Port and Harbour Structures.
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Module-2.
Lecture-8A.
Tide, Surge, Tsunami and Wave.

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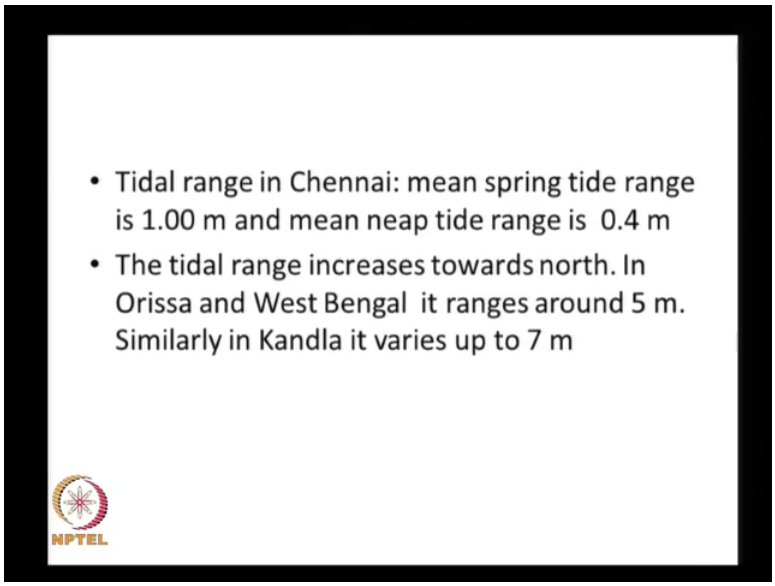

These Port and harbour structures are built in the ocean where we have the environmental influence. The parameters that are to be considered are listed here, they are tide, Surge, tsunami and Wave. So unless we know the physics as well as engineering behind this, it will be very difficult to design these structures. As you see here in this site, the tidal range in Chennai, the mean spring tide, range is 1 metre and the mean neap tide range is 0.4 metre. Basically we are unable 2 tidal ranges, one is the spring tide, another is the neap tide.

As we go towards the north, the tide range increases, on the East Coast it is around 5 metres, whereas in Kandla where there is the Creek, it goes up to 7 metres. That means in low water level, the tide will be at the entrance of ICSR building, then high tide level it will come to second-floor level. The distance if you see, it will be as far back as up to Kaveri hostel also. Water will be at Kaveri hostel during low tide, whereas in high tide it will come up to ICS R building. So there will be distance as well as elevation.

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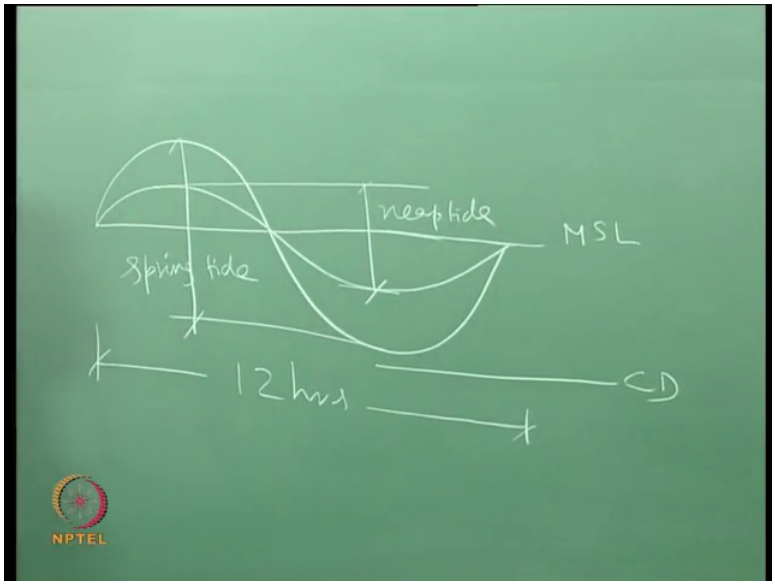

There are basically 2 types, one in the spring tide, another is the neap tide. This period is about 12 hours, each tidal range is approximately about 12 hours. And this tidal range is called as the neap tide and this is called at the spring tide. This is because of the Sun, Moon and Earth attraction, these tidal ranges takes place. This is a continuous process and normally what we call this initial level, this is called as M SL and we put a chart datum which is below the lowest water level. Right, CD is the chart datum which is kept below the lowest water level.

We will be talking about the mean of the spring tides, so the spring tides are during new Moon and full moon, that means every 15 days, every month also it will change, every year also it will change. So you take the mean of all the spring tides, spring tide has 2 water levels, one is the mean high water, another is the mean, another is the low water. If we take the mean of that, this will be the mean high water, this will be mean low water and I put this as spring, this is spring, this level is mean of high water neap, this level is mean of low-water neap.

So I define 6 levels, one is mean high water spring, another is main high water neap, mean sea level, mean low-water neap, mean low-water spring. Then we have the mean sea level. This mean sea level is used as a benchmark, so our civil engineering hearing students they will be studying the benchmark. Have you seen benchmark anywhere in IIT campus?

PSB.

PSB you have seen, nowhere else you have seen?

Hostels.

So if you have seen the means, this benchmark in Mandakini hostel it may be about + 4 and it goes maybe + 6 or so to Thirumanni guesthouse and ocean engineering maybe +8, Radiation maybe about 3 to 4 metres from ocean engineering side to Mandakini hostel. We have noticed, it is one floor difference, but that is the level.

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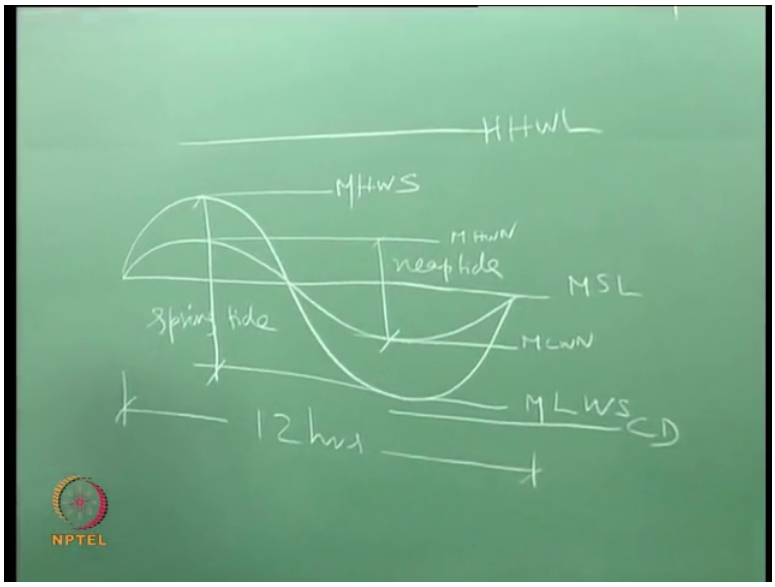

But we have to have one more level, that is high water level. So the chart datum is below the low water level and we can put highest high water level also. What is the requirement to know the highest high water level, engineering requirement, why should we know how much would be the highest high water level?

Structure should be above.

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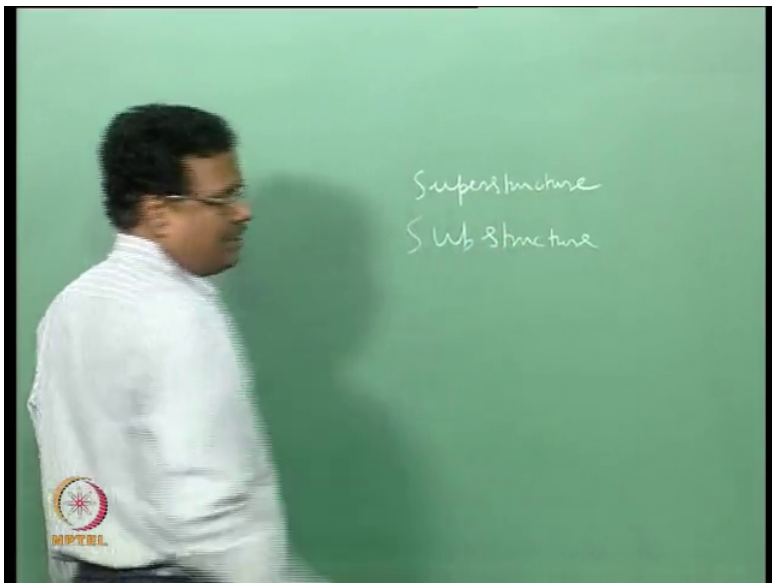

Structure should be above, structure means what should be above? Not the top level of the structures, bottom of the beam of the structure. We have typically 2 structures, one is called as the substructure, another is superstructure. Superstructure consists of deck beams and ramps. The deck beams should be, bottom of the deck beams should be highest high water levels. Why should we know the chart datum which is below the lowest low water level?

