Coastal Engineering
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Module - 3
Coastal Erosion Protection Measures
Lecture - 4
Coastal Erosion Protection Measures – III

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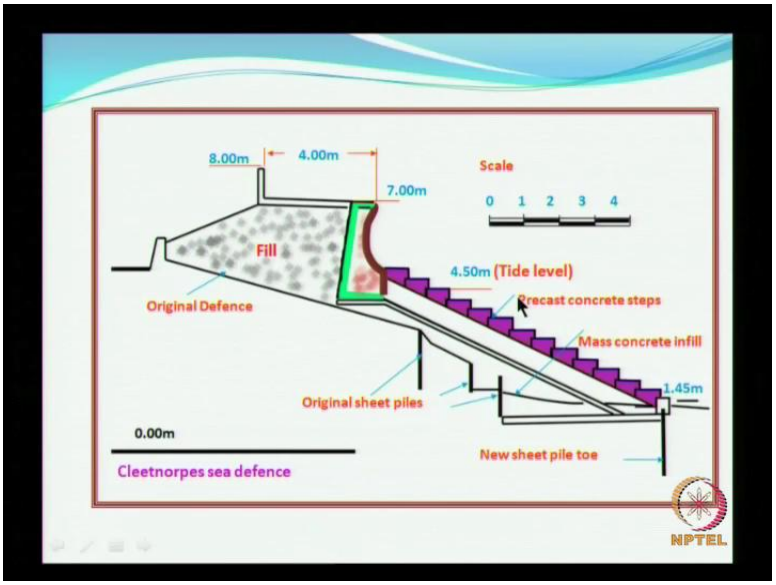

So we will continue to look at the, the different types of seawalls and then we will proceed with other types of coastal protection measures. So, now, if you look at this kind of a sea wall looks quite massive and this is a type of design that has been adopted in a few sides along the US coast and it has been, this is been taken from the coastal engineering manual. So, the concept would be a concrete wall with a surface front surface as shown here and you have the steps as shown here. These steps are supposed to gradually absorb the energy or not absorb, gradually dissipate the energy. So, the dissipation will be gradual, but it is going to be quite regular. And then apart from this gradual reduction in the energy, it also has to spend some amount of energy when it is trying to run over the curved surface. So, finally, the experience, the wall that is going to experience, the wall will not be subjected to that amount of pressures compared to a vertical wall.

Now, in addition, this original sheet, these are some sheet piles in order to retain the sand particularly when you have the backwash. But now, these sheet piles are going to be quite

expensive. People do not prefer this kind of sea walls, I mean sheet piles, but instead they have what is called as the geosynthetic material, which I have already explained to you earlier and which will be explained again later. So, with this kind of backing plus, then you have horizontal distance, so even in the event of a coastal (( )), this will, will take sand. And if you, in case you have lot of over topping, etcetera, this will be an impermeable surface and then you have protection provided by crown wall. So, this is, these are, these, the levels are all site specific and this is this quite a good concept and, but it is going to be quite expensive also.

Please note, that there is a small wall here in order to retain the earth, which is being filled up in this. Now, we can also have some kind of plantation over here or over here. And then now because of the geo-existence of the geo-textiles, we can cover this whole thing and then have plantations here instead of an impermeable wall, that will reduce the cost as well as the dissipation can be improved when you have the plantations here, and this wall will be subjected to lesser pressures and forces. So, with this we have come up, we have used some of these concepts for proposing coastal protection measure along our coast.

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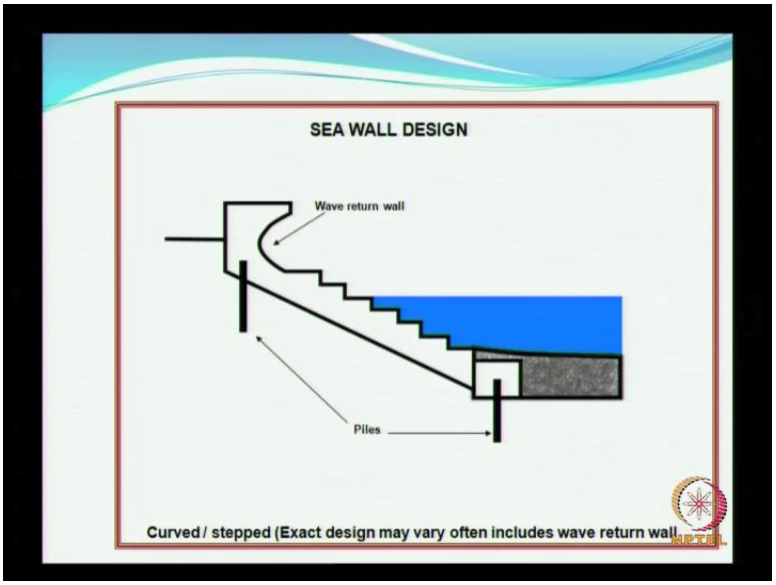

The same thing, a similar thing, what we have done, we have a wave return wall as shown here without all this key, I mean, the crown wall, etcetera. So, this has to be provided with a strong toe anyway. So, all this, this is another, yet another type of curved step concept.

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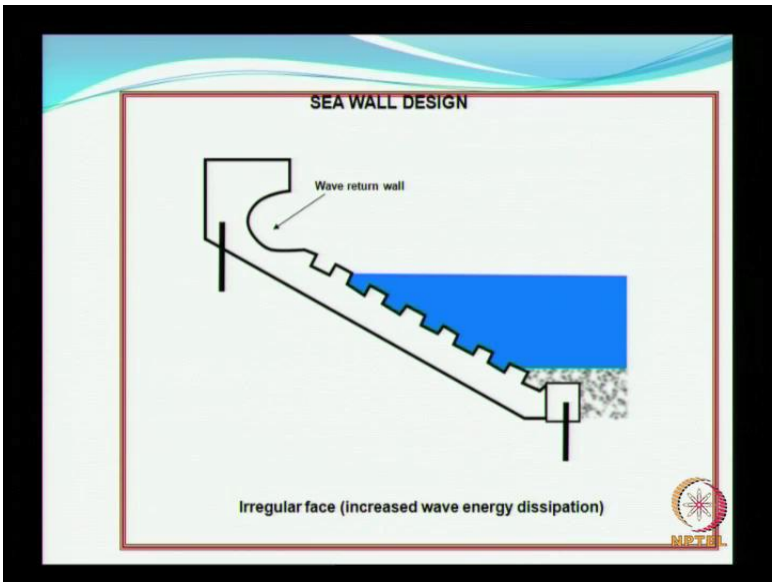

And there is not much of difference except that instead of, as you have seen here, instead of having these steps, you people have thought of providing dented or serrated wall. So, dented wall or a serrated wall is you have projections, so that it will offer some amount of friction to the incident wave energy and then reduces the incident energy before it strikes the curved wall. So, in this case the entire energy will be reflected back into the ocean. So, that is the kind of concept, which they have in mind.

