Ocean Structures and Materials
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Module - 1
Lecture - 11
Summary of coastal structures

Ladies and gentlemen, we are flowing lectures on first module of ocean structures and materials. Today we will discuss the eleventh lecture on the first module of ocean structures and materials.

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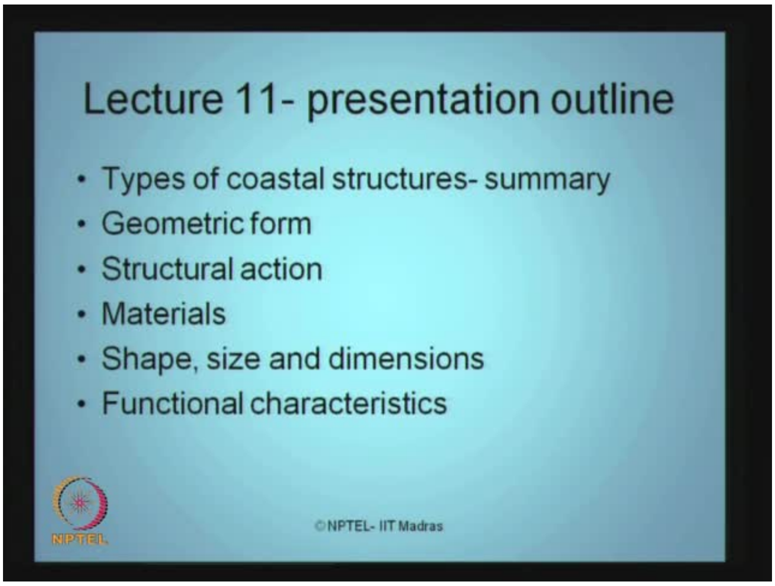

The presentation outline for the current lecture will be the following; we will talk about a summary of types of coastal structures, which we discussed in the previous two lectures, we will talk about the geometric form, the structural action, and the materials, which are exercised by different kinds of coastal structures. We will also discuss about the shape, size, and dimensions of typical coastal structures in this presentation. We will also talk about very briefly their functional characteristics of these structural systems.

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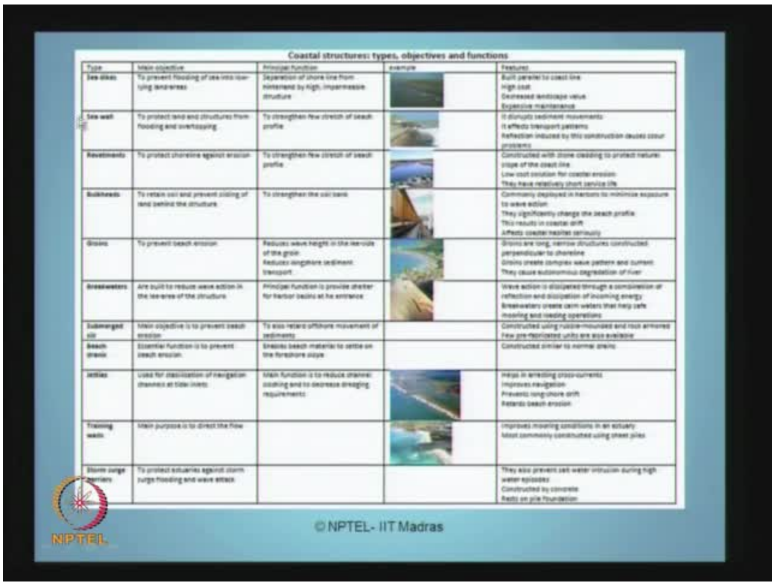

This is a brief overview of different kinds of coastal structures, which we have discussed so far. If you look at this table, we will talk about the different types of coastal structures starting from sea dikes, sea walls, revetments, bulk heads, groins, break water, submerged sills, beach drains, jetties, training walls and storm surge barriers. Some of the photographs of different kinds of coastal structures, constructed elsewhere in the world are also summarized here.

The main objective and the principle function and the essential features of these types of coastal structures are summarized in this table for your ready reference.

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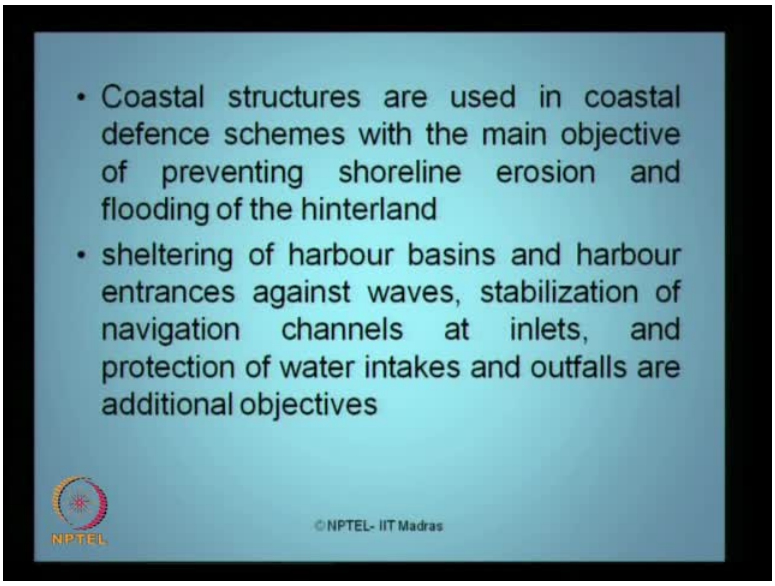

Coastal structures are used in coastal defense schemes, with main objective of preventing the shoreline erosion and flooding of the hinterland. Sheltering of harbour basins and harbour entrances against the wave action, stabilization of navigation channels at the inlets and protection of water intakes, and outfalls systems are additional objectives of any type of coastal structures.

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The photograph you see here has already been explained in the previous lecture. These are photographs of different sea dikes, what has been constructed elsewhere in different parts of the world.

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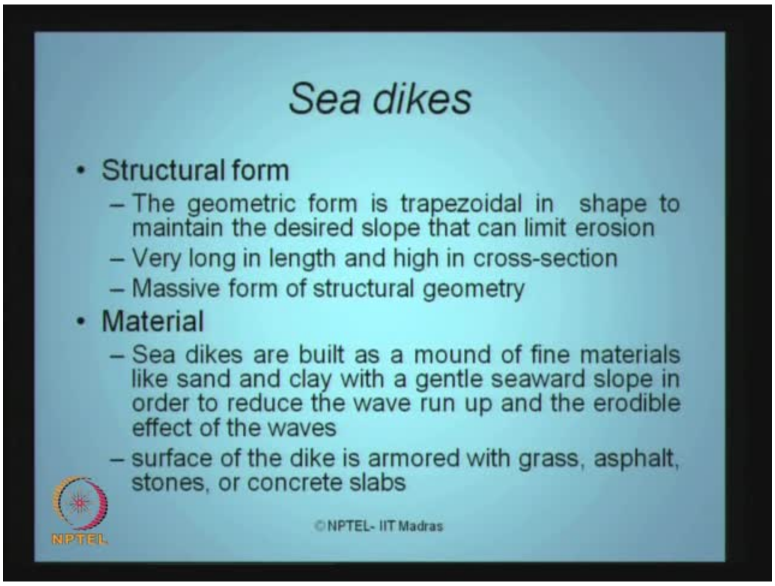

Now, what are sea dikes? Sea dikes are geometric form of trapezoidal in shape, which are constructed to maintain the desired slope that can limit erosion. They are very long in length and very high in cross section, they are very massive form of structural geometry. If you look at the material, which are commonly used for construction of sea dikes; the following are the material, which are preferred for construction of sea dikes. Sea dikes are essentially built as a mound of fine material like sand and clay, with a gentle seaward slope; this is then in order to reduce the wave run up and the erodible effect of the waves. Surface of the dikes are generally armored with either grass, asphalt, stones or concrete slabs to prevent the erosion of the fine material, which has been used as a mound to construct the sea dikes.

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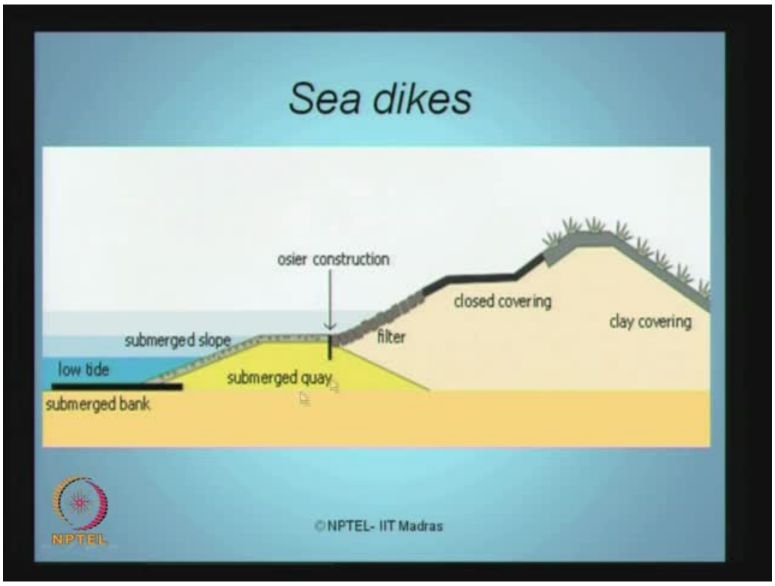

A typical cross section of a sea dike is shown in the picture here. For example, the low tide level is indicated in black color here, this is my submerged quay, which we are constructing here and you are using filters in the downward slope here. And this is the closed covering area; this is nothing but the clay or a finite sand material which has been used to construct the dike. Of course, on the upper crust and the leeward and the backward side can have even grass has the armored protection for the covered layer.

