Coastal Engineering
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Module - 3
Coastal Erosion Protection Measures
Lecture - 8
Coastal Erosion Protection Measures – VII

So, we have seen in the earlier lecture about the direction of and magnitude of the littoral drift.

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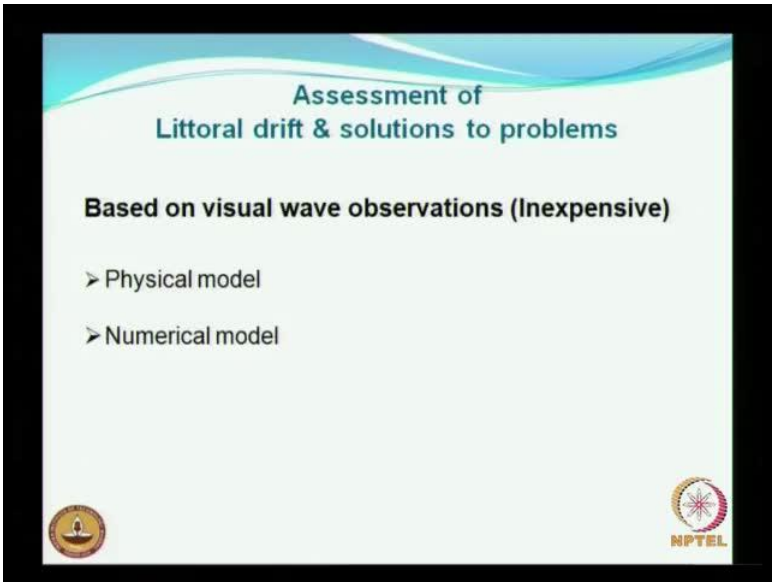

Although, we say that the average littoral drift along the east coast is approximately 1 million meter cube per year, there is a considerable variation. It varies somewhere as low as 0.7, 0.8 to about 1.2 million meter cube per year. This this has been estimated by several agencies within our country. And there is some kind of refinements to this quantity which is in progress through direct measurements.

But how are these sediment transports both the direction and this one is the quantity is estimated. It is either estimated mostly using empirical relationships as well as through direct measurements; unfortunately we do not have much of direct measurements going on along the Indian coast. So, we rely mostly on empirical relationships. There are a

number of empirical relationships which have been widely used and are being widely used.

So, that is on the aspect of estimation of littoral drift both its direction and see the direction actually depends on the direction of wave. Direction of wave which is going to control the long shore sediment, long shore currents, long shore currents are the driving force for sediment transport.

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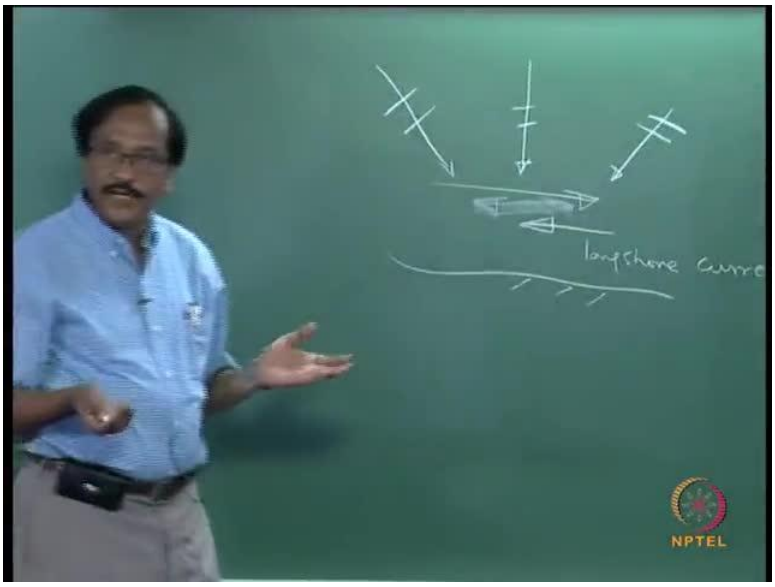

So, when you have the shore line. So, if the waves are coming in this direction when the waves break and that is what is going to set here long shore current. So, it basically depends on the angle at which the wave is going to break. If it is going to break in this fashion so naturally your long shore currents will be in towards this direction. Suppose, if you have the angle in this direction then you would have the current in this direction.

So, this clearly implies that along the east coast since we have two monsoons that is north east and south west monsoon, the direction of the littoral drift is mainly governed by this which is again governed by the monsoons, is that clear? So, suppose if you have only this kind of normal breaking I mean waves attacking the coast or propagating along the, towards the coast normal to the shore then what will happen?

In this case there will not be much of long shore currents. So, there will not be much of movement of the sediment in this along the shore. Instead there will be because the wave

is going to come over the beach and then return. So, it will bring some amount of sand and probably it might retain some of the sand along the coast or it might take back, it depends on the current on shore and the magnitude of the current on shore and off shore. If the off shore current is more than it is going to drag away all the sand.

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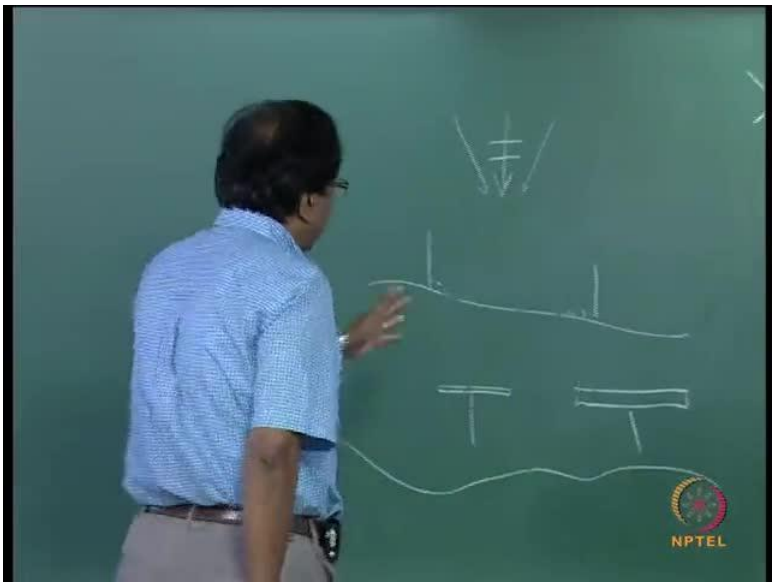

So, that is why when you are planning for a groin field what would happened in a place where you are having a long shore currents, in a location where the long shore currents are dominated then you have the groins, then these long shore will deposit all the sand. Suppose, if you do the same thing in a location where you have on shore off shore flow what will happen? This is very simple know, the sand will not be depositing here. So, no coast will be always exposed this this to this kind of a current.

