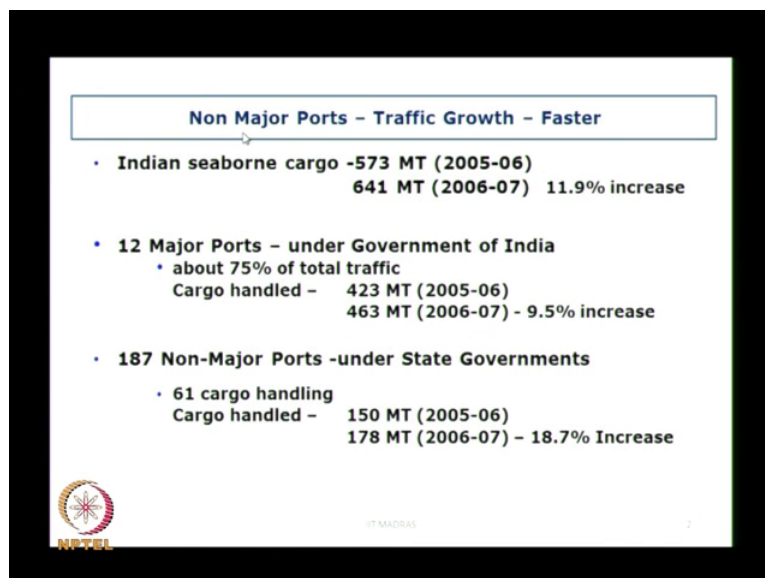


Port and Harbour Structures.
Professor R. Sundaradivelu.
Department of Ocean Engineering.
Indian Institute of Technology, Madras.
Module-1.
Lecture-5.
Port Planning.

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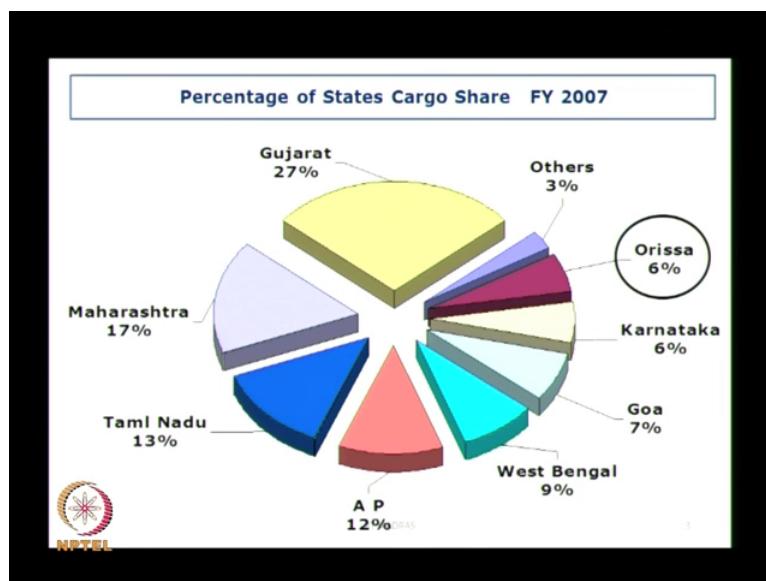


So next lecture will be on techno-economic appraisal and we will give the port sector overview in India, we will give with particular reference to the state of Orissa, what are the developments that are required. One of the major conclusion based on the review is the non-major ports, that is the ports which are under the state control, the traffic growth is faster. We

have taken 2 years 2005-06, 2006-07, total cargo has increased from 573 to 641, that is about 11.9 percent increase, overall growth.

The 12 major ports that are under the government of India, they are handling about 75 percent of the total traffic, that is 423 million tonnes to 463 million tonnes, about 9.5 percent increase, whereas we have 187 non-major ports under state governments. And there the cargo has increased from 150 million tonnes to 178, that is about 18.7 percent, it is almost double that of the major port, this trend is continuing.

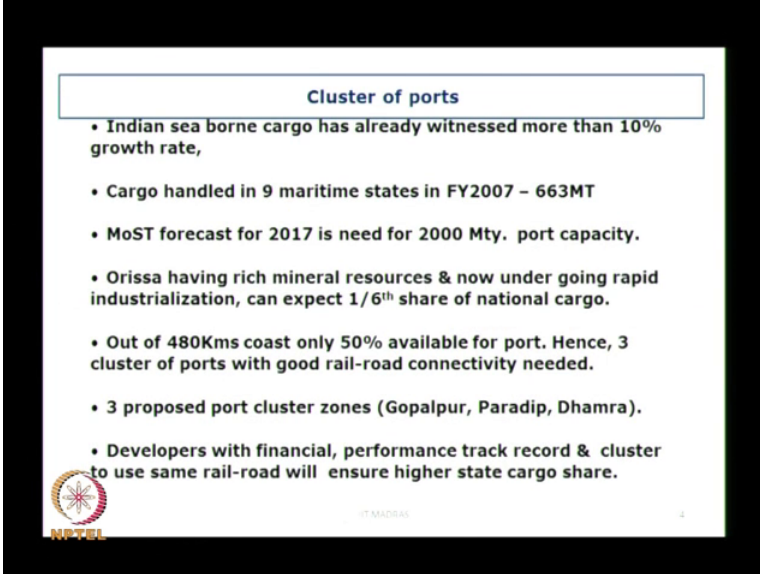
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If we see the share of the maritime states, I said in the first-class that there are about 9 maritime states, there is no surprise that the 3 states Gujarat, Maharashtra and Tamil Nadu, these are 3 major states that are handling the maximum cargo. If we see the living style of people in all these 3 states, they are much higher than other states. AP is fast catching up, they will come very close to Tamil Nadu, so these 3-4 major states, their handling the maximum amount of cargo, West Bengal is only 9 percent, Goa is 7 percent.


Though Goa is a very small state, its handling capacity is comparable because of the location of Mormugoa port as well as the hinterland what it has. Karnataka 6 percent, Orissa 6 percent, others are about 3 percent, this is what it shows. I will be concentrating on Orissa, just to give what are the reasons why it is not comparable. The reason for Gujarat is obvious, we have 2 Gulfs, Gulf of Kutch and Gulf of Bombay, the industrial policy of Gujarat government is also very good. Basically the Gujarat people are businessmen, anybody from Gujarat here? I do not expect anybody.

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Cluster of ports

- Indian sea borne cargo has already witnessed more than 10% growth rate,
- Cargo handled in 9 maritime states in FY2007 – 663MT
- MoST forecast for 2017 is need for 2000 Mty. port capacity.
- Orissa having rich mineral resources & now under going rapid industrialization, can expect 1/6th share of national cargo.
- Out of 480Kms coast only 50% available for port. Hence, 3 cluster of ports with good rail-road connectivity needed.
- 3 proposed port cluster zones (Gopalpur, Paradip, Dhamra).
- Developers with financial, performance track record & cluster to use same rail-road will ensure higher state cargo share.

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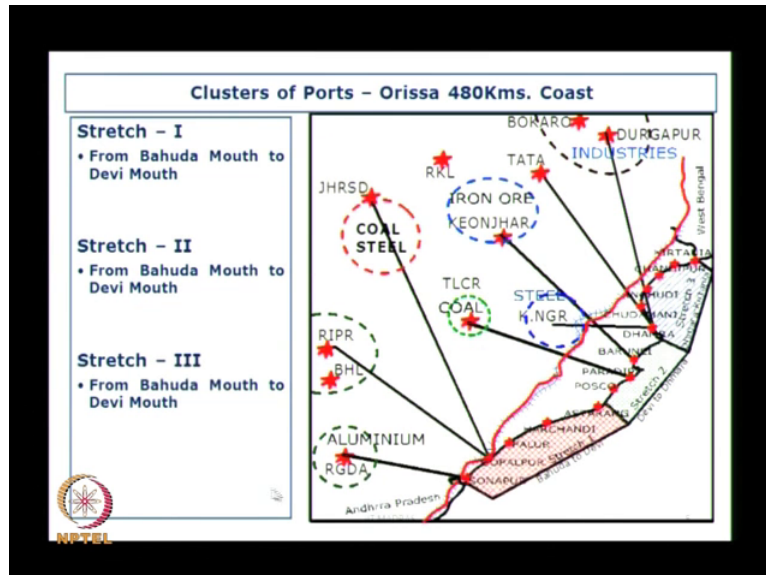
I think most of you may be Tamil Nadu and Andhra Pradesh because of the location of IIT Madras, but Gujarat, the people are businessmen, they may study MBA, not engineering. So these 9 maritime states we have in financial year 2007, 663 million tonnes, MOST means Ministry of surface transport, now it is shipping, Ministry of shipping, they have forecast in 2017, about 2000 million tons but because of the economic recession this 2017 may go to 2020.

