Port and Harbour Structures
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Module 11 Lecture 48
Model Studies for a Deep Water Port Case Study

For environmental impact assessment as well as to understand the behaviour of the plot own constructed numerical modelling is generally adopted now a days. Earlier we use to do a physical model also, but only important projects now we do a physical model. A physical model is generally done in India at a place called central water power station in Pune. We have one major port for defence coming on the east coast for which they have the model setup there.

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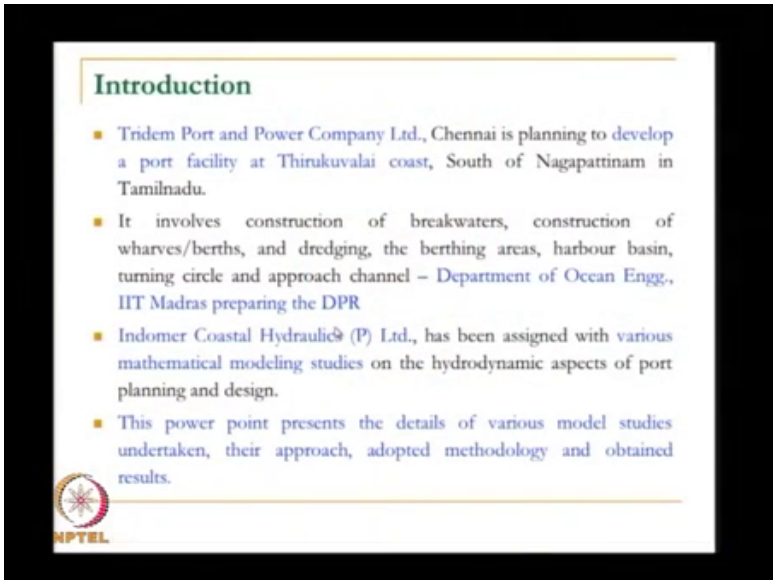

But this class we will be seeing we will be discussing about the numerical model, the port requires the port waters berths, dredging. Dredging is in the berthing areas, harbour basin, training circle and approach channel. All these things were prepared by department of ocean engineering and the design of break water, design of berths, methodology for dredging, disposal and what is the berthing area, harbour basin area training circle area pro channel everything comes under detailed project report.

We also give the cost estimate. Indomer Coastal Hydraulics is a private company. This has carried out the mathematical modelling studies. But this type of studies can also be done in our department. I also have the software as well as commercial as well as in house softwares

developed are also available. So in this lecture we will see the approach for carrying out these numerical models. What are the methodologies adopted and the results?

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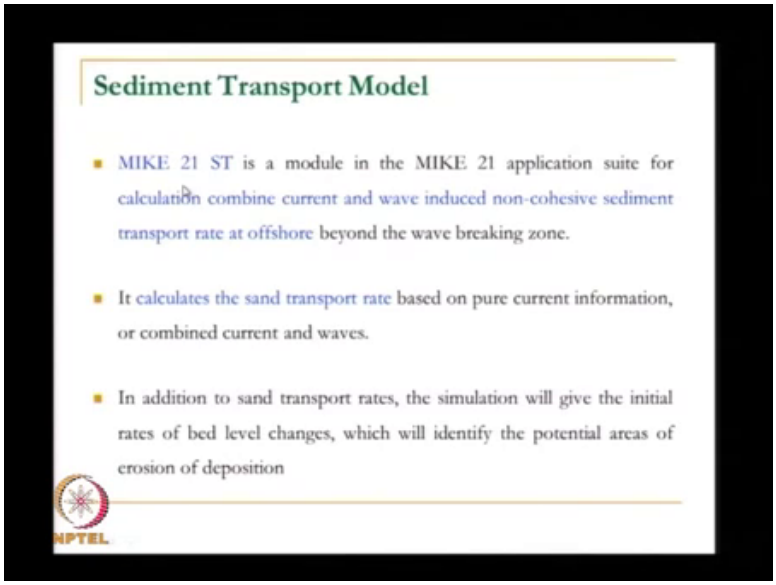

We use software called Mike 21. This is used for calculation of combined current and wave induced, non cohesive sediment transport rate at offshore, beyond the wave breaking zone that is the capability of this model. Basically you want to study how much sediment will be disturbed.

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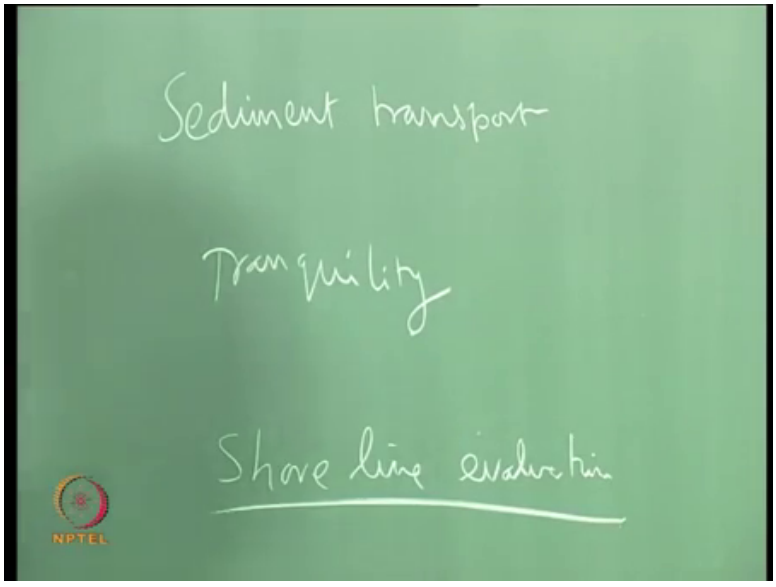

So we will be discussing about 3 aspects one is the sediment transport, the next one what we will be doing is we will discussing about that tranquillity the third one we will discuss about

the shore line evaluation. These are the three aspects we will be discussing. So all these studies are required because we have constructed the break water and that will create some erosion and deposition.

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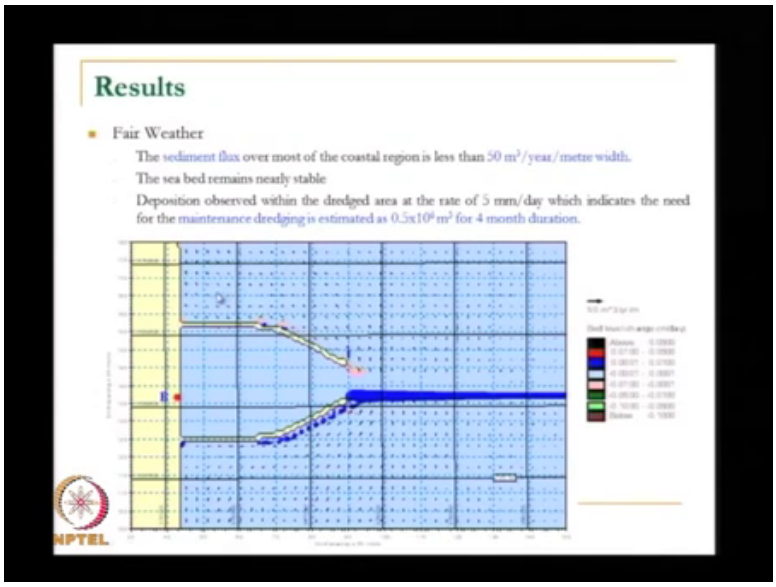

This is the layout of the break water almost symmetrical I am showing the result, the result is for 3 seasons one is fair weather, north east monsoon and south east monsoon. So for fair weather the sediments flax will be less. The unit for sediment flax is, how many meter cube of sediment per year per metre width that is per metre width. Mostly the studies are concentrated beyond the breaker zone that is if there is a one metre wave if there is a 0.78 metre wave that will break in 1 metre contour.

So this model estimate beyond the wave breaker zone how much sediment will be transported. There is a arrow indicated which is 50 metre cube per year per metre width that is per metre width is per metre width. And the length of the arrow indicates this is 50 metre cube this may be around 10 or 15 metre cube. That is what it shows.

We are giving one more colour code this is 5 millimetre per day that is the rate at which the deposition take place is about (5 metre per day), 5 millimetre per day. So there is an entrance channel which is here. So in this area during fair weather season there is a deposition the rate is given in metre per day that means it will be about 10 millimetres or 10 centimetres this one 0.01. There will be a negative sign here that means there is a erosion, is it clear?

There is deposition as well as erosion. Generally the deposition quantity and erosion quantity is the same. So this channel in this area there is a deposition somewhere here there is a

erosion which is taking place. This is calculated as 0.5 into 10power 6 metre cube for about 4 months duration. So we have 1 year period out of which 4 months are fair weather. During that the maintenance dredging is estimated about 0.5 into 10 power 6 cubic metre. The purpose of this sediment transport analysis is to find out how much will be the sediment transport and how much will be the citation.

