Coastal Engineering
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Module - 8
Physical modeling
Lecture - 2
Physical modeling of coastal structures – II

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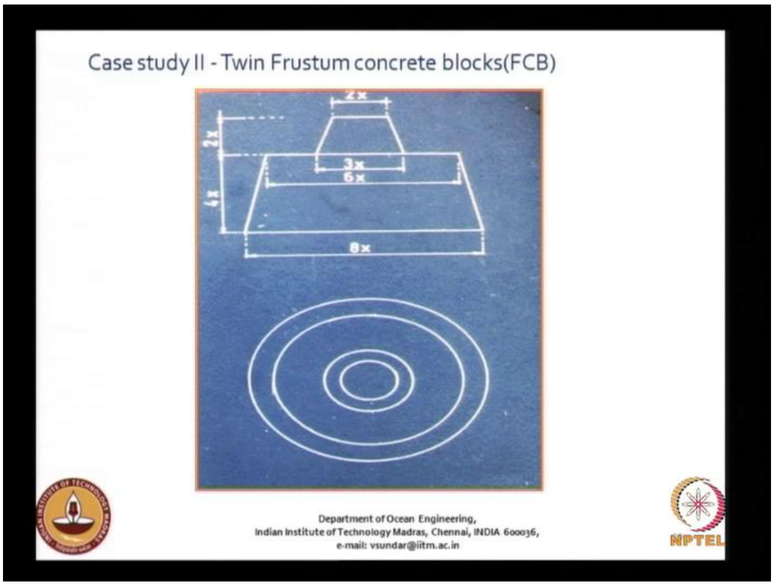

Next study again on stability test is shown here. Here there was a request to investigate the stability of twin frustum concrete block, and we were requested to look into its possibility for probably using it as one of the harmer unit artificial harmer unit for costal structure may be a breakwater or a seawall or whatever it is.

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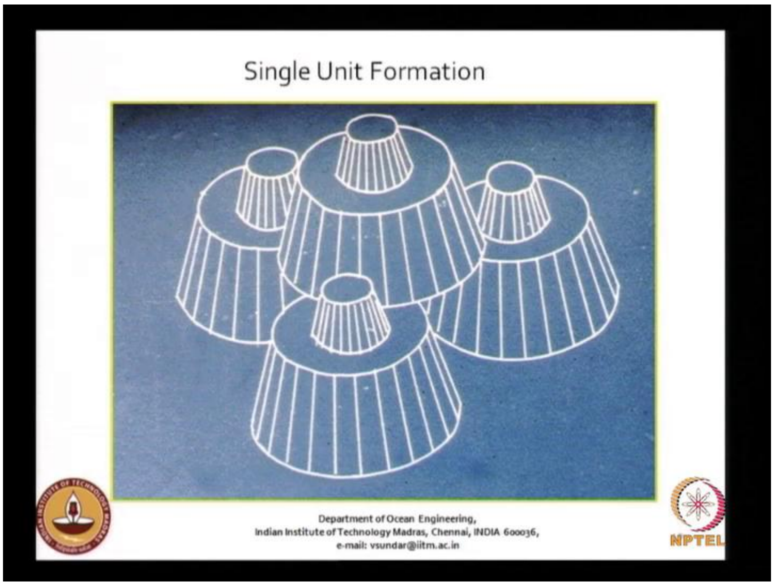

So this is the idea came by the person who coined this idea and this was referred to us for investigation. The idea looks so nice, because you see looking at this it gives a nice impression that the stability of this is being cornered by this three blocks is being held. So, we get a feeling that the stability, the interlocking capacity is quite good. This is a new block and any new block does not have any k d value; k d value means stability coefficient value. So, you need to investigate and arrive at the stability coefficient. So, for that purpose what we do is we assume a condition and then try to derive the weight and then from the weight we can again work back.

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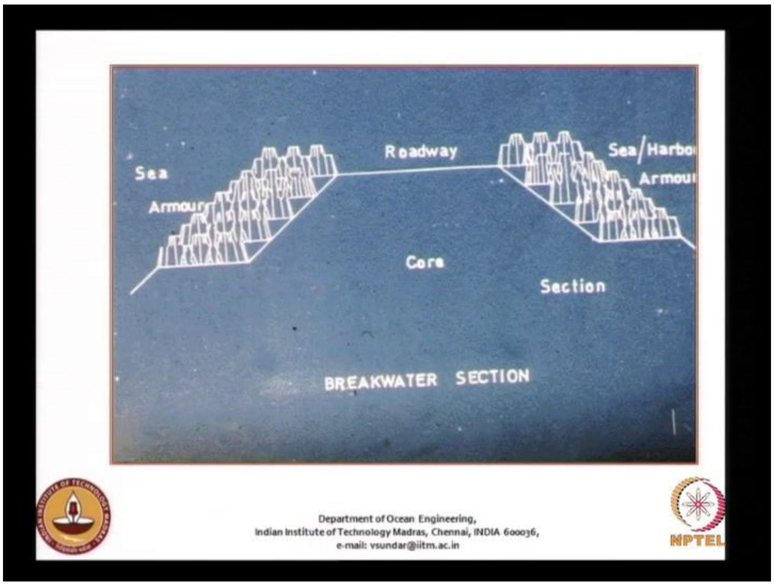

So, I do not want to go in to all the details but then I want to just show you what happened in this. So, there is no way to examine this through numerical model; you need to resort to physical model studies. So, this is the schematic representation of this. So, you have the core and over which it was thought that we can have a two layer of two layer or single layer whatever it is of these blocks.

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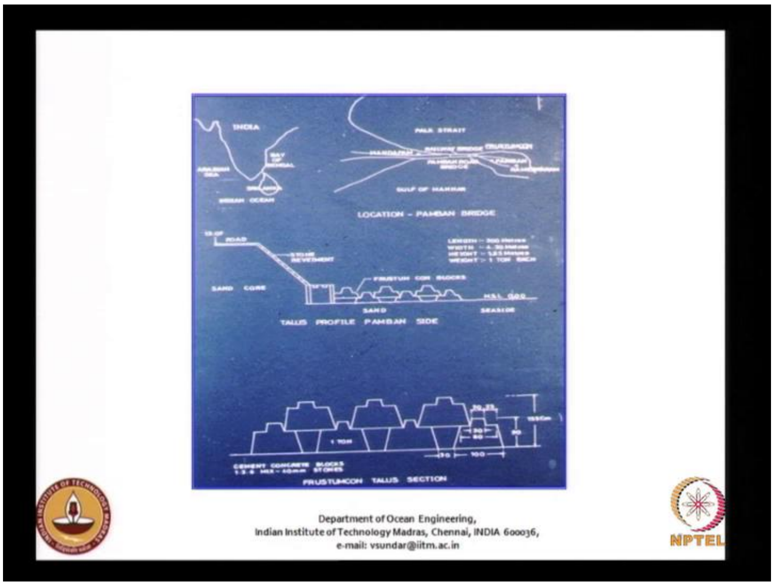

So the blocks were tried somewhere in the Pamban bridge that is connecting here somewhere near Mandapam and Rameswaram. This bridge has been tried out for as a toe protection by one retired chief engineer of highways.

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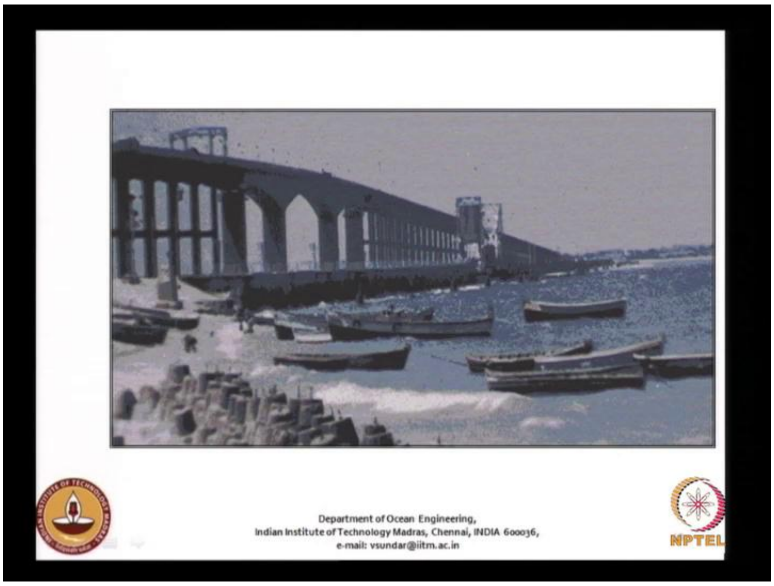

So, this came to us for examination. So, the remains of this are shown here. The only problem was it was stated that the effect of these blocks were quite good but only the structure integrity was questionable. So, we can always get over the structural configuration; I mean the strength of the concrete, etc. So, we wanted to examine only its stability.