Foundation.

Not for foundation. Why should we know the chart datum, lowest water level? Because when the ship is coming and the water level is going down, the ship also will go down, it should not go and touch the seabed. Suppose we want 10 metre draft, 10 metre draft should be with reference to CD, otherwise high water, the ship will not touch the bottom, low-water it will go and touch the bottom and it may break and it will cause a lot of damage also, that is why we need.

Okay, the surge means, whenever there is a cyclone which is crossing, cyclones normally cross from the sea to the land, when it is crossing from sea to the land, it takes some amount of, it pushes water into the land and the water level rises. It is a one-time occurrence, in 4-5 hours it will take place, then it will recede, it is not periodic, periodic means it is not a 12 hour cycle and all. Whenever the cyclone is crossing the line, the water level rises and then it goes into the land, it takes about 4 to 5 hours depending on the intensity of the cyclone, then the water level recedes.

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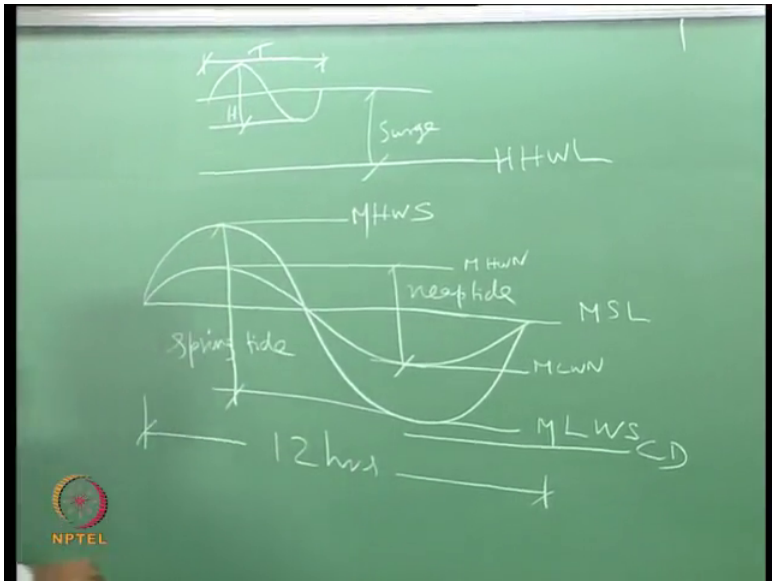

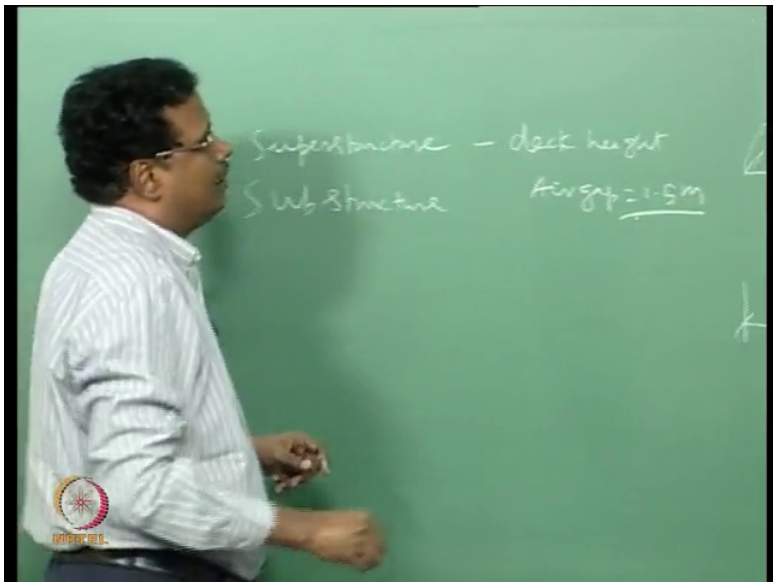

So your top of the structure should be about the search, this is your search, then you have waves above this, this is called as the wave right, this is called as the wave period. So your top of the superstructure should be, you have to put something to you have to put the deck height air gap, typically this is about 1.5 metre. So on top of this level, on top of this level we should give an air gap of 1.5 metre, then if it gives the deck height, then you have to fix the top of the deck level. Right.

Otherwise it will be a problem for you. Tsunami is occurrence which takes place 400-500 years, return period, it does not, you may not see another tsunami tell your lifetime. But tsunami has happened in India, I will give some details, we had Chola, Chera, Pandya, the kingdoms. The Chola kingdom, what was the capital?

Vijay Nagar.

You are going to Karnataka, where is Vijay Nagar? Chola is in Tamil Nadu, what was the capital of Chola kingdom?

Thanjavur.

Before Thanjavur?

Mahabalipuram.

Mahabalipuram is for Pallavas. Poompuhar, Poompuhar was the capital, Poompuhar is between Meladurai and Chidambaram. The Chola kingdom was there in Poompuhar and that whole city went into the sea in one of the tsunami. So now you know the importance of this, while we need to get all these things. If we take Kandla, the top level of the structure is + 9, with reference to the chart datum, the top-level is that +9, is we take Chennai, it is a +5.

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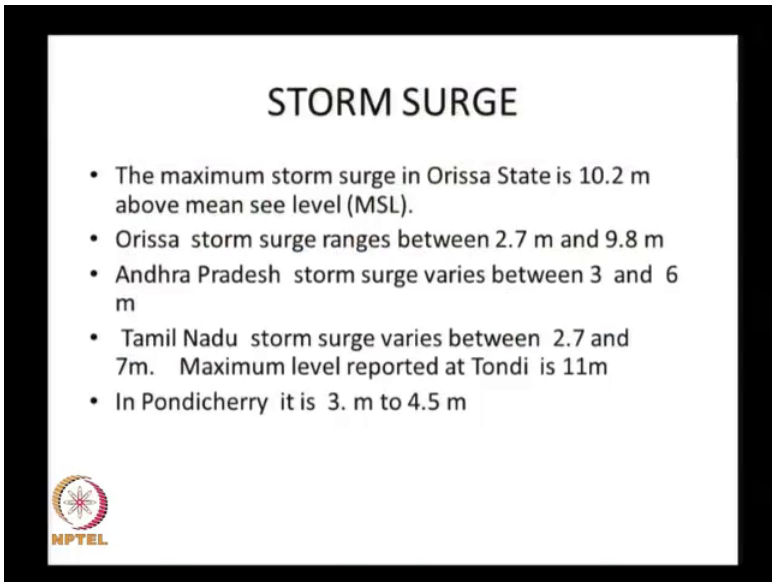

The cost of the structure also goes up, for the same draft, suppose the draft is 10 metre, you gave under keel clearance of + one, 1 metre, then - 11 is a bed level, top-level is + 9, that means about the bed level is 20 metre in Kandla, whereas the same thing in 60 metre. Cost is proportional to the cube of the height because the bending moment is to the cube, it is a linear relationship. The storm surge in Orissa state is 10.2 metres above mean sea level. Anybody from Orissa state here? Nobody. This Orissa state, they have what is known as the saline embankment.

Thus saline embankment is built to protect the seawater inundation into the land. This level is that +10.2 metre, very close to the West Bengal border. But generally ranges from 2.7 metre and 9.8 metre. Andhra Pradesh, storm surge varies between 3 and 6 metre, Tamil Nadu 2.7 metre and 7 metre, we have some records, in Tundi it is 11 metre, some people are disputing it is not recorded and all. Tundi was one of the sea ports for Madurai kingdom, but they are saying 11 metre is not correct information. Pondicherry is 3 metre to 4.5 metre.

See whenever a cyclone crosses, normally when a cyclone comes, it generally hits Nagapattinam, then it hits Cuddalore, then it stays near Chennai but generally it does not cross, it goes to Andhra, either Nellure or Machiliputnam. There are certain reasons for that, the contour and bathymetry and the shape of the coastline and all.

