Ocean Structures and Materials
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Module - 1
Lecture - 10
Types of coastal structures II

Ladies and gentlemen, welcome to the tenth lecture on module 1 on ocean structures and materials organized under the braces of NPTEL IIT Madras.

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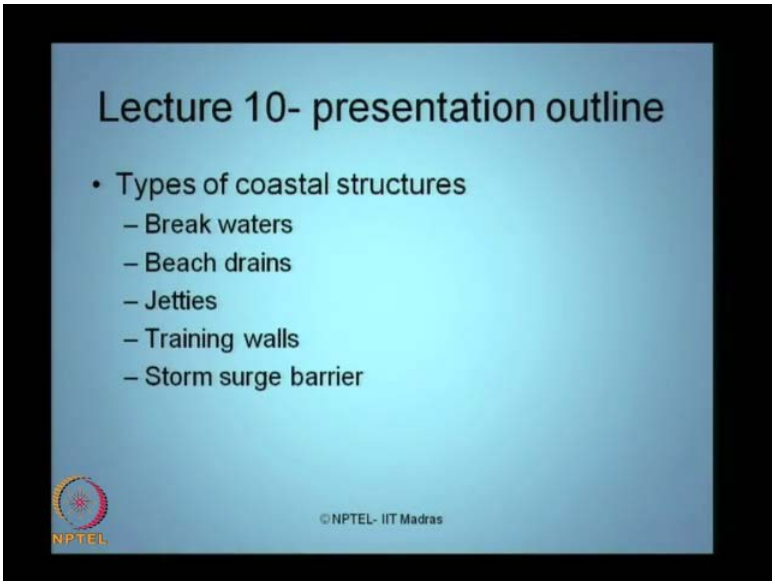

Let us quickly look at the presentation outline of the tenth lecture. In this lecture we will discuss about further different types of coastal structures like break waters, beach drains, jetties, training walls and storm surge barriers.

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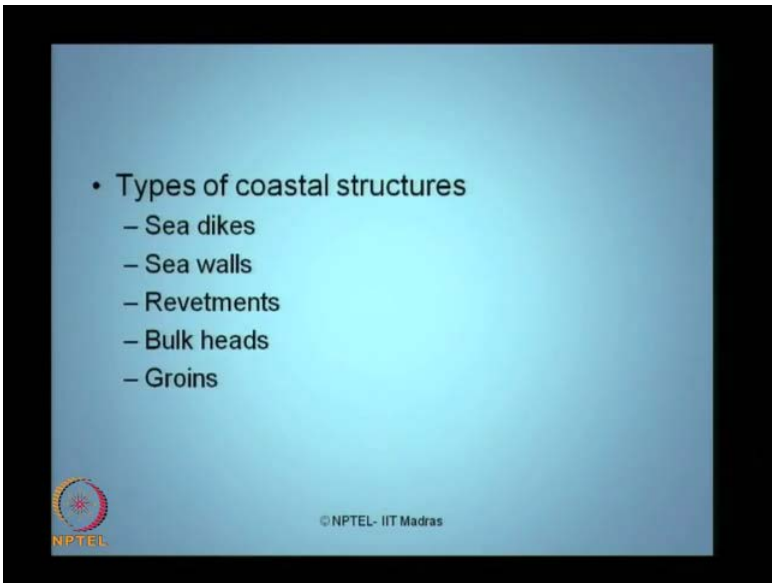

In the last lecture we discussed about different types of coastal structures namely sea dikes, sea walls, revetments, bulk heads and groins. Let us quickly review, what are the essential functions of coastal structures?

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We all know that to protect the shore from wave attack coastal structures are generally constructed to prevent erosion, and other similar damages caused to the shore from the wave action, to retain sand for long shore transport, to reduce inlet filling, to hold down or protect the mooring vessels.

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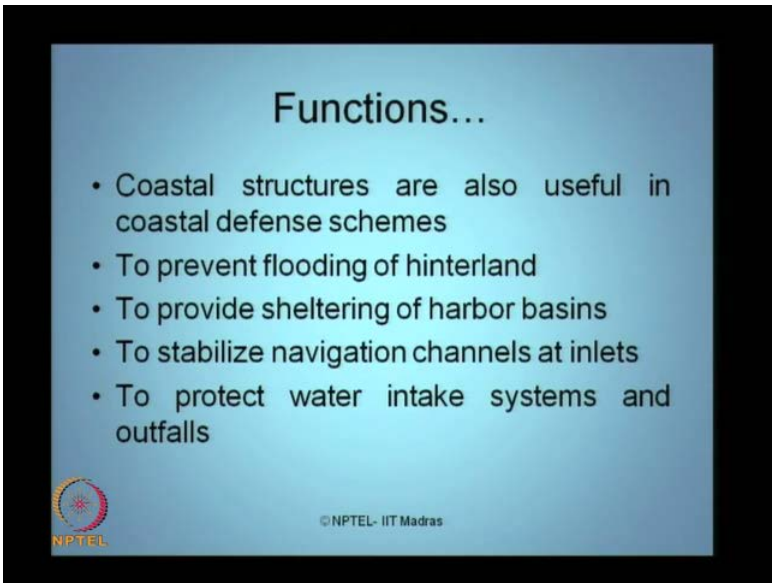

Coastal structures are also useful in coastal defense schemes. They are essentially serving good purpose of preventing flooding of the hinterland, to provide sheltering of harbor basins, to stabilize navigation channels at the inlets, to protect water intake systems and outfalls.

In this present lecture, we will discuss few more types of coastal structures. List comes in the first in today's lecture we will discuss about breakwaters.

