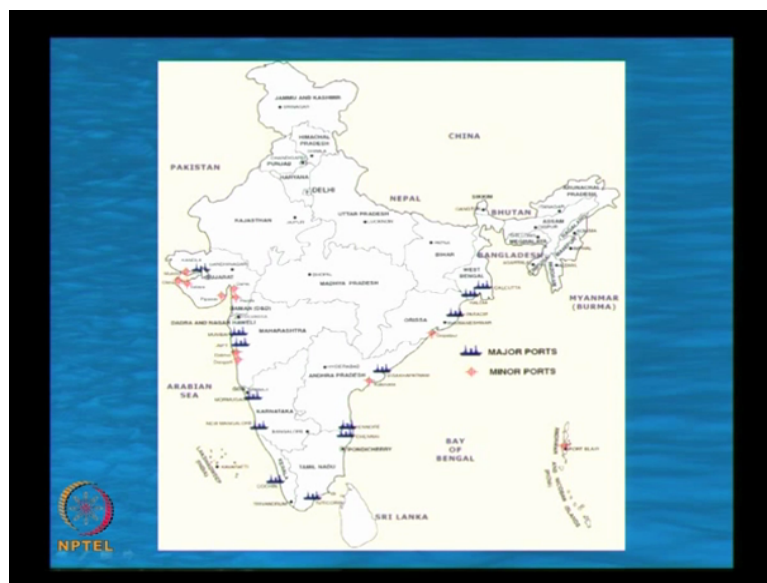


Port and Harbour Structures
Prof. R. Sundaravadivelu
Department of Ocean Engineering
Indian Institute of Technology Madras
Module 01 Lecture 02
Continuation of Layout of Ports

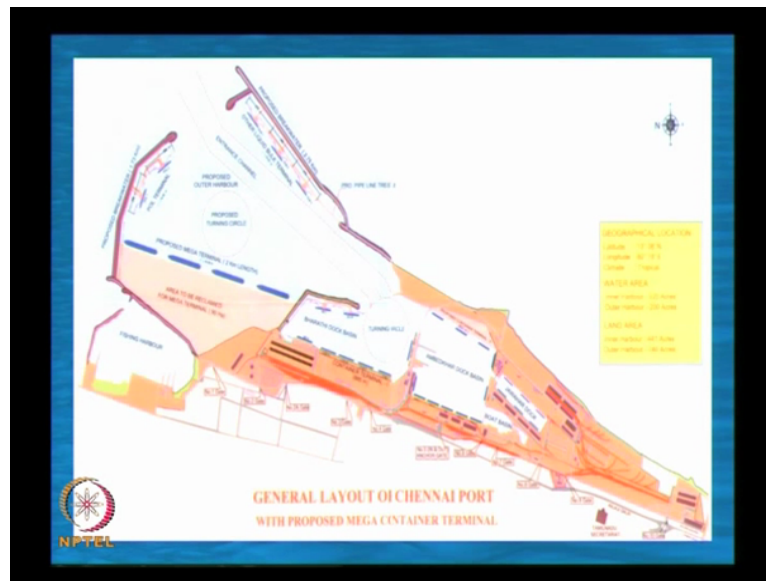
So in last class we were discussing about the ports, harbours, major-port, minor port. This class we will continue the layout of other ports. We have seen Chennai port last class. This we will discuss other ports like Ennore port, tuticorin port, kandla port, Jawaharlal Nehru port etcetera.

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Yesterday I have shown you this map India map showing the ports on the eastern side as well as ports on the western side. I want to discuss about artificial and the natural harbours showing the layout. Most of the ports on the east coast are artificial harbours and most of the ports on the west coast are natural harbours. Natural harbour means generally there will any break water, natural configuration of the sea provides tranquility. Tranquility reduced wave height within the harbour area; reduced wave height means generally less than 0.5 meters.

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Last class we have seen the Chennai port, I am again repeating this Chennai port layout in the context of artificial harbour. So we have built the breakwaters, on the eastern side as well as on the northern side. So these breakwaters provide tranquility inside the harbour area. So the tranquility means when outside 5 meter wave height is there, generally inside only 10 percent of the waves penetrate. How the waves penetrate? When the waves come from different directions, there is a opening through which wave comes inside, even if there is a wave coming from this side there is what is known as diffraction and waves coming from this side gets diffracted and comes inside, but when the waves are coming from this side, it will directly penetrate the north and since the width of the opening is limited, the waves will not come throughout the opening here, because this portion is protected. Only tis opening is there and through which only waves will penetrate.