But 2011, this 2007-663, 2011, we are handling very close to 1 billion tons, that is thousand million tons. Just like Goa, Orissa is also having rich mineral resources and there is also now undergoing rapid industrialisation, so this can expect about 1/6 of the National cargo, 1/6 means 15 percent of the National cargo. And we have about 480 kilometres of coast in Orissa, Tamil Nadu is about 600 or slightly more kilometres but out of this only 50 percent is available for port development.

And the purpose of this slide is to show what is the advantage of cluster of ports. If we see Tamil Nadu, near Chennai we have 3 ports, one is Chennai, other is Ennore, the 3rd one is L&T. There are some advantages of cluster of ports, so we want to say we need to have a cluster of ports. We are suggesting about 3 cluster of ports, the advantage is the rail and road connectivity. When we want to have the connectivity for the port, we have cluster of ports, then the rail and road connectivity can be common for one cluster of ports. So the development cost can be shared.

And we are suggesting 3 locations one is Gopalpur, another is Paradip and the 3rd one is Dhamra, they are distributed along this 480 kilometres. Another thing what we want to say is the development with financial performance track record and their willingness to use the cluster will be given the preference to develop this course.

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So this is your Orissa coastline starting from very close to Andhra border, this place is called Sonapur, it goes all along this, this we call it as 1st cluster, Gopalpur cluster. We are calling this Gopalpur cluster because already the approval has been obtained for Gopalpur, the construction is going on. The next cluster is between these 2 locations, that there is a river Devi coming here, from Devi to Dhamra, the 3rd cluster is from Dhamra to, the coastline goes like this. Then Chandrapur is the place where we have this ISRO and other establishments using this seacoast.

This portion is very calm area, is very good, not only from the Indian context, from the international context international context, it goes up to the West Bengal border. These are the 3 structures what we want to develop and each stretch we are showing were the cargo is coming and we can develop the, this shows the railway line, what you are seeing is the main railway line goes which all along the border.

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Gopalpur Cluster - Sonapur to Astaranga

- **Gopalpur Cluster (Sonapur to Astarang South) :**
 - Curvilinear coastal length - 235Kms.
 - Environment Restriction - 145 Kms. (by Chilika Lagoon, Puri-Konark)
 - 90Kms. coast available for Sonapur, Palur, Gopalpur, Bali Harchandi,
 - Sonapur, Palur, Gopalpur could be one cluster for rail-road connectivity.
 - For Gopalpur cluster, Raigada & Titlagada connection will fetch more cargo.
 - Raipur-Gopalpur Connection joined through Khurda Balangir to be developed.
 - Brahmapur-Therruvally will reduce Aluminum belt distance.

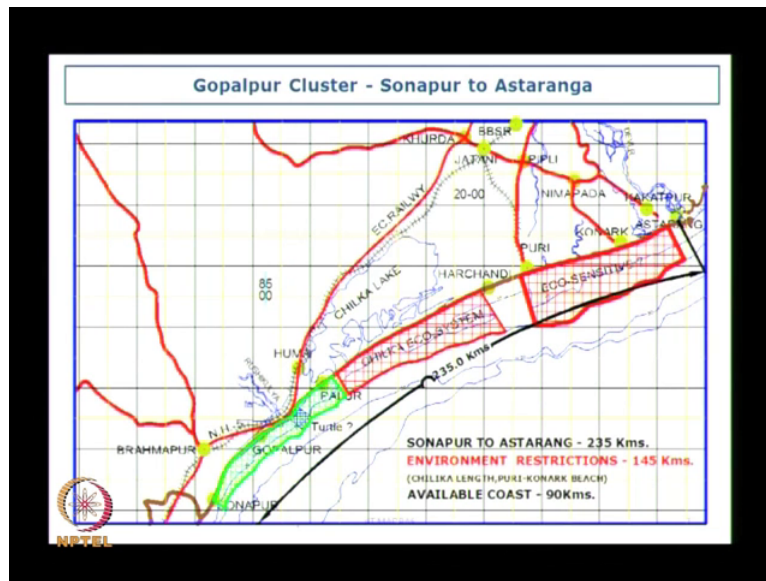
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This Gopalpur cluster, the details are given, what is the coastal length-235 kilometres. There is an environmental restriction, this point is very important, whenever we talk about port development, this environmental restriction is one which governs whether a port can be developed or not. We have one of the largest lakes, it can be called as a wetland also, that is called the Chilka Lake, it is very big, it is about 1000 square kilometres, 60 kilometre long and about 20 kilometres wide, maximum width.

It is an environmentally sensitive area, then we have this Puri and Konark, these are all heritage sites. There is a committee called MS Swaminathan, MS Swaminathan was the chairman Board of Governors of our IIT Madras, he has stipulated that no port can be developed at a distance of 10 kilometre from a historical site. For example from Puri, on either side 10 kilometre, you cannot develop any port, that is to protect the heritage sites. Chilka Lagoon is a wetland, so if we develop any port, it will affect the coastal inlets, so we cannot say.

So out of 235 kilometres, 145 kilometres we cannot develop, only 90 kilometres can develop. Only 3 places we can develop one is Sonapur, another is Palur and the 3rd one is Gopalpur. And this gives some details about the connection, I will not go into detail, unless you know the geography and the details it will be difficult for you to understand.

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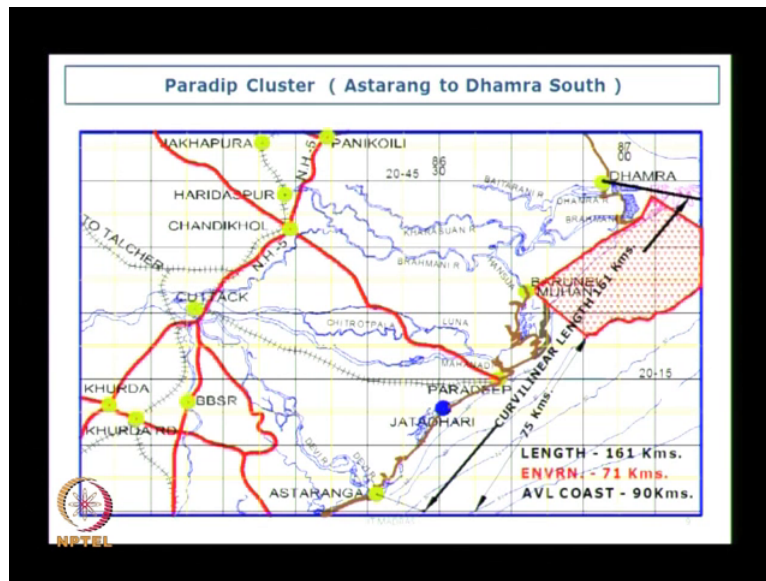


There is a river called Rushikulya river, which is draining into the sea and this is that stretch, Sonapur up to this place called Astaranga where there is a river Devi which is turning into this. So we are discussing about Puri, Puri somewhere here, the Konark is somewhere here, so this area becomes really very sensitive. And I was talking about the Chilka Lake, the length is around 60 kilometres, this distance is about 60 kilometre, the maximum width is 20 kilometres. What you are seeing here, the blue colour, this line in your Chilka Lake.

So this Chilka Lagoon ecosystem we cannot develop. Then we have Oliver Ridley turtles that come and rests by the side of the Rushikulya river, here also we cannot develop. So there are certain structures which should have been given red colour but this place, this place and this place you cannot develop. There is one place in between this at a distance of more than 10 kilometres, Harichandi where we can develop. Then we can develop a place called Palur, it is possible but it is not very economical.