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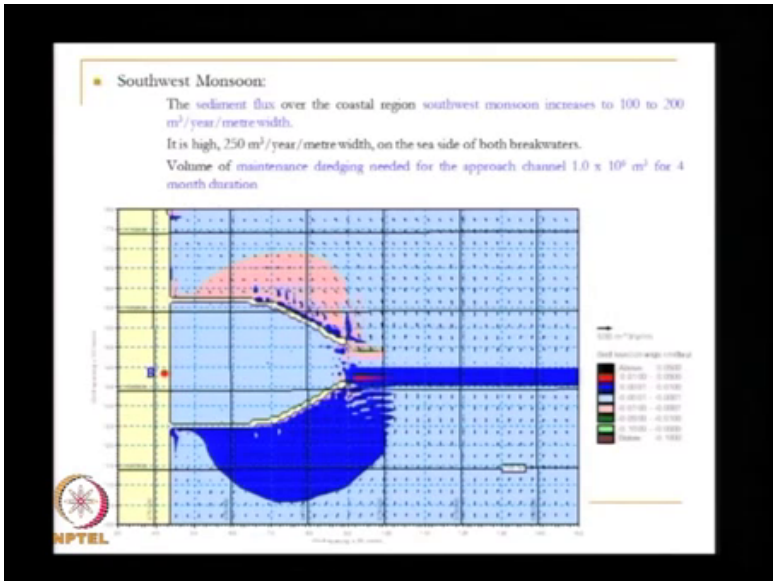

This is the southwest monsoon, so compared to the fair weather season you can see for the south west monsoon the sediment flux is increased from 50 to 100 to 200 cube. So this on the sea side of both the quarters that is this is the southern break water this is the northern break water. This is the sea bed side of this break waters it is about 250 cubic metres. This shows the deposition and this shows the erosion.

So south west monsoon the waves will be coming from this side. This volume of maintain and dredging is about 1 into 10 power 6 cubic metre for about 4 month duration. This is the south west monsoon. Here also you can see what the deposition rate is. Your entrance channel is getting deposited like this.

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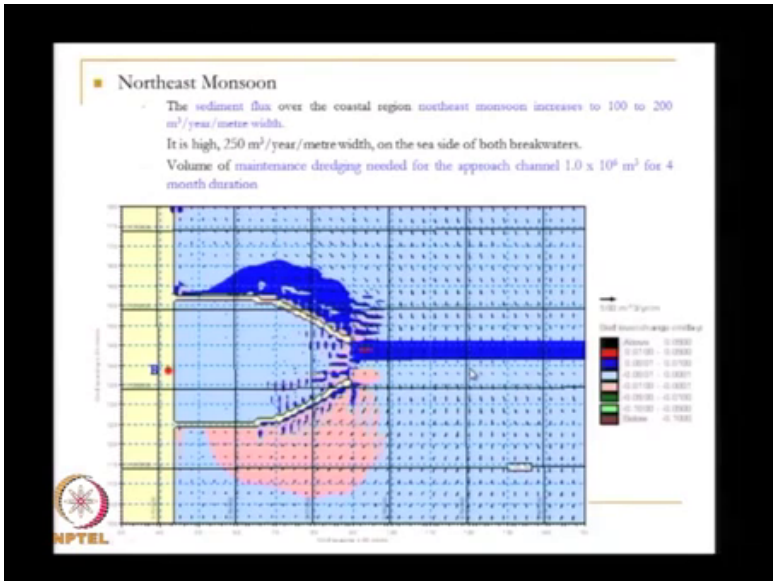

Now you tell me what does this blue colour indicate? Depositing, hmm? Why it is depositing here? North east, because the wave direction is like this depositing here and this will be erosion and if you see the previous figure the deposition was somewhere here this side of the channel whereas here it is on the other side of the channel. And north east monsoon is also about 100 to 200 cubic metre but this quantity is also estimated to be 1 into 10 power 6 cubic metre for 4 months duration.

But this is not the general behaviour if you summarize you have seen this is 5 into 10 power 5 it is 0.5 into 10 power 6 cubic metre. This is 1 into 10 power 6 this is 1 into 10 power 6. So this is the maintenance dredging is for a length of about 18 kilometres long channel which is 16 metre depth is about 2.5 million cubic metre per annum. This is the total quantum that is required.

You understood the purpose of doing this study. First what we have to do is, we have to carry out a bathymetric survey then we have to find out what should be the width of the channel. Last class I discussed what is the width, what is the length of the channel, length of the channel is very long 30 kilometre because at a distance of 30 kilometre only you have natural depth of 16 metres available.

This is not an ideal location for a port. Typically the 16 metre contour should be available within about 2 kilometres whereas it in 13 kilometre this project is located at this place because the power plant is nearby. Already they have a got a permission for a power plant that is why they are locating. And there is a software called HYPACK. If you give the

bathymetry survey, bathymetry survey means what is the water depth at different locations before construction of port.

Then you put the location of the break water navigation channel and other training circle then it will calculate the capital dredging inside the basin as well as the approach channel that is coming to be about 24 million cubic metre this is also very high. Gopalpur port which we discussed it is only 5 million cubic metre whereas it is 5 time costly 24 million cubic metre. Approximately 10 percent of this will be your maintenance dredging.

For engineering and when you want to work in a design organisation you should have certain numbers you cannot have the maintenance dredging about 30 percent of the capital dredging. It cannot be 1 percent also. Generally it is between 5 to 10 percent. If you are not getting within the bandwidth you have to check whether there is any mistake or otherwise. This particular project is southwest monsoon and northeast monsoon the deposit rate is almost the same.

Generally it does not happen like that in some places southwest monsoon deposition will be higher compared to northeast monsoon. We have divided this into 4 equal months. Sometimes the southwest monsoon is taken 6 months and northeast 3 months and fair weather 3 months. It depends on the location. Any doubts in this? as we are going to the study.

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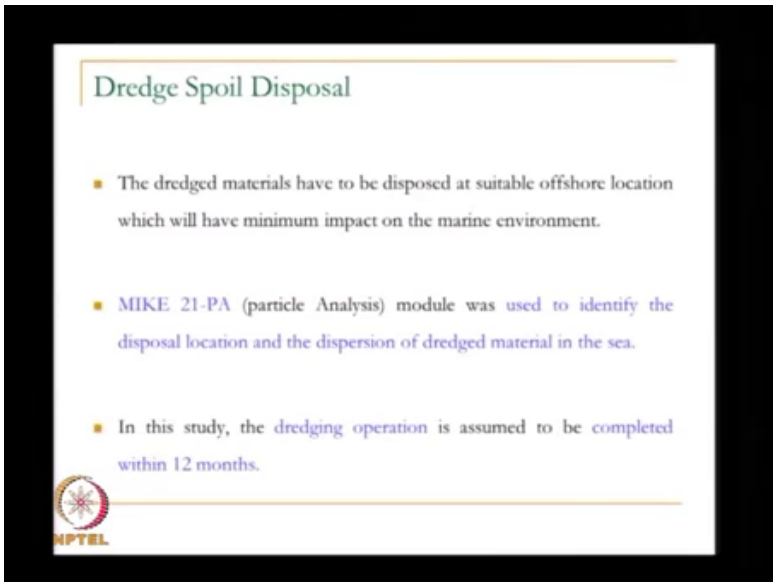

This is that I have not written here once you dredge it both capital and maintenance dredging this also I discussed in one of the lecture how to dispose the material. This MIKE 21 has different modules. One of the modules can be used for this study. We are assuming that the

total dredging will be completed over a period of 12 months that is a duration of this dredging operation.

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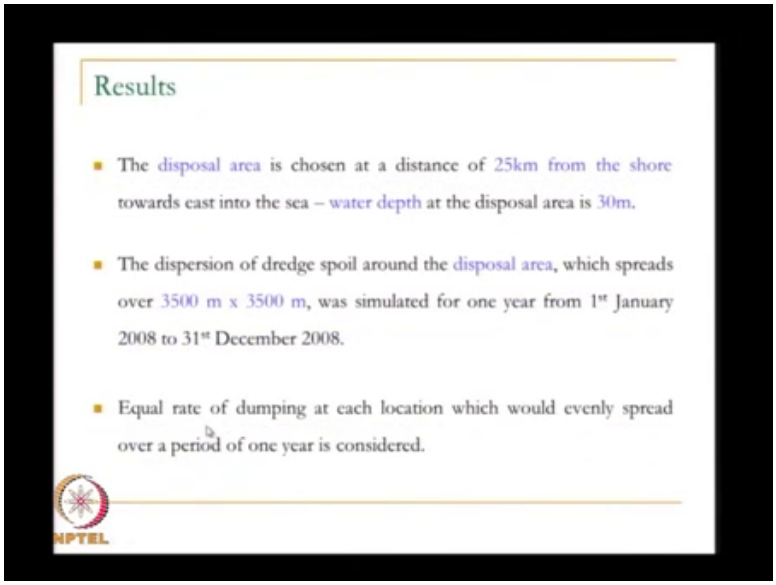

Then we have to choose a disposal area this at a distance of 25 kilometre from the shore towards east into the sea and the water depth is considered is about 30 metres sometimes we consider 50 metre also. So the disposal carried out at a water depth of 30 metre. The area over which the disposal takes place is about 3500 by 3500meters and we are simulating from first January to thirty first December 2008 for one year period. And we have different locations, I think 16 locations I think and we will be studying the dumping at this 16 locations.