There will always be some amount of angle, oblique wave of attack. So, because of this what will might happen is some of sand might get deposited at certain locations when there is small magnitude of your, for lesser currents you know in the long shore current or long shore direction so that will probably deposit some small amount of sand, but unfortunately this will be again removed when it is dominated by on shore off shore transmit. So, that is one of the reasons why people started thinking of off shore detached break water and also the T groins. What will happen? This is going to allow the deposition of the sand and these horizontal members are going to retain to some extent the sand which is likely to move back to the ocean.

Now, how much can be retained even if you have the on shore off shore mode of flow depends on the gap between this as well as the width of this. If it is too less you might land up in problems related to rip currents. So, although the structures, all these structures look quite simple it needs lot of investigation before you get onto the field for implementation. For that a careful understanding of the complete physics is very essential which was being carried out mostly using physical models in the earlier days, early 70s or even early 80s.

The results for coastal protection for that matter even the harbor problems that is tranquility inside harbors etcetera. It all relayed on physical modeling and later because of the rapid progress in the development of competing facilities, numerical model came into existence. Why numerical model? Why physical model? There can be a a debate. There are certain things, certain advantages with physical model. What you can achieve in physical model sometimes is difficult to achieve in numerical model. There are certain kind of facilities available in the numerical model which is not possible or not, I would not say possible, would which would be quite cumbersome in the case of physical model. You understood? For example, you want to test harbor break water.

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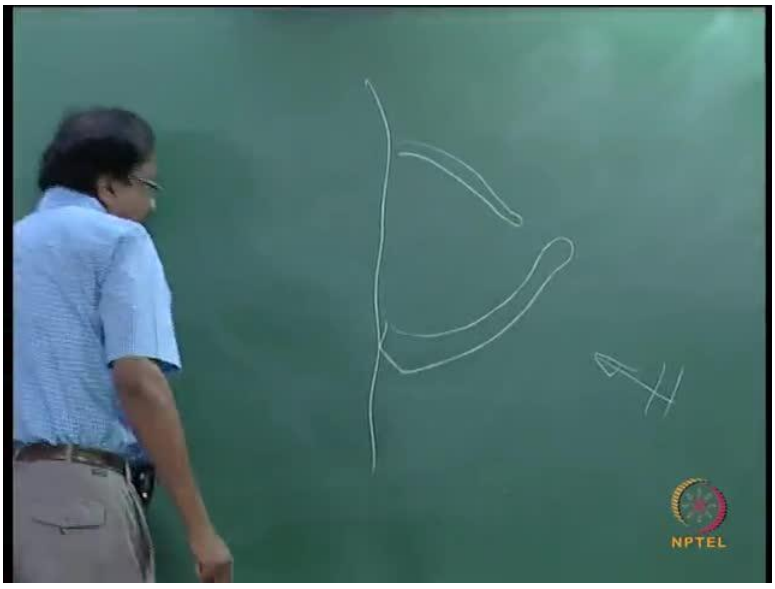

So, a coast is there and you have a wave direction. So, you want to check the alignment of the break waters whether it has to be like this.

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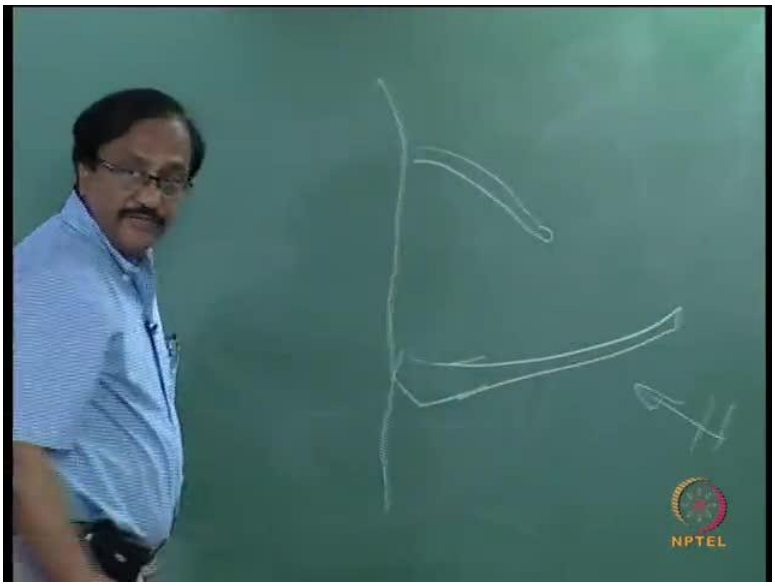

Or whether, it has to be like this. So, different configurations are there which we will be seeing when we talk about break waters. So, if I want to test a number of layouts and finally, come out with a kind of an optimum layout then which is better? Numerical modeling is better because once your numerical model is proved validated then it is very easy I can change the way I want.

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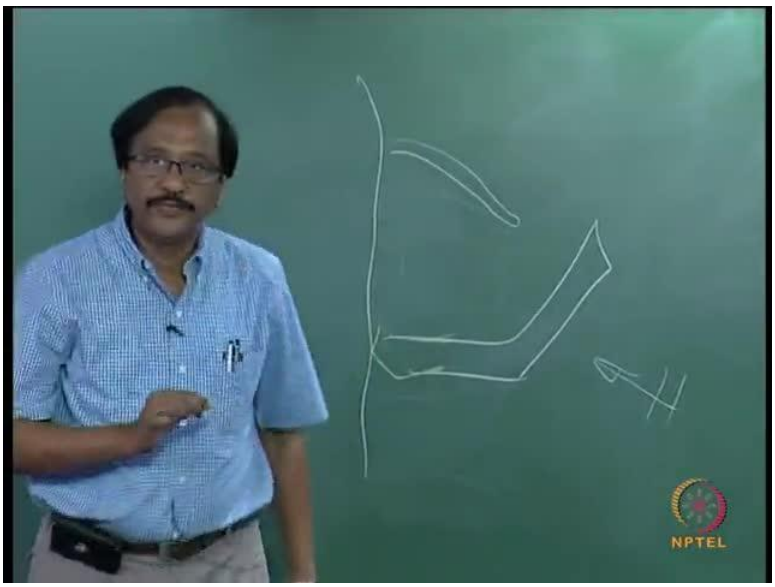

I can have break water like this, whatever it is and I can play around and it is not going to be cumbersome at all. Please remember when I am talking about this we are talking only

about the tranquility. When we are talking about tranquility the sea bed is considered to be impermeable, that is quite straight forward to consider in a numerical model. What is the kind of phenomena you have to consider here?