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So, on the left side you see the conventional tetrapods; on the right side you see this new twin frustum concrete blocks. So, you look at one block on the right side if you see one block giving the way. It leads to almost like a catastrophe; the whole thing that whole row of stones slide down whereas on the left side you see that the tetrapod is quite stable for both the design was based on same significant wave height. The volume of concrete or the weight of the individual unit adopted is same, so that only the shape was trying to be investigated. But then there was a problem or there was an objection raised because the right side for the twin frustum concrete block, you see that it is only one layer whereas the tetrapod is two layers.

So the objection was probably there might have been some kind of a problem because of this using of only one layer, but then if you want to place it on two layer, the frustum concrete it becomes very complicated placing. Because the base structure of the twin frustum concrete block is flat and then you need to place it over a secondary layer where you will have a lot of projections and then over it you have to have one more layer, it becomes very complicated. An attempt was tried but we failed miserably; the placing was almost next impossible. So, this kind of information can be obtained only though physical modeling; is that clear.

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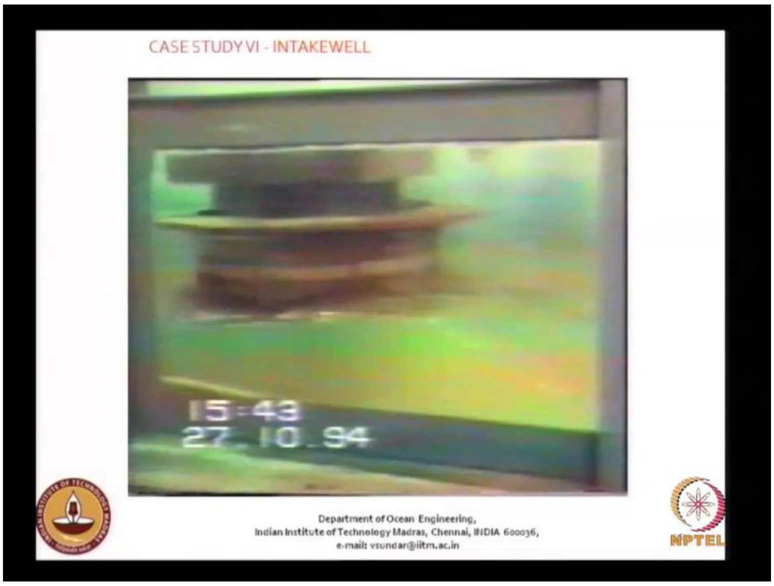

So, this is another problem where in the wave forces on an intake well are being measured in a flume. So, this of course can be calculated; theoretically you can use a linear diffraction theory to calculate the forces on a large diameter cylinder. But still we want it also verify with the external investigation by mounting it with a force balance and the total force on this intake well was measured.

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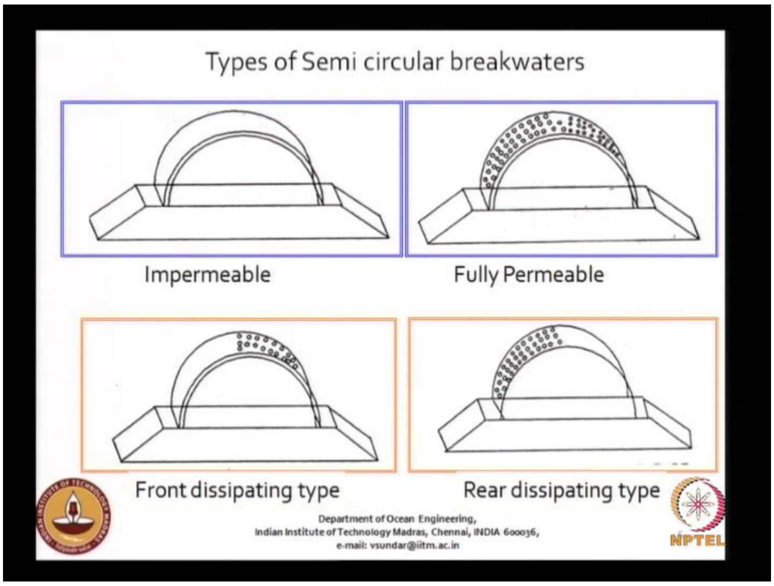

I have also mentioned about the types of semicircular breakwaters under my lecture on breakwaters. There wherein I said about the different type of semicircular breakwaters; one is the impermeable, fully permeable, front dissipating and rear dissipating. Depending on your requirement you can use any of these four types of semicircular breakwater.

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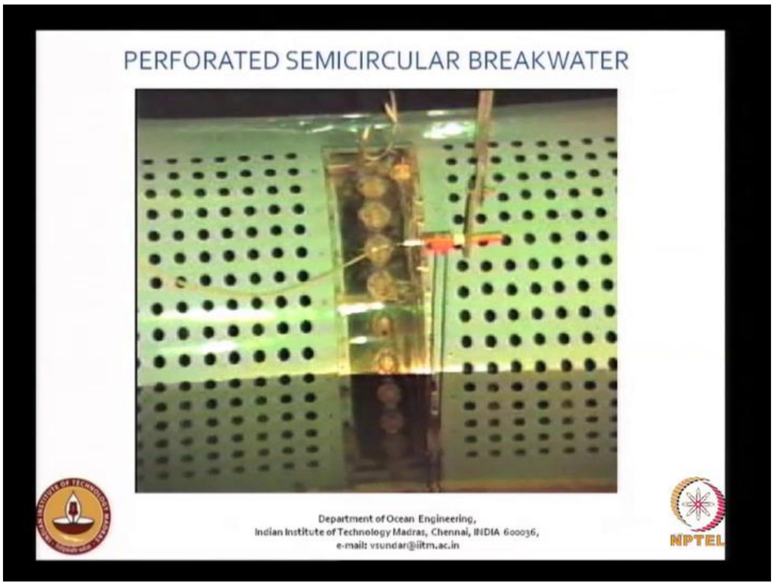

So, this is part of a project major project wherein the front dissipating structure; that is the seaside of the semicircular breakwater is permeable. So, the percentages of openings are changed in order to change the permeability and also the measurement of pressures. So, you see the pressure transducers in the centre. So, that is used to measure the pressure exerted on the semicircular breakwater. So, this was subjected to a variety of waves like random waves, regular waves of different wave characteristics and then we have come out with a number of publications and other. This is form academic point of view, research point of view. Some of the other problems which we have seen is user-need form client based problems. So, we have also mounted wave gauge along the surface of the breakwater in order to measure the run up over the structure. So, all these things are possible through this; is there anything else.

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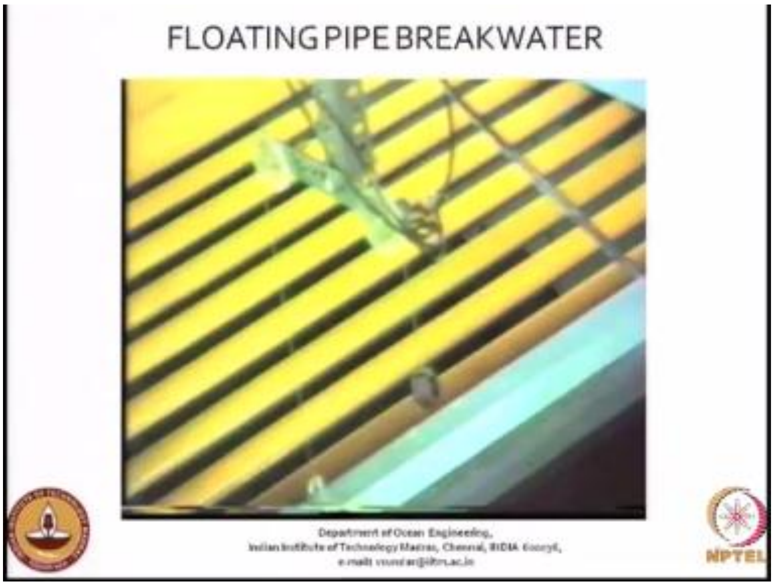

So, this is the floating breakwater; that is pipes which are placed at closer intervals. So, it acts as a porous medium and it is also floating. So, the idea here was to measure the motion responses of the structure and also the forces on the mooring line. So, all these things are being carried out using pulley measurement system. I do not want to go into the again the details but all these things are quite straightforward. You should look into the some of the other literatures wherein here the idea is to vary the spacing between the pipes and also the diameter of the pipe and also look at the variation in the porosity on the transmission coefficient. The main idea is to make sure on the lee side of the breakwater; the wave height is far less compare to the sea side. So herein that is what is called as your k t transmission coefficient.