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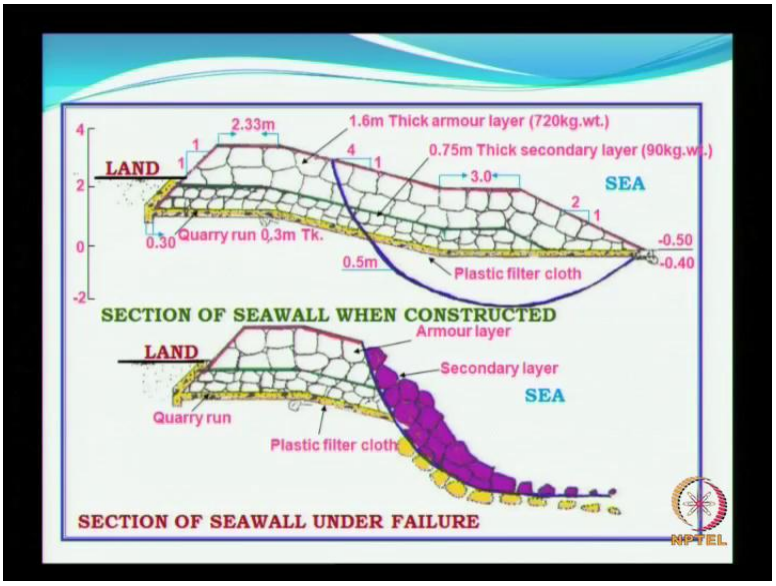

Now, this slide shows a typical cross-section of sea wall, which was used earlier along the Tamil Nadu coast, wherein you see, that you have a small burm of about 2, 3 meters and then there is a top crush with, of about 2.3 meters. And then some of the levels are indicated, these are all again site specific, the top level is considered to be around plus 7, plus 4. Now, these days this plus 4 will not be quite good enough for preventing the over topping, etcetera. So, the top level of the sea wall has to be raised particularly after the, in case of tsunami in 2004, this levels have been slightly increased, which we will see later, the details of which we will see later.

So, when you have a sea wall, the kind of failure is usually based on the slip circle failure, slip circle failure. So, if you have, do not have something to retain this at the toe of the wall, what happens is, this will yield and then you can have a failure as shown here. And once that occurs, unless you really come, go in for strong rehabilitation, you are not going to save this sea wall because the damage is going to progress towards the land and ultimately, the entire see wall will be lost. As we have seen in the case of Ullal, as along the Mangalore coast, where the entire sea wall has disappeared and number of, later when we look at the Kerala coast, you will, at least out of about, for 300 and 350 kilometers of the coast, at least about 250 kilometers of the coast line, I mean sea wall that was constructed, has gone, has been sacrificed to the ocean.

So, unless, when, whenever you have a sea wall, unless you have continuous monitoring and rehabilitation scheme, it is very difficult to, for that matter most of the rubble mould structures, it is very important to have periodic inspections and periodical rehabilitation.

So, you see that the failure, as we have seen earlier, it is mostly because of the absence of a toe. So, you need to have a toe and one such method is to provide a sheet, sheet pile, as we have seen in the earlier slides also, the older version, where they always have a kind of a sheet pile. But sheet pile these days is not been preferred because it is going to be quite expensive.

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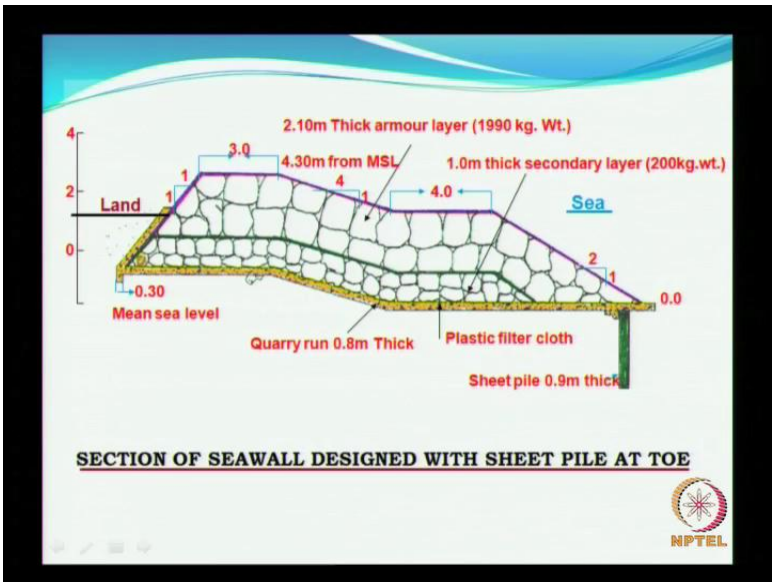

So, so the, however this is one technique where this sheet pile will not allow the progress of the sand, this side and hence, you can have the safety of the sea wall from slip circle failure. But then again there may be some amount of dislodgement of the stone, which you need to take care.

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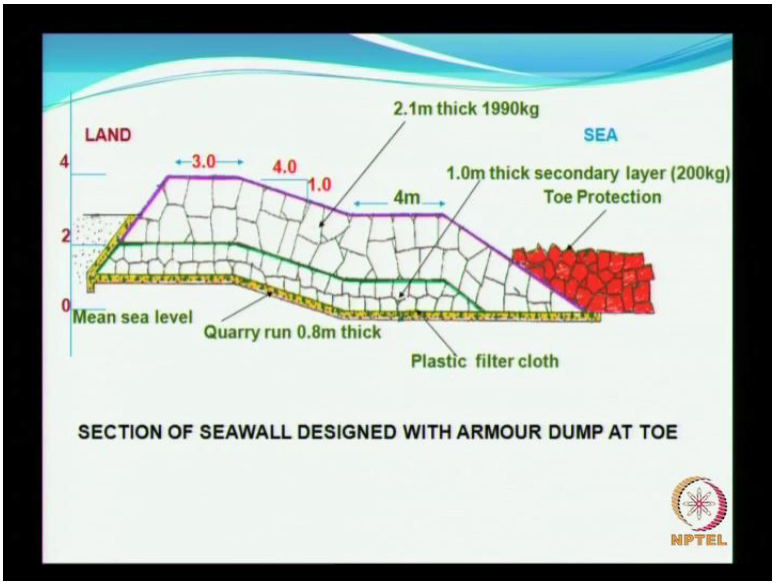

Then, the other method is having a toe, that is, this we call it as an exposed toe. So, as you have seen here, as we see here, probably the thumb rule, according to the thumb rule maybe the toe width is around 3 meters and the toe height may be anywhere between 1 to

one and half meters, and this will take care of, this is, this is like holding on to the sea wall in its position and trying to prevent, sometimes this toe itself can get, can experience this cover. So, you have to, even though you have a strong toe, but still it is quite important to keep verifying its status.

Now, and then here you have what is called as an exposed toe, that is, you do not excavate any sand. So, these, this toe, what you see here, is just put on the existing sea bed, so there can be some amount of settlement etcetera. So, all these things have to be taken into account. But the other way of constructing the toe is, excavated toe, so you excavate some material and I mean the sea bed, then you dump the toe from the excavated pit within the excavated and then you develop the toe.

So, you have two types of toes, one is the exposed toe, as you have seen here and other one is the excavated toe, the details of which again we will be seeing when we talk about the breakwaters and also, when we have, when I talk about the experiences with the geo-synthetic material being used as coastal protection. At that point of time, you will yourself see the effect of the difference between the effect of an excavated toe and an exposed toe. Excavated toe is always much better compared to the exposed toe. All said and done, a structure in the marine environment on the sea bed is of no use without a proper toe protection. So, even if you see in rivers, etcetera, when you have an exception it is properly protected near its toe.

