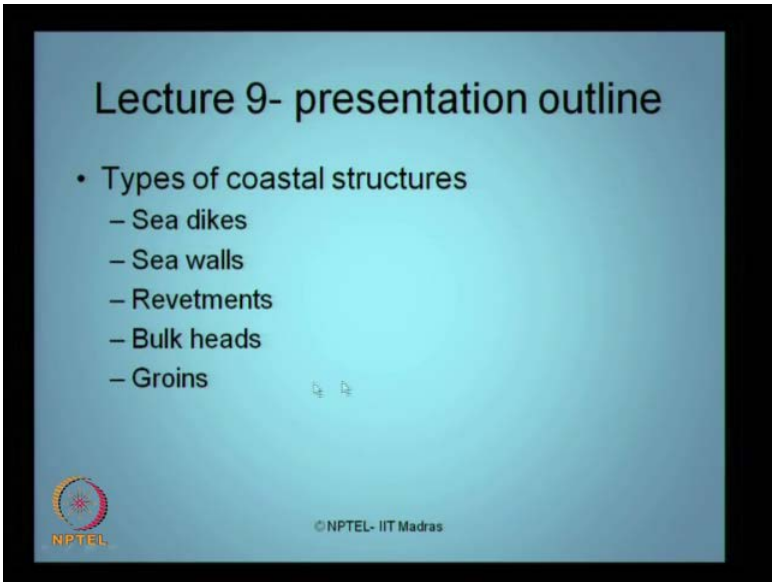
Ocean Structures and Materials
Prof. Dr. Srinivasan Chandrasekaran
Department of Ocean Engineering
Indian Institute of Technology, Madras

Module - 1
Lecture - 9
Types of coastal structures I

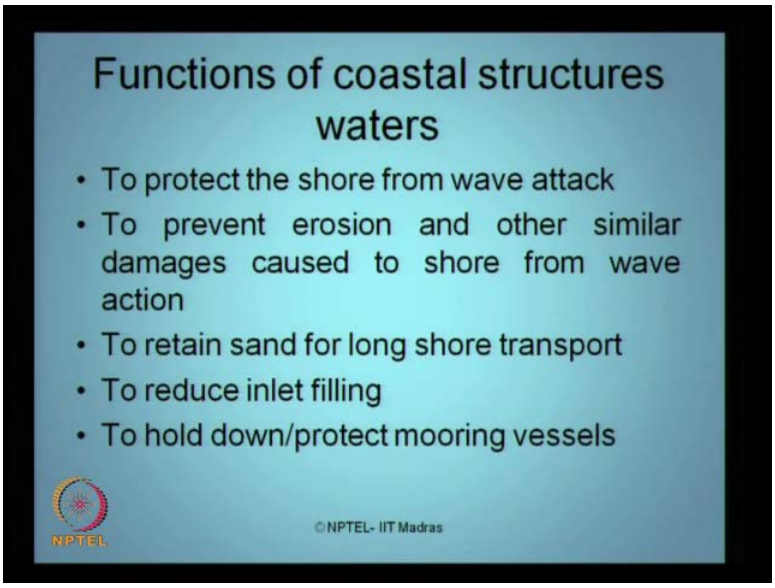
Welcome to the ninth lecture on module 1 of ocean structures and materials under the braces of NPTEL, IIT Madras. In this lecture we will briefly discuss the presentation outline of this lecture.

(Refer Slide Time: 00:29)



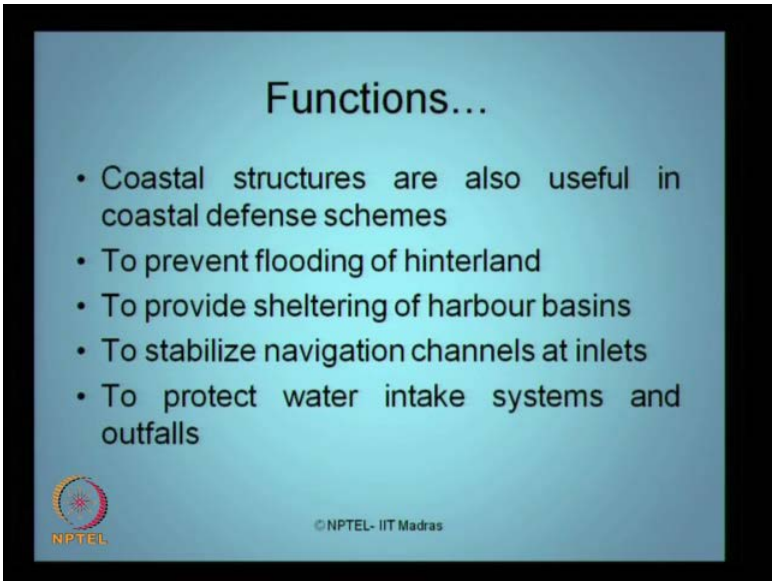
We will talk about different types of coastal structures, which are constructed for various purposes. For example, in this lecture we will discuss about, sea dikes, sea walls, revetments, bulk heads and groins.

(Refer Slide Time: 00:47)



Let us ask a fundamental question, what are all various functions of coastal structures constructed in waters? To protect the shore from wave attack, 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 protect mooring vessels in position.

