Coastal Engineering
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Module - 5
Breakwaters
Lecture - 2
Breakwaters - II

Having seen the vertical composite breakwaters, now we will go into the horizontal composite breakwaters. The wall of the vertical composite breakwaters suffers damage.

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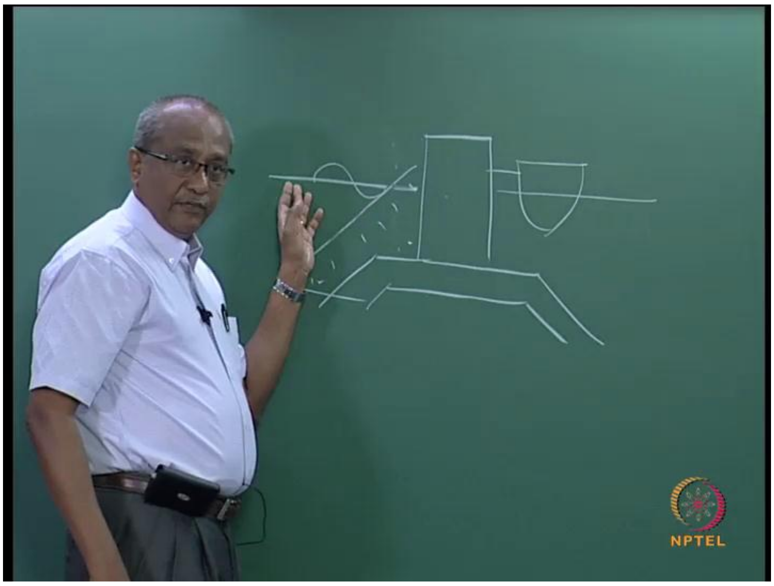

Because, you see that, although it is a gravity type of structure, it is resting on a rubble mound base. But, if there is excessive force acting on this structure, there is a possibility that the overturning can happen, and it can be catastrophic, I mean, sudden instant failure; the entire caisson can overtop. Or, over a period of its existence, it can have some kind of a problems, and you need to have possibilities, or look into the possibilities of rehabilitating the caisson. So, what is meant by rehabilitation of this? So, you need to have some kind of method to reduce the forces that is coming on the caisson.

One such possibility was having a perforated breakwater in front, which we have seen earlier. The other aspect is to have some kind of a rubble mound, completely fill it with rubble mound, so that, the forces will reduce, the forces coming on the caisson will be reduced. So, you still have a calm pool of water or tranquility can be established, and then you can still use it for berthing of vessels. So, here, in this case without this it is called, you have a rubble mound on bottom, so, it is called vertical composite breakwater; when you have some kind of rubble on the horizontal direction, in order to resist the horizontal force, then you have, it is called as the horizontal composite breakwaters.

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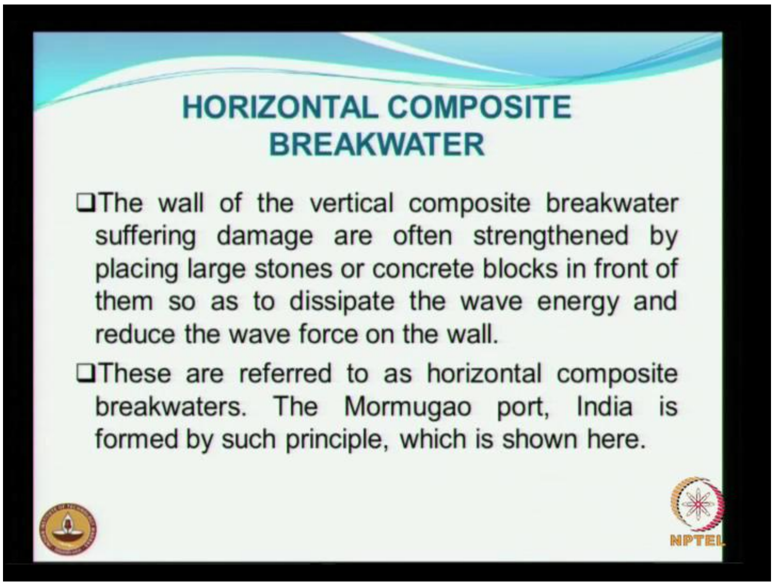

So, the Mormugao port in India is formed by such principle, and which we will be seeing soon. So, this Mormugao port harbor, Mormugao port harbor is more than 100 years old. And, these are all constructed by mass work, as you can see here.

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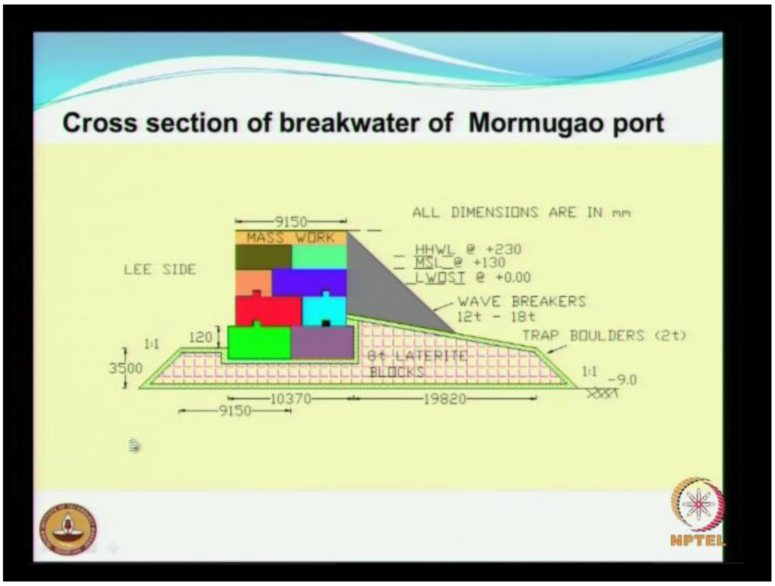

So, this is the mass work. And, this is the lee side, and this is the sea side. And, since laterite blocks are available in plenty, so, they have adopted laterite blocks here. And, this was the configuration; without this marked in ash color grey color, this was the original composite breakwater, vertical type composite breakwaters; wherein it was serving its purpose, and you see that this width was about 9 meters, and minus 9 is the bottom of the composite breakwater that is the levels, and all the other levels are also indicated here.

So, in due course, the, actually the design wave height for this is 5 meters. But, over a period what happened was that, they experienced a lot of overtopping and this started giving some way, because the loading due to coming on the caisson was quite high. And, then what they decide decided is, to drop in wave breakers; wave breakers are in order to, wave breakers are just kind of blocks, each weighing 12 to 18 tons. They used these laterite blocks, and converted these vertical composite breakwaters into horizontal composite breakwaters. And, in fact, we have done some studies on this, because even after having this obsorbus of, I mean, this laterite blocks which are, which are weighing between, they had only two classes: one is 12 tons and other kinds of blocks were weighing 18 tons.

So, these blocks were installed at a slope of about 1 is to 2 was formed, and this was giving a certain degree of relief for the caisson, but then still they could not come over the problem. So, this problem was referred to us, and then we did some, we did simulate the exact, I mean, the whole break water and then did some calculations, I mean, did some experimental research through which we have made some recommendations, which we will see later, is that clear.

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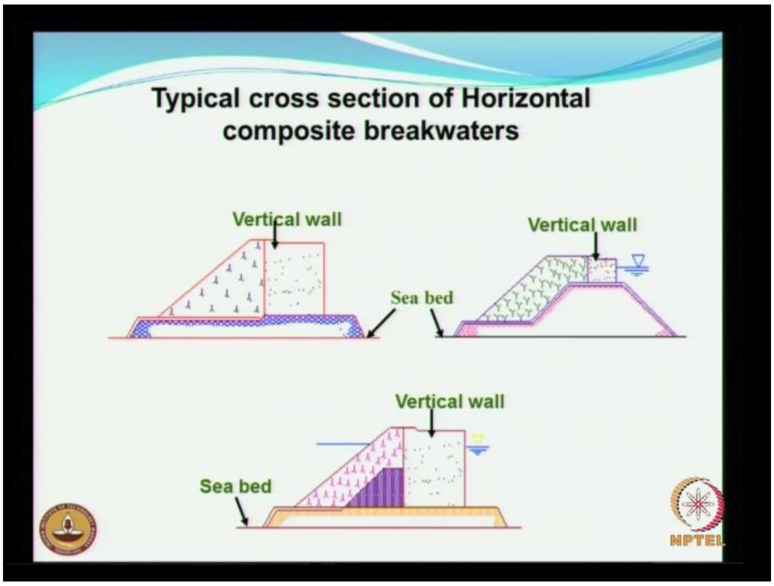

So, typical cross sections of horizontal composite breakwaters are shown here. It can be having a single core, a single core, as you can see, it is just dumping the laterite blocks, similar to what we saw in the case of Mormugao. Because, there was no core layer or secondary layer, or you can, you can have a kind of a core layer, as you can see here; and, this is just dumping of the stones; and, similarly you can have a secondary layer, over which you have the primary layer being dumped. So, these are typical examples for the horizontal composite breakwaters.