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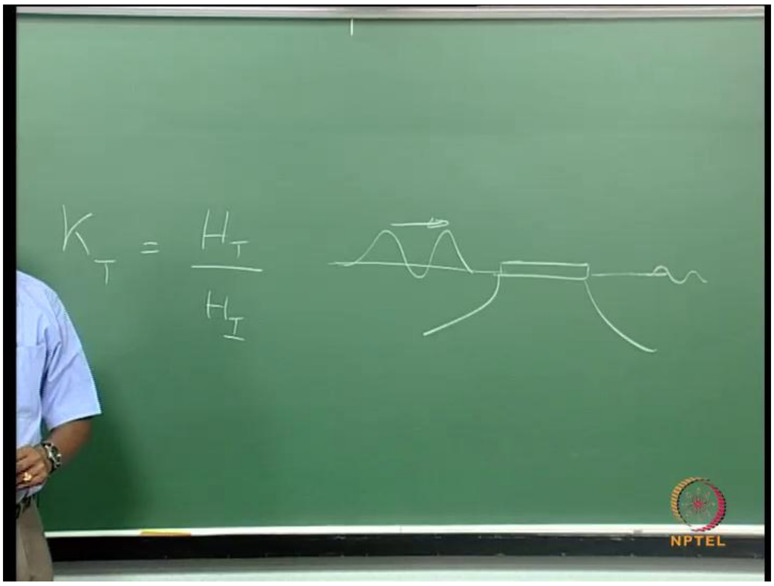

Transmission coefficient as I said earlier is the transmission coefficient divided by transmitted wave height. So, you have the structure here. So, this is sea side and this is the harbor side; k t is should be as low as possible. So, we could attain something like less than 40 percent here in this kind of breakwater. So, this as I said earlier can be used for short term solutions as a short term solutions also. So, it was a major part of a major project wherein. So, they may be surrounded by wave. So, out of that those may get transmitted. No, see initially we test only for regular waves. So, when you are testing for regular waves you are going to get regular waves only.

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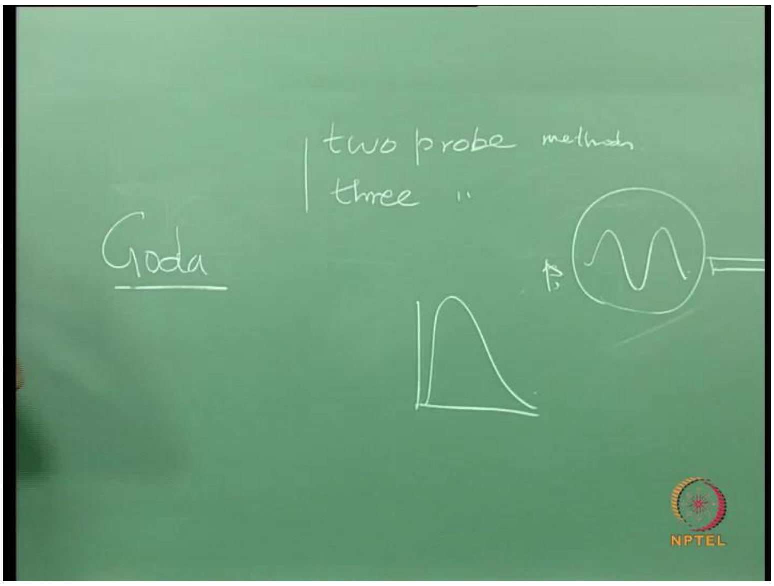

But when we are testing for random waves, then here we consider the spectral density of this and then we get the spectral density of this transmission coefficient; where? No no, we are looking only about the energy dissipation; on this side how much is the energy less. So, we talk in terms of energy or wave height is a general description. Finally you are talking about energy only. In the case of a regular wave we talk in terms of wave height. So, one is the incident wave height and another is the transmitted wave height. Of course when you are having a structure like this, see it is what you have you have the incident wave height, you have the transmitted wave height but one thing there is certain amount of waves getting reflected.

So, you need to find out from this what you measure here is the composite wave elevation; composite wave elevation I mean this is a combination of the incident wave and reflected wave and there are methods of separating the incident wave height and the transmitted wave height. There is what is called as two probe method; very simple ones, two probe, three probe method. So, the best book for this is to look into the book by Goda. So, he gives explains the both the methods very clearly and there are other published literatures also available but the best book is he has really elaborated the whole thing.

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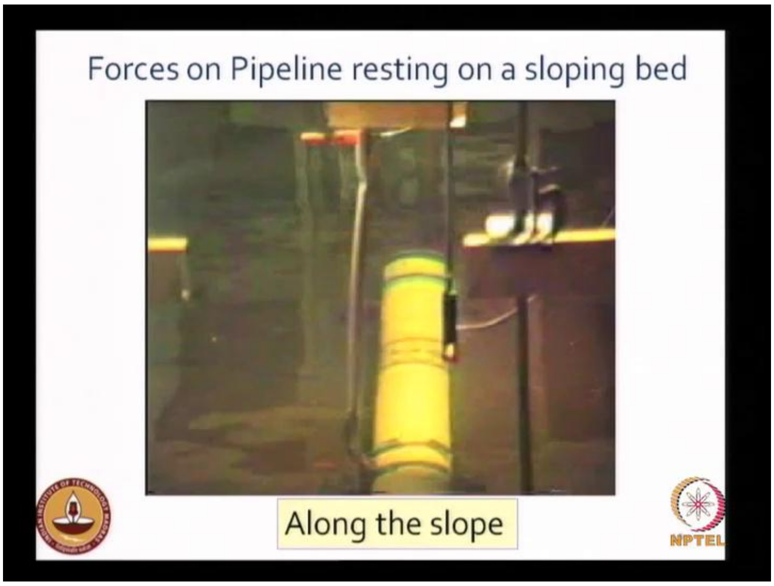

So here, is that clear. Now the next problem which is projected there is see normally when you look into the literature what happens is.

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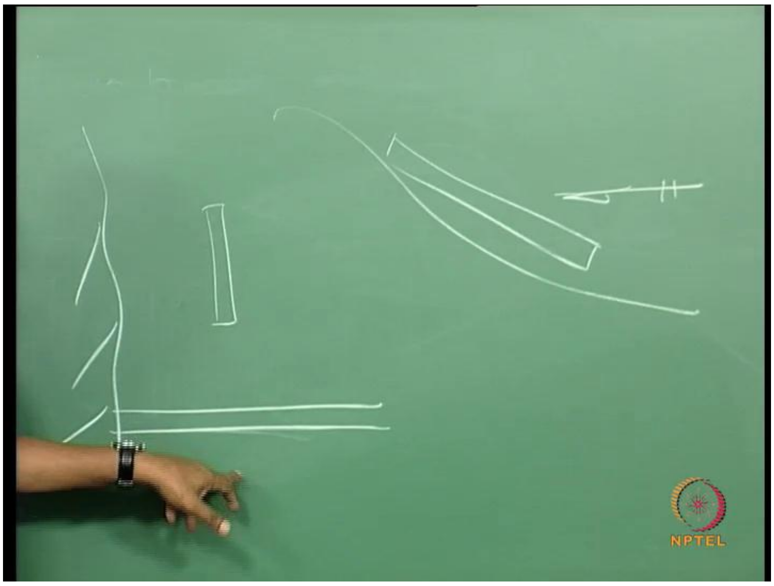

What you have in the literature is when the experimental work is you have a pipe separate pipeline and then you have the wave generated and you measure the forces horizontal force and vertical force and this is what we normally use for all the design purpose for the design of looking at the stability of pipeline, etcetera. So, but in reality what will happen when you have the coast, the pipeline are not like this; pipeline are usually like this. So, if you take the beach slope the pipeline is like this; right. So, there is not much of work done in this area.