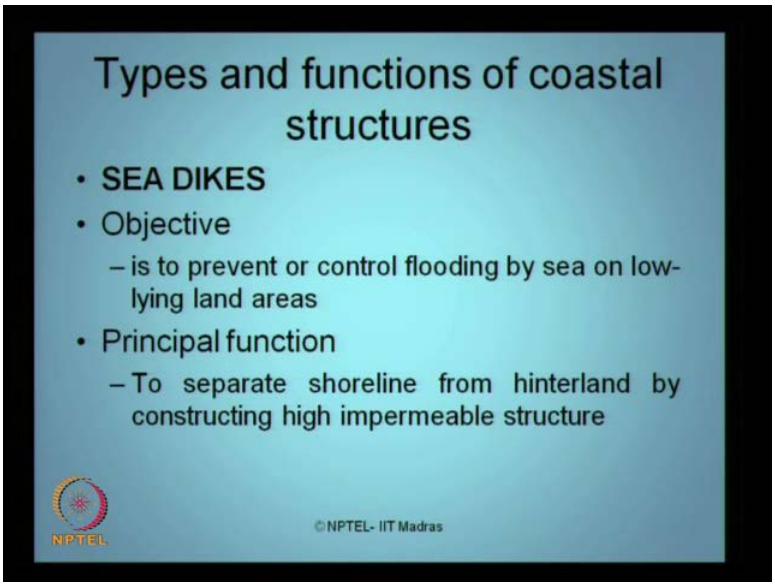
(Refer Slide Time: 01:18)



Further functions can also be listed as coastal structures are also useful in coastal defence schemes. They are also very helpful in prevent flooding of the hinterland, to provide

sheltering of the harbour basins, to provide or to stabilize navigation channels at the inlets and also to protect water intake systems and outfall systems.

(Refer Slide Time: 01:49)



There are different types depending upon the functions of the coastal structures. For example, let us quickly name few of them here, which we will discuss in the current presentation sea dikes.

(Refer Slide Time: 02:29)

Let us quickly look at the objective of the sea dike. Sea dike is essentially constructed to prevent or control flooding by sea, on the low lying land areas. The principle function of

a sea dike is, to separate the shore line from the hinterland by constructing high impermeable structures. Let us quickly look at the photograph of the sea dike constructed at Vietnam shore; you can see here the essential purpose of the sea dike is to prevent erosion on the hinterland side.

(Refer Slide Time: 02:44)

This photograph shows the Hondsbossche and Pettermer sea defence system constructed at Netherlands; you can see here a very long coast line has been protected by construction of sea dikes.

(Refer Slide Time: 03:00)

This figure is another example of construction of sea dike near Westkapelle near in the Netherlands.

(Refer Slide Time: 03:12)

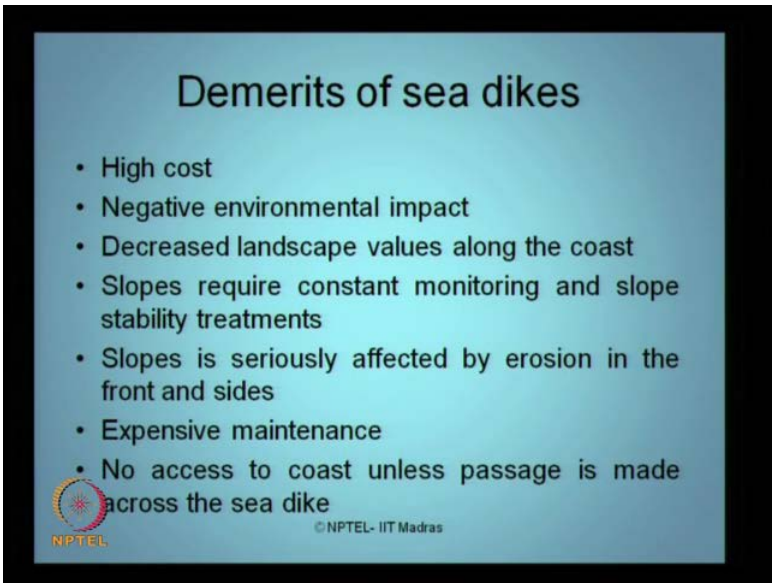
So, if you look at the objectives of construction of sea dikes, sea dikes are actually flood protection systems. They protect the low lying land areas, under the wave action. They are actually built along the coast line, they act passively by preventing wave overtopping over the dike's crest. Sea dikes have the crest, which is the top portion of the sea dike. They passively act by preventing the wave overtopping over these crest of the dikes.

They protect the areas lying below the mean sea level or high sea level. So, the location of sea dike depends on, the sea statistics at the specific location. In general they are actually flood protection systems, constructed along the coast line, to protect the low lying land areas under wave action. Sometimes naturally formed dunes can also act as sea dikes.

(Refer Slide Time: 04:24)

I will show you couple of examples in the next slide. These are what we call natural dunes, which are formed by plantation or vegetation of grass on the green segments. Even sometimes these naturally formed dunes can also be used as sea walls or sea dikes for coastal protection systems.

(Refer Slide Time: 04:53)



There are of course, couple of demerits of sea dikes, let see what they are quickly. The initial cost of construction of sea dike is phenomenally high, because generally they are constructed for very long length along the shoreline and the material used and the cross section has got to be very massive and heavy, and the height of the sea dike should suffice the requirement of the sea state at that coast. Therefore, the initial cost of construction of sea dikes is very high. Alternatively if you look at after the sea dike construction, they also sometimes have negative environmental impacts.