Combined refraction diffraction. Combined refraction diffraction as well as reflection from the break waters, but then what about the permeability of this break water. How will you handle in the case of numerical model? You consider an average coefficient and then try to do this. Average permeability and try to investigate. So, you can to some extent incorporate all these things, but then this bed, it is a bit difficult.

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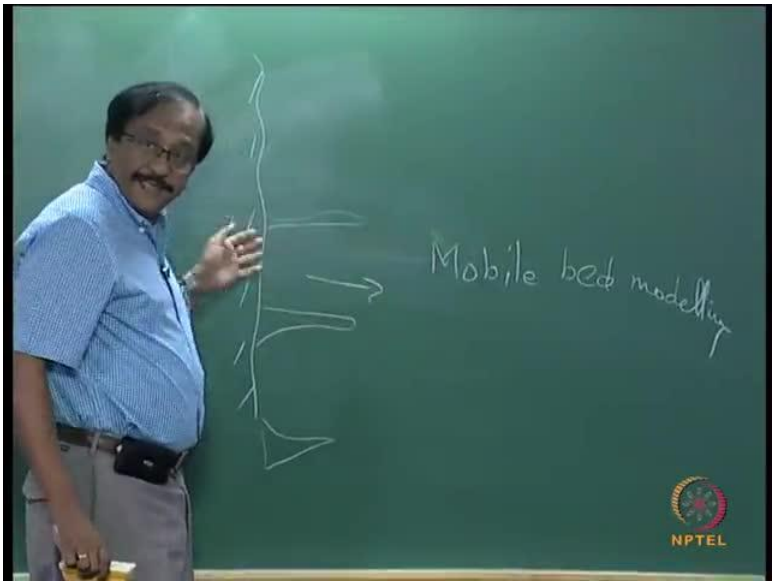

Suppose, if I want to have a groin field and I would like to check how the shore line is going to oscillate? How the beach build up is going to take place then you can either resort to numerical model or physical model, but then if you are talking about the movement of sand when you are talking about the physical model we talk we should have what is called as mobile bed modeling which is not so easy to implement.

What is meant by mobile bed modeling? You have to also scale down the movement of the sand, the characteristics of the sand apart from the wave characteristics. So, herein you will be using what is called as a distorted model. You will be using the vertical scale and the horizontal scale will be different.

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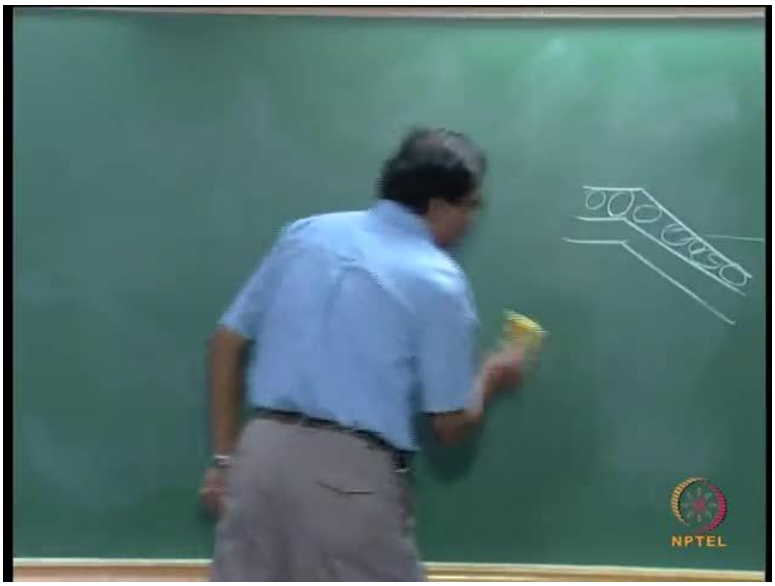

Suppose, and the other case is physical model if you want to test the stability of a break water or a sea wall. All of us know that the design of the weight of this individual alma stone is based on, significant way that is a different issue, but this is based on, it is an empirical coefficient. When you use those coefficient for example, you use a a natural rock it is very essential to check its stability through physical model. What do you do? You scale down the weight of the individual stone as well as the weight of the individual stones provided in the secondary layer as well as the core layer and then subject it to waves. You understand?

So, which I will try to cover about the physical model of a stability of break waters in a later class, but this is, this, it is very difficult to do it using a numerical model. So, most of the major projects they are done using numerical model, but many of them also try to verify the numerical model using physical model. Physical model is expensive, quite laborious, but certainly it gives a lot of information provided the modeling is done properly. At the same time numerical model it may sound very nice. Numerical model says the graphics are sometimes fantastic particularly the commercial available codes.

What happens when you have the commercial codes you have to give some input, use the entire process as a black box and you get some output. Sometimes, what happens junk in you get junk out. So, if you do not know the physics of the problem you still be presenting the result which is quite dangerous. So, whether it is numerical model or

physical model the first step is to understand the physical phenomena of any process. In this case it is coastal process. Any doubts?

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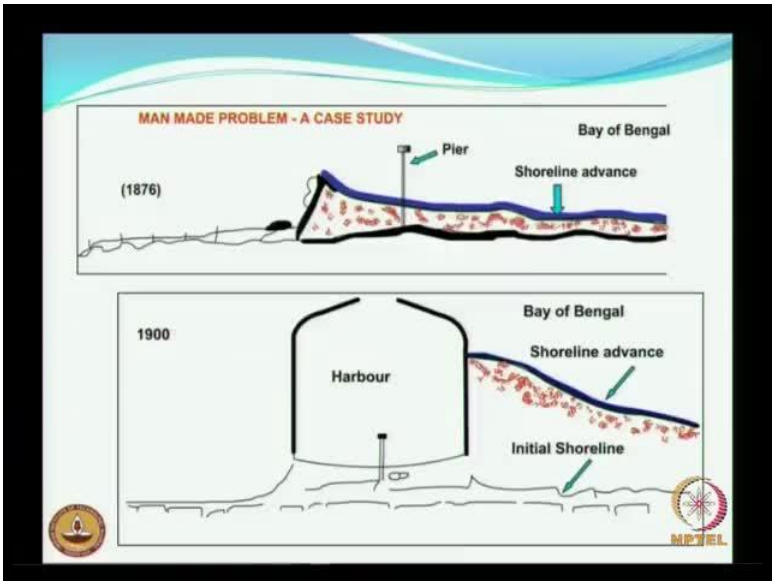

As we have seen, try to recollect. So, there are two types of problems.