So, this is a decent cross section of a proposed sea dike, which has been commonly practiced in coastal protection systems.

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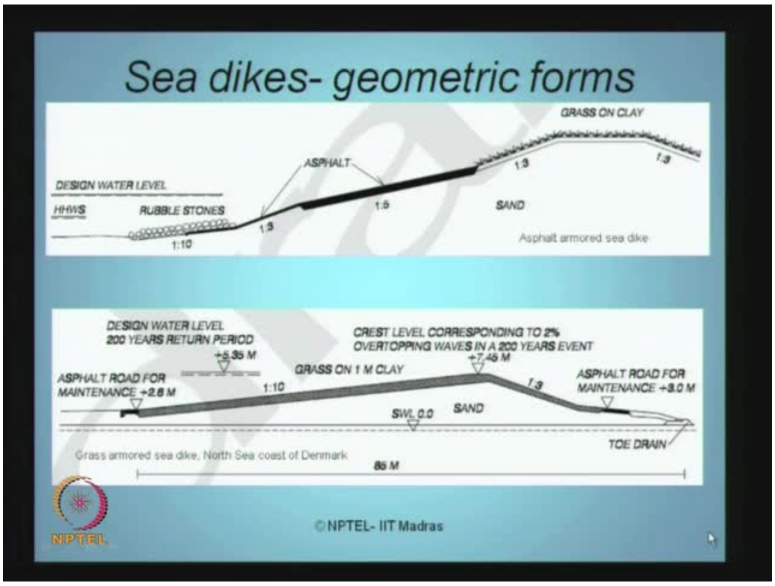

There are different geometric forms, we can see for sea dikes here. For example, if this is my design water level at which I have water construct or for which I should design the sea dike, then the slope initially is given as gentle as 1 is to 10. Then the slope raises to 1 is to 3 and 1 is to 5, and further 1 is to 3, then the crust and then 1 is to 3. Generally, the upper portion of the crust here is used by grass on clay to armor the clay or the sand material of the dike, to protected from the top.

Whereas for a certain slope of 1 is to 5 to prevent the ability or capability of the sea dike to protect the sea dikes from surface run up, asphalt lining is being given. So, rubble stones are generally put at the entry level of the sea dike here, so that erosion is minimized here. Generally, the design water level calculate of designing the sea dikes are about 200 years return period. You can also do something called the crest level over topping, can also be done with grass with 1 meter clay.

So, you can also cover the sand with the help of the boundary material, which is grass, which can be used as an armored material for covering the slope or the protecting the slope. So, generally the slope here is much more gentle compare to that of the leeward slope. At the end of the slope you also have what is called as a toe drain, which collects the run up from the surface, which can be reuse later for maintaining the sea dikes. So, these are two common geometric forms, which have been in practice for sea dike construction in coastal protection systems. Let us look at the functional aspects of a sea dike.

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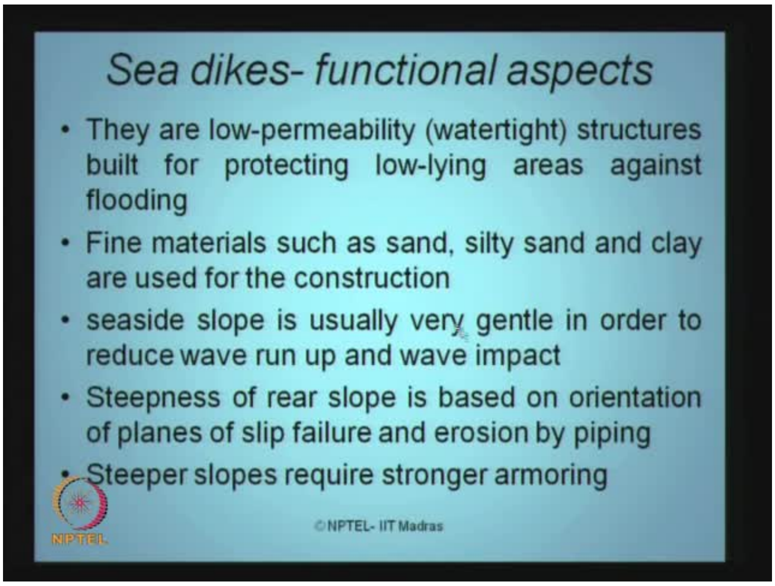

They are actually low permeable structures, which are essentially water type systems that are built for protecting the low line areas against flooding. Fine materials such as sand, salty sand and clay are essentially used for construction of sea dikes. Seaside slope is usually gentle, as we saw in the previous picture, which is the slope of 1 is to 10 whereas the other side the slope is much deeper, may be in the order of 1 is to 5 or 1 is to 3 even. The seaside slope is kept gentle in order to reduce the wave run up and the wave impact on the sea dike structures.

The steepness in the rear slope is actually depending on the orientation of the plane of slip failure and also depends on what is the erosion of the piping, which is being done at the rear end of the steepest part of sea dike. So, sea dike is actually a trapezoidal cross section, which has got two different slopes; one on the seaside and one on the rear slope. Of course the rear slope guidance is based on the orientation of the plane of slip failure, which are happening on the rear side. Whereas the seaside slope are for gentle in order to protect or prevent surface run up or the wave run up and the wave impact on the sea dikes. Steeper slopes obviously require stronger armoring, otherwise the armoring is weak then the gentle material, which is lying below the armored area, will get washed away by the run up.

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The other type of coastal structure, which we discussed in the previous lecture is what we call as sea walls. Two photographs you see here on two different varieties of sea walls, which have been constructed elsewhere in different parts of the world.

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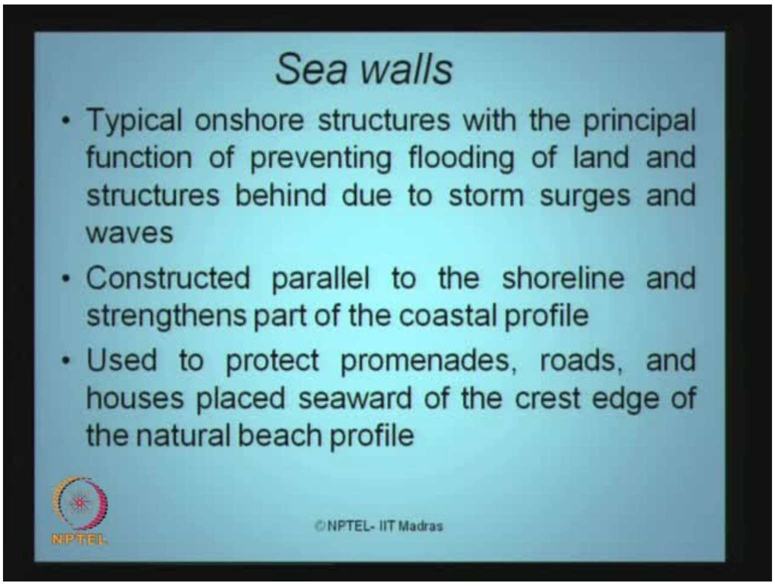

Let as look at the functional aspect of a sea wall and the geometric form typical onshore structures, named as sea walls have a principle function of preventing flooding of land and the structures behind them, due to storm surge action and waves. They are constructed generally parallel to the shoreline; sometimes you can also see a curvilinear geometric profile of sea walls as in the previous photographs. They are generally constructed parallel to the shoreline and it strengthens part of the coastal profile, which we call as reinforcement of the coastal profile. They are essentially used to protect promenades, roads and houses that are placed seaward of the crest edge of the natural beach profile of the coastal side. Let as look at the structural action of a sea wall, how does it behave when it is subjected to wave actions? It is highly vulnerable to what do we call as a toe scouring, which causes instability to the wall.

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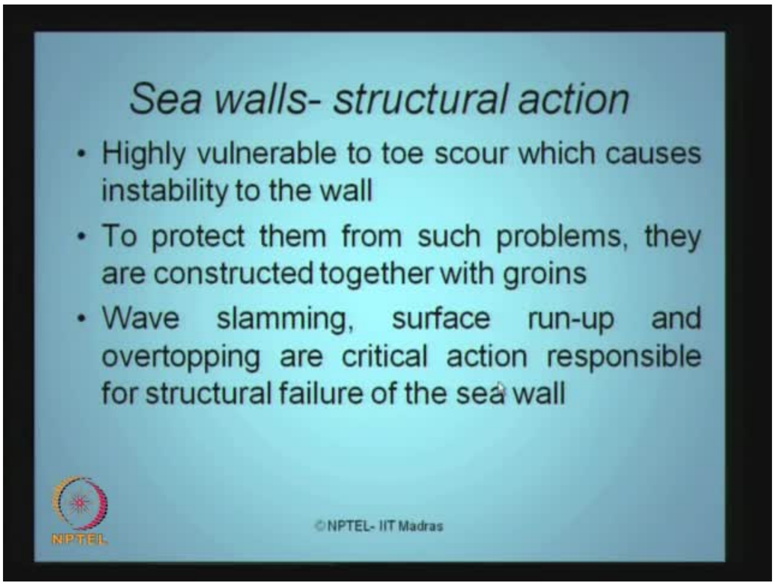

Now, the question is how to avoid this kind of toe scouring? To protect these sea walls from such toes scour problem, they are actually constructed together with the groins. Ladies and gentlemen, you will recollect that groins are coastal protection structures, which are constructed perpendicular to the scours line or the pre set cost. Wave slamming, surface run up and overtopping are critical actions that are responsible for structural failure of a sea wall.

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Let as look at the construction aspects of a sea wall. They are classified as sloping front or vertical front structures. As the name suggests, if the front side of the sea wall is having the sloping gradient, we call them a sloping front sea walls on the contrary. If the front side is having a vertical front, we call them as vertical front sea walls. The sloping front structures are generally constructed using flexible rubble mound structures. They have flexibility to overcome the toe and crest erosion and therefore, they advantageous in terms of avoiding the toe or crest erosions.