How does it vary when the pipe is like this and when the pipe is like this and in order to understand this, we have done here was a study conducted to measure the forces on pipeline when it is normal to the shore line. So, here it is placed over a seabed or a simulated seabed impermeable seabed and over that the forces are measured by measuring the pressure distribution around the circumferences of pipeline. Once you measure the pressure distribution around the circumference of a pipeline, you can integrate and get the total force acting at on the pipe around the cross section.

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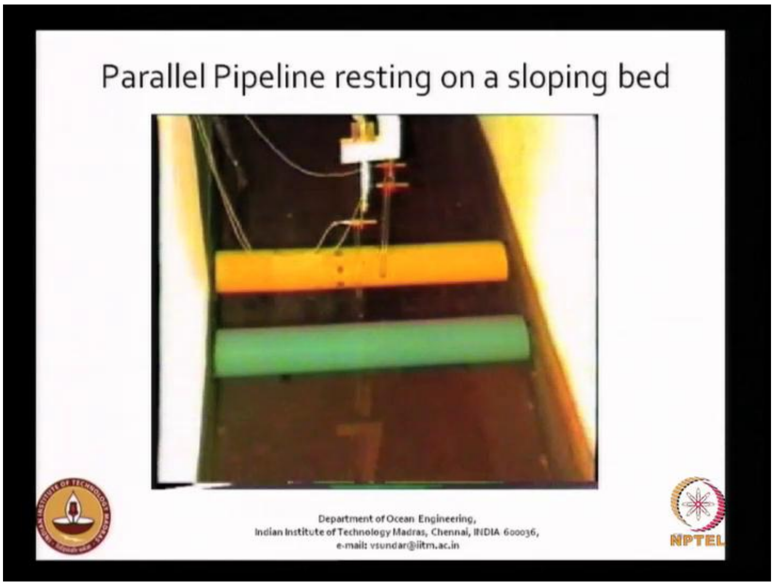

So, this is what was done in one of the studies and here this study is about the interaction between two pipe lines. For example, if you have gas and oil pipelines; if these two pipe lines are placed side by side, the distance between the pipelines as well as the diameter of the pipelines come in to picture. So, this two have some suppose if this is going to be your main pipeline, how does the force on this pipeline vary because of a neighboring pipeline. It naturally depends on the size of the pipeline and also the distance between the pipelines as well as if there is a gap between the sea bed and the pipeline. All these parameters apart from the wave parameters would really control or have an effect on the wave forces would be dictating the wave forces. This is again a doctoral thesis, part of the doctoral thesis which I am presenting here.

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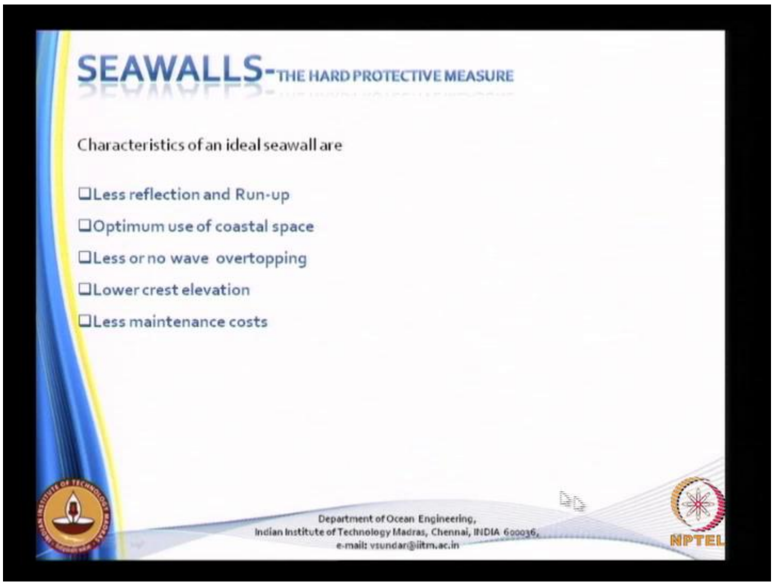

So, I think that is about pipeline. Then coming back to the costal protection work, this is on seawalls. Seawalls as I said, normally we talk about rubble mound sea walls but there are there are lot of ideas.

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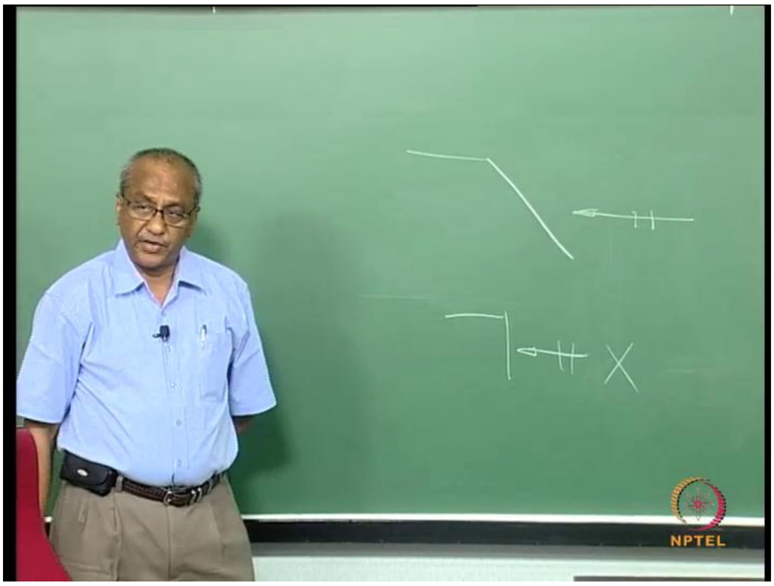

There has been number of ideas. So, usually when the waves are coming in this direction you have a vertical wall is no good; when the wave is coming in this direction this is no good, for simple, I have told enough number of times the reasons. So, you have to have go in for this kind of a seawall or because of you have a bound also, bound sea walls and apart from that if you have impermeable seawalls.

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You can think of having the shape something like this and how does this matter because when the wave is coming and hitting the structure, you see that the wave is getting back. So, this front shape is very important in order to effectively reduce the energy; I mean the waves overtopping energy, I mean overtopping or the wave run-up. So, how do you do this? So, this was one of our attempts to understand the effect of the shape and the shape of the seawalls. Some this could probably be done both in numerical as well as in experimental because we are dealing only with an impermeable structure.

So, the shape can be easily modeled but looking at this what were the characteristics, what are the characteristics of an ideal seawall. An ideal seawall it should have less reflection, less run-up, optimum space of coastal space; that is it should not occupy more space and less overtopping, less or no overtopping. This of course depends on the crest elevation lower crest elevation. So, you want to have lower crest elevation at the same time no overtopping. So, trying to achieve all these things are not easy.

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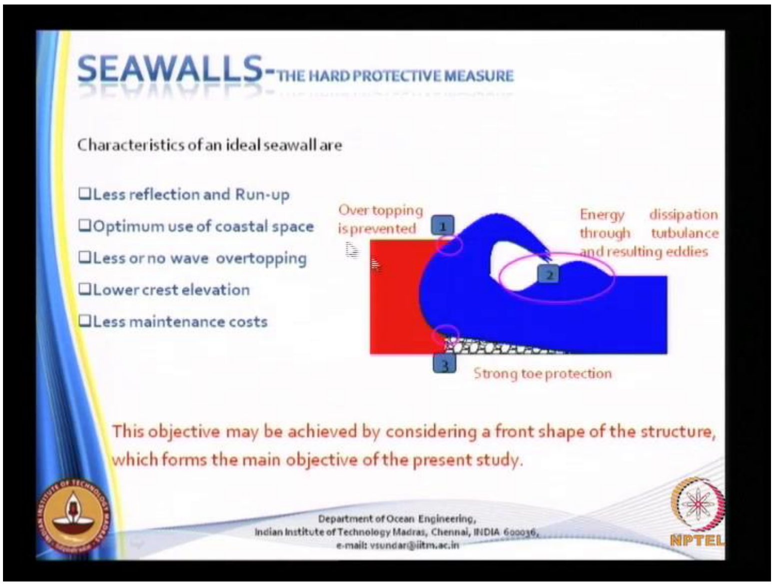

And finally less maintenance cost. Then I can add one more esthetic. So, this is called a challenge; you want to have all his boundary conditions and come out with an ideal seawall; it is not so easy. So, the objective may be achieved by considering a front shape of the structure which forms the main objective that was the objective of this study. So, this is again repeated here that does not matter. So, this is the one. So, this is what I have mentioned here is pictorially shown here. So energy dissipation, so the waves are returned back energy dissipation and strong toe protection. You need a strong toe protection, overtopping should be prevented and the energy dissipation so due to turbulence and eddies.

