Port and Harbour Structures.
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Module-2.
Lecture-8.
Bathymetric Survey.

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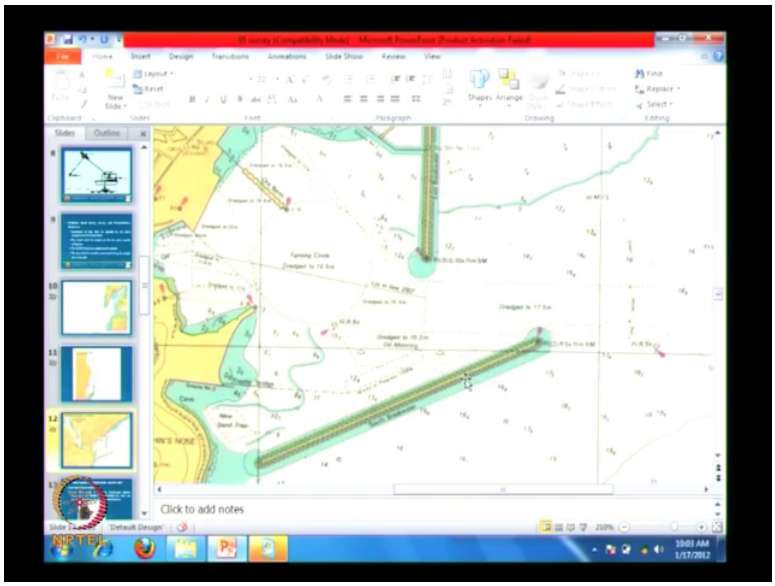

So last class we were discussing about the bathymetric survey, it is published by the naval hydrographic chart. So in this slide, I have zoomed breakwater, turning circle and entrance channel. Here you are seeing a number, the number is 12 suffix 2, this means 12.2 metres below the chart datum. Chart datum is generally the lowest water level, so that we will not be, the ship in all tides when it is travelling, we need the water depth at the low water, that is what is shown.

This line what you are seeing is the 10 metre contour line, generally this is typically required for development of many ports what distance this 10 metre contour line is there, it is given in bold colour. What you are seeing here is about 19.4 metres and this line what you are saying is the 20 metre contour line. This is the breakwater which was built and here you are seeing 16, 16 4, things like that, 11 means it is 11 metres exactly. Then there is turning circle which is to be dredged to 16.5 metre, there is an over berth which is to be dredged to 16.5.

This is the entrance channel, this is partly in the protected zone and partly in the expose zone, where we need higher water depths 17.5 metres. It is clear now what it gives, this I have

zoomed and given it to you. And you can clearly see that you take this debt that random but still it gives required information and this is available for the ship Captain to command. When the ship is coming here, normally the captain of the ship, he hands over the ship to the Port conservators.

He hands over the ship to the Port conservators, Port conservators, each port he knows the requirement at every port and he knows all the details what is required. So the ship Captain is playing from one place to another place, one is forced to another port, whereas the ship, for conservator of each port, he takes over the ship once it enters. The tugboats also goes and connect to the ship, then they bring the ship through this entrance channel. When turning is required, they turn through this. This is what is the movement of ship that will take care, that will take place.

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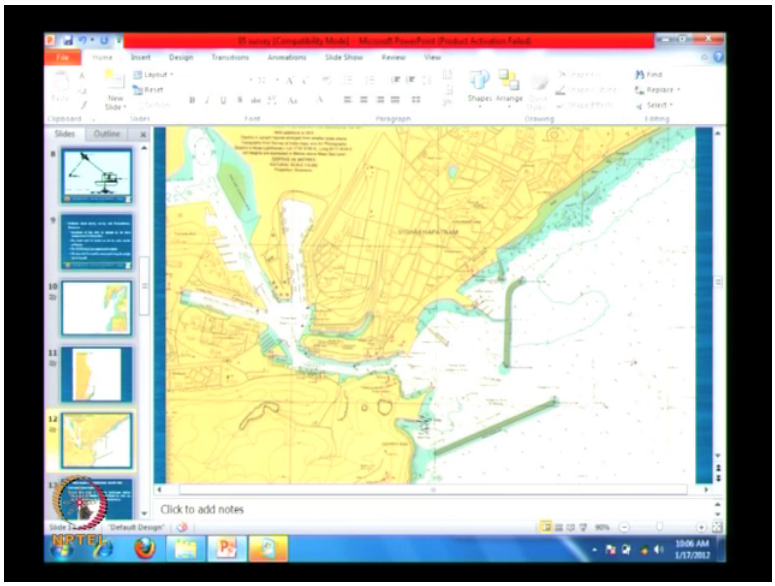

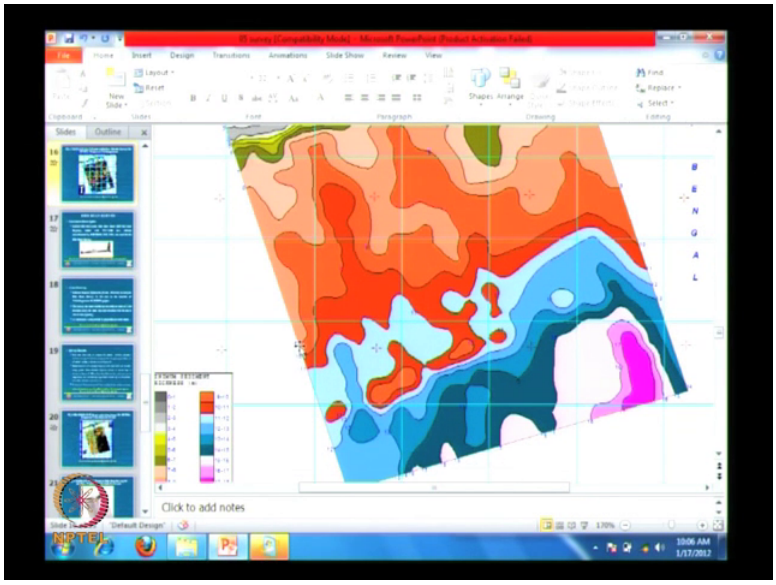

So if you see any bathymetric Chart, you should be able to understand what it means. This shows topography as well as the, topography is here, this is your bathymetry. Last class I was also discussing about this side scan survey. Zoom this and here also you are seeing certain numbers, this number is 9, this number is 10 and you are seeing some colour also, this colour indicates 9 to 10 and this shows minimum sediment thickness. That means what you are seeing below 9 and 10 metres is hard rock, that is what it implies.