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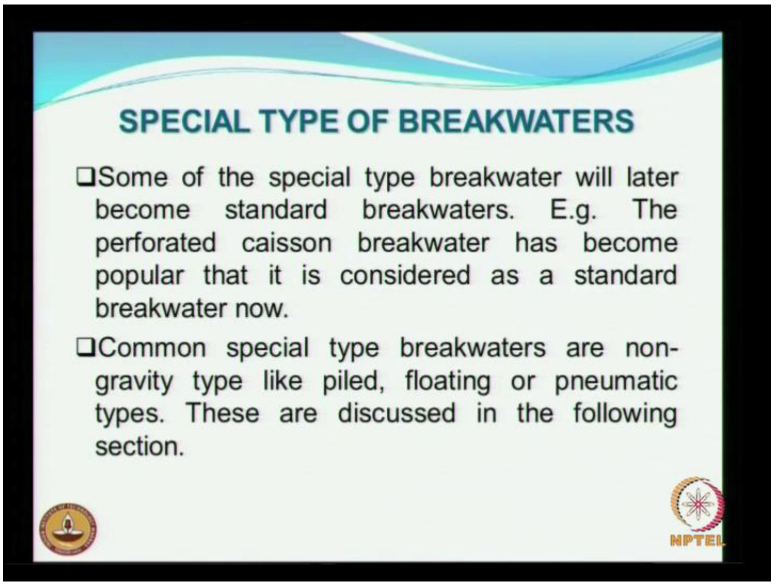

Now, moving on to special type of breakwaters, some of the special type of breakwater which can later, after its continuous existence, it can become a standard break water; for that matter, even the rubble mound breakwater, once upon a time it should have been a new kind of structure, right. Slowly there has been improvement and then it becomes, for example, your bump type of breakwaters, or the s type breakwaters; bump type breakwaters is this.

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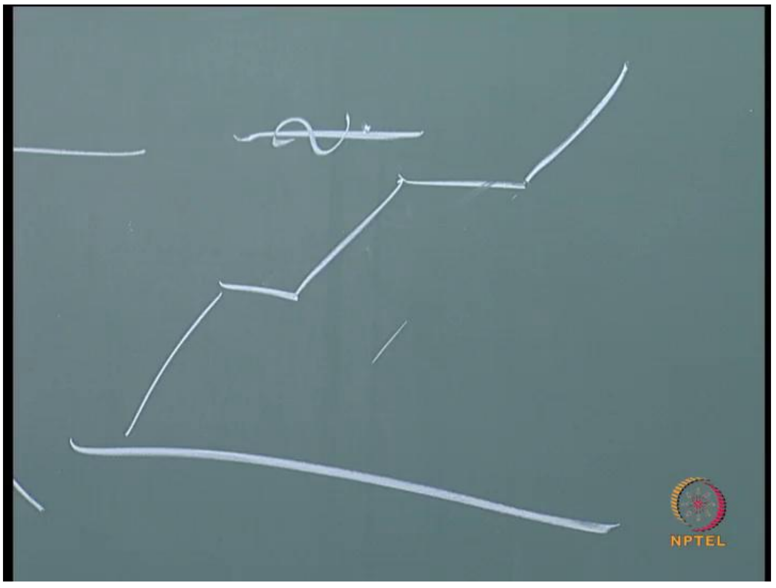

So, this was a, initially it was this is the wave. So, we had only, initially only one single slope; now you have a bump here; and, in fact, you have multiple bumps also in certain cases, composite slope breakwaters. So, the special type, for example, the perforated caisson break water has become widely popular that it is considered a standard break water, as of now. The common special type of break waters are non gravity types, like piled, floating, or pneumatic types.

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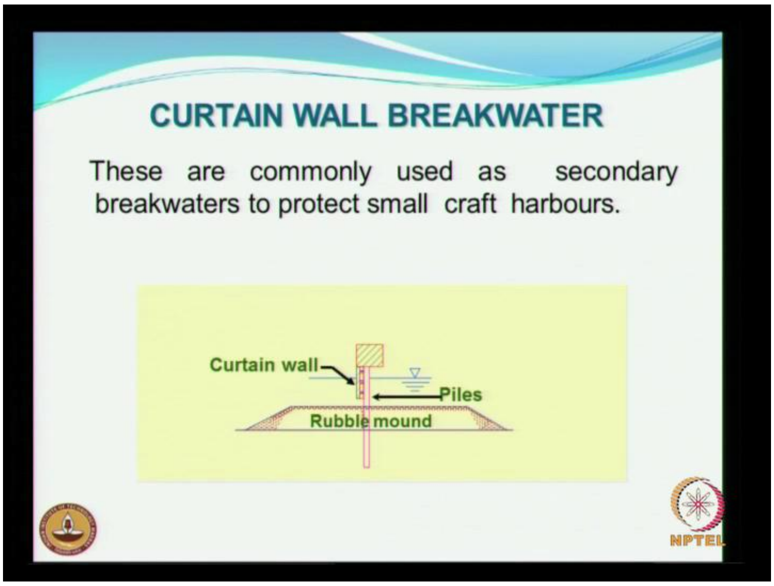

So, now, this, we will just take up all these things. Now, look at this curtain wall break water, curtain wall break water, this can be used for small craft harbors, for, to protect small crafts. So, you have piles, you have piles; it can be over a rubble mound, or without the rubble mound, also you just have some scour protection here, and then it can have piles, and then you have a skirt here; skirt in the sense, if you look from this end, how it will be?

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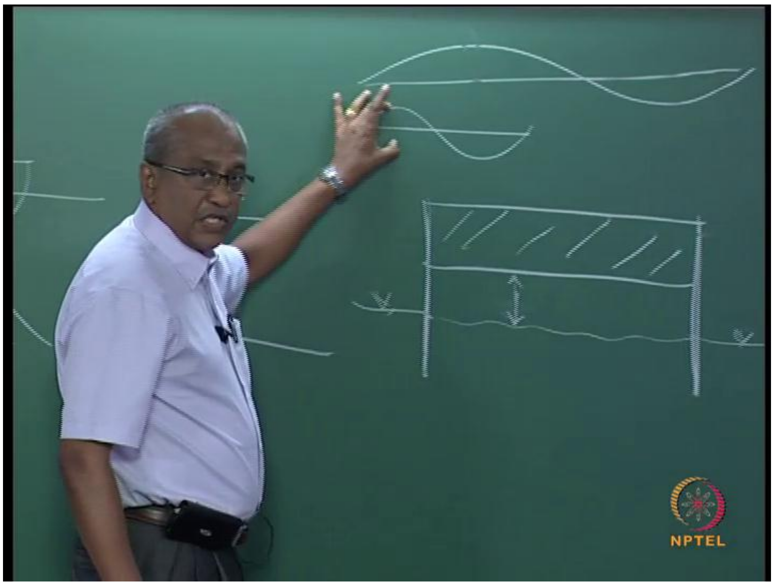

You have the piles, and you have the skirt; this is the skirt. The skirt can be as less as possible, maybe this is going deep into the, this is the sea bed. So, this will be the, this will be the only gap through which the energy can move. Because of this obstruction, most of the energy is getting reflected back. So, the energy which will be escaping through the, under the skirt maybe less; and hence, this can be used as a skirt breakwater. In fact, you can also have this kind of a breakwater with moorings.

So, temporarily you want to have some kind of a calm area within the shallow areas, you can just have this fixed through moorings, and then when you want to transport it you can just remove the moorings and shift it, you understood. But, this can relatively, it is quite effective for particularly in short period waves, in the case of the locations where the wave period or wave length is less; why do, why do I say that? So, for example, if you have a long period wave, this will easily penetrate through under the, under the, without getting attenuated, without the amplitude getting attenuated this can simply move, understand. Whereas, if the period is short, it can get attenuated when it is going under hitting the structure, you understand. These are some of the considerations, which you need to take into affect when you are planning for any kind of a breakwater.

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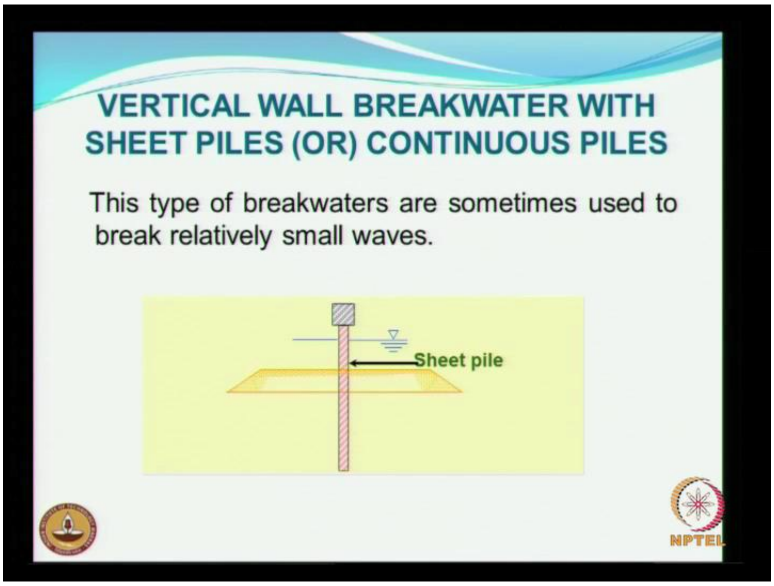

Now, this is a sheet pile. So, these are more or less, these are fixed type. In the case of skirting, skirt breakwater, you can either have it as a fixed on fixed pile, or you can still have it as a floating type; you can easily modify that as a floating type. But here, this will be a continuous sheet pile that is the sheet pile is running perpendicular to the screen, you understand. So, this is going to be quite expensive. There are other associated problems, if you do not have proper toe protection near the sheet, you can have very deep scour taking place because its abrupt solid obstruction. So, you can have anticipate significant scour. And, the founding level has to go well below, so that the scour much below the scouring depth. So, that it does not lose its stability. So, this is also quite expensive, and also you have corrosion problems, all those things.