The stability of slope of these kinds of sloping front sea walls is very major concern in its design, the geometric form of the sea wall. The stability of this slope depends on the intact toe support given to the front side of the sea wall. The loss of toe support generally will result in significant damage of the armor layer of us because the armor layer will get washed off by the surface run up when the toe wall gets damaged. It also results in either a partial or a complete failure of the armored slope. Once the armored slope is fail then the material, which is lying below the armored one, which is the soft material will also get washed away and the total functionality of the sea wall, especially in case of sloping front sea walls will completely lost.

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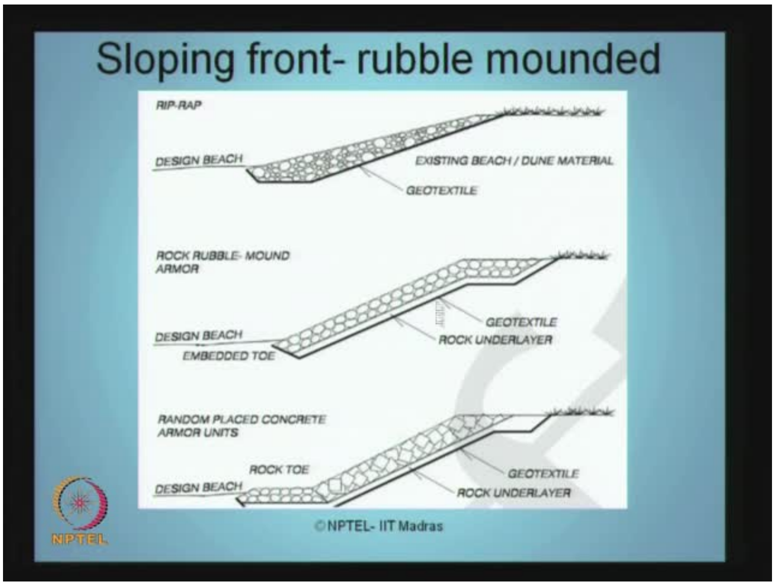

Let us quickly look at the sloping front rubble mounded sea wall, (( )) photograph. These are three different types of sloping front rubble mounded because we say the front side, which is the seaside is having the sloping front. That is why we call as sloping front and we are using rubble for mounding the surface, this existing beach and the dune material is been shown here. Some times in general in all the three shapes we use geotextiles to strength or to stabilize the slope in the front side. It can be either rock rubble mound armor or it can be even a random placed concrete armor units. You can see the armoring can be done with either rubble mounding, in a regular form or can even use concrete cubes or big blocks of concrete to the armoring of this. However, in all the three types you will see to stabilize the slope, we generally recommend geotextile layers to be put for the slope stability

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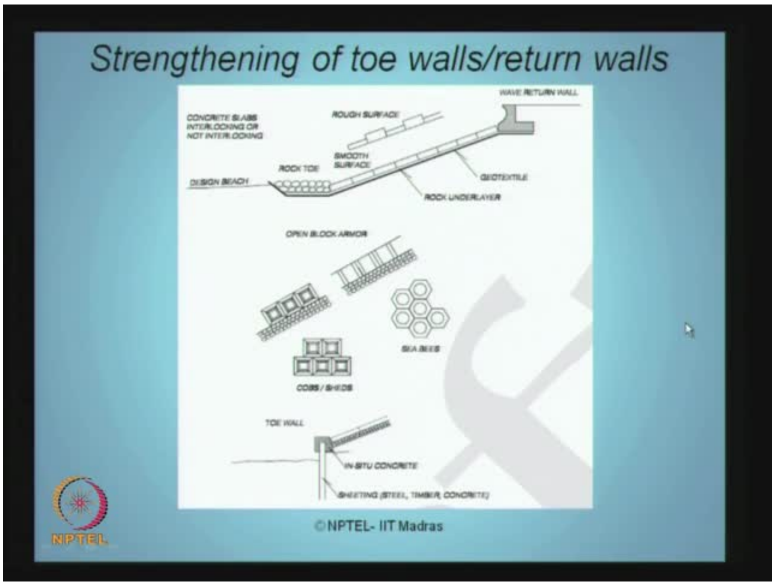

If you talk about the strengthening of toe wall, which is going to be one of the very serious issue as per the design point of your sea walls are concern. We also call them as a either toe walls or return walls. So, you can see here either a return wall or a toe wall should be properly strengthen, just prevent the erosion caused because of the wave run up on the top on the slope side of the armored portion. Because, if the toe walls are not protected comfortably, then the armored layer may get washed of completely, which will result in a design failure of a sea wall? So, the toe wall which is nothing but the protection wall at the end, which is vertical sheeting pile, which can be in-situ concrete, which actually protects the edge of the sea wall from serious toe scouring problems encounters from the wave action.

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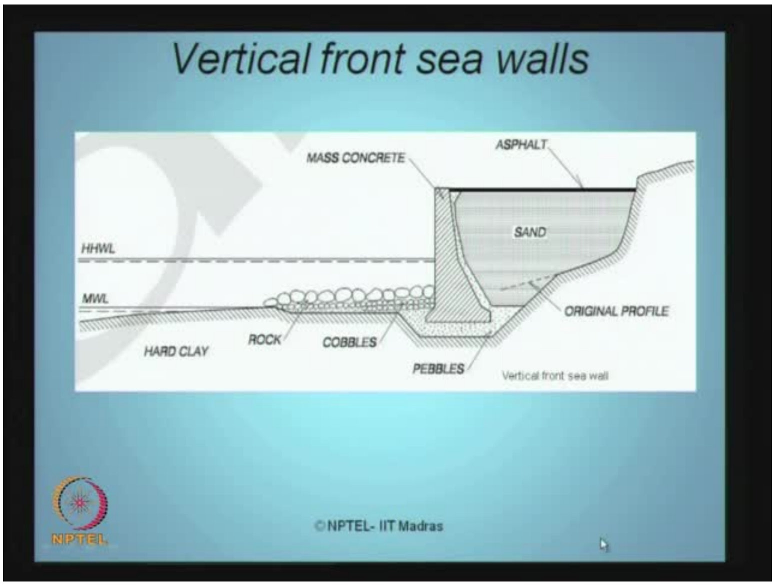

Vertical front sea wall iswhat you see here In this picture. Instead of having a sloping front now I have a vertical front, it can be a mass concrete. It is basically a gravity based structure for a coastal protection, so mass concrete which protects. On the other side, which is filled up with the sand or a lose fine material, which is compact completely and then the asphalt lining layer can be given on the top, to provide a proper finish on the top.

So, the vertical front pipe sea walls have vertical front wall, which is founded below the pebbles and then you got the rock layered armoring in front of the sea wall. This is the original profile of the beach, this been refilled using a sand or softer material over which an asphalt lining is generally given. Generally, the design height of a vertical sea wall depends on what is the high tide level and what is the mean water level. Depending up on this oceanographic data on a specific sea state or a sea sight, the height of thisvertical front sea wall are generally fixed up on as a design parameter.

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The next classical type of coastal structure what we saw in the literature, in the earlier lecture is that, revetments. You can see interestingly two beautiful photographs of two types of revets, which has been revetments, which has been done in the structural side for coastal protection. You can see both of them having a great similarity, the front side of the seaside have a gentle slope. One is having a different kind of protection system, whereas the other one has different kind of geofabric layers, which are used as an armor covering for slope protection. So, either way you construct revetments, so that the slope stabilization also forms an important part of these kinds of coastal protection structures.

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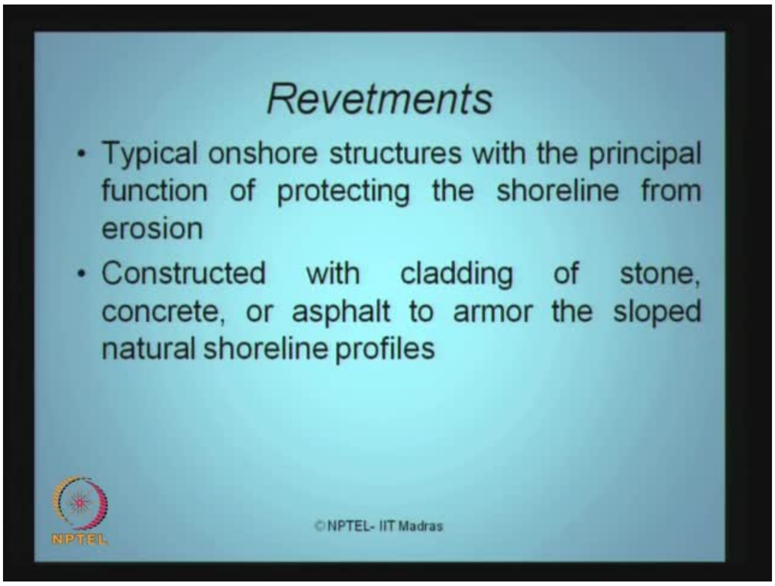

Typical onshore structures are revetments with the principal function of protecting the shoreline from the erosion, constructed with cladding of stone, concrete or asphalt to armored the slope natural shoreline profiles. The natural shoreline, which is on the seaward side is protected either by cladding of stone or by concrete cladding or by even asphalt lining, as we saw in the previous picture.