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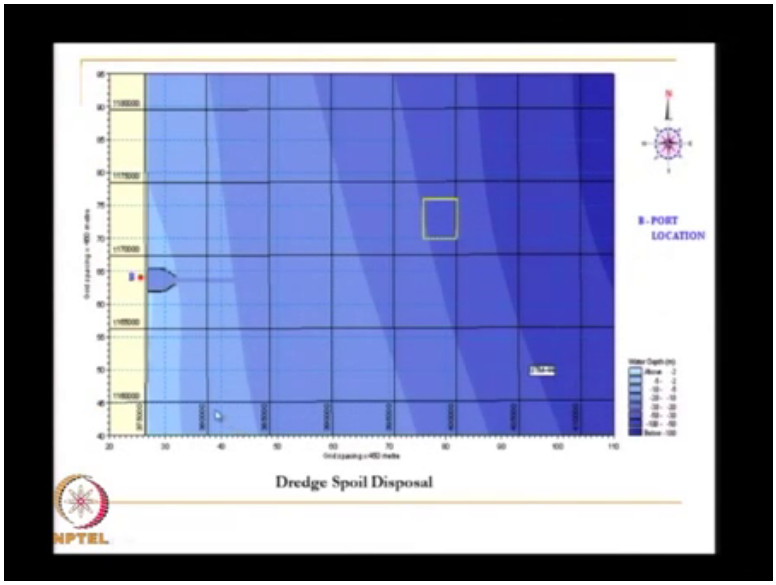

This is your break water this is your entrance channel this is the location for dumping area. Here we have given grids spacing into 400 metres that means if it is 60, 60 into 400 is 24 kilo metres, something wrong here no no it is not starting from 0 ok it is starting from 30 38. So this distance is about 24 kilometres. One of my students has done a mistake he has not multiplied by the grid spacing. He told that 80 metre we are getting 20 metre contour got the point?

Whenever you use a commercial software or general purpose software you please read the manual. Normally we do not do it even if you buy some equipment kitchen equipment or electrical equipment you just open the box and put the plug and start using it. You should not do it you have to read the manual. Similarly I have seen many youngsters who are venturing into this they do not read the manual. But when we started working in Numerical methods using software we generally do not use the commercial softwares.

We develop our own softwares in that case we know what is inside. So what you are doing is a black box. Atleast when you use a black box you read the manual. Let us start doing it this colour code gives a water depth at various locations so here it is a darker mainly because we are dredging it here more. So this is how this water depth has been simulated.

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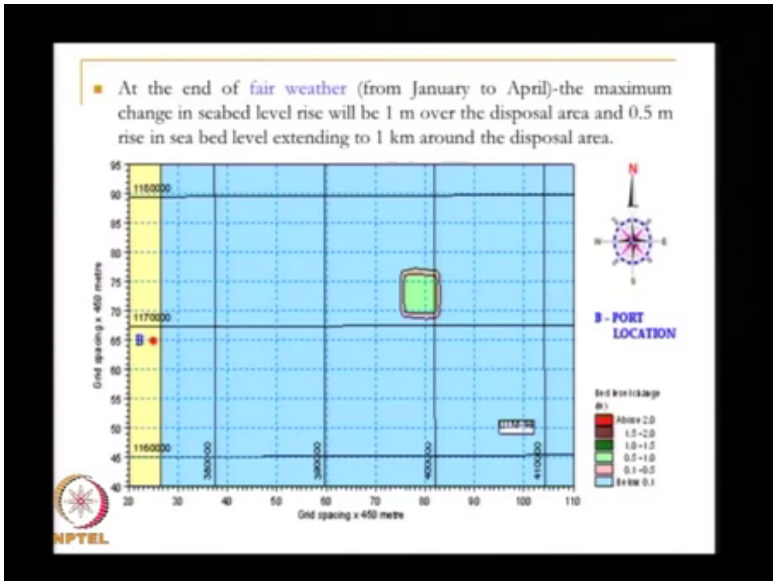

So here also we are deciding into fair weather I did not say which is the fair weather, fair weather is from January to April. The maximum sea bed level rise is will be about a metre or the disposal area and 0.5 meter rise in sea bed level extending to 1 kilometre around the disposal area. So suppose this is a point of disposal here it will be rising this green colour is here 0.5 to 1 metre and where the distance of about a kilometre on all the sides this will increase to 0.5 metre. That is this 0.1 to 0.5 metre it will increase.

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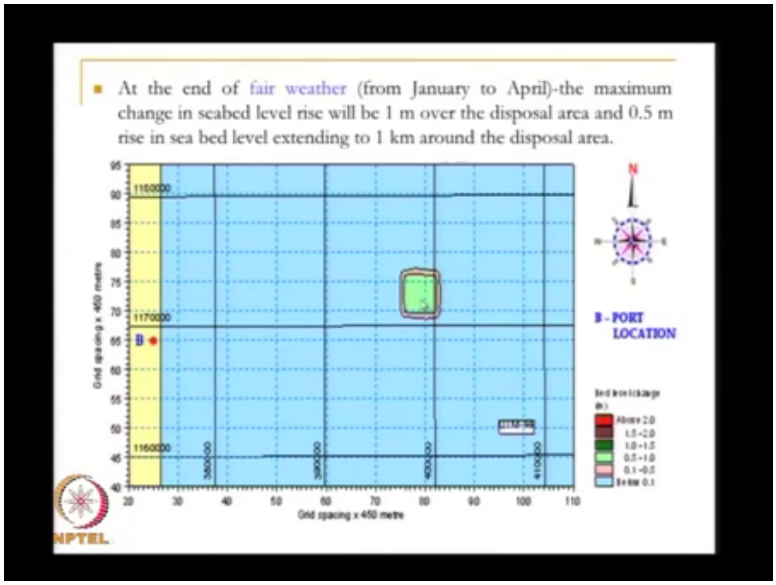

So when you dispose the material here how much increase in the bed level this is what is been shown here.

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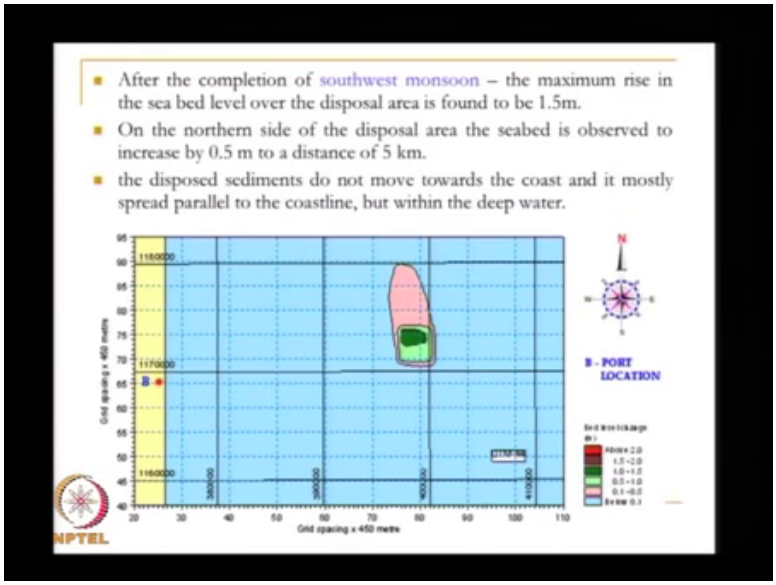

This is during the southwest monsoon. So if you see here disposal it is a uniform around the disposal point. It is symmetric in both the directions. What is happening here it is not symmetric, why? There are two types of currents one is a tidal current another is a wave induced current. This is mainly due to wave induced current because in fair weather also you will have the same tidal currents. So southwest monsoons means the waves will be moving in this direction. So the sediment is displaced here.