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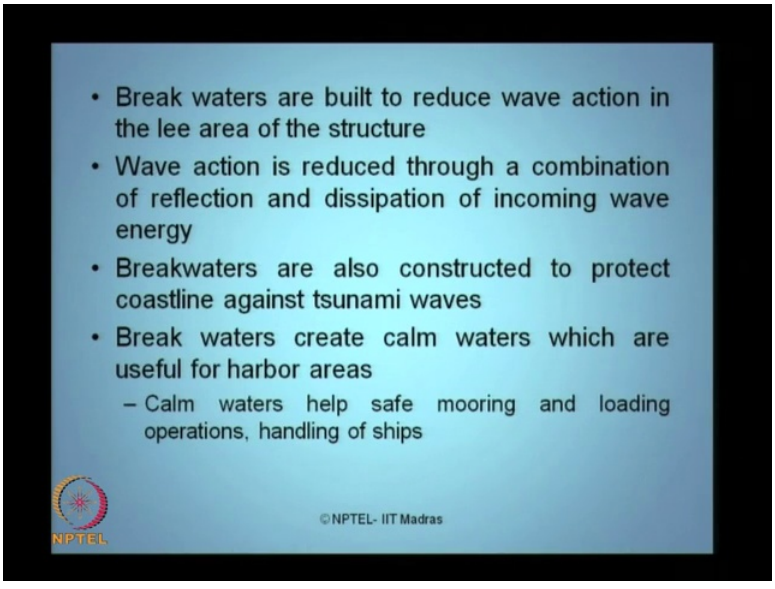

Now, the question comes what are breakwaters? Breakwaters are types of coastal structures that are built to reduce wave action in the lee area of the structure. Wave action is reduced through a combination of reflection and dissipation of incoming wave energy. Breakwaters are also constructed to protect the coastline against tsunami waves. Breakwaters create calm waters which are useful for the harbor areas, because calm waters help safe mooring and loading operations and comfortable handling of cargos and ships.

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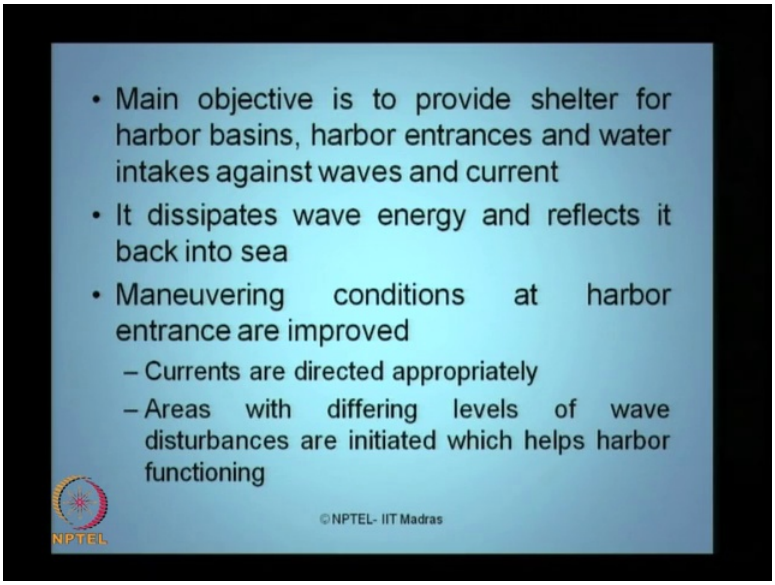

Main objective of break water is to provide shelter for harbor basins, harbor entrances and water intakes against the action of waves and current. Essential function of break water is to dissipate the wave energy and reflect it back into the sea. The maneuvering conditions at harbor entrance are greatly improved by providing breakwaters. Currents are directed appropriately, areas with differing levels of water disturbances are initiated which helps harbor functioning effectively.

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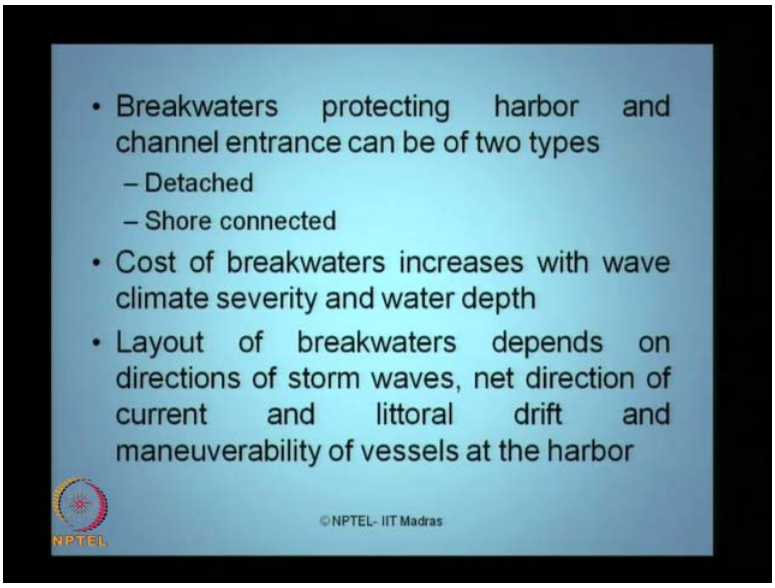

Breakwaters protect harbor and channel entrance. This can be of two types, one is what we call detached from the shore, and other is shore connected breakwaters. The cost of breakwaters increases with wave climate severity and of course, the water depth at which the breakwaters are proposed. The layout of breakwaters depends on many factors like direction of the storm waves, net direction of current and littoral drift and maneuverability of the vessels that are required at the harbor at which the breakwaters are designed. Let us quickly see, what do we understand by detached breakwaters?

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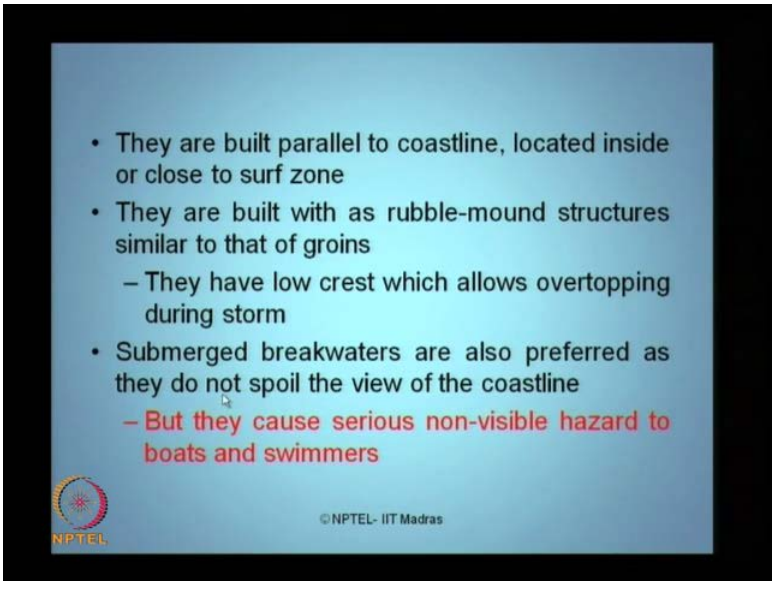

Detached breakwaters are coastal structures that are built parallel to the coastline, located inside or very close to the surf zone. They are built with rubble-mound structures. They are similar to that of groins which we saw in the last lecture presentation. They have eventually a low crest which allows overtopping during the storm. The submerged breakwaters are also preferred as they do not spoil the view of the coastline, but they cause very serious non visible hazard to the swimmers and the boats.