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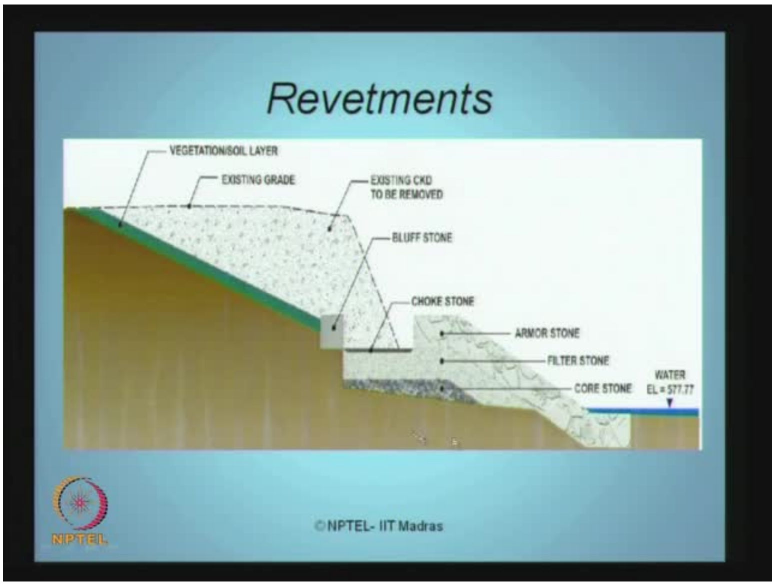

This is the typical cross section of a revetment, what you see here. To protect the slope you can even do what we called vegetation or a soil layer, over which an existing grading can be done, an existing CKD can be removed and can be filled up. So, protect this slope and to improve the stability of the slope, I put the end of this toe, what do we call as a bluff stone and to protect I also put what is call choke stone here. Then I put a armor layer covering to protect the slope, so that the slope which is design for maintaining a coastal protection should be always permanently seen, that the slope does not get eroded away because of the wave run up.

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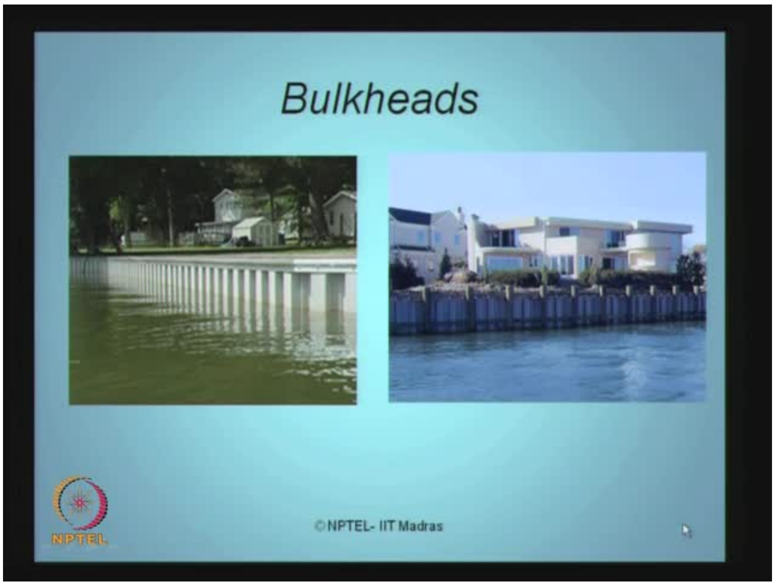

The next type of classical coastal protection structure is what we call as, bulk heads. These are two interesting photographs of two types of bulk heads, what you see in the picture.

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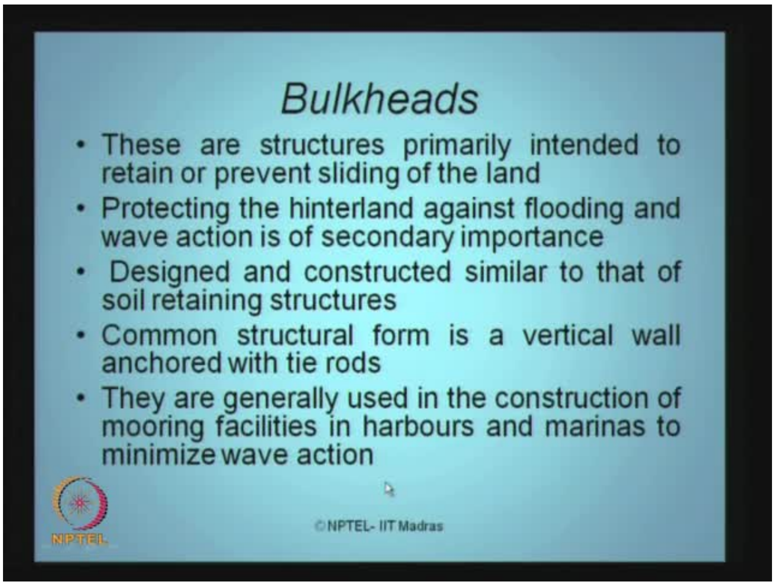

Bulk heads are actually structures primarily intended to retain or prevent sliding of land. So, essential function of a bulkhead is similar to that of retaining wall. The retaining walls generally retain soil, whereas this retains again the leeward side of the soil from the wave action on the coastal side. Protecting a hinterland against flooding and the wave action is the secondary importance for a bulk heads. Essentially it prevents sliding of land. So, it is nothing but a type of a retaining wall which functions to provide or to prevent sliding of a land. It is designed and constructed similar to that of the soil retaining structures, as you see on the road sides in hilly terrains. The common structural form is actually a vertical wall, which is anchored with the tie rods. They are generally used in the construction of mooring facilities in harbours and marinas, to minimize them from the wave action.

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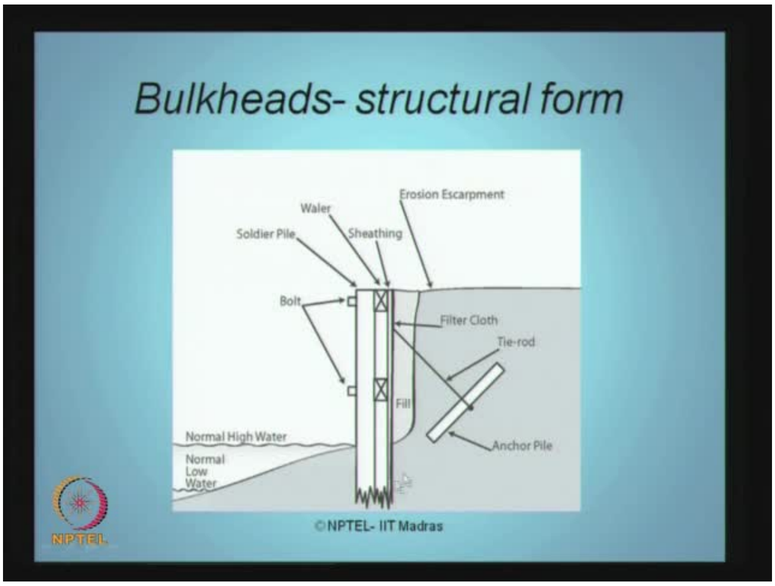

Here is a typical cross section of the structural from of a bulkhead. You can see this is a vertical wall, which is anchored, which is an anchor pile and anchored to the pile using a tie rod, to provide lateral stability of this wall against wave action. So, essentially the sheathing is done here and the erosion escarpment is done on the surface, we use the filter cloth here to protect the sheathing from the soil erosion characteristics. Then we use fining on this area to protect the filter clothing or to protect this layer of the back side of the sheathing. So, these bolts will whole the sheathing with that of the solider pile together in different position along the length of the bulk heads.

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The other type of structural form what we see for coastal protection is groins. Ladies and gentlemen, it is easily recollect that groins are coastal structures that are constructed generally normal to the coast shoreline, perpendicular to the coast shoreline. Whereas the previous types of structural forms are generally parallel or curvilinear to the coast lines. So, two photographs you see here are groins structures constructed normal to the coast line.

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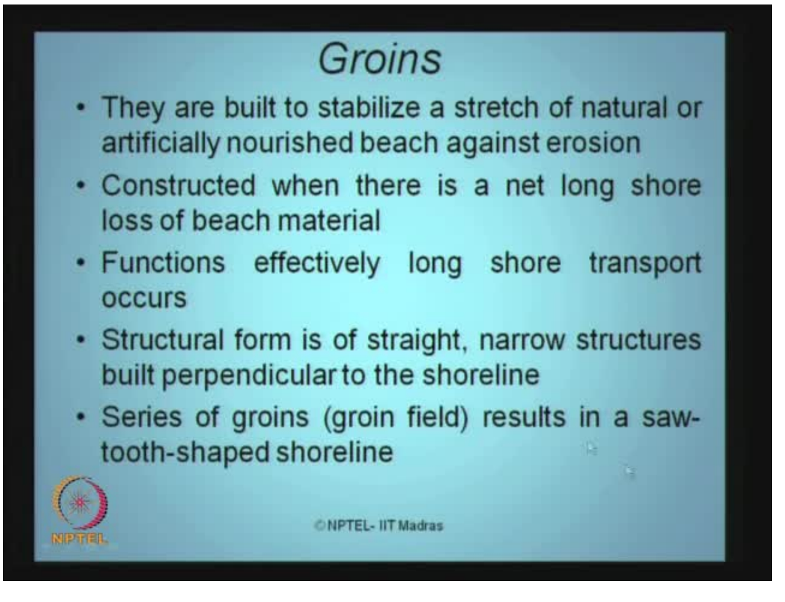

Now, what are groins? Groins are essentially built to stabilize a stretch, a small stretch or medium length of a stretch of a coastal side, of a natural or artificially nourished beach against soil erosion. It is constructed when there is a net long shore loss of the beach material; beach material is nothing but the sand.

So, when you anticipate or when you monitor a long shore sediment transport of the beach material, which is effectively very bad then you want to protect the coastal line of the beach side against this kind of erosion, groins are generally constructed. It functions effectively for protecting the long shore transport. The structural form of a groin is very simple; it is straight narrow type of a structure, which is built perpendicular to the shore line. Series of groins are generally constructed; they are never constructed in isolations. Series of groins otherwise referred a literature as a groin field, this results in saw tooth shape shoreline, which is a better form of protecting the shoreline from soil erosion.