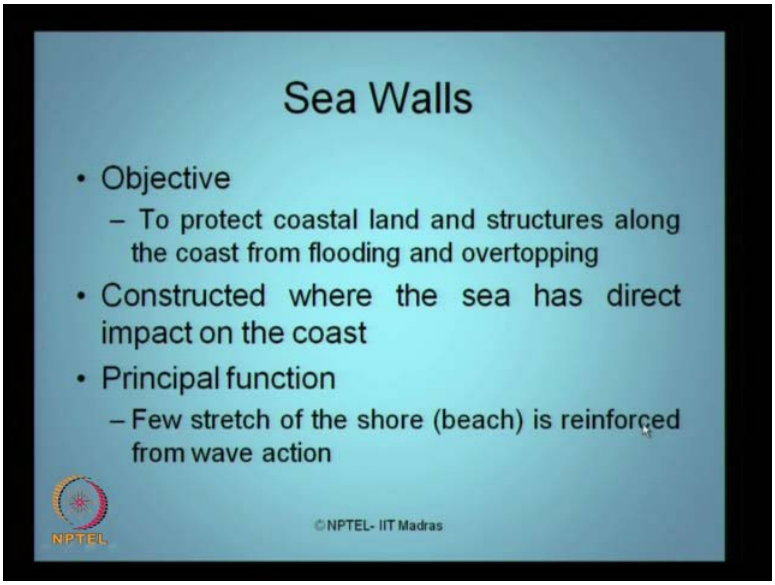
It actually decreases the landscape value along the coast because wherever you got a sea dike construction along the length of the coast, for a longer line, then the landscape beauty of the coast are phenomenally affected. Basically it decreases the value of the coast line, in terms of its natural architecture beauty. Now, the slopes which are used or which are constructed on the sea dike requires a very constant monitoring, otherwise they will be subjected to severe erosion and you lose the functional characteristic of a sea dike. So, it requires a constant monitoring, the moment we say constant monitoring, it means that we have got to spend money constantly and continuously, on what we call slope, stability, treatments of sea dikes.

Now, ladies and gentlemen though sea dikes are effective, protection systems of sea flooding on the low land lying areas because of its initial high cost, because of few negative environmental impact caused by the construction along the coast. And it

requires constant and continuous monitoring and maintenance, what we call by slope stability treatments. Sea dikes are not very popular mode of construction. If you do not maintain the slope properly, then the slopes are seriously affected by erosion in the front and the sides of the sea dike, it loses the functional characteristic in due course of time.

They have got a very expensive maintenance, as I said slope stability treatments are highly expensive. One of the greatest demerits of construction of sea dike along the coast is, it prevents access to the coast, unless otherwise you make a passage across the sea dike. It means the coast and the land behind the sea dike are separated by the structure and you deny or basically do not have an access, to the coast which is otherwise made across the sea dike. The next type of construction of coastal structures is what we call as sea walls.

(Refer Slide Time: 07:48)



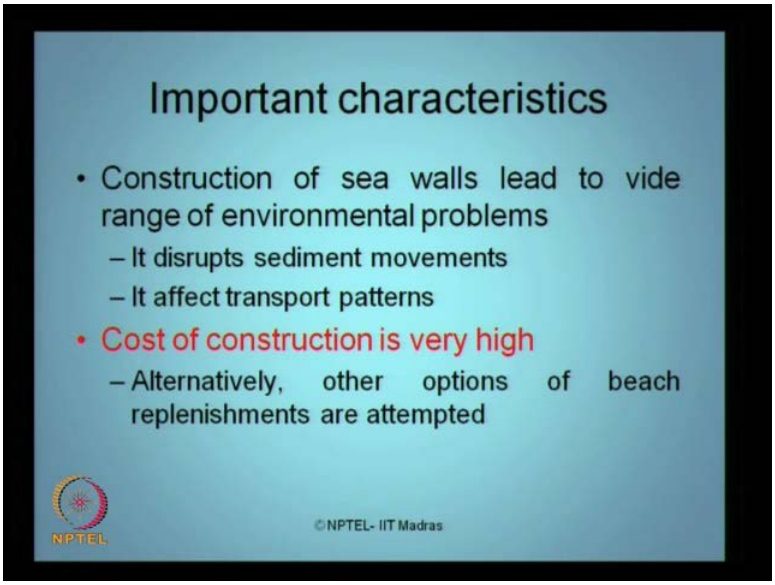
The principle objective of a sea wall is to protect the coastal land and structures along the coast from flooding and overtopping. They are constructed where sea has direct impact on the coast. The principle function of sea wallsis, essentially to reinforce certain stretch of length of the shore from the wave action. So, they protect or on the other hand reinforce, strengthen certain stretch of the shore, that is the beach side from the wave action, which is the principle function of a sea wall. You can see a photograph here, which is sea wall in Ventor isle of Wight, constructed in England. You can see this is

basically one of the type of sea wall constructed, which actually protects the land behind it.

(Refer Slide Time: 08:55)

There is another example of a sea wall constructed at Melecon in Hawana.

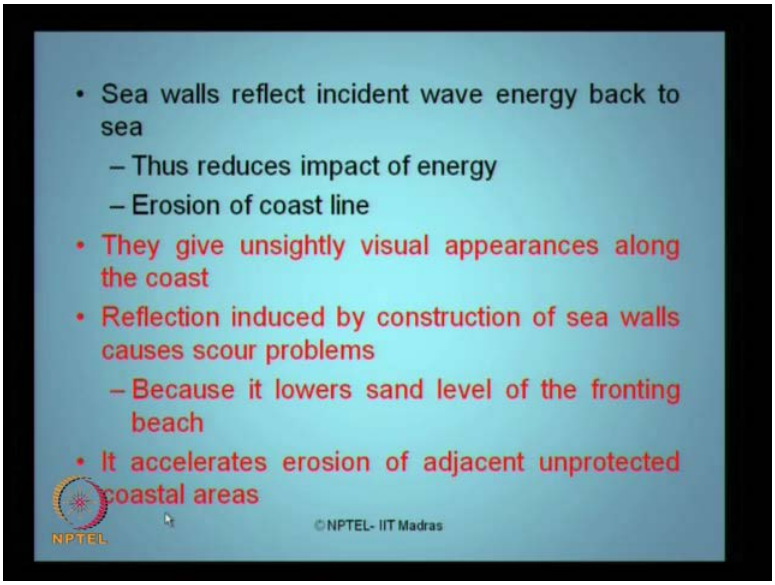
(Refer Slide Time: 09:01)



There are important characteristics of a sea wall, which we require to understand. The construction of sea walls leads to wide variety of environmental problems. For example, it disrupts the sediment movements, it affect the transport patterns of the sediment. The cost of construction of sea walls is very high, so it is consider as one of the negative or

undesirable characteristic of a sea wall. Now, alternatively instead of a sea wall you have other options of beach replenishments, which are attempted by various researchers in practice.