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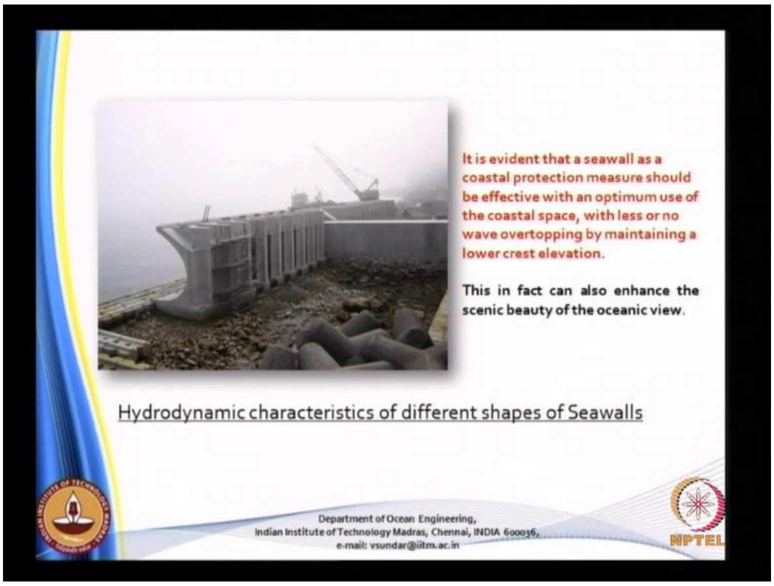

So, it is evident that a seawall has a coastal protection measure should be effective with an optimum space; whatever I have said is repeated here. This in fact can also enhance the scenic beauty. So, if you have a structure like this and if you have a kind of a walkway here do not you think that it will be so nice to look at?

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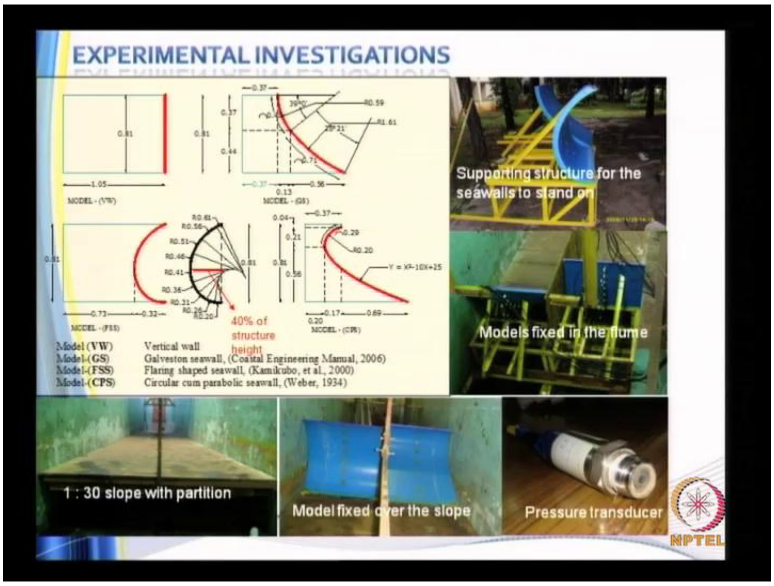

To achieving this, so what we have done is here in this particular study we have a vertical wall because this is the base for which you can compare your ships because vertical wall you know what is the kind of reflection, what is the overtopping you have, etc, there are enough literature available. So, try to make this is one shape, this is another shape and this is another shape. So this is VW, then this is GS and this FSS and then finally CFS. So, you just have a look at it because I am just showing all these things, I am not going to the details; just I am showing all these things what are the possibilities you can do, why you need the physical model testing of costal structures need be done; that is the purpose of this lecture.

So, see here what we have done? We have all these ships fabricated and then we have used pressure sensors to measure the pressure as you can see here and this is another model. So, we place in one the model is divided into two parts; in one compartment one of the model is placed with the pressure sensors, in other thing you have the other model with the pressure sensors. Almost the same level the pressure sensors are in the same level, so that only the only the shape is discussed because the shape is also changed, the level also is changed, then you get a total confusion. So, whenever you are having additional parameter, you maintain all the parameters same and only the parameter which you are interested in need to be varied. This is very important when you are dealing with experimental or even in the case of numerical work.

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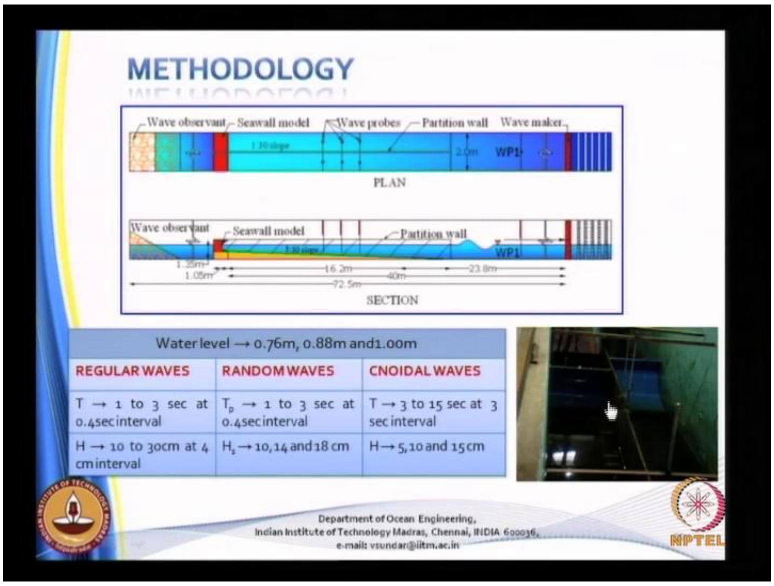

So, this is what we have done. So, I do not know whether this is. So this is the, are you able to see some picture; here is it clear, I think because of the light. So, you see the deflection of the waves back into the ocean. So, although it is bit evident from the shape itself but you need to verify you know.

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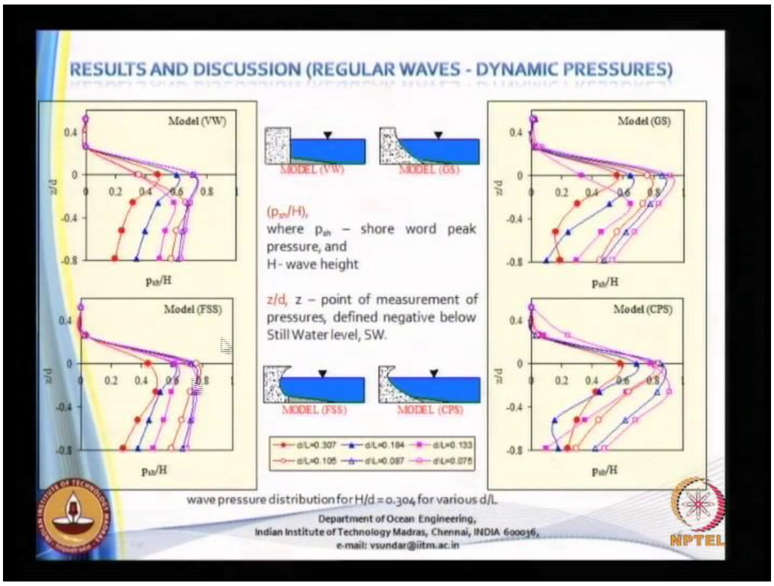

So, here are some of the results how the pressures vary. So, what we do is here the dynamic pressure divided by the wave height at different z by d that is elevation of. This is the mean water line and you see the points where you have the pressure sensors one, two, three, four and each of this line represent different d by l; d is water depth, l is the wave length. So you see that this is the smallest d by l and this is the largest d by l. So this clearly shows that for the longest wave period for long period wave, water depth is constant. So, water depth is constant. So, you will see that for the longest wave longer wave the pressure is more as we have seen earlier also through help of problems.