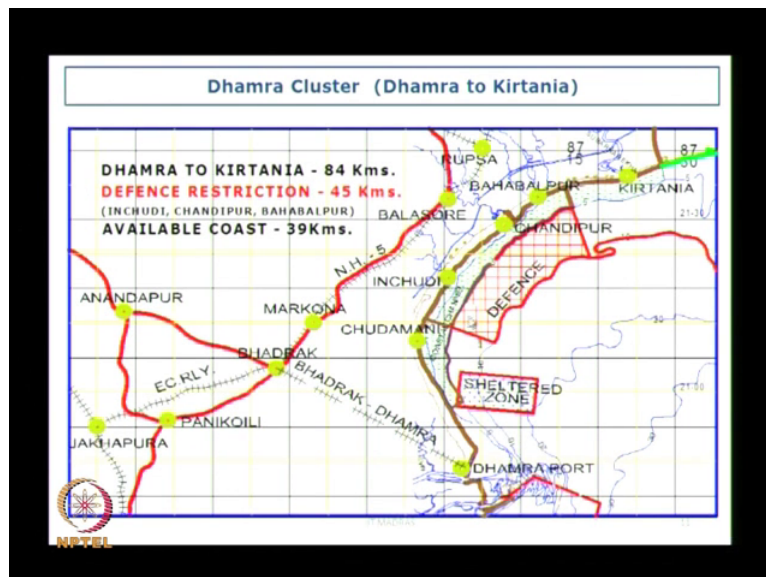
Gopalpur already developed, the other potential location is Sonapur, which also can be used for development. What is shown in the blue colour is the railway line, what is shown here in the red colour is your road network, that is being shown. So in summary we have only 90 kilometre of coast which is available for development.

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Then we have this Paradip cluster, so this area also is very sensitive area, so we cannot develop here and we have a place called Dhamra where the river is draining. This area is also very sensitive area for our Indian Navy, there are certain establishments where you cannot develop. Only Dhamra you can develop.

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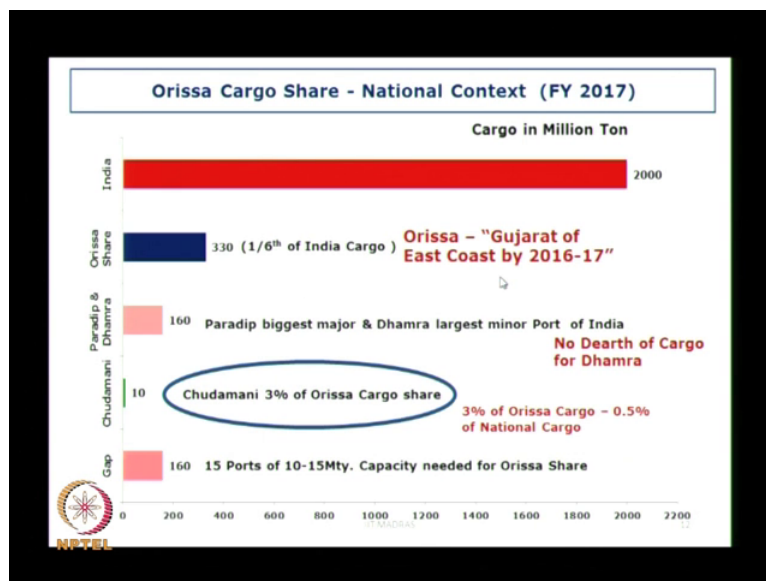


Then we have the other cluster, this is the Dhamra port, starting from Dhamra to West Bengal border, there is a 3rd cluster where we have this portion shown here which is your environmentally sensitive area, I am sorry, it is not environmentally, it is the defence, they have some restrictions. They are doing some operations here, we cannot, they do not permit any commercial activity in this. What you are seeing here is this red colour is your 10 metre

contour, this blue colour is the 50 metre contour and this is about 80 metre contour. And here we have developed the Dhamra port.

So just below this defence restricted area there is a place called Chudamani where you can develop. North of this where we have the river mouth, Sonarika mouth where they can develop a port called Kirtania. There is one more port planned on the other side of the river. So these are the 3 clusters, the distance from Dhamra to Kirtania is 84, out of which defence restriction is 45 and the available coast is only 89 kilometres. This railway line which is connecting this main railway line is being laid for the Dhamra port.

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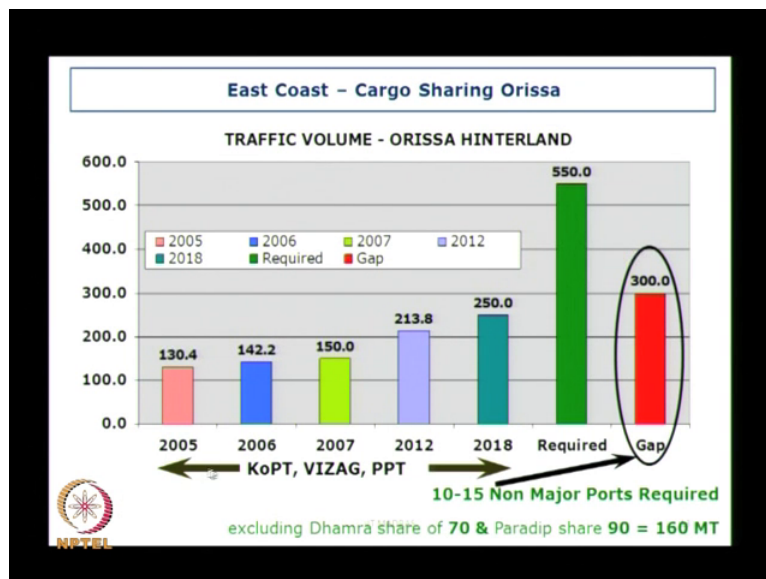


So what is the cargo share that has to come to Orissa. If you take 2020, it is given as 2017 but we will make it as 2020 where there is some. So you have to see this in the context, that is in 2011, we have about 1 billion tons, that will be increased in another 9 years or 10 years to another 1 billion ton. So from independent 1947 to 2011, slowly we are increasing to 1 billion ton. So from 2011 to 2020, it may go to 2 billion tons. This shows how fast the development will take place, what are the requirements for port industries.

So, the spinoff of any development of port is the hinterland development. So when the hinterland develops, it needs a port, vice versa also, when a port develops, the hinterland also develops. So we have one 6th of the share, about 30 million tonnes, that is to be your. So Paradip is the biggest major and Dhamra is the largest minor port of India, sorry it should be Orissa. And this may, the projection goes to 160 million tonnes and we need another 15 ports of 10 to 15 million tonnes capacity.

And Chudamani they are planning, that is about 10 million tonnes. If we see the development of course, Dhamra is being developed by L&T and Tata group and Chudamani is being developed by the Birla group. So the major industrial players, they want to develop the port. The biggest player in India is the Ambani group, Reliance, they have the port facilities in Gujarat, as well as they are planning in Maharashtra also.

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So this also shows the nearby ports like Calcutta Port trust, Vizag, and Paradip port and what is the projection, along the East Coast traffic volume considering the hinterland required is 550, all the ports put together, they will develop 250, so another 300 million tonnes gap is there. That is enough potential is there for development.

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Summing up : Orissa Share increase from 6 - 16% 2017

- Orissa's share 330 Mty. - (Paradip 100 + Dhamra 80 + Others 150 Mty)
- Hence 15 - 20 more minor ports needed
- To ensure State's share of 16% from current 6%, ports are required to be developed on a priority basis
- Emphasis on more captive ports
- Developers having strong financial & performance track record may speedily implement port development works. They needed to be encouraged

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So to sum up, we need about 330 million tonnes and with existing major ports, they are handling about 40 to 50 million tonnes, it can go to 100 million tonnes. But the minor ports, what they want to develop in future, it cannot be of very small size, it has to be of considerable size, considerable size is about at least minimum 10 million tonnes has to be handled by any port. That means it should be about 15 to 20 more ports should be developed. So the state share has to increase from 16 percent from the current 6 percent, then only the Orissa State will get developed.

The ports are required to be developed on a priority basis. The State development area, it is all based on agriculture. Mineral resources and what is happening today in the context of imports, exports and globalisation is the port development is one of the vital parameters. So once the port develops, the state also develops. And then we have written has captive ports, so we have terminology called captive and non-captive port. Captive port is for industry, so Birla group wants to develop a port and Chudamani, that they will be using is only for the industry, they will not handle for others.