So we have shown the northern direction here like this. Generally we have 3 monsoons in India. One is called as the north-east monsoon, another is called as the south-west monsoon, the third is called as non-monsoon. So when we have different monsoons, the wave directions will be different. South-west monsoon predominantly wave direction will be like this. North-east monsoon wave direction is, north-east monsoon is generally for 3 months starting from October, November and December. A non-monsoon is also for 3 months or 4 months 3 to 4 months, January, February, March, April. Then we have the remaining 5 months where we will have the south-west monsoon that is May, June, July, August, and September. So one of the problems of artificial harbour by constructing the breakwaters is when the waves are coming in this direction, it carries certain sand along with that the water.

So the breakwaters arrest the sand movement and deposition takes place you have very good marina beach on the southern side. Since the northern side is (())(4:41) of sediment we will have erosion on the northern side. This is during south-west monsoon. During north-east monsoon, this side we will get deposited and this side will get eroded. Predominately, the wave climate is more during south-west monsoon consistently only occasionally in north-east monsoon we will have cyclones and that time the wave height is very high. So the net movement is from south to north getting deposited and forming marina beach. So this is one of the important considerations when you build artificial harbour that is environmental management talking about costal process and shore line evaluation.

So we will discuss that in one of the lectures about this. So this to cap what we have discussed in the last class, we have discussed that Chennai port has 3 docks, Jawahar dock, Amberdkar dock, Bharathi dock. The wave climate inside jawahar dock is much less compared to amberdkar dock and Bharathi dock will have slightly higher wave climate than amberdkar dock. The water depth is more in bharathi dock. They are increasing the water depth inside the ambedkar dock as well as the jawahar dock to receive bigger size vessels and to keep space with the development in the world (())(6:24), because the ships are coming from ports from abroad to India. So in abroad if we have dipper draft in India also we have to create dipper draft. So we have vessels normally use for container about 4500 TEU vessel.

The 4500 TEU vessel can be **can be** berth in the first container terminal, which is in a public private partnership scheme with deeply well (())(7:01) as well as a second container terminal, which is developed by port of Singapore authorities limited. When we have more than 4500 TEU, now there is a possibility to go upto 18000 TEU, we need the bigger draft upto 18 meters. So it is proposed to build the terminal pair. Last class I told this as a transshipment terminal that means 18000 TEU vessel will come and berth here, they will unload the containers.

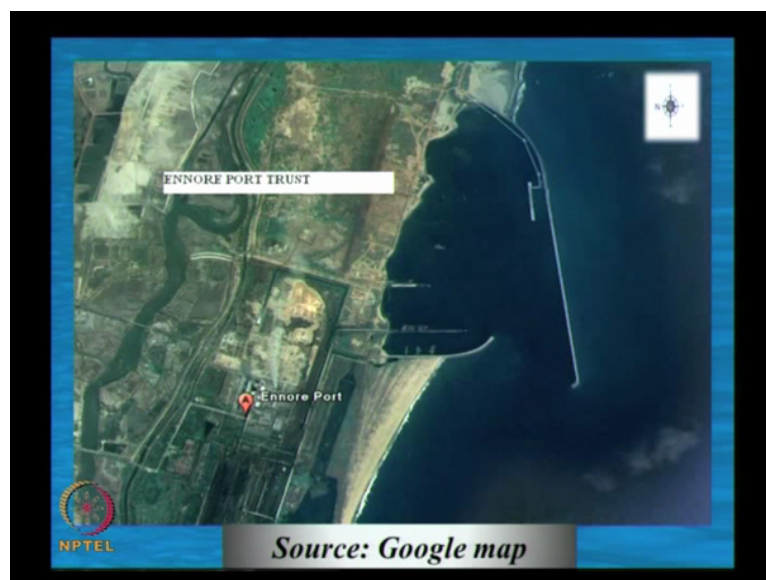
Then smaller container vessels starting from 600 TEU to 4500 TEU will come and take the containers from here and it will move to all along the east or west coast or other countries. So this container berth length is around 2 kilometers, we have to discuss about the capacity of the berth. The capacity of the berth is generally about 1500 TEU per meter length per year that means if we have 2 kilometers long berth into 1500 TEU it comes about 3 million TEU that is a capacity of the berth, but this is on a lower side 1500 TEU with the increased number of cranes on the berth we can increase to 2000 TEU. 2000 TEU is generally the benchmark

for good operation and management. In that case, this facility for 2 kilometers will handle about from here to here 2 kilometers will handle about 4 million TEU.

One of the advantage of the transshipment terminal is when you unload about 1 million TEU, you load again 1 million TEU that means the same container you are operating twice that means it becomes 1 million TEU becomes 2 million. Singapore is a very big transshipment terminal. Most of our containers to India is coming from Singapore, because they have very good operational facility.

