Ocean Engineering
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Module - 3
Coastal Erosion Protection Measures
Lecture - 2
Coastal Erosion Protection Measures – II

So in this class, let us continue about the topic we have been discussing so far that is on the coastal erosion, and then later initially we have seen so far about the physics behind how the sand from the sea belt is being transported along the coast. So, all of us are clear. Now, that the sand lying in the sea bed is being brought by the wave induced currents. Apart from this you have under the classification of currents, we have seen about the rip currents very briefly. Now, I will just take few minutes on on this aspect of rip currents.

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What is a rip current? See, from the deep ocean, there is a mass transfer as we have already seen, and when there is a mass transfer in the direction, when there is a, when the waves are moving in this direction there is a mass transfer and you see that there are the wave heights can vary along a wave crust. The wave height along the wave crust can vary for example, if the wave crust is moving, the wave is moving like this there can be a variation of the wave height in this along the wave crust. In which case there can be locations where you have zones of higher wave height and zones of lower wave height.

Now, this kind of a variation depends on the wave climate as well as the bottom topography geomorphology etcetera etcetera. All the costal environment will be responsible apart from the wave mechanic, apart from the waves. So, when there is a variation in the wave height then there is a flow taking place along the coast. So, this kind of a motion is again this is this is the kind of currents you can have and at certain locations what can happen is there can be a flow there can be a flow of these flow in this direction and just adjoining the location, adjoining the same location there can be some flow directed from the opposite direction. So, this depends mainly because of the variation in the wave front.

So, what will happen is when they converge around a location where you have a two flows along the shore and then when they converge you have the bathometric going towards the sea. So, what will happen when they converge it will go into the ocean. So, that is what is called as a rip currents and the speed with which the rip currents can move is tremendous, is quite fast. So, in case if someone is caught here while swimming somewhere in a location where you have strong rip currents, this guy, this person can be easily drawn into the ocean and several meters into the ocean and then you you will pop up somewhere here when after certain distance the energy will, the flow will get diverted.

So, this is what is a called as rip currents and rip currents are located and wherever you have such rip currents you can see the display boards as you see somewhere near the beaches, somewhere I think in, it somewhere somewhere in the US where they display the boards that rip currents are there. So, please do not venture into the ocean. For India near the tip of Indian peninsula that is one location where the location is really marked by the presence of strong rip currents. So, this is one phenomenon which is also contributing towards the near near shore flow field, apart from so near the flow field we apart from the low long shore current we also have the rip currents. The, and this is something different from the cross shore currents which we see, which we saw in the last class. But all these things are induced by the waves.

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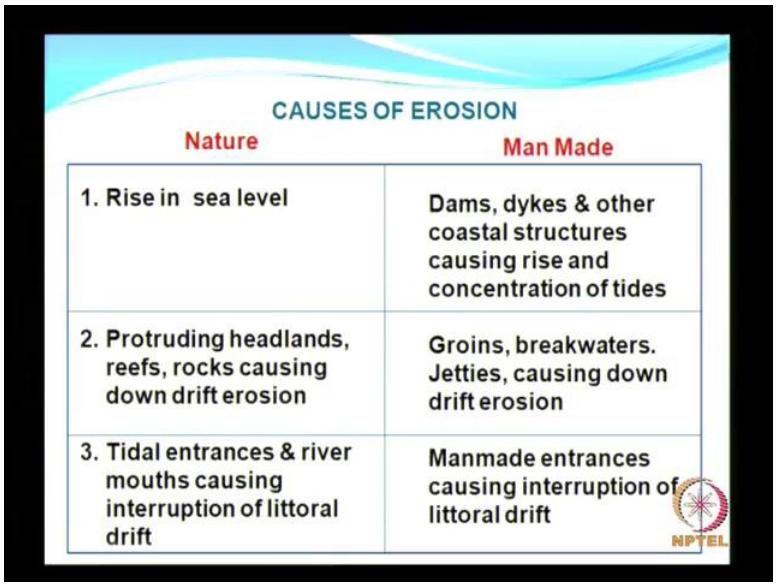

So, having seen all the kind of flow field and other aspects we will now move onto we will now move onto causes for coastal errors. As I said earlier there may be two causes, one is due to nature and another due to another due to man made. Sometimes, you can have a combination of these two and we will have some few case studies in order to understand better. Now, the causes are under nature is the very much talked topic that is the sea level rise and you know what happens when there is a sea level rise. When there is a sea level rise, this is something, it is going to be a gradual phenomenon.