If we take Chennai port, Chennai port is a non-captive port, it is in the public sector, so it will be handling cargo for many industries. Whereas once it is that captive port, the captive port will be handling only for its own industries. One of the captive port for Reliance is in Jam Nagar, that is used only for the refineries. Any questions in this? No doubts?

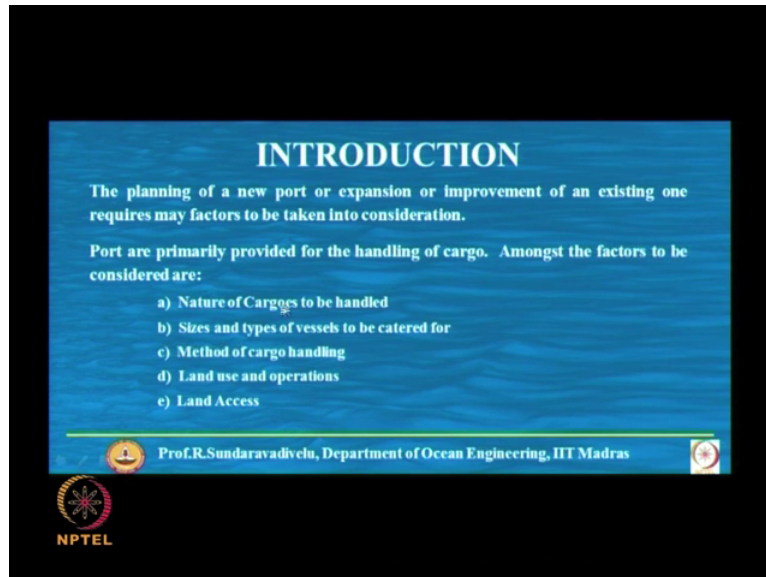
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So we will continue with the other lecture, that is about port planning. This port planning is not essential part of, it is not one of the components of this course but it is essential to learn

about the design of port and harbour structures. I will be having the PowerPoint presentation of port planning, but in addition I will be discussing about the code, IS code which is used for port planning.

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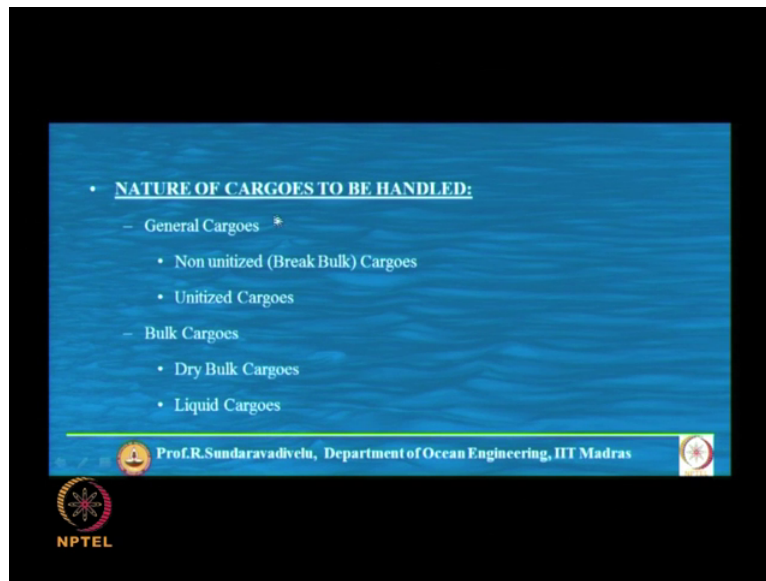


The planning of a New port, New port means it is called as a greenfield port or expansion or improvement of an existing one requires many factors, it is a typing mistake, many factors to be taken into consideration. That is both are important, we have to develop the greenfield ports, new ports, as well as we have to expand the ports. For example we were handling in 2005-06, about 600 million tonnes, by 2020, all these ports which were handling the 600 will double the capacity to 1200 million tonnes.

The balance 800 million tonnes will go to new ports. Then factors to be considered for port planning are nature of cargoes to be handled. Nature of cargo means basically 3 types of cargo, one is liquid cargo, another is the bulk cargo like iron-ore, coal, the 3rd type of cargo is the container cargo. And other important thing is about the size and type of vessel is to be catered for. So size means DWT length, depth, type means, the type itself is different, container vessel is different from iron cargo.

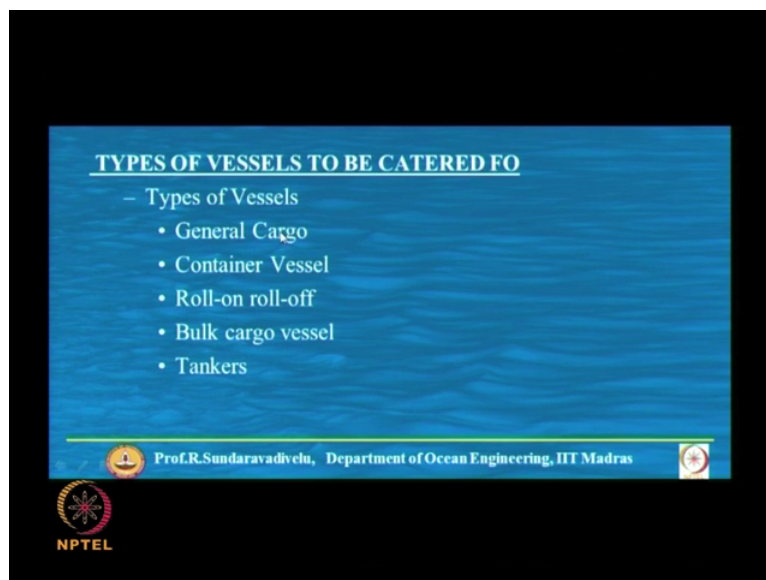
The method of cargo handling, how do you want to handle the cargo. If it is a liquid cargo, it is marine unloading arms, container means it will be key cranes, rail mounted key cranes, then we have mobile harbour cranes also. And the land used in operations, how do you want to store the cargo, evacuate the cargo, it is also important. The land access, we saw the various factors, so when you want to plan the port, these 5 aspects are very important.

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So we are explaining what is the nature of cargoes to be used. The general cargoes or the non-unitised cargoes, break bulk cargoes, break bulk means the steel finished products, that can be break bulk. Unitised cargo means it can be in a container or things like that. The bulk cargoes, we already told it can be dry cargo or wet cargo, wet cargo is liquid cargo. The handling method is different for different types of cargoes.

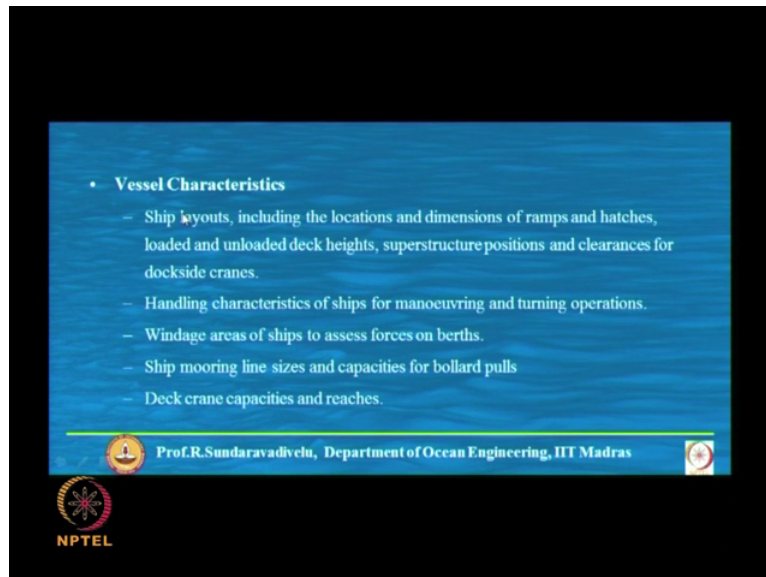
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The types of vessels what you handle, it can be classified into 5 different types. There is a general cargo vessel, container vessel, roll on roll off vessel means at the end of the vessel you will have a ramp, that ramp will be used for taking the cars, especially for cars you will be using roll on, roll off. Then we also have a bulk cargo vessel where we transport iron ore

and coal. Then we also have the tankers, clean and dirty cargo, dirty cargo is crude oil and clean cargo is products.