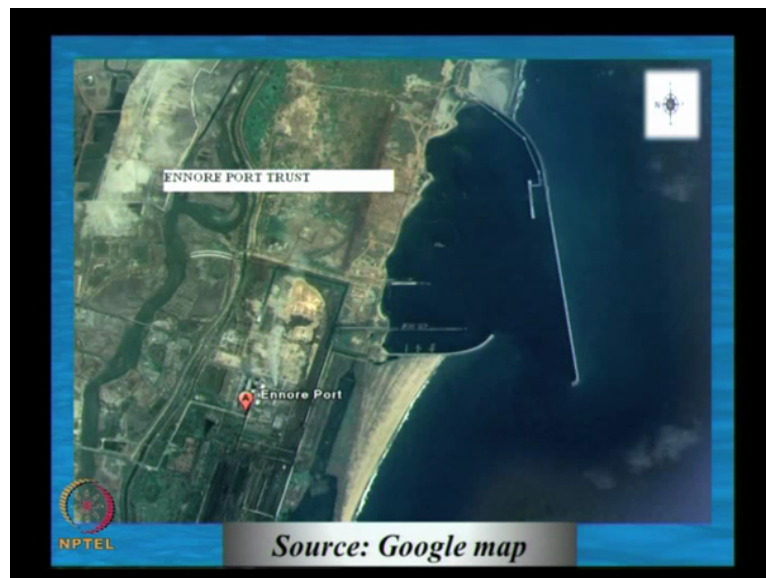
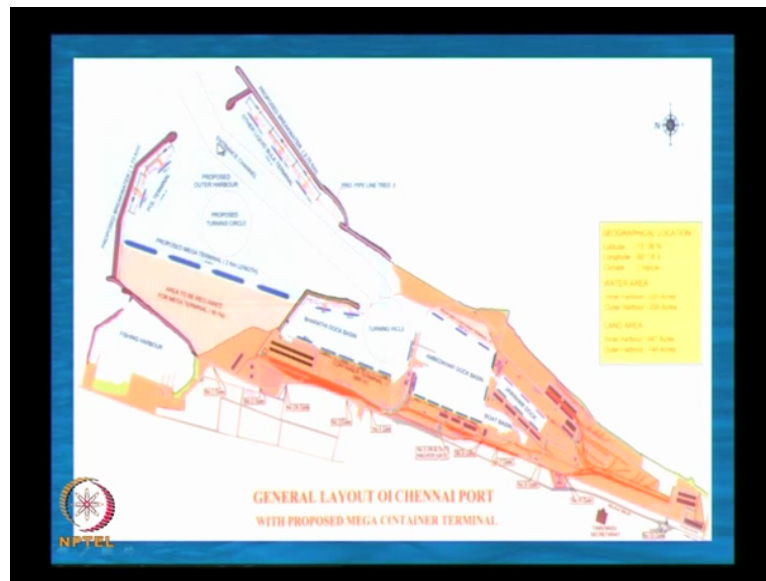
One more factor that is to be considered when you discuss about the port development is berth occupancy ratio. The berth occupancy ratio is defined as number of days the ships are in the berth divided by the total number of days available for berth. Generally the berth occupancy ratio should be about 0.5 to 0.6. In India it is very high. Very high means it may go even upto 0.8 to 0.9, but that is not good, because the ship we have to wait outside because of non-availability of berth, whereas in Singapore, the berth occupancy ratio is very close to 0.5 that means the berth is always available for the ship to come. So we are trying to achieve that so that the ships will not be standing outside. The berth will be available here as soon as the ship comes very close to the port limits. I will discuss about port limits in another slide.

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Nowadays with the satellite imagery we get very good pictures of the ports.

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If we see the previous port, the entrance is from the north eastern side. This is for Chennai port whereas if we see the Ennore port, north-east this direction your entrance is coming from the southern side south-eastern. So the entrance is one of the important consideration for designing the port layout. They are specifying this southern entrance mainly, because they have lot of shoals, shoals means sand deposits here. So the water depth shallow here if you keep the opening from this side, they have to do lot of maintenance dredge.

So we will discuss about 2 types of dredging, one is called as capital dredging, once we develop the port inside the harbour basin this area as well as the entrance channel over a period of time, since we have increase the depth inside as well as outside compared to the places adjacent whenever the movement of wave transport sediments, since the depth is more

here, the velocity becomes less and it gets sediment, point is clear to you. You have more depth here; more depth means area of cross section is more in the entrance channel. So the velocity becomes less and the water will get when it is passing through this, the sediments in the water will get deposited here and that we have to do maintenance dredge.

Maintenance dredging is approximately about 10 percent of capital dredging, suppose you dredge about 4 million cubic meter in the entrance channel as well as in the harbour basin, your maintenance dredging will be about 0.4 million cubic meter. We see the layout here, this is your shore line we have one breakwater here and we have another breakwater here. The entrance is from this side. This is your north side. This is your east side. Generally we have to show the port layout in this configuration. What is that you are seeing here this portion? What do you think it is sedimentation?