But when there is a rise in the water level in the ocean the chances of coastal flooding is more because the wave which is supposed to, the the wave will not be breaking in its original position, but it will be breaking more towards the land. So, sea level rise, if there is a sea level rise that can cause erosion or manmade if you are constructing damns, dykes & other coastal structures that can result in the rise and concentration of tides. We will look at the these all these examples I will just list all these causes, but we will be looking at all these various causes when we look at, when we see the different case studies. Then protruding headlands, reefs, rocks etcetera this I have already shown you with an example earlier with the Visakhapatnam headlands which is protruding in to the ocean.

So, when you have a headland then that access a barrier, when you have a barrier in a area where you have movement of sand, when you have a movement of sand.

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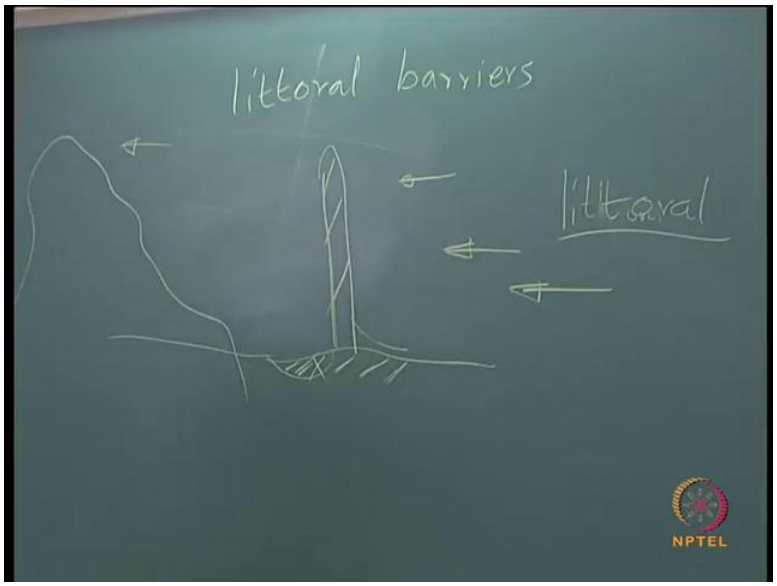

So, when you have a sand moving in this direction, weather you put a, an artificial construction like a groin or if it is something like a natural headland, then you see that in this case if the sand is moving in this direction you expect the beach formation and then you have the erosion taking place. So, here again you have the erosion taking place because if the sand is moving in this direction. So, these are all because these these are going to act as barriers.

Barriers for what? Barriers for the movement of sand transport, from sand transport is termed as littoral drift as I have told earlier it is littoral drift. And these barriers are now referred to can also be called as littoral barriers that is, littoral barriers means it stops a movement of sand and creates a beach on the up drift side and beach and erosion on the down drift side. So, both this causes and in the case of manmade you see groins, breakwaters, jetties etcetera. See, groins, breakwaters and jetties see for example, particularly in in particular the groins and breakwaters look alike, the structure look alike, but why are they having two different names? The two different names is for the purpose which which for the purpose for which it is constructed.

So, we will we will look into those details later, but please remember that you should not keep on misusing breakwaters for groins or groins for breakwaters. These two structures all although they look alike, they are called, they have a different terms because of based on their functional aspects, because of their functional aspects. Now, tidal entrances, river mouths causing interruption of sediment transport. So, when you have a tide, when you have a river.