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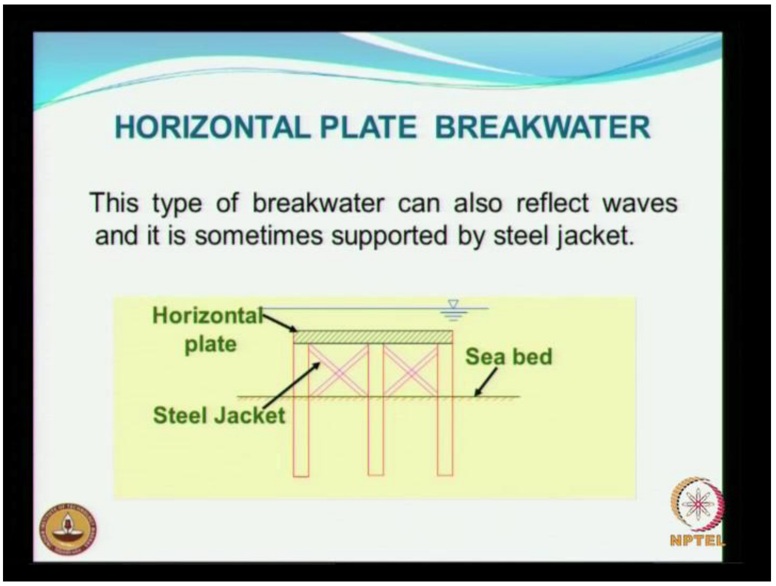

So, a careful, we need to carefully look into the, these aspects. Then comes horizontal plate breakwaters. So, here, you have a horizontal plate running over a distance, over a length. Now, the length of this breakwater certainly has to depend on the wavelengths.

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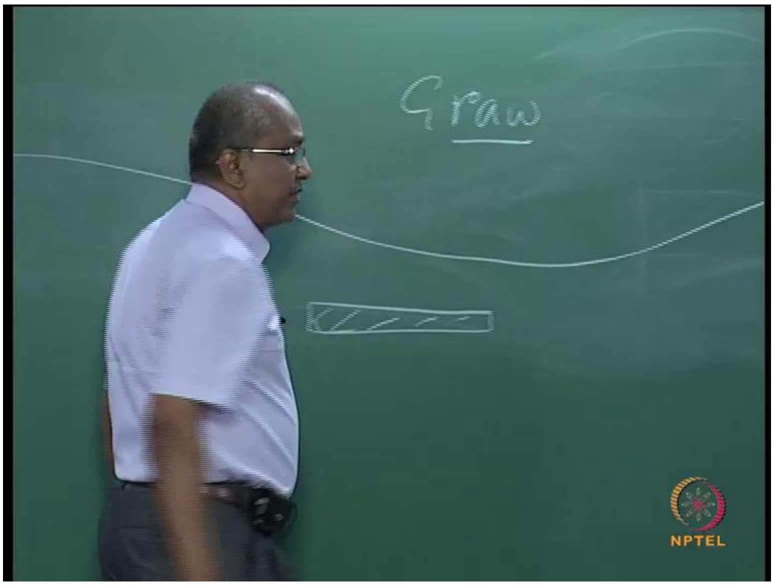

So, in a location, where again, if you have a long wave, and then you have a horizontal breakwater like this, then there is a possibility that the wave will just go through this horizontal plate without getting attenuated, you understand. So, there are some guidelines for designing this, the length of the breakwaters. So, the idea is, it is going to destroy the, or destroy the particle, orbital particle velocities when the waves are propagating in its direction; and, thereby offering enough amount, degree of attenuation.

So, a careful understanding of the length; length is one of the important aspect; length in the sense, length of the, length of the horizontal plate breakwater, in the direction of wave propagation. And, I would just like to make a passing remark that horizontal plate, there is one concept wherein a horizontal plate breakwater can be used as a energy converting device, to convert the energy contained in the ocean waves into electrical, meaningful electrical energy; so there are some attempts.

So, you have to, the moment you put horizontal plate breakwater into the internet, I am sure you are going to get some information about that. So, the person who has worked is professor Graw. So, he has also done some work on this horizontal plate breakwater. So, that gives, that will give some, or you can just search for horizontal, horizontal plate breakwater has wave energy converter. So, you are bound to get some information on these aspects.

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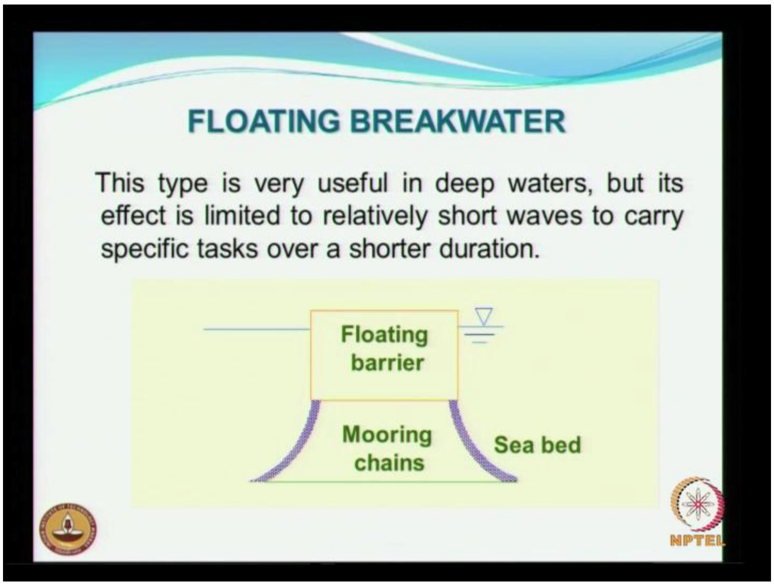

Then, comes the floating breakwaters. Floating breakwater usually has a floating barrier; the concept is the same as earlier case, wherein you have a horizontal plate, but this is now extended, its something like a floating barrier. So, it can be used for floating bridges, etcetera; and also, for mooring, for birthing of small craft vessels. So, the whole thing can be used for birthing of vessels on the lee side of the breakwater.

And again, the width of the breakwater is quite important. And, these type of breakwaters may not be so effective at locations where you have long period waves; as I have said earlier, number of times the long period waves, what happens? It pulls the structure to the extreme end. So, then your cable, your mooring cable is going to be beyond the tension, allowable tension, then there is a possibility of the breaking of the mooring line. So, these are the some of the problems you need to consider.

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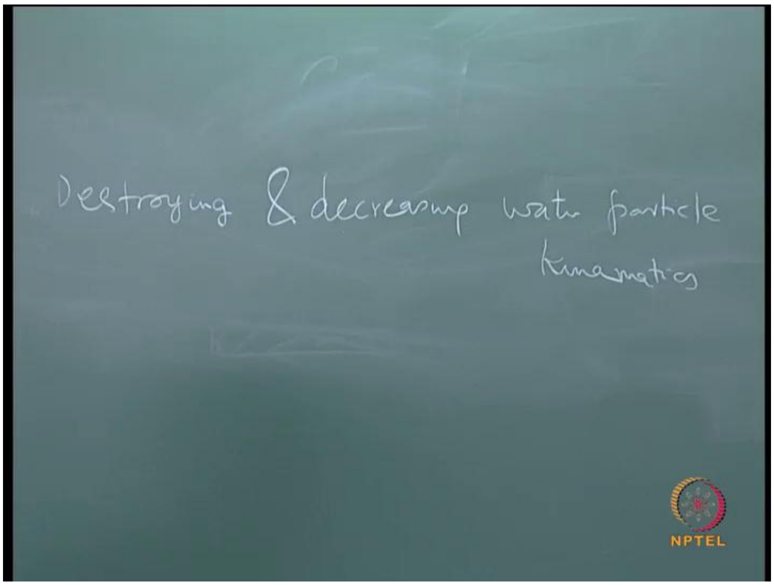

The another thing is, when you have a floating barrier like this; what is the kind of energy dissipation that is likely to take place? What are the physics which is going to take place? The one is the destroying or reduction, I would not say destroying, although I am writing it here, it will be decreasing or reducing the water particle kinematics. So, it reduces the water particle kinematics thereby you have energy being lessened, less; by what? Because of the barrier; because of the obstruction.

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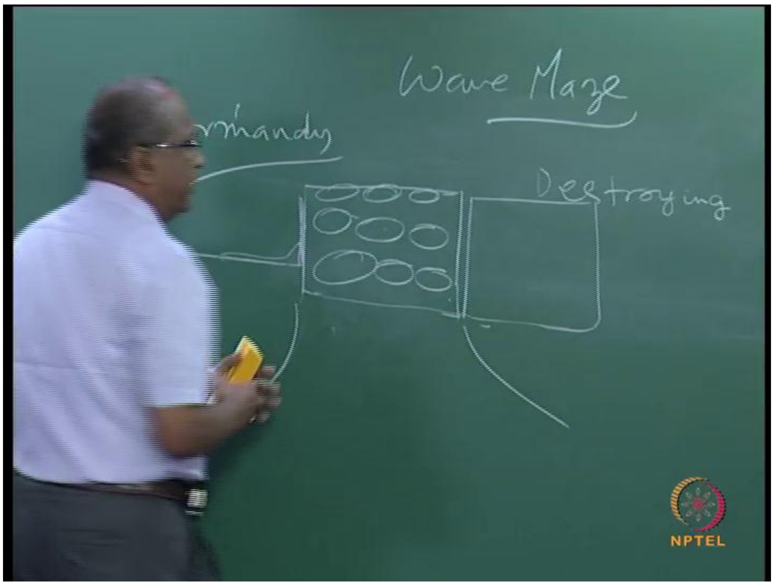

But, because if you have a solid obstruction, you should know that there is going to be certain, when you have a solid obstruction like this and the waves are going to come and hit the structure; so, this is your floating breakwater structure. So, when the wave is going to come and hit that structure, you see that this is going to be, if it is going to be a solid structure then you are supposed to, you are likely to have reflection; and, when there is more of reflection here because of the vertical surface, then you see the forces exerted on this structure is going to be more. When the structure is going to experience more force, then the mooring line also becomes, the mooring lines also have to be taken care of, if you want to maintain the stability the force has to be, the mooring line has to be designed for the maximum force that is likely to be, likely to the, break water is likely to be submerged.