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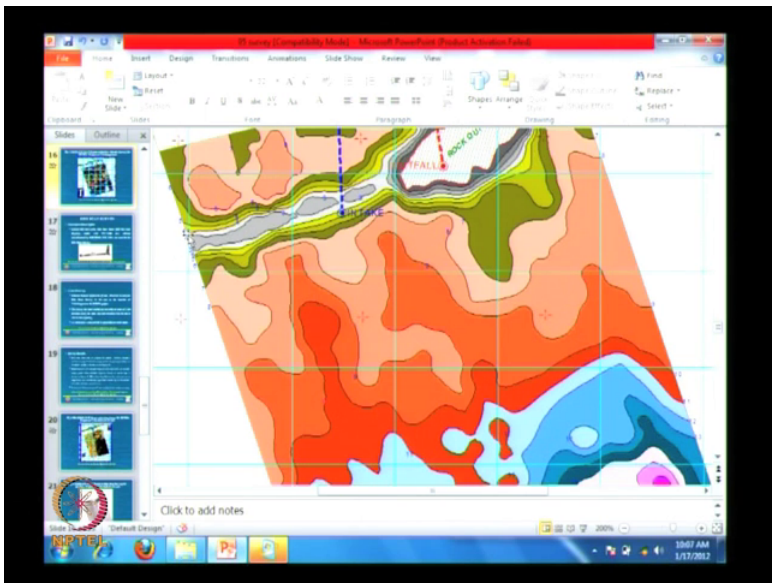

So somewhere here this will be, see here, we are seeing the numbers 3, 4, 5 and all. That means between this point and this point you have a sediment thickness of about 3 metres. And somewhere here you will see 0 and all, you see the black colour, black colour is 0 to 1, 1 to 2. What it means is, between 0 and 1 metre you have the hard Strata available, 1 and 2 hard

Strata available, 2 and 3 hard strata available. Is it clear to you what it means, ISOPACH means? What is the thickness of sediment that is available below the seabed and above the hard strata, that is what it shows.

Information is, if you want to dredge, then you want to know what is the type of rock, when you will encounter the rock. Rock means the cost is very high, so what is the depth of minimum sediment available. Another thing in contour is, these contours will not cut each other, I think you know this already. When you see any contour map, one contour will not criss-cross with another contour, simply hold good for ISOPACH map also. The type of sediment what is there is 9 to 10 metres, approximately we can get by side scan sonar that we will see the next slide.

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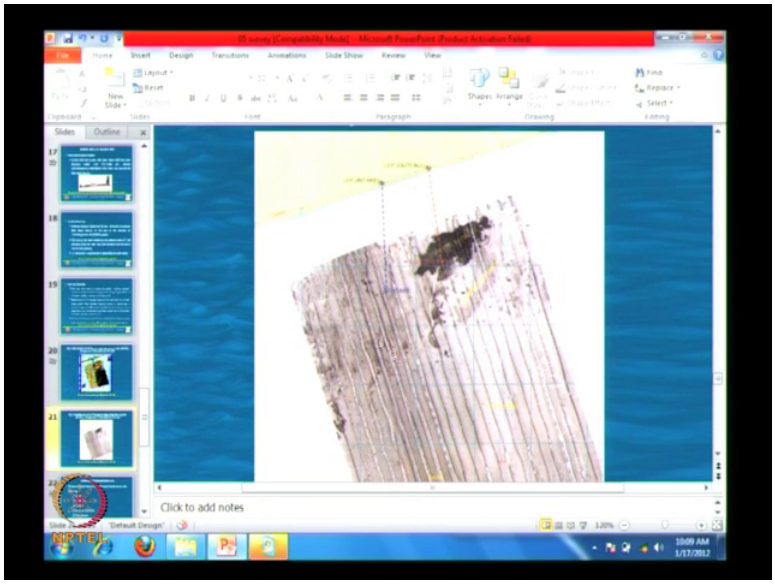

Side scan sonar is generally used to come as you see the other side scan sonar, this is your shoreline, the side scan sonar cannot work very close to the shore, up to 3-4 metre water depth it cannot work. So what you are seeing is the submerged outcrop rocks what is there. It also indicates if there is any ship which has sunk, any hard material, all those things it gives. Side scan scanner, what it typically gives is the strata at the seabed and it also will give what is the type of sediment that whether it is sand or silt or clay.

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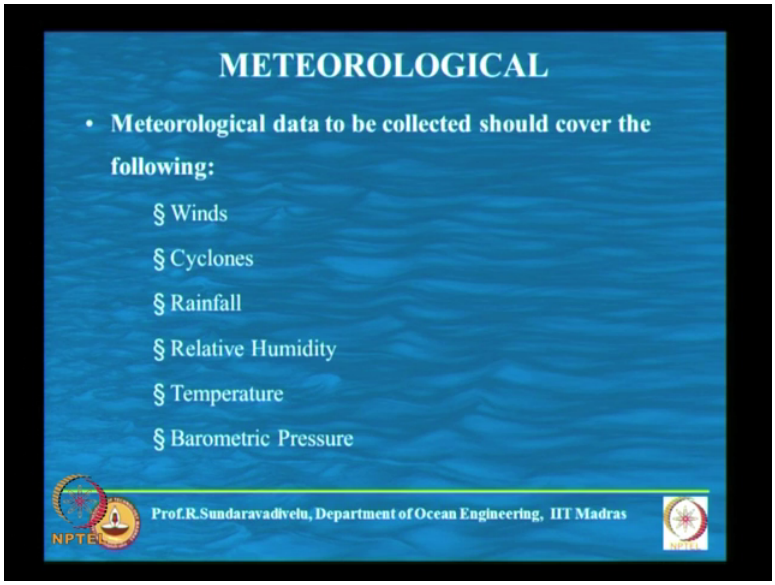

Then we will go to next slide, here we will be discussing about different types of investigation that is required. One is called the meteorological information. What are the meteorological data, you have answered this question when I have asked, you told about wind, and other things which are required are cyclones. So they have a record how many cyclones has crossed a particular site over a period of 20 years, 80 years, some location 100 years. Normally on the East Coast, during north-east monsoons, between October to December, at least 2 to 3 cyclones cross minimum.

Then rainfall, what is the requirement for rainfall, why do we need the rainfall? Why should we need the rainfall? We will start from the beginning, why do we need the wind? For design purpose, why do we need the wind?

For structural design you have to measure the lateral force.

Structural design?

For building you need (())(8:49) the lateral force.

Lateral force. So when the wind is blowing, there will be some force, that force you have to calculate, that wind force is proportional to the square of the velocity, so we need that. Cyclone, why do we need the Cyclone? What is the difference between wind and cyclonic wind? During cyclone also you have wind, normal case also you have wind, what is the difference? Cyclonic wind means you will have heavy wind, the wind velocity will be very high. Wind velocity can be as high as 200 kilometre per hour.