So this I told you in the previous slide that because of the movement of waves. The wave may act like this in this direction that is from here to here. This will have two components, one is called as long shore component another is called as on-shore off-shore component. Once we have the long shore component, we carry some sediment along with this. Once, we have a breakwater here like this, the sediment get deposited.

Original coast line was here. This was the original coast line over a period of time this much portion get deposited, as you are building the breakwater the sediment also gets build up, you have to continuously built the breakwater otherwise the sediment if you stop and then start stop like that, whatever sediment your coming here, it will come upto this entrance, then it will bypass that is not desirable, okay. So this distance is I think approximately about 600 or 700 meters and this distance is about 400 meters, but this will reach certain equilibrium, as much you are getting this sedimentation northern side, there will be erosion, but northern side already shale is there that will get eroded, then when you do the capital dredging another environmental impact assessment is where your disposing of the dredged material, you can put it on the northern side (15:25) that there will be erosion and it will be taken away is called as the landfill or you can dispose of the dredged material at the deeper waters in about 30 meter water depth, because in 30 meter water depth if you (15:43) 30 to 50 meter water depth if we dispose-off. Whatever you are disposing from here to here will not come back to the shore.

So normally in maintenance dredging they do not dispose at correct point. So whatever they are depositing will come back to the entrance channel as well as inside the harbour basin. So

you should see what you are dredging is disposed-off properly. We have to do some studies to find out where it can be effectively disposed. Here what you have is POL terminal which is used by Tamil Nadu electricity board and here we have a temporary jetties (16:29) where they are using the iron ore export to the temporary they have removed it. Now they are trying to build a new facility here and this is your POL berth.

What is POL? Lubrication, petrol, oil and lubricant. So this is called as a POL berth and POL berth is very long berth. This can handle from a smaller vessels to bigger vessel. Smaller vessel means 5000 DWAT (17:04) to upto 100 thousand (17:07). So they have a continuous berth here. We will discuss layout of berth later, but here it is a continuous berth. Normally POL berths are with dolphins (17:20) and isolated structures, but here it is continuous to take care of smaller to longer vessels and more number of vessels also. What you are seeing is a pipeline (17:31) through which the pipelines are used to transport the cargo on top of the piles to the land area and typically this breakwater one of the breakwaters will be longer compared to another breakwater, because one of the critical problem for ship approach is, suppose a ship is coming here, in the outside completely outside. All the portion of the ship will be subjected to same waves and (18:07).

Suppose it is come inside waves are less, but suppose 50 percent of the ship is this side and 50 percent of the ship is this side. The waves will be more on wave will be more on the exposed area beyond the breakwater and placed on this that will try to shift the ship like this. So the our ship going like this, it will go like this that is why we have to very careful in designing this and once it comes here, it will get good tranquility. This another study which we have to do that is called as ship (18:42). How we are bringing the ship here.

Last class I told the ship will be stop somewhere here and it takes a stopping distance is called as a stopping distance that is equal to 7 times the length of the ship, then the tugboats are connected here itself, but when the ship stops then it will tend the vessel and bring the vessel very close to the berth. Now there is lot of development in Ennore port. They are building a car (19:13) terminal here. It is not shown here. They are also building a container terminal. It is called as Ennore port limited. This is called as land lord port. Land lord port means Ennore port limited as built only the breakwater. They have done capital dredging. They have done the maintenance dredging.

Here, there are 3 arms shown here. These are used for the tugboats to berth at this location. So they are maintaining the tugboats, maintaining the channel and maintaining the harbour

basin whereas the berths are built in public private partnership and this is done by one company called the IMC. This is for TNAB (20:05). Container berth has gone into a (20:08) some foreign companies and Indian companies. So the land lord port means only the breakwater, the dredging and operation of vessel using the tugboats will be done by the Ennore port limited, whereas the terminals. This is the coal terminal, POL terminal will be operated by the PPP operator. Terminal means they will have the berthing structures, they will have the cranes and they also will have a conveyer. There will be a conveyer which will be transporting the cargo to the stack yard. The stackyard also will have stacker and (20:54).

When we talk about port engineering, it is not civil engineering alone. It is a mechanical engineering also there in the sense that all the mechanical handling systems should be of high quality, maintenance free as well as high capacity of loading and unloading. The loading and unloading is about 2000 tones per hour approximately, 2000 tones per means 20 hours of operation you will get about 40000 tons per day. Typically panamak (21:32) vessel will have 60000 DW that means the (21:37) size vessel 60000 tons of cargo can be handled in one and half days . is it clear 2000 tons per hour 20 days, 40 thousand tons per day 20 hours of operation, if we take one and half days 60 thousand tons of vessels will be evacuated within a one and half days. We have this called as a unloading terminal.