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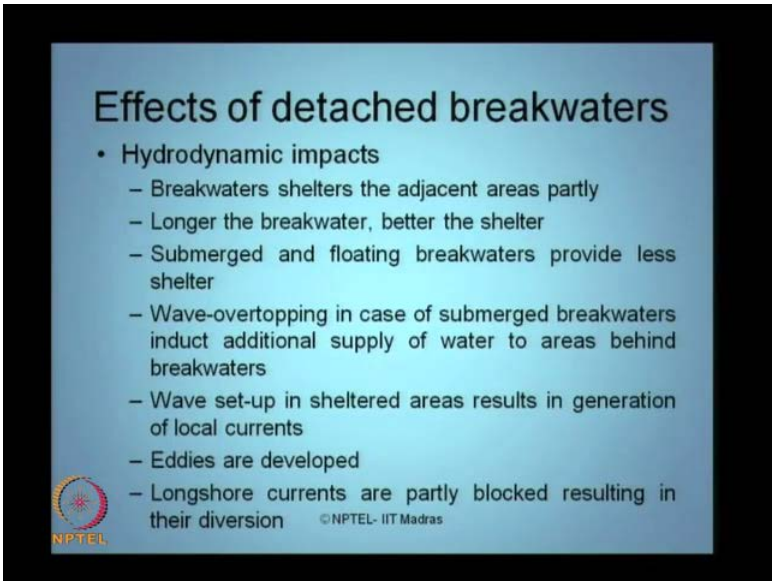

If we look at the effects of detached breakwaters on the coastline protection, there are some noticeable hydrodynamic impacts which are caused by the breakwaters on the coastline protection. Breakwaters shelter the adjacent areas partly; it is very simple to understand that longer the break water better is the shelter. Submerged and floating breakwaters provide of course, lesser shelter. Wave-overtopping in case of submerged breakwaters inducts additional supply of water to the areas behind breakwaters. Wave setup in sheltered area results in generation of undesirable local currents. They subsequently develop what we called eddies. Long shore currents are partly blocked resulting in their diversions.

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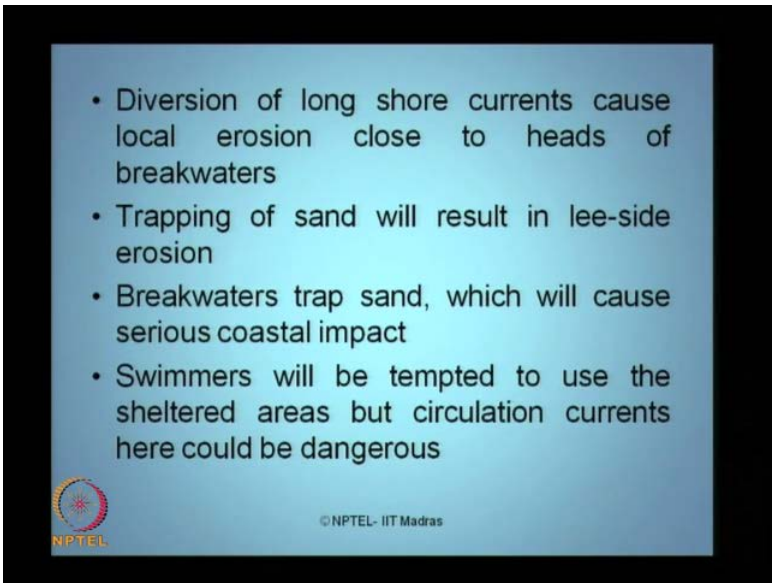

The diversion of long shore currents cause local erosion effects, the in the areas which are very close to the head area of the breakwaters. The trapping of sand which is an eventual part of the areas where break water is constructed, it will result in a lee side erosion which is an undesirable feature on the coastal segments. Breakwaters actually trap sand which will cause serious coastal impact, swimmers will be tempted to be use the sheltered areas, but circulation current present in this area because of the intervention of construction of breakwaters can be dangerous for the swimmers as well. So, breakwaters do protect coastal region from wave impact, but there are some negative aspects of providing breakwaters along the coastline.

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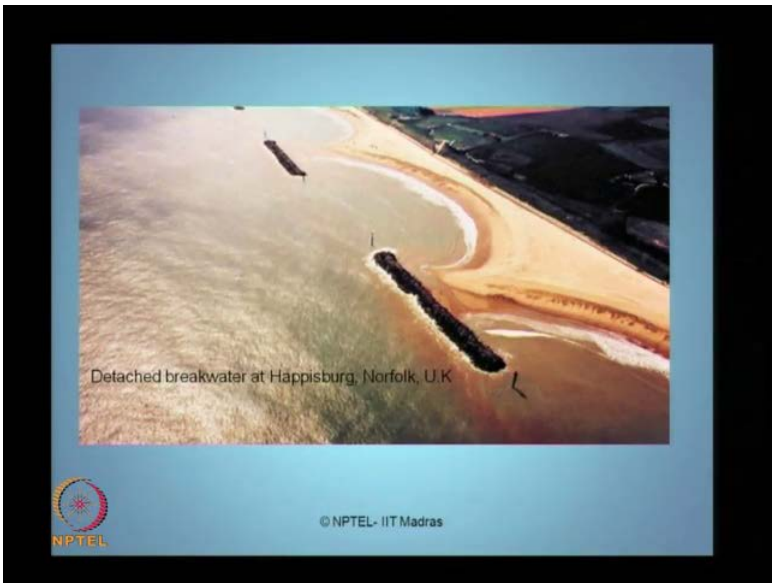

Here is a picture in which you see a detachable break water at Happisburg, Norfolk, UK you can see the breakwaters are not continuous, they are not attached to the shore. So, they are separate units as such which are constructed in parts which will have desirable benefits only on these segments where these breakwaters are constructed.