What is the speed of the trains? Maximum speed in India, how much it will be?

220.

Abroad?

300.

300, I think they are going up to 500 now I think. What is the speed of a bus in India? Normally maximum speed how much they will go? (())(10:26) no bus goes, even village nobody goes at 40 kilometres per hour. Normally on Highway and all they go very high speed. Whenever you see the roads, our roads are designed for generally 80 to 90 kilometre per hour, but most of our buses, when you see the National Highway 4 lane roads, they do not go less than 100 or 120. So I am telling all these speeds just to have an idea what is the speed of the wind.

Normally wind is about 20 to 40 kilometres. What is the use of rainfall? Cyclonic means whenever you have the cyclonic conditions, we have to move the vessels out of the berth. In addition when there is a crane, the crane we have to anchor it, we will not do the operation, ship is not there, then you have to push in the crane properly, otherwise the crane will fall down. Crane is also a tall structure, it is also having a wind force, normally the crane is on wheels, it will be moving. So during that cyclonic conditions you have to park the crane at a predesignated place.

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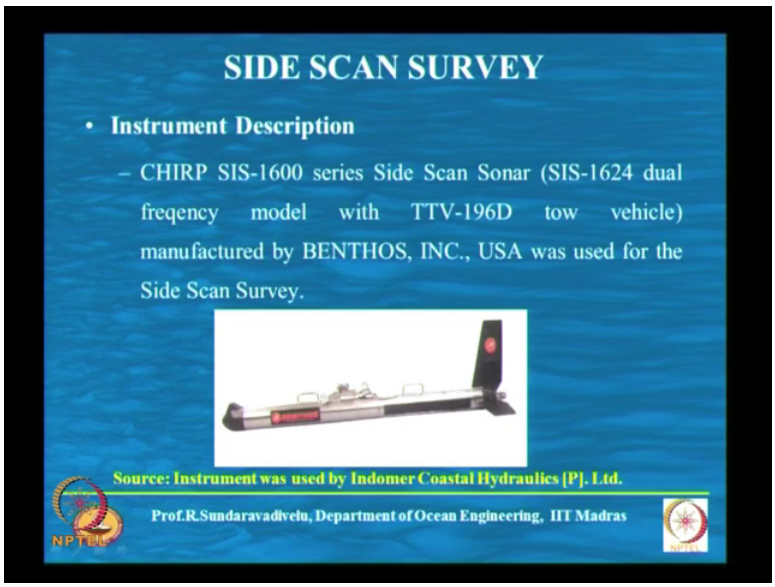

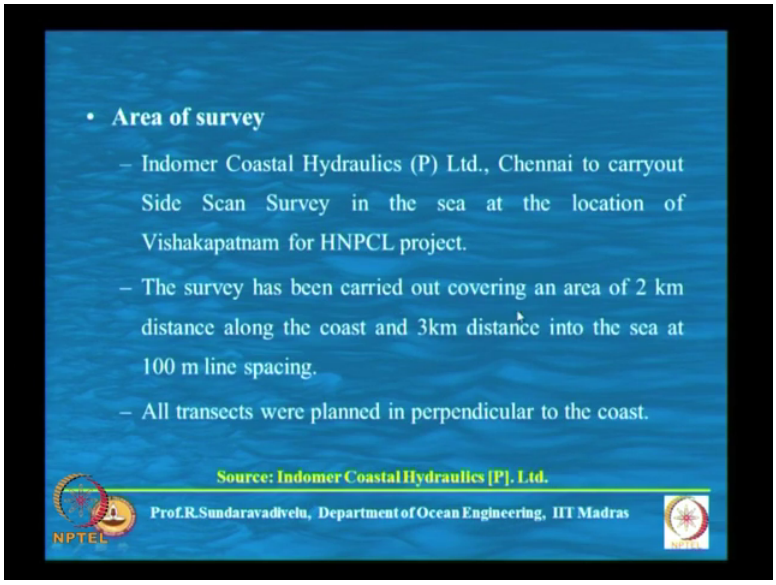

We will go back to the side scan survey. So the side scan survey, the instrument that is used is this side scan sonar which is the dual frequency model, the company which manufactures this. This is the photograph of the side scan survey. So the side scan survey, a typical, to say bathymetry as well as the Seismic, shallow Seismic survey, it is done for a length of 2 kilometre along the coast and 3 kilometres into the sea. This side scan is done at a every 100 metre line spacing.

Line spacing is critical because as we go to closer spacing, the time taken will be more and the cost also will be higher. All the transects were planned perpendicular to the coastline, transit means there is 100 metre line perpendicular to the coastline.

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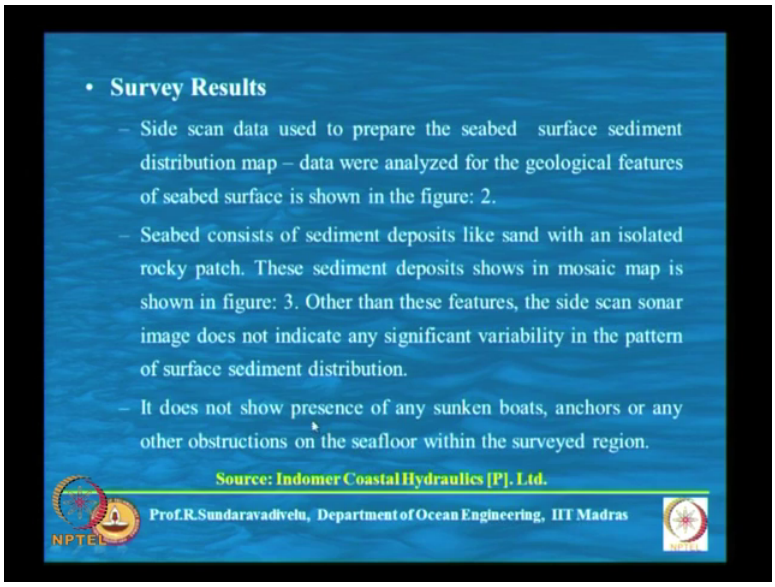

One of the important requirement for side scan survey is to show the presence of any sunken boats, anchors or any other obstructions on the seafloor within the surveyed region. So near Sri Lanka, there are some boats which have capsized and it has fallen down, our Indian government is helping them to find out where this wreckage is there, for that they use this survey, side scan survey. They should know exactly where the wreckage is, then only we can have a firm to come and then they can remove the wreckage and then take it out. So for that we need this.

Main purpose is to indicate any significant variability in the pattern of surface sediment distribution. This is for assisting the geotechnical investigation. Other one is if there are any sunken boats and things like that.