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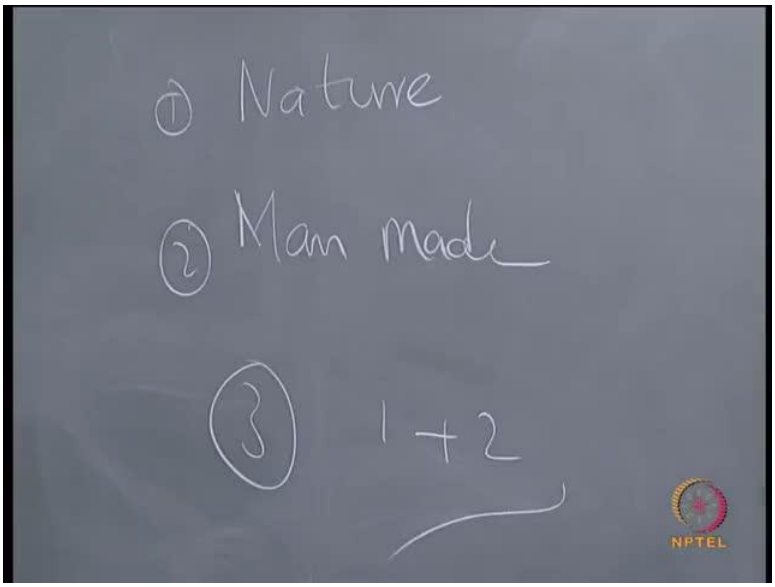

As for a coastal engineering problems are concerned one is due to nature. This was the first slide which I projected then due to man made. So, then 3 is 1 plus 2, it can be due to both. To illustrate this first let us look at the manmade problem and I am considering problems, I mean the case studies only along the Indian coast.

In this lecture I am just introducing you to the manmade problem along the Chennai coast. All of you know Chennai coast. The Indian map somewhere here is our Chennai formerly called as Madras. It was sometime as early as 1876 that was the first time when they started bringing in cargo mostly pertaining to getting the spices.

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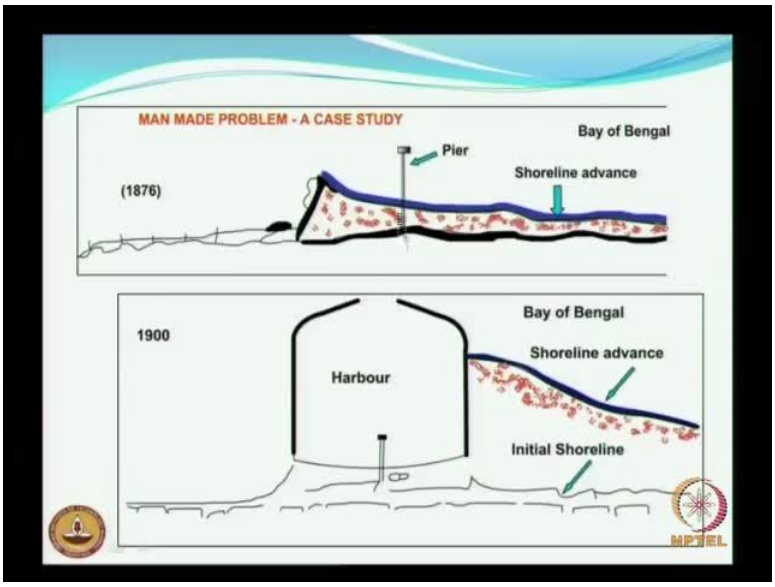

So, they had just a pier jetting into the ocean and that pier itself facilitated the shore line advancement on the north of the pier because as I said the net drift along the east coast is towards north. So, earlier class there was a question why we are not touching about west coast. First, let us finish the east coast and then we will have some few case studies along the west coast. When they realized the advancement of the shore line and also due to the increasing in the marine traffic they wanted to have a harbor basin. The harbor basin was created by having a pair of break waters with an eastern entrance. As you can see this is the eastern entrance.

The moment they constructed this pier of break waters the advancement of the shore line was a continuous process and then it started leading to a fear that they might have problems with the choking of the approach channel because approach channel naturally has to be somewhere here. So, slow bypassing of the sediment will naturally occupy the approach channel. So, that leads to so around the same time there was erosion here. This is a very classic problem you know.

So, you are putting an obstruction in an environment which is dominated by the littoral drift moving from right to left and this is now the direction here. So, naturally you will have the advancement of the shore line and erosion on this side. That time the erosion was not a big problem, but the advancement of the shore line was a huge problem.

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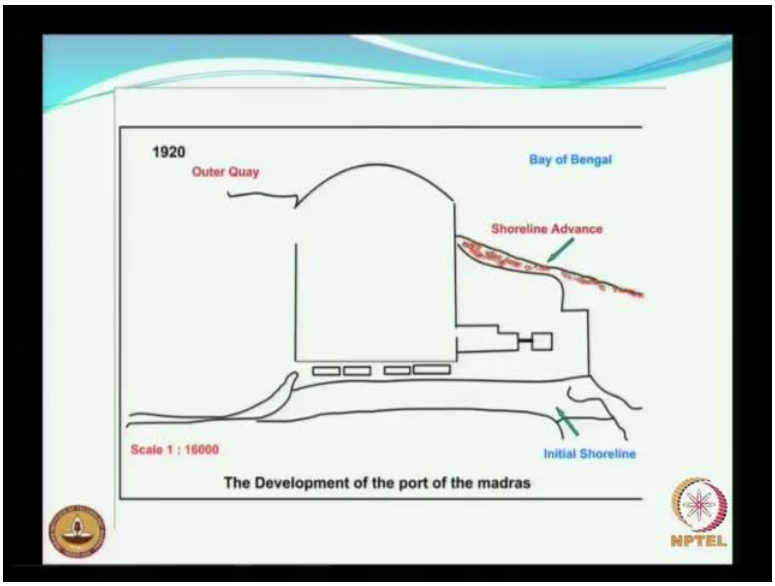

So, what was done in 1920 there was an outer key constructed and this entrance was closed. In fact in the port if you go that still remain the two pillars which were serving as the previous entrance of the harbor. So, this was closed because it was said that the sand will move like this. There may not be much problem, but any port for that matter, most of the ports. After the capital dredging is done the maintenance dredging has to be carried out. Only thing is the how periodical it has to be the maintenance dredging and how much would be the quantity of dredging it depends on the environment. If course, which is going to be governed by the quantity of sediment transportation. So, when this was going, but still this was the problem of the shore line advance was not being solved.