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One of the main feature for this course is how to design the structures, whether it is a breakwater or a working structure, for which this vessel characteristics, these are very important. The layout of the shape including the locations, dimensions of the ramp and hatches. Hatches means last class, last class I told about bulkhead, each bulkhead is covered by hatch cover, the location of the hatches is important. The loaded and unloaded deck heights, that is the freeboard, it is loaded and unloaded.

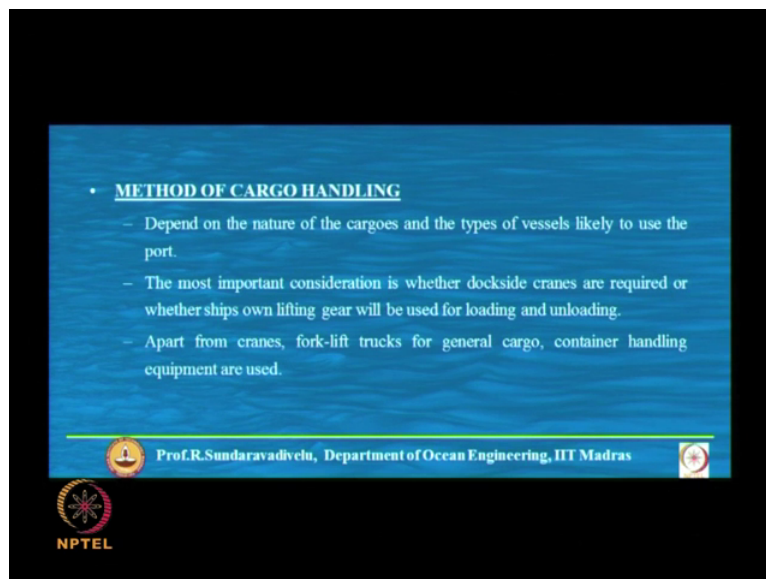
Superstructure positions and the clearances for dockside cranes. What it means is when it is completely unloaded, the ship will be above, so if it is rolling, it may go and hit the crane, dockside crane. So you should see the crane rail is, minimum specified in our code is 2.65 from the face of the berth, then only we can have the rail for the crane. Then we need to see whether it is the handling characteristics of the ship and that is how do you handle the ship for manoeuvring, manoeuvring means stopping distance, going through the inter Channel and all.

And turning operations, that is the amount circle, how do you turn the vessel, this is the handling characteristics of the ships. Somehow the ships are having good manoeuvrability nowadays, even without tug they can be manoeuvred, otherwise we needed a tug to manoeuvre the ship. And windage areas of ships to assess forces on the berth, that is whatever force is acting on the ship is due to 2 Mainly Predominantly 2, 1 is the wind, another is the

current. The 3rd one is wave, what we say that, we reduce the wave by providing the tranquillity.

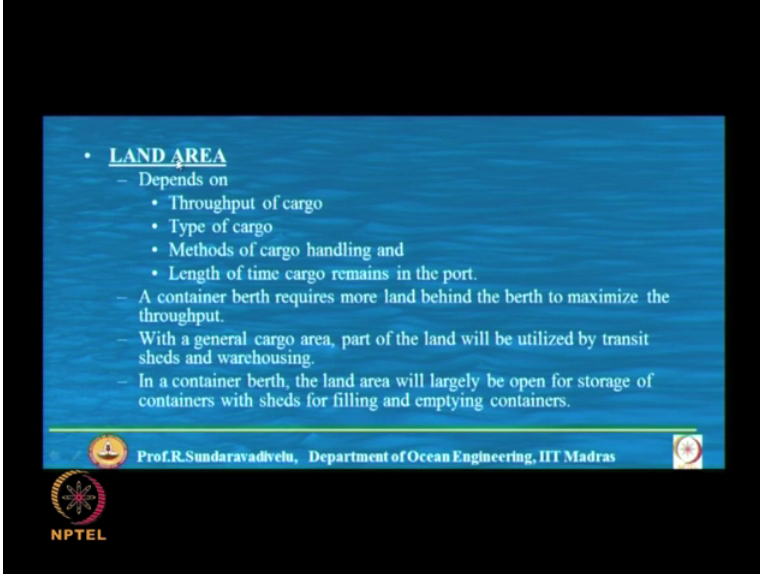
So the windage area of the ship is also important. Last class we have given the ship mooring lines, the size and capacities of Bullard pulls. And another thing is about the deck crane capacity and reaches, reaches means width of the ship is 40 metres, that I has to reach 40 metres to take the ships. These are the 5 important parameters of the vessel which will cover the design of the port planning as well as the design of structures.

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The method of cargo handling, so the cargo handling, that depends on nature of cargo, then type of the vessels likely to use the port. The most important consideration is whether dockside cranes are required or whether ships own lifting here will be used for loading and unloading. I said last class about the handy size and handy Max which are having is shown here. So we do not need any dockside crane. This own lifting gear ships are very much important in Indian context, all along the coast, every 50 kilometre you can have a small working facility where the small ships with its own gear will come on load and unload the cargo.

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The slide is titled "LAND AREA" and contains the following text:

- **LAND AREA**
 - Depends on
 - Throughput of cargo
 - Type of cargo
 - Methods of cargo handling and
 - Length of time cargo remains in the port.
 - A container berth requires more land behind the berth to maximize the throughput.
 - With a general cargo area, part of the land will be utilized by transit sheds and warehousing.
 - In a container berth, the land area will largely be open for storage of containers with sheds for filling and emptying containers.

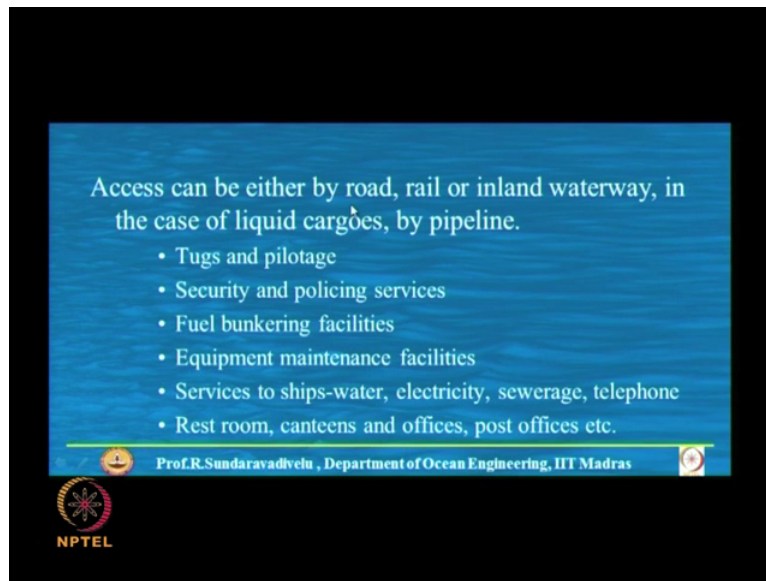
At the bottom of the slide, there are two logos: the NPTEL logo on the left and the IIT Madras logo on the right. The text "Prof.R.Sundaravadivelu, Department of Ocean Engineering, IIT Madras" is centered below the logos.

Apart from these cranes, we need these forklift trucks for general cargo, container handling, for general cargo. Then container handling equipments are also used, that is inside the storage area. This land area, this is also important, depends upon the throughput of the cargo how much land is required behind the berth. And the type of cargo, the methods of cargo handling and length of time cargo remains on the port. This length of time cargo remains in the port is very important, we do not want the cargo to be in the port for a very long period of time.

This container berth is generally requires more land behind the berth to maximise throughput. With a general cargo, part of the land will be utilised by transit sheds and warehousing, this is also important because general cargo, unlike container cannot be immediately transported, we need transit shed as well as the warehousing. And this container cargo, it can be, the land area can be open, because containers give the cover against rain and sun. Whereas for this general cargo, we have to provide transit shed and warehousing, that means it is a covered shed.