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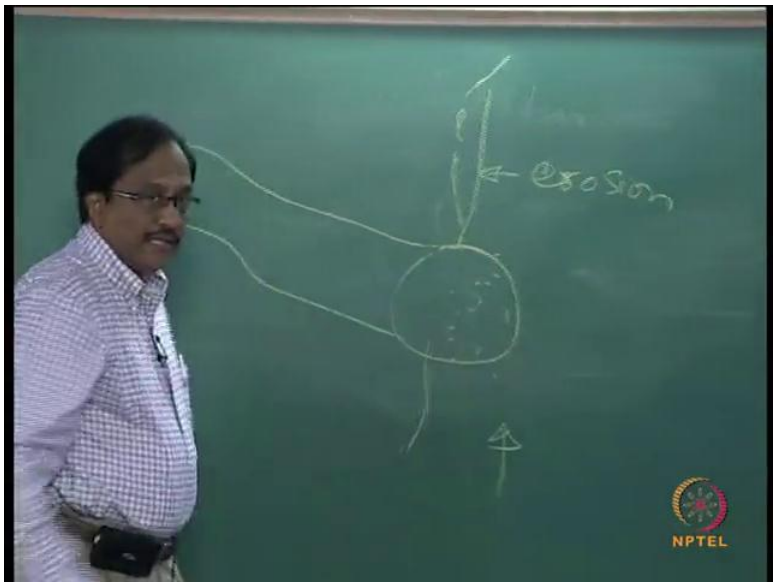

So, as I told you when you have a river and you have the sand moving in this direction, what will happen? The movement if this is not there the movement will be free. Now, if you have a something like this the sand will get draped here because this is slightly deeper. So, all these things will get settled and then the swallowing of the mouth will take place then the closure of the river mouth will take place because the sand is being trapped by this inlet. So, there will be erosion taking place at this location.

So, this will be erosion erosion caused by nature that is a inlet. Under man made entrances, yes, I want to make an entrance here, I want to stop this thing. So, I put groin or sorry in this case it is called as training wall when I put that then you are going to have deposition and erosion as I have earlier said.

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The next one is shoreline geometry causing the same shoreline geometry is nothing but the if there is a a deep projection in to the into the ocean so that also can act as a littoral barrier or fields protruding under man made you have fields protruding in the ocean to an extent that they can change the shoreline quite radically. Such fields are called as are often termed as bulk headed, we will we will looking at bulk heads and sea walls etcetera later.

Then removal of beach material from the by the wind drift that is again coming under nature. When you look at a the man made removal of material from the beaches for construction and other purposes. So, all of us know that there is so much of debate going on and so much of problems we face on sand mining. Sand mining is prohibited, but still it goes on at certain locations. The important problem is if you mine or if you remove the sand for whatever purpose it is then you are going to invite problems associated with the instability of the coastline. So, instability of coast line is going to rip is certainly related to the livelihood and the safety of the coastal villages. Now, the last item is there are several other reasons also, but these are the most important ones.

The second one, next one is the removal of beach material by sudden outburst of flood water. This is sudden burst during the flood or digging or dredging of new inlets channels and entrances and also the offshore dumping of materials. So, these are all some of the important aspects for the causes of coastal erosion classified as nature and manmade. So, what will happen is there is a case where there is a continuous erosion due to nature and in order to

arrest the nature, if we go and construct there some structure without doing serious in depth scientific study that will lead to, that will aggravate, that can aggravate the problem. The problem can be more severe. So, you have to carefully understand what exactly is the physics behind all these things so when you have a problems connected with coastal erosion which we have seen now do we have any options, do we have any options for protecting the coast?

So, what are the options? Now, the first one is do nothing. You may be surprised. In fact we had a, recently we had a, not recently about 4 5 years back there was a coastal erosion somewhere close to our Chennai, Chennai coast and this was during a flood, during a cyclone. The entire coast was washed off and then they wanted to have some kind of structural measures and when they reported to us our department then what we had suggested is you please wait and see, wait and watch, but they were bent upon having a structure because under the because normally they get a kind of a relief fund some kind of structure is been planned for.

What we had suggested is to be for as a, as an immediate measure, as a short term measure please use some sand bags because that is in order to aggravate and leave it. What happened after sometime they they followed that advice a bit reluctantly. Only to see after about 3 4 months the entire sand which was removed came back and the coast became stable. So, in such an instance what would have, if we had gone for a structural measure you think that would have solved the problem? It might have even aggravated the problem. So, it is always better to look and monitor the problem first, understand the problem, monitor the problem and then come to a kind of a solution.

