Port and Harbour Structures.
Professor R. Sundaradivelu.
Department of Ocean Engineering.
Indian Institute of Technology, Madras.
Module-1.
Lecture-6.
Harbor layout.

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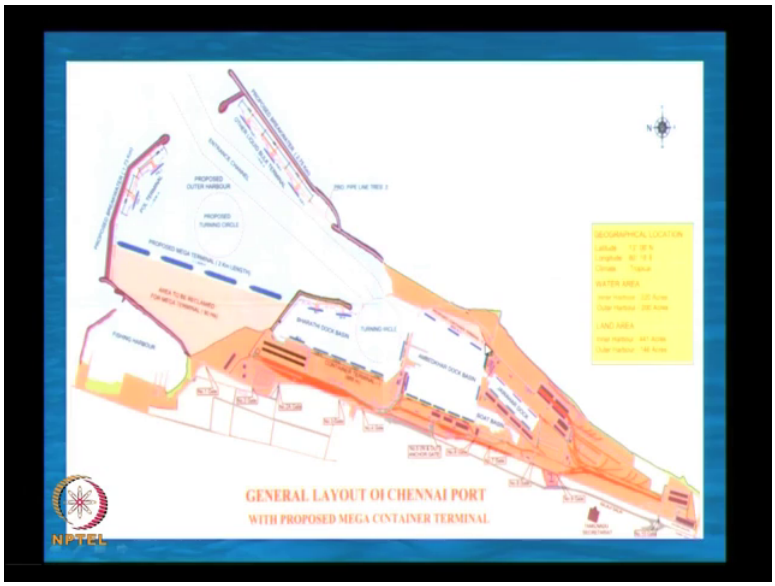

Last class we were discussing about planning of harbours. Planning of Harbour means the entrance channel, the turning circle, the alignment of breakwater, these are all parts of Harbour layout. But in addition, there are certain numerical studies that are being carried out related to manoeuvring of the ship through the entrance channel. We have real-time manoeuvring also for the vessel inside or you can, that is pilot of the ship can sit in the console of a computer and see how he can navigate the ship inside the entrance channel and turning circle.

Or you can do a numerical study also giving the different parameters to see how the navigation takes place. Other study is, important study is about the tranquillity, tranquillity means you will have similar waves from different directions and find out what is the waves inside. Now one of the problems is the entrance, suppose the wave is coming from the side, it will penetrate through the entrance and it will go inside, so we have to keep the orientation of the entrance in such a way that the predominant position of the wave is not in this direction.

But for the wind which is also critical, it is very difficult to see, because in a particular day, the wind direction may change from the side to this side and things like that. So it is very difficult but we have to consider the different types of winds also, as far as the ship manoeuvring is concerned. The other type of study is tranquillity, tranquillity means what is the wave height inside the Harbour place, that is when the waves are coming through this side, the waves might diffract and go inside.

What is the wave height outside and what is a wave height inside, for that we can do numerical modelling. There are certain commercial softwares like MiG 21 which are being used to study the tranquillity, in our department we have our own softwares developed also for this particular case. We have another thing called as Harbour resonance, Harbour resonance means when there is a cyclonic conditions, that time generally the wave period is very long and I will be discussing some parts of waves in one of the class. Corresponding to have a period we have a wavelength.

Suppose that wavelength is multiples of this Harbour base in dimensions, then resonance will take place. When resonance takes place, whatever waves which are inside, the waves will go on increasing as the resonance takes place. So normally what precaution that is taken is, whenever any cyclonic storm is there, the vessels which are berth inside the harbour basin, they are asked to go out. Because when the Harbour resonance takes place, the motion of the vessel is very large, it may go and touch the bottom of the sea.

So what they do is they take the vessel from the harbour basin, take it to deep waters, more than 30 metres water depths because here the water depth is only about 17 to 18 metres, near about 14-15 metres. So when they take the vessels to outside with water depth of more than 40 to 50 metres, then even when the vessel is going up and down, it will not touch the bottom of the vessels. And the orientation of the vessel, they will put a single anchor, it itself weathervanes, it is called is weathervaning, it rotates itself so that it is always in the head sea condition, that is not possible inside the harbour basin.

This is for bigger sized vessels, but in a fishing harbour you have sufficient water depth, more than 5-6 metre water depth, draft is only 2 metres, the fishing harbour, when there is a cyclone, they will come inside. So the fishermen will come inside, the commercial harbours, the vessels will go outside whenever a cyclone is coming. Any Harbour, they rise the flag, the flag is having numbers from 1 to 10, so when a cyclone warning is there, the cyclone is a few

hundred kilometres from the harbour, they will start with Flag number 3 and it is approaching, it will go up to 6, 7, 8, 9 and so on.

After 7 they have to start moving the vessels outside. The recent cyclone in Chennai, I think they have gone up to number 9. So these are the 2 things we have to study, one is the ship manoeuvring, another is what is the numerical study on the waves. 2 kinds of studies, one is throughout the we have to find out what is the predominant wave direction, maybe a few directions and wave period and wave height. 3 parameters duration of the wave, height of the wave and the period of the wave you have to study.

Then during storm weather Harbour resonance takes place. All of you know about resonance I think, so same thing happens here also. And one of the precautionary measures, not precautionary, one of the measures to reduce the Harbour resonance is, whenever the waves are coming inside, there should be some place where the wave energy will get dissipated. The natural restriction is the beach, if we go to the beach, the waves come and break, like that we have to provide what is known as the spending beach, we can provide somewhere here, the spending beach. Means the slope, natural slope which can absorb the wave energy, that can be provided at this location.