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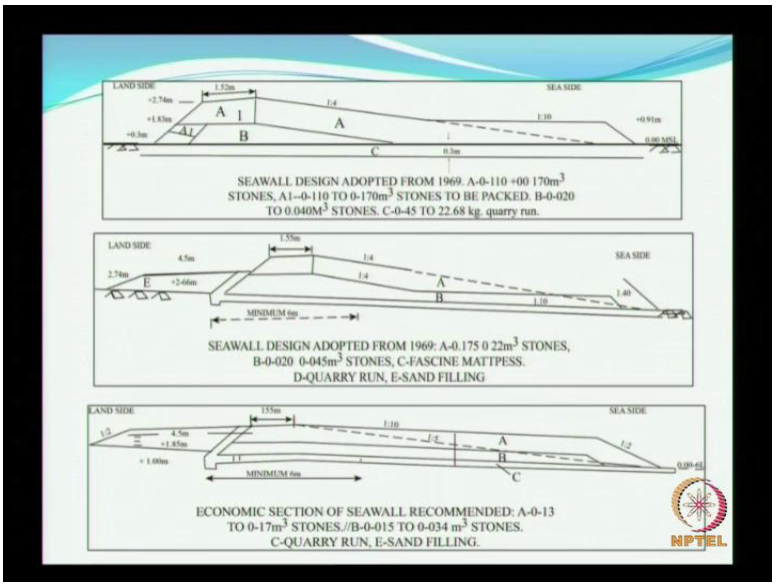

So, these were one of the standardization of the sea walls all along the Indian coast. Most of the structures that were adopted for protecting the coast were sea walls most of the places, most of the locations. And it was the Kerala government, which came up with standardization of its sea walls. So, you, the idea is very good.

See, you look at the concept, wherein you have a front slope as 1 is to 10, very mild slope and then you have steep slope of 1 is to 4. So, this is going to allow the phenomena of shoaling as well as the percolation of the, I mean, the, because of the permeability of the armour layer you expect a gradual decrease in the wave energy and then. So, then now what you have here is only less amount of energy, just something like run up over the structure.

This is alright when under the normal circumstances, but in the event of coastal hazard, when there is storm, then you see that the whole water level will go up and then that can be some amount of over topping. And if the waves are over topping and then there can be down rush and then you see all this when there is strong percolation here, then you see the whole thing can be, can penetrate here. And this, initially this will go and then the progress will be again towards the land side, and the entire structure can fail. Although the seawalls was, the sea wall was standardized, most of the sea wall, as I said, along the Kerala coast was, has been experiencing continuous erosion and at several stretches the entire seawall itself has disappeared.

Now, we will also see how we have rehabilitated some of these sea walls, how the sea walls has been made to a, mucher, much better perfection and how it has served etcetera and this, particularly this kind of an exercise was taken, took place after the recent tsunami, I mean, 2004 tsunami. So, this was again one of the typical kind of a sea wall used for the Tamil Nadu coast, that is, for along the Cape Comorin, that is, the tip of Indian peninsula where it is similar to what we had seen earlier for the Kerala coast.

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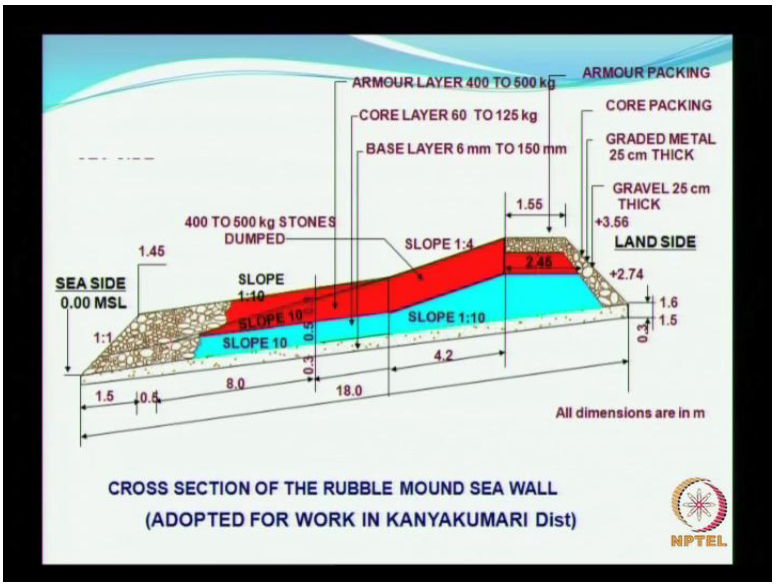

Note, that there is not much of, there is no, there is no toe at all. So, this was the one, which was forgotten. Toe is very, very important. If you do not have the toe, the failure can start from here under the normal circumstances, that is, under the normal wave action and during a storm you can have failure from here.

So, when you have the overtopping, then you can have the failure from here. So, this also did not really prove, proved to be very good and this sea wall was slightly modified to suit the present circumstances typical effects, that is, terminals cover associated with a sea wall.

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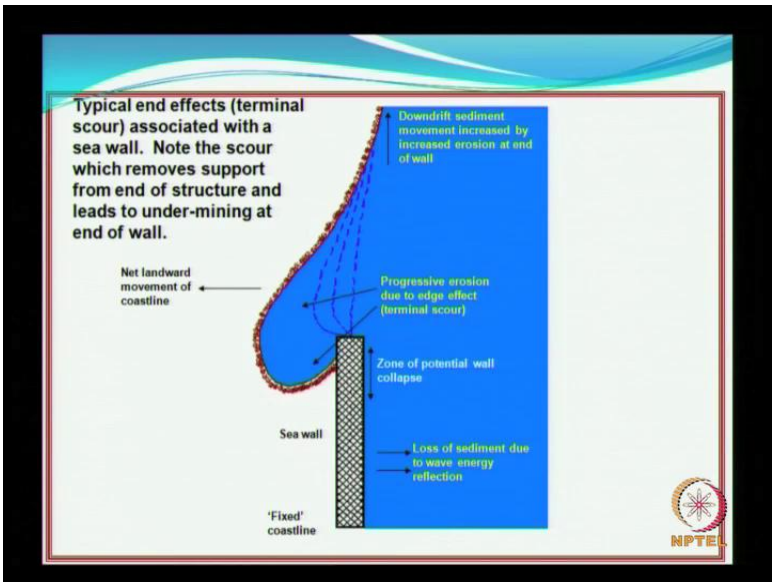

So, when you a sea wall, as shown here, and when the sand is moving in this direction, which is the littoral drift or the sediment transport is moving in this direction, then you see, that the terminal there will be a progressive erosion due to the edge effect or the terminal scour. So, and this can penetrate into the beach and this again depends on the type of the coast. If it is at sandy beach, this can, easily can take place and you are likely to have problems. So, this is the kind of the zone of potential wall collapse because it is experiencing the terminals cover and you expect the, because of this cover you expect the failure to start from this side, from this end, plus if you have some amount of, I mean, improper toe, etcetera, you can lose a sea wall in this direction.

So, both the terminal scour associated with your removal of stones in the, due to the onshore waves, you, you can have, one final day, one fine morning you will see, that the entire sea wall itself has gone, is gone. So, here again, loss of sediment due to wave energy reflection, that is, due to energy reflection also you will be having some amount of sand being lost. So, note, that the, so this is what I wanted to explain. So, this is very important. When you have a sea wall, the terminal effect has to be very carefully done. So, there should be some kind of a streamlining effect, which we will see later.