So, the other possibility, the efforts where to create some kind of a porous medium; you still have a structure like this, but then allow the, one thing is, when you have something like this, then you have the same principle plus in addition the dissipation can be because of the waves running through the porous medium, you understand; we have already, have already seen that is the principle on which your rubble mound breakwater is designed for, is that clear.

So, these are all some of the concepts. And, there were lots of efforts that has gone into in order to make this floating break water. The concept of floating breakwater started as early as, early nine ninety 40 s during the world war, during the invasion of Normandy; that is the, that is the time when the concept of floating breakwater came into existence. Floating breakwater has its own advantages, but it certainly it has its certain disadvantages; particularly it is not that effective in attenuating long period waves. But, and then, you can have a number of units also, depending on your need.

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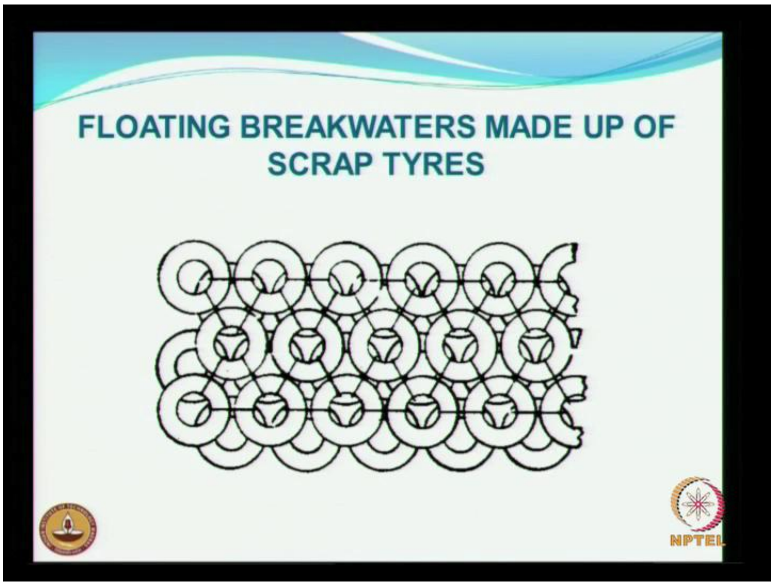

So, realizing some of this in concept, one such concept was, for example, there was one type of floating breakwater which was called as the maze. What does that mean? That means, that, see, you have the used, tires you have the used tires and these tires are just inflated with some kind of material. So, that to, I mean, to enhance the flotation. So, there some kind of materials, which can be injected within the tires, so that the whole thing can float.

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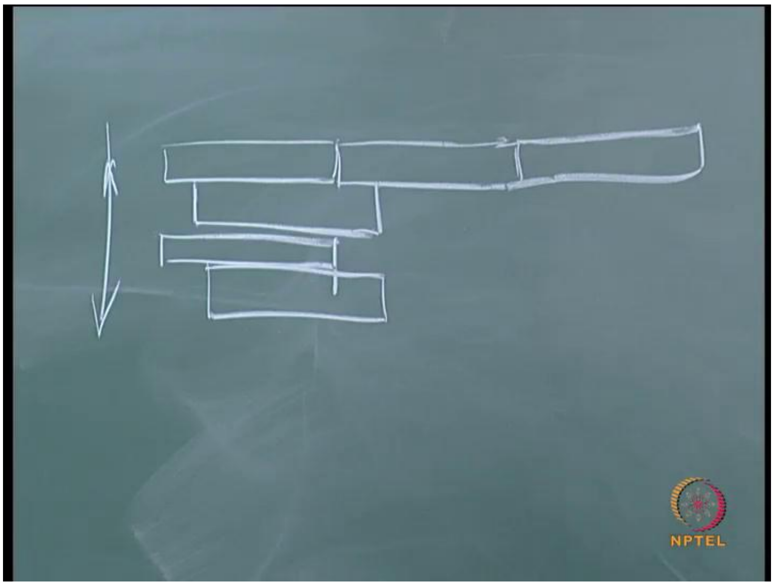

So, you can, so, the people, what they did is, they did like a number of, a number of tires linked together, as you can see, as you can see alternative this is in plan, this is in plan. Now, in section you can have tires; here this is, I am talking about tire. So, here, they tied about 3 or 4 tires, because this depth of submergence is also important for you to, for breakwater to attenuate the energy.

So, in this case, the energy is dissipated through the porosity that has been created because of the tying up of a number of tires together, is that clear. So, there has been lot of other works also, having a floating break water with a skirt, a number of skirts, etcetera; different configurations have been tested and their efficiencies are all available in literature; and, you can look into some of these aspects.

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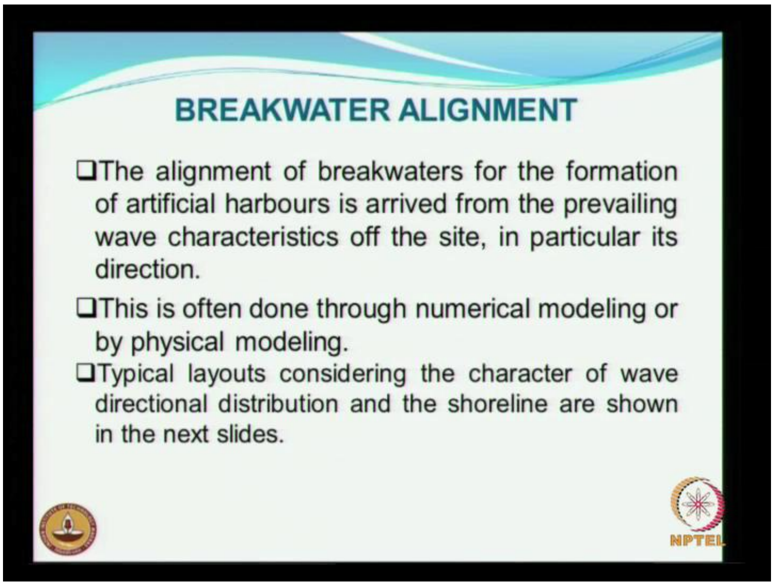

Now, having a, been exposed to some of the basic types of breakwaters, now we will, let us go into the break water alignment. The alignment of breakwaters for the formation of artificial harbors, is arrived from the prevailing wave characteristics of the site, in particular its direction. That is true, because as I have already told you, the orientation of the breakwaters has to be normal to the predominant wave direction; that is very very important. Without knowing, without having a knowledge on the wave direction, it is impossible for you to finalize the alignment of the break water.

So, this is often done either through numerical modeling or by physical modeling. Earlier days, it used to be mostly physical model through physical modeling. Now, these days, I think maybe from mid 80s, ever since the computers, the progress in computing facilities increased, people have resorted to numerical modeling. There are, either this or that, both has its own benefits and, I mean, drawbacks. Because, adopting a physical model, a scale model for physical modeling for this kind of a problem, sometimes it is a bit difficult.

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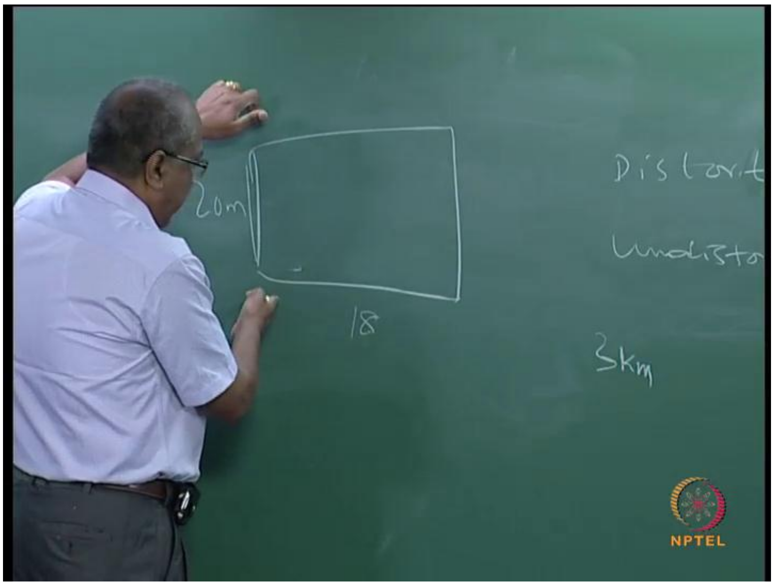

Because, you should know what is meant by distorted and undistorted modeling here in the case of, distorted undistorted, I am sure that you would have heard in your B tech course, when you are talking about geometric similarities, all those things. So, we will also be talking about those aspects later. So, that is, when you want to model a basin; and your wave basin is say, for example, it is 18 20 meters, 18 meters by 20 meters in your lab, and you want to model a distance of about 2 kilometers or 3 kilometers off the shoreline.

So, you cannot do that with the kind of scale which you have; and your wave height that can be generated, maybe maximum is 20 centimeters. So, the vertical scale has to be definitely different than the horizontal scale. The vertical scale, you are talking in terms of 20 centimeters; whereas, the horizontal scale, you are talking in terms of 3 kilometers. So, you are forced to use a distorted model, sometimes this may give some problems. Another thing is, if you are not, if you want to include the sediments then it becomes a very difficult thing; that is a problem both in numerical as well as in physical models. Well, I will not go into all those complete details; the typical layouts considering the character of wave directions distribution and shoreline are shown in the next slides.