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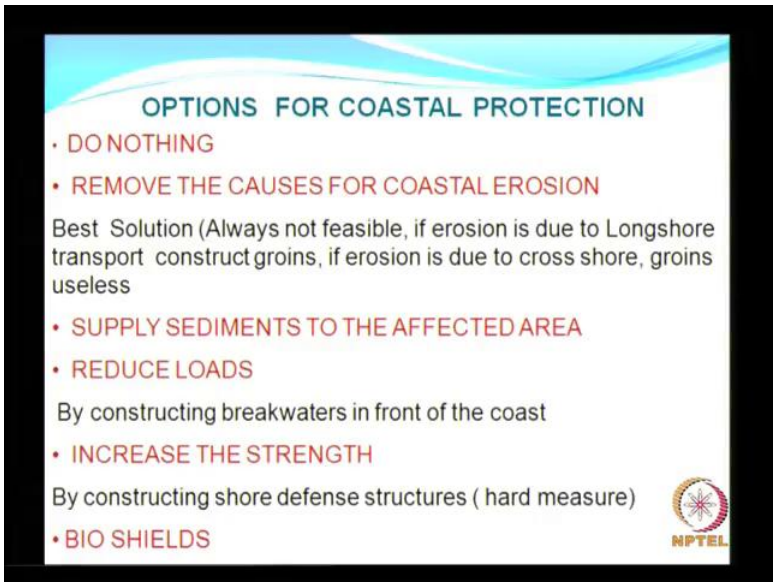

Then remove the next one is remove the causes for coastal erosion that is this is the best possible solution. For example, cancer if u can know the cause for cancer you can treat it. So, here best solution is always not possible, is not always feasible. So, if the erosion is due to longshore sediment transport which I have explained due to the presence of littoral barriers then possibly the construction of groins or also detached break water which we will see can be a kind of a solution. Not always, but in an area where you have domination of long shore current, longshore sediment transport probably it may be a good solution. But you need to be very careful while planning for all this things.

Then the other one is the third one is supply of sediments to the affected area. This is very clear. Very clear in the sense everyone knows everyone knows that when there is an erosion taking place simply it supplies sand to that area, but how? From where will you get the sand and how will you pump it on to the land because it is on the coast because you need to have proper equipment. First is the supply of sand source, where are you going to remove the, because earlier I have said removal of sand is going to cause erosion. Now, what are you saying supply sand, but there are locations where sand will be coming in abundance. One typical example I will tell you.

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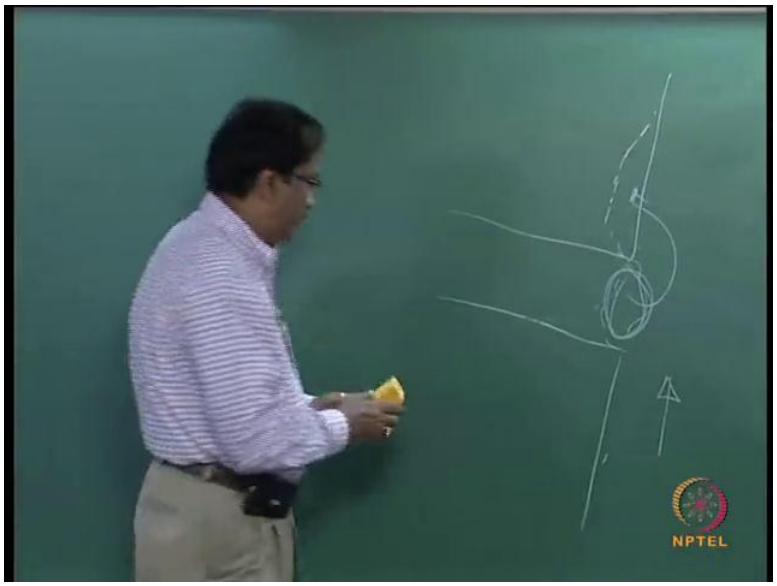

If there is a if there is a a an inlet because of this and if the transport is moving in this direction I mean the sediment transport is moving in this direction and as as we have seen the erosion is going to be like this and here it is going to be deposition. If this is not there, if there is no structural measure and if the sand is coming and depositing here, this is going to result in erosion as we have seen earlier. Now, what if I have a kind of a pumping mechanism, pump all this sand and then nourish this breach.