But container berth also needs some storage with sheds which is only for filling and emptying containers. When you have a container which has to be inspected by customs, it has carrying cargo for 2-3 parties, then you could do the filling and emptying, only for that purpose we need these sheds, warehouse mostly it is open only.

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This is another important thing, this is only is creating a lot of problems for development of port, that is access. Access can be by roads, this can be by rail or inland waterway. In case of liquid cargo is it can be by pipeline, these are 4 modes of transport. In this context, the biggest port as on today is in China, Shanghai. They are handling containers, they are using the water route for evacuating the containers. They built the road bridge for about 40 kilometres into the sea.

For many years, there is a port in Europe, there is called as Rotterdam, the Rotterdam port is having the unique advantage of this inland waterway. So it is a gateway to Europe, they use the inland waterway for evacuation of the cargo. The Singapore has reached the top position than Rotterdam, one of the advantages of Singapore, it is transshipment terminal. Transshipment means, all the cargo required for India, at one point of time has been transshipped from Singapore, sometimes from Colombo also.

That means the bigger vessel will go to only Singapore, mainline vessels, mainline means point-to-point, it will go to only Singapore and from Singapore it will be transshipped and come to India. That means the transport is through the waters, so if we have, developing inland waterway you can go in for very big development in the port structure. That is shown in China in Shanghai, Rotterdam in Europe, as well as Singapore in, Singapore port. Singapore is not an inland waterway, it is a seaway, it is the transshipment terminal.

We have not developed this inland waterway so far, it has to be developed. The road and rail sector is fairly good and there is a lot of development that is taking place. And for liquid

cargoes we have to use the pipelines. And the other things that are required in a port planning is the tugs and pilotage, the security and policing services, this is also very important. Then fuel bunkering facilities, whenever the ship is coming, we can provide bunkering facilities for the ship, bunkering means we can give fuel, water and things like that.

Then it also needs some equipment maintenance facilities, both for the ship maintenance as well as the workshop and things like that. Services to ships, that is water, electricity, sewerage, telephone, all these things can be given. Then many people will be working there, then would restaurant, canteens, offices, post offices, all these things are required.

Any doubts in this? How many of you have seen codes, IS codes or any codes? Which code you have seen? Which year you have seen that?

Last year.

Last year?

Yes.

Last year means after January in IIT?

No, sir, even when I was in UG IT, we were asked to use the code.

What about others? Which code you have seen?

IRS.

Anybody else?

IS 800.

What is that IS 800 code?

Steel codes.

Okay. Anyone else? Civil engineering students, you have not seen IS456 codes, B tech civil engineering?

I have listened about it.

You have listened in the class or you have seen the code?

I have seen the code.

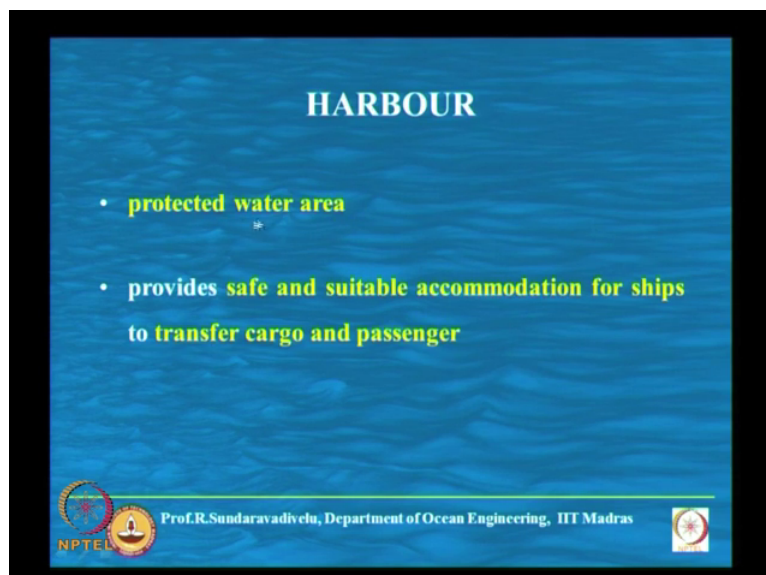
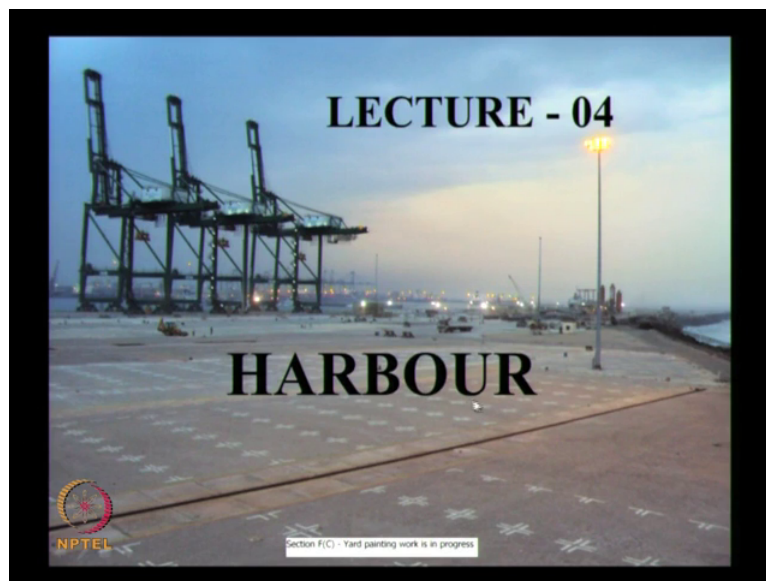
What is your name? Where did you see the code? Hardcopy or soft copy or...?

Hardcopy.

Where is the soft copy available?

So you can load it.

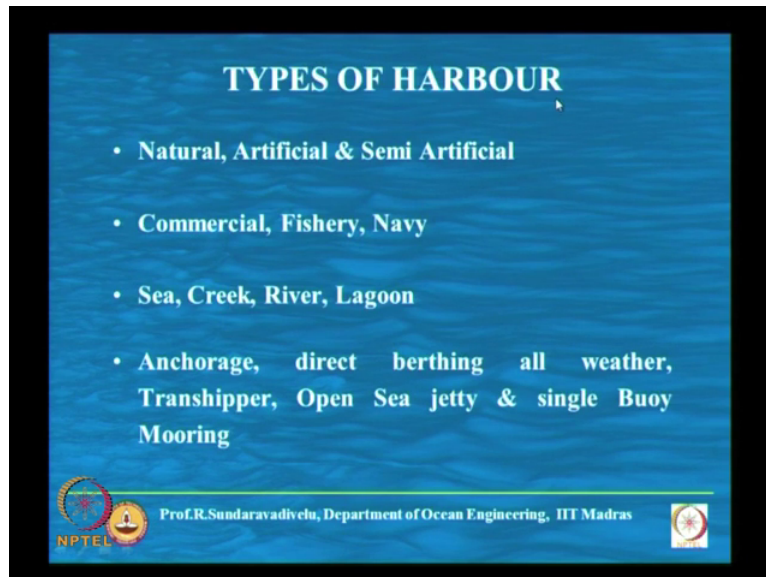
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I will discuss about the codes in next class, now we will want to lecture number 4, that is about the planning of Harbour. We have discussed about this, Harbour is a protected water

area, this provides safe and suitable accommodation for ships to transfer cargo as well as passengers.

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When you talk about Harbour, there are different types of classification, what is listed here. What is the advantage of listing different types of classification? This is better for your understanding. So we can call the harbour as a natural harbour, artificial harbour and semi-artificial harbour.

Can you tell me which is the natural harbour in India?

Cochin.

Artificial harbour?

Chennai.

Semi-natural?

Visakhapatnam. Vizag.

Best example is Goa. Vizag also can be classified, inner harbour is natural and outer harbour is artificial. Then depending on the usage we can classify whether it is commercial, fishery or Navy. The commercial is all the major nonmajor ports, what we were discussing. Fishery means adjacent to every port we have fishery harbour, then we have many minor fishery harbour also. Which state will be having the maximum number of fishery harbours?

Can you guess?

West Bengal.

