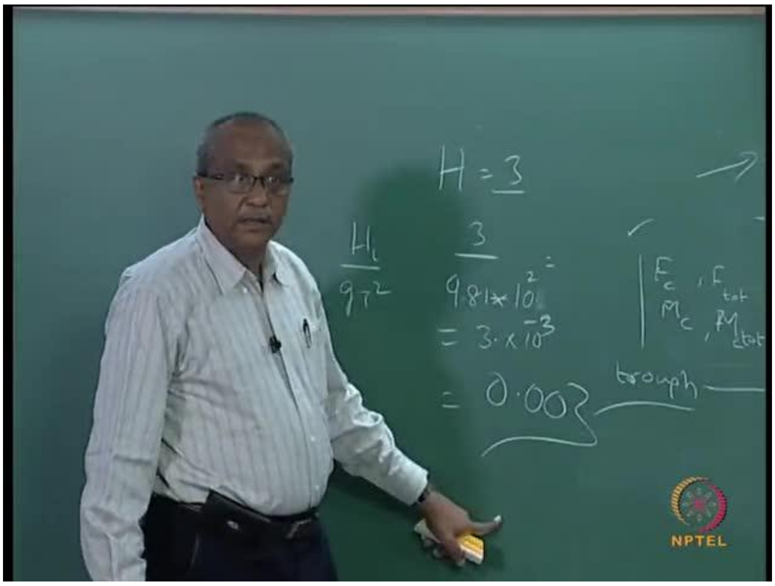

Okay, so 0.003 and your H i by d is how much? H i by d is point, 0.6. So, 0.6 is somewhere here, 0.6 is somewhere here. It is almost close to 0.9, almost close to 0.9, so that is H not by h i is approximately 0.9.

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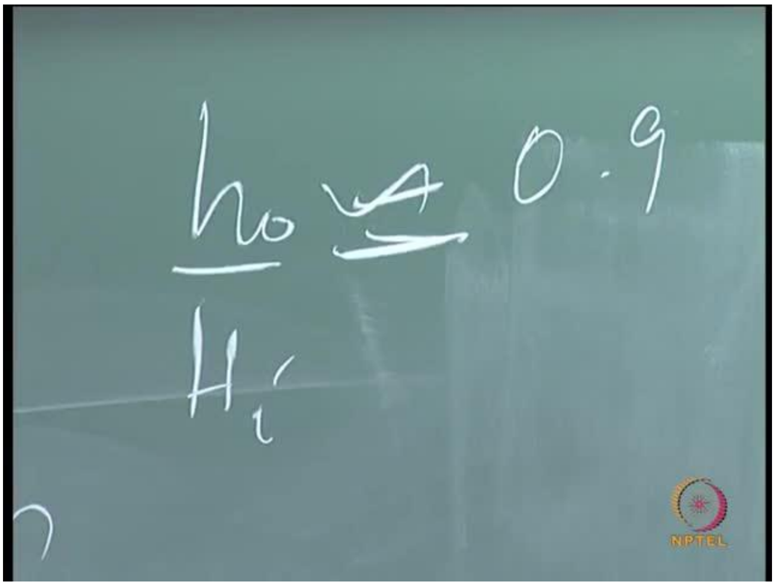

So, H not will be almost equal to H now, you understood right? So, you need to calculate all those stuff and then that is the reason when you work out with the numerical values, then you you will understand better. So, now you have only 1 meter. Let us stop that and then we proceed only 1 meter then in that case, so what does that say? That says even if you have a base like this protection, still the 3 meters wave height would act on the wall, am I right? Now, this is one situation. Now, we have understood this, now the other situation is when on this side you can have a, you may have a reduced water depth for some reason.

There may be a rockfish, I I am just this is or there is not much of scu, scour anticipated. So, in this way you do not have any any problem with scour. So, base no base is seen so the wave force will be the non breaking wave force provided the water depth is slightly may be around 5 meters itself. Not 5 meters, 5 meters means it will get cancelled. Say I I will say that may be it is 4 meters water depth. Then in that case I have to consider F c and sorry F t total F c total, if it is only 5 meters on both sides only M c and F c is needed or F c, F t and M t is needed, is that clear?

The other situation is that, what are the other kinds of situation? So, again here you consider here, when the crest is here this side, trough is this side, so there is different combinations now. So, when you have this kind of a situation, now in this case you have to have make sure that a trough is here.

When the trough is here, there is a reduction of force, it will not be same as that due to non breaking waves, where you are having a submerged structure. How much is the reduction? That reduction is going to be also dependent on the wave characteristics. All these wave characteristics come into picture, you understood?

