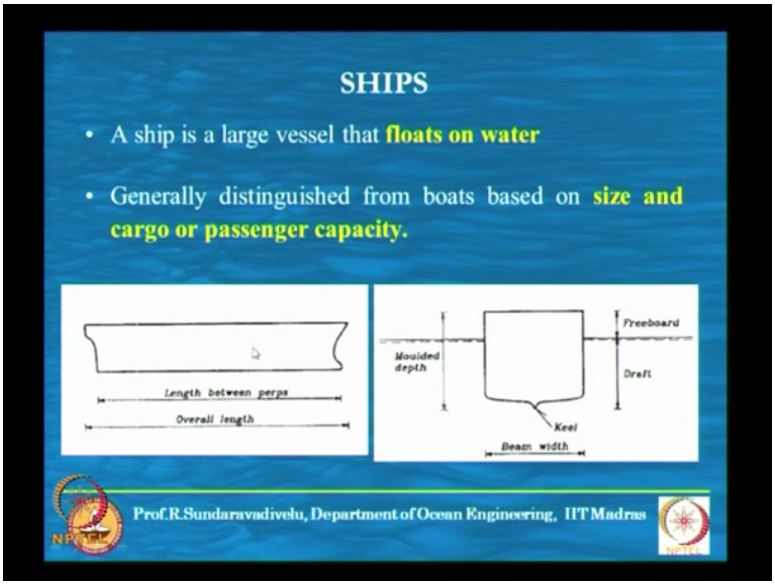
Port and Harbour Structures
Prof. R. Sundaravadivelu
Department of Ocean Engineering
Indian Institute of Technology Madras
Module 01 Lecture 04
Ships and Size of Ships

So in this class we will continue the second lecture that is regarding the ship dimension towards the end of the class some of you ask some questions that also I will clarify.

(Refer Slide Time: 0:25)

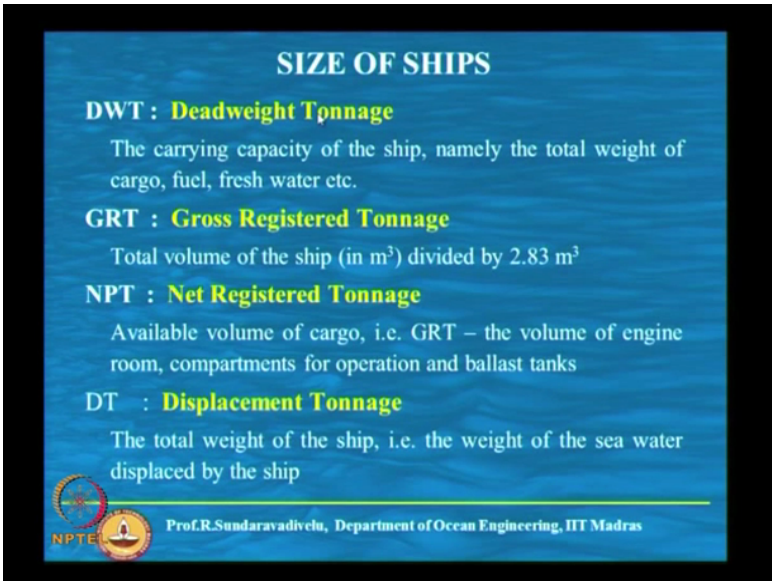


One of the question you have asked is when the ship is like this. How do we load the ship? Suppose you load the ship this side that is a forward end, you have a dought whether we can load like this, your dought is genuine you cannot load only at one point like this. If you load at one point like this, (this point) this side of the ship will go down and actually this may get submerged. So what they have to do is? They have to load simultaneously this forward end as well as the aft end, you need two unloading arms or loading arms to load both aft and aft and forward end simultaneously or we have to load some portion here and then move the crane here and then load at this portion. If it tanker, they can pump from the center. Usually the ship will be divided into compartments; generally typically about it is a 5 compartments. It can be more also which are called as bulk-heads what you are connecting here is called as a bulkhead.

So if it is oil you can using a marine loading arm we can form from the middle and then the water the oil will flow then come up(())(1:43). How many you are met M. Tech students here, ocean engineering, any naval architects B. Tech, you know what is mean by free surface

effect. Partially filled tanks in water (())(2:04) wash while the ship is loading, see what is mean free surface effect is partly what you have told is right, but in the context of this, suppose you do not have the bulkheads where we have compartments, if you do not have the bulkheads, when there is free surface here, when the vessel is moving, the free surface suppose this is pitching (())(2:28) like this, the free surface will become like this that means the center of gravity center of (())(2:33) and all will get change. So that is not desirable. The stability of the ship will be affected that is why we need the bulkheads. Another important aspect of this bulk head is we are dividing this into individual compartments. So what we are loading here you can load it partially here you can load it slightly more here and things like that.