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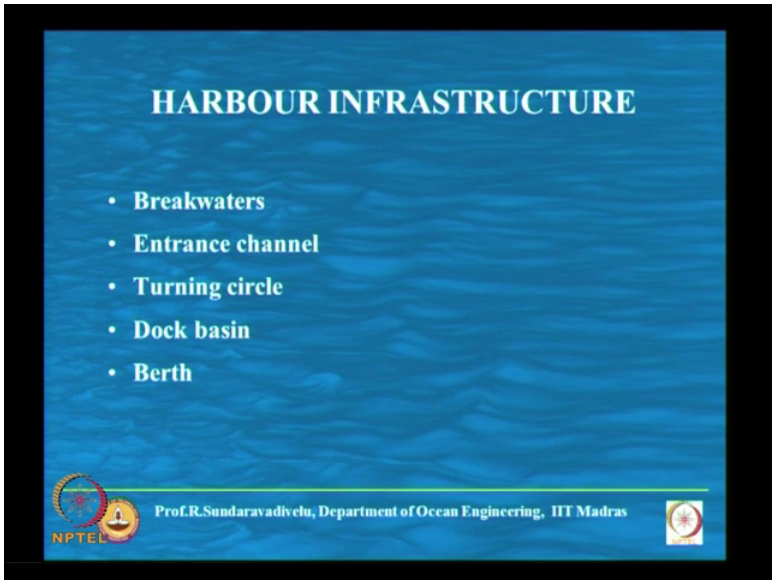

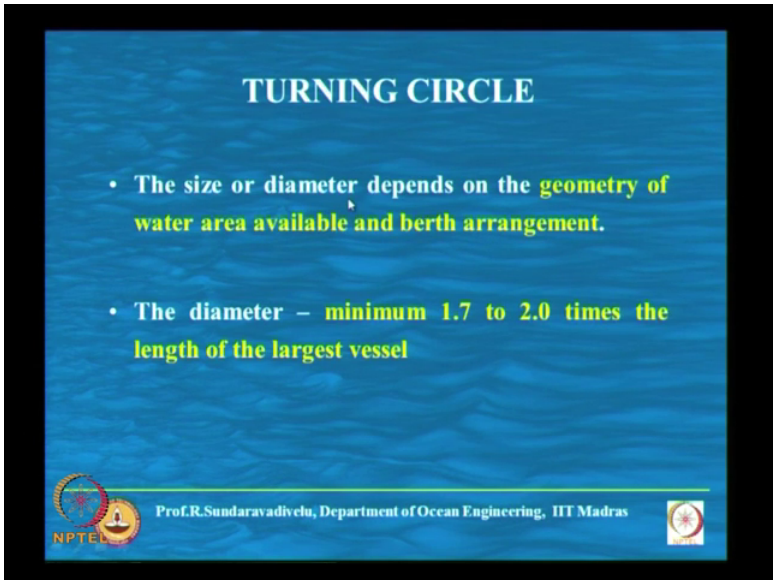

So last class we were discussing about the infrastructure for the Harbour like breakwaters, entrance channel, turning circle, Dock basin and the berth. And I will be discussing about certain planning aspects for entrance channel and turning circle using a IS codes. So we have discussed about breakwaters entrance channel, the types of channel and turning circle. Turning circle means the size or diameter of the turning circle will depend on the geometry of the water area available and the berth arrangement.

So these are the 2 things which control what should be the size or diameter. Typically the diameter is about 1.7 to 2 times the length of the largest vessel. Another important parameter is the water depth also is increased, the turning circle. We said about 10 percent of the under keel clearance, the navigation channel, maybe in turning circle they may increase the water depth. Then dock basin, each dock will have a water depth maintained constantly and this depends on the vessel size, tranquillity and salinity conditions.

What is the effect of salinity in draft of the vessel? Somebody is (())(7:51) can tell, who is that, tell me. Now fresh water, a vessel playing, then it goes to salt water, what happens to the draft?

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Why?

Because density is higher of saltwater.

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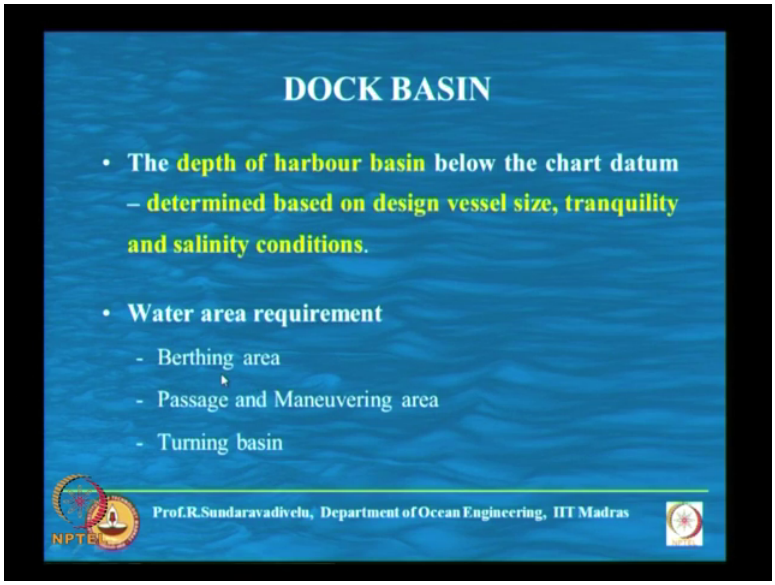

Now vice versa is more dangerous, suppose the visit is playing in a saltwater and it is coming to a freshwater, suddenly the draft increases, so the under keel clearance reduces, so it is one of the aspects. Then the water is a new comment is about the berthing area where the vessel is berth for loading-unloading operation, the passage and manoeuvring area and the turning basin. That means in a Harbour layout we are more worried about the water area requirement, in the port layout we should be worried more about the land area requirement.

So port means you should consider the planning of water area as well as the planning of the port area. Now we will go through these codes, this IS 4651 part 5 1960 and it is reaffirmed in 1997. I think this every alternative year they reaffirm. But now IIT Madras, our department has not given the responsibility to have a relook at all these all the codes and we have revised part 4 in part and 5 we are planning to revise. This is called as bureau of Indian standards. And it has code of practice for planning and design of ports and harbours, this is for all the IS4651 the title.