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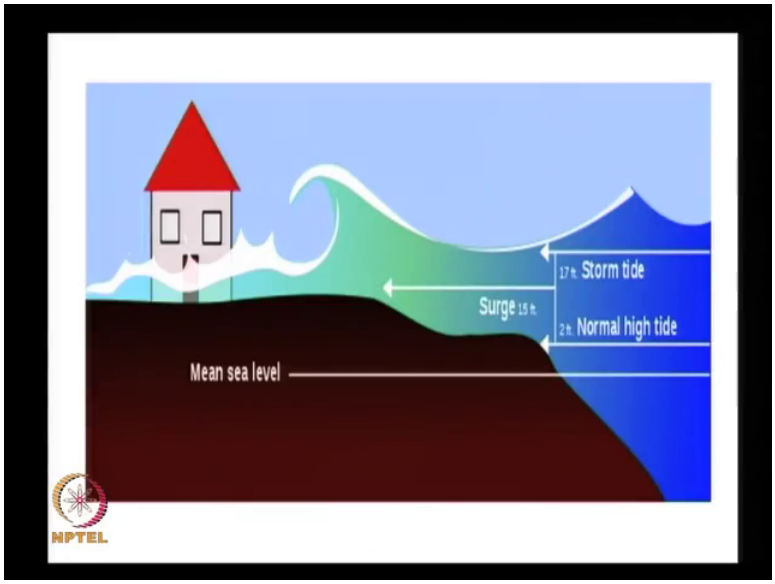

This figure shows what is the mean sea level, what is the normal high tide, what is the storm tide, what is the surge. So this 17 feet is the height, he asserted height is 15 metre which has to be placed about this, it is 17 metre, then there is a wave, wave is breaking, if you have put some columns and building, it should not go and hit. So you should see that the top-level is not hitting the building.

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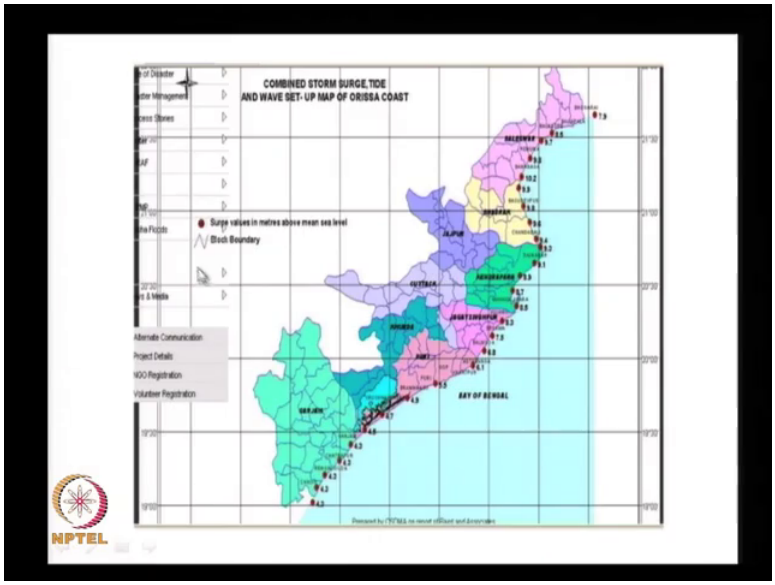

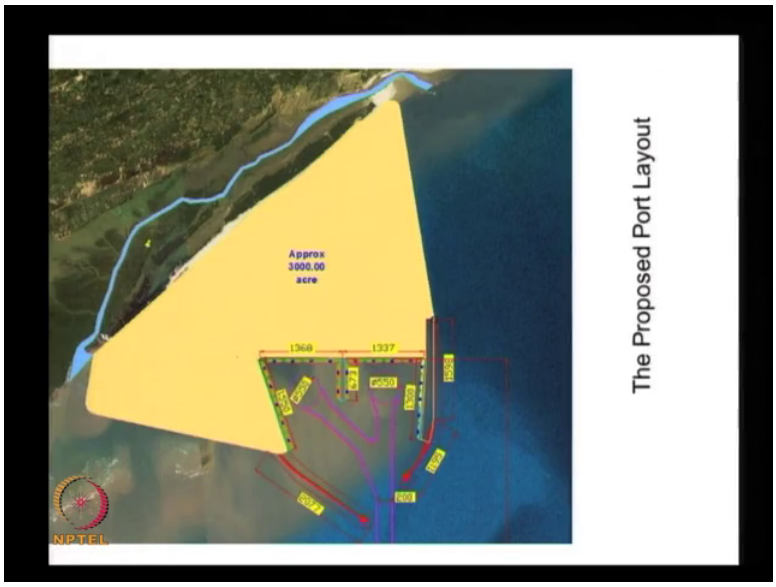

This figure shows the tidal range at different locations, what I have discussed in Orissa state, somewhere here, this is about 10.2 metre, so it depends upon the wave formation, it is not, at other place it is less, somewhere here it is 10.2 metres. This is the border of Andhra where it is about 4 metre only, as you go up, it is going higher and higher. So we have planned one port, somewhere north of the location where we have got 1.2 metre, this is called as a backwater. What we are seeing here is a backwater and they want to fill up this area because it is a very shallow contour, they want to get about 3000 acres.

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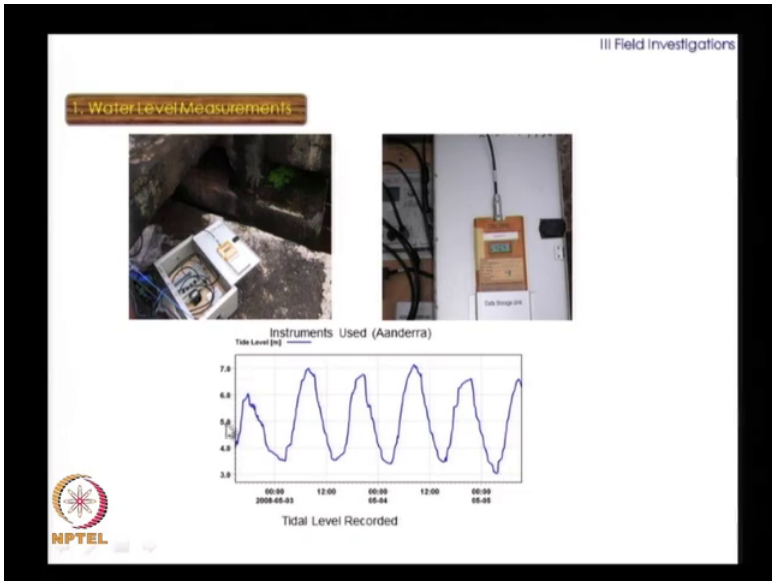

3000 acres is about 5 times over campus size, campus is around this hundred acres. So much area is required for port development, they want to build 2 breakwaters, so here they have made certain measurements, services for water level measurement. One instrument is used to record the tide, you can see here near 0 you have low tide, near 12 hours another low tide, near 0 another low tide, like that you can measure the tide. The levels are given here, it varies from 4 metre to 7 metres, so this is the equipment which is used to measure the tide.

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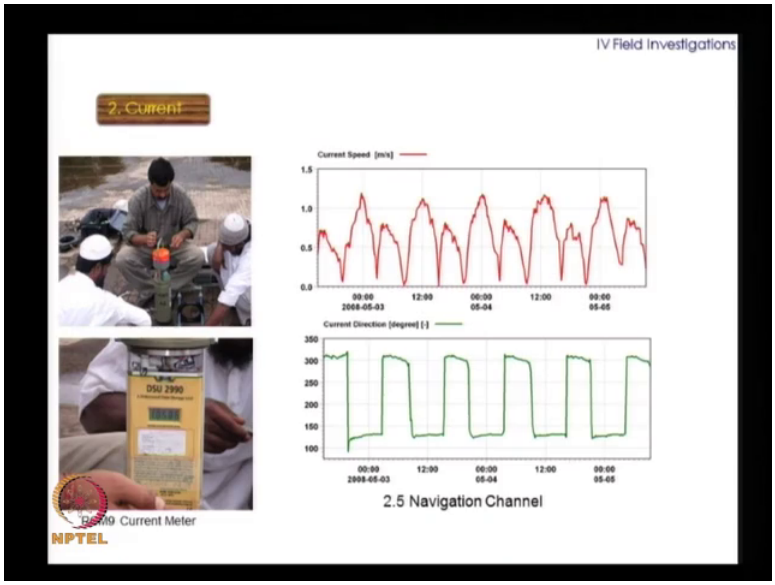

We can also, I have not listed current, current also is a part of the tide. When the water level goes up and down, there is a current, velocity which is coming, that also is measured. They generally measure it in a navigation channel so that to see what will be the speed of the

current. They are giving 2 informations, one is the speed of the current, bottom one is the direction of the current. Both the informations are required, so when the tide rises, the water is moving towards the coast and when the tide is going down, the water is moving away from the coast.

This phase difference will be about 180 degrees, so this is somewhere around 120 and about 300, so the phase difference is about 180 degrees. So this shows the speed of the current, it is 0 to 1 metre per second for 2 knots, that is a speed of the current. When will be the current be maximum?