Unloading means the Pol is coming from paradip or somewhere else Indonesia or other countries then it is unloaded, and it is taken into this. So there is a port in Indonesia or paradip in Orissa that is called as a loading port. Which rate will be higher? Loading rate and unloading rate? Unloading rate is wrong answer; loading rate is a right answer. Unloading rate means from the ship you have to pick up the cargo. Loading means from the berth you are loading into the ship means from the berth, you are loading into the ship.

Suppose you put the cargo, it is faster, you take the cargo. Suppose I put one kg of rice, I can put it very fast, if I take 1 kg of rice it will take more time, another thing is I cannot take 1 kg of rice even by hand if you are taking 1 kg of rice if I want to take only 900 grams I will be able to take 100 grams will be (23:06) here to take first 500 grams, it will be faster. Then another 200 grams will be slower. The last 100 grams will be very difficult same thing happens in the ship also. The unloading rate is not uniform. This point is clear when the ship is full with a cargo, then you can unloading rate will be faster. When the cargo is getting reduce and (23:32) removing the cargo will become a problem. So loading rate is

generally higher is about 2500 to 3000 tons per hour. It depends on the type of cargo also, density of the cargo.

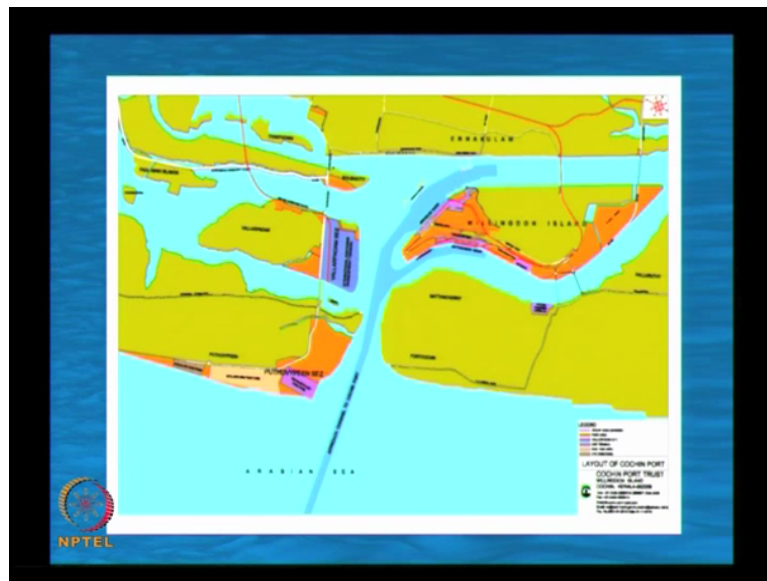
What is a density of cargo? What will be the density of Pol and what will be the density of iron ore? Which will be higher? What will be the density? (())(24:04) 6 to 7 and that is the density of the metal not the ore, iron ore means it is a bulk density. It will be only around 2.2 iron ore. Pol will be very close to 1 understood. Now density means you are thinking of the density of metal is not density of metal. It si density of material bulk density it is called.

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Then we will go to question 4. So question 4 just like previous, I have given the latitude and longitude and again this is connected to the hinterland to Kerala, south Tamilnadu and south Karnataka. The connectivity is important national highways NH47, NH49, NH17. There are 3 NH, kanyakumari-salem, cochin-Madurai, cochin-Mumbai. So any port need to have a connectivity. This is very important. So port development means it is not the development of the port only, it is development of hinterland also and any port is not state dependent. It is covering Kerala, South Tamilnadu and South Karnataka also not one state alone even if it is minor port under state control will attract cargo from neighboring states.