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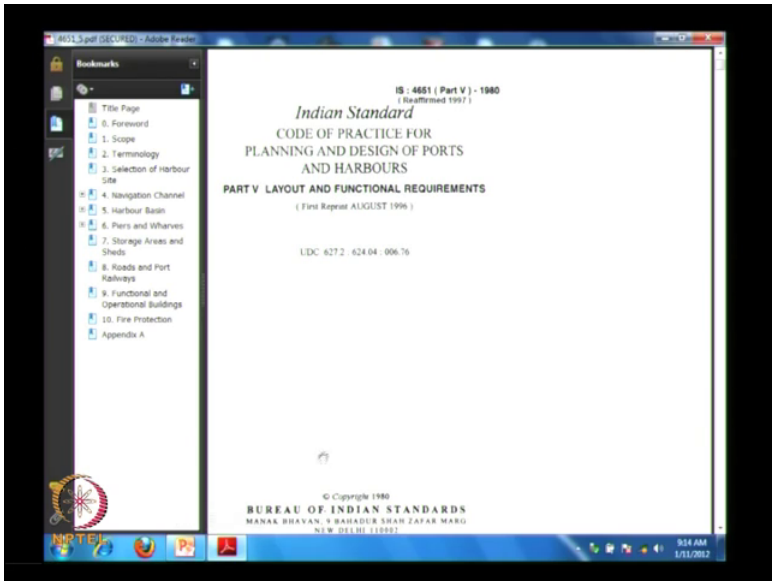

The title for part 5 is layout and functional requirements. So here you have the details that are given in this code, like the different chapters which you can go through, navigation channel, harbour basin, these are the 2 things which we have studied in the harbour lecture. Another important thing is how to select the Harbour site, this is also important. When L & T wanted to develop the shipbuilding facility in India, they have visited 3 sites, one in Gujarat, 2 in Tamil Nadu, one is Tuticorin and other is Chennai and based on that they have selected the site.

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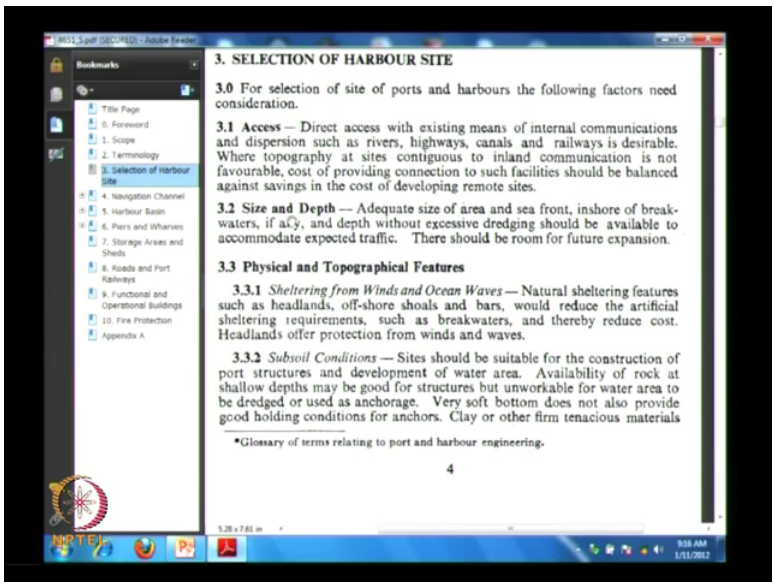

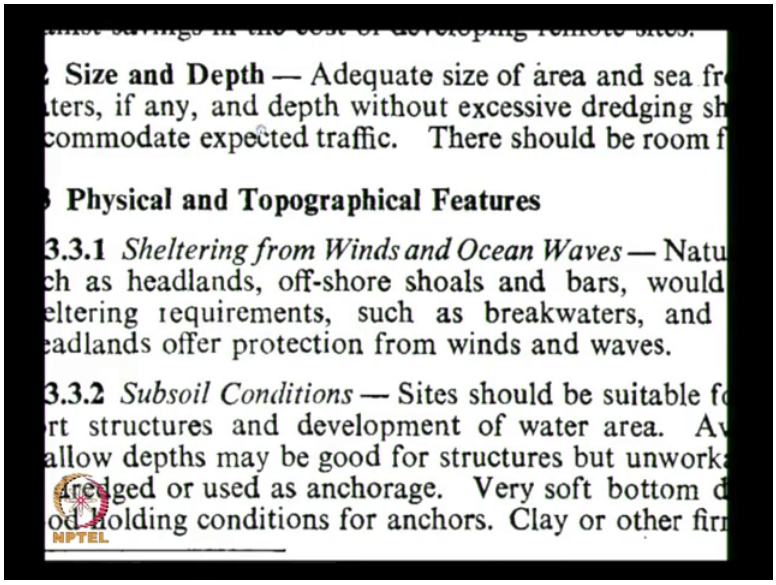

The selection of the site not only depends on the technical requirements but also the commercial requirements, both are important. Now we will go through this Harbour site, selection of Harbour site. One is access, another is size and depth. Main thing that is required is the direct access with the communication, connectivity with Rivers, highways, canals and railways. Nowadays air connectivity is also required, the size and depth that is also a requirement.

Adequate size of area and seafront, typically because of so much of port development that is taking place, it is very difficult to get a seafront of more than 2 kilometres. That is for the width of the other facilities. And we should also find out what is the requirement of dredging, if the water contour, that is water depth contour 10 metre is available very close by, maybe at a distance of less than a kilometre, then excessive dredging can be avoided. Another important parameter is room for future expansion. Indian is inching towards 100 million tonnes per port, whereas abroad it is going very high.

Shanghai where we have the maximum throughput is about 40 million TU, 40 million TU means very close to 500 million tonnes, single port. What we are handling in JNPT is 4 million TU, one 10^{th} of what is being handled in Shanghai. The expansion is very much required, so only for the captive ports they are giving restricting the widths for about 2 kilometres, other ports they can go upto 5 kilometres and things like that. When we select, we have to decide about the physical and topographical features, that is sheltering from winds and ocean waves.

It can be by natural phenomena like headlands, offshore shoals and bars or we can provide artificial requirements such as breakwaters. So headland means projection of hilly areas inside the your, inside the sea. Vizag we have the Dolphin Hill, that is headland, offshore shoals and bars, if you take Katapalli, L & T, we have the offshore shoals and bars on the northern side. Otherwise you have to go for this artificial breakwaters. But advantage of head land is it offers protection against both from the winter as well as the waves.