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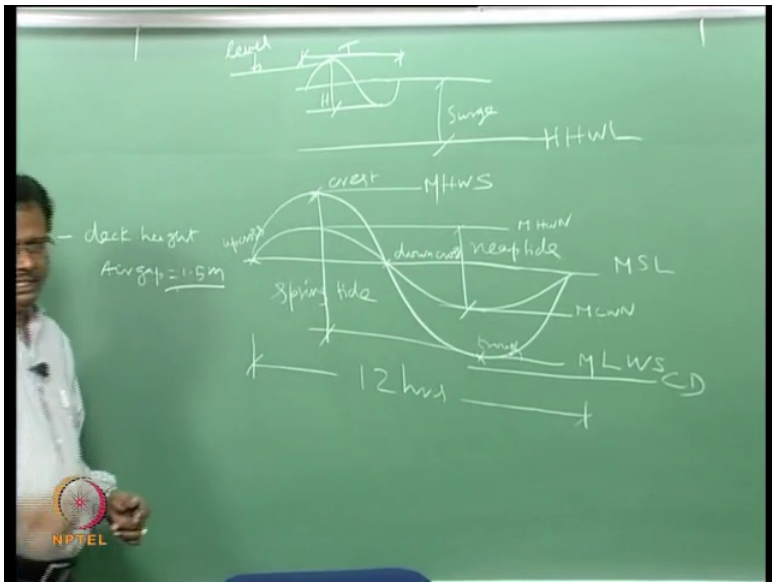

So I have drawn this figure, in this figure, this is the crust point, this is the trough, this is called as up cross, this is called as down cross. I have marked here in the current varies from 0 to 1 and coming back to 0. You tell me when the current will be maximum? It will be at the trough or crust or up cross or down cross?

Up cross and down cross.

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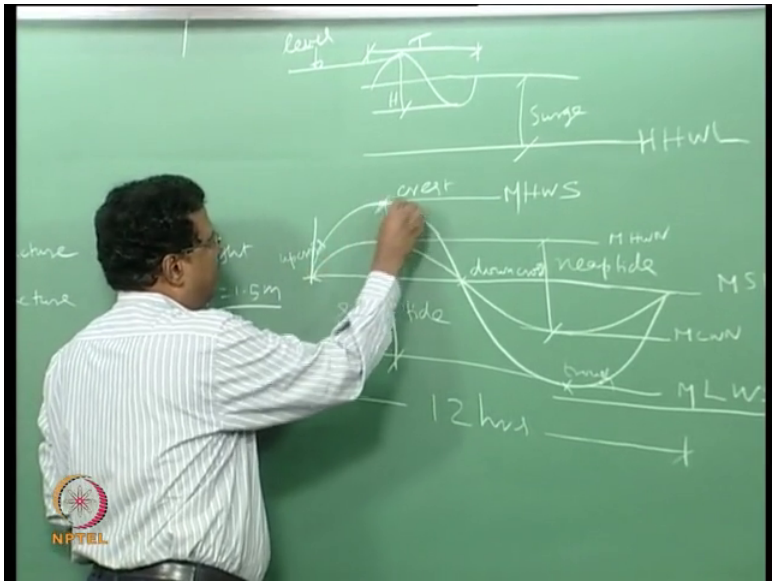

Up cross and down cross it will be maximum. Current is nothing but the change of elevation with respect to time. So if you take X axis as, X and Y axis, Y axis is the height and X axis is the time period, dy by dx will be the current, so it is the rate of change. So rate of change here will be nearly 0, here also it will be 0, that has the slope of the curve, slope of the curve is this, this will be the maximum here, this will be the minimum here. So that is why this point also is important. When you want to design a structure, you will be calculating 2 things, one is how to fix that occurred of the structure, 2nd one is how to estimate the force acting on the structure due to current and way.

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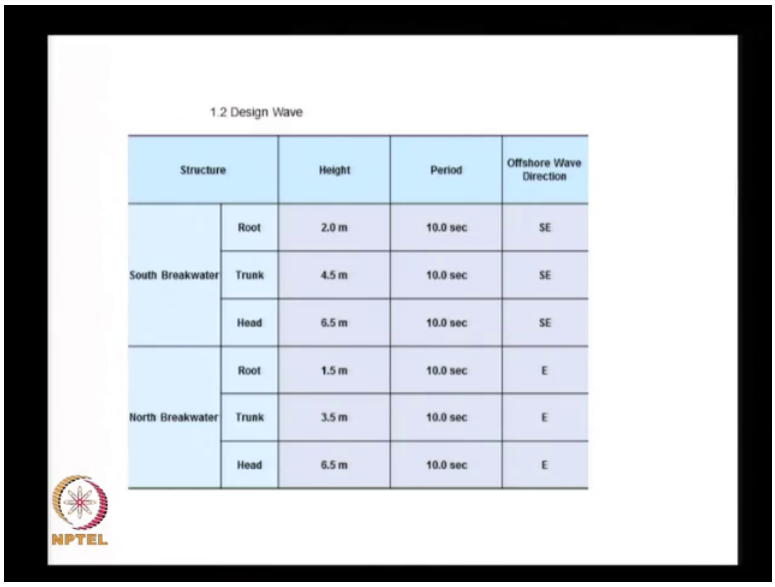

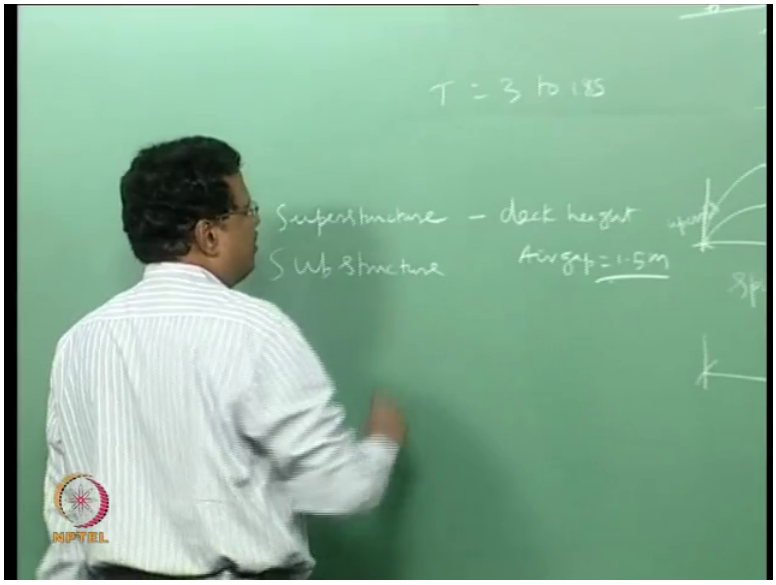

For that the phase difference is also very important. Then we will talk about the design wave, this is an important information, what is the design wave. The period of the wave as given here is about 10 seconds, generally the wave period can start from 3 to 18 seconds, that is the range of wave period. So every day you have the wave, every hour, every minute. So one minute is having 60 seconds, so you will have about 10 waves, if it is a 10 seconds, 6 seconds wave. Mostly 6 seconds wave is more predominant.

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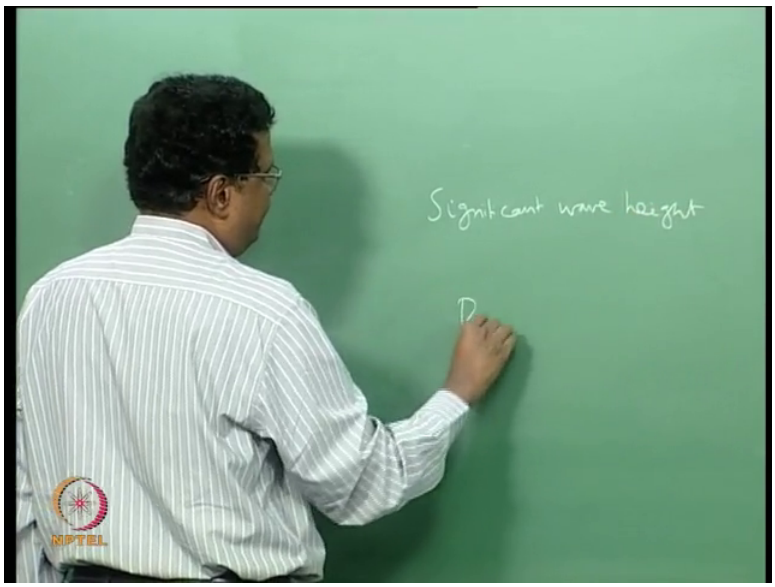

This design wave, there are 2 important information we know, we should know, one is called is a significant wave height, another is known as return period. So if you want to plot normal wave which are recorded, the wave maybe of like this. It will be a random phenomena, it will have smaller waves, larger waves, height wise, period wise. So it is a statistical information.