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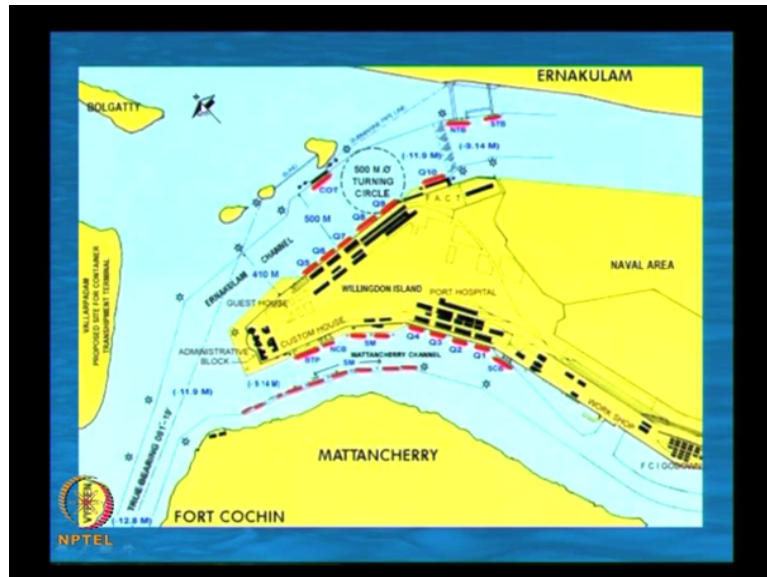
This shows layout of Cochin port. This is entrance channel we have two channels here, one is called as the vallarpadam channel another is called as the Ernakulum (25:55) channel. It is a natural backwaters, natural channels per entry. There is no breakwaters. This is on the east coast it is on the west coast ideal location no breakwaters are there, just like unlike Ennore and Chennai, because we are able to maintain the channel with dredging, the siltation (26:29) is not much. We are discussing about vallarpadam container terminal last class. This is the location of the vallarpadam terminal. We have one more island here called is called as puduvaipin (26:44) island. This puduvaipin (26:45) island means pudu means new in Tamil as well as in Malayalam. This puduvaipin island is formed because of the sediment deposition here. Original coast line was somewhere here and now we have formed the new island here. We are here we have oil terminal and we also have what is called as puduvaipin (27:06) SEZ means special economic zone.

So here we get lot of consideration and new industries are developed and this island is called as a Wellington island. The real estate prices are very high very close to the port in any port city; it is not the mount road or basal nagar, which is very costly in Chennai city. It is a land area adjacent to the port. Similarly, in Cochin Wellington island is very expensive area we get the land Wellington Island or temporary container facilities handling facilities is very expensive.

Here also you can see some of the bridges which are being builds for taking the cargo. Any doubt in this? This is the Arabian sea, there is no breakwater, natural opening is there, one of the thing is this opening should be natural not on the sea side between the sea and the land

area lot of water area is there. All the water coming to Kerala state. They get drained out and due to tidal variation also water goes into this channel, we have the berthing structures all along this as well as along this. We have a shipyard also in this cochin fort and we have certain naval facilities also in cochin fort.

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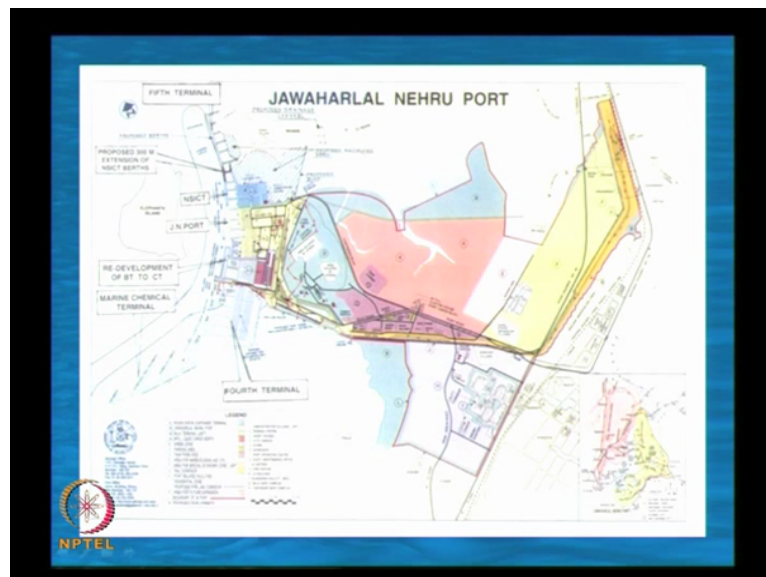
This shows the layout. This is called as mattancherry, fort Cochin. This is how the vessels normally go inside the channel. This is a naval area. It is the 500 meter turning circle, is called as Ernakulum channel. There are many facilities here on this side also tourist come through this side. They can also go all the way to fort Cochin and this is the location path vallarpadam channel. This shows the northern direction.

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Then we will see next JNPT. Jawaharlal Nehru Port Trust is the latitude, longitude is given. This port is handling mostly container and we also have a liquid terminal we also have shallow water berth, where we use the break-bulk and container traffic. Break-bulk means coal, iron ore and things like that, but mostly JNPT is handling only container traffic.(30:08)

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This gives the overall picture of the Jawaharlal Nehru Port Trust, but you please concentrate on this area. This is the entrance channel through which the vessels will come and go all the way and there is a turning circle you come back. This is showing the berth areas, mostly these are all container berths. Here we have some terminals where oil can be handled. These are

showing some future developments. Here also certain approaches and new developments will take place.