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The other photograph you see here is again detachable breakwaters constructed only on certain segments, which we see which is not neither continuous nor they are connected to the shore.

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The segmented detached breakwaters what you see is again in small pieces which are constructed parallel to the coast, but not in a continuous mode, but on intermittent modes. So, detached breakwaters have their merits as well as few disadvantages as discussed in the previous slides.

Next type of break water what we see in the literature is reef breakwaters.

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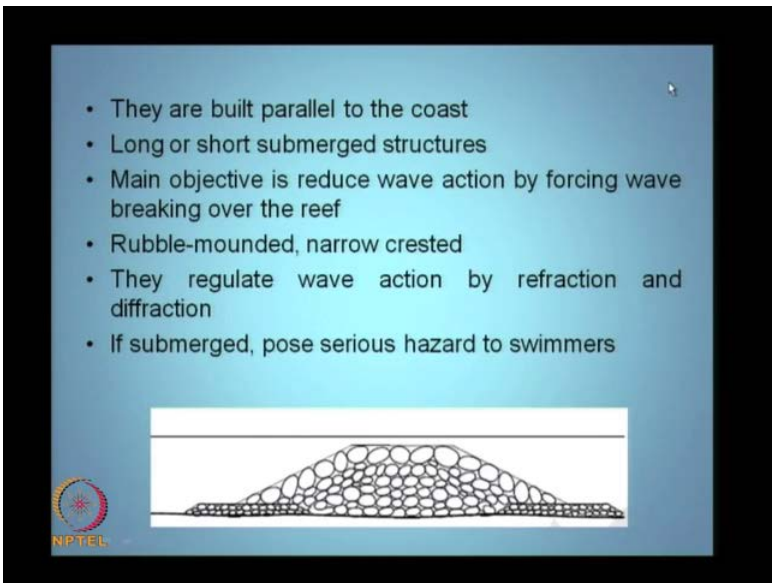

This is a cross section which shows a reef break water which is essentially rubble mounded. Rubble means stone lining are constructed with large size of stones. They are essentially built parallel to the coast; they can be sometimes longer or shorter in length when they are submerged structures. The main objective of reef break water is also to reduce the wave action by forcing wave breaking over the reef part of the break water. They are essentially rubble mounded and narrow crested, that is the geometric form of reef break water. They regulate wave action by two phenomenon's called refraction and diffractions. If submerged again they can cause serious hazard to the swimmers because they will not become noticeable therefore, there can be hazard cause to the swimmers in case of submerged reef breakwaters.

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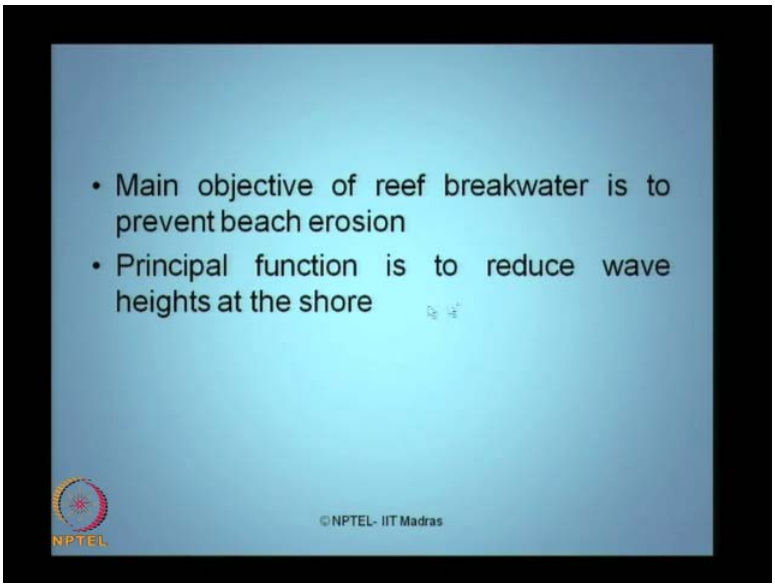

The main objective of reef break water is to prevent the beach erosion as we see in the last slide. The principal function is to reduce the wave heights at the shore action.

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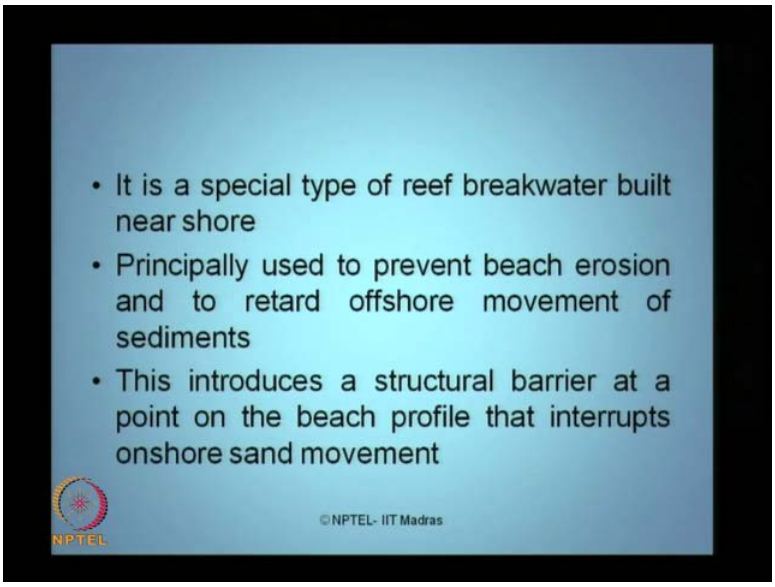

The next type of coastal structure what we are going to discuss very briefly today is submerged sill. What do you understand by a submerged sill? It is again a special type of reef break water which is constructed near shore. Submerged sills are essentially special type of reef breakwaters which are constructed close to the shore. Principally they are used to prevent the beach erosion and also to retard the offshore movement of the

sediments. This introduces basically a structural barrier at the point of the beach profile that interrupts onshore sand movement. That is how these kind of breakwaters basically prevent beach erosion and to retard the offshore movement of sediments.