So, this seems to be quiet viable right and there can be sand which is being brought by the river also, that sand also can be removed. You understand? If the shallow patches in the river is removed that can be used for this also because by doing so the free flow between the river and the ocean, the free flow from the river into the ocean is taken care of and the flushing of the tide is also ensured. So, it looks so simple now, when I explained it look so simple, but when you go into the field there are so many other complications. It is not so easy as we think, but it is a it is a possibility, there is a possibility of doing, solving this problem this way. So, for this also we will have a case study. Then the next one is reduce loads.

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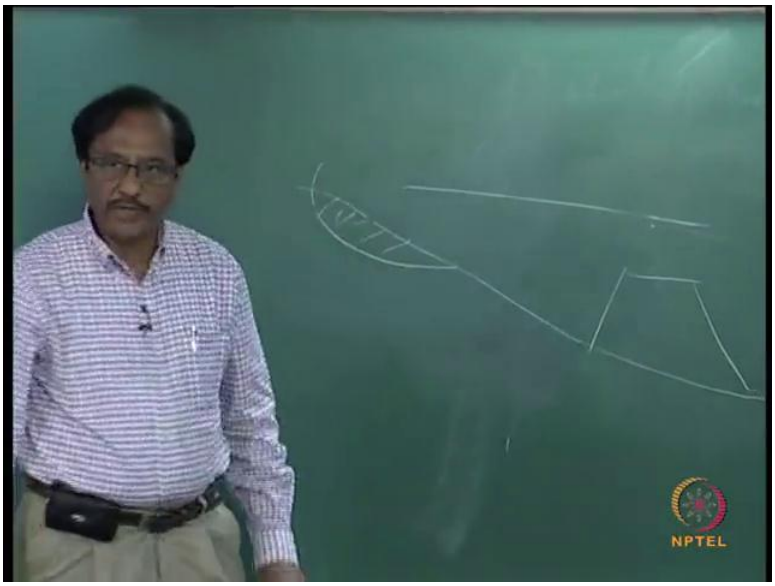

This also we have seen for example, if you have erosion taking place here. The sand is being removed and if I have something like a structure, what will happen? The pre mature breaking will take place so you have the deposition taking place, the beach build up will take place. So, that is what I mean by reduced loads, increased strength that is by providing structures, sea walls etcetera which we will see later. Finally, we have what is called as bio shields and bio shields are nothing but plantation. Bio shields became very popular particularly after the 2004 great Indian Ocean tsunami.

There are number of evidences that at locations where you have a number of bio shields structures behind such bio shields were not affected that much, but structures which are exposed directly, which were directly exposed to the tsunami those were very badly damaged. So, there has been already even before the tsunami itself there were some considerable amount being done, research. What is the kind of research? They tried to look at the kind of flow fields, the kind of attenuation it is going to give because these are all stems which when the flow is taking place, the stems the place, the stems as well as the space between the stems are going to endure some kind of turbulence so the energy is going to be de dissipated. There has been lot lot of work.

Now, since the tsunami, the Indian Ocean tsunami that occurred near Banda Aceh which we will be discussing later, there has been a rapid rapid progress in research on vegetation flow

field interaction. So, then that is these are the different options we do have under for the coastal protection.

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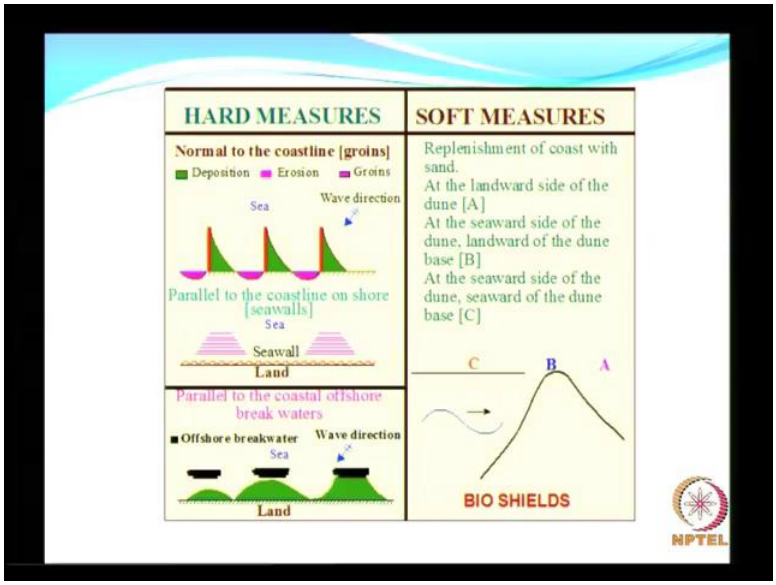

So, now we will move into what are the major measures. Before I proceed are there any questions from any of you? Is everything clear? I can proceed. Broadly you have two kinds of measures one is the hard measures and the other one is the soft measures. What are the hard measures? Broadly, it can be classified as construction of groins, construction of sea walls and construction of offshore detached break waters.