Another important consideration is the subsoil condition. If we have rock, it is very good for port structures, whereas if we have the rock, the cost is more for dredging. So very soft bottom does not provide good holding conditions for the anchor, so you should provide very soft soil if it is existing, then sometimes it is unavoidable.

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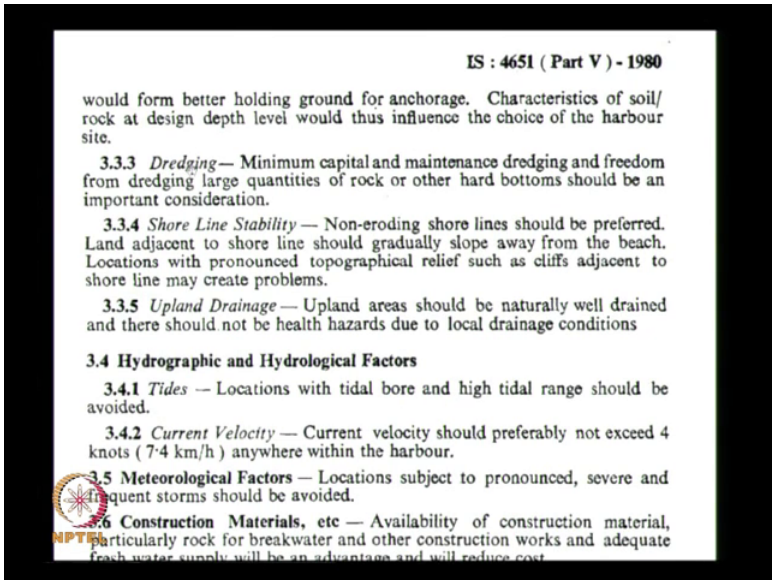

The other important parameter is dredging, that is minimum, capital and maintenance dredging. So capital dredging means when you start developing the harbour, the time you have what is known as the capital dredging. Maintenance dredging is about 10 percent of capital dredging. So when you dredge the, in the sea, artificially, you are increasing the depth, velocity reduces and it gets deposited, so we have to go for maintenance dredging. And freedom from judging large quantities of rocks or other hard bottoms should be an important consideration.

In India all these conditions are violated in certain locations, since we developed ports in those areas because of various reasons, political reasons, commercial reasons and all. Tuticorin Port we have the rock, we are spending a lot of money, in Mumbai JNPT also, the

allotment is restricted, it is not growing like Shanghai, mainly the reason is we have the rock, up to -14 metres only we have dredged. For port to have high-capacity, we need at least 18-20 metre water depths. So whence it is rock, the cost is increasing.

Dredging means normally the cost is about 200 to 300 rupees per cubic metre, if you want to dredge material, 200 to 300 rupees per cubic metre, if it is rock, it goes to 2000 to 3000. That is how the cost increases, that is one of the problems. Another problem is when you do that dredging rock, we have to use explosives and it creates some environmental problems. This point is very important, unless the shoreline stability. So India we are doing a lot of scientific studies on shoreline stability, we are identifying certain locations which are prone to erosion.

And we suggest that you do not provide any port facility where it is eroding coast. Eroding coast, it may be due to natural or man-made reasons. Natural reason itself there are certain locations which are eroding, those locations it is preferable not to build a port facility. So non-eroding shorelines should be preferred. The land adjacent to the shoreline should be gradually sloped away from the beach and location where we have topographical. There are 2 things, one is on the seaside, another on the landside, if we have cliffs, that and all will create problems because you have to level the surface, so that problem will take place.

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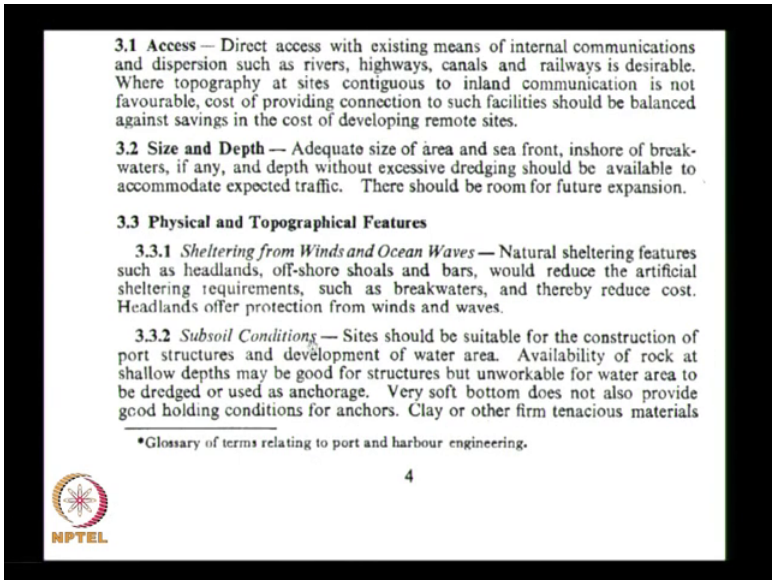

And the drainage also is very important, it should be naturally drained. So there are 5 aspects which we have discussed, one is planned drainage, shoreline stability, dredging, sheltering from winds and ocean waves and subsoil conditions, these are the things which govern the location. Then we have other hydrographic and hydrological factors. One of them is tide,

another is current. They have written locations with high tidal range should be avoided. But if we see Gujarat where we have very large tidal variation, they use it to their advantage.

One of the problem is we have about let us say 6 metre tide, the vessel in high tide will feel 6 metre above the low tide, that means when it goes low tide, from the top of the berth it is 2 storey down, the ship, so that is a very difficult problem for mooring and things like that. And whenever there is a large tidal variation, the current velocity is also very high, so it is preferable not to create a facility where we have more than 4 knots. These are general consideration, if you are planning a greenfield port, you should avoid, that L & T Katapalli, they have not gone to Gujarat, mainly one of the reason is this, large tide and current variation.

Meteorological factors, location subject to pronounced severe and frequent storms should be avoided. There are certain locations where the cyclone passes, if we take the east coast, generally the cyclones will hit Nagapattinam or Cuddalore, generally it does not come to Chennai. It will stay near Chennai it will go to Andhra, Andhra there are certain locations like Machilipatnam and other places where it will cross, Nellure is another place where it will cross.