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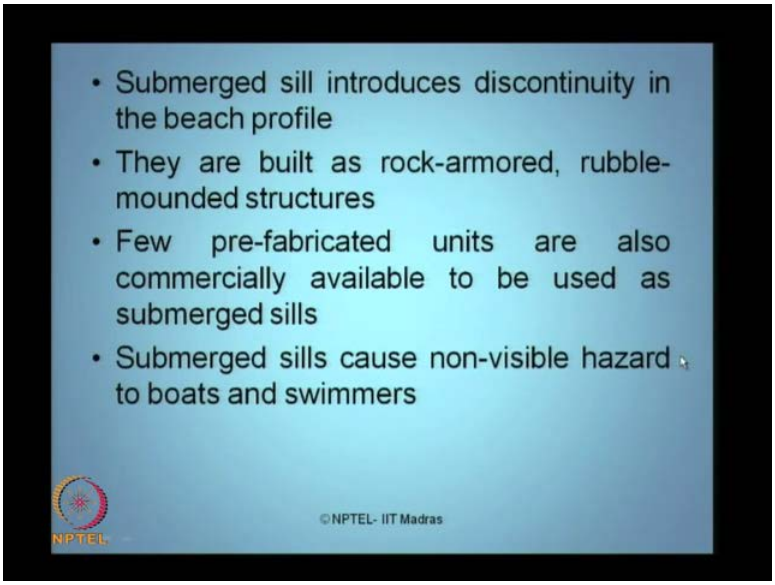

Submerged sills introduce discontinuity in the beach profile. They are also built as rock armored, rubble mounded structures. Essentially they are all massive gravity type structural form, which are rock armored and rubble lined or rubble mounded structures. Of course, in recent times people have started using few pre-fabricated units which are commercially available in the market essentially which has made out of reinforced concrete structures. They are used as submerged sills. The submerged sills also cause a non-visible hazard to the swimmers and boats and can be very dangerous in the case of shore closer to the coastal lines.

The second type, the next type of breakwaters are the coastal structures what we see is beach drains.

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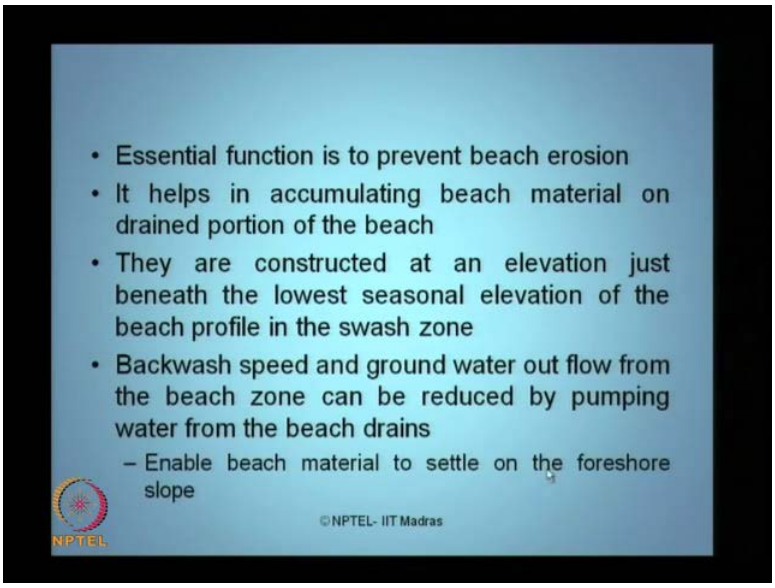

As a term, specifically say, drain is a conventional form of structure which is essentially used to prevent beach erosion. Let us see quickly how a beach drain can prevent beach erosion? It helps in accumulating the beach material on a drained portion on the beach. Basically the locations where beach drains are constructed it accumulates the beach material at the drained portion of the beach. They are constructed in elevation just beneath the lowest seasonal elevation of the beach profile in the swash zone.

Backwash speed and the ground water outflow from the beach zone can be reduced by pumping the water from the beach drains because beach drains will not only accumulate the sediments on the beach material, but also water will accumulate along with them. By pumping this water out from these drains the backwash speed and the ground water outflow from the beach zone can be tremendously controlled. This enables the beach material to settle on the foreshore slope calmly.

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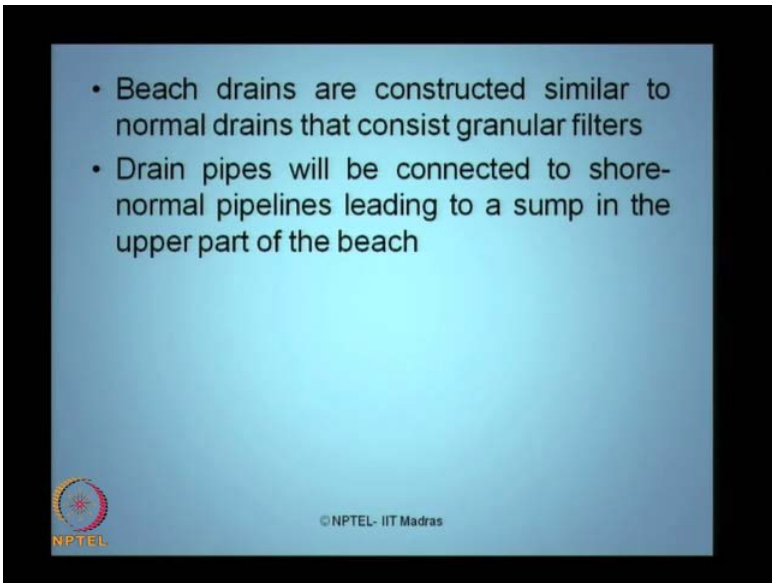

Beach drains are constructed similar to that of normal drains which are using granular filters. Of course, the size of the granular filter and the layout and the grading of the granular material depend on what type of protection and what type of sea state we are handling for the beach drains. The drain pipes which are coming, arising out from the beach drains will be connected to the shore normal pipelines leading to a sump in an upper part of the beach.