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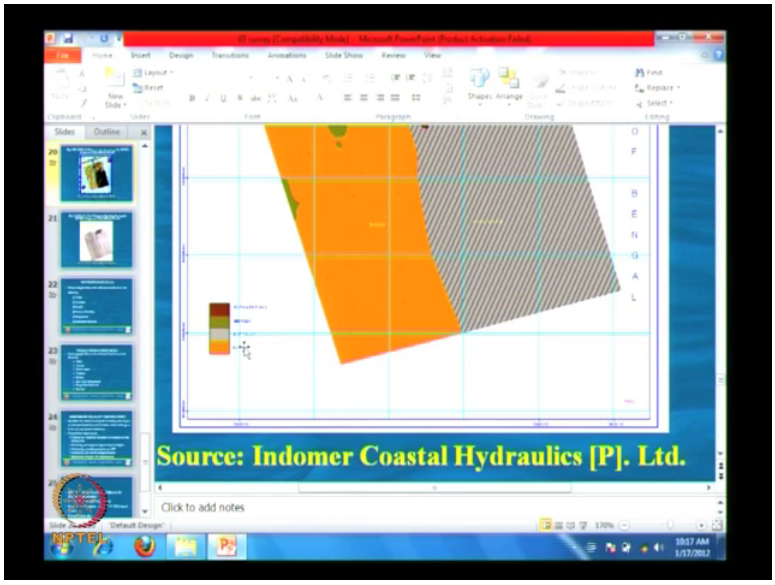

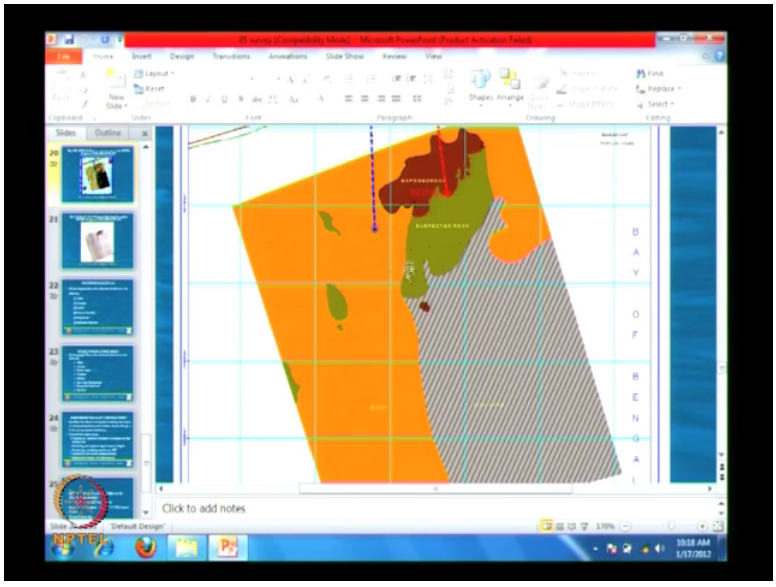

This figure shows what is the seabed, various colour code is also given here. So basically we are trying to find out, this is exposed bedrock, this is bedrock and this is sand, other one is silty clay, this colour is silty clay, green colour is bedrock, this is exposed rock about the seabed and this colour is sand. Now you can see this is sand and they have a suspected rock, this is the exposed rock and this is silty clay, understood the advantage. The earlier graph it was shown, what is thickness of this sediment between the rock and seabed? And the side scan survey as shown, what is the type of rock on the surface.

But between the surface and the hard-rock strata, there can be some other sediments, some other the type of sediments, that has to be done by geotechnical investigation. Now you should understand why we do this, because it is covering a distance of 2 kilometre by 3 kilometre. The other investigation what we are going to do is after doing all these things, I said we are shifting this outfall looking into this same location.

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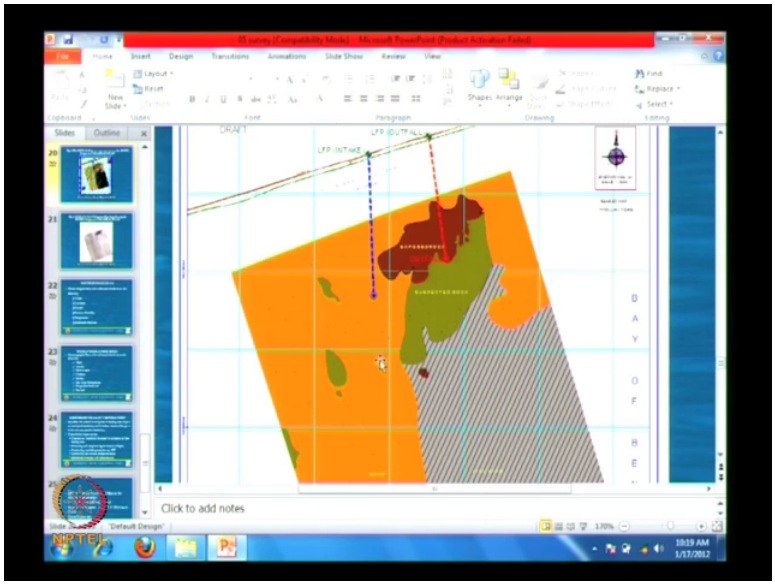

We will have intake and outfall like this, outfall will continue here, intake well will be here, outfall disposal system will be here. So once you fix the alignment, you see the alignment, the alignment is fixed, it is not going through rock. Once you fix the alignment, all along this alignment we will do the due technical investigation. What is the spacing of geotechnical investigation, suppose this length is about a kilometre, what they do is, they do at every 100 meters or 50 metres, one borehole. That means at every 50 metre if you are doing for a distance of 1000 metres, we will have 20 boreholes.

Borehole means from the seabed they will go maybe 20 to 30 metres. The type of structure what we build is a pile supported structure, for that we need the seabed investigation, typically for a depth of 20 to 30 metres below the seabed. So we need 2 types of survey, one is the survey which is to be carried out on a large scale for which we use this shallow Seismic side scan survey, fix the alignment and then go for a detailed investigation along the alignment. The cost of doing the geotechnical investigation 20 boreholes will be about 1 crore, 100 lakhs, it is not a small amount.

So if we do the geotechnical investigation here and you found the rock here, then if you shift it here, this one crore will become waste. The side scan bathymetry shallow Seismic survey and all will cost maybe 40 to 50 lakhs. So you get the whole area, what is the type of sediment, this will be used not only for, typical study only will be carried out for a port development also. At a distance of about 2 kilometres and for a length into the sea, for a distance of about 3 kilometres and maybe about 20 to 30 metre contours.