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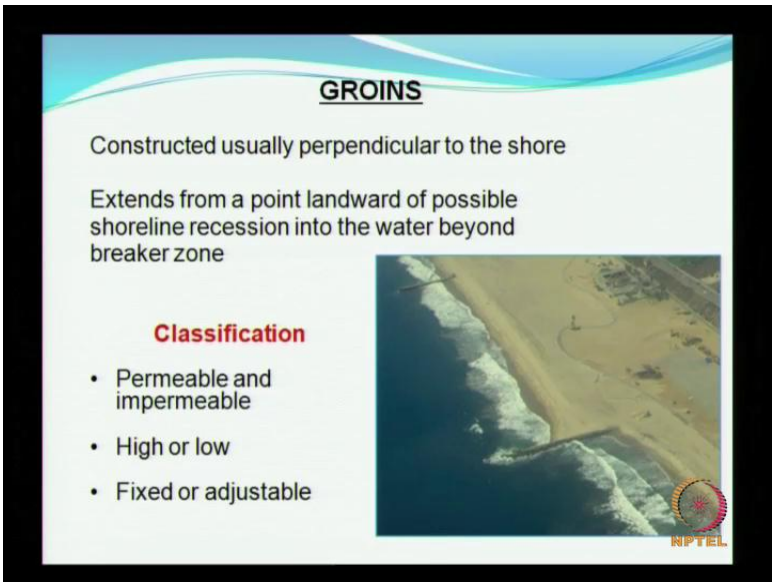

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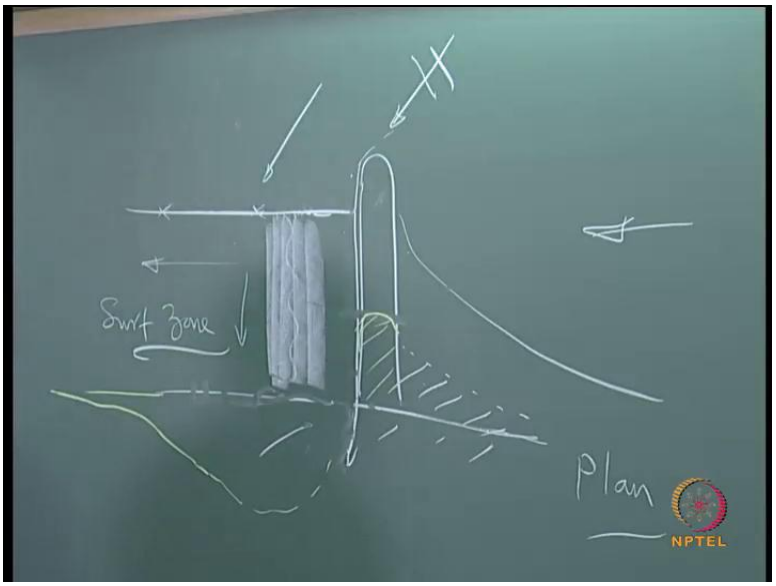

So, now, that I have just pointed out for the sea walls what are the benefits, what are the demerits, etcetera. So, benefit is: easy to construct; easy to design; easy to handle; equipments are, not very sophisticated equipments are needed; not much of skilled labour is needed; a proper design, etcetera. If a proper design is done and the proper construction is executed in a nice way with the satisfactory fashion and flowed by continuous monitoring and continuous rehabilitation, then the sea wall should be good enough as a structural. But there are locations where sea walls cannot be really so effective, but groins may be more effective.

The demerits in the case of a sea wall is, you are fighting the, if you are losing the battle with the waves and you just put your marking, that is, you will forget, whatever beach, which has been lost is loss. So, you are not really interested in having more beach. Once you have put your sea wall, your boundary is fixed. This we have already seen. So, that is about the sea wall.

Now, are, what are, what are the other protection measures? Now, we start with a groin. As you see in this picture, you see, if you have a groin, we have already seen earlier, that when there is sediment transport moving in this direction, then you see on the up-drift side you have the deposition or the advancement of the shoreline. And on the down-drift side you have the deposit or the erosion taking place. So, when the, when the littoral drift is moving this direction, you expect the erosion, I mean, the deposition take place like this and then you have the erosion taking place in this direction.

So, so this is what we have already seen in the first one of my earlier slides. But when you see this picture, you can easily say, that the sand is moving in this direction, that is, looking at this picture itself you can say that, which is the direction of net sediment transport? The net sediment transport is from top to, from top to bottom moving in this direction and you see that the scour will penetrate into this shadow area. So, when you have the waves coming in this direction, as I have told you earlier, the diffraction, the phenomenon of diffraction, the waves will penetrate into the shadow area and then this will, the scour will be more near the tip of the, I mean, the toe of the groin.

So, this, this is quite important because if you put in a location where you are not supposed to have erosion, then that is going to be a problem. You, although you will be preventing erosion this side, there is the possibility you are creating erosion on the adjoining area. So, this has to be bored in mind when you are planning for the construction of a groin. So, constructed usually perpendicular to the shore extends from a point landward of the possible shoreline recession into the water beyond the breaker zone.

Why this beyond breaker zone? As we have seen earlier, by the, from the phenomena of sediment transport, the sediment transport takes place only when the waves break, when the waves break, this is where you have the, this is in plan anyway. So, this, the place where waves break, at that point only you have the mixing taking place. And then you have the setting in of the long shore sediments transport, moving long shore sediments,

long shore current moving in this direction and the onshore offshore currents moving in this direction and these are the two current, which are going to drive the sediments along the shore or normal to the shore. So, that means, this is the zone where you are going to have the distribution of the sediments, so this zone is called as the surf zone. So, you see that the sand will be transported with in the surf zone.

So, if you want, the concept here is, suppose if you want to have building up of the beach, that is, you are trying to win the lost beach, then you have to, necessarily you have your groin jetting into the ocean and extending or piercing the surf zone, that is the basic requirement. If it is you construct a groin, but it does not pierce the, pierce the breaker line, then if it for example, if it is going to stop here, if it going to stop here, then you see, that it is going to capture only the sand distributed within this distance.

So, the effectiveness of the groins is not much compared to a long groin. So, but you have the options of having the long groin or having a short groin. So, if you have short groin, the deposition the advancement offshore line will be something like this. Am I right? Suppose if you have a long groin, you are going to have wider beach. What exactly you would like to have? You would like to have wide, wider beach, etcetera, all these things. And how much of amount you can invest on this, all these things have to be considered when before you really go in for the planning of a construction of the groin.

So, although I said, that the surf width, the, the, the groin has to extend one surf (( )), you will see, that later when we do calculations on the distribution of the sediment transport within the surf zone, the calculations will reveal, that even beyond the surf zone you will still have some amount of sand being moved being transported, so you can extend even slightly beyond. But the best option would be to pierce the breaker zoon if you want to have quick result of the advancement of the beach.

So, then classification, this can be either permeable groin or impermeable groin or high or low and fixed or adjustable fixed or adjustable. So, this is made out of, the groins are made out of stones, rocks, etcetera, material like that. So, that is, those are all fixed, adjustable, you can have screens, that is, screens, which can be moved along the shore, which is going to be quite sensitive in the sense, the durability becomes a bit question mark. And it has to be, their design also has to be done carefully.