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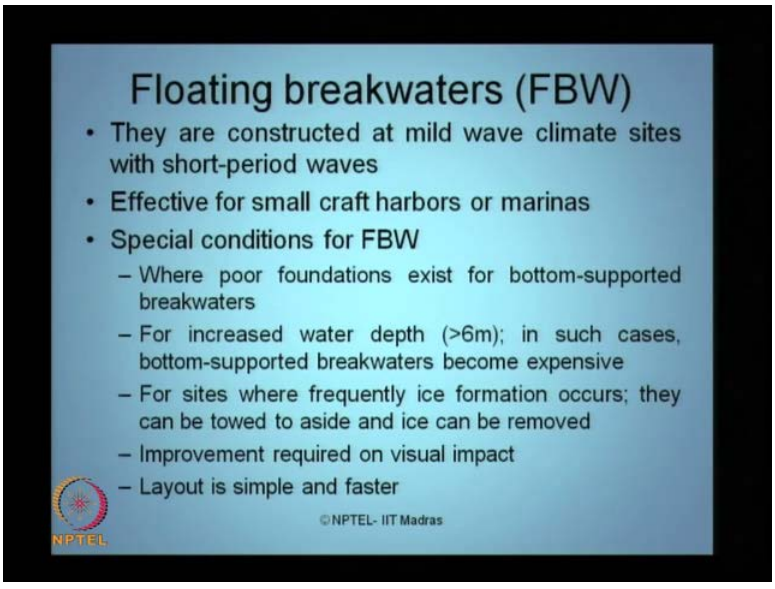

The next type of coastal structure is what we again see is break water, but a floating type what we call FBW which is floating break water. These kinds of breakwaters are constructed at mild wave climate sites where short period waves exist. They are effective for very small craft harbors or marinas. The special conditions for which or the sites specific conditions at which floating breakwaters are recommended may be listed as follows. Wherever you have got poor foundations and bottom supported breakwaters are not possible to be constructed, because of poor soil condition then one can opt for floating breakwaters.

When you wish to construct break water at a site whose water depth is exceeding 6 meters in that case bottom supported breakwaters will become very expensive. In such situation floating breakwaters can be an additional option. For sites where frequently ice formation occurs, if you have got a bottom founded or bottom supported break water, it is very difficult to remove the accumulated ice. In such situation if you have a floating break water then these floating breakwaters can be towed to aside and the ice accumulated in the section can be removed easily.

Wherever you want to improve the visual impact on the coastal line because of construction of breakwaters you have got two options. One option can be to construct a submerged break water because it will have less impact on the visual dimensions of the coast line, but submerged breakwaters have their own demerits because they cause hazardous situation for the swimmers and the boats. Alternatively, one can think of floating breakwaters. So, they can improve visual impact created by the breakwaters on the coastal sites. The layout of floating breakwaters are very simple and the construction is much faster and therefore, they are preferred of course, they are effective only for small craft harbors or marinas.

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Here is a picture in which you see a floating break water constructed Fezzano in Italy. You can see the structure is as long and quite wide as that of break water. The only advantage is this can be planned and constructed much faster than that of a bottom founded or bottom supported breakwaters.

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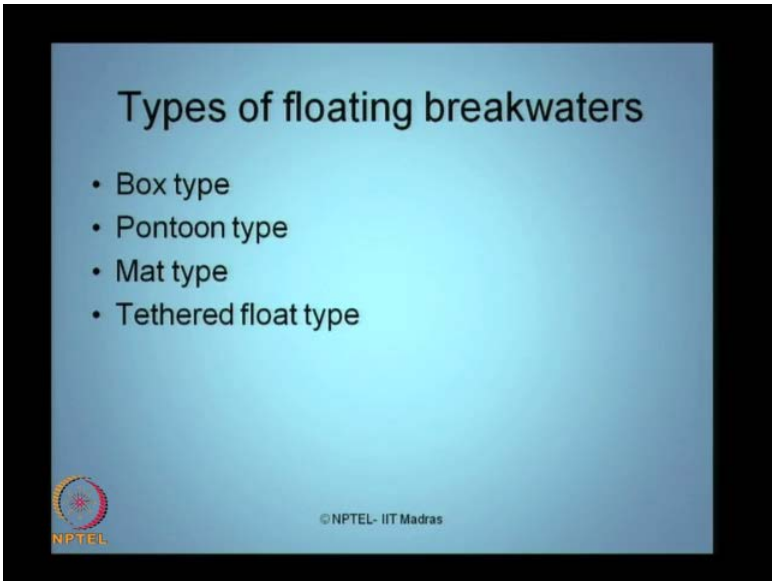

There are different types of floating breakwaters which we will see now. The box type, the pontoon type, the mat type and the tethered float type, these are four types of floating breakwaters which are normally seen and constructed in different sites all over the world.

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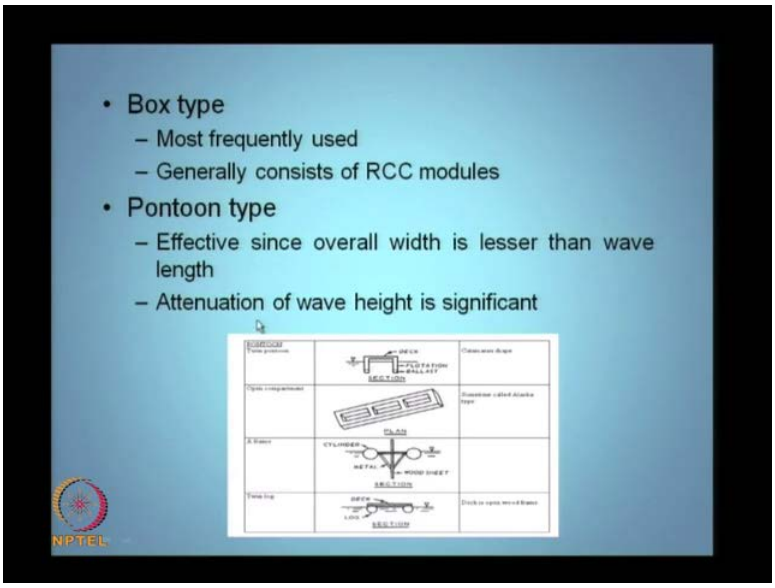

Let us quickly see what box type floating break wateris. This is the most frequently used type of the floating break water. It generally consists of RCC modules. RCC expands for reinforced cement concrete modules. The next type of floating break water which is commonly seen is the pontoon type. The table here shows different types of geometry of a pontoon type where I say twin pontoon can have a deck connected together which is a floatation ballast, which is essentially used for a catamaran shape. You can also have what we call open compartment type pontoon type floating breakwaters.