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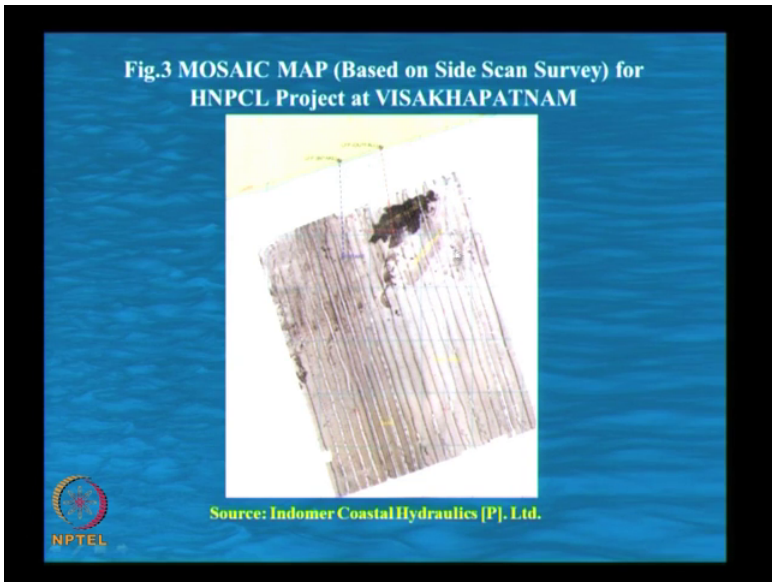

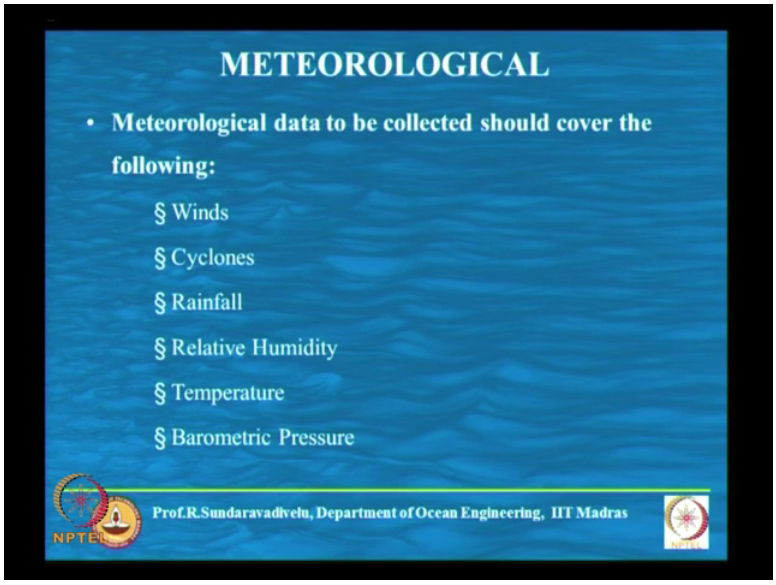

So this is to find out what is the dredging requirement, the whole 3 kilometre what is being done. So this is the same, it is called as the mosaic map which gives the transects and if there is any sunken boats and all. This shows the exposed rock, what is shown here. We were discussing about this meteorological data. Wind, this shows what is the operating wind and maximum design wind. Cyclone also we have to do to find out when it is occurring, what will be the wind speed during Cyclone.

I was asking about rainfall, what is the use of rainfall? No idea? Rainfall is mainly for stormwater drainage. So whenever we design a port, we stack a lot of cargo, during peak rain the water level shall not rise and it should also get drained easily. So for stormwater drainage you need the rainfall. Relative humidity, temperature and barometric pressure, these are all not directly required for port development but anyhow these are given. If you are using some equipments, the equipments have to be specified for this relative humidity, for that purpose we give this.

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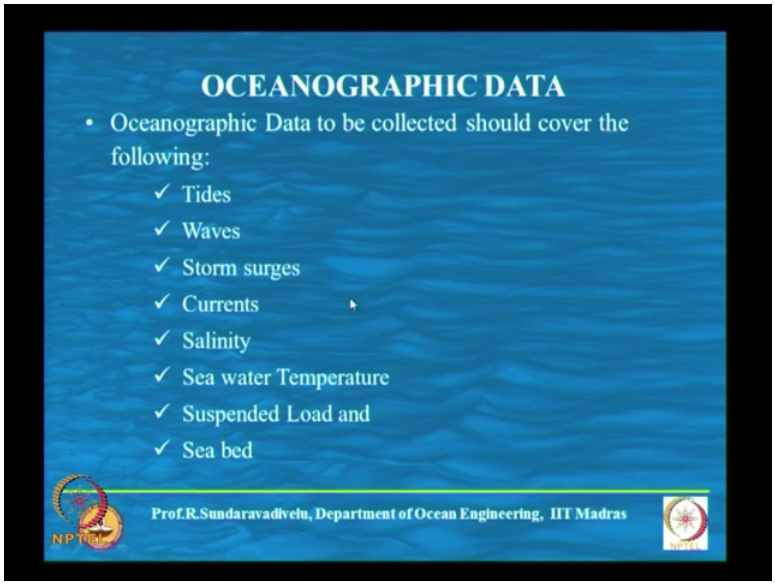

So as shown the meteorological data, there is a one is the oceanographic data. This data is to be collected and the following data is to be done. We have given most of the things tides, waves, tide is the level of water level variation, it is the attraction between the Sun, Moon and Earth. We typically have 2 high tides and 2 low tides in a day, we should know the tidal range. In Chennai it may be around 0.6-0.8 metres, in Kandla it will be about 4 to 5 metres. So for that reason we should find out the tidal range.

Waves, we need 3 parameters to be measured, one is the direction of the wave, height of the wave and period of the wave. This also typically should cover for a period of one year but we have to extrapolate to get the maximum wave heights, that is for 100 years. One in 100 year, is called, that is the written period, it holds good for many parameters. Over a period of 100 years, what will be the maximum wave height, that is to be determined, because Because for that only you have to design the structure.

Storm surges, whenever Cyclone crosses a particular site, landfall point, there is a shift of water which goes along with the Cyclone where it is crossing, that raises the water level. Once Cyclone goes to the land, the water level resets. The period of the tide is 12 hours, that is from the crust to trough. Period of the wave is 5 seconds to 20 seconds, cyclonic time, maximum wave height should be 20 seconds. There is no period for storm surge, storm surge means when the Cyclone crosses, the water level rises, then when the Cyclone has crossed the water level goes down, there is no period for the storm surge.