So if we get some type of wave like this, how can you represent these waves, a single parameter? Wave height and wave period.

This is a big classroom, you know how the grid is evaluated, some statistics is involved. Suppose we will find out the height of each individual, we want to represent the class to a single height, what height you will use?

Average.

Average means what? Sum of all the heights divided by total number, that is not used in engineering for design. It can be used for engineering, we will use significant wave height. Significant wave height is also Average, average of highest one 3rd in the class. Suppose we have 54 people, we take the tallest 18 people and take the average of the 18 people, that is called as a significant wave height, sometimes it is called as H 1/3. Mostly they will ask significant wave height in the interview, it is the average of the highest one 3rd of the record.

What is the duration of the record they will take? You have to take the average, average of how many records? Ocean engineering students, average of how many records you have to see?

3 hours duration.

3 hours duration, anyone told you about this? Who has told? Nobody told, what is 21, I am hearing 21, 21 is only for marriage. 3 hours durations they record, you take the average of 3 hours, but you cannot take one average of 3 hours record, you take over a period of one year. Right, it is not that one average up to take. What is this return period? What is return period? In civil engineering also this terminology is there.

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Statistically I told 3 hours duration, 3 hours duration for a period of one year you can take. You can actually measure it, for one year you can put a wave radar buoy and you can make the measurement of waves and take the average of all the one-year data record, H 1 by 3 you can get, that is one-year return period. In that year cyclone can come or may not come and things like that. But you connect up late for 10 years, 100 years, 1000 years. The period of occurrence of cyclones in India, it may vary coast to coast, maybe Andhra once in 2 years, Tamil Nadu once in 3 years, like that it may vary.

When the cyclone comes, surge also will be there and there will have very high wave heights also. So is we take a return period of 100 years, then the significant wave height will be much higher, not very much higher. For example this is a class where you have people from civil, mechanical, aeronautical, ocean engineering, the population is 54. You take the significant height of this class, but our institute may have about 7000 or 8000 people, you take the average of all the 8000 people, will it be higher than this or lower than this?

We cannot say, maybe these 2 ladies are taller, so if you take all (())(22:36) population by the ladies are shorter, your average may go down, when generally it has to be higher. You are all in 3rd year, most of the boys who are joining 1st year may already attend that height, otherwise there will be a problem, we cannot say but if we take the wave record, if we take a hundred-year return period wave record, it will be much higher than the one-year return period. There are statistical methods using which we can extrapolate. Do not think that we have to take a hundred-year record and then build the structure.

Typically they take only one year record, then design. Sometimes they do not even measure the wave, still they will get the wave heights. How to get the wave heights without measuring the wave heights? What is causing the waves?

Winds.

Wind data is available, wind data is recorded from 1875 or something like that, you can get the wind, from that wind you can find out what will be the wave height, then we have what is known as the ship observed wave height. There is an Atlas prepared, when our department started in 78 or so we spent some money to develop a record, this is done by NIO Goa. So based on the ship observed wave data, at each location, each grid point, there are about 12 grids or 16 grids along the Indian coast, they have given the wave heights, that is also another information which can be used.

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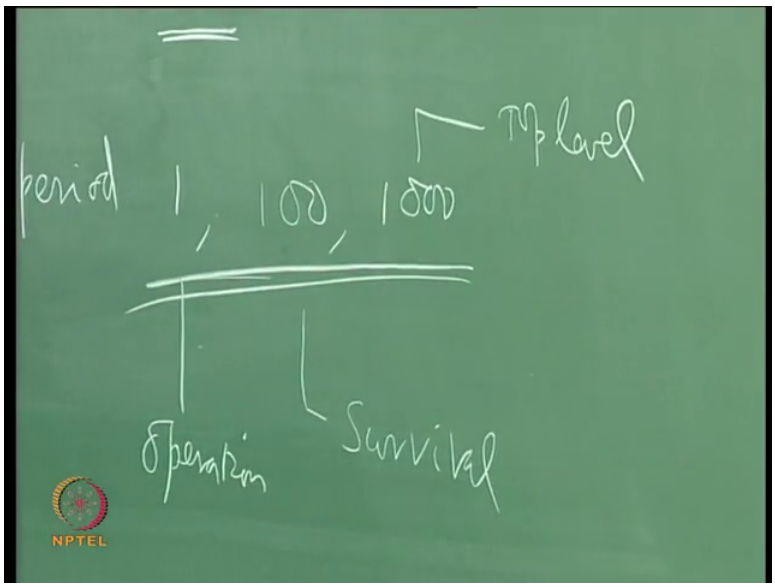

Return period can be one-year, 100 years or 1000 years. They may use 100 year return period for survival condition of structure, one-year return period for the operation, this is to fix the top level, this has recently come. So design wave height, this is more for offshore structure than for port and harbour structure. You take the return period of one year and if possible and assign that value for the operation of the structure. Take it for 100 years, survival, that is for estimating the forces and designing the structure, take it for 1000 years to fix the top level. Right

And this significant wave height also can be H 1 by 3 or H 1 by 100 or H average. The statistical information H average, H1 by 3 or H1 by 10 is used. So now it is clear, it is not one single parameter, one wave height and one way period you are using as shown in the table. What we are using is the statistical parameter depending on the significant wave height and return period.

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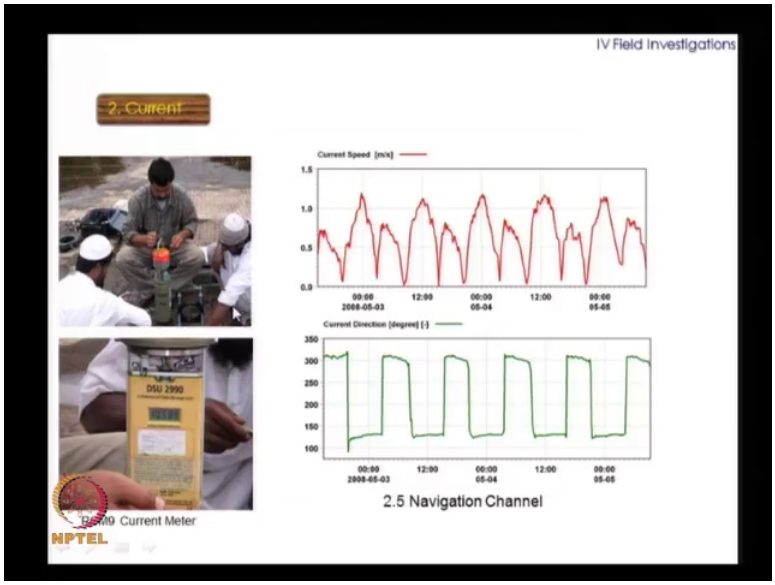

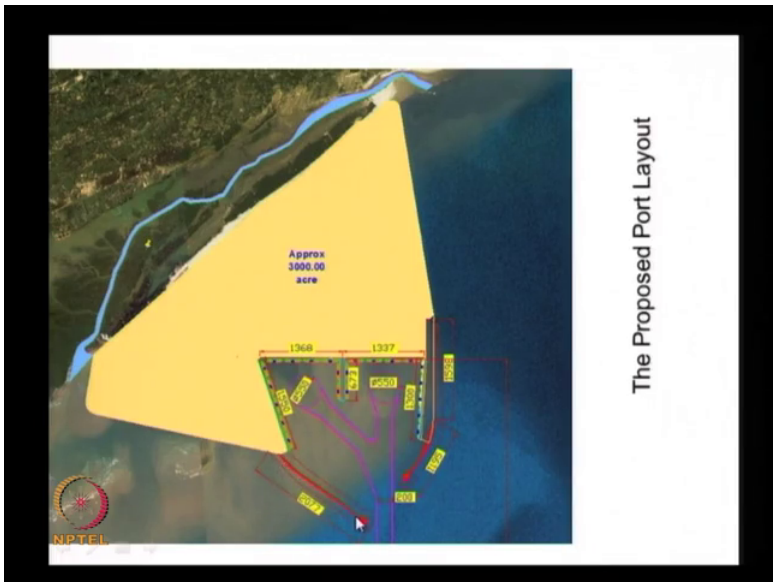

So there is a location is also important, there is root, trunk and head. So this breakwater, this is called as the root, this portion from here to here is called as the trunk at this portion is called as the head. There are different locations and this is the South breakwater, generally we mark the figure North pointing upward. So this is a southern direction, this is the northern direction, it is on the east coast, so this site is the east, on the seaside. So here we have marked root 2 metre, root wave height is less because the water depth is less.