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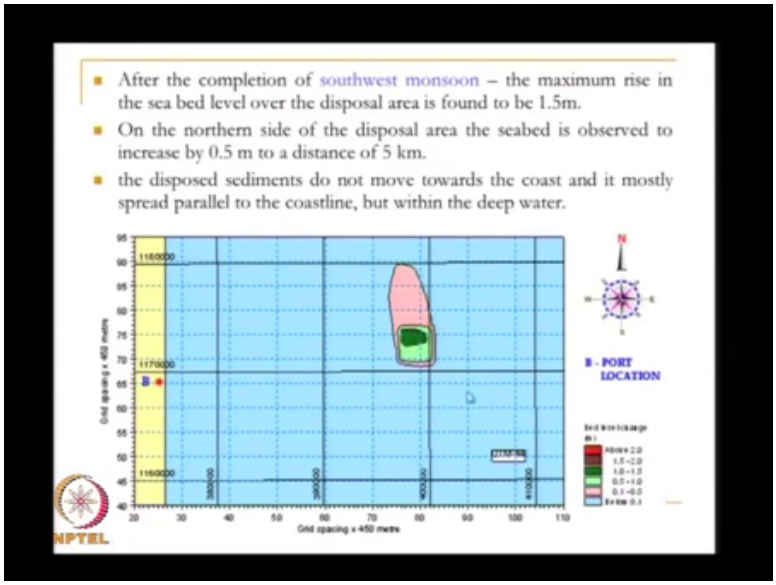

This black patch correspond to about 2 metre 1 to 1.5 and 1.5 to 2 metre increase in bed level and about a distance of 5 kilometre earlier it was only 1 kilometre now at a distance of 5 kilometre the bed level increases by 0.5 metre. Another important aspect what we interested

is the sediments should not move towards the coast line. The disposed sediment do not move towards the coast and it mostly spread parallel to the coast line it is also within the deep water.

See we are bringing a vessel with 16, 17 metre draft let us say here the water depth is 25 metre it will be less by 1 and half metre 23.5, still you have sufficient margin. But MOEF says the bed level should not increase more than 0.5 metres. So subsequently this grid spacing that area over which the disposal to be carried out has been revised.

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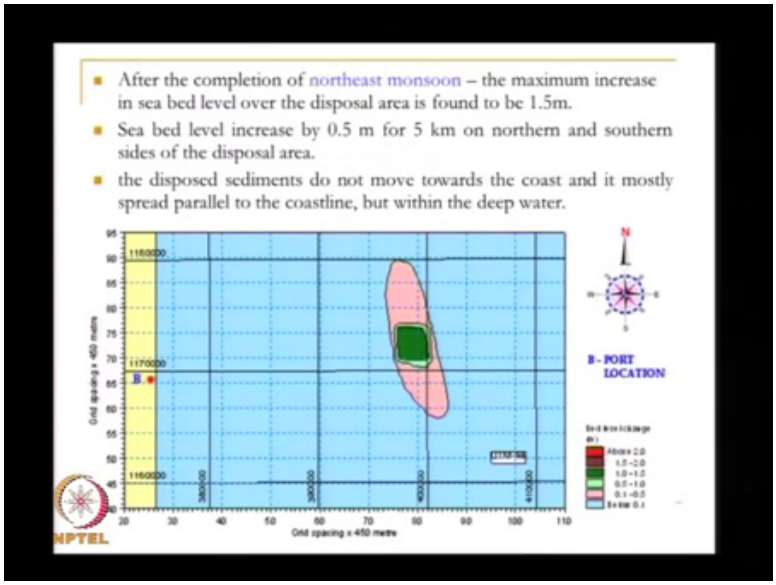

This is a peculiar in north east monsoon we did not expect that to go like this but it is going in both the direction during the north east monsoon. And north east monsoon also the quantity of sediment is very high over the patch 2.5 metre. See north east monsoon is very difficult to predict if you say the wave rose diagram is not always unidirectional and some times you have some waves coming from the east also. And depends on the site also what is the input data we are giving.

If you are we have to give input data. What is the input data we are giving you have to simulate different wave site and wave periods and wave directions. So all these things will have an influence on this. Strengthening the north and south is almost same. I have to see what input they have given. It depends on the location where we are disposing location means your wind rose diagram.

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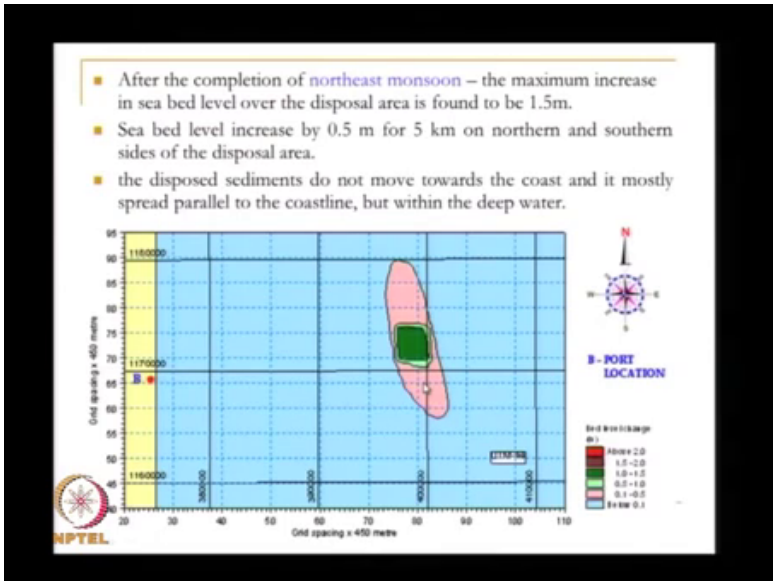

Personally I do not have this but it should not be like this it should be mirror image of this, whatever is shown here it should be the mirror image of this. May be we will see the tranquillity at that time we will see what is the angle we are using.

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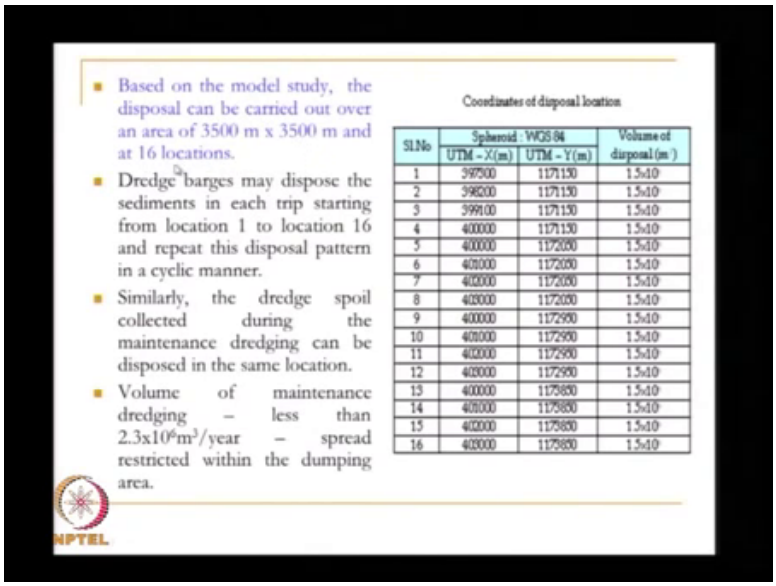

So we have given 16 locations to give the UTM coordinates and the volume how much you are disposing in each location what we are do is we have to start from the first location and go to the sixteenth location then come back to the first location and then do the sixteenth locations. Like that you should continuously do this is done for capital dredging the same thing can be done for maintenance dredging also.

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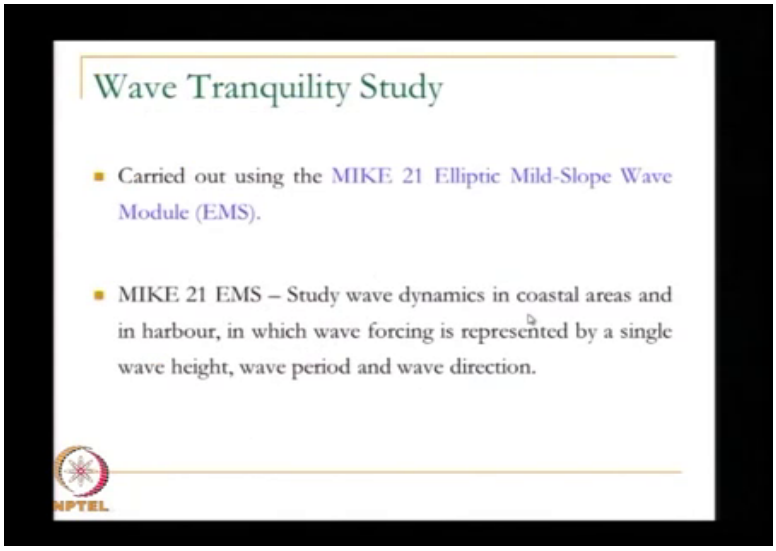

So these are the two studies which we have done one is the sediment transport and the dredge disposal. The next study is wave tranquillity study. So you are supposed to know about this elliptic mile slope wave module this equation is there which is used to solve this problem. So we have to study the wave tranquillity for a single wave height, wave period and wave direction.