So, all these pa, combinations need to be worked out when you are really dealing with a problem. Have you understood now, how to deal with such problem? So, and also you need to work out complete all this exercise with the help of range of with, range of wave heights, range of periods and make sure that the stability is assured for the complete range of wave characteristics you are working in the field. So, with this I think we have and there is another possibility also. You can have a wall where in a one side of the wall you can have waves breaking because of lessen, lesser water depth on other side waves are not breaking.

Similarly, one side of the wall you can have soil so you need to consider the soil pressure on other side you might have breaking pressures or non breaking all these combination are given. And this is a problem which is very frequently need to be handle and that is the reason we have spent slightly more time and then you need to calculate now, then let me have, I want you people to work out the different combinations whatever I have we have seen today, different combinations, any of this combination will be asked for the examination. Do not assume that only what, whatever we have seen through the presentation only those things will be asked in the examination. I am free to ask any kind of question, any kind may be the question carries has some values and within the first two lines itself, you might be in a, you might have to say that the problem is wrong, you understand?

When I ask you to calculate the forces due to non breaking waves, giving you a wave height which is likely you break then you have to clearly say that this wave is going to break or there are some situations like this. This is just to test how much you have understood the subject, is there any other doubt? So, we are fairly covered in detail the non breaking wave forces having seen the details on the wave forces on slender piles as well as on large structures. We now move on to wave slamming. Wave slamming is because when a when a due to the sudden immersion of a structure in water, when a wave is in is propagating in that location. So, this is this this kind of a a sudden so you expect the impact force, the force will be similarly, to an impact force and it is an impact force.

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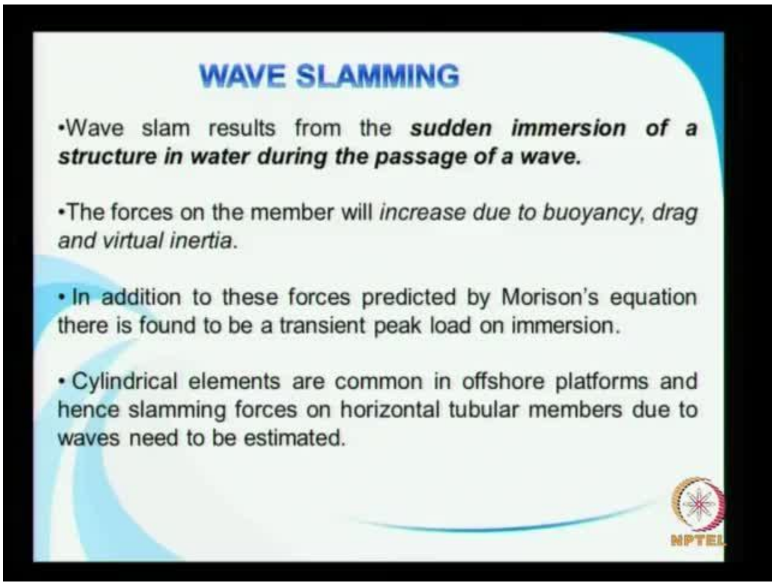

The forces on the member will increase due to buoyancy, drag and as well as virtual inertia. So, in addition to these forces predicted by the Morison's equation, there is a kind of transient peak load on the immersed body. So, this the unlike, like a a sinusoidal variation it is some kind of a a sudden transient kind of a phenomenon, so which needs to be taken into account while designing this members. So, symmetrical elements are common in offshore platforms and hence slamming forces on horizontal tubular members. So, that is so these horizontal tubular members only will be having the slam force. So, will be due to that is, slamming force due to waves need to be estimated.

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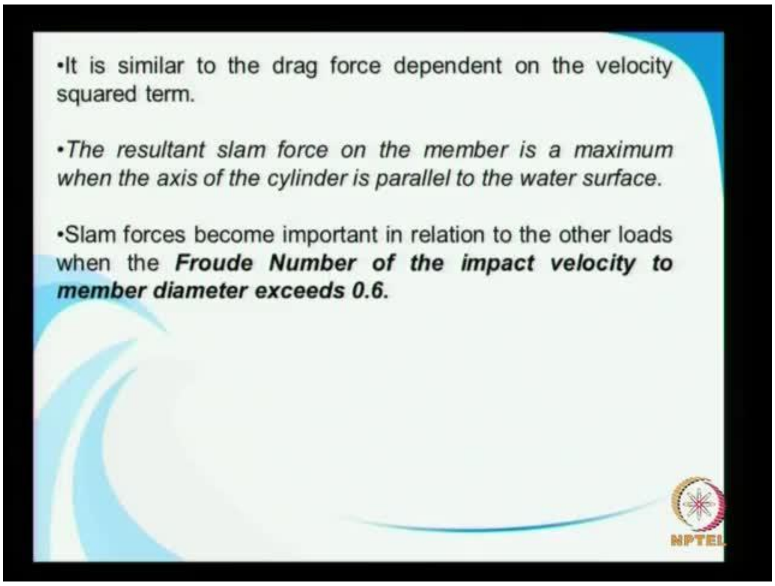