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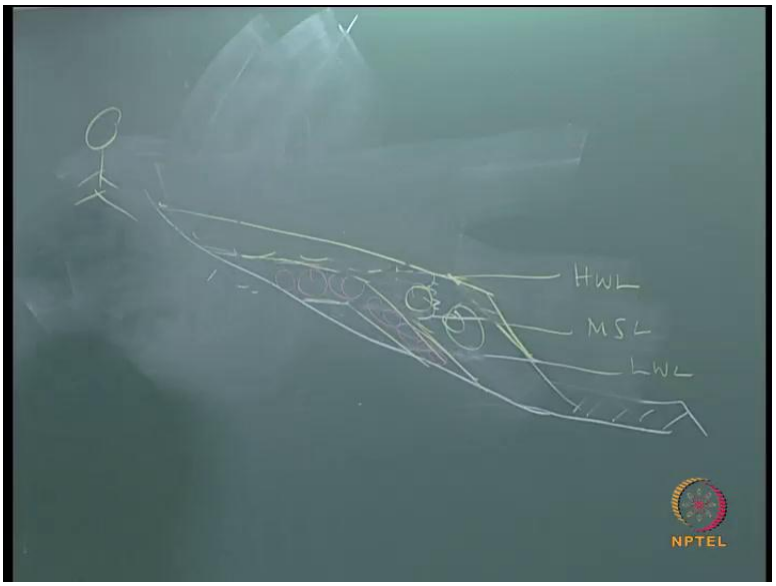

Then, high or low, for example, what you mean by high or low. So, high or low is, suppose if you have, which I am showing it in the cross-section, the groin can, so this is your water level, may be I, I show the high water line and you have the MSL and you have the low, tight level, low water line. All of you know what is LWL, low water line; MSL, mean sea level and high water line.

So, when I have the structure extended like this, may be I have a toe protection here, these are the levels, which I just indicate here and now I have the, I may have something like this. So, now I have the second layer and then the third layer. If it is something like this, so you see, that this portion is always exposed and this is your wave, it is always exposed. So, when you go and stand here and see into the ocean, you will always see the groin jetting into.

So, what are the low groins? Low groins can be in the same thing, what I will do in order to make my drawing easier, what I will do is, I will mark the top level. The top level can be, sorry, I will retain the same thing, high W, HWL, MSL and say WL. So, but if I want I can take this as something like this, and I have something like this. This will be my primary layer, you understood.

So, what it would mean is, at certain time you may not be able to see the groin at all. It will be submerged during the high tide and sometimes what happens is, it will be exposed up to a certain distance from the shore line beyond which it will go down. The idea is, the sand

is moving as a form of, so when the sand is moving, so the sand can be moving in this direction as a bed load or as a suspended load in a location where you have a lot of bed load compared to your suspended load. Then you need not have to, have all the way up. So, you can have it like this. This also results in saving of material. At the same time, the purpose of trapping the sediments moving along the coast is also achieved, you understood. So, these are all some of the concept, which need to be looked into.

So, before you plan for a groin, it is also quite important, that you look at the suspended sediment transport as well as the suspended as well as the bed load. So, so this as explained. Are there any doubts now? Are there any doubts?

Now, permeable or impermeable, permeable or impermeable, you know the meaning of permeable or impermeable. Impermeable, what happens is the effect of the impermeable, see the sand, not the entire sand will be accumulating here. So, the advancement of the shore line will be much faster compared to permeable groin, but there are some problems of reflection in the case of an impermeable groin. But in the case of permeable groin, the advancement may be slightly less compared to an impermeable.

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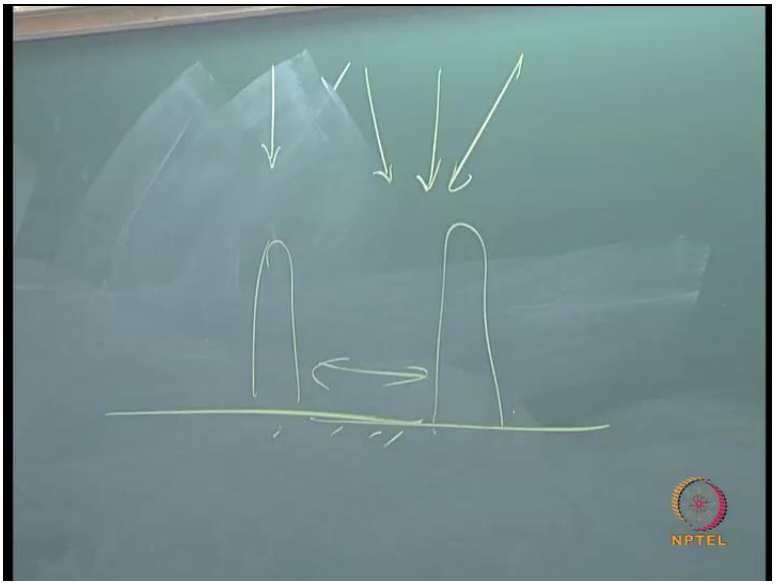

But you do not have problems concerning reflection, particularly when I am talking about reflection, cross-shore oscillations when you have, because wave is moving in this direction and you have the structure in this direction. You might ask where is the reflection coming here, but if you extend, if you have one more groin here and when the waves are

moving in this direction or in this direction or in this direction, you can always have cross reflection. When you have cross, cross reflection and that to when you have adopted impermeable groin, then you see, that there will be the lot of oscillations of the or magnifying of the flow, I mean, magnifying of the wave heights. So, it is important to have this dissipated in lateral direction also. That is why it always better to have permeability (( )).

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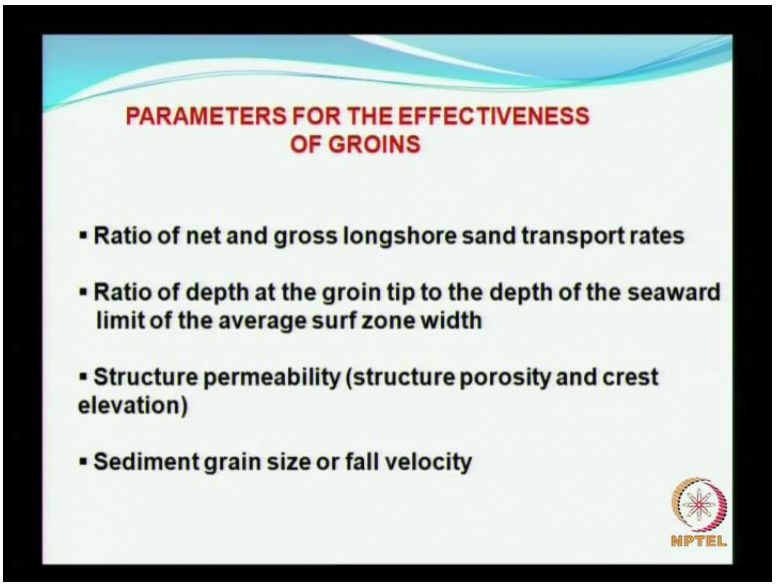