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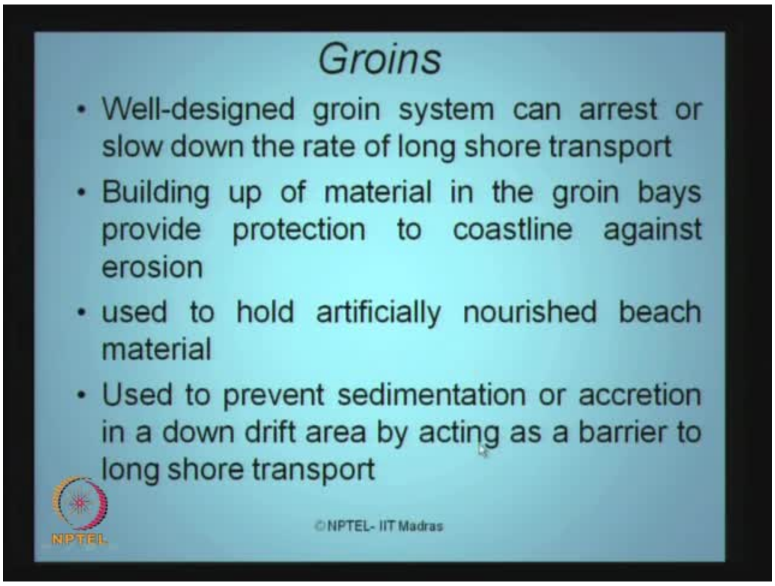

Groins are well designed so that they can arrest or slow down the rate of long shore transport. So, the fundamental objective of the groin structure is to retard down the long shore transport of sedimentation, building of a material in a groining bay provide protection to the coast line against erosion. It is used to hold artificially nourished beach material in a very common format. It is used to prevent sedimentation or accretion in a down drift area, by acting as a barrier to the long shore transport.

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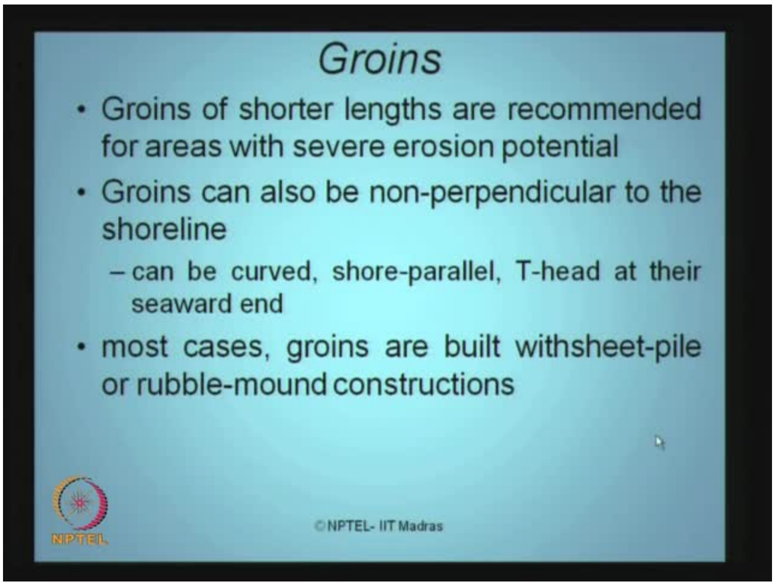

Groins of shorter length are generally recommended where you got areas with severe erosion potential. Groins can also be non-perpendicular in an unusual form; this can be curve, shore parallel, T headed at the seaward end. In most cases groins are built with sheet piles or rubble mound constructions, as we saw in the earlier case of like sea walls.

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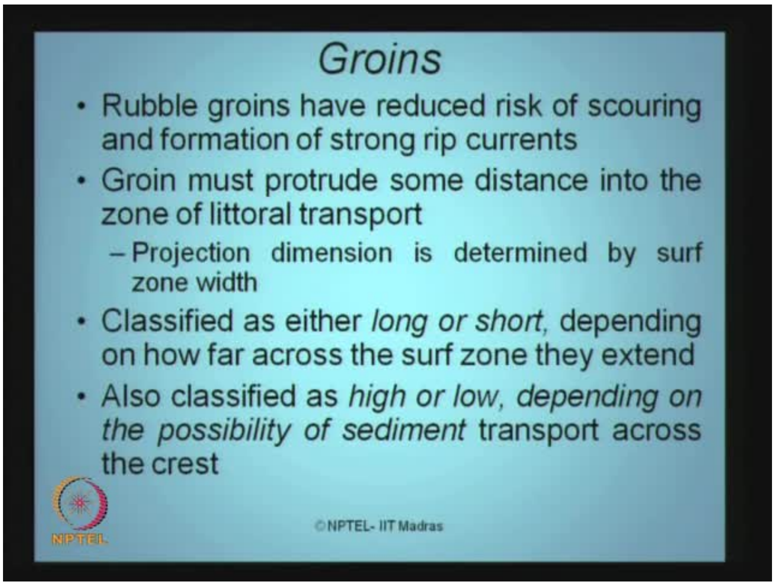

Rubble groins have reduced risk of scouring and formation of strong rip currents and therefore, they are preferred for much type of groin structures. Groins must be protruding some distance into the zone of littoral transport. The projection dimension of this groin, which is projecting in to the littoral transport zone is determined by width of the surf zone. It is classified either as a long or short, depending upon how far across the surf zone they are extend. They are classified as high or low, depending on the possibility of sediment transport across the crust.

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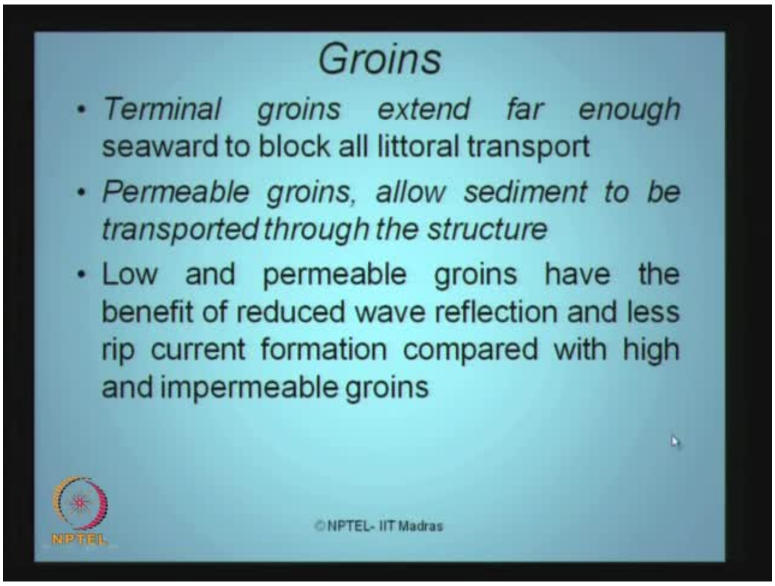

Terminal groins extend far enough seaward to block the entire littoral transport, whereas permeable groins allow sediment to be transported through the structure.

So, fundamentally these two types of groins are different in their functional point of view. Low and permeable groins have the benefit of reduced wave reflection and less rip current formation as compare to that of high and impermeable groins, and therefore low permeable groins are generally preferred.

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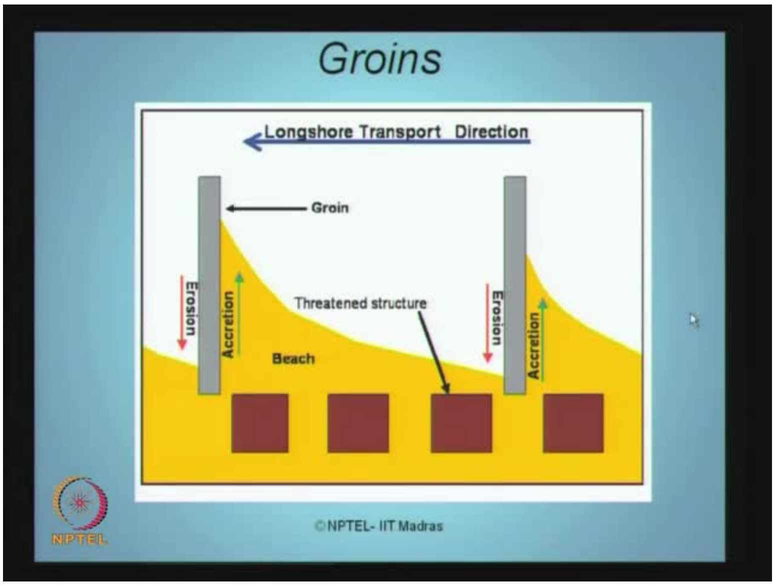

You can see a cross sectional dimension of groin, which is been shown here. So, you can see, once the groin is constructed the erosion is controlled and accretion takes place on the other side of protection area. So, a threaten structure which can be protected from erosion on the beach side, which is depending up on what is the long shore direction of the long shore transport.

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The next common type of coastal protection structure is break waters. Anyway, however detach breakwaters are more commonly used in different parts of the world. The photograph what you see here are two classical long detach break waters, detachment in sense they are not continues and parallel to the coast line. You can see here, the detach break waters of specific length will always formulate a specific kind of sediment formation on the beach side, as seen both the photographs.