It is the predetermined locations where the cyclone chooses to cross. Normally the cyclone does not cross south of Nagapattinam but Dharishkodi it has crossed once. So we know where cyclone crosses, we have this date also available. Another important requirement is the construction materials because the transportation of construction in material is not only expensive but also it creates a lot of environmental problems. As it creates a lot of pollution, traffic congestion, that is also a consideration.

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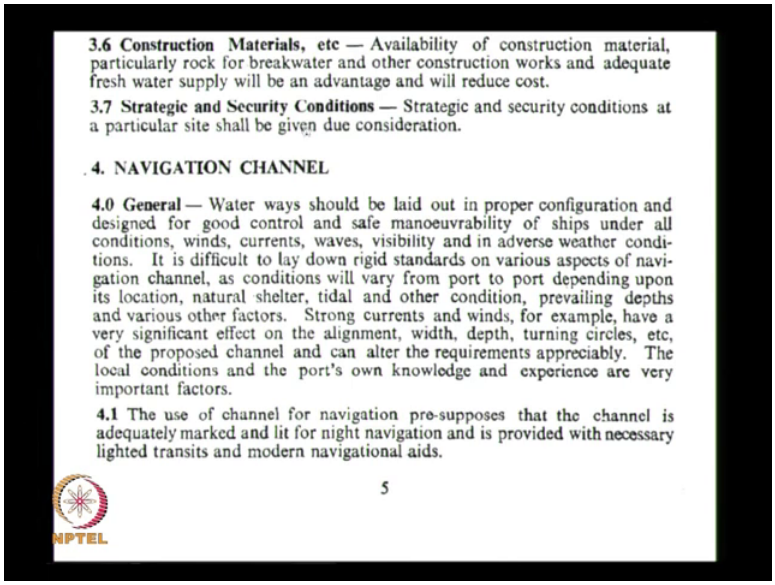

3.6 Construction Materials, etc — Availability of construction material, particularly rock for breakwater and other construction works and adequate fresh water supply will be an advantage and will reduce cost.

3.7 Strategic and Security Conditions — Strategic and security conditions at a particular site shall be given due consideration.

4. NAVIGATION CHANNEL

4.0 General — Water ways should be laid out in proper configuration and designed for good control and safe manoeuvrability of ships under all conditions, winds, currents, waves, visibility and in adverse weather conditions. It is difficult to lay down rigid standards on various aspects of navigation channel, as conditions will vary from port to port depending upon its location, natural shelter, tidal and other condition, prevailing depths and various other factors. Strong currents and winds, for example, have a very significant effect on the alignment, width, depth, turning circles, etc, of the proposed channel and can alter the requirements appreciably. The local conditions and the port's own knowledge and experience are very important factors.

4.1 The use of channel for navigation pre-supposes that the channel is adequately marked and lit for night navigation and is provided with necessary lighted transits and modern navigational aids.

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This also is nowadays important, strategic and security conditions, this also should be given importance. We have, we have always problem with Pakistan, so we should not have certain facilities which can be targeted very close to Pakistan border. The security for harbour facility is one of the important considerations, because most of the cargo which is coming, comes through the harbours only.

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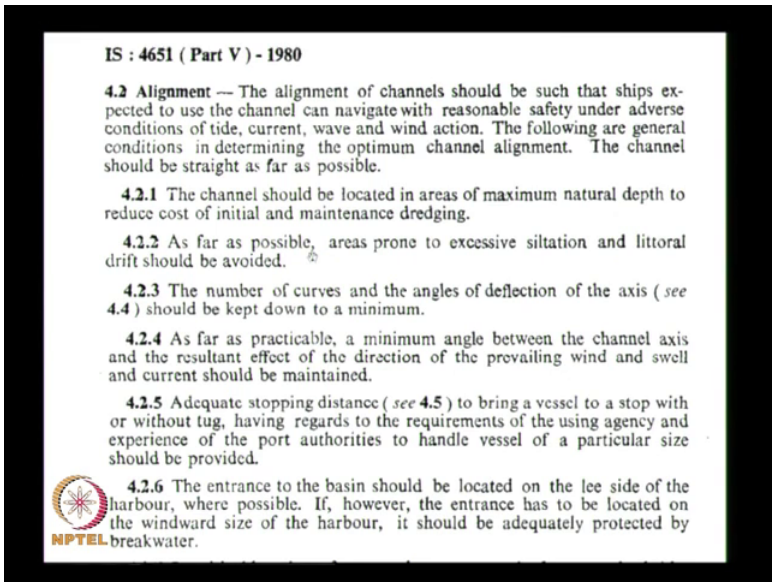


IS : 4651 (Part V) - 1980

4.2 Alignment — The alignment of channels should be such that ships expected to use the channel can navigate with reasonable safety under adverse conditions of tide, current, wave and wind action. The following are general conditions in determining the optimum channel alignment. The channel should be straight as far as possible.

4.2.1 The channel should be located in areas of maximum natural depth to reduce cost of initial and maintenance dredging.

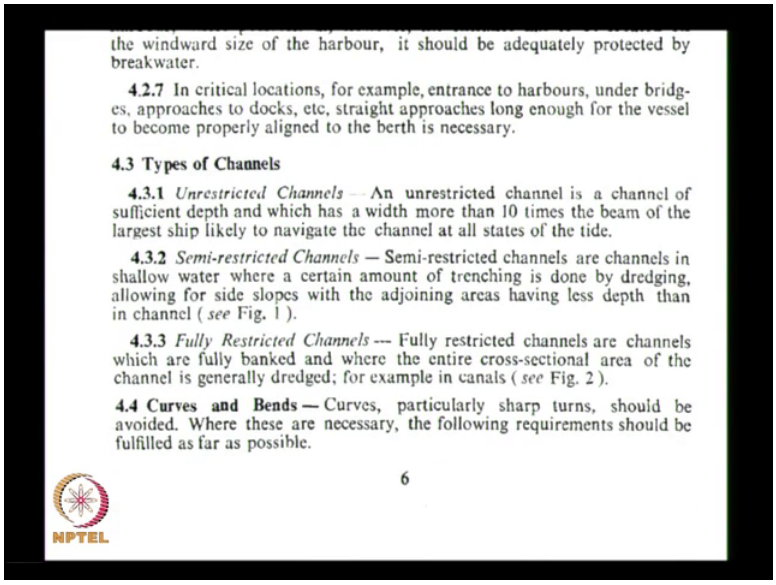
4.2.2 As far as possible, areas prone to excessive siltation and littoral drift should be avoided.