You can also have a frame type break water where two cylinders are connected by a metal frame and a wooden sheet in between them which can be also assembled to become a floating break water. You can also have twin lock type breakwaters where there are two pairs of locks which are connected as a deck and this can be used as break water. The advantage of this break water is the deck is an open wooden frame which can be used for some inspection purposes as well.

Now, floating type breakwaters has specific advantage when you are using in the pontoon type. They are effective since the overall width of pontoon type break water is much lesser than the wave length. Practically, it is half of the wave length. Because of this the attenuation of wave height is significant, it means the wave height reaching the fore site of the break water is significantly reduced, it is attenuated because of the

pontoon type breakwaters because the overall width of this break water type is much lesser than that of the wave length.

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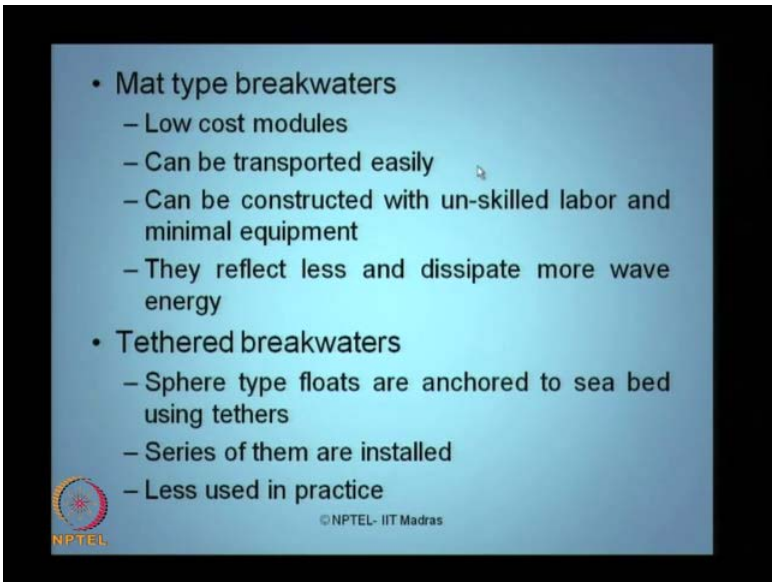

The next type of floating type break water is a mat type breakwater. They are essentially used as low cost modules. They are much cheaper compared to floating type breakwaters in case of pontoon type or in the box type. The one great advantage what this mat type breakwaters possess is they can be transported easily from one location to another, these type of breakwaters can be constructed with an un-skilled labor and use of equipments to construct this break water is highly minimal. They reflect less and dissipate more wave energy that is another merit what you obtain from mat type floating breakwaters.

The last type of floating type break water what you see in the literature is tethered breakwaters. As the name spells very clearly, ladies and gentlemen, these breakwaters are anchored to the sea floor using tethers. So, essentially they contain sphere type floats, may be one or in series which are anchored to the sea bed using tethers. That is why they are called tethered breakwaters. Series of them are generally installed not a single piece. This kind of breakwater do not have significant advantage in controlling the wave action on the coastal site and they are very less used in practice.

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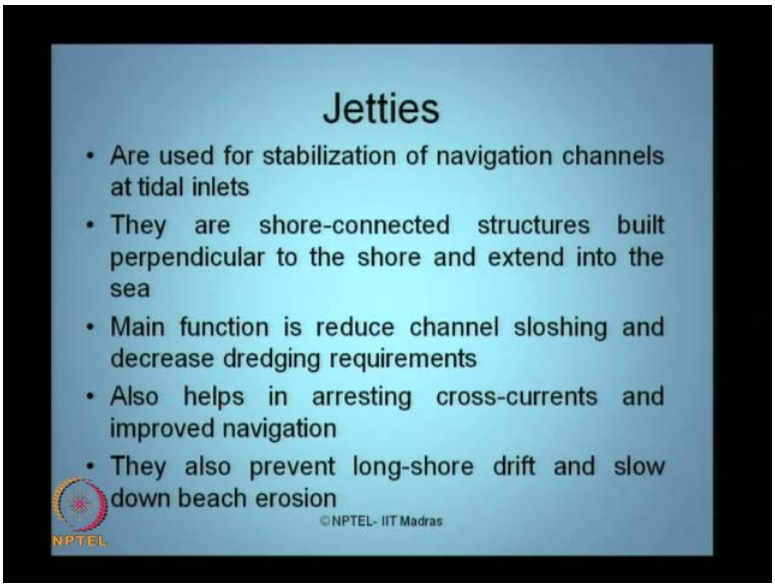

The other type of coastal structure what we will discuss today's lecture will be jetties. Now, what are jetties? Where are they used? Jetties are coastal structures which are used for stabilizing the navigation channels at the tidal inlets. Ladies and gentlemen understand this very clearly that jetties are specific type of offshore structures or coastal structures which are built for stabilizing the navigation channels exclusively at specific location especially at the tidal inlets of the channels. They are normally shore connected structures, whereas breakwaters can be isolated as such. So, they are shore connected structures which are generally built perpendicular to the shore and extend into the sea.

Now, I want you to name another coastal structure which is generally built perpendicular direction of the coastal line. Yes, you are right groins are another type of coastal structures which are protected and constructed perpendicular to the shore line and extend it into the sea. The main function of jetties is to reduce channel sloshing and of course, they decrease dredging requirements because dredging is one of the very common and expensive maintenance processes which happen to maintain the navigation channels for housing the vessels. So, wherever jetties are constructed they reduce the channel sloshing and thereby they decrease the dredging requirements significantly on the channels.

Jetties of course, help in arresting the cross-currents and this will certainly improve what we call the navigation facilities of the channel part at the tidal inlets. They also prevent long shore drift and slow down beach erosion. So, in general if we look at the

fundamental principle and the desired advantage of any kind of coastal structure they are all constructed in general to protect the coast line from the wave action. One of the serious wave action caused by the waves on the approaching shore is beach erosion. So, most of the coastal structures are constructed with the principle objective in mind to prevent the long shore drift and to slow down or to eradicate completely the beach erosion.

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The photograph what you see here is a jetty at Carlsbad constructed in California. The other photograph what we see down the line is a jetty at Dolos in Humboldt bay. Both of these have a similarity that they are connected to the shore and the length and the projected into this, they are normal to the shore line, they are perpendicular into the sea and they are connected to the shore, they stay connected and essentially they exchange into the sea for relatively a long distance.