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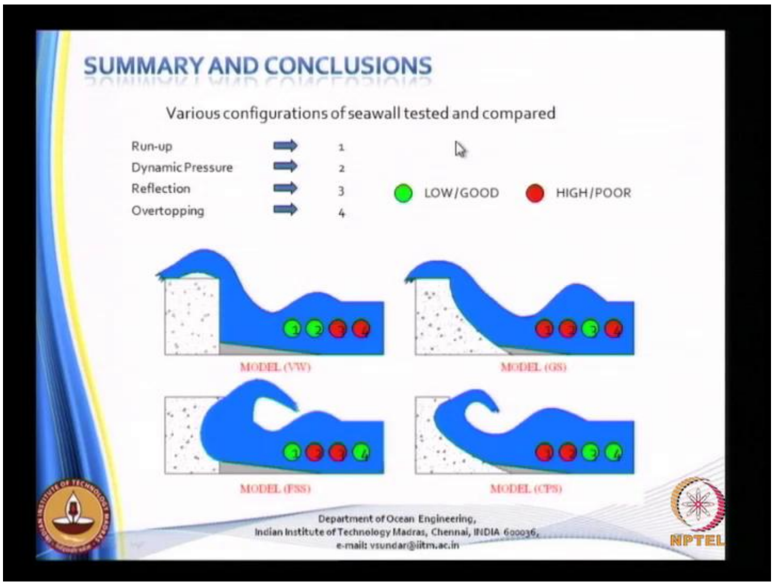

So, various configurations tested and compared. So, we quantitatively said we give some kind of ranking one, two. So one, two run-up and then dynamic pressure is two reflection, overtopping, etc. Then we finally recommend that this structure is quite good for when you want to have less reflection and less overtopping. So, such decision can be made using this kind of experiments and modifications are also possible.

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Is it all right; all of you are ok. Now after the Tsunami when I take the Tsunami lecture, you will see that the role of vegetation has been very, very heavily discussed because the vegetation had hector as buffers in order to by reducing the inundation distance as well as the inundation heights. So, wherever you had the obstructions in terms of a plantation as you can see here; there are plantations here, just by side of this you see this is directly exposed all this things are gone but whereas these buildings did survive and there are number of examples for this. So, is it the role of vegetation? Yes. So, how do you understand the role of the vegetation in case of Tsunami, how do you plan for it? So, it is that just like that you go on and plant some trees or can you have a engineering method for planting the trees and these were some of the questions being raised.

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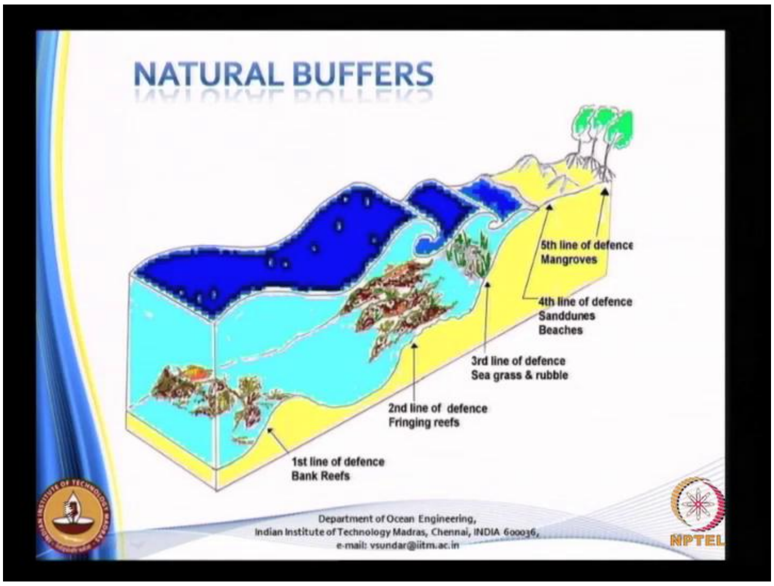

And so in fact, when you have these are the kind of a barriers; this interesting picture I have taken it from the internet, unfortunately I do not have the source here. So, you see that they say that this is the first line of a defense bank reefs and then fringing reefs some growth and then you also have the sea grass and then you have here the final thing which is the fifth level fifth line of defense that is the mangroves. So, everyone must there are lot of scientist who were talking about mangroves but mangroves can thrive only in locations where there is a continuous exchange of sea water and fresh water. But open cost, only salt water you cannot have mangroves flourishing. So, you need to go in for some other kind of plantations. What are other kinds of plantations, how do you design, how the physics is involved, what is the basis or the mechanics by which the dissipation of energy takes place? These are all the questions which need to be asked.

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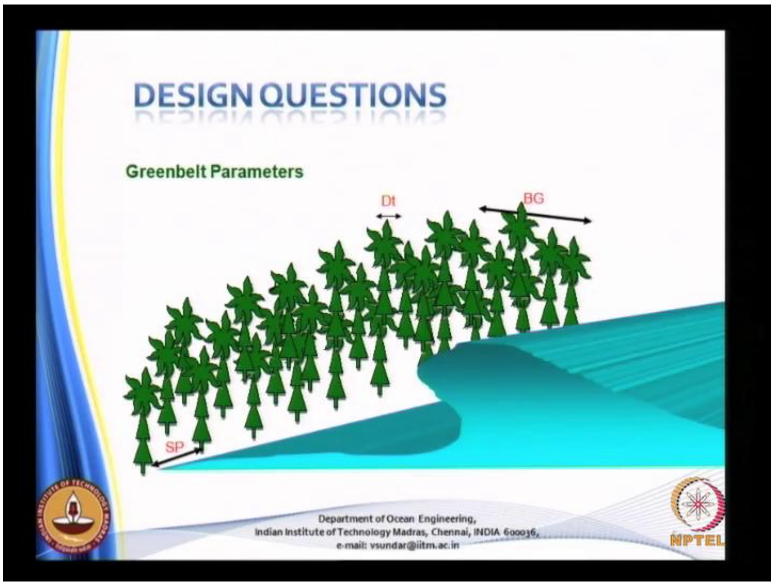

And what are all the parameters, for example, when you look at this is also to referred to as greenbelt; quite popular or quite heavily investigated in Japan because you know that Japan is a frequent visitor of all this natural costal hazards. So, they have done lot of work in greenbelt. So, what is important is the diameter of the stem and if you want to call it as a greenbelt the entire width of the greenbelt is important, how wide it is, how long you want to protect along the coast and then what is the diameter of the individual stem and what is the distance between the stem and finally about the rigidity of the stem; has it to be very rigid or some kind of flexibility. So, all these things need to be considered.

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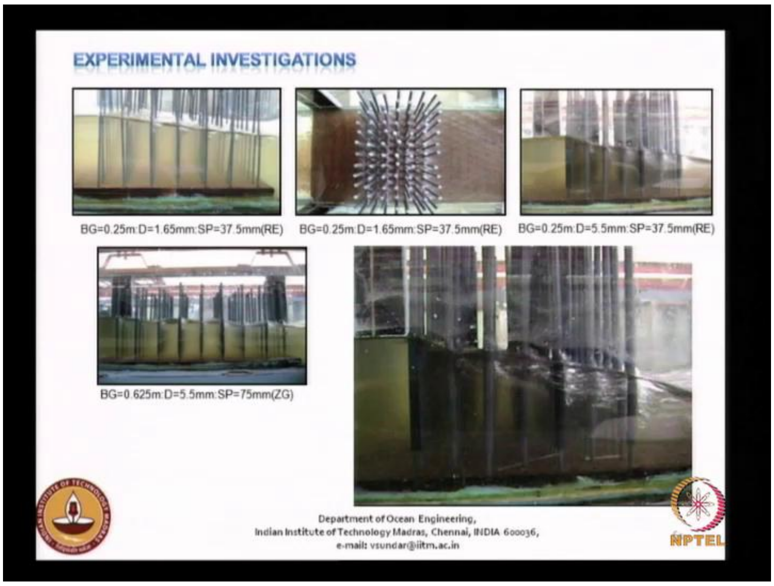

So this is part of a PHD which was done soon after the Tsunami. So, you look at here. This is do we have a steady state flow; there is no wave here just to understand the mechanism. So, these were some of the different sizes of I mean stems simulating the stems of the plantation and adopted different spacing’s, different diameters, different width of the greenbelt and then subjected to the flow and then you try to find out how much of energy is being dissipated. So going back into classical hydraulics, we try to find out what is the friction factor; do you understand. So, you clearly saw in that movie how the energy is being dissipated and when you look at the energy being dissipated, you see that the direction only you get a feeling that.