Tsunami is also like a long period wave but it has a period, maybe 10 minutes or 6 minutes, it is in minutes, not in seconds. It is in hours, tide, waves are in seconds, tsunami is in terms of minutes. Then you have to measure the currents, current speed and direction, 2 parameters. Salinity you have to measure because the draft of the vessel depends on the salinity. We need seawater temperature also, then suspended load and seabed. Suspended load means what is the amount of silt or sand which is in a suspended condition in the water.

This is to find out what will be the siltation that will take place and also we should know what is the seabed condition. So these are the various oceanographic data that is to be collected.

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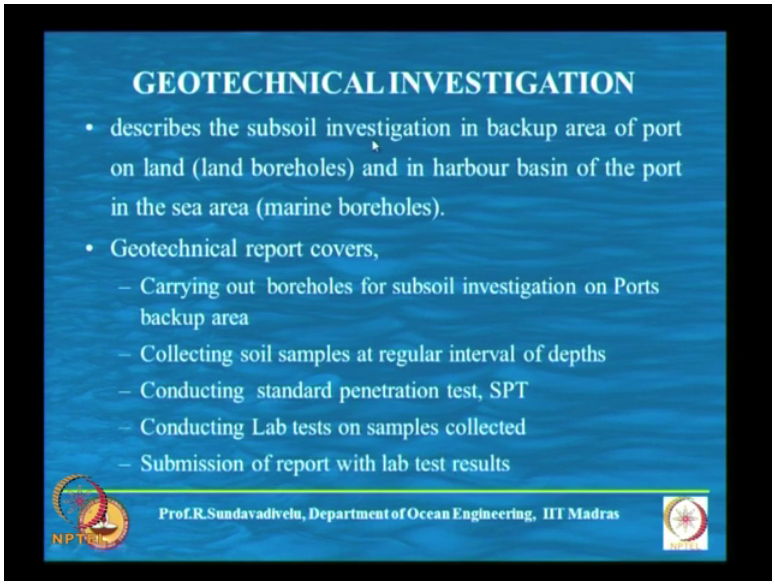

Now we will see the geotechnical investigation, this describes the subsoil investigation in the backup area or of the port on land, it is called as the land borehole and in the harbour basin of the port, in the sea area, that is given by the Marine boreholes. So we have 2 sets of boreholes, one is on the land, that is called as a land borehole, one is on the sea, it is called at the Marine borehole. It is clear land borehole is cheaper, each borehole will be only about 20-25,000 rupees for depth of about 20 metres, whereas Marine boreholes will be about 2 to 3 lakhs, sometimes it may be higher also.

You have to mobilise special equipments for Marine boreholes, that is called as a jack-up rig. So the mobilisation cost itself will be about 20 to 30 lakhs. Then what the geotechnical report should cover, they should collect the soil samples at regular interval of depth. I said about 20 to 30 metre we need, that means every metre they have to collect the sample and carry out the

tests. One of the tests is to find out the particle size, what is the size of the particles. Then we do what is known as the standard penetration test, SPT test, I will tell what is the importance of SPT test.

Once you have the SPT value, from which you can get the properties of the soil. Then we collect lab test, I will not go in car details about the lab tests, you refer some of the civil engineering textbooks, geotechnical, liquid limits, plastic limit, shear and so many things, then we have to submit the report with all the lab test results.

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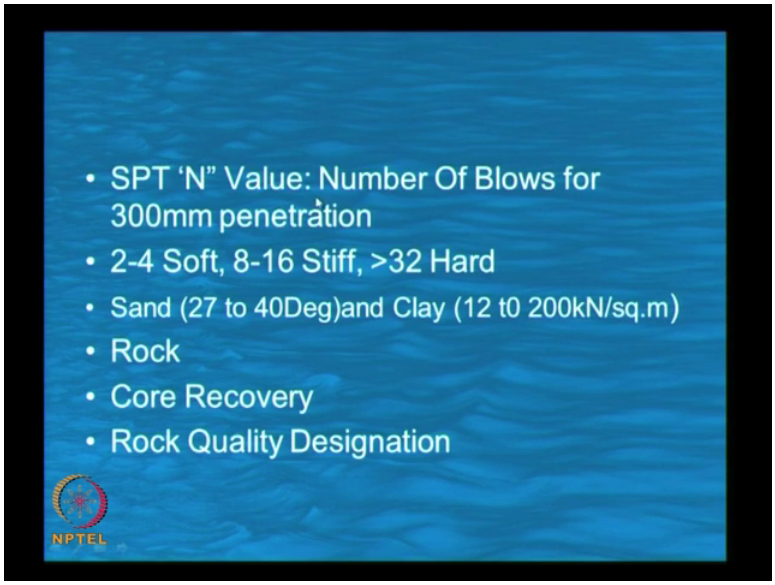

So what is this SPT N value is number of blows for 300 MM penetration. They have SPT spoon and there is a hammer and there is a drop weight, they will count the number of blows, number of drops, they will count the number. There will be penetration in the soil, 1st 150 millimetre they will neglect, then they will do next 150 millimetre, then the 3rd 150 millimetre. The 2nd and 3rd 150 millimetres, they will sum up, they will count what is the number of blows, is it clear?

The 1st 150 they remove because when they do the boring, what they do is, they go to the site, they try to remove the soil by Boring, suppose they remove for 1 metre, then they will use SPT spoon to drop 1st 150 millimetre, how many drops are there they will count. Let us say about 30 blows required, they will not use the data, then they will continue for next 150 millimetre, count the number of blows, let us say it is about 40, then another 150 millimetre they will count the number of blows, 30 let us say. So 40 + 30 is 70, so they will say 70s the SPT N value.

Then they will drill through that and go to next 1 metre. When you are drilling and removing the soil, the soil will be disturbed, they will 1st do for 150 millimetre which is on a disturbed soil and that they will neglect, then they will do the next 150 and next 150. Suppose the soil is very hard and you ask a fellow to go and do the number of blows, there may not be any penetration, you cannot ask the fellow to sit and count the number of blows, there should be some point where they have to stop.

That is when the number of blows are greater than 100, they typically stop. When N is greater than 100, the soil is assumed to be very good. So we have basically 2 types of soil, one is called as the sand and clay and we also have something in between, that is silt. Particle size of clay is small, particle size of sand is more, that is size of the particle in microscope. Another thing is the clay particle will be cohesive, sand particle will be cohesion less. What it means is if you take the clay particle, it will stick into your hand, you have to naturally wash hands.

But if you take sand, it will not stick into your hand, point is clear no? Silt is in between. So for a clay, if the N value is between 2 to 4 it is called as soft, 8 to 6 it is stiff and greater than 32 it is very hard. For a cohesion less soil like sand, we need what is known as the angle of internal friction, that is given in degrees between 27 to 40 degrees. 27 means it is a loose sand and 40 means it is dense sand. Which sand is better for foundation, loose or dense? Dense sand is better.