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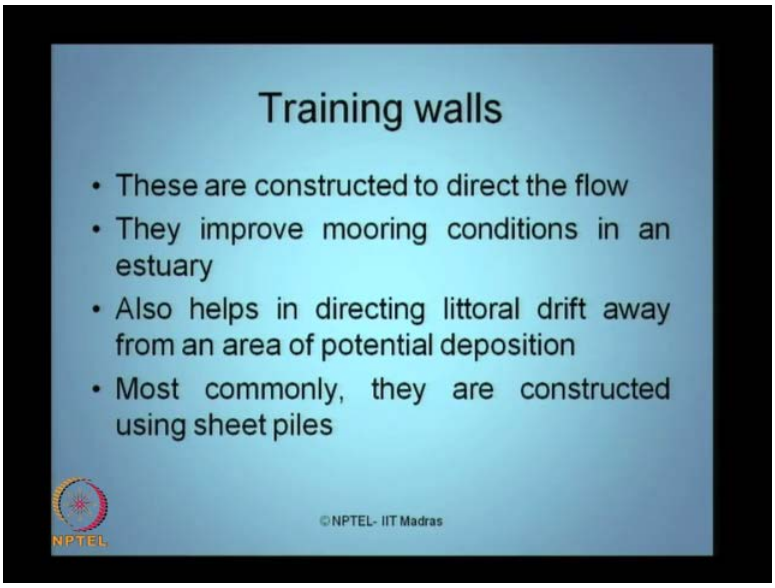

The last type of coastal structure what we see in this lecture will be training walls. Let us quickly see, what do we understand by training walls? Training walls are constructed actually to direct the flow; they improve the mooring conditions in an estuary. Also, it helps in directing the littoral drift away from an area of a potential deposition. Most commonly, they are constructed using sheet piles.

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The training wall at Wallis Lake is what we see here. These are the training walls which are constructed, which directs the flow in a calm smooth manner. There is a training wall

constructed at Tweed river entrance in Queensland, Australia which is also used for guiding the flow in a smooth manner.

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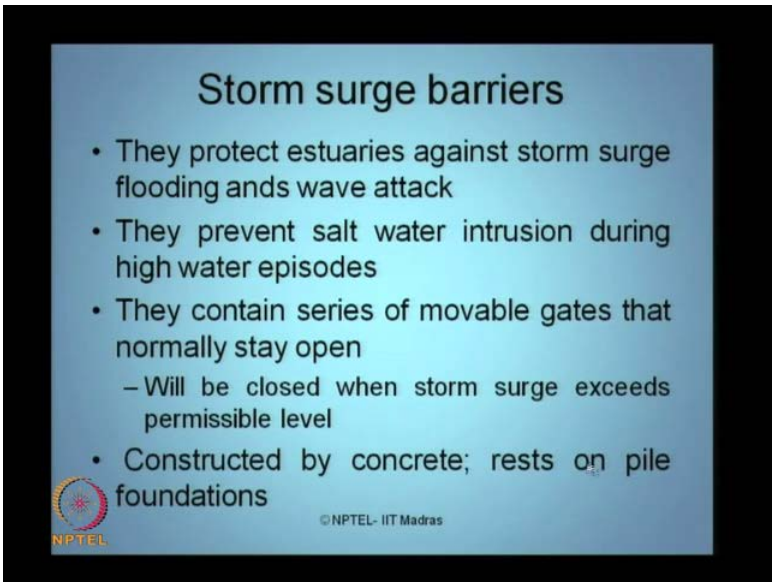

Storm surge barriers are also another type of coastal structures which are constructed to protect the estuaries against storm surge flooding and wave attack. They prevent salt water intrusion during the high water episodes, that is one of the great advantages of storm surge barriers constructed. They contain series of moveable gates which are kept open, they normally stay in open position, but they will be closed when the storm surge exceeds the permissible level which is undesirable; constructed, generally with concrete, rests on pile foundations.

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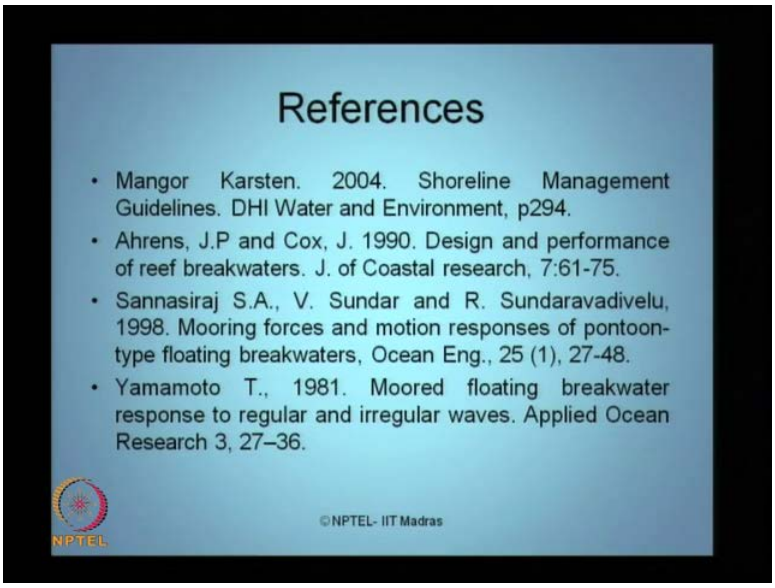

There are some few references which are very important for you to be given in addition to what we have discussed in the presentation in the website of NPTEL IIT Madras. There are few references what I want to list it here, Mangor Karsten 2004 Shoreline Management Guidelines, DHI Water and Environment 294 p p, Ahrens and Cox Design and performance of reef breakwaters which is available in Journal of Coastal research volume 7, Sannasiraj, Sundar and Sundaravadivelu, 1998 Mooring forces and motion responses of pontoon type floating breakwaters available in Ocean Engineering volume 25, 27, 48; Yamamoto discussed in 1981 the Moored floating break water response to regular and irregular waves in Applied Ocean Research volume 3, 27 36.

So, ladies and gentlemen, we have given a very brief overview of different kinds of coastal structures in these past two lectures. In the next lecture we will discuss about the structural form, the geometric form, plan, location, guidelines and essential functions of different kinds of coastal structures before you move further to discuss about the design aspects of offshore and coastal structures. Thank you.