We see here, one of the features of JNPT is we have the berths all along this for a way from the shore line, shore line is somewhere here. So it is one of the new concept. There is an approach from the shore line to the berth. Normally this is use only for liquid terminals, but now they are using it for container terminal also, because the water depth is available only here. If you place this berth along this lot dredging is required and cost of berths also will be more, because this has to retain too much of soil. Here, it will not retain the soil; they will dredge upto 14 meter. They will have about 200-300 meter distance so that there will be a natural slop and here you need only less (31:51) for providing the turning structures. We have writturn NSICT (32:00) this si none of the terminal which they have develop. The whole area is divided into 2 terminals one is NICET another is operated by JNPT Jawaharlal Nehru port.

What you are seeing is the Elephanta Island. This Elephanta Island is natural formation and it si a historical place and when they want to do the dredging here, they have to blast some rock. So we have done some measurements on the caves, the Elephanta island so that when you are blasting the rocks here it does not have any blasting or dredging does not any impact on this. This is another factor that you have to consider that is 3 points I have told, once you build the breakwater there will be shore length changes you have to do the shore line evaluation. Second one I was talking about dredging. Dredging means capital as well as maintenance dredging. How you are dredging? How you are disposing?

Third one is, if the soil is consisting of rock you may use some control blasting and that operation is taking place especially to the historical monuments. There should not be any damage that also you have to study. This also is a natural harbour; your bombe island is here that gives protection to this. Elephanta island also gives protection to this. So it is not directly facing the Arabian sea. Arabian sea is faced by bombe island here. So it gives lot of protection to the JNPT.

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KANDLA PORT

Location

Latitude : 23°01' N
Longitude : 70°13' E

Major Future Plan

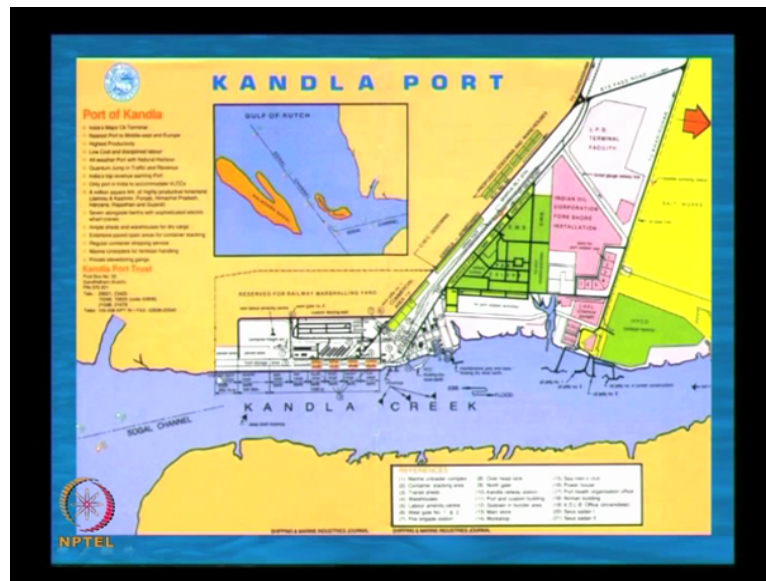
- Addition of four Dry Cargo Berths - 13th to 16th with 8 MMTPA, draught of 14 m to be developed on BOT at a cost of Rs.701 Crores.
- Offshore Berthing facility with 12 MMTPA at the cost of Rs.882 Crores at Satellite Port of Tuna with 15 mtrs.

NPTEL Prof.R.Sundaravadivelu, Department of Ocean Engineering, IIT Madras

Next we will see the port which is handling the maximum cargo in India is called as Kandla port. We have shown the latitude and longitude, you can go to the Google and see for this latitude and longitude of the layout is and they have some major future plans. They want to build the four dry cargo berths number is given as 13th to 16th with 8 million metric tons per annume say MMTPA mean million metric tons per annume. There four berths 13, 14, 15 and 16 each berth they have given 2 million metric tons per annume. this capacity of 2 million metric tons per annume each of about 300 meter length is less compared to other berths which are being used in Ennore or Chennai. There they may handle from 4 million tones to 6 million tones, because it is only single cargo single commodity cargo.

Ennore port, Tamilnadu electricity board is having coal terminal only coal is coming. It is coming in bigger vessel. They have very good handling system, conveyer system to take the cargo whereas here, in kandla when we build the berth you will have a general cargo only, you may get fertilizer, you may get rock phosphate, wheat (35:11) iron ore scrap. They may come in smaller vessels that why the handling rate is very less. They also want to build the one offshore berthing facility is 12 million metric tons per annume. The cost of about 882 carores is at satellite port which is called as Tuna with 15 meter draft, whereas here this draft will be about 14 meter, the cost is about 701 carores, 1 carore is certain million rupees.