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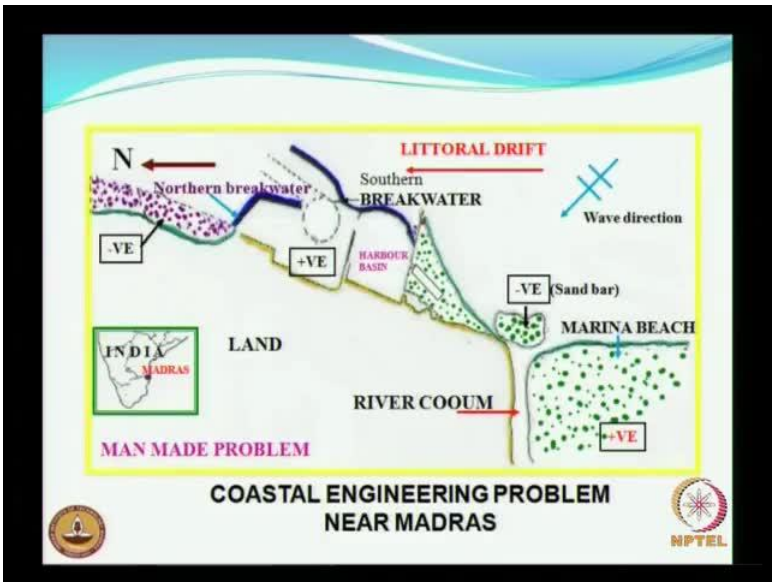

So, this is the present problem. This is not to scale that this figure is just for illustration. What has happened here? The long shore sediment transport is moving in this direction. Now, they extended at the outer arm. I think it is of the order of about 1.7 kilometers or 2 kilometers nearly and this is the inner harbor this is the inner harbor and this is called as the Jawahar dock and this is the turning circle all those things.

So, this is actually the old harbor. They also had a a sand screen, what is the sand screen? Sand screen is something like a littoral barrier which will arrest the movement of sand, but what has happened is in spite of having this barrier the sand was, sand bypasses and still there is some problem with the approach channel. Not, not just because of the movement of the sand from here there is always a littoral drift taking place here. Am I right? Movement of sand will always be there either in form of bed load or in the form of suspended load.

The quantity which it is going to increase is somewhere near the within the surf zone only, but even beyond the surf zone towards the ocean there is certain amount of sand which will be moving and you see that all these areas, this is going to act as an obstruction. So, naturally there will be some amount of long shore currents here also. That is going to also bring in some amount of sand.

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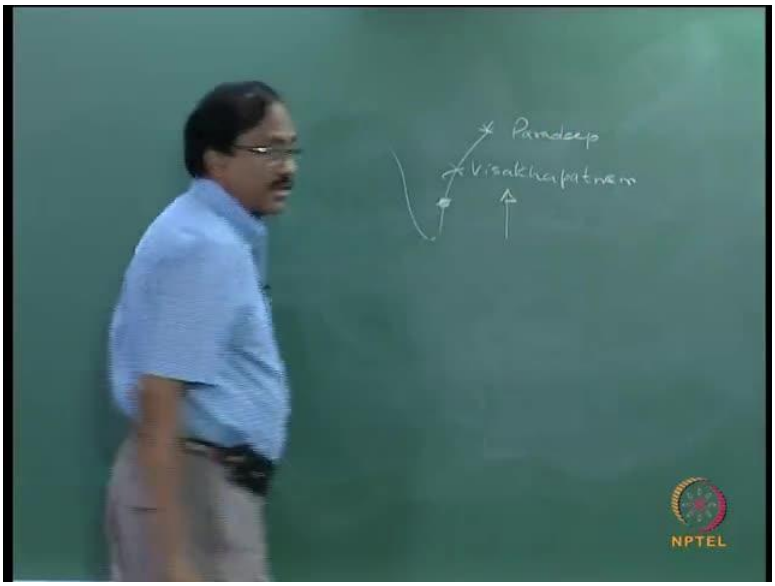

So, leading to the deposition of sand along the approach channel which needs to be rich the problem, this problem is not only for Chennai port it is also for other ports like your Visakhapatnam port or the Paradeep port along the east coast. So, the problem is see mostly the waves are approaching the coast in this direction. When you have the waves approaching in this direction naturally the break water has to be like this, if you want to develop a harbor basin here.

So, tranquility conditions forces us to have a break water alignment like this, but at the same time unfortunately it gives raise to problems concerning the deposition or advancement of the shore line on the south and on the northern side it has disadvantages due to erosion. The advancement of the shore line has both no I mean the problems related to it can have the beach formation on the south of the break water, can have both advantages and disadvantages, but on the northern side erosion is has to be a problem here. So, now you see that the present configuration look something like this.

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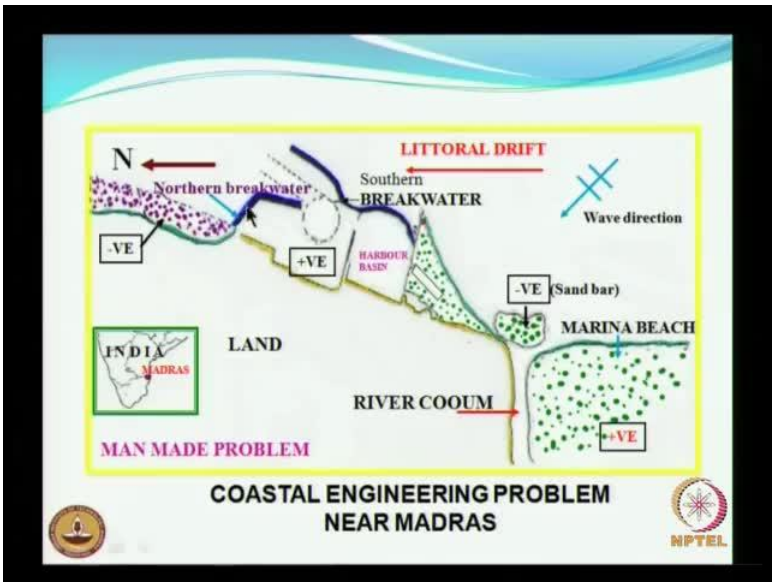

And because of this interception by the littoral barriers that is these are the break waters which the littoral barriers are nothing but the break waters. You have a negative effect that is the coastal erosion directly pertaining to this problem of I mean this topic. So, what are the other? What is the other negative effect? The negative effect is river Cooum. So, you remember some of you getting down at central railway station. The first thing you see is the sinking of you get the pungent smell from the river and unfortunately this river moves all around the megacity of Chennai, but this river is becoming a iso not only a because of so many problems. Particularly it is becoming an health hazard also.