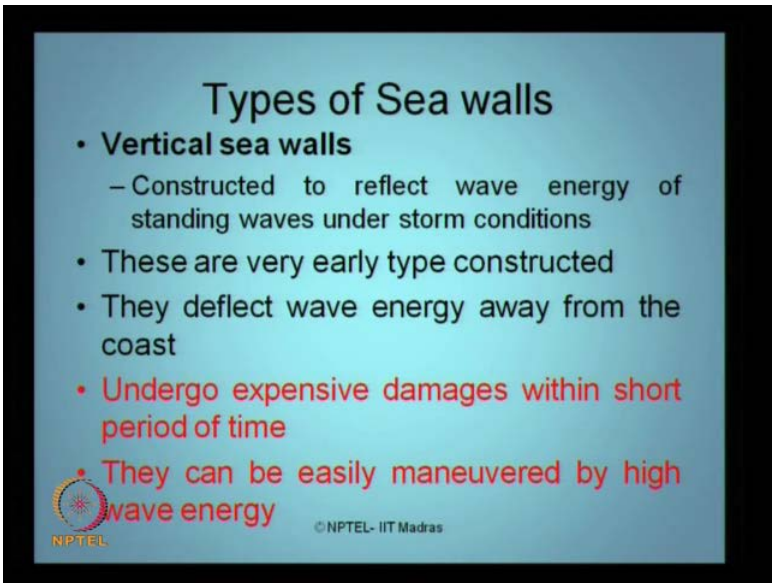
(Refer Slide Time: 09:48)



Sea walls reflect the instant wave energy back to the sea that is how the functional requirement of a sea wall is. Therefore, it reduces impact of energy on the coastal sides. Of course, it protects the coast line from erosion; however they give very unsightly visual appearances along the coast. As you saw in two photographs earlier, when you start constructing a huge massive structure along the coast side or along the beach side, you have a very unsightly visual appearance on the coast sides, which is actually not having a natural environment of a very nice beach along the coast side.

The reflection induced by construction of sea walls causes severe (( )) problems because it lowers sand level of the fronting beach, that is one of the negative impact of what construction of sea wall has on the environmental side. It accelerates erosion of the adjacent unprotected coastal areas, which is one of the very major impacts of construction of sea wall on the coast sides.

(Refer Slide Time: 10:57)



There are different types of sea walls being constructed in the literature, let say for example, vertical sea walls, are actually constructed to reflect the wave energy of standing waves, under storm conditions. These are very early type of sea walls constructed along the coast side. They deflect wave energy away from the coast very effectively, but they undergo expensive damages within short period of the service life. Therefore, the investment made on construction of vertical sea walls has not been seen, as a very advantages methodology for protecting or for reflecting the wave energy under storm conditions. Other demerit, what sea walls of vertical type has been envisaged, is that they can be easily maneuvered by high wave energy. If the wave energy potential is very high, then the sea walls can be easily maneuvered by these kind, they will not able to control.

(Refer Slide Time: 11:59)

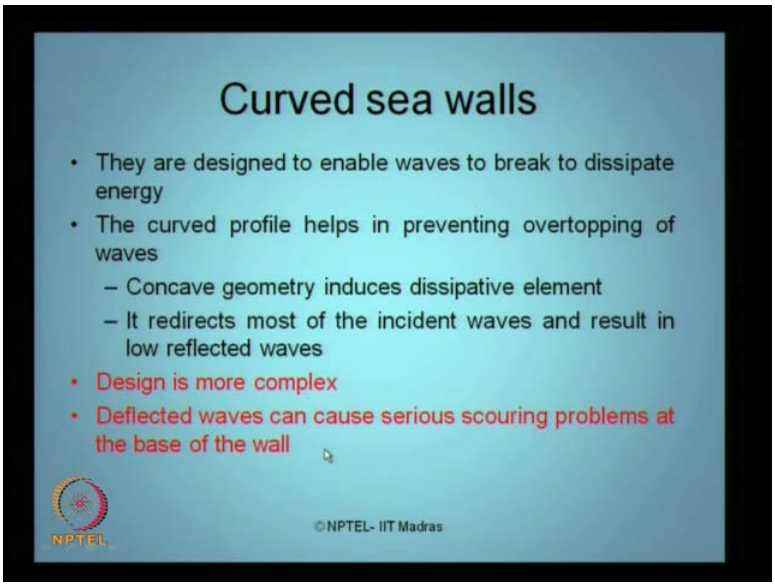
The photograph you see here shows a vertical sea wall at Saint Jean de Luz in Sainte Barbe. We can see here, it is constructed along the coast and actually the construction is practically more or less a vertical structure, which is protecting the land behind the sea wall from the wave energy impact on the land. It of course, protects the land behind the sea wall from soil erosion. The picture what you see here, is a vertical sea wall at Stanley park Vancouver, Canada, you can see all along the coast, they have created a vertical sea wall, where and they again created a beautiful landscape by passing a road along the side.

So, they also form a very good coastal protection side, all along the length of the coast, to use the coastal side for some other navigation or transportation purpose as you seen in Vancouver, Canada site. However, it gives an unpleasant appearance when we have a protection structure constructed like this. You can also construct a vertical sea wall not purely vertical like this or like this, can also have what we call a stepped construction. So, this is the stepped sea wall at Wheeler's bay as you see here. So, the stepped construction will try to give you a larger spread area, but of course, this gives a better aesthetics compared to these two.