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This shows the layout of Kandla port we have the Gulf of Kutch here. Then we have a channel called as sogal channel. This sogal channel is coming here not here. The continuation of this portion is here. There is a long channel goes here. In the layout of Kandla is called as a quick port where the due to tidal waters, there will be moment of water in this direction during high tide, moment of water in this direction low tide, we have shown here F band (()) (36:21) flood. So when there is a flood that is high tide is there water will go inside. When there is F (())(36:28) there is low tide water will flow here.

We have the bulk-berths here on this side and we have the oil berths here on the other side. If we see the layout of the port you will always see that there will be 12 segregation between the liquid berths and other berths. Similarly the container berths, clean cargo berths and the dirty cargo berths. Here, there is only one berth which si handling container some (())(36:59) berth also, all other berths are using different types of products. This Kandla port there was earthquake, some damages taken place for about 6 berths, we will discuss about that later. Whenever there is a damage that is taking place due to earthquake or tsunami we repair the berth that is called as rehabilitation we will discuss about that later. So here these are all the oil berths and these are all the (())(37:30) berths. They are building 13, 14, 15, 16 like this.

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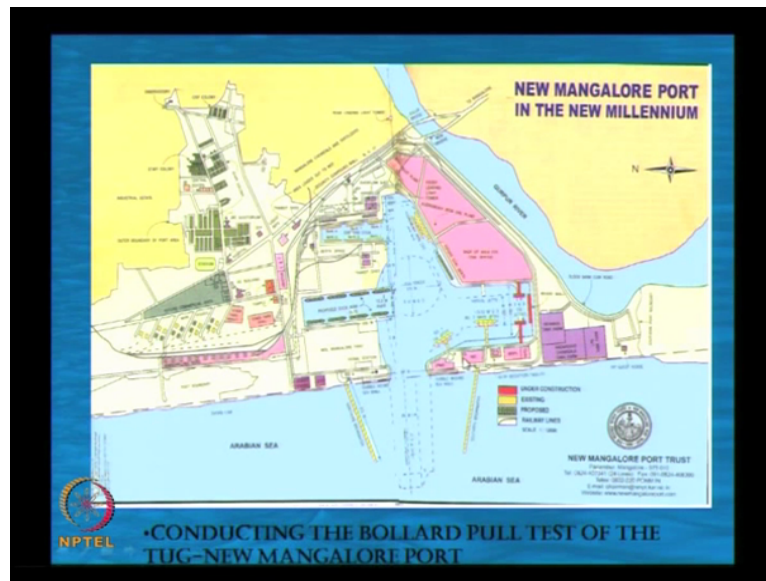
NEW MANGALORE PORT

- **Location**
 - Latitude : 12° 55' N
 - Longitude : 74° 48' E
- The Port has 14 berths, which includes 9 General Cargo berths and 4 oil jetties.
- Handling liquid chemical through POL products, containers and bulk cargoes like Granite stone, Timbers, Coal, Coke, Iron Ore pellets, Fertilizers
- **Largest LPG handling Port in India**
- **3rd Largest POL handling Port in India**

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Then we will see the new Mangalore port. The new Mangalore port is also on the west side. This has about 14 berths, 9 general cargo berths and 4 oil jetties. This is handling liquid chemical through POL products containers, bulk-cargoes. Bulk-cargoes consist of granite stones, timbers, coal, coke, iron ore pellets, we have (38:03) facility in near Mangalore. So this port is developed only to export of iron ore pellets, fertilizers. This is one of the largest LPG handling port in India. This is a 3rd largest POL handling port in India. More than 50 percent of the cargo which is handling the port is POL products a very important that POL facility is operational all along the coast of India because, distribution is problem we do not have many facilities at every 200-300 kilometers center to center, the distribution becomes a big problem.

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This is called as lagoon harbour, we have a river called as a (38:47) river. This is the northern side, this is the western side. Lagoon means unlike Chennai or Ennore we have the breakwaters to protect only the entrances channel the port is developed in the land is called as a lagoon, we have created artificial lagoon. This is your shoreline. The krupu (38:55) river goes here and then it gets into sea after some distance and we have built 2 breakwaters only to protect the entrance channel from siltation. There is a turning circle here; we have one set of berths here.

Another set of berths here handling the products other than POL and these are the berths which are used for POL products. It includes LPG also. So this is located very close to the entrance far away from this side, because if there is any fire hazard here then it will not get distributed to this (39:52). This is the berth used for iron ore. So when there is any vessel which has to be evacuated, the chemical tankers, POL product tankers they can come very easily out. So normally the liquid cargo vicinities will be very near the entrance. So with this we will complete today's lecture. We will discuss about other ports in the next class. Thank you.