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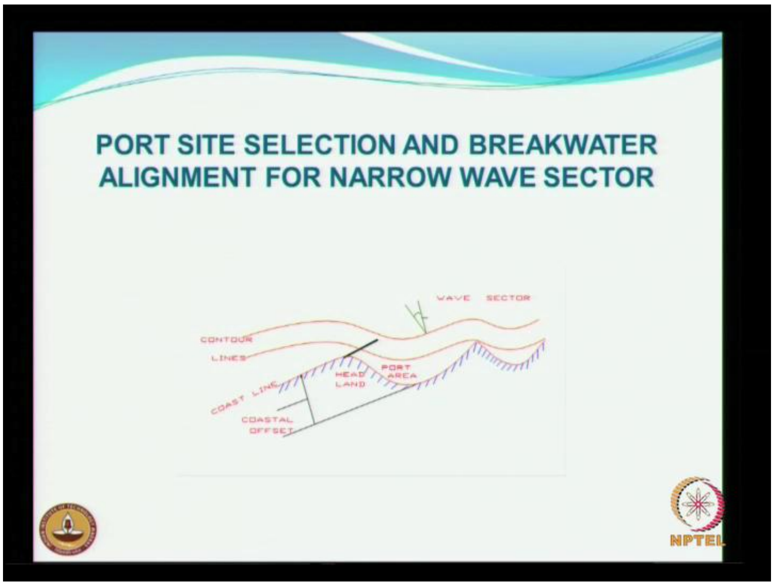

For example, a port alignment, a port selection and the break water alignment for narrow, narrow wave sector; that is you have well defined wave directions; throughout the year if it is very, very well known direction pre almost 100 percent pre defined; then, as in this kind of a configuration. So, you see a head land, you see a head land; and then you see that adjoining the head land if you come across something like a bay formation; wherever you have bay, it is an ideal place where you can think of stable bay. It is a, there is a possibility for you to develop a port; and, of course, there are other aspects we need to look into.

So, in this case, you see that the waves are mostly come in this direction and hence the alignment of the breakwater can be in this, in order to take care the affect of this break. So, how long this has to proceed? May be here upto this; all these things you can do with numerical modeling by combining the affect of refraction, diffraction and reflection, and running your numerical model and also optimizing your breakwater alignment, is that all of you are with me.

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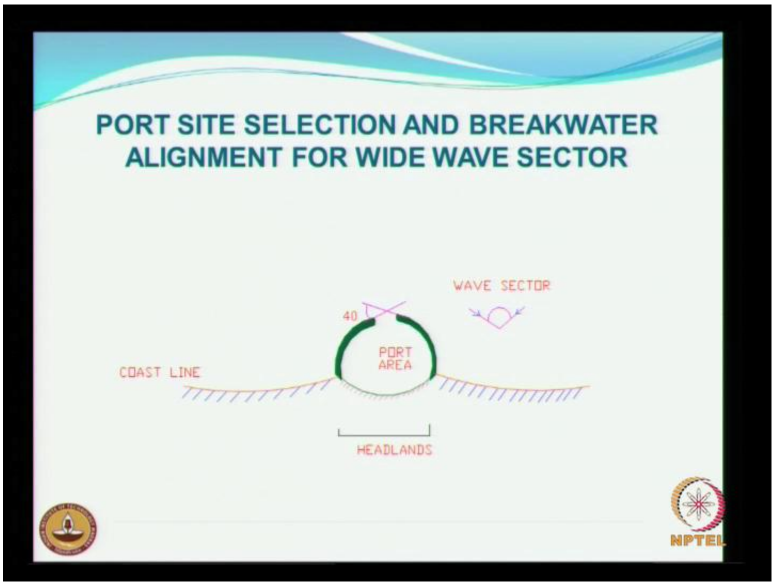

Now, here, the port selection, when you have a wide range of white sector direction then the waves come from the both directions; then in this case we go in for this kind of harbor; both of same length, so that, so we do have some, such kind of configuration even in India. But, this is not a port, may be a fishing harbor; to the best of my knowledge there is an which is called as Arokiapuram, I do not know if so, this is a small for a, I mean, landing of small crafts we have had this kind of layout.

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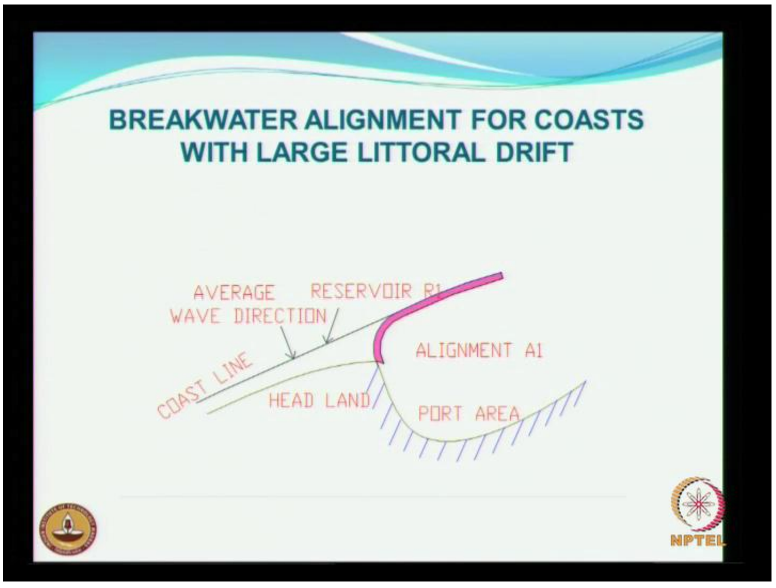

Now, you can have a something like this, where you have large littoral drifts are moving in. So, these are all broader aspects when you have a one side predominant wave direction, but at the same time you have the other side less direction.

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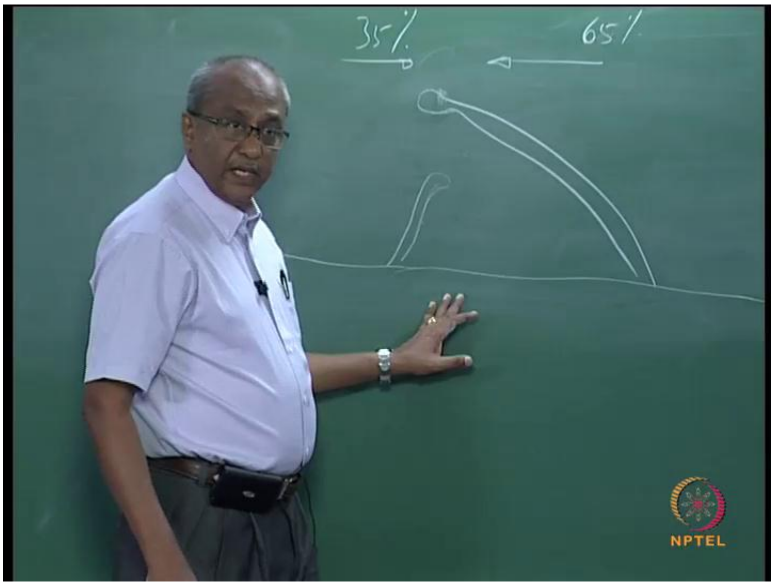

So, for example, you have a coast, wherein you have about 60 percent of the tide, the waves are in this direction; may be 65 percent of waves in this direction and 35 percent of the tide, the waves are in this direction. This is one of the, may be an example of your, our east coast of India. So, what will happen? Then naturally you need to have a breakwater in this direction which will be definitely longer; and, this if you leave it only with this breakwater then the other months you will have problem. So, what you do is, we need to have one more breakwater here, and this breakwater can be something like this, smaller in order to care of this direction.

So, all these seem need to be decided properly. So, you need a good amount of area here. It depends on what exactly you are planning for, whether it is a fishing harbor, commercial harbor, etcetera; and then, so this is just a broader idea concerning the alignment of breakwater.

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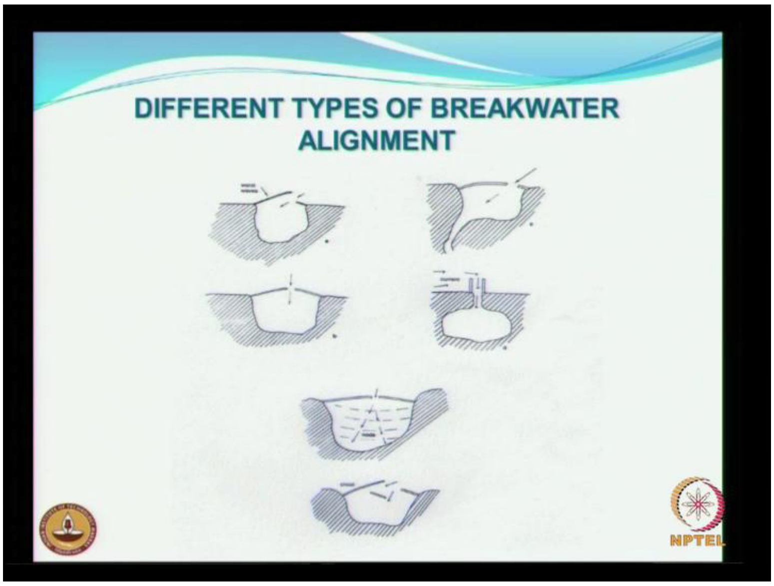

Now, there are different types of breakwaters. This is, this is, this information is given by prof Herbich, is brought a good hand book in coastal engineering; I wish, if you have the time you should look into this book also; it gives lot of other information on the behavior of waves and associated aspects. So, here you see that you have different alignments. So, for example, similar to this a longer breakwater and smaller breakwater; and then, you have this constructed in, near the mouth of the river, wherein this also very common, wherein you have the, you have the opening here; remember, in the case of Pondicherry port we have seen that it is lying inside the river.