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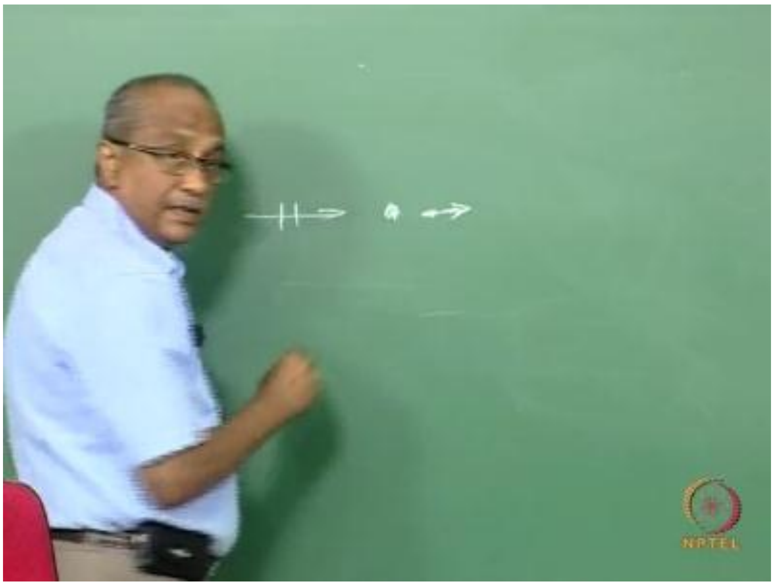

When the structure is like this, it is not a rigid structure; it is oscillating. When the flow is taking place in this direction, how does this will oscillate? It should be oscillating in this direction, right. Now we will look at the next picture.

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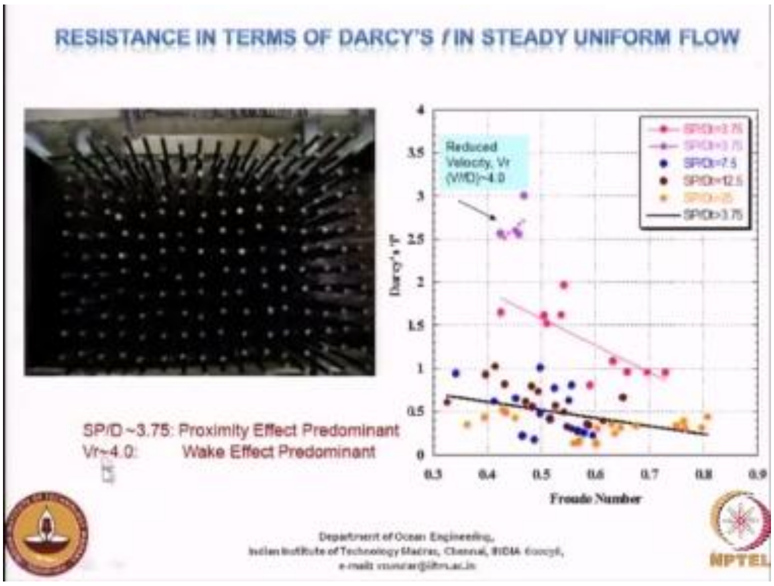

So look at this, have a closer view of these oscillations. So, when the flow is taking place in this direction from left to right, you see there is a significant oscillation in the transverse direction. So, this leads to a lot of discussion about understanding the wave or steady flow wave interaction with the plantation. So lot of studies have been done; one typical study is the proximity effect, the ratio between the spacing of the stems divided by the diameter that is approximately when it is about 3.75, we see that the proximity is quite good. And you also found out that the relative velocity it is given as shown here is approximately 4, you have very good effect; that is we have a high friction factor. So, I would not go into the details of this again; all these information's are available with the department. So, if you are interested you contact me or the department.

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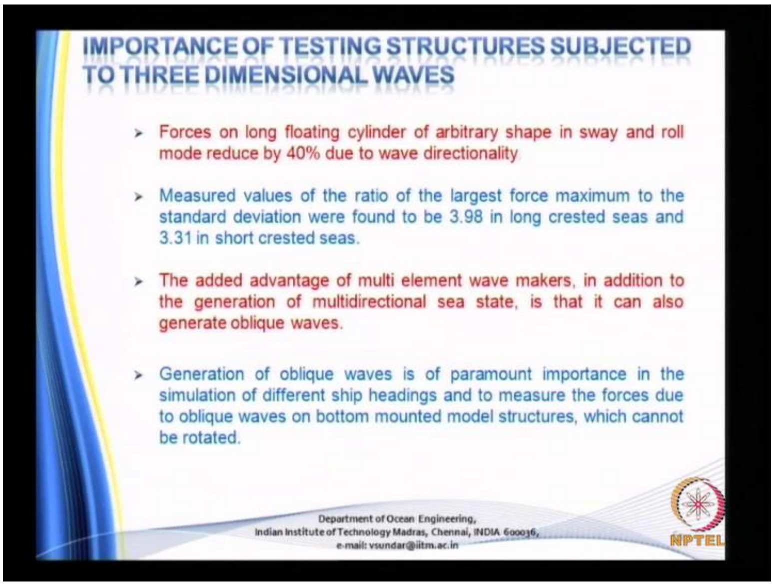

Now having seen so far, all that we have seen are regular waves and random waves. You know why we need to use random waves, why we need to use regular waves. When you use regular waves, when you use random waves and now the final thing is when do you go for multidirectional waves multidirectional forces? For example, forces on long floating cylinder of arbitrary shape in sway and roll mode reduced by about 40 percent due to directionality. For example, if you having a floating structure and if you are considering in its design only the motions due to the waves attacking from one direction that is normal direction; you get the values. But in the ocean this structure is not going to always have direction only form this direction. It will be from the different direction; that means actually the loads will be less compared to only considering these directions.

Measured values of ratio of the largest force maximum to standard deviation were found to be about 4 in long crested waves and about 3.3 in short crested waves. So, this explains that in the long crested waves, then the long crested wave means like this; a structure is here, only waves are moving in this direction. Short crested is when waves are moving from different direction. So, naturally when it is considered only the long crested, then the forces exerted in this is going to be more. So, then you are not really but in the ocean you are not going to have long crested waves. So, you do the experiments in the lab for long crested waves and then apply it to the field, then what is that you are over estimating the forces. So, the added advantage of multi-element wave makers; that is you need a number of wave makers if you want to generate multidirectional waves. So, the added advantage of multi-element wave makers in addition to the generation of multidirectional waves, it can also be used for generating oblique waves.

So, if you take a tank if you take a flume you will generate only waves coming from one direction. So, what you do is if you have the structure like this, when the waves are it can be generated only in this direction and if you want to also understand how the forces on this structure due to oblique waves; what we do earlier what people used to do is you turn the structure, orient the structure so that we account for the wave direction. But with this kind of a facility where you can generate multidirectional waves, you need not have to change the direction of the orientation of this; you can change the direction of the waves. Generation of oblique waves is of paramount importance in the simulation of different ship headings and to measure forces due to oblique waves on bottom mounted a model structure which cannot be rotated; that is what I have been mentioning right now.

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Name of Basin	Basin		No.of Segment	Segment		Stroke /2(±)	Wave Ht.(m)
	Size(m)	Depth(m)		Width (m)	Height (m)		
U.Edinburg	27x11	1.2	80	0.30	0.70	15.0^0	.22
HRS (Wallingford)	30x48	2.0	90	0.31	--	--	.50
MARINTEK (NorwaY)	50x72	0-10	144	0.50	1.30	16.5^0	.40
DHI (Denmark)	30x20	3.0	60	0.50	1.50	16.7^0	.50
CERC(Washington)	59x11	0.76	60	0.46	0.76	0.15m	.30
DHL (Delft)	Variable	1.3	80	0.33	1.28	0.40m	--
NRCC	30x50	0.3-2.9	64	0.50	2.00	0.40M	.70
OEC,IITM	30x30	3.5	52	0.50	2.167	15^0	.60

So, there are wave basins worldwide. This is some of them, there are some more in China which are not indicated here but this are all general. It gives a general impression about the number of wave basins. But now slowly it is coming down because people are talking more about the numerical wave tanks. So, whatever you can do in the physical model physical tanks physical model tanks, we can also do it in numerical model tanks. So, the emphasis is coming slowly down for at least deep water basins.