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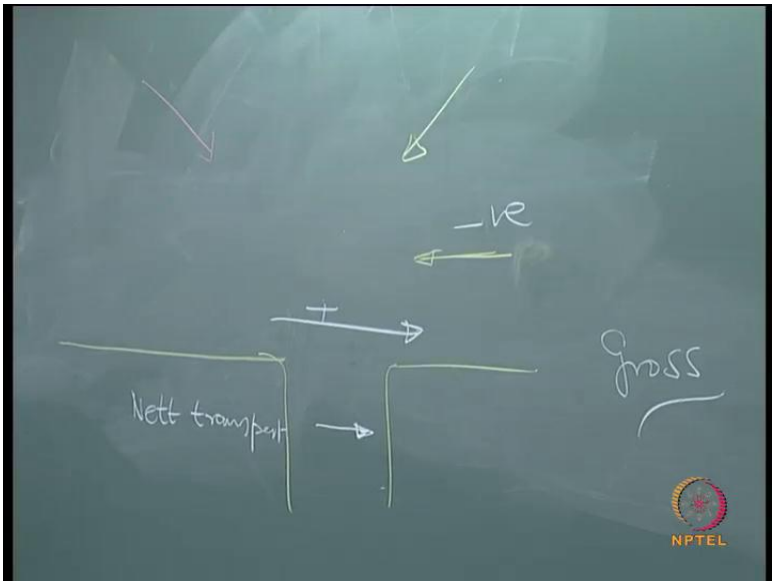

Parameters for the effectiveness of groin, so the ratio between net and gross sand transport, what is meant by net and so if you have an ocean, I mean, if you have along a coast, along a particular coast the waves can be moving in this, from this direction, the wave direction can be in this as shown or it can be in this direction, accordingly there will be the movement of sand, either in this direction or in this direction.

What does this indicate? If this is, if the direction, in this, if the movement in this direction is more, then I can get the difference. So, if I have this as positive and this as negative for instance, then the length of the arrow shows the magnitude. Then you see, the magnitude in this direction is more compared to in this direction. So, this minus this, the net drift will be in this direction. Am I right? The net drive direction will be in this direction. So, this is nothing but the net transport, net sediment transport. But if you simply add both, irrespective of the direction simply add this and this, then that is called as the gross sediment transport. Later we will try to estimate the gross sediment transport, the net sediment transport, etcetera and where exactly all this things will be playing an important role.

I have just introduced what the concept, the, the terminology of net and gross sediment transport, the ratio of the depth at the groin tip to the depth of the seaward limit of the average surf surface width because the surf width has to be average because it is going to change every month. Am I right? In fact, it may be, it, it, it will be changing continuously, so you need to work as an average. So, the depth, the ratio of the depth at which groin depth, groin tip, so that is when you construct a groin, so this is the depth at which the groin tip, that and your surf width. So, this is also very important.

So, structure permeability, structure porosity, etcetera and also, the crest elevation we have already seen when we discussed about the groin going like this or going like this. And then the sediment, sediment grain size or the fall velocity about the sediment grain size or all the fall velocity we have already covered under sediment characters. So, these are some of the parameters, that is going to have an effect on the effectiveness of the groins. All of you are alright, it is ok, no doubts?

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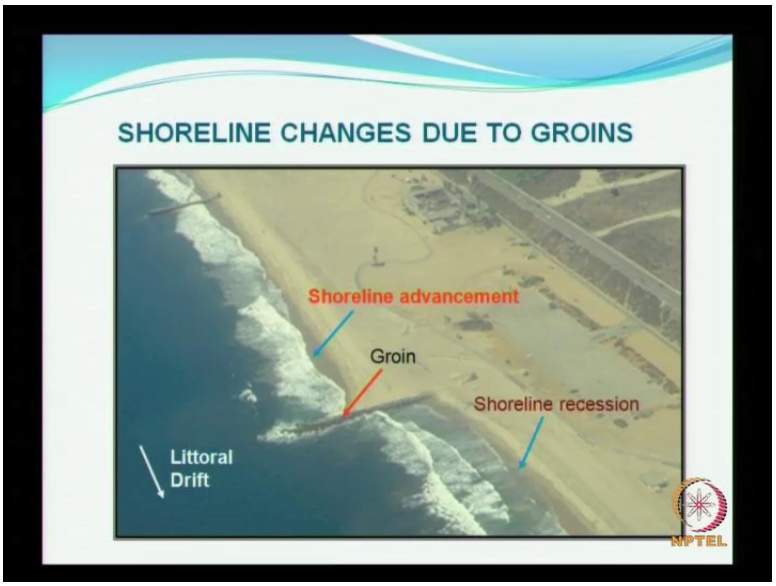

So, this is what is as explained in the earlier figure. So, you have the groin, you see the shoreline. This is the same picture as we have seen earlier.

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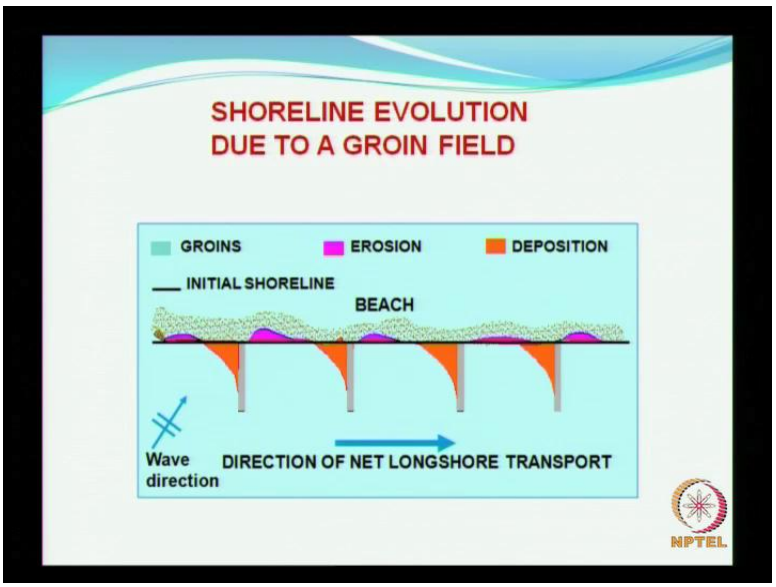

So, we now know, that if you have a single groin you have the, on the up-drift side you have the advancement of the shore line and the down-drift side you will have the erosion taking place. So, now, if we have a series of groins as show here and the assumption, that the next sediment transport is from left to right, as indicated in this slide, so because of this you have the advancement of the shore line, and the down-drift side you will have the

erosion taking place. So, what will happen? Ultimately, you will have alternative zones of erosion and deposition.

Over a few years, after the construction of the, existence of, after the existence of your groin field you will see, that there is a beautiful beach built up. Now, you see, that it is reversible that is what is reversible; the phenomena is reversible. In the case of seawall the phenomena is non reversible, that is, the beach you have lost will not come back to you. But here you see that it is possible to get this reversed. So, the lost beach can again come back and then you can try to get the, at least you can make an attempt to get back your last beach. So, that is the advantage of the groin field.

But please remember that what is that you need for the groins to be effective? What is the most important feature or which would, I mean, the physical, physics behind them if you want the groin field to be effective? What is the basic requirement?