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So, you have a river, and then the river will go inside, and then maybe you have some wide area here, the river will be going here. So, this area is now developed as a port. So, in order to make sure that the vessels enough draft is maintained here, and so, this will be having a training wall; that is what is shown here. It can be either this way, or the type of what we have here; and then, it can be like this, almost on same direction; this some typical of training wall. And, a bit rare, this is a bit rare where you have a two breakwaters and then in between they have a another break water. And, you also have to recollect, when we saw the, when we had the lecture on what is that, we saw the lecture on, I forgot.

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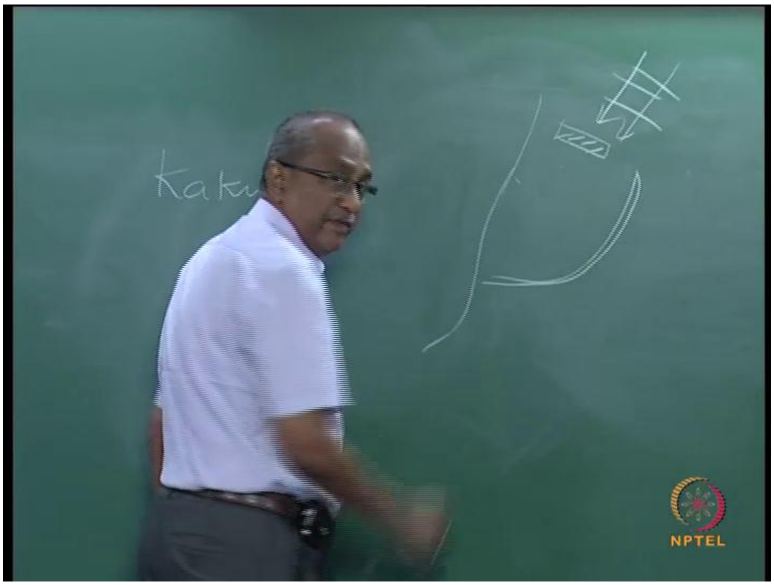

Remember, we saw the lecture on coastal protection, where we had, I had mentioned about Kakinada; remember the formation of Godavari spit, and then the spit extended, and then the spit itself was acting as a long breakwater, so that, we now, in that case, we had a free breakwater caused by nature; and only then is, what happened was, the breakwater, something like this, the split was going; and then we needed to construct only one breakwater here, because you did not have some amount of disturbance because of the waves coming from this direction. Please recollect or you can go through the lecture, my lecture on the Kakinada port, on this one.

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So, typical layouts, other typical layouts taken here; and there, are looking like this, as you can see here. For example, here, although this itself is offering certain amount, the certain degree of tranquility, you need to, if you need more tranquility then they have extended the breakwater like this, so that, the tranquility in this portion, in pieces. Now, probably this would have been a harbor, wherein they would have done the layout analysis everything. And then, once after execution, probably they would have still felt that there is a need for increasing the tranquility, in that way looking at different alternatives, they would have decided to have a breakwater, understand. This is something to shield, before it reaches the harbor, is that clear.

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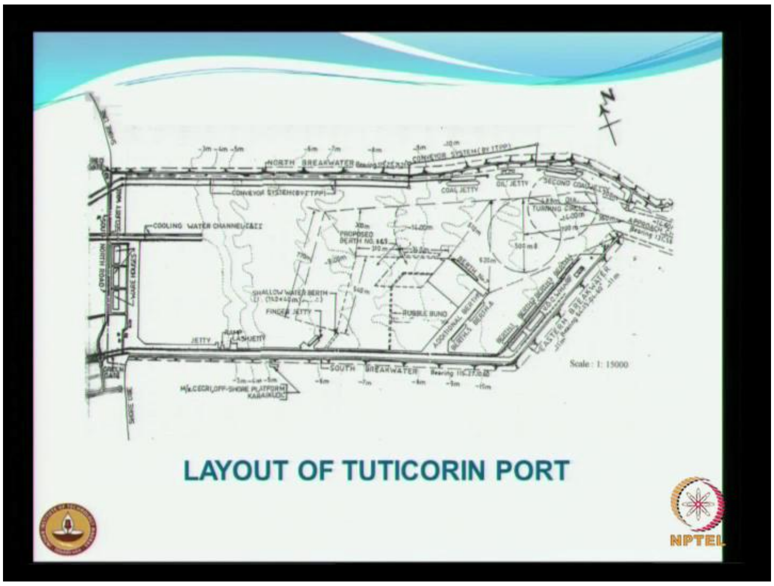

So, this is the typical layout of Tuticorin port which is situated south of Indian peninsula. So, you look at, one of the longest breakwaters; and, it is around 4 kilometers, the breakwater is around 4 kilometers. But here, we do not have much of problems concerning the sand movement; this mostly for the tranquility.

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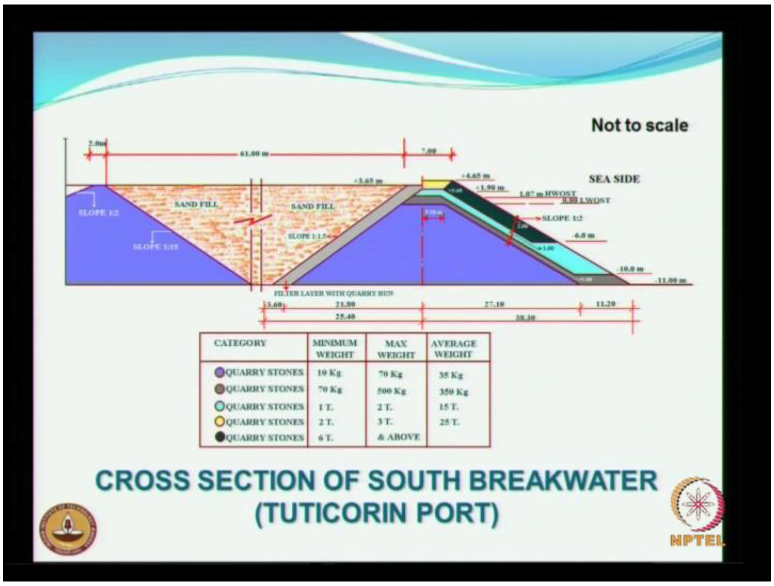

So, these are all some of the pictures about this cross section of the southern breakwater of Tuticorin port. So, quarry stones, they have used; average weight is about, maximum weight is 70 kg; and some of these things have been adopted.

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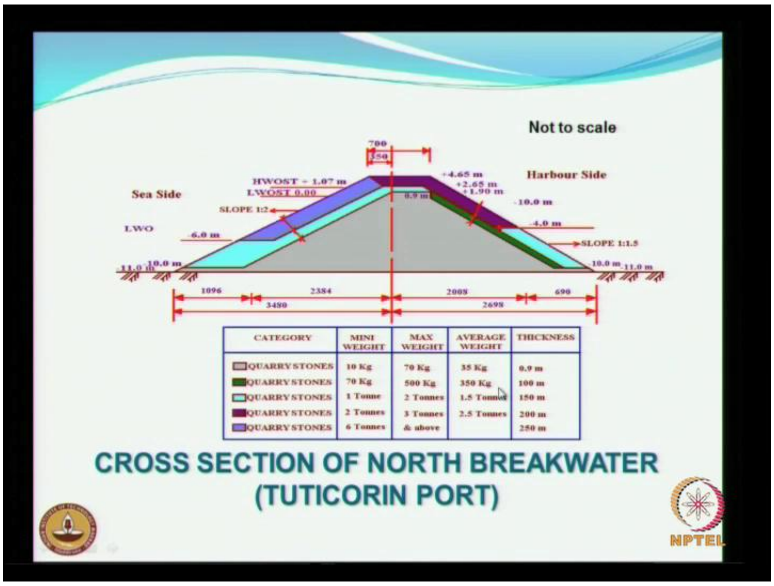

And, I leave this; all the materials that are available, so, you take your time to look into these details. So, here you see this 6 tons stone is adopted for the seaside.

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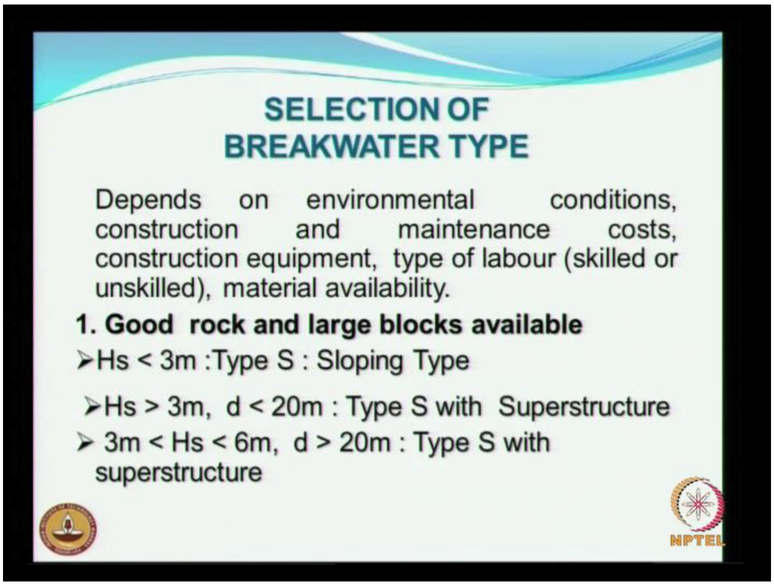

So, usually, you cannot just take it for granted, usually it is around about 3 meters water depth.