The other one is soft measures. Soft measure is nothing but where you have lot of sand getting accumulated, remove that sand and then replenish the affected area with this sand. I just now told you about the littoral barrier when you have a inlet because you want to clean the inlet, remove the sand and nourish it to the beach. And under the soft measure you also have bio shields because we are not using any stones or anything like that, no hard measures no concrete or stones etcetera.

So, I have just included bio shields under the soft measure. This also can be called as artificial beach nourishment, the first one under this. This can also be called as artificial beach nourish. Now, what is meant by let us see the groin field. See, you see this groin field when the waves are approaching the coast after the phenomenon of refraction, it will be attacking the coast at an angle and it is while doing so it is going to bring lot of sediments along with it as we have seen already.

And we have also seen that when that is the situation when you construct a littoral barrier like this you are going to have some kind of an advancement of the shore line on the up drift side and erosion on the down drift side. That is clear, am I right? We have already seen that. Suppose, if you have a stretch of the coast. Normally, it is the stretch of the coast which is affected. Now, you extend the same kind of a structure in series. So, I have one more groin here and one more here. I am just showing you three groins.

So, what will happen you will have deposition, erosion, deposition, erosion. The phenomena of diffraction, refraction, sediment transport all these things come into picture here. Is that clear? I have explained this why you have the erosion with the single groin earlier. Do you remember that in the last class? Because of penetration of wave into the sheltered area it penetrates and then remove the sand from the beach and then you have the longshore currents trying to push this sediments along the shore, is there any doubt.

So, this is the phenomena that takes place so with which you have alternate zones of erosion and deposition and over a period of time you see that the beach will really advance and then you will be able to win the beach. What do you mean by win the beach? That is, it is not that your beach which is last forever is lost you are able to now get back the last beach, under this case. So, groin field, what does the groin field need? It needs sand to move along the shore. Only then it can be useful because in need it needs sand to be to get trapped in between the compartments.

If you do not have any longshore currents, longshore sediment transport and in such a location if you construct a groin field, it is not going to give you any result. So, it is very important to find out even before you plan for a coastal structure, what is the mode of sediment transport in that particular location? Whether it is dominated by the longshore currents, longshore sediment transport or it is going to be cross shore sediment transport?

So, having ascertained then ascertain that you have the longshore sediment transport then you can you decide on going for the groin field fine, but then you have to decide about the length about the gap between the groins etcetera. This has to be carefully done. We will look at the, those aspects later then comes sea sea wall. Sea wall earlier there was no scientific background like in the case of breakwaters. So, what was the so if you have erosion taking place simply dump stones.

What is the size of stones? No, simply dump stone. Now, these days we know what should be the size of the stone and how it has to be placed. We have already seen that you have layers. The top layer will have bigger stones and the size of this stones will be governed by a formula. It is going to be a function of h the wave height probably h cubed which we will be seeing later. So, we have all established for formula. So, using that formula you can calculate all these things and arrange it in a more scientific manner.

So, sea walls once you construct we will see that the sea mostly, in most of the cases the beach loss is lost forever. You admit the defeat with the waves, you have lost your boundary, it is lost and you do not want to lose further. So, you put this is sea wall. Compared to groin this is more of defense where as there you try to play, try to get more beach. Trying to get more beach do apply even in the case of offshore detached breakwaters. In this you can keep on conquering the beach if you want, conquering or I mean what I am trying to say is you can keep on slowly extending your land. Although it is not so easy and cheap, but there is a possibility.