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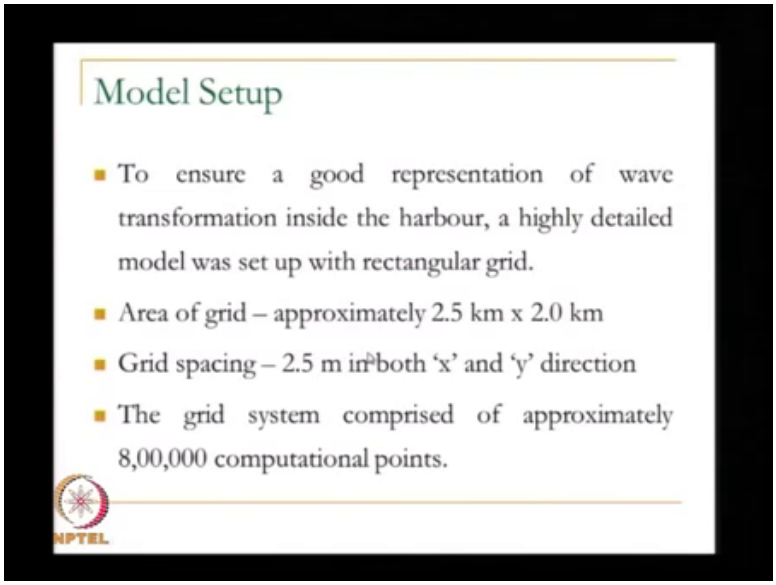

Whenever you do this type of modelling one of the main requirement is what is the area you are taking for the study, here we are taking 2.5 by 2 kilometre. Suppose you do not take the area properly then also the model will fail. The second one is what is the spacing of the grid points that should be 2.5 metre is a fairly closed grid which you are using. And we have 800000 computational points within this grid.

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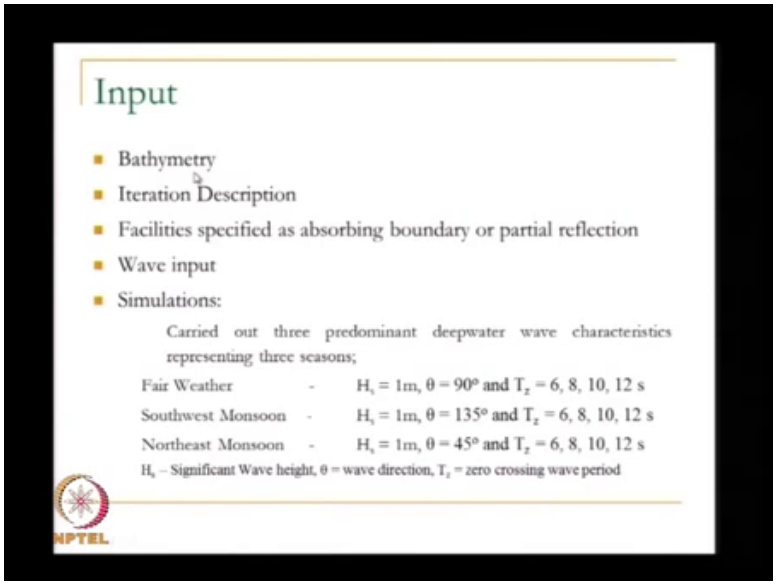

So we need the bathymetry it is a iterative method we have to describe that then we have to provide the boundary condition. Some of them are observing some of them are partial reflection that means if there is a break water it will observe some of the wave energy that has to be given if it is a vertical wall it may reflect those boundary conditions to be given. And we have to give the wave input.

I have given the wave height is 1 metre but if the wave height is higher or lower we can multiply correspondingly, because it is a linear analysis. Suppose in fair weather wave height is 0.5 metre in south west monsoon 1.5 northeast monsoon 1.2 you can multiply whatever results you have got by the corresponding magnitude that is why you are doing it for unit wave height.

The fair weather the wave direction is assumed as 90 degrees southwest monsoon 135 degrees and northeast monsoon 45 degrees. And then we do the analysis for each wave period each one has to be done separately you have to have the model and do the analysis for 1 metre 90 degrees and 6 seconds then 8 second 10 second 12 second then 1 metre 45 degrees 6 second 8 seconds 12 like that you have to do for all these combinations.

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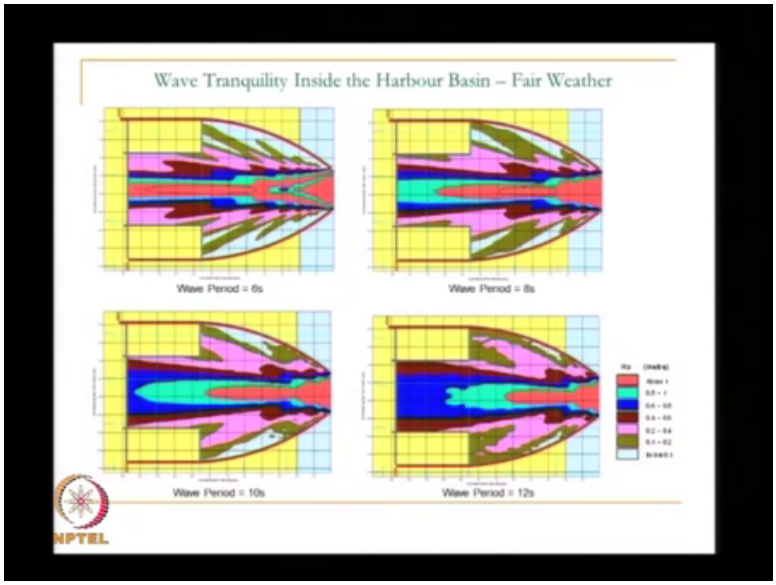

This is not the total area in which the study has been carried out. That is done for I think slightly higher area I think. But the fair weather season the waves are coming like this. The red colour indicates about 1 metre it goes straight away into 1 metre here. And the berths are located somewhere here this is the point where container berths are located (this is the point) this is the area over which we have the coal berth located.

Very close to the berthing area we have lesser wave heights that is 0.2, to 0.4 metres. When you see about 8 seconds 10 seconds and 12 seconds it gets reduce here it gets reduced to 0.6 to 0.8 that is what is written here.

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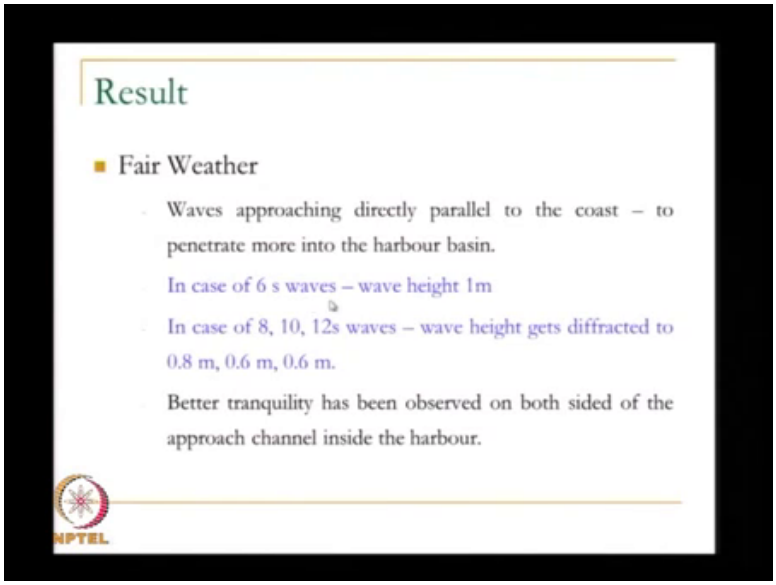

For 6 seconds waves all the waves are (())(22:33)same as 1 metre. But higher period waves when it goes inside the wave height become lesser. The better tranquillity has been observed and both side of the approach channel inside the harbour. This is approach channel so when either side of this we have better tranquillity. So this is about the south west monsoon and north east monsoon.