However, even then the area along the coast where the sea wall constructed, is actually giving an unsightly appearance. You are able to have the natural feeling of the beach

side, if a sea wall is constructed. Alternatively to improve the aesthetic of sea wall, can have what we call curved sea walls.

(Refer Slide Time: 13:49)

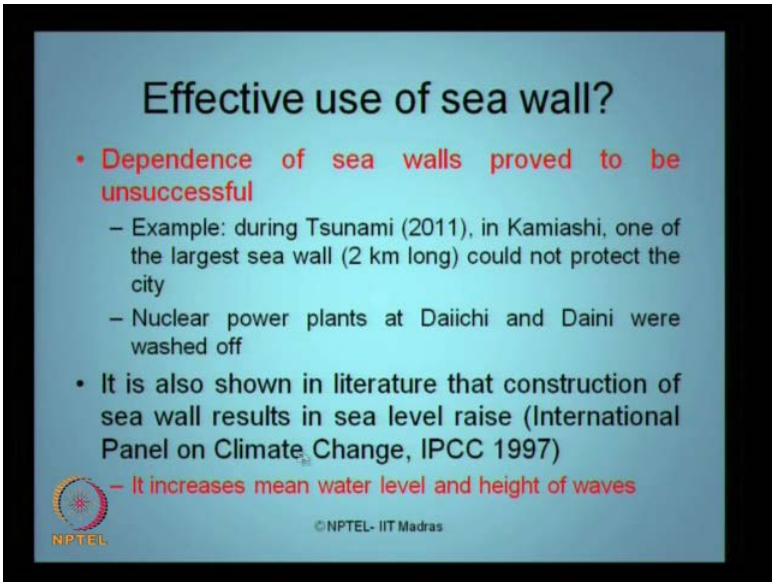


They are designed to enable waves to break or to dissipate the energy. The curved profile helps in preventing overtopping of the waves. The concave geometry induces dissipative element therefore, it dissipates the wave energy attacking the wall. It redirects most if the incident waves and results in low reflected waves. However, the design of a curved sea wall is more complex in nature, the deflected waves which are arising because of the construction of concave geometry of curved sea wall, can cause serious scouring problems at the base of the wall.

(Refer Slide Time: 14:35)

This is again a same picture, which we saw in the previous slide, is an example of a curved sea wall constructed. You can see another example here, where beautifully a curved sea wall is constructed, and the aesthetics of construction looks neat, whereas the beach is protected, but it nevertheless destroys a natural interface between the coastal site with that of the beach.

(Refer Slide Time: 15:02)

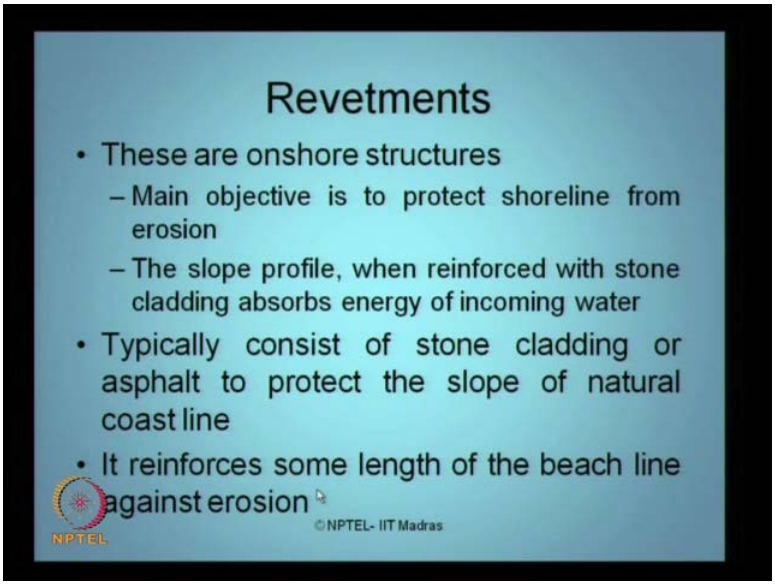


Let us ask a question ourselves, what are the effective uses of a sea wall, which has been constructed after a huge investment, made in different countries? The dependence of sea

walls proved to be unsuccessful, I can quote this from an example during Tsumani 2011 in Kamaishi, one of the largest sea wall constructed which is about 2 kilometre long in Japan could not protect the city. There were two nuclear plants at Daiichi and Daini, which were completely washed off, which were otherwise meant to be protected by this largest sea wall constructed on the Japanese coast.

So, the dependence of sea walls be it vertical or be it curved, irrespective of the geometry of the sea wall the dependence or the functional dependence of the sea walls are not seen to be very successful in the past history. It is also shown in the literature, that construction of sea walls result in a serious sea level rise actually. This has been shown in one of the reports submitted by international panel on climate change which is call IPCC 1997. The report says the sea wall construction increases mean water level and height of the waves. So, these two serious questions post by the presence of sea walls in the recent past really shows the defective use of sea wall is still a subject of question.

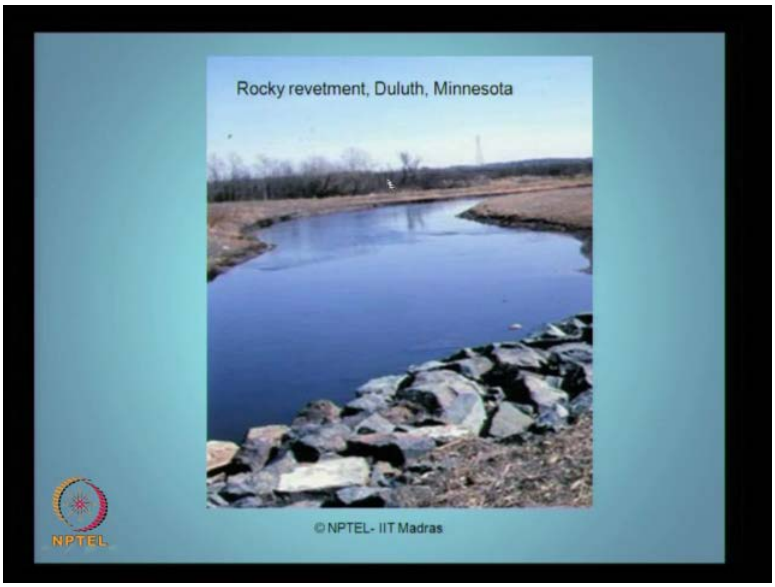
(Refer Slide Time: 16:38)