So, that is gradually you can, but this has nothing to do with reclamation. Reclamation is completely different. Another thing is when you have the sea walls the recreation aspect of the beach is lost. It is mostly it will be like protecting loss of land further, whereas groins if properly planned for with the help of a proper spacing etcetera you can, it can still serve as useful beach as far as recreation is concerned or even for small marinas or boat landing centers etcetera. We have effectively used such kind of a design for stretches of coast along our Indian coast, examples of which I will show you later. So, next comes offshore detached break waters. What is offshore detached breakwaters? You have breakwaters along the parallel to the shore line with a gap in between them, with a gap in between them. What will happen if you have a gap in between them? Please recollect our discussion on the phenomenon of diffraction.

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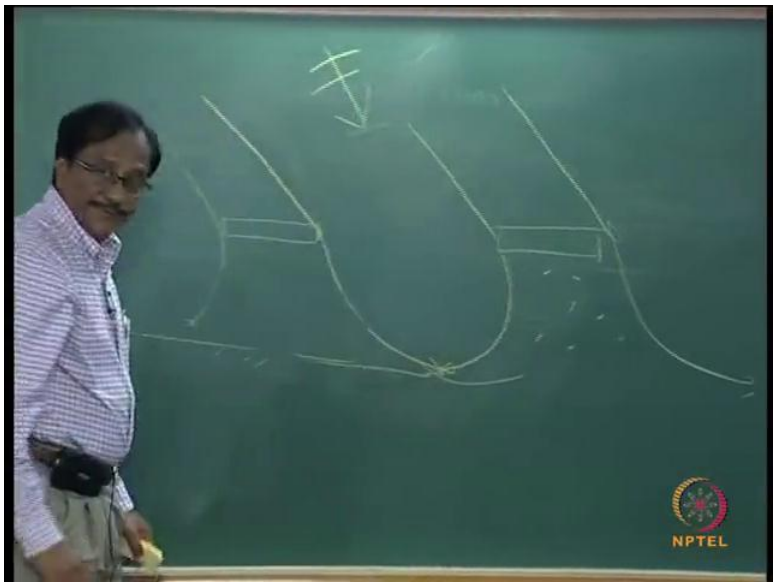

When you have a structure offshore and this is the shoreline you have already seen that the dive because of the tip of the breakwater. You see that because of the waves coming and once they, when they feel the end or the obstruction you will have the bending of the wave cross. So, what will happen this area is going to be dominated by lesser wave energy compared to the incident wave energy, but here you see that the energy will be same or it will be less, but certainly greater than the energy here because all these things depend on the topography. For sure the energy here is going to be less than the energy here.

What will happen? So, you will have some kind of an erosion taking place here, but when you have one more offshore breakwater so this can create something like this and then this can create like this. So, you have again sand filling up because this is on the lee side, wave is coming from this direction.

So, now you see alternate zones of erosion and deposition as is projected on the slide. So, as you leave as years roll down, so you see that the, the advancement of beach a shoreline will take place and you can, here again win the lost beach. Similar, to what we have in the case of groins. Is that clear? Any doubts? So, these are broadly classified hard measures or structural measures and we also have the soft measures, is that clear? Now, in this slide we we see what are all the physical parameters of physical factors needed for the selection of coastal protection measure.

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Geomorphology of the coast, that is very important. I have already shown, told you with some examples of having a protrusion of the shoreline into the ocean that can also serve as a sea, I mean littoral barrier etcetera. Now, we have material characteristics on sources. If you have rivers, the rivers can bring in some sand. So, that means you will have sand along the coast adding on to the sources. The characteristics of storm wind and and also the tidal ranges. Of course, waves and currents are important both for design of the structure as well as to estimate the quantity of, quantity and direction of the littoral drift. Shoreline details, when I say shoreline details, shoreline details running for several years. Now, with the satellite imageries you can obtain such kind of information without much of problems, then superpose these satellite imageries over years and try to assess how the shoreline has been behaving over years

That will give you an indication about the oscillation of the shoreline. Is that clear? Then of course, you need to know the nature of sediment transport that is the quantity as well as its direction. How do we do that? We will look into some of the aspects of estimation of sediment transport later in the course.

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Under coastal protection works we have a number of structures that are types of structures. Namely sea walls, bulkheads, revetments, groins, jetties as well as offshore breakwaters. These are all the different kinds of structures and of course, added on to this will be the artificial beach nourishment. Let us now try to understand one by one.