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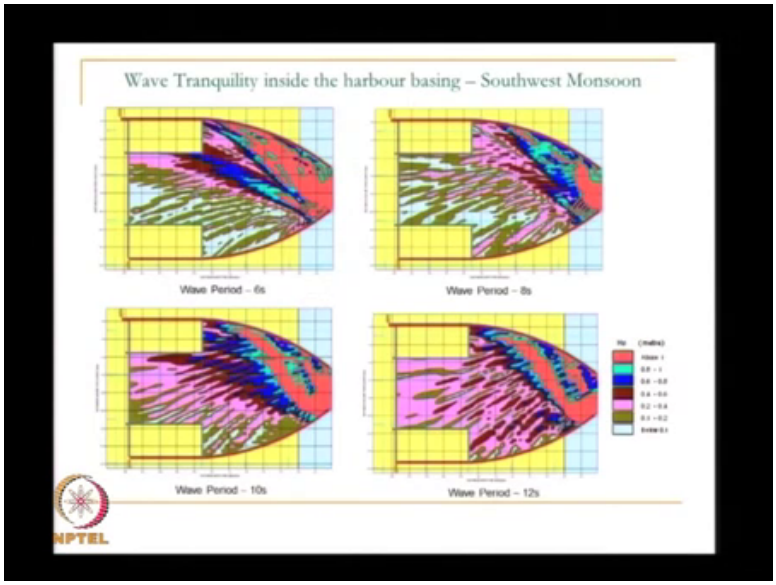

So here you will get a different pattern here south west monsoon the waves are going like this 135 degrees it will penetrate like this and you will have better tranquillity on this side of the berth and this is a north east monsoon the wave will penetrate like this and you will have a better tranquillity here. You understood this tranquility studies that is showing the wave heights at different points.

Finally when a ship is to be in this location, we have to see what is the permissible wave height you have to multiply that unit wave height by the corresponding wave height and see and tell how many days the berth can be operational. Based on these studies they have decided to extend one of the break water further that was the conclusion.

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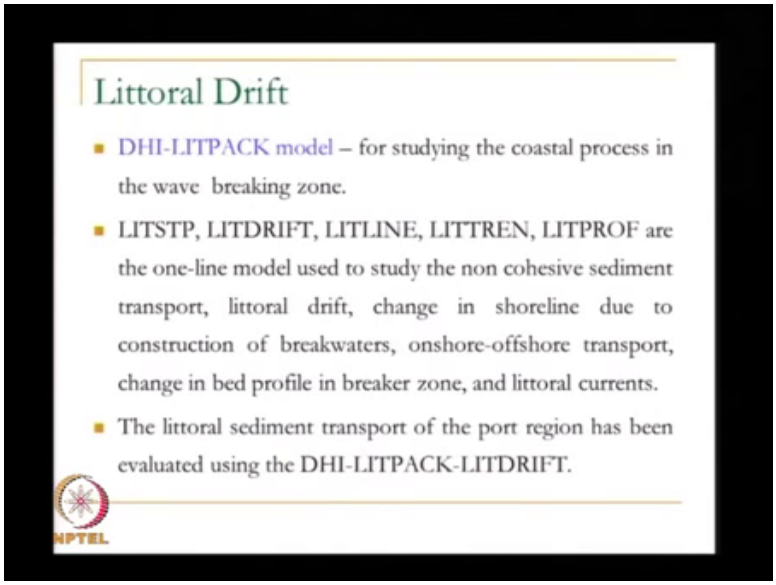

The next model is literal drift this is very important for shore line evaluation that is the third study which I have written here. This is developed by one institute called Danish Hydraulic Institute. We will be using this model for finding out the shore line changes. The shore line changes occur due to construction of break water on shore – off shore transport change in bed profile in breaker zone and literal currents. These are the various requirements.

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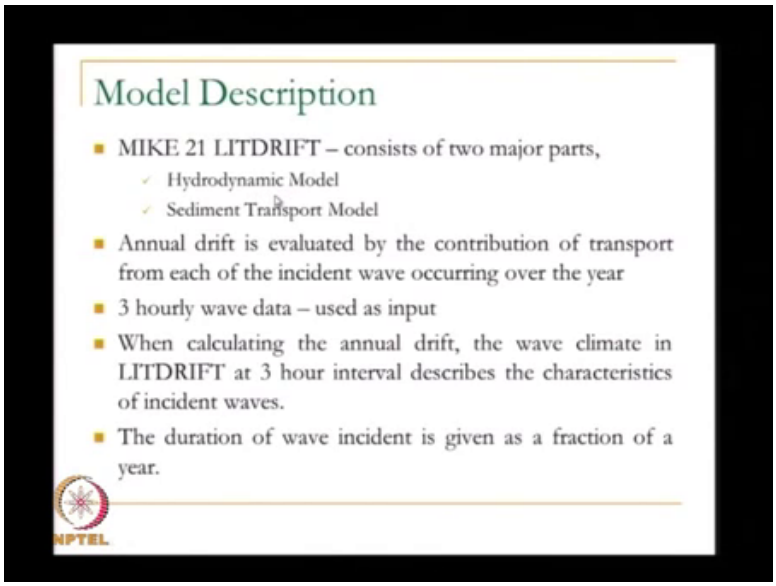

This LITDRIFT model consists of two parts one is the hydro dynamic model another is a sediment transport model. So this transport is for each incident wave occurring over the year we get the three hourly wave data. Generally we record this three hourly wave data which is used as a input.

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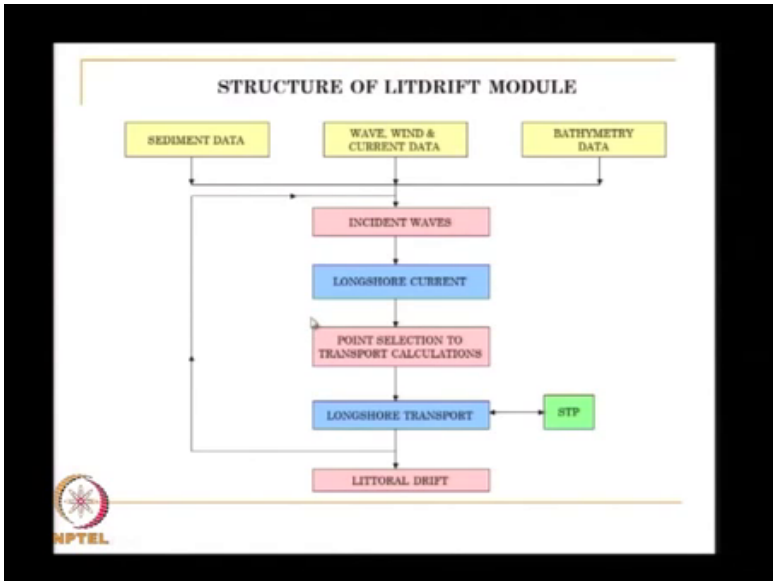

Now this shows the flow chart for this module You have to get the wave wind and current data, you have to get the sediment data you have to get the bathymetry data wave wind and current data typically consists of for wave it is wave height, wave period and direction, wind is wind speed and direction, current also the direction and the velocity. Bathymetry data means water depth at various locations. Sediment data means they will give the particle size d 50 size.

One of the classes I explained what is the D 50 size that is to be input. Then we have to input the incident wave long shore current, point selection to transport calculations, and then long shore transport then you have to calculate the literal drift.

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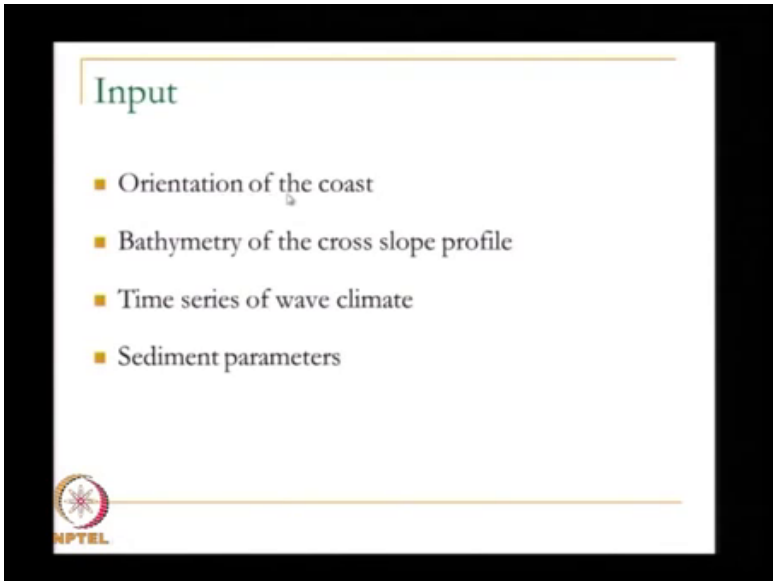

I write about the orientation of the course because generally the orientation of course is not parallel to north south. So you have to mark the orientation of the course normally the orientations the directions everything is given with reference to the true north. This shows the quantity of a sediment transport.