And it is often it is similar to nothing but the velocity dependent drag force. In the case of drag force you know that the drag force is a function of square of velocities right? So, you need to use that same thing the the slam force is also be similar to a drag force. The resulting slam force on a member is maximum, when the axis of the cylinder is parallel to the water surface. Slam force become more important in relation to other loads, when particularly when the Froude number, that is Froude number calculated based on the impact velocity to the member. That is if, that exceeds a 0.6 then it is extremely important to consider the impact loads or the slamming forces.

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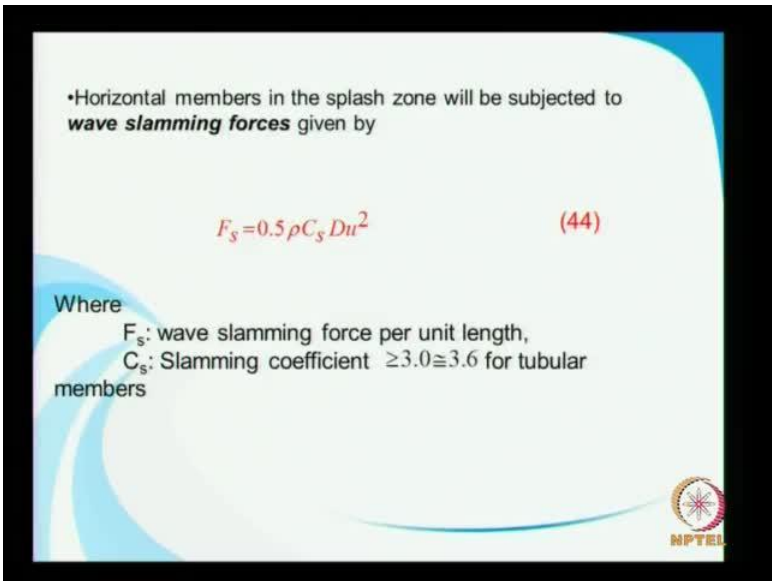

So, we have an imperial relationship to get at the slamming force and the assumption member particularly in the slap, splash zone will be subjected to such slamming forces and that is given to, given as a similar to what we have seen the drag force. So, you have a slamming force here that is the only thing which is not known and slamming coefficient can be approximately said to be equal to 3 to 3 and 3 and a half, 3.6 for tubular members. So, the with this we have covered forces on small bodies, large size bodies that is in the diffraction regime.

So, we have in we have seen the liner diffraction method, I mean liner diffraction theory and then we went on also we also examined the (( )) forces and now the slamming forces and we have considered the most common types of structures, that is horizontal members, inclined members as well as the vertical members. So, this wave forces on members wave forces on structure is still a grey area, where a lot of work need to be done and research is in progress and some of the lectures, most of the lectures are available in many of the text books.

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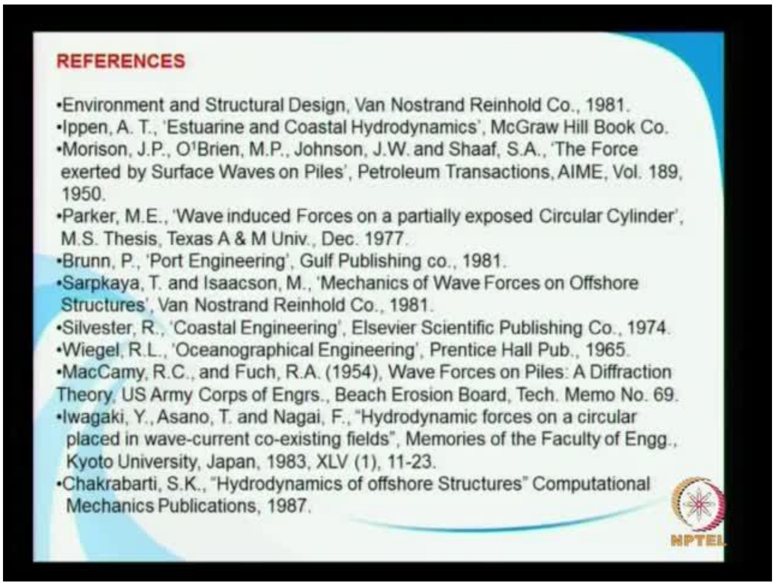

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