(Refer Slide Time: 2:57)



Next is important definition of a ship. The ship is defined mostly by this DWT. This is called as deadweight Tonnage. So this classification is very much important, most of them will be using this, though there are other classification which I will discuss later in the class. DWT is the one which is mostly used. DWT defined as the carrying capacity of the ship, namely the total weight of cargo, fuel, fresh water etcetera. So this is called as the deadweight tonnage. This definition is taken from our IS-4651 code.

Then we have what is known as GRT. GRT means gross registered tonnage that is the volume of the ship in meter cube divided by 2.83 cubic meter. We assume the density of the cargo is 2.83, I have find out the volume of the ship and divide by this. Net registered tonnage is available volume of cargo that is GRT minus the volume of engine room compartments for operation and ballast tanks. So GRT includes all this volume where the engine room is there,

operational compartments and ballast tanks. Ballast tanks means you know what is ballast tanks. Ballast tanks means you have there is a tank in which you can ballast and de-ballast. Ballast means you can fill in water so that the ship will go down, you can remove the water when the ship will come up that is called as ballast tanks. The use of ballast tank is it is not desirable that you have the light draft; light draft means minimum draft. Minimum draft is not always advantageous, because the propeller has to get submerged. So you have to ballast it.

Another thing is when you are ballasting it with water and you are taking a ship in light draft condition and if you want to add more cargo what we can do is, you can remove the water from the ballast tank and add more cargo, point is clear, now you will load and unload in a ballast tank depending on the requirement. If you want to add more cargo you will use the tank to ballast use the tank to de-ballast the water, whatever water is there, if you want to load cargo and if the draft becomes very less, then you may not be the propeller will not get completely submerged. In that case, you will use the ballast tank and fill the water so that the draft will increase.

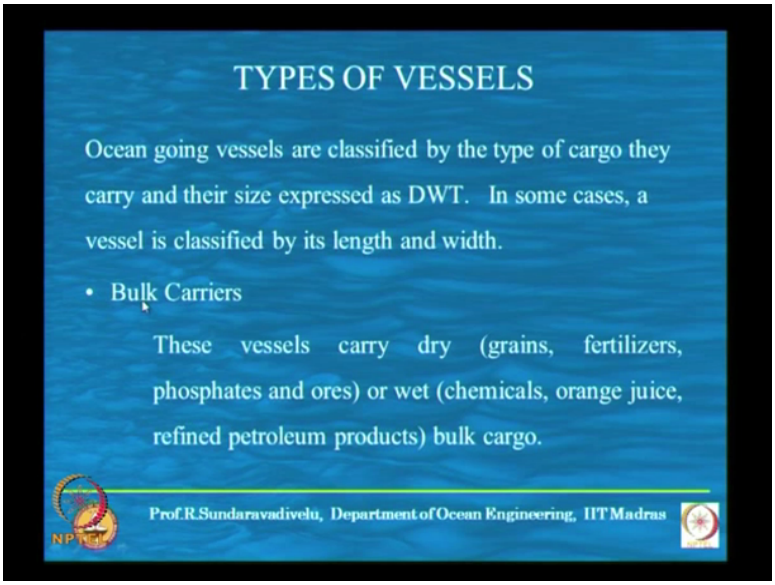
Displacement Tonnage, the total weight of the ship that is the weight of the sea water displaced by the ship. This is a simple classification for calculating the berthing force and other things we need this displacement Tonnage. In simple terms displacement Tonnage is DWT that is a dead weight tonnage plus light ship weight that is the weight of the ship that is what is termed as displacement Tonnage, I will repeat once again deadweight Tonnage is the carrying capacity that is how much it can carry the cargo, but (the) it includes the cargo plus fuel plus fresh water that means the cargo, it carries will be slightly less than the dead weight tonnage. Displacement Tonnage is when the cargo is fully loaded let us say including the weight of the ship, the cargo will be added to that and there will be some amount of volume of water displaced, using the volume of water displaced into density of sea water, you will get the weight that is called as the displacement Tonnage.