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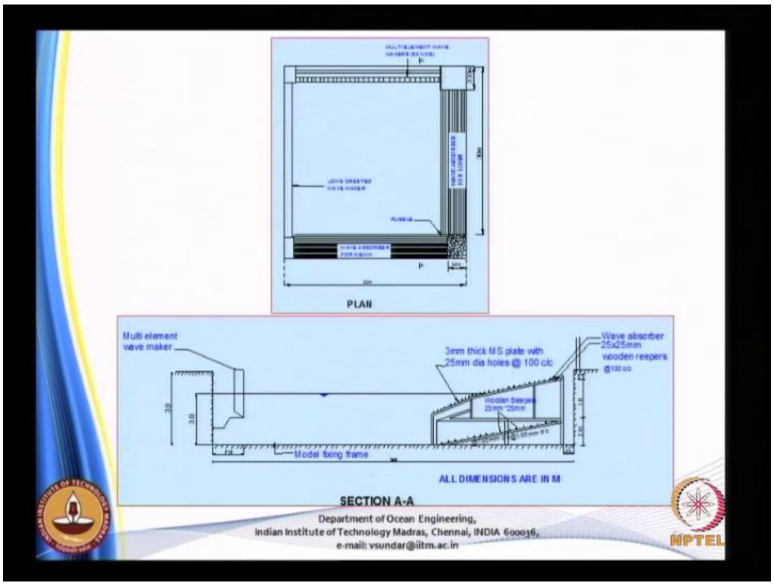

So, this is our typical wave basin in our department in the ocean engineering department where in you have the multi-element wave maker here and the long crested wave maker here and there is an absorber here for taking care of the waves approaching from this wave maker and there is an observer here to take care of waves coming from this direction. Now you see that this is the kind of model, the tank is 3 meters deep and the cross-section is 30 meters by 30 meters. So, you have the wave absorber occupying just distance of about 2.5 meters very effective wave absorber because if you want to go in for a conventional wave absorber, you are going to lose lot of space. Usually the wave absorber occupies one is to six slope for wave flumes. But if you adopt the same kind of principle here you are going to lose that. So, what you need is you need to have usually they say that there are lot of proofs saying that parabolic surface.

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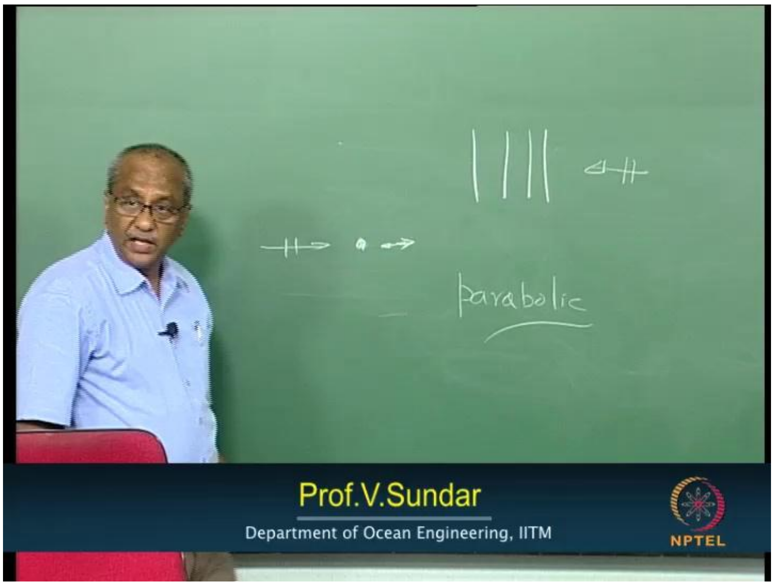

Parabolic surface with some kind of perforations are very important, very effective for this one. Then the other kinds of wave absorber are the progressive change in the when the waves are moving in this direction, vertically it can be vertical but progressive decrease in the porosity. So, this is another vertical absorber. This is another thing which is quite popular in the western countries. So, you can think of suppose in case you are planning I think, you are having an idea of having some kind of tanks, so if you want you can think of this and if you need additional literature you can come to us.

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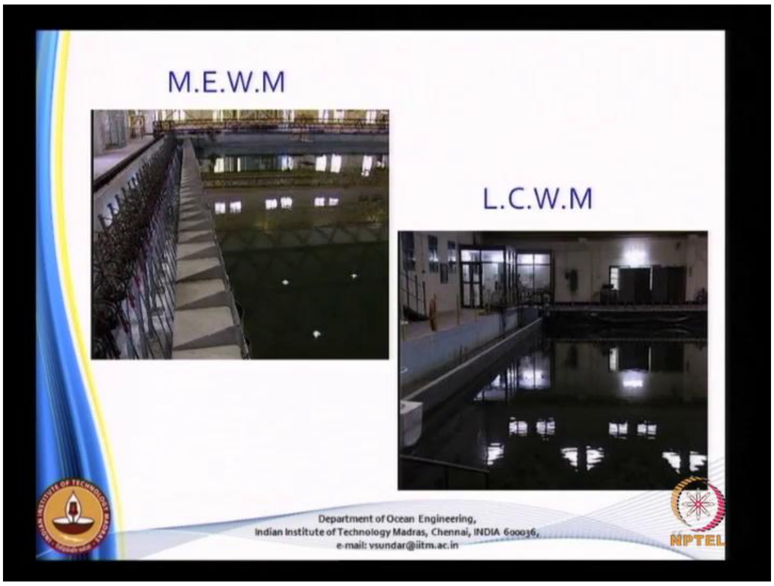

So, this is the operation the top one shows the operation of the multi-element wave maker in the department of ocean engineering and the bottom one shows the movement of L.C.W.M. So, you have the top one as your, so you see only the long crested wave maker on the bottom and in the top you have the multi-element wave maker moving. So, with the multi-element wave maker you can generate either multidirectional waves or oblique waves, etc, and in fact it can also be tuned to generate breaking waves. In fact the long crested wave maker was used to generate breaking waves or focusing waves.

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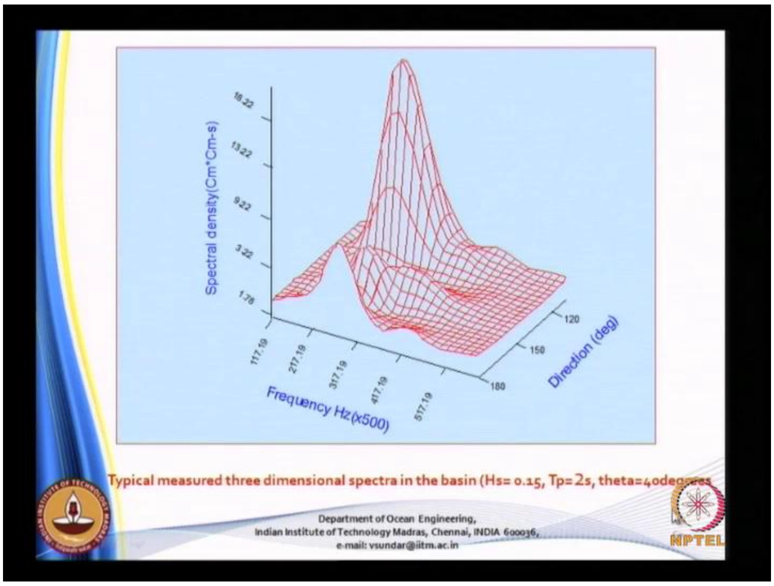

So, this is how a spectral density looks like when you have the three dimensional waves being recorded. So, you have the distribution of energy versus spectral density that will be the 2d spectrum but when you show it as a function of direction, then it becomes a three dimensional spectrum. So, for each direction you will have a spectral density or for a given frequency you can have a directional spread; any doubts in this, so that completes.