Why? A simple reason the sand bar is found here, closing the river mouth. Once the river mouth is closed what will happen? Where will the water go? It will not go anywhere. So, it becomes a stagnant pool of water excellent for what? Excellent for breading of mosquitoes, excellent for pungent smell and do not you think it is going to be a health hazard? Certainly, on the other side the positive this is because of the deposition of sand, but we do not need the deposition of sand at near the river mouth, do we? No, but the plus point is again due to this is the plus point now.

The negative point due to sand deposition is this closing of river mouth, but the positive aspect of deposition of sand is the formation of Marina beach. The Marina beach is become half the littoral the advancement of the shore line south of Chennai harbor and it

is claimed to be the second longest beach in the world next to Miami beach. The width of the beach gradually increased and it is something like 600 meters now 600 to 700 meters.

Have you ever gone to marina beach? All of you? So, you see the width of the beach right and you see the kind of people there particularly during this kind of summer season. During summer season the marina beach is really flooded, but you never knew that this marina beach is because of this. So, what is the problem here? So, we we are happy with the marina beach, but what is the problem here? How do we solve this? Can anyone give some solution?

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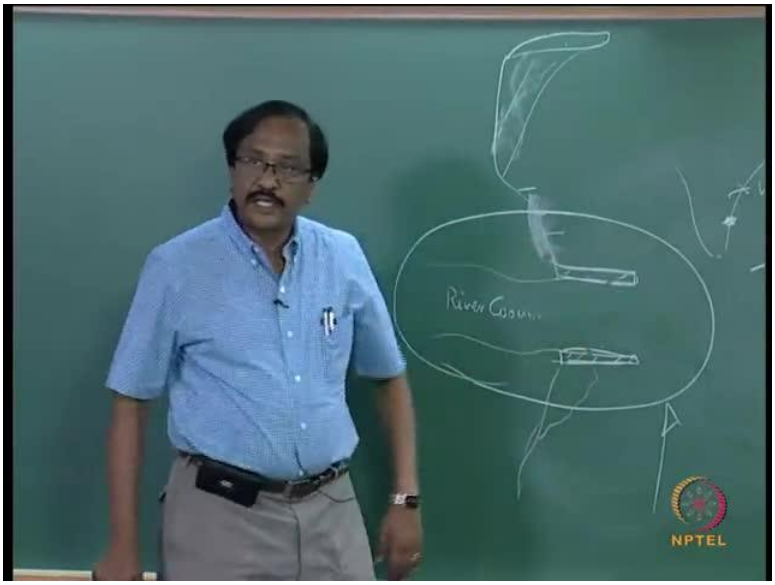

Training wall, training wall everyone can say that when you have an inlet like this which is being blocked by sand you construct a pair of training wall. Is the solution correct? How many of you say that the solution is correct? Not correct? No, you please tell me.

So, the harbor is somewhere here. So, you say the littoral drift is in this direction. So, you say that if as suggested by, what is your name?

Chaitanya.

Chaitanya. So, Chaitanya says he will put a pair of training wall which I feel it is correct. What is your problem? Because of this the sand bar is not allowed to be formed instead I have advancement of the beach, but his concern is this is going to erode, but anyway this break water is there, know. This is the harbor break water now. So, this is the harbor

break water you see in the picture, this is the harbor break water, this is the river Cooum and in between he says that there will be erosion. Can this not be tackled?

There are two things. I agree that the pair of training walls is going to create erosion. So, do you mean to say that we should not construct the training wall? Yes or no? Yes, but initially you objected, but when I said now you are a bit submissive. Now, you agree. So, there is no problem. I can construct a a pair of training walls and if at all there is going to be any erosion here which we could, we have to anticipate. I can have one or two, three or four transition groins to take care of that. I already showed you some nice pictures which is important. In this kind of a situation where this river Cooum is running into a mega city, thickly populated, being blocked.

You try to solve this problem or address this problem. I would address this problem first. So, when I address this problem I would also consider this problem and take care of it. This is what to some extend what is meant by integrated coastal zone management. You just try to integrate all the problems and try to manage the coasts, it is a small example. Is that clear? So, was this done? Was this done? This Cooum problem? I mean the solution.

The solution to this was construction of pair of training walls, but unfortunately the process implemented, but unfortunately it proved to be ineffective for the simple reason not because of the physics because of technical problems. Technical problems in the sense when you construct the groins or the training walls there are very, there are certain important points you need to consider.

So, what I will do is I will consider this river Cooum problem after addressing the coastal erosion problem. I think that would be alright. What is this problem, is it a natural problem or a manmade problem? It is a manmade problem because of the presence of the harbor break waters you have a and now we are dealing with all these problems, but here we are not directly involved. But I will give my comments in the next class probably. So, we will, is that clear?

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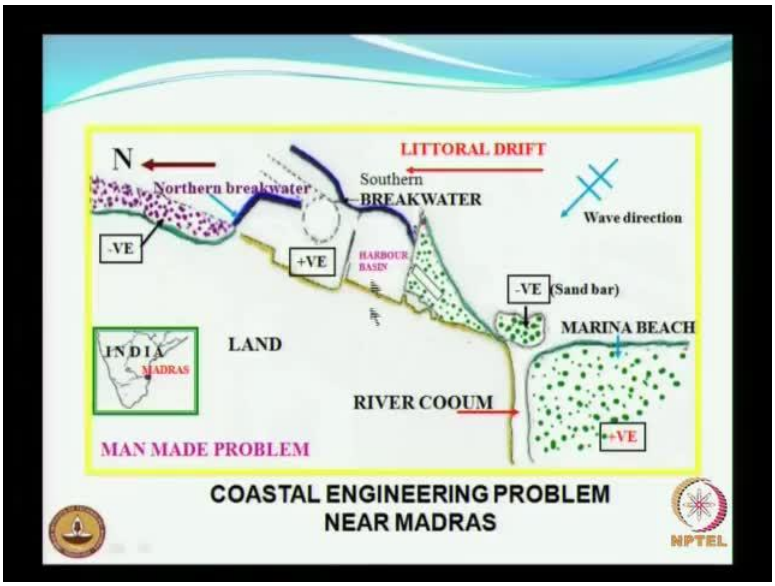

Now, here this problem has become more severe. In fact if you ask me personally this problem is much more serious than this problem because there as so many people living along the banks of the river. Yes, I will be talking about this tomorrow, about this dredging point also I will be discussing. At that point of time you ask. In the next, next on Monday right? We will discuss about that. Not that this problem cannot be solved, this problem can be easily solved provided there is a detailed engineering study and implementation in full, I will explain to that, explain it later.