Typically displacement tonnage is about 25 percent more than the dead weight tonnage 25 to 30 percent that means the weight of the ship is about 25 percent of the cargo that is being taken. So if you compare with a car, you know what is a weight of the car. What will be the weight of the car? How many kgs to be louder, it is will be? What will be the weight of the car? 4000 kg will be a truck weight or will be around 1000 kg, 4000 kg may be from special type of, how many people can go in a car, normally what will be the weight of this people (()) (7:56), 400 plus put space another 200 kg. A 1000 kg car will at the maximum carry about

600 to 700 kg of the personal including the weight of the fuel and things like that, whereas in the ship terminology, if you want to carry 600 kg cargo we need only 30 percent of it. It is advantage of the ship, okay.

The passenger car when it is taking 600 kg, the weight of the car itself is 1000 kg. Now you have to spend the fuel for 1000 plus 600 that is why ship transport is cheaper. What will be the typical speed of the ship? What is it? 15 knots, 15 to 20 knots or 10 to 20 knots, 1 knot is equal to approximately 1.8 kilometer per hour that means it is about 20 to 40 kilometer per hour. That will be the speed of the ship. Typically around 20 to 30 kilometer per hour, the speed is very less. If the speed is increased you will have resistance from the water that also will increase. So it is better not to go in for very high speed and you cannot go for very low speed also, because your control will not be good (()(9:23), you cannot go for 2 knot, 3 knot (())(9:26), then you cannot control the ship. So the speed is less however the weight of the ship to carry the cargo is much less. It is only about 20 to 30 percent that is why the ship transport is cheaper.

(Refer Slide Time: 9:44)

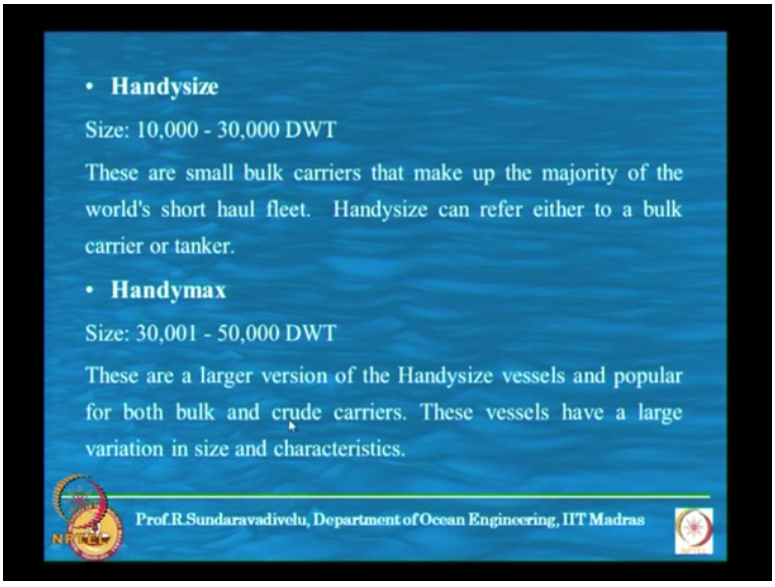


Now we will classify the vessels, (I want to) earlier we have classified in terms of deadweight tonnage. Now we classify depending on the type of cargo. Next we will classify depending on the size of the vessel. So this ocean going vessels, there are different types of vessels. When I write ocean going vessel, there can be another vessel, which can go only in the land water waste. The design of these vessels are different. If it is a ocean going vessel, it is defined for very high wave heights and the wave periods and it takes care of the voyage (()) (10:19) distance and the depending on which ocean it is crossing under. They can be

classified by the type of cargo they carry and their size is expressed as DWT. In some cases, a vessel is classified by its length and width. So we can use either DWT or length and width.

We have what is called as bulk carriers. These bulk carriers carry dry. So we have types of cargo one is called as a dry cargo another is called as a wet cargo. So the dry cargo is grains, fertilizers, phosphates and ores and wet cargo is chemicals, orange juice, refine petroleum products. These are all called as wet cargo, you can either have a dry car5go or you can have a wet cargo. Bulk means it is in good quantity. It is a an volume is very large.

(Refer Slide Time: 11:15)



So in this bulk carriers we can classify them as different size, one is called as a handysize. The handysize is between 10,000 to 30,000 DWT. It is a very small size. They are small bulk carriers. This make up the majority of the world's short haul fleet, short haul means shorter distance. We will not go for very long distance, we go only for a very short distance in terms of kilometer, it may be 500 kilometers something like that. Handysize can refer either to a bulk carrier or a tanker. So when you classify the vessel either as a bulk carrier or a tanker. In bulk carrier also you can have a handy size in tanker also you can have a handysize.