And if it is a clay soil, we have what is known as cohesion, that value is between 12 to 200 kilo newtons per square metre, it can be more than 200 also for very stiff clays. Then we have rock, we can have weak rock, whether to rock, hard rock, rock can also be classified based on the formations, can be called as basalt, can be called as granite and we discuss about core recovery and rock quality designation. Core recovery means when you are drilling through the rock, it takes typically about 1 metre, what is the type of, what the size of the rock pieces. So if we core through the rock, we will use board.

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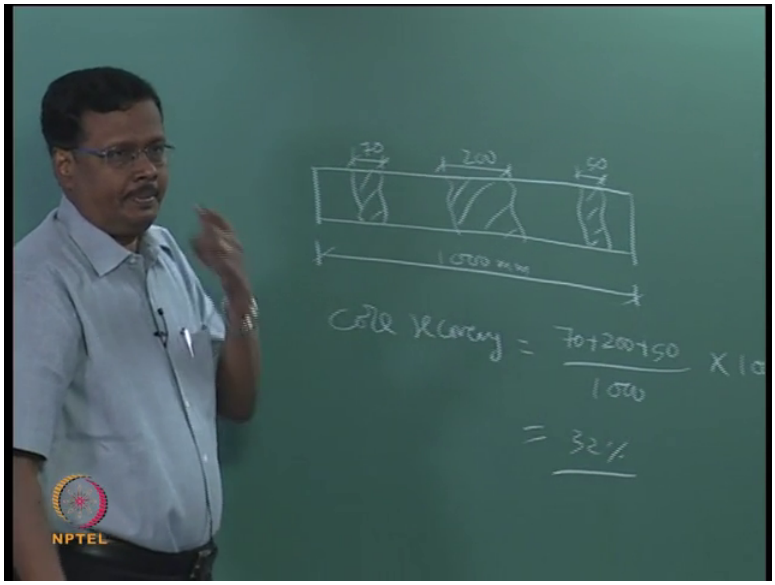

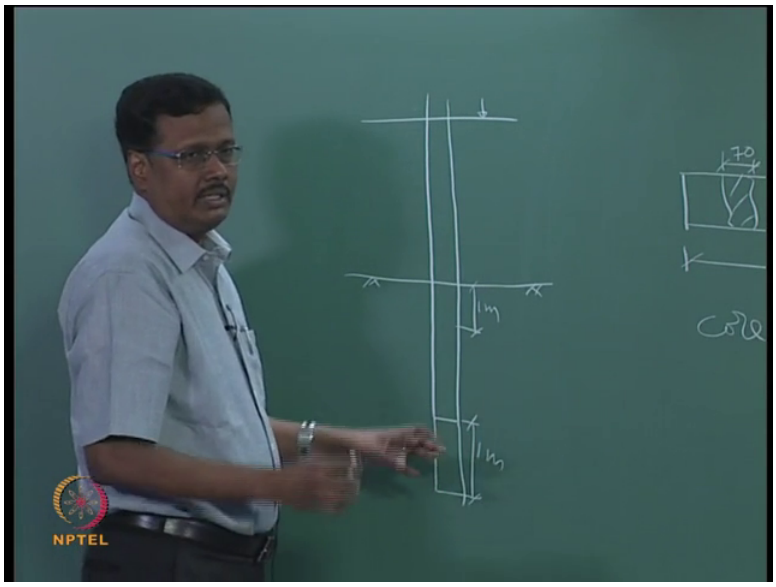

Suppose you take a rock, you core through the rock and this is for a length of 1000 millimetres. So you get 1 rock piece here, get another rock piece here, another rock piece here. This may be about 50 millimetres, this may be about 200 millimetres, this may be about 70 millimetres. So Core recovery equal to 70 + 200 + 50 divided by 1000, so if you want to express it as a percentage, multiply by 100, that is 32 percent. So what we do is, we have the water level here, we have the seabed here, so we have a floating barge or jack-up rig, we take a core through this, so every one metre you take one Sample.

Suppose there is a rock available here, you take for about 1 metre, you drill through this and take the pieces and you assemble the piece like this. So you have here the rock has become powdered, when you are drilling through that, the rock has become as a powder, the rock

piece is not available. So when you assemble it in 1000 millimetres, we have one rock piece available there, 70 millimetre in size, another rock piece 200 millimetres, another rock piece 50 millimetres.

So you count 70, 200, 50, that is about 320, that is equal to 32 percent. So can anyone tell what is the RQD for this, civil engineering students? You do not know? RQD is nothing but what is…

About 100 MM.

100 MM? That it is 150.

100 MM.

So here the RQD will be 20 percent, we want to take only this, you have to neglect these 2. So if the RQD, RQD is same as Core recovery, then the quality of rock is very good. Core recovery can be 100 percent, RQD also can be 100 percent. We have basalt or granite, then we will have the RQD and core recovery same and equal to 100 percent. We have weathered rock, then we will be having very less value.

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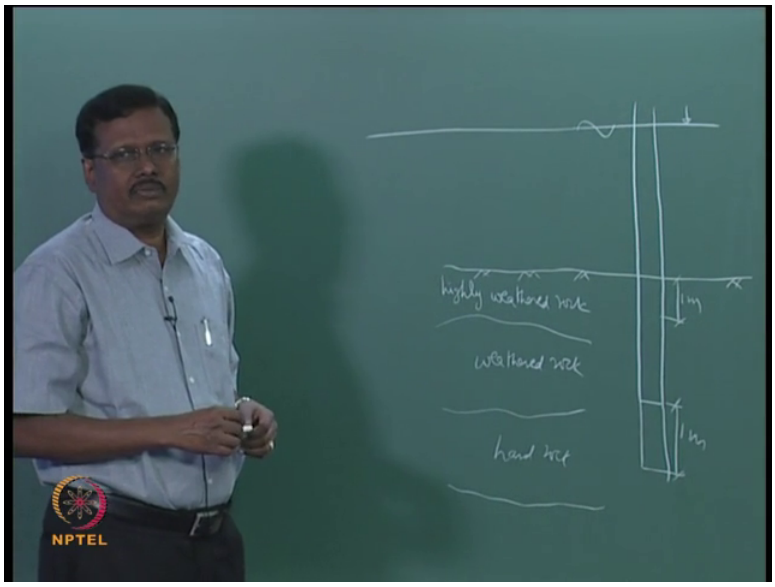

So normally this is your water and suppose there are certain locations where we have rock available, rock can be like this. So we have, when we have the rock, we have, we are sorting with highly weathered rock, weathered rock, hard rock. So very close to the seabed you will be having weathering taking place. The parent rock which is a hard rock loses its property

and we have highly weathered rock, highly weathered rock means it is not having high strength, it is having very low strength because the weathering action is high.