The other type of coastal structure, which we will discuss today's what we call revetments. Revetments are actually onshore structures constructed to the main objective to protect the shore line from erosion. The slope profile when reinforced with stone cladding, absorbs energy of the incoming water. So, investment of revetments is start very large, compared to that of reinforced concrete construction, which has been done for sea walls and dikes. However, they are actually stone rubble slope lining, which has been

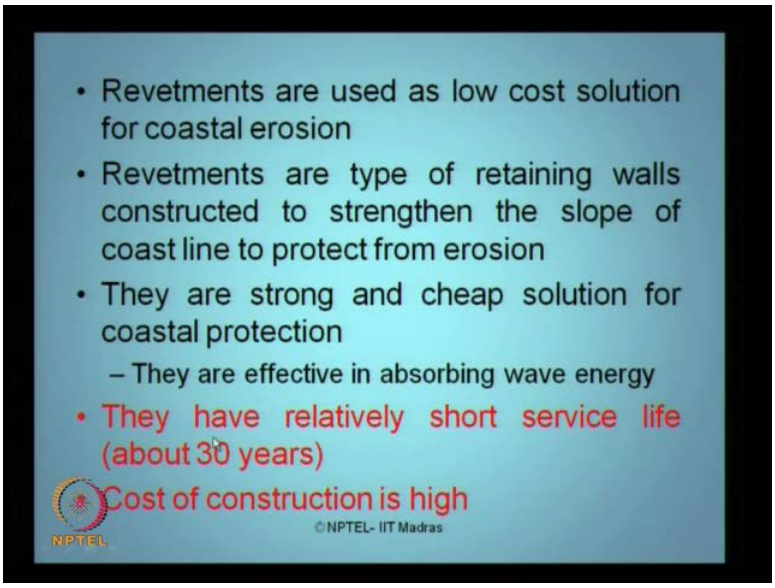
done as stone cladding, which actually absorbs energy of the incoming water. However, the typically consisting of stone cladding or asphalt to protect the slope of natural coast line, remains effective only for a very short service period of their life. It reinforces some length of the beach line against soil erosion.

(Refer Slide Time: 17:44)



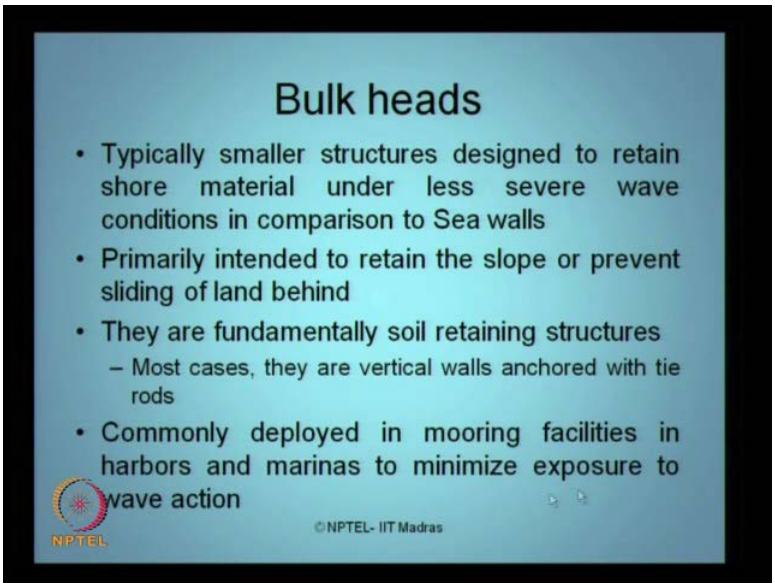
You can see here, the picture of a rocky revetment constructed at Duluth in Minnesota. You can see here basically it is less investment, is actually only a rubble lining or what we call a rocky revetment. So, the investment in terms of construction cost is not high. However, the effective functionality is also not very large compared to that of sea walls and dikes.

(Refer Slide Time: 18:11)



Revetments are actually used as low cost solution, for preventing the coast from soil erosion. Revetments are actually one of the types of retaining walls only. They are constructed essentially to strengthen the slope of the coastal line to protect it from erosion. They are strong and cheap solution for coastal protection, they are seems to be very effective in absorbing wave energy, but they have a very relatively short service life, it is only about 25 to 30 years. The cost of construction for a longer length of coast line is relatively high for that service period.

(Refer Slide Time: 18:56)



The other type of coastal structure what we see today is, what we call bulk heads. Now, what are bulk heads? Bulk heads are typically smaller structures, designed to retain the shore material under less severe wave condition in comparison to the sea walls. So, bulk heads actually are smaller types of structures. They have relatively lesser difference between the sea wall in comparison, but they are smaller in size. The geometry is more compact and effective compared to that of sea walls. They are primarily intended to retain the slope or to prevent the sliding of land behind the construction of bulk head.

They are termed as soil retaining structures in the literature. In most of the cases they are vertical walls, which are anchored with tie rods, commonly deployed in mooring facilities in harbours and marinas to minimize the facility of harbour to the exposure of wave action. So, it is actually to control or to retain the shore material and to reduce the severe wave impact on the harbours. So, they are constructed for a smaller domain or geographic location.