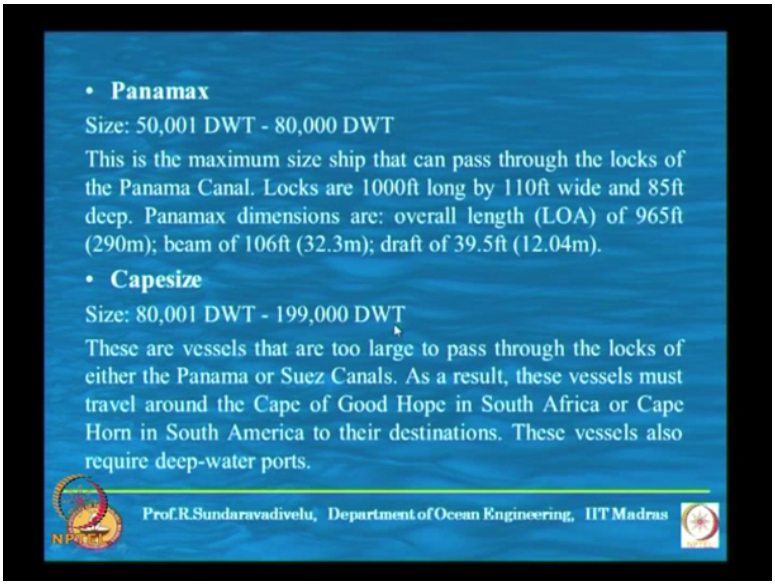
So most of the handysize bulk carriers, they are called as self-geared vessels, self-geared means the crane will be in the vessel itself, you do not need a loading unloading equipment on the berthing structure. So this vessel itself will have a gear. This called as a self-geared vessel which can be used for loading or unloading of cargo. Then we have the handymax. In handymax also we can have self-geared vessels, but not allow them are self-geared geared.

So this vessel size varies from 30,001 DWT to 50,000 DWT. So what is the maximum size of the cargo that can be transported by road in a vehicle? How many tons you can carry?

A civil engineers are there now, raise your hands overall civil engineers, you have studied class AA,(())(13:00) and all those things . What is a weight it can carry big truck? How much weight it can carry? Big truck small truck or I told car will carry about 600 to 800 kg, you are transporting water, water tankers are there. How much it can carry how much? 20 tons, 3-4 tons how much? 4 tons I am not hearing, you tell some other number, we have started from 4 to 20 ton tons (())(13:52). All the results all the answers are correct on the maximum how much it can carry 500 tons (())(14:01), you cannot carry, we have about 70 tons, 70 tons is a maximum that can be carried by road. special purpose vessel vehicles which can carry 70 tons, but normally when we transport most of them are about 10 to 12 tons of (())(14:23).

Normally in India, but either 20 foot equivalent unit container box that may be having a weight of about 14-15 tons plus truck weight, may be about 10 to 12 tons or about 25-30 tons it can carry. So general range is between 20 tons to 40 tons. It is a operating range. So I have told that the in comparison with you have see, how may if we have a 20 tons that is equivalent to about 5000 trucks that is what okay, 5000 or 500, 500 tons 500 trucks for this 10,000. These are larger version of handysize vessels and popular for both bulk and crude carriers. These vessels have a large variation in size and characteristics. So I have writturn this bulk and crude carriers and this here I have writturn tanker that means this is product tanker that is once you have a refinery and you have the product you are transporting. This crude means crude oil which is come in for refinery.

(Refer Slide Time: 15:36)



Then we have the panamax size vessel. This is the most commonly used as well as economical size of the vessel. We talk about the economical size of the vessel means if the vessel size is bigger and bigger then you will be spending less money on the self-weight of the ship less fuel that is why panamax size vessel is better, but some of the cargo we may have to go in for bigger size vessel, for example the crude oil which is transported which goes to refinery directly then we may using much bigger than that otherwise for general type of transport we generally use what is called as the panamax size vessel. This is between 50,001 DWT to 80,000 DWT. This is a maximum size of the ship that can pass through the locks of Panama Canal.

So Panama Canal is the place through which most of the transport goes and there have a lock. The lock is having a length of 1000 feet, width of 110 feet and the depth of 85 feet; I have given the dimension in feet, because they have built it in feet. The size of the panamax size ships are overall length that is called as LOA. This is of 965 feet that is about 290 meters, beam of 106 feet that is 32.3 meter and draft of 39.5 feet that is 12.04 meter. So the typical draft is about 12 meter, 12 meter is a equal to about force to rebuilding that is you can imagine how much will be the depth and this length can vary. It is not 290 meter fixed, it can vary from 260 meter to 290 meter; the breadth is 32.3 meter.