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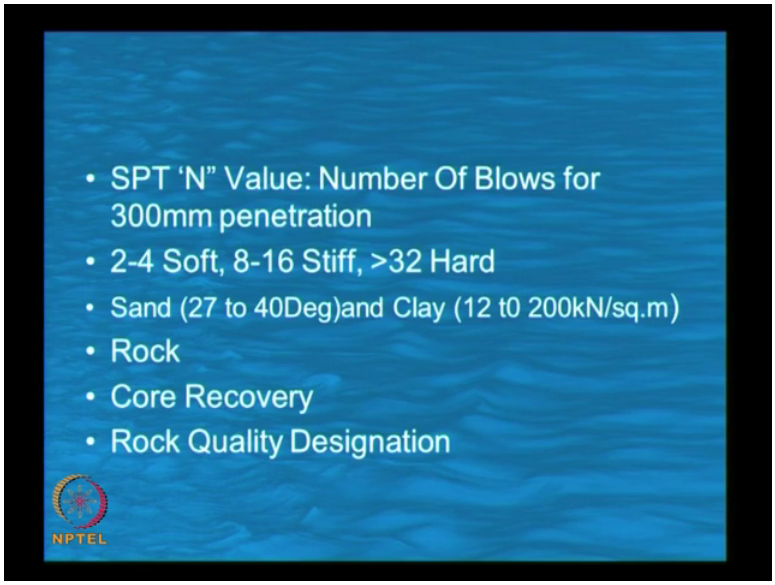

Then we have the weathered rock, then we have the hard-rock. So we have the information based on the core recovery and RQD what will be the type of rock. So this is what we get when you do this soil investigation. This is SPT N value is very important, from there only we get a lot of information about the type of soil and when you go in for calculation of pressure, I will let you know how this soil investigation results will be useful. I think I will stop with this, if you have any questions you can ask. Then the other lecture is breakwater. Any doubt so far? No doubt, okay. What is the doubt?

The numbers are there 11 suffix 2…?

N value?

No Sir, on the picture 11 suffix 2 depth is there no?

Yes. Yes.

Please explain that again.

11 4 it is written, it is 11.4 metres.

Depth at that point?

Depth at that point. See they do not want to write 11.4, they do not want to put 11.4, sometimes the dot will be missing, if the dot is missing, it will give 114 metres because bathymetric Chart is given for whole region. We have 114 metre also is there water depths, water depth can go up to 3000 metres also.

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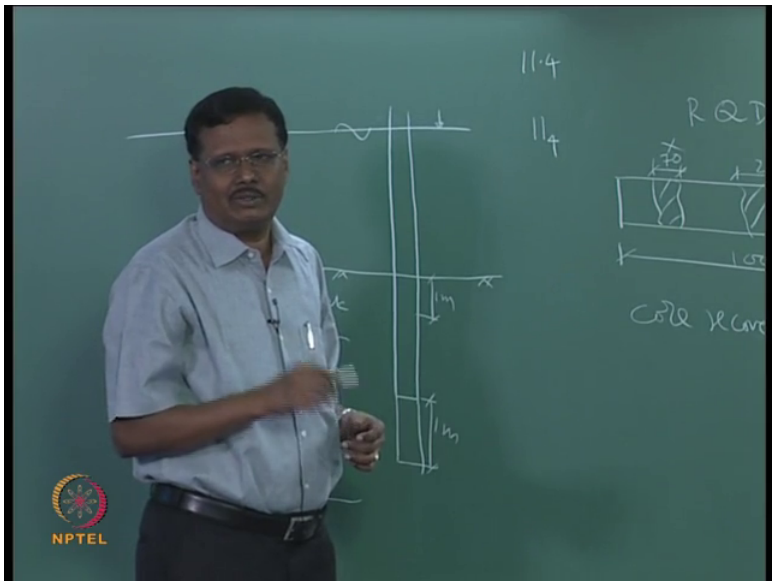

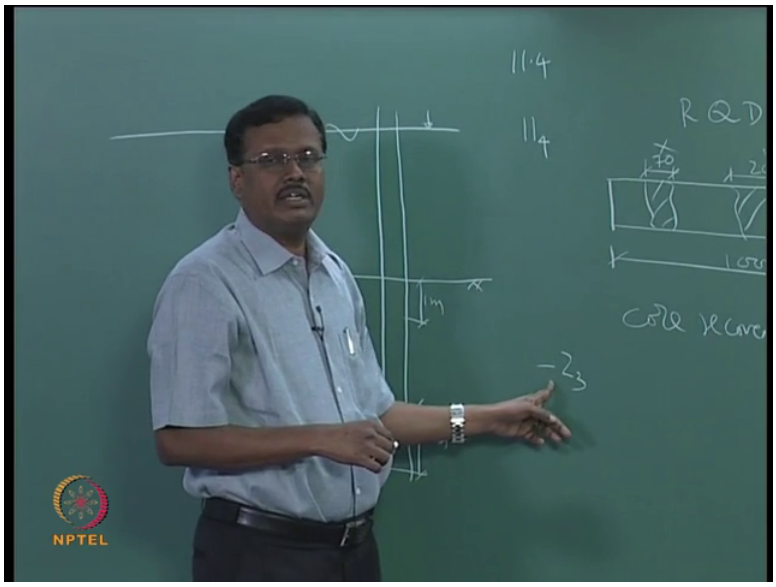

So to make it clear they make 11 suffix 4, we should not make a mistake in not showing the point, that is the reason. Understood the reason now, if they put 11.4, point is not visible, the captain will think it is 114 metre because in the mid-sea also there can be exposed rock. At place you can have, suddenly it will reduce from 100 metres to 11 metres, that is why it is 11 4 metres, 11 suffix 4. Some places you can see - 2 3, it means what is the depth above the chart data.

In a tidal region, your high tide will be 5 metres, low tide will be 0 metre. If you are doing the studies let us say in 5 metres, you find out the depth, make the tidal corrections, whichever is above 0, you write it as -. This point is clear now? When you do a survey, you cannot expect that you will do the survey only in the low tide, you will do it in the low tide as well as in the high tide, preferable to do it in the high tide. More the depth you measure, accuracy will be better and you can also measure up to high tide what will be the portion that you will get submerged. So that they will put a - sign, - sign means it is above the chart data, + means below the chart data.

We are using - above the chart data, mainly because it is only in some places you will have -, whereas most of the places you will have + only. You can give below chart data - and above chart data +, that means everywhere you have to put - below chart data. Any other doubt?