No one from Kerala here?

Kerala.

Kerala is having many fishery harbours. Gujarat is also having, but people in Gujarat, they do not eat fish, they are mostly vegetarian. In Kerala, most of the people, how many are from Kerala here? I think all of them eat fish in Kerala, they do export also. Tamil Nadu also has but not like Kerala. Where do you have harbour for Navy? Any other place? There is a harbour and port only for Navy in India, where is it? I told you in the class, it is called as Karwar, Karwar in Karnataka. It is a very important place, Karwar. It is especially developed for Indian Navy. There is a saying in Tamil, one who rules the sea rules the world. Like that Navy is very important for our dominance in the military and strategically is very important.

We have very big naval establishment in Port Blair, Andaman group of islands. It is a very, strategically very important. If you have read the newspapers, the Navy is not permitting the exploration of oil and gas in Indira point, it is the southernmost tip. And it is being planned to develop another naval facility south of Vizag, mainly for Navy, about 3000 crore project. The Karwar and this project is called as Project Varsha, south of Vizag, these 2 naval facility are very important.

The fishery harbour is also very important. Apart from agriculture, the other 2 important trades that are being practised by the population, one is fishery, other one is this making this textile, it is lying in a very big size as well as for small size. So these are the 3 trades which you have to cater for, the fishery harbour is very important. Then the harbour can be on the sea, it can be on the Creek, Kandla is on the Creek, Calcutta is on the river. The lagoon is both Paradip and Mangalore, they are on the lagoons, inside the land area.

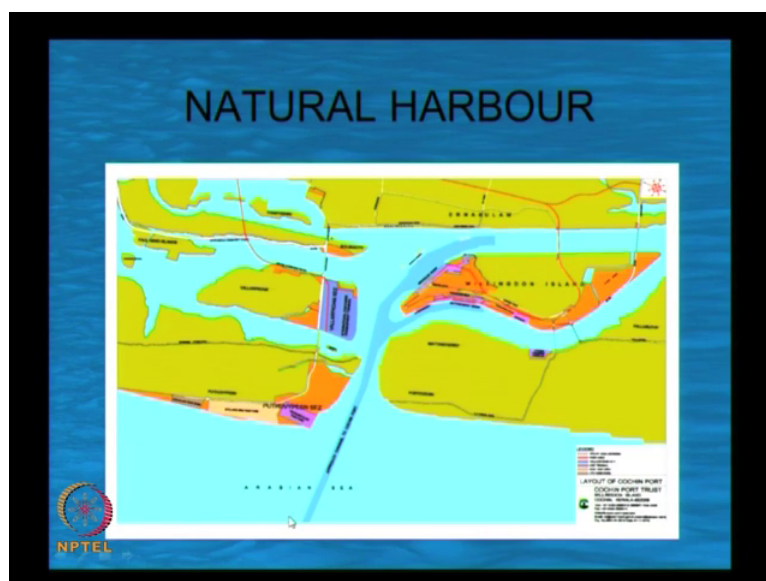
So these are the 3 types of classification of Harbour. The next one is Anchorage, Anchorage means Gopalpur minor port is an Anchorage Port, many places earlier days we have Anchorage only, even Chennai was an Anchorage Port. Anchorage Port means the ship will be coming and it will be at a distance of a few kilometres, maybe 10 kilometres or 5 kilometres, the kilometres from the shore and small barges will go and load and unload the cargo, that is called as the Anchorage Port.

But the loading and unloading route is very, it is very small, so then we need a direct berthing port. Direct berthing means the bigger size vessels will come directly into the harbour. All-weather means it will be for throughout the year, 365 days, normal it is about 300 days. Fairweather means it will come only in non-monsoon and non-season monsoon also it may come, that is Fairweather. So we have direct berthing all-weather and direct berthing Fairweather. Similarly Anchorage all-weather and Anchorage Fairweather.

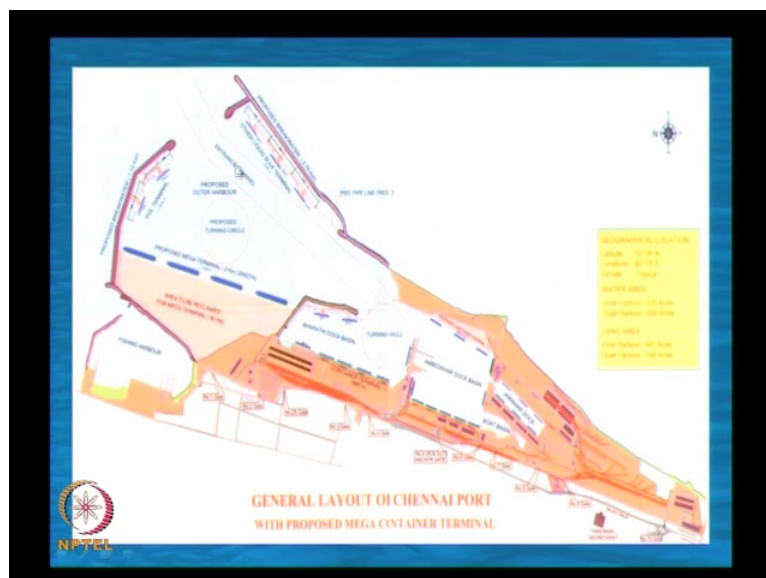
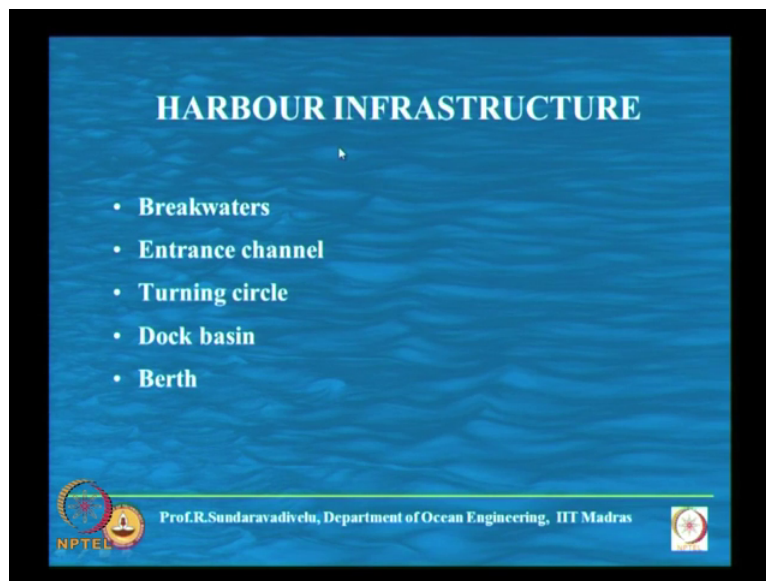
Then we have what is called as the transshipper, transshipper means it is, the operation is faster but it is somewhat similar to Anchorage. This is being practised in Goa, transshipper means the ship will come and berth by the side of another floating vessel which is a transshipper and small barges will bring the cargo. So when there is a transshipper, on one side you will have a big ship, on another side you will have a barge. Then we have open sea jetty, it is mainly used for liquid cargo, in Cuddalore we have open sea jetty, in Nagapattinam also we have open sea jetty.

So we put approach for a long distance, maximum approach what we are doing is about 6 or 7 kilometres in the gauge, Nagapattinam, Cuddalore, Nagapattinam it is about a kilometre or less than that but in China in Shanghai, near Shanghai the open sea berthing facility connects to the mainland by a distance of about 40 kilometres. Then we have a single buoy mooring system. So in Gujarat in Gulf of Kutch is a part of Kandla port, we have a single buoy mooring in Vadinar. It handles about 30 million tonnes, one single buoy, so it is most economical system of handling.