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Sea walls, sea walls are massive and quite expensive, but not that difficult to construct. At several locations sea walls may mean just dumping of stones which is not correct, out of desperate situation what they do is if there is an erosion taking place they simply go and dump

the stones. So, which should be avoided and it should be based on proper scientific methods in designing the structure.

Sea walls should be considered only where the adjoining shore is highly developed and the storm attack is quite severe. The next one is the sea wall protection for all practical purposes an irreversible act because the beach front is, of it is removed. This is what I said the beach lost is lost forever. We play a role of complete defense, we do not want to lose land further to the hungry waves. How devastating waves can be you may not know because you would not be going near the beach when the waves are severe. Naturally, you would not may be through video clips etcetera you might have seen. So, the design of any structure for that matter in the marine environment has to be done systematically and carefully so that it can resist the different kinds of forces, it can be breaking waves or non breaking waves.

The sea wall will eventually have to be rehabilitated under in constant intervals. This is the problem with sea walls, construction is easier once you have a different grades of stones, you simply construct. The equipment needed are not much so you start constructing the sea walls, but what you should understand is that you need to have a continuous re habilitation.

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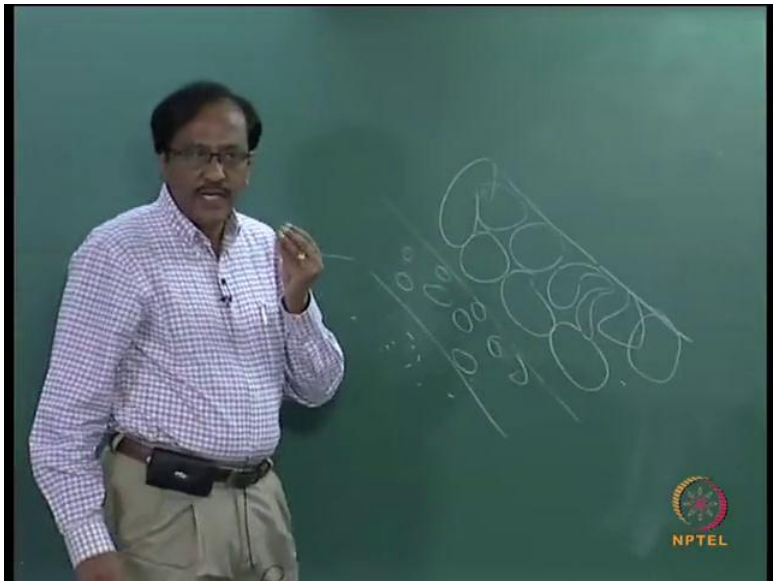

For example, you would have had a nice sea wall you would have put the stones and then you have a a smaller size stones and then you have the core material. This is going to allow careful I mean gradual dissipation and this boulders are going to absorb the incident wave energy, the coastal flooding will be reduced, all these things it has a very nice effect, but in the case of a

storm, if you have not, if the wave height exceeds, the wave height for which the stone is designed, it may still withstand the waves. If if it is of the order of few centimeters or even few meters it might stand, but if the order of same kind of waves which are exceeding the designed wave height comes and hits the structure at regular in intervals or quick intervals then there is a possibility of the sand, of the stone being removed.

So, you see that one stone if it is removed the other stone will fall and that is going to lead to the instability of the armored layer. So, the sea wall itself can fail like this which we will see later. So, to avoid this whenever you see some kind of a dislodgement of the stones you need to immediately rehabilitate that rehabilitate the section by putting in new stones. At locations the exposed to harsh wave climate, very severe wave climate then sometimes it may be difficult for you to get big size rocks. So, you go in for armored units made out of concrete which has better interlocking capacity and some of these aspects I will cover under breakwaters.

So, you see that rehabilitation at constant intervals is a must and this has not been carried out in several locations several locations and and hence the persistence of, hence you you have the persistence of the coastal erosion. And finally, they you keep saying that the sea wall is not effective. If it is properly constructed sea walls can be a good solution or coastal protection, but the aesthetic value of the beach is lost the moment you have your stones. Now, these days in order to take care of the aesthetic point of a value also into account we have what is called as geo synthetics which we will be seeing under the topic geo synthetics. Is there any other, any questions? I would like to stop here.