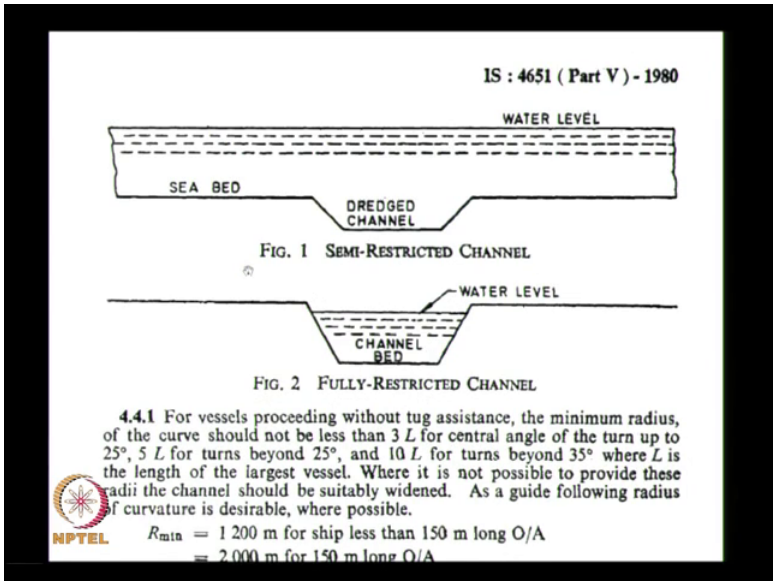
4.2.3 The number of curves and the angles of deflection of the axis (*see* **4.4**) should be kept down to a minimum.

4.2.4 As far as practicable, a minimum angle between the channel axis and the resultant effect of the direction of the prevailing wind and swell and current should be maintained.

4.2.5 Adequate stopping distance (*see* **4.5**) to bring a vessel to a stop with or without tug, having regards to the requirements of the using agency and experience of the port authorities to handle vessel of a particular size should be provided.

4.2.6 The entrance to the basin should be located on the lee side of the harbour, where possible. If, however, the entrance has to be located on the windward size of the harbour, it should be adequately protected by breakwater.





Next, certain details about navigation channel is given. You please go through this, the type of channel, already given in the PowerPoint about unrestricted, semi-restricted and fully restricted channels. The curves and bends, we need special consideration. Here we are given 2 figures, figure won it for semi-respected channel and figure 2 is for fully respected channel. The free channel means there is no dredging, that this the 1st one, unrestricted channel.

Unrestricted channel means there is no dredging required, sufficient water depth is available in the particular site, that is called as unrestricted channel. Semirestricted channel means you do only part of the dredging, already we have sufficient water depth but, not sufficient water depth but already we have some water depth, let us say we need to develop a port for about 16 metre water depth, 10 metre is available. Then what you do is you create a facility,

harbour facility and terminate the water depth, then you dredge only for 6 metres, this is called as semirestricted channel.

Fully restricted means right from the water level you restrict completely, that is called as fully restricted channel. I may ask this question, so you have to try and explain. Whenever the questions are asked in this course, mostly I will like you to draw the figures and explain.

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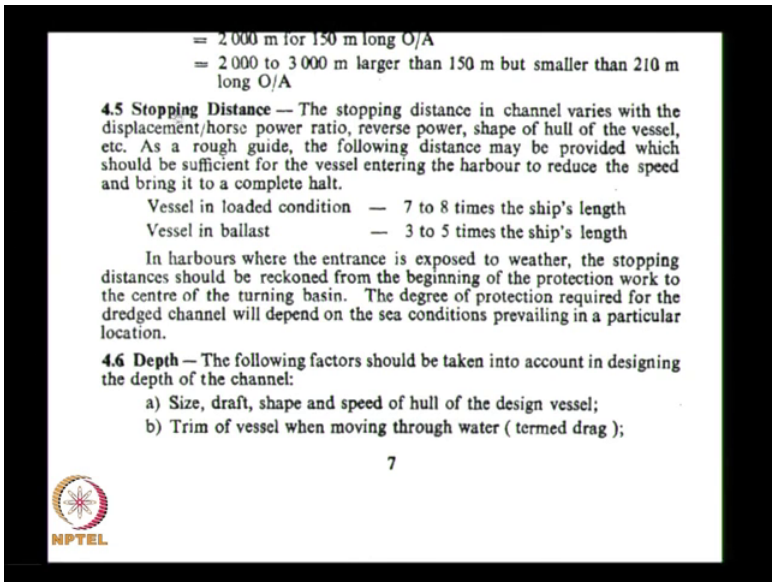

Then there is what is called as the stopping distance. Normally when the vessel is stopped, when it is going inside the harbour, from the point the vessel stops to the point where it is going to the turning circle, we need protection from the waves and winds. That means we need the breakwaters and natural protection. So what is the stopping distance, stopping distance in engineering practice, whenever we have a parameter to be defined, we should always define it with reference to some other parameters.

So if we take the stopping distance, I say it is related to ship lengths. Now suppose I want to know what should be the width of this channel, either this width or this width, it depends on what? Beamer ratio, that is correct. We want to find out what should be the depth, depends on what. So I have given a lecture in which I have told you what is the length beam and draft of the vessel, so based on that you have to find out. So if we see here, the vessel in Loaded condition, we need about 7 to 8 times the ship's length.

The vessel in ballast, vessel in ballast means it is a light draft, all the cargo has been unloaded and the ship is moving out or moving in, that is called as vessel in ballast. The we need 3 to 5

times the ships length. Tell me why we need more length of the ship in Loaded condition compared to ballast condition, that is in light conditions? What could be the reason?

It has high mass, so high momentum.