I will tell how water depth is increasing the wave height later. Period is taken 10 seconds, wave direction also they are giving. Similarly for trunk as well as for the head. This is for the South breakwater, this is for the North breakwater, so this type of information is required.

Generally if they give the significant wave height with a hundred-year return period, if it is not mentioned in the table, generally what is given as H 1 by 3 with 100 year way period.

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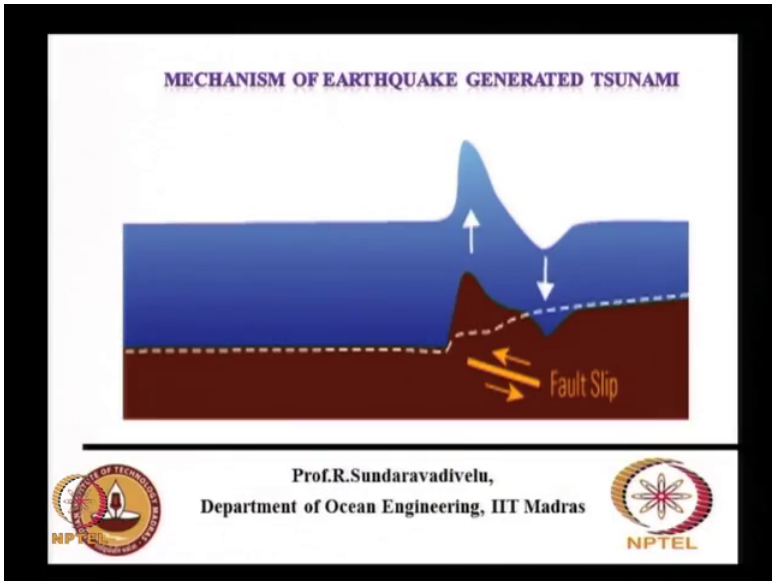

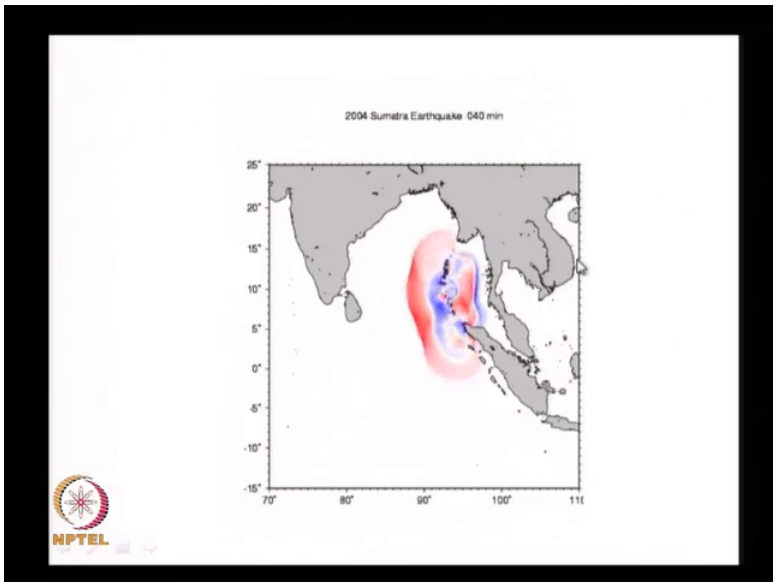

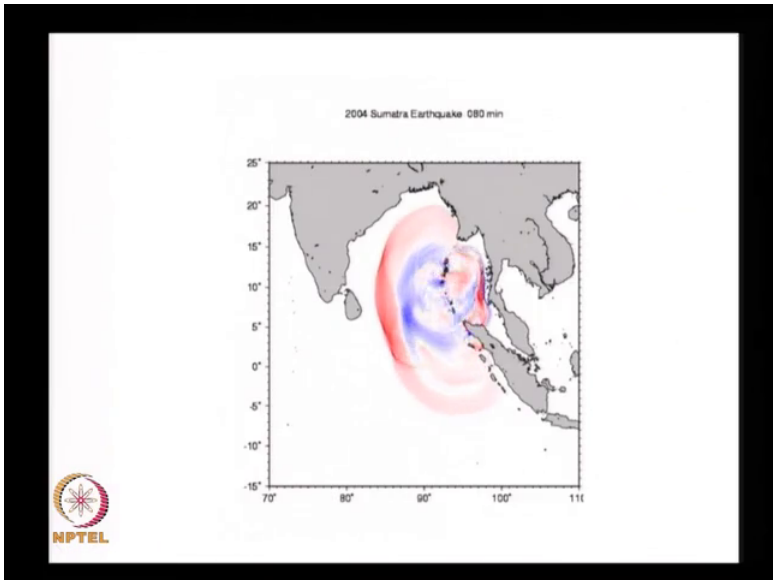
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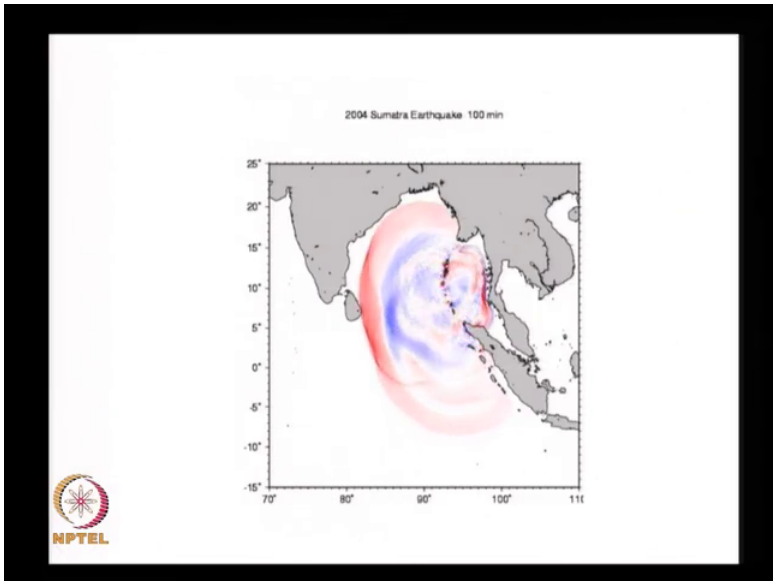
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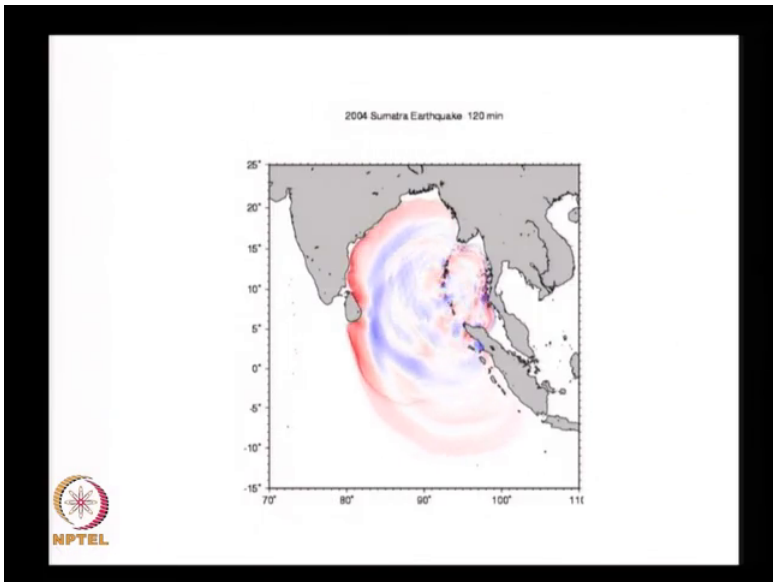
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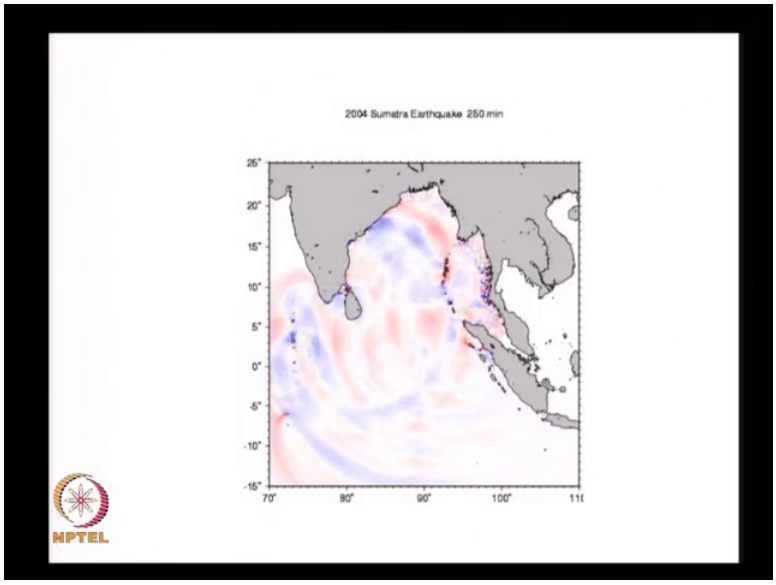

Now we will move on to tsunami, so all of you might have studied about the tsunami. So it is because of the earthquake, because of 2 fault planes, one is going down and another is going up, the wave is generated, that is called at the tsunami. This shows how the tsunami is generating and then going to different places. So when it comes to Sri Lanka, it diffracts, so if you see here, the diffraction means it goes and there is some diffraction wave is close to the West Coast also, that is to the Kerala border also it goes.