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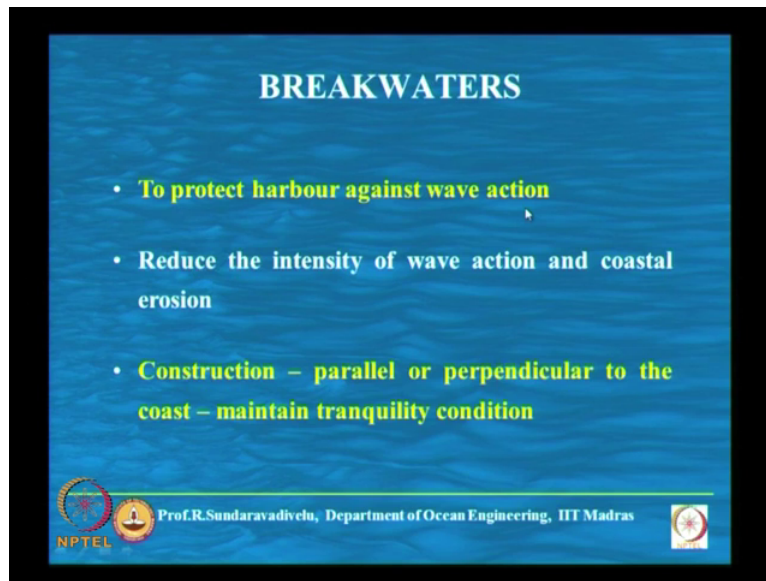


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So we have to see, when we go into the course, mainly we have to study what are all the design parameters required for ports as well as for harbour. This harbour infrastructure consists of breakwaters, entrance channel, turning circle, dock basin and berth. For example, this is a breakwater, entrance channel, there is one turning circle here, they want to propose another turning circle here, then these are all dock basins, these are all berthing structures. So this berth actually goes into port infrastructure, but we can say that there is a boundary between harbour and port.

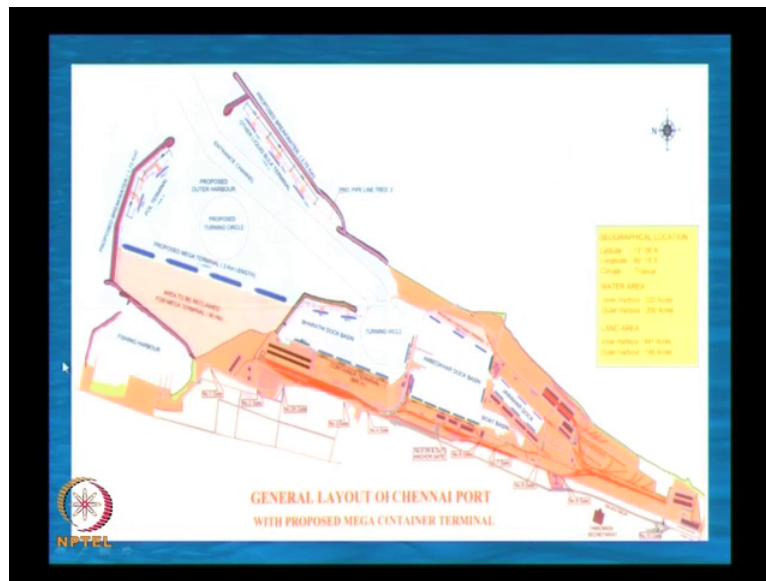
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What is the function of breakwater? The function of breakwater is to protect the harbour against wave action. So any waves when it comes inside, it will damage the vessel of structure and it will create a lot of problems. So we have to protect the harbour from wave action. Then we have to reduce the intensity of wave action, as well as the coastal erosion. These 2 are different, protect the harbour means, in cyclone and all, it should not permit more waves, that is the thing. In a normal operating conditions, it will reduce the wave.

For example severe waves during Cyclone can be of the order of about 9 to 10 metres in Chennai, that time no vessel will be inside, they will take the vessel outside. But we will see a lot of infrastructure is there, that should not be damaged. And the intensity of the wave action should be reduced by one 10th of waves that is acting outside. Normally it is about a metre or 2, so at that time you have to reduce. Then the coastal erosion due to the waves, that also should be reduced. These breakwaters, they can be either parallel to the coast or perpendicular to the coast to maintain tranquillity conditions.

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ENTRANCE CHANNEL

- Water ways should be laid out in proper configuration and **designed for good control and safe maneuverability of ships** under all conditions, winds, currents, waves, visibility and in adverse weather conditions.
- **Alignment**
 - Design ships expected to use the channel can navigate with reasonable safety conditions of tide, currents, wave and wind

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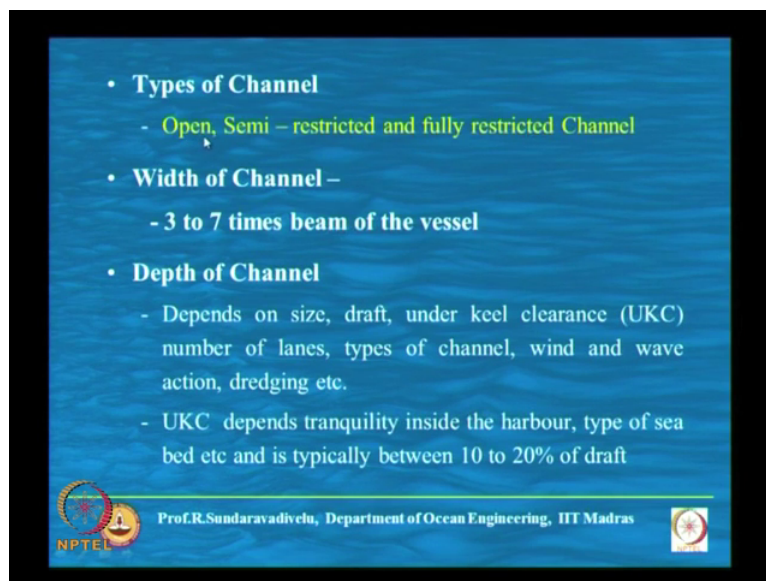
So if we see this Chennai breakwater, if we talk, this is the shoreline, this breakwater is perpendicular to the shoreline, this breakwater is parallel to the shoreline. We have many types of breakwaters, we will discuss separately in 2 lectures about breakwater. The entrance channel, entrance channel is like a roadway marking, there should be water-based in proper configuration and these are to be designed for good control and faith manoeuvrability of the ships.

When you bring the ship inside, there should be sufficient breadth and depth of the channel, so that we can bring the ship under all conditions, conditions means currents, waves, visibility as well as in adverse weather conditions, not during sidelong at well. In non-cyclone periods, about 300 days, whatever adverse conditions is there, you should be able to protect.

Visibility is also important, just like air navigation and all. Alignment, this alignment is important for the entrance channel.

The design ships expected to use the channel can navigate reasonable safety conditions of tide, currents, wave and wind. For example, to make it very simple, we have different conditions for the ship related to the current, wind and wave, it is called the head sea, beam sea and quarter sea. Head sea means the duration of all these parameters which are perpendicular to the width of the ship, that is beam of the ship, that is called as the head sea, where the area is less, that is called as the head sea.

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If it is perpendicular to the length of the ship, that is called as the beam sea, which is undesirable, because the exposed area is small. The types of channel, I will show what is open channel, semi-restricted and fully restricted. There is a figure in I S codes that I will be discussing it later. The width of the channel depending on whether it is then open, open means it is more than 7 times beam of the vessel. It is about 10 times the beam of the vessels. If it is a single lane traffic, you can go for a 3 times, double lane means one ship can come and one ship can come out, that time we need more than 3.

The depth of the channels, this depends on the size, size means length of the channel, as well as the draft, it is the main parameter. Size means length and beam, that also governs because we have the rolling and pitching of the vessels, that is depending on the length and beam of the vessel. Draft means the portion of the ship which is below the water line. This is important, under keel clearance, number of lanes, single lane or double lane, type of channel,

I will explain with figure in one of the class, type of channel is open, semirestricted and fully restricted.

Wind and wave action and the dredging etc. And it also depends on the type of seabed. UKG depends on tranquil inside the harbour, type of seabed, etc. and this is typically between 10 to 20 percent of the draft. That is under keel clearance depends on the tranquillity, that is the wave action inside the harbour. Type of seabed, if it is a rocky seabed, under keel clearance should be more, if it is a clayey seabed, under keel clearance can be less.

Clay means about 0.3 metre, rock means about 0.621 metre because when the ship goes and hits the bottom, if there is a clay, there cannot be much damage, if it is rock, there can be severe damage, typically between 10 to 20 percent of the draft. So we will continue the lecture in the next class.