(Refer Slide Time: 20:27)

Essentially they are constructed to retain the soil slope to prevent the sliding of land behind it. This is very effective in reinforcing some portion of the beach profile, there is no doubt on that. However, they influence significantly in changing the beach profile. This is one of the demerits, what you have in construction of bulk heads. The increased wave reflection caused because of the construction of bulk head, results in increased re-suspension of the sand, in front of the bulk head. So, it has got a very serious counter effect, it results in what we call coastal drift, it seriously affects the coastal habitat.

(Refer Slide Time: 21:12)

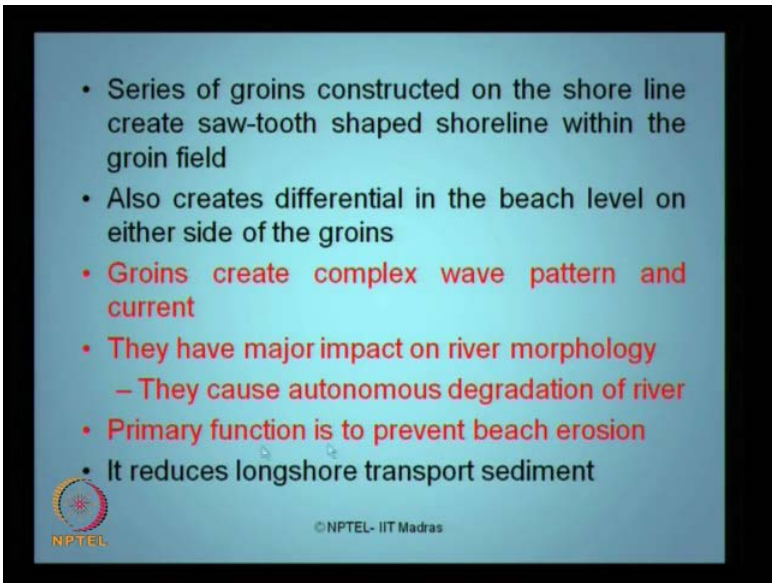
This is one of the pictures, which shows construction of bulk head in Bolinas Laggon steel bulk head in Stinson beach, California. The other picture shows the view of the same bulk head where the steel is coated with epoxy and tar for enhanced protection. So, bulk heads are essentially used to protect the marinas or the harbour sides. So, bulk heads are similar to that of sea walls, but smaller in geometry and profile. That is how the bulk heads can be used to have very effective way of protecting the shore from erosion. Of course, they have a very short service period of life as well. The other type of coastal structure what we see today, is what we call as groins.

(Refer Slide Time: 22:09)

Ladies and gentlemen sometimes the spelling for groins can also be finally, literature as g r o y e n e s. So, groins are essentially structures which are built for a small stretch of a naturally or artificially nourished beach, to prevent it against erosion. The protection is offered to the beach against, what we call long shore loss of the beach material. Groins are a narrow type of structure, which are essentially longer in size and constructed perpendicular to the shore line that is a very important aspect in geometry here. So, far you have seen different kinds of coastal structures starting from dikes, sea walls, revetments, bulk heads, they are all constructed parallel to the shore along the shore line.

Whereas, groins are narrow long structures, which are constructed essentially perpendicular to the shore line. Primarily the use of groins is to accretion of beach material, on the up drift side whereas, the accretion of erosion on the down drift side. The principle function is actually to protect or to prevent the beach from erosion. It reduces long shore sediment transport, it reduces the wave height in the lee-side of the groins.

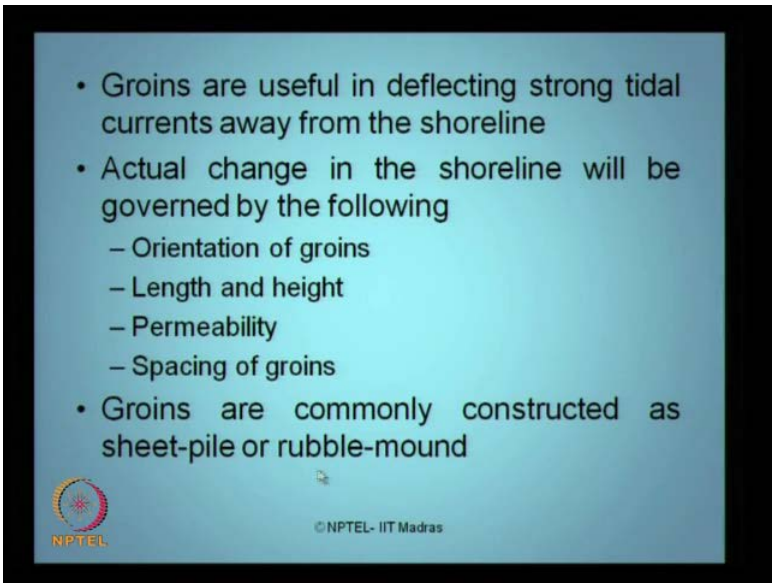
(Refer Slide Time: 23:42)



Series of groins constructed along the shore line, which is normal to the shore, creates what we call a saw-tooth shaped shore line, within the groin field. It also creates differential in the beach level on either side of the groin that can be consider as one of the negative environmental impact, which is caused to the sea front or to the shore line after the construction of groins. Groins therefore, create what we call complex wave