Now, the negative problem is negative aspect is this erosion. The erosion has gone over a distance of about 12 kilometers, 9 to 12 kilometers and we have lost nearly 500 meters or even slightly more of width of the beach. So, many buildings have gone into the ocean along the coast because of this in spite of several solutions that where being attempted. I will just show you some of the problems, some of the solutions attempted and the final solution which has given a significant amount of relief.

So, this problem has been in existence for nearly 5 decades. Now, we are in 2011. For the first, for the last five decades we had been experiencing this erosion problem. We will look at the rate of the erosion along the Tamil Nadu coast.

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Sl.No.	Location	Length in m	Accretion/ Erosion	Rate in m/year
1	Pulicate	0.71		3.20
2	Ennore	3.27		1.30
3	Royapuram	5.38		6.60
4	Marina	2.97		1.70
5	Foreshore	2.3		1.09
6	Elliot/Astalakshmi temple site	2.08		1.28
7	Kanathur	0.24		1.4
8	Kovalam	3.15		0.81
9	Mahabalipuram	5.45		.25
10	Pondicherry	1.19		0.15
11	Cuddalore(North)	1.538		8.00
11a	Cuddalore (south)	0.483		2.98
12	Poombuhar	1.905		0.65
13	Tranquebar	.76		1.80
14	Nagapattinam	4.27		0.11

Sl.No.	Location	Length in m	Accretion/ Erosion	Rate in m/year
15	Point Calimere	6.66		3.40
16	Annapattinam	3.6		0.72
17	Keelakarai	2.9		0.29
18	Mandapam	2.19		0.25
19	Rameswaram	3.3		0.06
20	Tiruchendur	1.53		0.33
21	Manappadu	1.6		1.10
22	Uvae	2.6		0.86
23	Kanyakumari	0.7		1.74
24	Manakkudi	3.65		0.57
25	Pallam	2.6		0.93
26	Muttom	3.0		0.17
27	Manavalakurichi	2.5		0.60
28	Colachel	1.75		1.20
29	Midalam	2.5		

Tamil Nadu coast is, this is sea area. Somewhere here this stretch of the coast about 900 kilometers there is about small stretch of the coast about 50 kilometers on the west coast also. This whole coast about 950 kilometers they have carried is a vulnerable location for coastal erosion.

So, Tamil Nadu coast has estimated that this area which we are discussing now, right now that is this area which is called as Royapuram they have estimated to be the highest with about 6.6 meters per year getting eroded. In fact that is on the lesser side, it is, this is on an average 6.6 meters. So, there are other locations where you have so the red line indicates its erosion and the other ones shows that it is deposition. So, I will just look at some of the other location unfortunately I have not given you the latitude and longitude or presented any picture because I was not, I am not interested in showing you point by point. This slide is just to illustrate that the location which we are discussing today is a location which is experiencing severe erosion.

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So, this is a typical view of the Marina beach which we had discussed. This is a age old picture, but it gives you the kind of beach and in fact this is much more now, much more wider.

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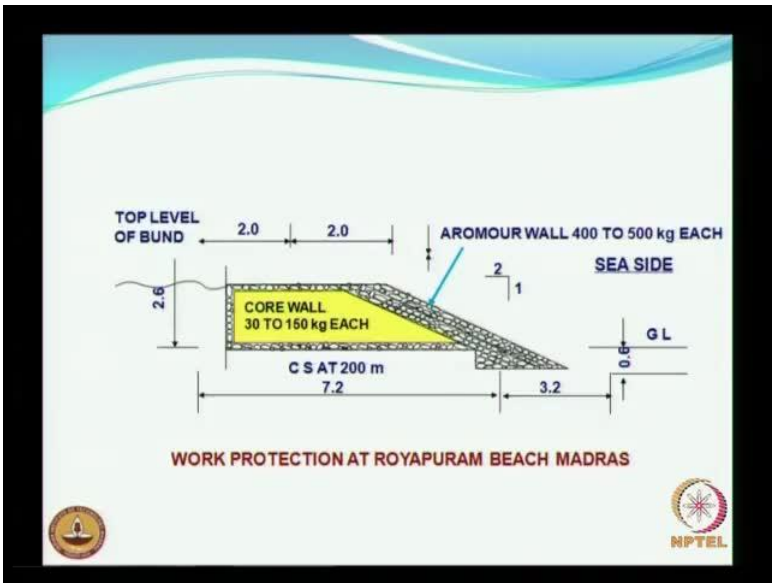

What was the solution that was attempted for a protection measure for the Royapuram beach? This had a core wall with 30 to 150 kg's the weight of individual stones with an aromour 1 is to 2 and the aromour layer consisted of only 400 to 500 kg stones. So, by looking at the figure if you later work out some of the examples then you will

understand, then you will be able to immediately say what kind of structure this is because when you calculate using the size of a stone. So, here you have the size of the stone, please remember when we do the calculation of the weight of the stone for a particular wave height.

See, how normally the weight of the stone is directly proportional to H cube. All of you know this, right. That is used by the that is based on the Hudson's formula which we will be seeing anyway people who have not, have not heard about Hudson's formula do not worry we will be having a lesson on that, but then once the weight is known you can easily calculate the wave height. Now, if the wave, weight is 500 kg then you can calculate what is the weight or what is the wave height that it can sustain. When you do that the weight will be around less than 1 meter and very often the wave height will be exceeding 1 meter right. So, naturally during a kind of a small monsoon I mean a moderate monsoon itself the whole structure will collapse.

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So, this collapses and I wanted to say that along the coast you know, along the coast north of harbor there is a coastal highway. On that coastal highway got collapsed as you can see here.

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So, for example, I will this is the harbor, this is the river Cooum and this is the area which we are talking about eroding. This is the area. So, along this coast there is a road, there is a highway and this highway has collapsed because the erosion has penetrated even the highway. Initially there was a small road, but then there was a highway formed, but part of the highway also collapsed. What is this solution? Around the same time there was a severe water problem for the city of Chennai or that time it was called as city of Madras and we had what is called as Veeranam water supply scheme.