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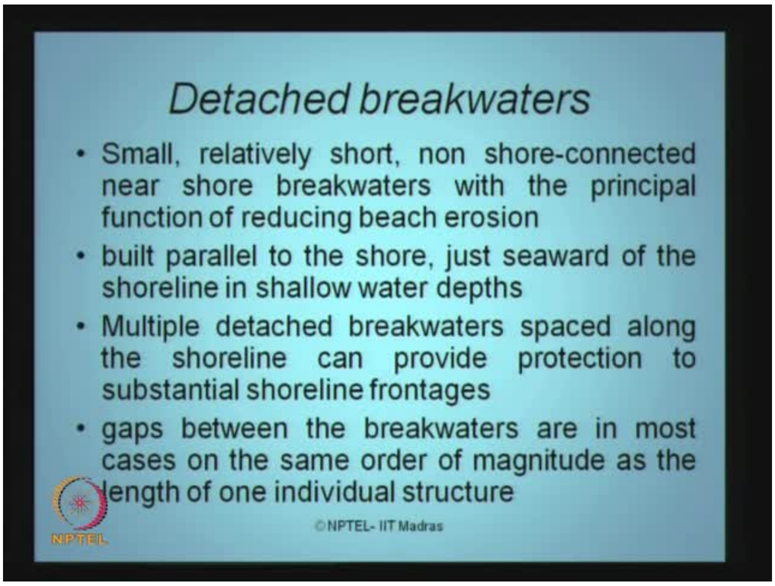

Detach break waters are relatively small, short in length, non shore connected, near shore break waters. The principal function is to reduced beach erosion. They are built parallel to the shore, just seaward of the shoreline in shallow water depths. The multiple detach breakwaters space along the shoreline; can effectively protect the substantial shoreline frontages in a very nice manner. The gap between the breakwater are in most cases of the same order in magnitude of that of the length of the individual breakwaters.

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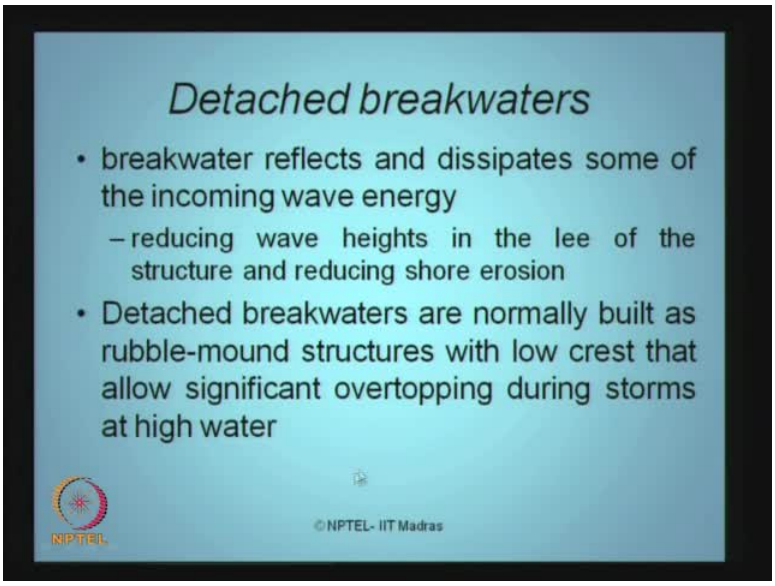

Breakwater reflects and dissipates some of the incoming wave energy, it reduces wave height in the lee side of the structure and reduce ashore erosion as well. Detach breakwaters are normally built as a rubble mound structures, with low crest that allow significant overtopping during storms at high waters.

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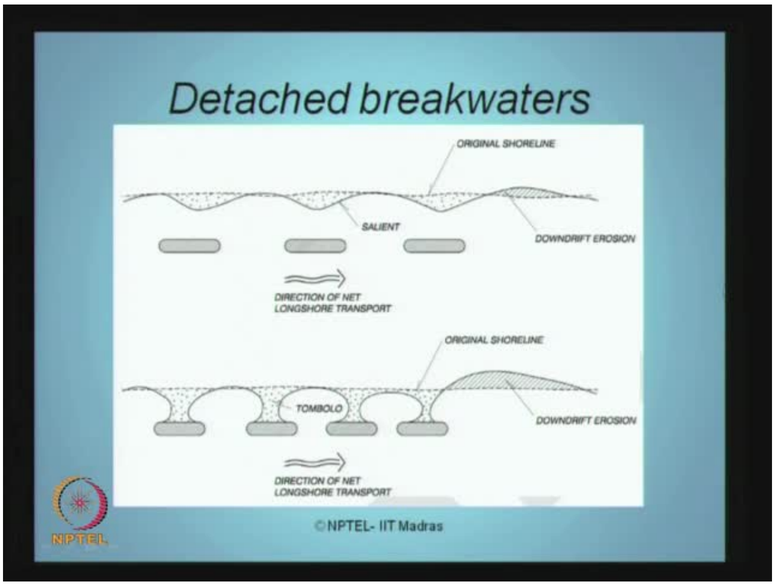

It is a typical photograph and the schematic view of a detached breakwater, so original shoreline what you see here. After constructing breakwaters, you will see there is a formation of tombolos, which is happening depending up on the construction and the spacing of the break waters. The usual design of these kinds of breakwater is that, the spacing is at least is 70 percent equal to the length of the break water itself.

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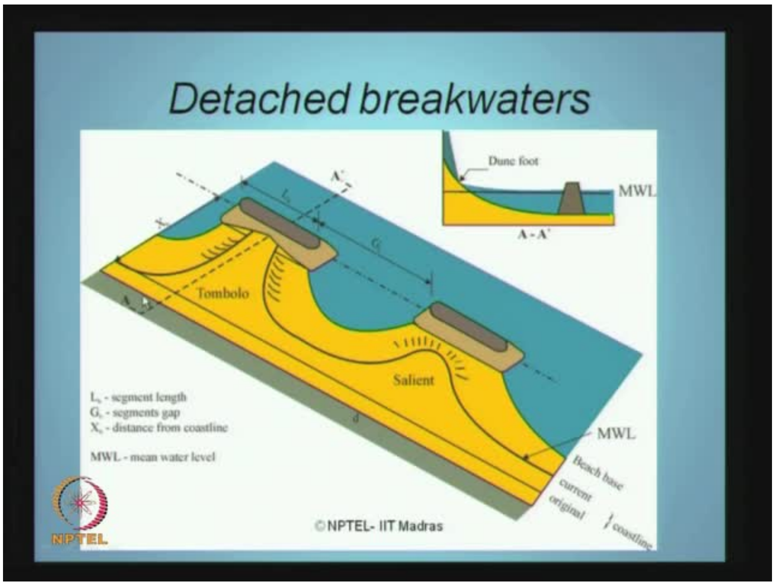

If you look at the formation of tombolos and the salient features of the breakwater, the spacing between the break water G is more or less equivalent to that of the length of the break water, which is L. If you look at typical cross section of break water as you see in this photograph here, it is a trapezoidal cross section of the low crest low, less wider crest, which allow sometimes overtopping during high tide waves.

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Rubble mound break water are very classical examples and very common application seen in coastal sides. You can see a very long curvilinear shape rubble mound breakwaters in both these photographs very closely. These are rubble stones which are used for armor lining of breakwaters.

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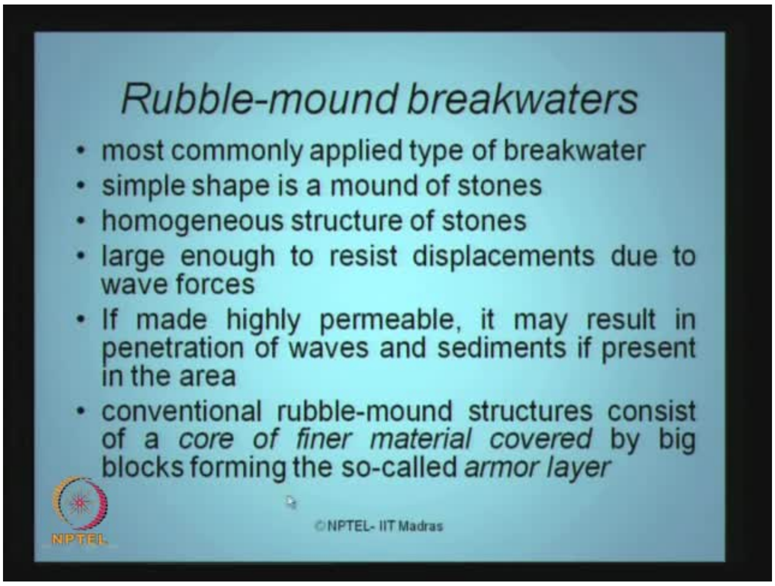

They are most commonly applied type of break waters in the construction practices. Simple shape is a mound of stones; they are homogeneous structure of stones, large enough to resist displacements due to wave forces. If made highly permeable, it may result in a penetration of waves and sediments if present in the area. Conventional rubble mound structures consist of a core of finer material covered by big blocks, forming the so called armor layer.

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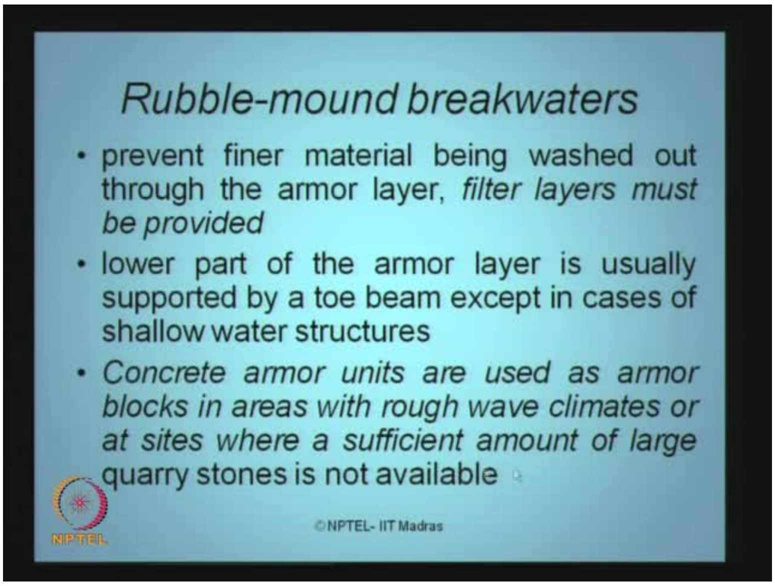

Rubble mound breakwaters prevent finer material being washed out through the armor layer, filter layers must be provided to enhance the capabilities. Lower part of the armor layer is usually supported by a toe beam, except in case of shallow water structures. Concrete armor units are used as armor blocks in these areas, with rough sea wave climates or at sites where sufficient amount of large quarry stones are not available.