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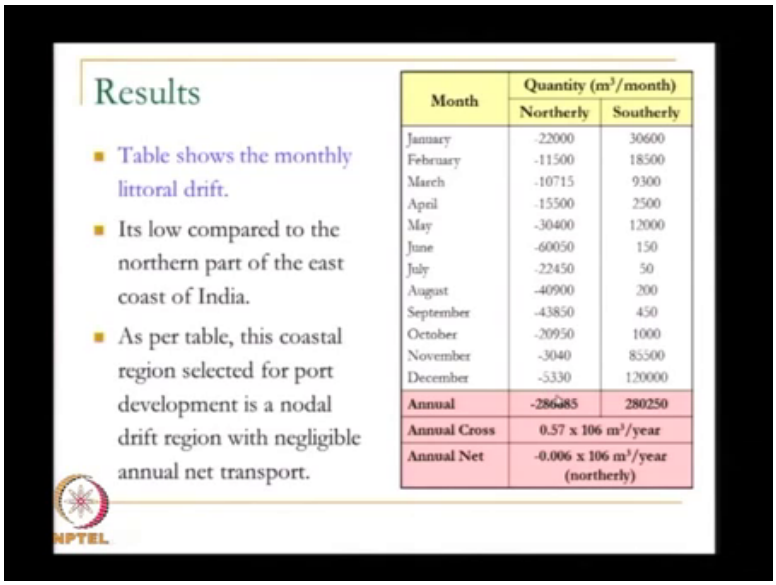

Month	Quantity (m^3/month)	
	Northerly	Southerly
January	-22000	30600
February	-11500	18500
March	-10715	9300
April	-15500	2500
May	-30400	12000
June	-60050	150
July	-22450	50
August	-40900	200
September	-43850	450
October	-20950	1000
November	-3040	85500
December	-5330	120000
Annual	-286685	280250
Annual Cross	0.57 x 106 m^3/year	
Annual Net	-0.006 x 106 m^3/year (northerly)	

See there is a difference between what we are calculating here and what is shown there what is shown in the first slide that is to find out the sediment transport beyond the breaker zone. Breaker zone means where the way break. And here shore line evaluation we are very much interested about the sedimentation from the shore to the breaker zone. That is why 1 metre the wave is breaking. What we discussed earlier is beyond the break water which is a 02 kilometres.

Here it is 0 to 1 kilometre that is the width. So this annual is like this net is very small this is 10 power 6 it is not 106. This is typical of that coast this coast is near Nagapatnam where the literal drift is nearly 0, you have a northerly drift and southerly drift which are equal and opposite and there is no net drift that means there won't be any severe change in the shore line evaluation.

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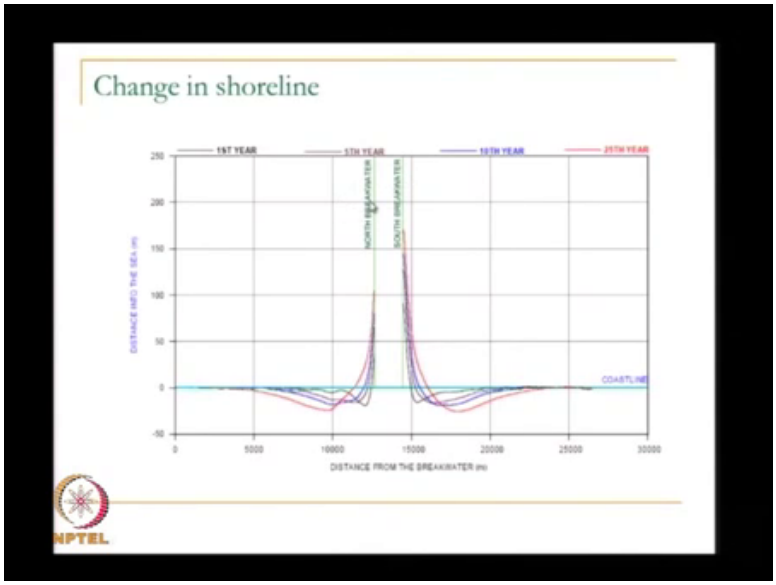

So this shows the result what is happening this is your shore line of the coastal line and this has been developed for about 250 metre into the sea. Here the distance from the break waters are shown these two are the north and south break waters they are extending for about 2 and half kilometres. Each break water is going for about 2 and half kilometres. But we are showing only 250 metres and here we are showing first year fifth year tenth year and twenty fifth year.

this is the first year, fifth year, tenth year and twenty fifth year. The shore line adjacent to the break water gets deposited both the sides north as well as the south. Deposition is more on the southern side less on the, you see the distance it is deposited about 160, 170 metres whereas here it is 100 metres. The distance from here is about this 5 kilometres this is from 15 to 25 about 10 kilometres here it is about 8 kilometres.

Afterwards there is no effect of this break water, so the break water is about 2 and half kilometres, three times the length of the break water afterwards you cannot see any effect. What you are seeing is this is the original shore line at a small distance there is a deposition afterwards there is a erosion. Erosion is about 25 metres it is almost the same on either side about 25 metres.

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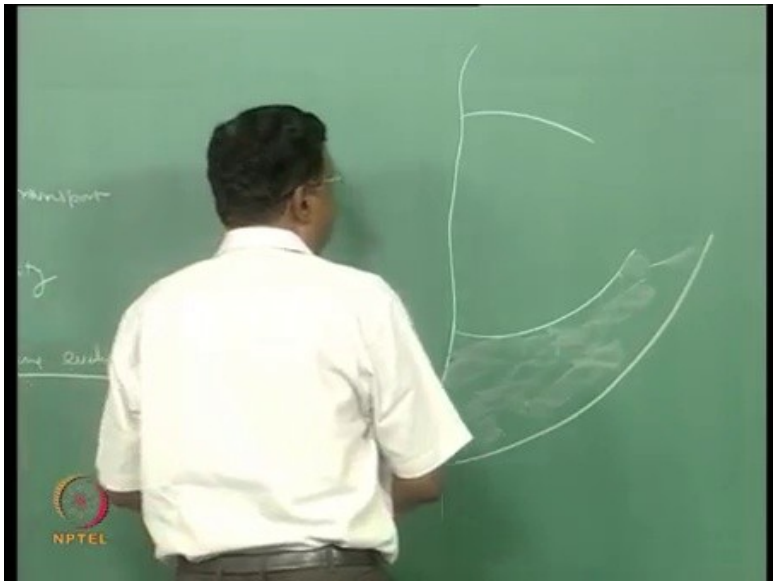

So this is not a very serious issue as far as this particular project is concerned, but if you see the Chennai Port where you have the break water originally built like this. Whatever figure I have shown there the deposition has taken place like this. This much area has got a positive that is why you are seeing Marina beach and all then this there was entrance channel here. So when this deposition takes place it goes and gets deposited here again. This is what I said back.

Then what they did is they extended this break water further towards this side. This also called bypass and they extended one more like this. The problem of this deposition getting it goes to the entrance channel is the maintenance dredging will be verify so it should be avoided.

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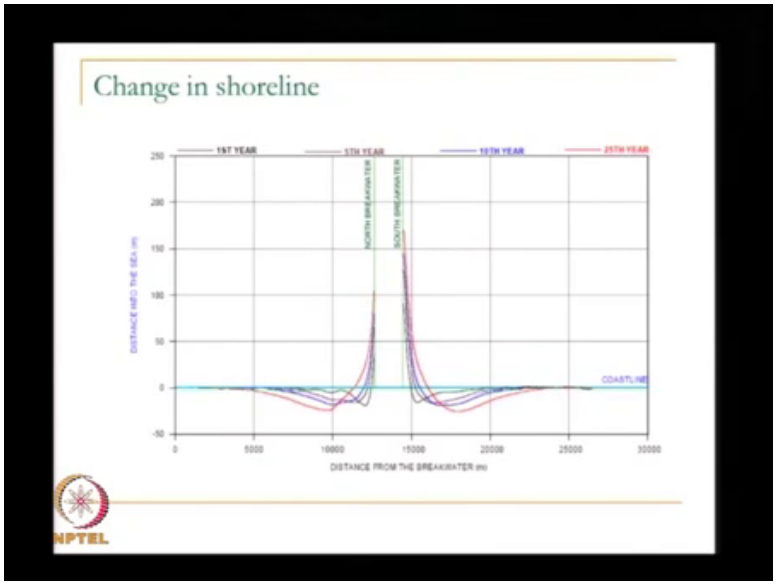

The another aspect is here deposition is seen on both the sides whereas in this particular project for this Chennai coast line.