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So some shadow zone, there is less disturbance. What are you seeing in this figure? What level is, to the deck level. This is the deck, this is what is called as the Fender, this is a ship. This photograph is taken in Port Blair, the water level is very close to the deck level. Normally it is not like that. If the water level goes up, what happens, the ship may ride on top

of, it will go on top of this. So it should be avoided, mainly to fix the top level but here the water has gone on top of it and it has receded but luckily none of the ship has gone on top of this.

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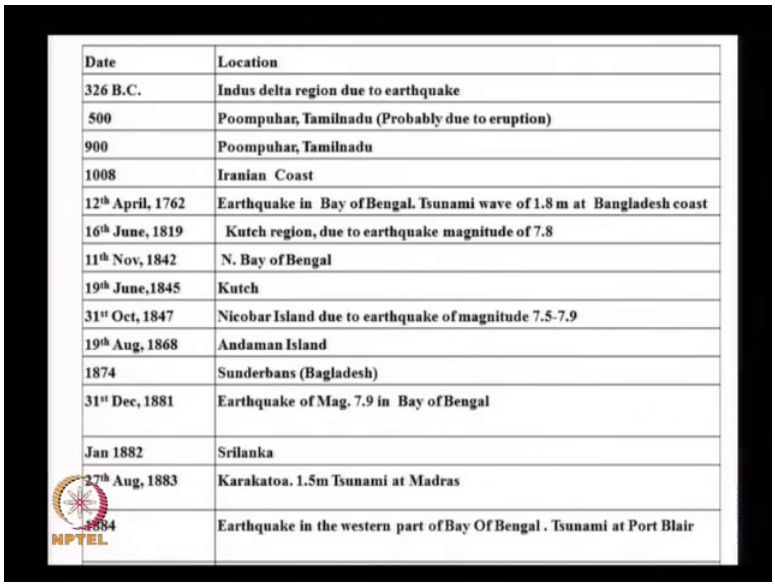

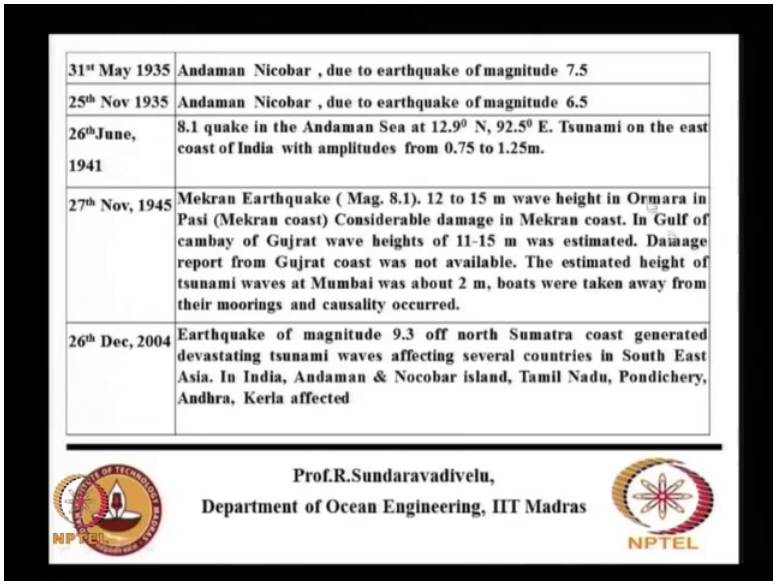

There are various locations, starting from 323 BC, 12 April 1762, 1868, Bay of Bengal, Andaman Islands, Sundarbans, Sri Lanka, Poompuhar, all these places tsunami has taken place. The latest one is on 26 December 2004. This was one of the worst tsunami, whatever we have historically shown, based on that this is the worst tsunami. This is of 9.3 in Richter scale, North Sumatra coast, it has affected India and what is the input here.

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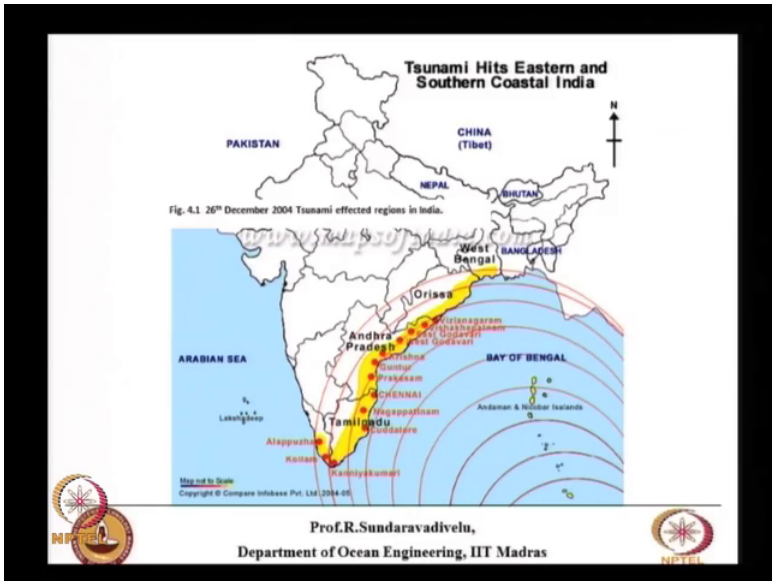

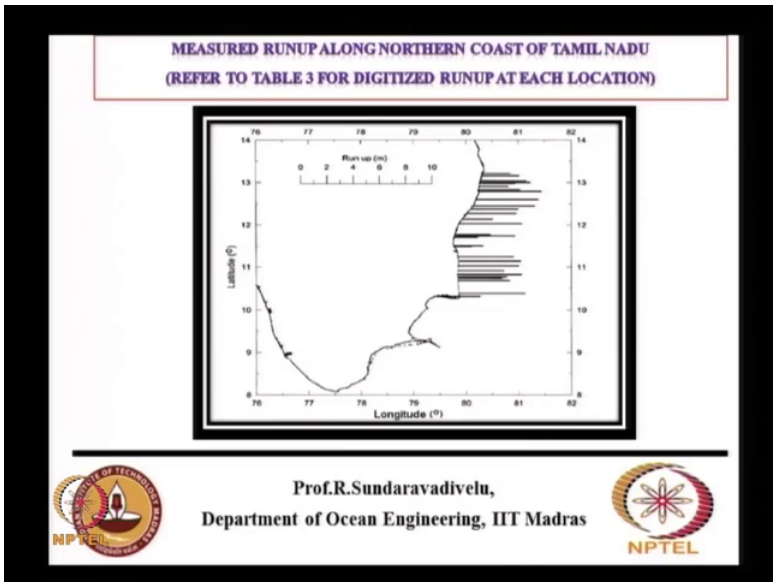

It shows where it has got affected, where the tsunami has hit on the southern end coastal India. This is made by our department people, there are 2 charts I am going to show you. One is the run off, another is the inundation. Run-up means how much water level has gone up. So here the scale is given, this is the typically the Tamil Nadu border, Tamil Nadu coast, from here to here it may be about 1 centimetre, it is about 2 metre, so if we see here, this may be about 3 centimetres, that means it is about 6 metre of run-up. Run-up means how much the water level has gone up. Okay.