When the vessel is in Loaded condition, we have the mass is the maximum. When you are stopping the vessel, stopping the vessel means not applying brakes, stopping the engine. So it is moving at a certain speed, some acceleration is there of the vessel, when you stop it, there is a deceleration. Energy required to be dissipated is mass into the deceleration. So that is more because the mass is more, that is why we need more length for Loaded condition unless length for unloaded condition or light condition.

The next parameter is about water depths, for the depth it depends on the size, draft, shape and speed of hull of the design vessel, trim of vessel when moving through water. I will describe about trim and all in another class.

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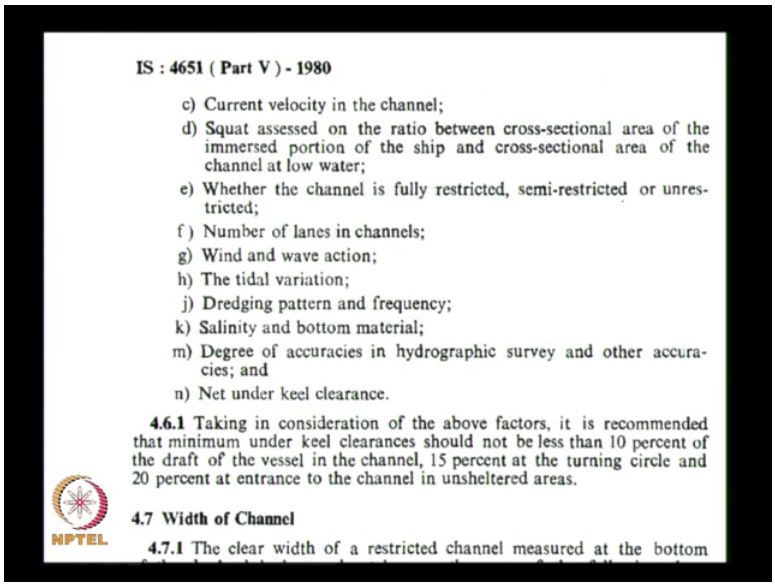

The current velocity, squat also I will discuss in some other class. When the channel is fully restricted, semirestricted or unrestricted, number of lanes in the channel, wind and wave conditions. So this parameter what we are calling the wind and wave, we have to study about this, wind and wave. So you should, there is some statistics involved in about the wind and wave, it is not constant. The 2 parameters are used, one operation, another is exchange, operational wind, operational wave, extreme wind and extreme wave.

The operational consideration, the wind speed will be much less, then only you will bring the vessel inside. If the wind is more, the ship will be anchored outside the harbour basin, it will not come inside. Then the tidal variation, it is very important in certain ports which are called as tidal ports, they use the tide to bring the vessel. For example Kandla, it is in a creek from the Gulf of Kutch, they bring the vessel where there is a very open channel only, unrestricted channel, whether water depth is only about 9 metre in low tide but when high tide it goes to 14 metres.

That is a narrow stretch, there is what is called as local channel, through which they will bring the vessel only during high tide. So time is important, whenever a ship manoeuvring takes place, it is always related to tide. The tides are not normally occurring at the same time everyday, it is slightly different. So there is a tide chart which is published by survey of India, every year it is published, January it is there, they give for measure ports in India, what is the time for high tide as well as for low tide. So you see the tide and bring it, so this is very important.

The dredging pattern in frequency, so this is mainly for maintenance dredging. Certain ports the maintenance dredging is done throughout the year, whereas certain ports it is done seasonally. The Salinity, we already discussed, bottom material also we discussed, for clay soil, the bottom material required for clay will be less, whereas if it is rock, it is small. Then this is called as sounding accuracy, this may be hydrographic survey, there is accuracy and what we measure is 10.1 metre, the accuracy of the instrument, it may not sense 10.95. So it give 10.1, that you have to take care.

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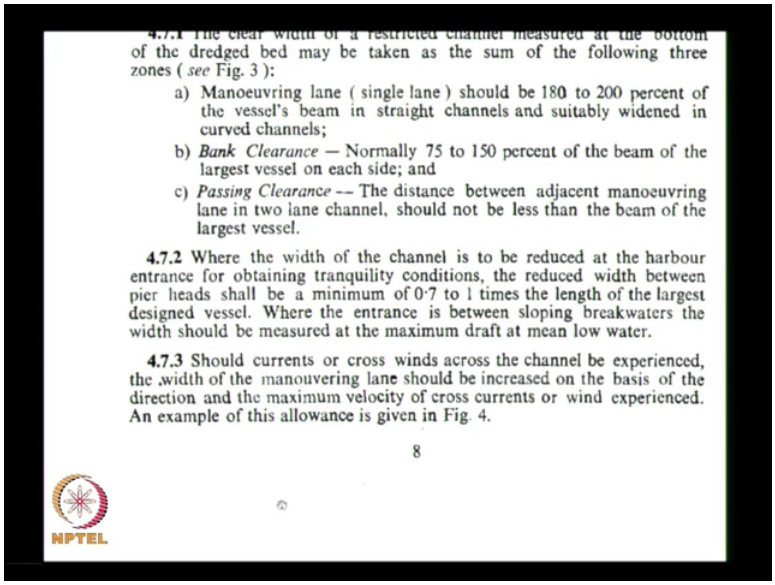