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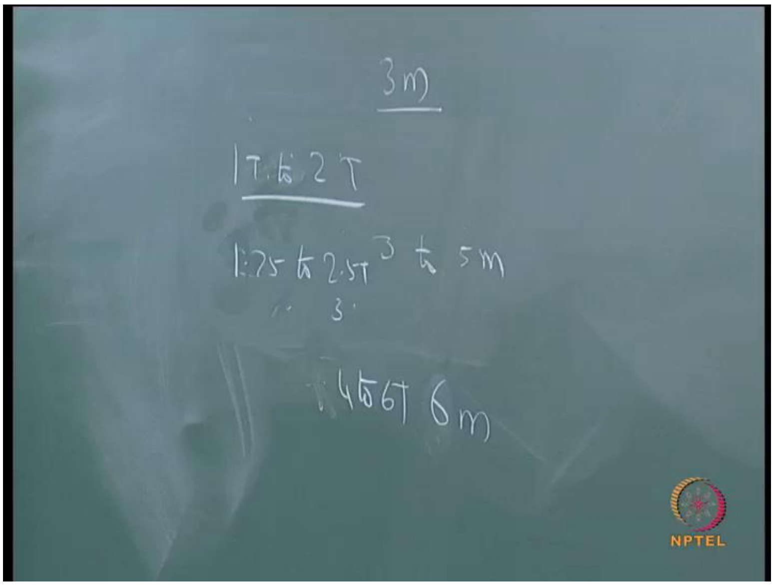

Upto about 3 meters water depth, your weight should be around 2 tons. But, you cannot, I do not want to generalize this, but it gives you some kind of an idea; between 3 to say 5 meters, it should be around, I would say, about, maybe I would go further 1 to 2 tons approximately; and, may be from this one, may be around 1.5, 1.75 to 2.5 tons, may be even 3 tons, upto about, upto about 8 meters, upto about 8 meters, you can, you should have something like around 4 to 6 tons, I would say, I would reduce this to 6 meters, 4 to 6 tons. So, these are all approximate guideline. But, you need to calculate using the Hudson’s formula, or the Van der Meeer’s formula to calculate all this, the weight of the stones. Mind you that the, fixing the wave height is extremely important; you have to take utmost care in finalizing the design wave height for the breakwater.

Now, selection of breakwater since we have so many options, although we have a number of options, but it is normal tendency that we think of sloping breakwater. Sloping breakwater, it is easy to construct, but there are certain disadvantages which I have said, because the base width is huge and it occupies more of the, more of the, its foot print is more; and, it is, really it looks very massive. And here, from esthetic point of view it is not good. So, now, depends on selection of breakwater type, depends on environmental conditions, construction and maintenance costs, your construction equipment is very important; type of labour, skilled or unskilled; and then material availability.

See, for example, if you are talking about developing a fishing harbor. A small fishing harbor, wherein the breakwater need to go upto only about say, 3 to 5 meters watered up, 3 to 5 meters. So, if we are working really in very shallow waters, wherein the draft of vessels for the depth you need for the harbor to be maintained may be maximum of 3 meters; then, the construction can be from on land, you can use just a tipper, and then you can just small cranes if you want, then cranes are definitely needed. So, you just have to use the end on method that the construction will start from the roadside, from the road, and then you keep on progressing as you proceed.

So, in that case, it is more easy for us to go in for rubble mound breakwater, because skilled labor is not needed for this; skill labor is not needed; and, mini, minimum experiment, I mean, equipment needed, not very sophisticated equipments. Because, if at the maximum you may need a crane; a cranes are having different degree of sophistication; crane, the most important, one of the most important is the boom length.

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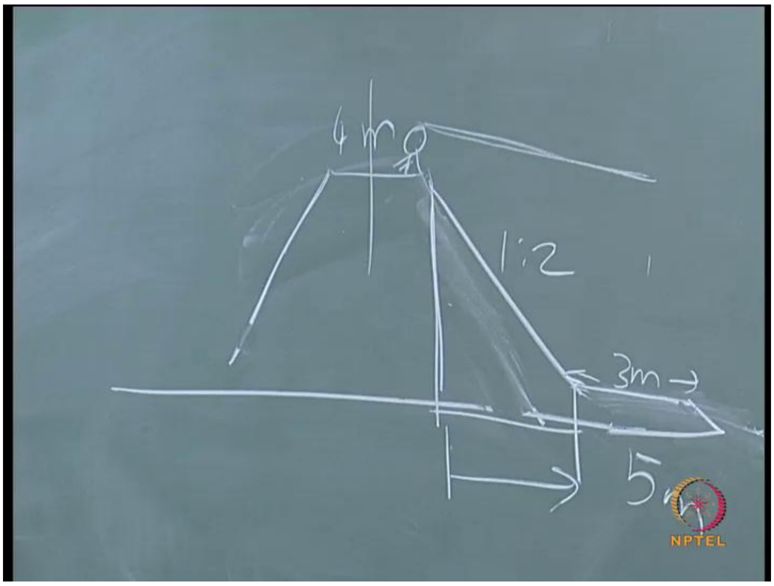

So, you have a breakwater, rubble mound breakwater. Say for example, as I said, maybe this is 4 meters for a fishing harbor for example, I am talking about the fishing harbor. And then, in that case, if you are having a water depth of about 5 meters; see the boom length can be, so the, this is 1 isto 2, from here if the crane is there, what is the boom length? It has to place the toe also, right. You know, we have seen that now, this is 5 meters; now the toe has to extend for another 3 meters from here. So, from this end, this is the distance; 3 plus this distance. So, may be about 15 meters maximum.

But, same thing, you imagine that you are running in 10 meters water depth, then your boom length becomes more. So, and getting such kind of a crane becomes bit difficult. So, all these aspects are to be looked into before you really gets started with the construction. So, selection under this, where you have good rocks and large blocks available; that is the area where you can just simply go in for this kind of breakwater, where H s is less than, these all are some guidelines; H s is less than 3 meters type s, where in case H s, the signifying height you are considering is more than 3 meters, but water depth is less than 20 meters. In fact, 20 meters itself is on the higher side, but it does not matter because there are so many breakwaters which are constructed even up to about 20 meters with S type breakwater. And, this is usually associated with the superstructure; superstructure in order to take care of the over topping, understood.

Then, if the H s is between 3 to 6 meters and water depth is greater than 20 meters, then you still sometimes think of going in for type s with superstructure, sometimes it may be quiet expensive. So, in which case you might have go in for special type of breakwaters, may be a vertical composite breakwaters.

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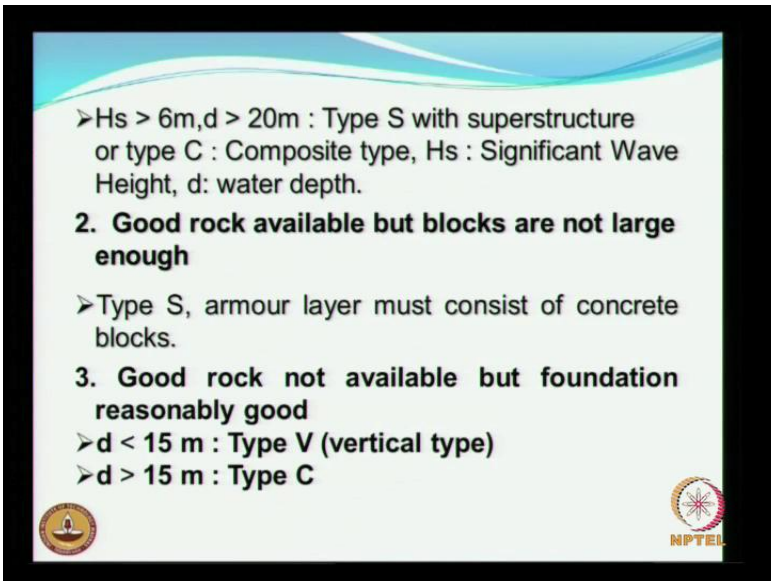

So, if it is greater, type S with superstructure or composite breakwaters, etcetera, can be taught of good rock available, but blocks are not large enough; type S amour layer must consist of concrete blocks, because good rocks are available. This happens in many of the projects. Many of the projects, you may have rocks of smaller size from the quarry, but when you want to have a large size boulders it may be very difficult. And, another disadvantage is if the individual rocks are greater than about say 6 tons, it is very difficult to transport also, because you have to transport it from the quarry to the site, naturally you have to use the, use the existing infrastructure, the roads. So, this is going to lead to lot of complications when it is being transported from around the cities, within the cities.

So, what happens if the individual block which you want to use for design of breakwater, for construction of breakwaters which are greater than 10, 5 tons, then probably the best way is to deal, go in for concrete blocks. Because, concrete blocks can be cast in on sites, on sites, and then just use it. You need a mould, and then you cast the whole thing and then just install it. Good rock not available, but foundation is reasonably good; if the foundation is really very good, then ideal one would be to go in for vertical type, for water depths less than 15 meters, but for water depths greater than 15 meters you just simply go in for type C. Type C is what? Composite breakwaters; type V is vertical breakwaters, is that clear.