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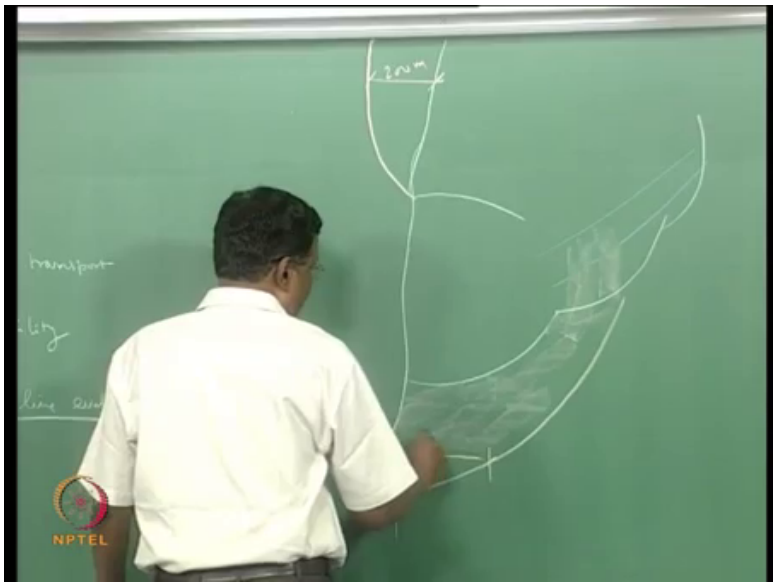

The erosion is taken place like this, this distance is more than 200 metres, this deposition is on an average is more than 500 metres. So about 200 metre of coast line I have got eroded on the northern side. (())(31:52)is here only but sometimes it has gone even 400 500 metres also on the northern side. Subsequently our department only has given some solution to this we have given some crowing fields like this for about 8 to 10 kilometres.

And afterwards only this there was a highway which was going on this side it is a national highway going to Calcutta, they will lay the road and the road will disappear one season only it will be there. Then again they will shift the road towards inside like that they are doing. For this particular project Chennai port is NITDRIFT is 1 million cubic metre, here it is nearly 0 whereas there it is 1 million cubic metre towards north.

South north is about 1.3 million cubic metre, north south is about 0.3 cubic metre NITDRIFT is 1 million cubic metre. But even now there is the bypassing is taking place even today after the extension you have not able to arrest the this is called as the bypassing of sediments. They use the entrance channel as the silt rap and they are removing they are removing there sediments which are there in the entrance channel.

So to summarize this particular site the sediment transport beyond the breaker zone only deposits in the entrance channel whereas in a harbour like Chennai port it is a sediment transport beyond the breaker zone as well as the bypassing of the sediments both the things will contribute to the depositions. But after some years about 30-40 years this will get stabilized.

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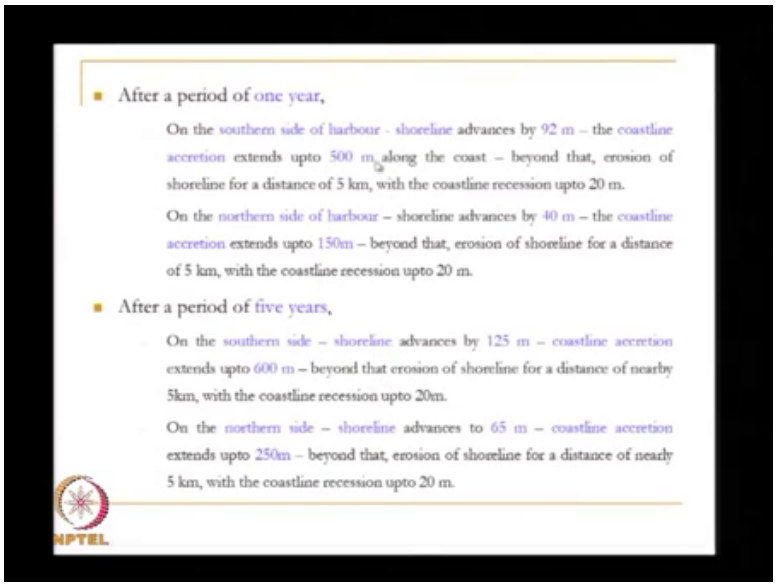

Shows in detail what happened after period of 1 year, after 5 years;

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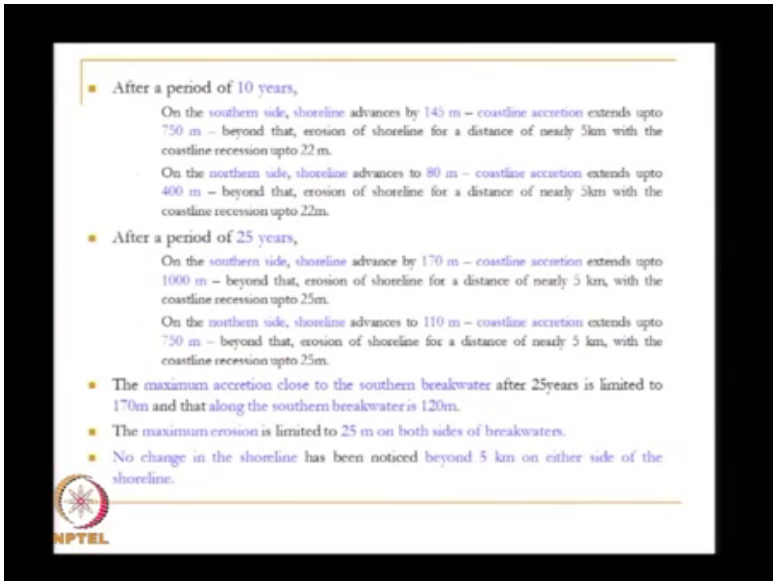

After 10 years; To summarize the maximum accretion close to the southern break water of 25 years is limited to 170 metres and that along the southern break water is 120 metre. So what they are telling is this is 170 metre and this is 120 metre. Maximum erosion is limited to 25 metres on both sides of break waters.

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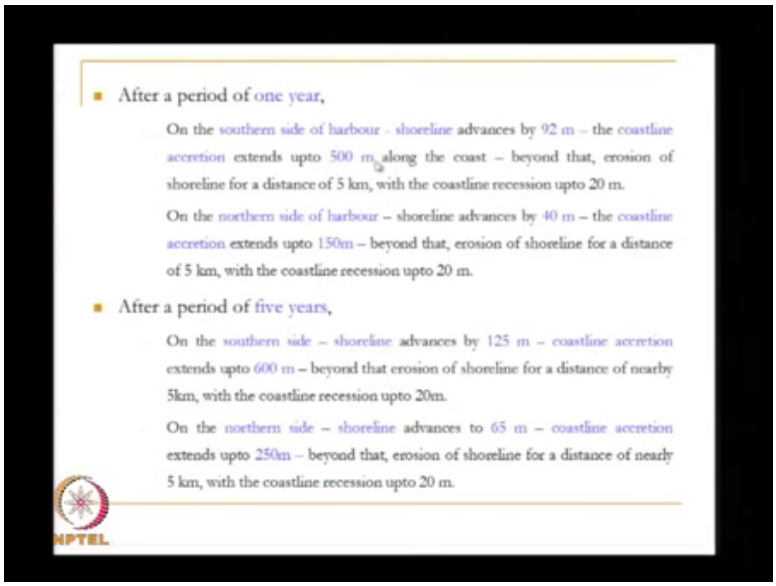

So this is a 25 metre this is erosion on both sides of the break waters. No change line shore line has been modified beyond 5 kilometres on either side of the shore line. So if you see the distance from here about 5 kilometre and 5 kilometres there is virtually very negligible chain.

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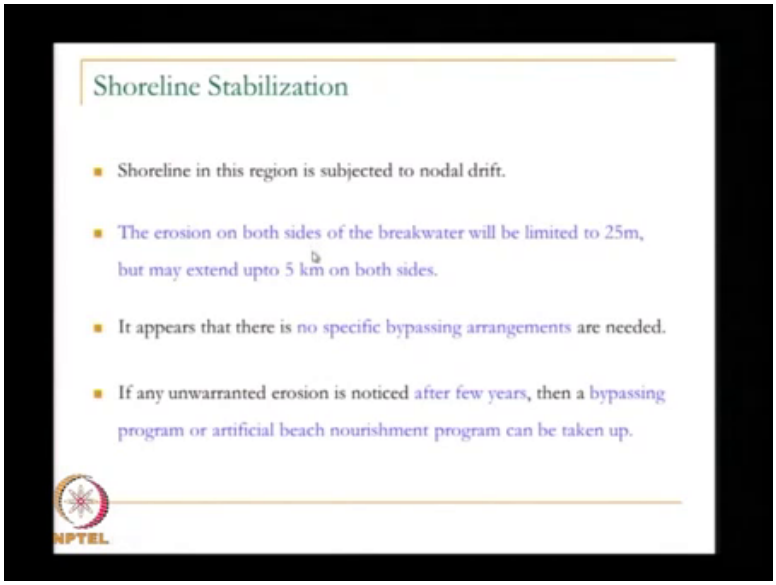

So what is to be done for the shoreline stabilization? So we do not need a bypassing arrangement. Bypassing arrangements means you remove the sediment from the southern side and put it on the northern side so you do not need this. If anything is seen then we can go for a bypassing program.