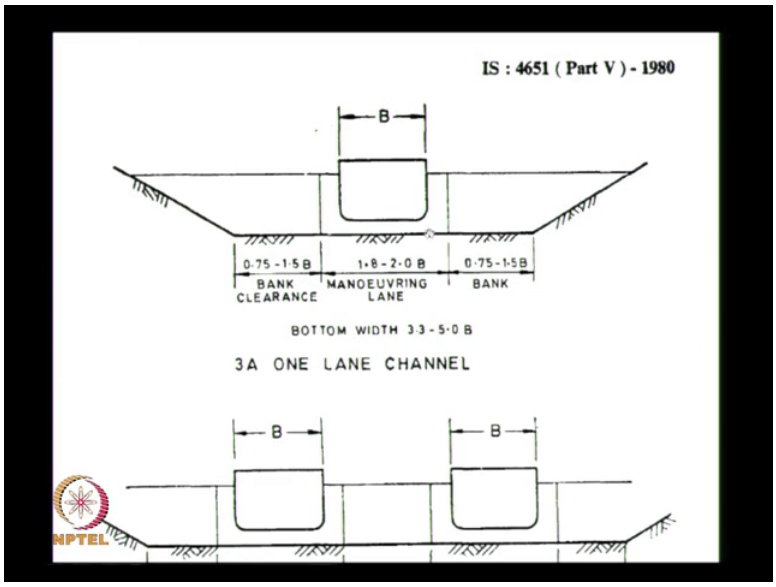

What is the net under keel clearance, these are the various things. Then about the width of the channel, you please go through these details what is given here. Normally this one lane channel, this is a restricted channel, when there is B, that is the beam of the vessel, when the vessel is to be going only within this place, that is called as a manoeuvring lane, we are deciding this width to be equal to 1.8 to 2 times the beam of the vessel. Because due to wind and correct, the vessel being in the centre position, it can move this side, it cannot move very much, that is called as a manoeuvring lane.

And there is a bank, to the bank, the clearance is 0.75 to 1.5 B, this site 0.75 to 1.5 B. You may wonder why we are giving 2 values, 2 ranges, it depends on the site conditions, each side the current speed will be more, the current speed is high, we have to go for higher values, if

the current speed is less, we have to go for lower values. But it should not be less than the minimum value, that is 1.5 + 1.8, that is 3.3 times beam of the vessel you have to provide. But sometimes you may go for slightly less than this, but it should be based on detailed numerical calculations as well as we have these simulators where we create navigation channels.

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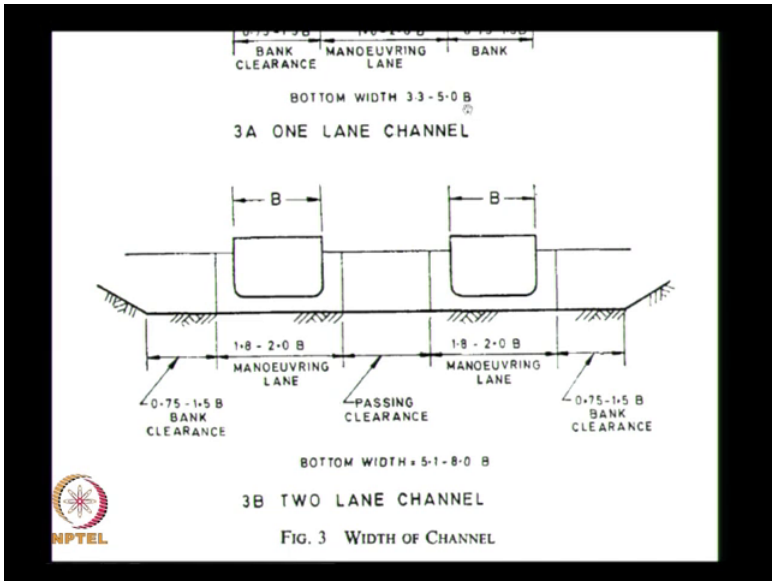

FIG. 3 WIDTH OF CHANNEL

Simulator is, there is a simulator in Indian Maritime University, so they will have the layout of the harbour, the ship's pilots sits there and they create various conditions, he does the manoeuvring how the ship is moving. Normally we use only 2 lane channels. So here it is given one lane channel, the bottom width varies from 3.3 times to 5 times the beam of the vessel. The beam is the largest beam of the vehicle. Typically it is about (())(31:46) is about 82.3 metres, so vessel, whenever in lane will be, the one lane channel will be about 150 to 200 metres, that is for single channel.

When a greenfield port is developed, they will start with a one lane channel, and subsequently they will move onto a 2 lane channel. So when you, when I want to do draw the figure, you please draw the ship at least like this, do not draw in some other manner, I want the proportion of the beam to the depth, to be almost equal to the reality and the bottom clearance also. Whenever you draw the figure, you should take care of that. And when I say 1.82 to 2B, do not what you do draw with the scale but still if this is B, this should like, look like 2B, not 3B or 5B, something like that.

It should not come very close also, so you try to practice. And this passing clearance also should be there, I think he has not given the passing clearance in this figure, maybe it is about the same as this bank clearance. And we have 2 vessels going here, there are certain waves that are developed when the ship is moving and there are certain effects when this vessel is moving due to the formation of some vertices and other aerodynamic properties, there is some additional forces that is coming onto the nearby ship, that is why we have to create clearance.

The bottom width should be about 5.1 to 8B, that should be the bottom width. When I say bottom width, it is the width at the bottom, not at the water line. So whenever you read, generally we do not read it with a lot of concentration. So any word that is used in a code has a meaning. It may not be explained in the code, bottom, it means the width of the bottom. That means what is the width at the water line? Width at the water line is very difficult, suppose it is a rocky strata, this can stand vertical, in that case the top width and bottom width is same.

It is a very soft clay, there is a slope here, what could be the slope, so many civil engineers here no, what should be the slope? So when you are dumping sand from a lorry, sand is forming an angle of repose, what will be the angle?

30 degrees.

30 degrees so in slope if you say, it can be from 1 is to 1.5 to 1 is to 2, that is one vertical to 1.5 horizontal. In clayey soil, that is mostly experienced in many of the ports in India, the flow can be 1 vertical to 10 horizontal, it can be so much. And whenever there is a tsunami or cyclonic storm process, even if there is a steep slope, it becomes flattened. So we can take only in 3 as a general guideline for this bottom slope.

Why this slope is important? This slope is important because the dredging quantity, you have to calculate the volume, for that you need the bottom width as well as the side slope. There is lot of financial stake associated with this dredging quantity. The slope, whether it is 1 is to 3 or 1 is to 1.5 or 1 is to 2, the quantity can vary from, variation can be 5 percent, 10 percent or even sometimes 15 percent, so that is a very huge quantity. Normally nowadays we pay for the actual quantity what is dredged. Earlier people used to specify that this should be dredged to particular slope, where they want the stability of the slope. We do the mathematical

calculations, the slope comes 1 is to 10, they want to study 1 is to 10. So we will discuss the other things in the next class.