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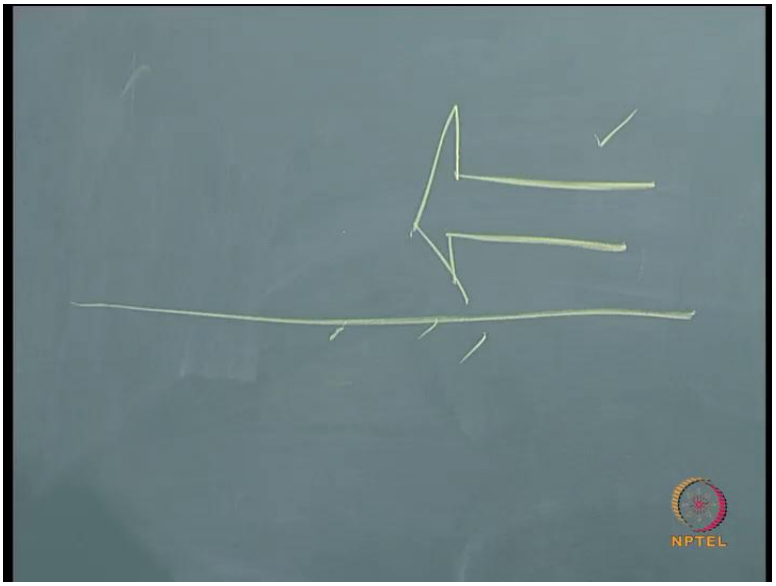

So, it has to be a long shore sediment transport only at locations where have the long shore sediment transport taking place, only in such locations it will be working, alright. So, just because the groin field has worked at certain, at a particular location, has been proved to be very effective, that does not mean that you can have a groin field all over the coast. That is completely ridiculous. So, now, and groins are, they knew, no, they are not all new.

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It is, so this I have downloaded from the net, which shows the world's oldest groins constructed, constructed as early as 1503. That is in Netherlands, place called Vissingen. They have protected of that point of time with a few groins, as you can see here.

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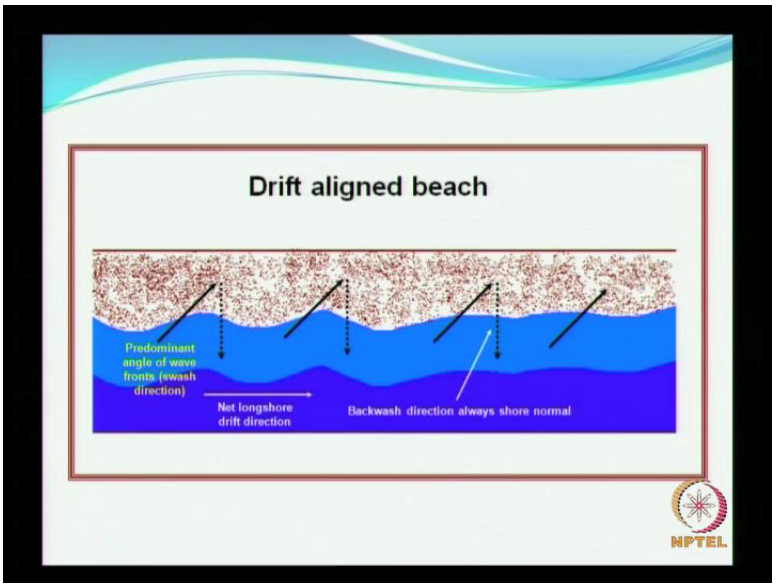

So, so what is that we have understood? The drift aligned beach, what does that mean? This shows the predominant angle of wave fronts, swash direction and you have net sediment, sediment direction, there is a backwash.

So, even if you have some kind of a groin here, you also have, have to take care of the movement of sand after it is settled. There can be some amount of sand, which is taken away into the ocean because of the setting of the onshore, offshore currents or it is referred to as cross shore currents. So, all this things have to be taken in to the account.

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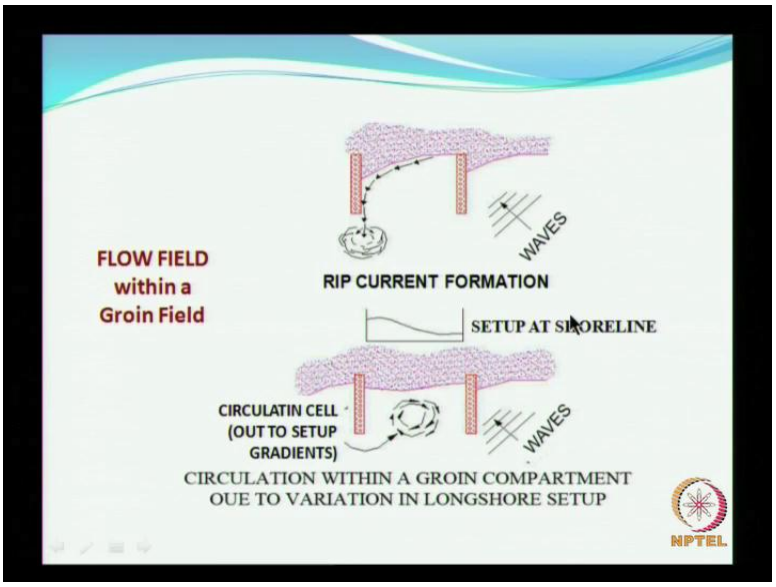

Circulation within the groin field, groin compartment due to variation in the longshore, so if you have a predominant direction as, as indicated here, you can have a kind of a rip current form. And you know what is meant by a rip current in an open coast because it is, because of the variation in the head, wave height along the shore and then you have the feeder current, which we have already, I have already explained. Please refer to my lecture on the rip currents.

So, when you have such kind of a pair of groin, for example, or a single groin, you can have the direction of flow towards the ocean. The groin is forcing the floor to take place to and it is directing the shore towards the ocean and after the certain distance, away from the groin, the flow gets diverse. That is obvious because there is no obstruction, right.

So, you see, that this is where, this, this in fact will be quite strong, the rip currents are expected to be very strong. And its effect is, it can remove some of the materials here if it is an impermeable groin. So, you have to be very careful in monitoring the groins because this, because of this power you need continuous monitoring and see this is the setup on the

shoreline, as shown here. So, you can have setup on the shoreline and wave setup and set down. We will take it up when we, as a different, completely different topic.

So, you can also have, instead of this kind of circulation you can also have a circulation cell as you see here. This entirely depends on the local wave climate, the spacing between the groins and the length of the groins. All these characteristics contribute to the generation of the circulation, which is going to be quite different. So, the spacing between the groins is also very important in order to make sure that it is effectively retaining the sand in between the compartments.

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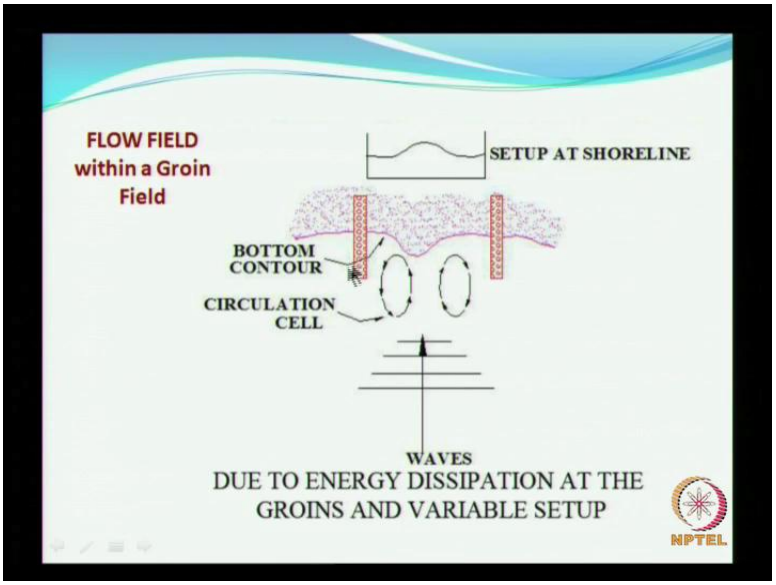

So, you can have something like this. You can have two, two circulations as shown here and you can have a hump or an advancement of the shoreline somewhere in between the two groins.