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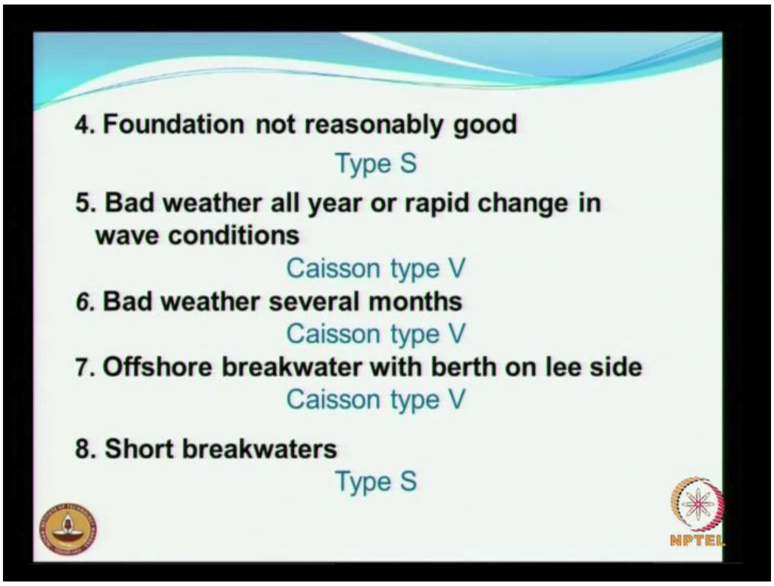

Foundation not reasonably good, then it is better you go in for type S. If the, if the seabed is of, we have come across in one area where you have some kind of loose sand under the seabed, or if you are forced to construct a breakwater under such environment, it is better to remove the entire material although it is going to be very expensive; or, have a kind of special treatment to improve the strength of the soil and then start installing the breakwater bad. So, bad weather all the year, or rapid change in wave conditions, caisson type V; bad weather several months caisson type V; offshore breakwater with berthing facility on the seaside, on the lee side of the breakwater caisson type V; and then short breakwaters, we can go in for short breakwaters may be for fishing harbors, etcetera.

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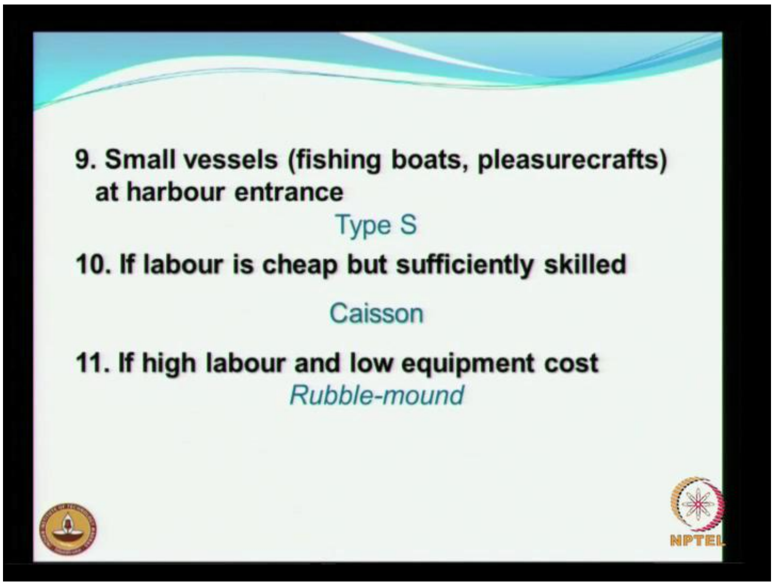

Again, this is the same thing, type S. If labour is cheap, but skilled, sufficiently skilled then you can very easily go in for caisson. If high labor and low cost equipment, you can think of rubble mound.

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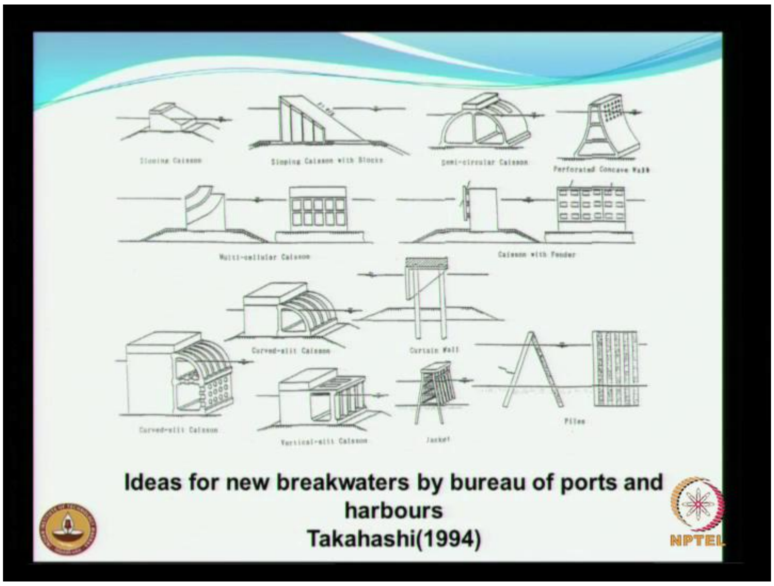

So, ideas of new concepts of, new types of breakwaters by bureau of ports and harbors; that mostly in Japan; so where you have the, this picture itself gives you an idea about different types of breakwaters that, that are, some of them have been, have been constructed, some of them are still on the paper. These all are some kind of concepts, the concepts. Looking at the concept itself you get a clear idea, because the main, one of the main idea is, you should not have vertical face on the seaside; another idea is minimize reflection, but at the same time absorb energies.

So, if you look at these basic ideas in mind. So, that is why you have the perforations here, you have a these kind of configuration, so as to dissipate the energy while the waves are running over these curved surfaces. Or, you have a some kind of a holes here, perforations again. The slits is, this are called slits, slits types of breakwaters; then you have a different shapes, sloping, or semicircle, or perforations here, all these things; mostly it is just to, that is if you construct a vertical wall it gives you an idea that you are trying to be greedy, greedy in this sense you are trying to absorb the entire energy. But what happens is, it is not absorbing the entire energy; although you are trying to absorb the entire energy, you are allowing the forces coming on the structures to be more than 2, or approximately twice the energy that is contained in the waves. Later, when we look at the wave forces, you, on the coastal structures, you see that the amplitude on the wall, if the wall is impermeable it becomes 2; increases, increases by a factor of 2.

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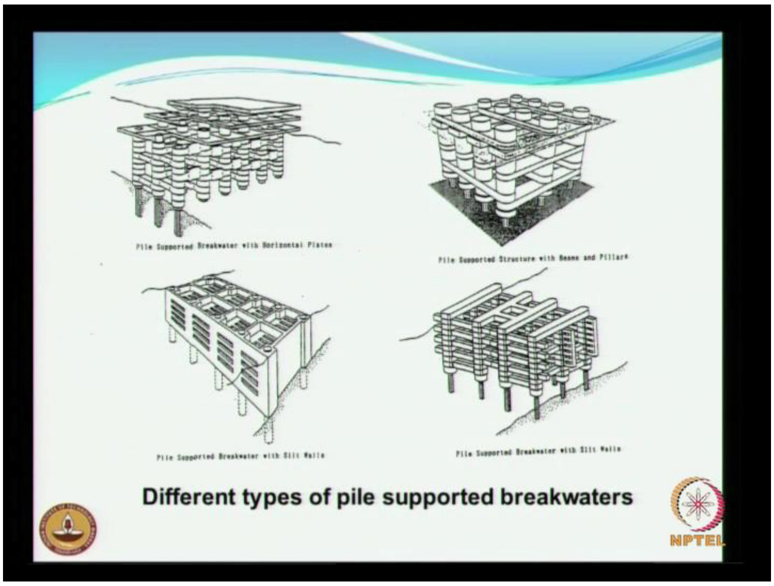

So, these are all the concept, wherein you can have create some kind of permeability by having slits, a slits by having number of piles grouped, etcetera. So, all these things automatically gives you an idea that these concepts can be used a breakwater, is that clear.

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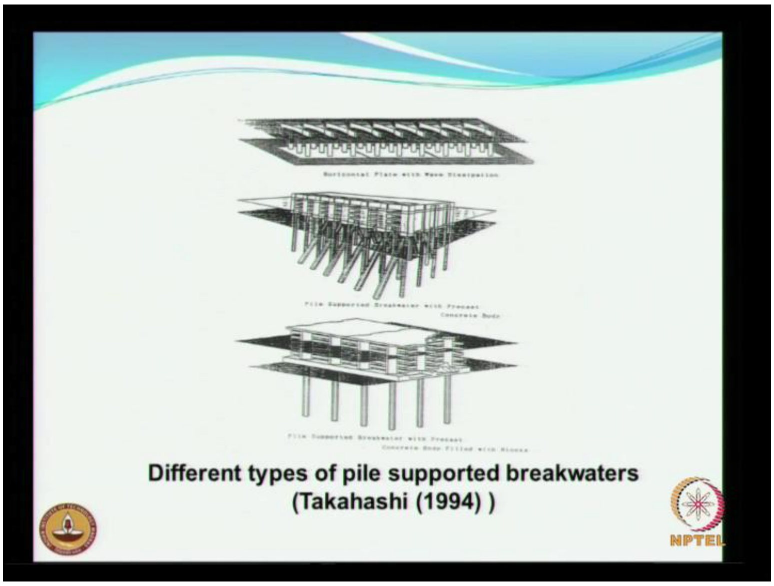

So, a few more, different, and these are all basically piles supported structures. So, you can go even for water depth beyond about 20 meters, or slightly more than 20 meters.

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So, I will stop here, and then we will go into the recent developments in breakwaters, in the next class.