Under this scheme from the outskirts of the Chennai Veeranam lake, we wanted to get the Veeranam reservoir, we wanted to get the, the idea was to transport the water through pipelines. Unfortunately the, this water supply scheme failed. For this purpose of this water, for the purpose of this water supply scheme there were lot of concrete pipes, precast pipes already ordered and it was lying all along the coast, but when the water supply scheme is failed all these pipelines were just lying along the coast.

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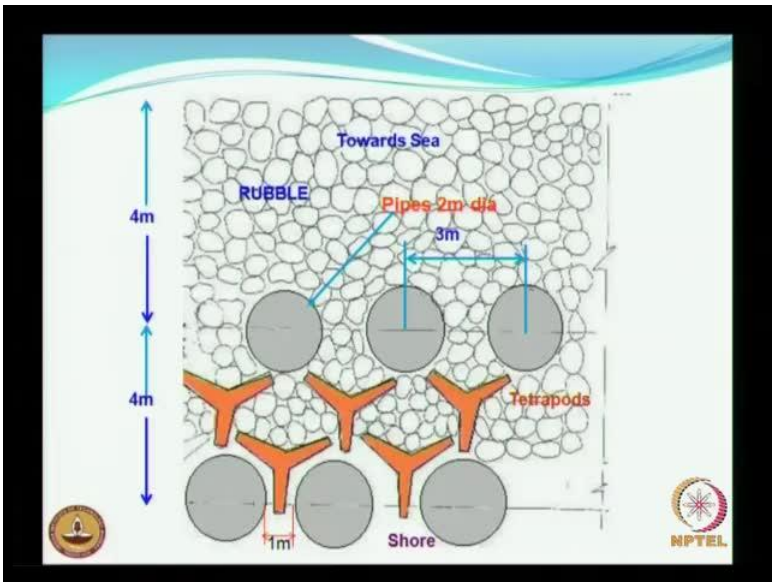

And for some unknown reasons it was decided that we, they will use the pipes for the protection of the Royapuram coast, you understood? So, what they did is they used a combination of tetrapods. Tetrapods are, it has four legs. I will show you the model of tetrapods when I take about the, when I take the lecture on break waters. So, right now you imagine that this is, this has four legs. So, the tetrapods were put here and you see that this is only 8 meters and the clear distance was maintained as 1 meter. Alternate, I mean spacing; it was spaced in an alternate fashion. The pipes diameter was 2 meters and this was placed here.

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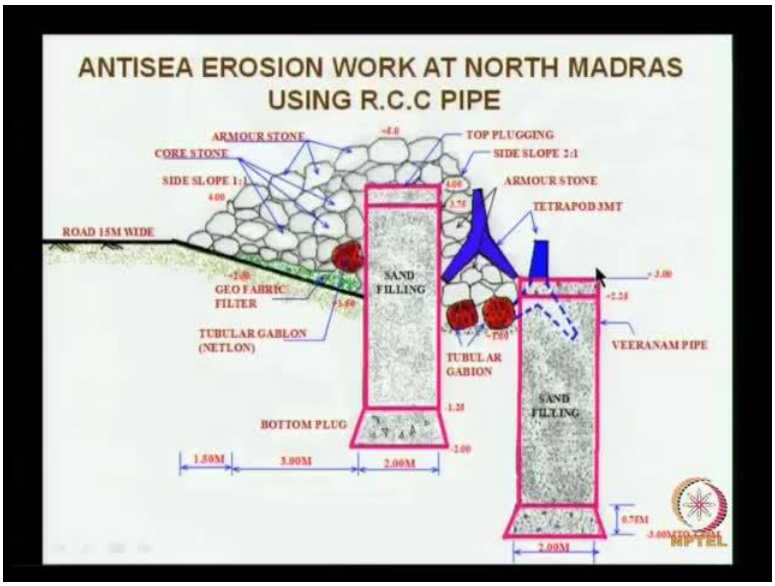

And in section this is the concrete pipe wherein they filled with sand, caped with a concrete and then erected it as shown here and in between they had put tetrapod's plus they had gabions. That is small size stones are being used. So, they had used gabions. All of you know what is meant (( )) Do you think that this is a good engineering solution? You have to be bold, when you are clear about engineering you have to be clearly bold and say is it worth investigating or not. It was already in installed, as I told you any vertical obstruction is very dangerous and there are absolutely no toes cover given.

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And this is the situation in a mid-90s when the problem of coastal erosion of this location was referred to us. So, all these, most of these pictures were taken by us. So, you see that this is the coastal view of the tetrapod on the concrete pipes. The erosion before implementing some of the locations and look at the concrete pipes, the erosion has gone behind the concrete pipes, then some of the concrete pipes due to scour has lost its stability and it has gone down plus you see the falling down of the and you see the extend of erosion.

There is the guy who is standing here. So, that gives the depth of erosion taking place and this is again a closer view. Again all this survey, all this photographs was physically done by the students of our department, that is Department of Ocean Engineering, IIT Madras complete survey and we designed; we came up with a solution.

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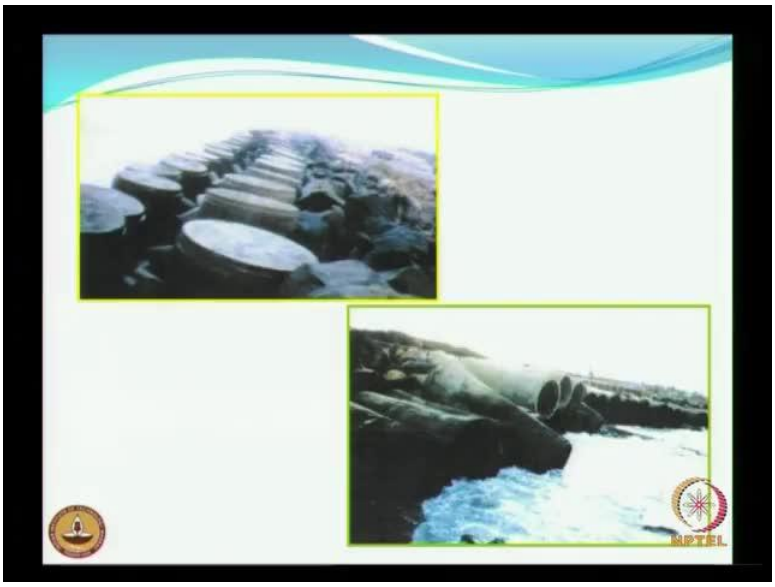

So, look at some of the pipes. What I will do here is we will continue the rest in the next class.