So, the behavior of the shoreline is basically because of the variation in the wave energy along the coast, alright, because of the variation in the wave energy. So, if the wave energy is (( )), is less around this location, then they, then the sand from low, from, from locations of higher energy will get transported and then start settling down, that would result in the building up of the beach.

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So, now you see the importance of the spacing between the groins. Materials used, you can either use timber, people have used timber, steel, stone, concrete. Sometimes there are some other materials and other materials, I can also suggest geosynthetic tubes, which we will see later or gabions.

And as far as the shoreline changes are concerned, we have already seen enough about the shoreline changes. And we will move on to the next slide.

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This is the picture showing how effective the shoreline or the beach formation is when you have a groin field. So, built, they, they, they are built to reduce or halt the shoreline erosion by obstructing the free passage of the littoral drift plus this not only serves as a coastal protection measure in order to prevent further erosion, but it also enhances beach formation.

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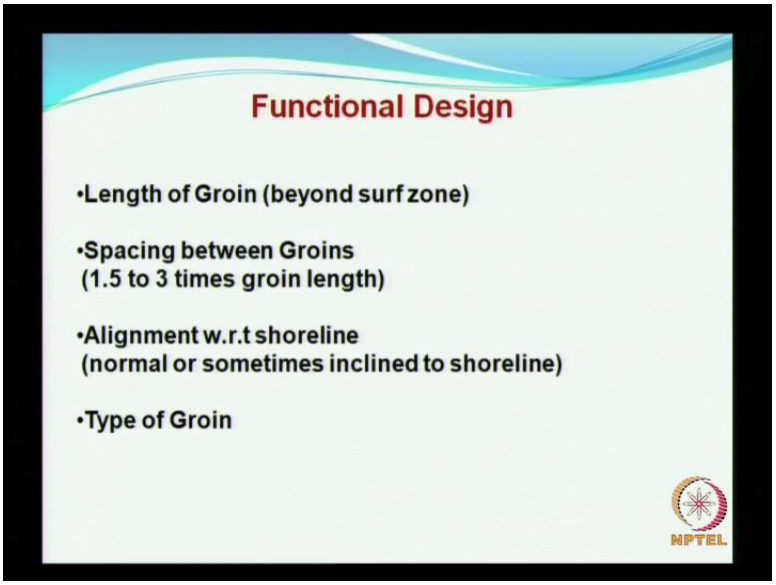

Functional design, the length of a groin, as I have said earlier, has to pierce the surf zone. That is very clear spacing between the groins, should be between 1.5 and 3 times the groin length. And alignment is usually perpendicular to the shoreline, but sometimes it is normal, it is slightly inclined. And also, type of groin, it can be straight groin or an inclined groin or a T groin, etcetera. We will see later.

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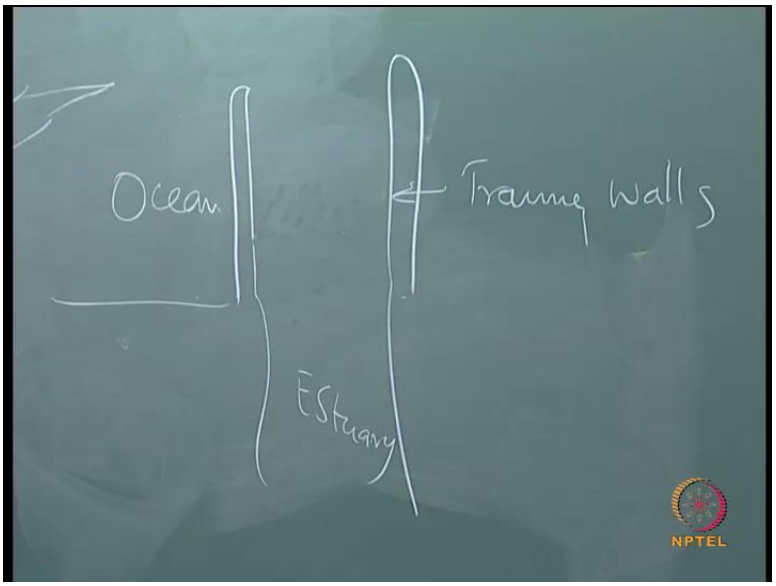

As I said earlier, groins, the term groin means that the structure would be trapezoidal mostly and it is used for protecting the coast. The same structure, the same structure, if it is used in order to prevent sand bar formation. This is the, this is the ocean and this is the estuary. For example, if there are two structures like this to allow free navigation and to prevent the sand bar formation, then they are called as training walls. The cross-section may be looking same, but it has its own name because of the purpose for which it is used.

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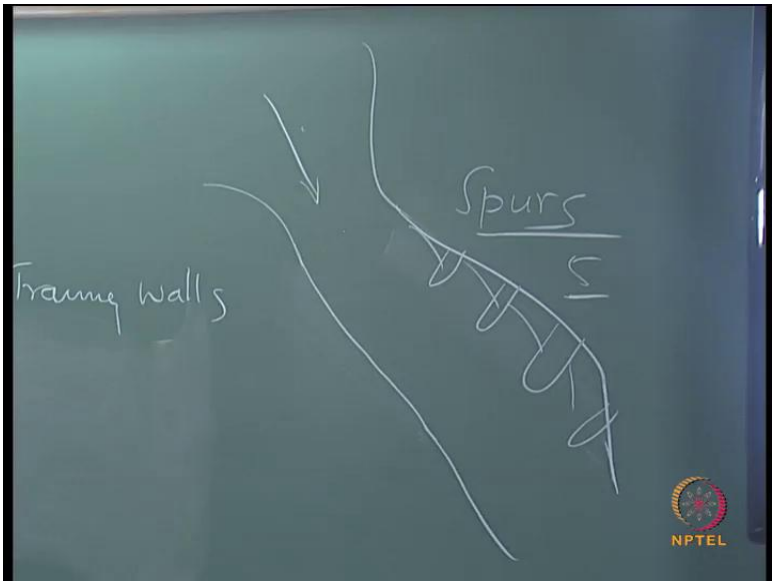

For example, If there is a river and you assume, that there is a very thickly populated area along the banks, may be this area, may be this is getting eroded, this is not much of a problem. Suppose, if you have this kind of configuration, I am talking about a river where there is a flow taking place, how to prevent the erosion of this bank.

Here also, you can have something like this and in this case this will act almost same as that of a groin, but we call this as spurs. Here we see, it is 1 to 1.5 to 5 times the, I mean the times the groin line, whereas in the case of spur it can be even up to 5 times the spur length. For a groin if the spacing is more than 3 times, then it is not going to be effective at all.

So, now you have been introduced the terminologies of what is meant by a groin, what is meant by a turning, I mean, a training wall, what is meant by spur, then comes breakwater. Breakwater also looks like this. When do we call the structure as a breakwater? When we are using this in order to develop up an artificial harbour. So, I am sure, that this is quite useful to you people.

Anything else? I think I will stop here.