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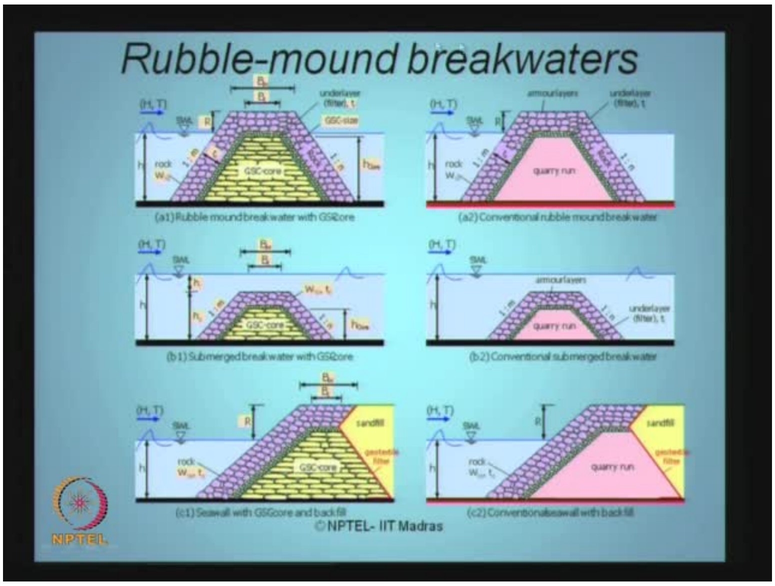

These are different cross sections as shown in the rubble mound break waters. In one case the break waters can be projected high, the crest can be much above the still water level. Otherwise you can also have submerged breakwaters as you see here, which are conventional. You can fill up the soft core using a GSE core or a quarry run material, which is armored using different kinds of material has suggested in the previous slide. It can be either projected up or as can be submerged as well. The other types of breakwater; rubble mound breakwater, where they are built only on only one side of the coast side, whereas the other side as being used for sand filling, as you see here. The inner core again can be either a rubble core or a quarry run material, as see in this picture.

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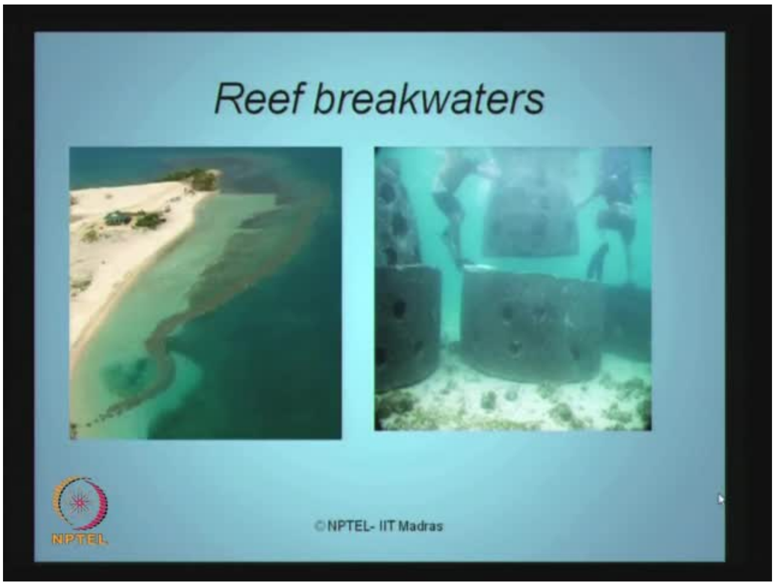

Reef breakwater are other type of breakwater which has been commonly used.

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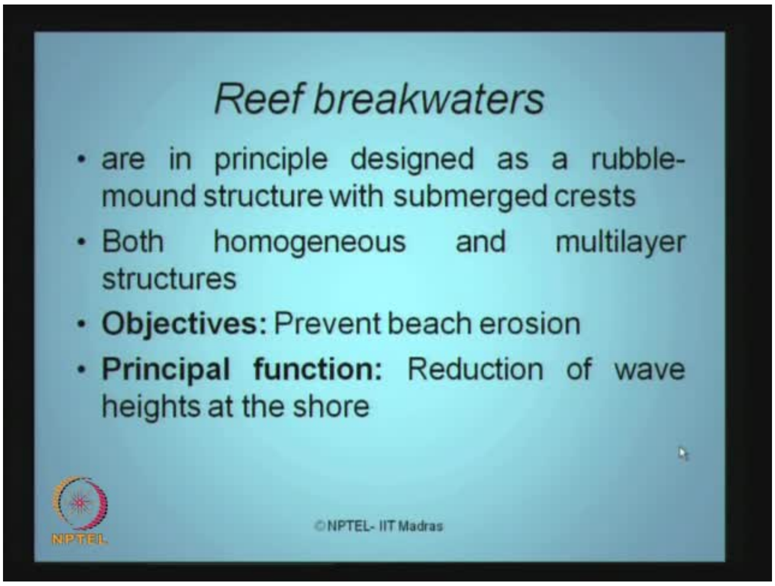

They are in principal design as a rubble mound structure with submerged crest. Both homogeneous and multilayer structures are constructed as reef breakwater, where objective to prevent beach erosion. The principal function of reef breakwater is reduction of wave heights at the shore.

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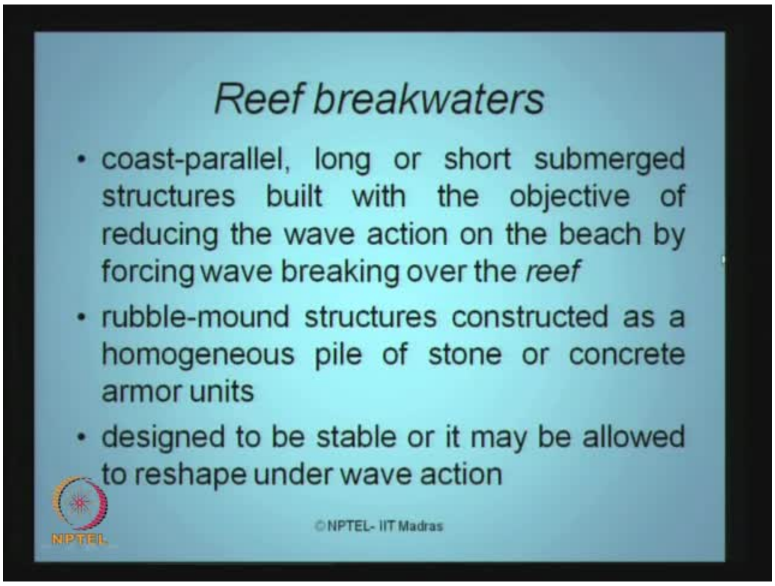

They are coast parallel structures either can be long or short submerged structures, built with an objective reducing the wave action on the beach by forcing wave breaking over the so called reef. Rubble mound structures constructed as a homogeneous pile of stone or concrete armor units are generally material used for construction of reef breakwaters. They are designed to be stable or it may be allowed to reshape under the wave action depending upon the design concepts.

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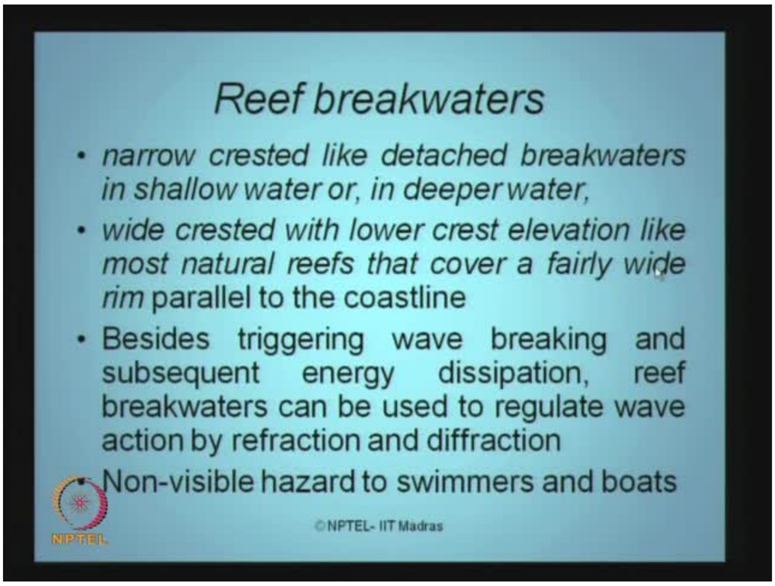

Narrow crested like detached breakwaters in shallow water or in deeper waters can also be re-break waters. The wide crested with lower crest elevation like most natural reef that covers a fairly wide rim of the coastline. Besides triggering wave breaking and subsequent energy dissipation, reef breakwaters can be used to regulate wave action by refraction and diffraction. They are non-visible hazards to the swimmers and boats and therefore, they are got to be very carefully placed along the coastal side.