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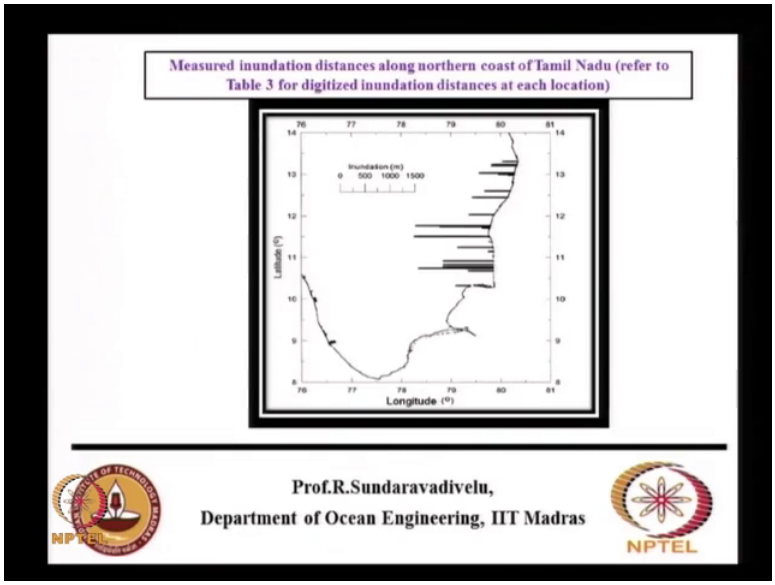

Then another important parameter is inundation. Inundation about 1 centimetre is 500 metre, how much distance it has travelled in, so this may be around 1500 metres, one and half kilometres. Inundation only is creating a lot of problem for human life and property, mainly because of the shoreline is very flat, the coastal land. The topography contour is not varying very much like Nagapattinam and all. The variation one and half kilometres away from the coastline and where the coastline, the level difference may not be even more than 1 metre.

Water rises by 6 metre means, so much water will go in. A lot of people's life is lost when the water was receding. What happened is initially the water was receding when they saw, about 500-600 metres on the sea, where the water was there, it was going back, people went inside to see why it is going back, then another wave has come, tsunami wave. The period is very large for the tsunami, wave period is not 10 seconds and all, it is in minutesSo when another wave is coming, people started running, the speed of this tsunami wave, can you tell me what is the speed of the tsunami?

Numerical value, how many kilometres per hour? Who is the, who are aeronautic students here? Aeronautical, what is the speed of the plane? Not dream liner and all, I do not know what is this dream liner. What is generally the speed of the plane? Aeronautical students, what is the speed of the plane? How many of you have travelled in the aircraft? Okay, where from you have travelled, which place to which place?

Bhubaneswar to Vizag.

You are from Vizag or Bhubaneswar?

I live in West Bengal.

Bhubaneswar to Vizag, what is the distance?

It takes about 15 minutes by flight.

15 minutes you will not go. 15 minutes it will not take, it will take more, 50 minutes, about an hour. What is the distance? How many are from Andhra here? Andhra what is the length here? Chennai is the border, very close to Chennai is the bottle, northern border is somewhere near Gopalpur, Bhubaneswar is another 300 kilometre or 200, it will be about 600 kilometres. Flying time in one hour means it is 600 kilometre per hour. Tsunami speed is 600 kilometre per hour, very close to that.

From Port Blair when they sensed the tsunami and they reported, we had about 1 and half hours, very close to 2 hours one. The tsunami has taken 2 hours, the flight also will take roughly about 2 hours from Port Blair to Chennai, tsunami will also take 2 hours to reach. We could have saved the lives because previous tsunami was 500 years back, so we do not know what is this and all. But future we will take care, there is about 2 hours time difference is there. Once it strikes Port Blair, it will take 2 hours to come.

But the 600 kilometre per hour is not at the coast, it depends on the water depths. When it comes to the coast, when it feels the sea bottom, the speed reduces, it reduces to about 40 kilometres per hour. But nobody can run 40 kilometres per hour. So that is why this sure loss.

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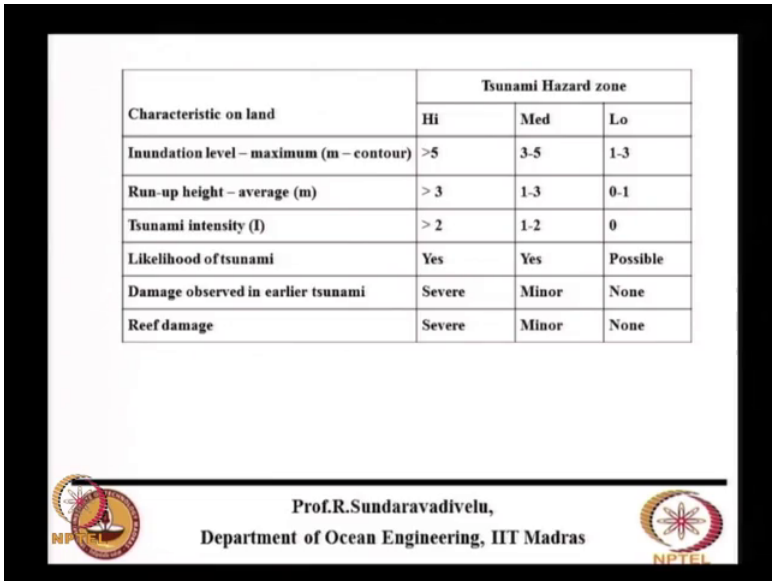

I will be discussing another lecture on tsunami where all these calculations will be given. Then we give this tsunami hazard, differentiate into high, medium and low, depending on the inundation level, run-up height, tsunami intensity, likelihood of tsunami, damage observed in earlier tsunami, Reef damage. So you can classify the different locations in Indian coast has high, medium or low. Then it means the inundation level is about 5 metres, run-up height is 3 metres, tsunami intensity we give some factors 2 and then likelihood and damages. This is how we go on to classify the tsunami.

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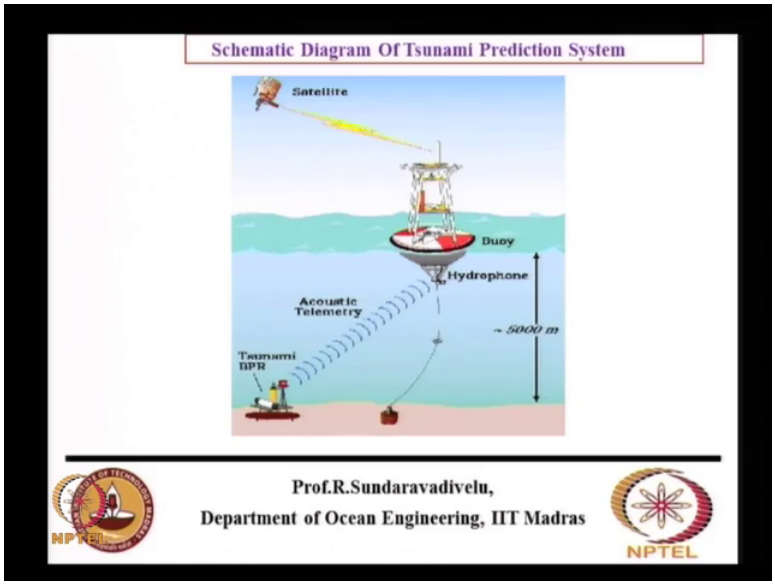

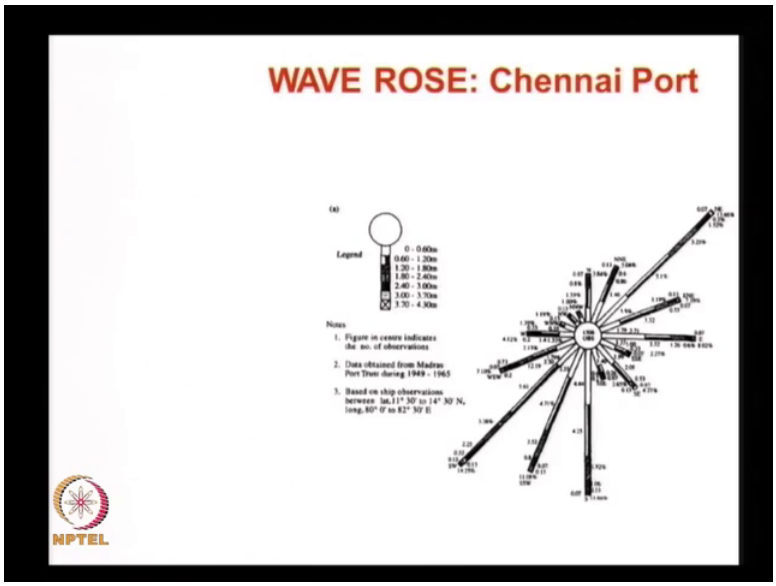

This is tsunami prediction system where we measure the water level variation in very deep waters. In very deep water the tsunami height is not much, maybe about half a metre or 1 metre only. In 5000 metre water depth, water level variation will be only half a metre or 1

metre, so it is very difficult to sense this pressure but we need sophisticated equipment to do this. Then we will move onto the last topic, that is about the wave rose diagram. Maybe we will do it in the next class.