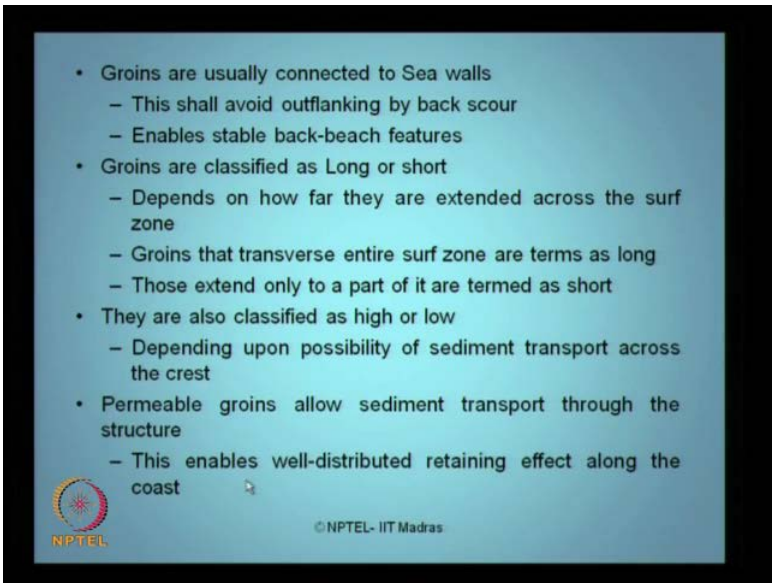
pattern and current. They have a major impact on the river morphology, they cause autonomous degradation of river. The primary function is to prevent the beach erosion, but they drastically vary the river morphology on the coastal side. It reduces of course, longshore transport sediment; there is no doubt on that.

(Refer Slide Time: 24:45)



Groins are very useful in deflecting the strong tidal currents away from the shore line. Actual change in shore line will be governed by the following. Orientation of groins plays a very important role, in altering the morphology along the coast line;. of course, the dimensions of the groin in terms of its length and height. How permeable the groins are? How are you making it more permeable? It also affects the actual protection offered to the shore line, the spacing of groins because generally groins are constructed in series therefore, the spacing between the groins also significantly influence the effective protection offered by this groins, to the coast land. Groins are commonly constructed as sheet-pile or rubble-mound. Rubble-mound in the sense they are actually mounded by rubble or random rubble masonry stones.

(Refer Slide Time: 25:53)



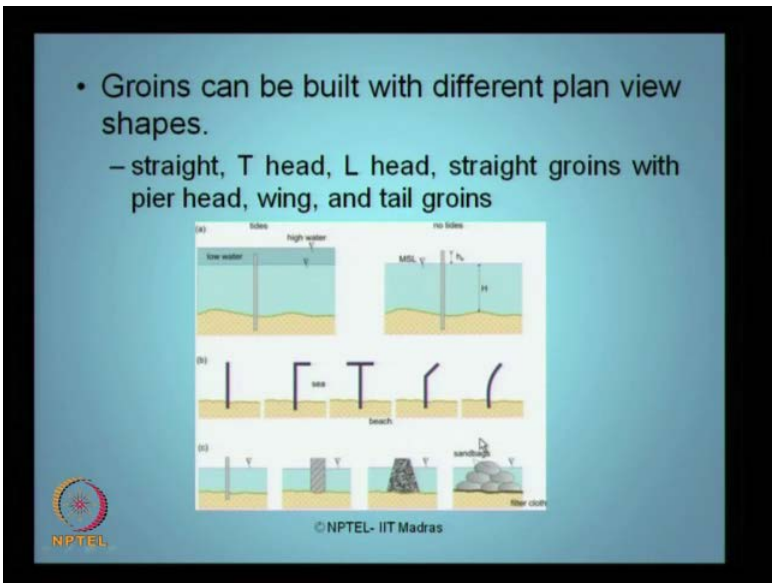
Groins are usually connected to sea walls, for effective continuity and functioning. If you connect groins to the sea wall, then this shall avoid what we call, outflanking by back scour. It enables stable back-beach features, if they are connected together. Therefore, generally groins are integrally connected to the sea walls. Groins can be classified as, long or short; depending on how far they are extended across the surf zone. Groins that transverse for the entire surf zone are called as long groins whereas, groins that extended only for a part of it are called as short groins.

Groins can also be classified as high or low, depending on the possibility of sediment transport across the crest. Ladies and gentlemen you can see the literature, people have also constructed permeable groins. Permeable groins actually allow sediment transport, through the structure. So, this in effective use of permeable groin, this enables well distributed retaining effect along the coast line.

(Refer Slide Time: 27:13)

So, this one of the interesting groin you see here, in Citges in Barcelona, these are all which are groins, which are constructed normal to the coast line. Is that what you see here, is actually a rubble mound groin.

(Refer Slide Time: 27:29)



There are different shapes of groin, which can be constructed depending upon their shape in plan view. There can be straight groins there can be T head groins, there can be L head groins, as you see here the straight groins can also have pier head, wing and tail groins. Groins sometimes can be deviated and curved also, depending upon what kind of design

you are offering for the coastal protection. Now, groins sometimes can have for the low water level or mean sea level, the groins height can be either lower than the low water level, so that can over topple or can be even above in the mean sea level, when there are no tide effects in the specific area.

You can see different kinds of cross sectional groins, so thin, slender, long structure which is constructed for shoreline protection. It can be of masonry, it can be of random rubble mounding, which can be of a triangular cross section. It can be simply sand bags, which are arranged in a specific form normal to the coast to protect it from erosion.

(Refer Slide Time: 28:42)

This is a picture of the groins constructed on the east coast of England for a small area.

(Refer Slide Time: 28:51)

This is another picture, what you see here is a groin, which is a rubble mount groin constructed near Ennore express way, Chennai in India, this is one of the effective protection measure, which has been designed by the department of ocean engineering at IIT Madras, which is one of the post-tsunami protection measure offered to the southern Indian coast, along Chennai. So, you can see series of groins in this picture you can see only one, there are series of groins constructed along the Ennore express high way in Chennai in India, which is considered as one of the effective protective measure, of the post-tsunami on the Indian coast. In the present lecture, we have discussed few types of coastal structures; we will continue to discuss more about the coastal structures in the next lecture.

Thank you very much. .