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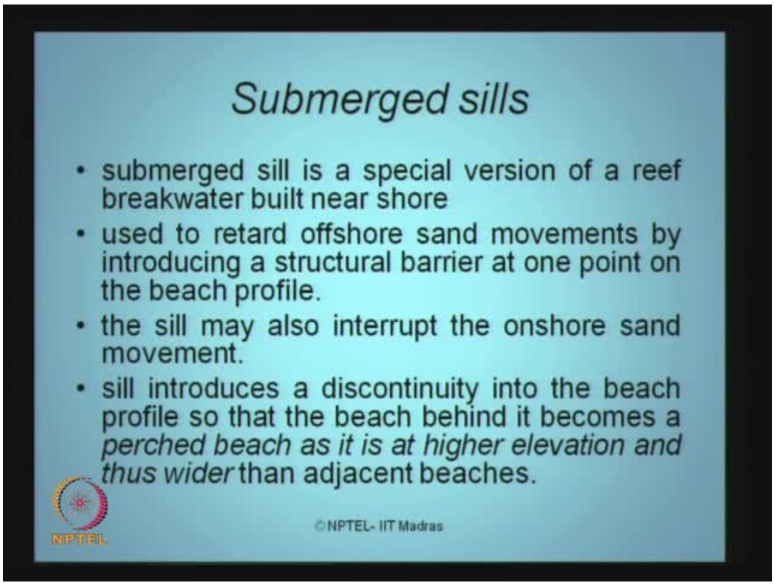

The next type coastal structure what we see in the literature is submerged sills. Submerged sill is a special version of a reef breakwater, which is built near the shore. It is generally used to retard offshore sand movements by introducing a structural barrier, at one point on the beach profile. The sill may also interrupt the onshore sand movement considerably. Sill introduce a discontinuity into the beach profile, so that the beach behind it becomes what we called as a perched beach, as long as at higher elevation and thus wider than the adjacent beach. So, perched beach is a specific name given for beaches, which are casted higher elevation and wider than the adjacent beaches.

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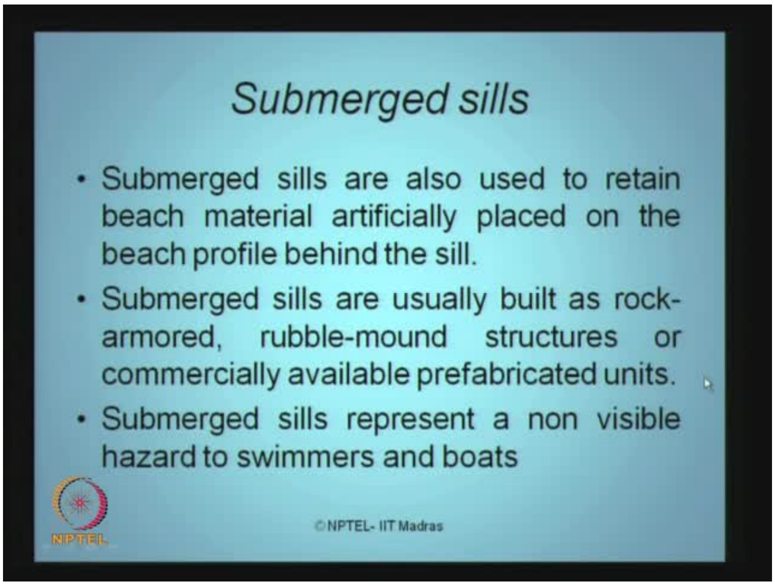

Submerged sills are also used to retain the beach material artificially placed on the beach profile behind the sills. Submerged sills are usually built as rock armored, rubble mound structures or commercially available prefabricated units can be used to construct the submerged sills. Submerged sills also cause non visible hazards to the swimmers and boats because as name suggest they are submerged in water, which have a better visual impact, but cause serious hazard damages to the swimmers and the boats in the vicinity of the coastal sides.

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The other common form of coastal protection structures is jetty. You can see a beautiful photograph where boats have been parked; the vessels have been parked along the jetty side.

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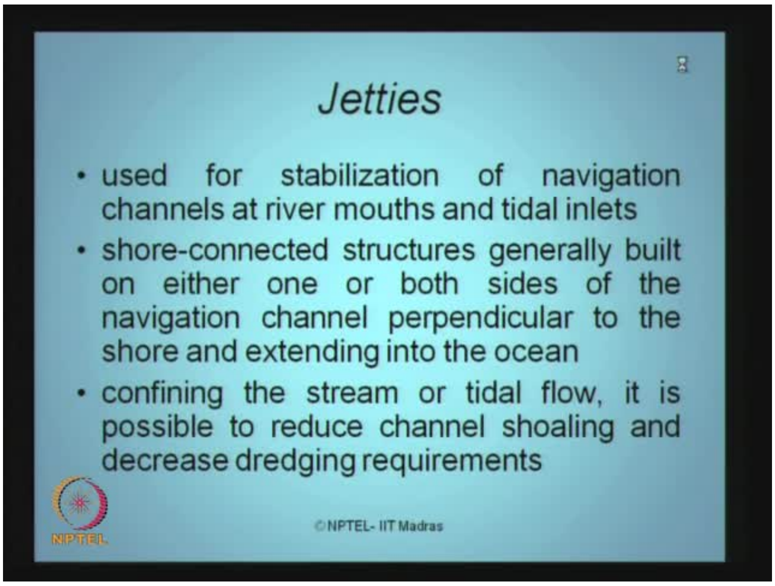

So, then what is the jetty? Jetties are essentially used for stabilizing the navigation channels at the river mouths and tidal inlets. Shore connected structures are generally built on either side or both sides of the navigation channel, perpendicular to the shore and extending into the ocean. They confine the stream or tidal flow therefore, it is possible to reduce the channel shoaling and decrease the requirement of dredging in the navigation areas.

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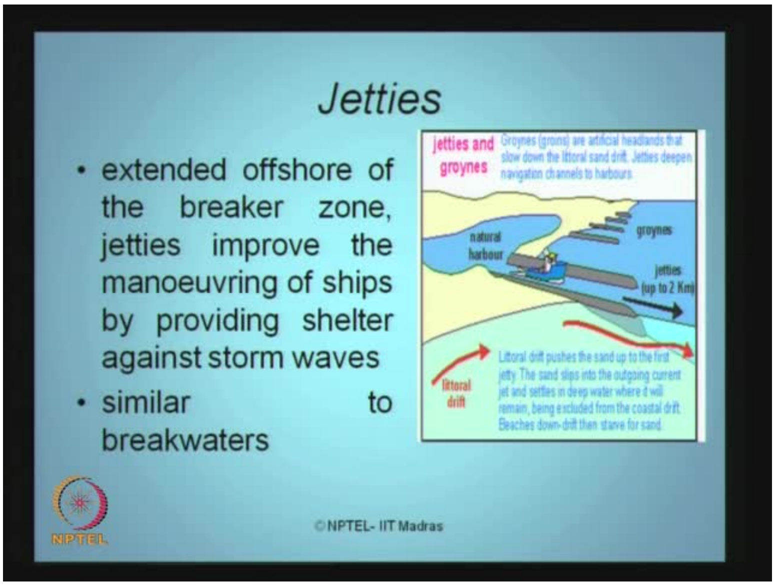

The figure what you see here is a combination of a jetty and groin. You can see these are all groins, which are constructed and the one is extended first for beyond up to length of practically 2 kilometers is what we call as a jetty, which is a part of a natural harbor.

So, basically this stabilizes the navigation channel at the entry level or the intake level. Therefore, after construction of the jetty is the littoral drift pushes the sand to the first jetty and the littoral transport takes a different phenomenal route, as you see in the figure here. So, their extended offshore, of the breaker zone, jetties improve the maneuvering of ships and provide shelter against the storm waves very effectively. They are similar to break waters in their functional characteristics. We have interesting references for this lecture.

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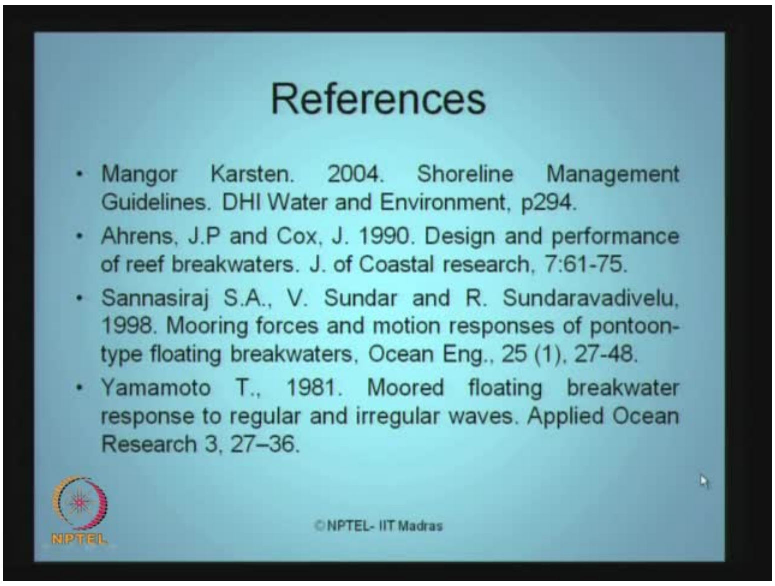

As we have seen through the previous three lectures on coastal systems; Mangor Karsten; shoreline management guidelines, Ahrens and Cox; design and performance of reef breakwaters- Sannasiraj, and tell mooring forces and motion responses of pontoon type floating breakwaters and Yamamoto discussing moored floating breakwater response to regular irregular waves. Ladies and gentlemen, we have completed three lectures on coastal protection systems. In the next lecture, that is lecture 12 on module 1, we will talk about interesting parts of questions for you, which are on tutorials, which can in conclude the first module lecture.

Thank you very much.