So you should find out the ratio between the lengths to the breadth. The length to breadth ratio is generally about 7 L by B ratio, because we want to design a ship, typically the length to breadth ratio is about 7 and the beam to draft ratio is about 2.5 that is ratio. Typically the ships are having this type of dimension. So you should keep that in mind. If you have a

compact ship that is the length to beam ratio equal to about 4, 5 and all it will have it is not having good characteristics for stability as well as ((()))(18:03). So the L by B ratio is typically about to 7. The beam is the nothing but the width of ship. This is a terminology used in the ship. Beam is nothing but the width of the ship.

So when you want to design a berthing structure for 12 meter draft. This is a called as a fully loaded draft , we need under keel clearance of about to 10 percent of the draft that is about 1.2 meters that is about 13.2 meter depth is required. There should be some clearance between the bottom of the ship to the seabed that is typically around 10 percent of the draft of the vessel in a protected harbour, but if it is not protected harbour. This will go upto 20 percent. This is called as under keel clearance UKC under keel, keel means KEEL clearance , I have given in approximate thing, but approximate value, but it depends on so many factors like the motion of the vessel, type of seabed, the dredging tolerance your equipment which is used to measure the water depth and when we see the water depth required. (it) the water depth is related to the lowest water level, the lowest water level that is being measured at a particular size that is taken as the chart datum.

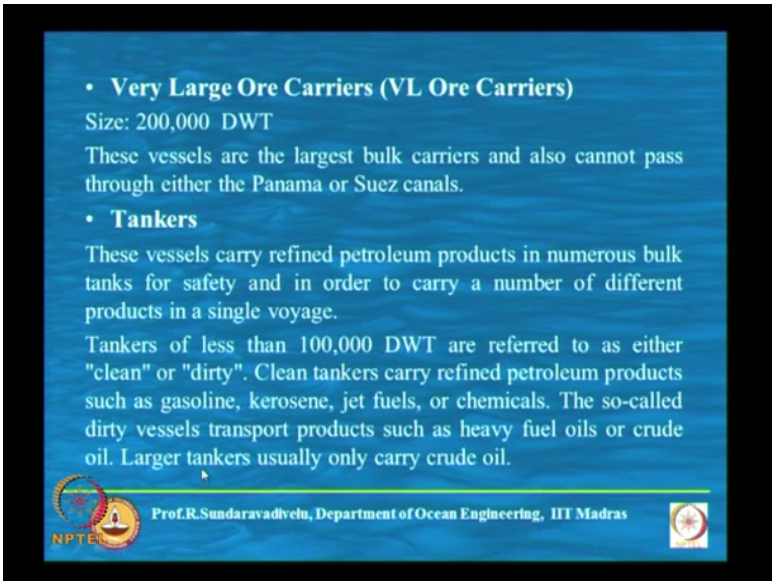
The chart datum for civil engineering purpose is mean sea level. Mean sea level is it can be taken as average between the high water level and low water level, it is not always like that, for example you can take it as average. So mean sea level for Chennai may be around the plus 0.7 or 0.8 and the chart datum will be 0.0 that plus 0.7 and 0.8 whatever I am telling as a mean sea level is taken as the chart datum for land based structures. When you have a building when you find out the level what level is a foundation, you would have seen in all the hostels, if you are not seen it go and see all the hostels, they would have (())(20:19) to writturn what is a foundation level that foundation level is with reference to the mean sea level that is taken as the chat datum, whereas for ocean engineering purpose chart datum is the lowest water level. One of the class I will show you the naval hydrographic chart where they give the chart datum.

Then we have the capsize that is between 80,001 to 199,000 DWT. This pass through the locks of this cannot pass the locks of panama or Suez Canal. As a result, these vessels must travel around the Cape of Good Hope in South Africa or Cape Horn in South America to their destinations. So there is a place which is called as a Cape of Good Hope in South Africa, you can go through that. So this has to travel around that and similarly for South America also it cannot goes through Panama Canal. They have to go through the Cape Horn. It is a place if

we go to Google and search these locations we can see that means it has to travel around a long distance. These vessels also require deep draft vessels.

So towards the end of the lecture I will be giving you the size of the Capsize. So you will find out what will be the draft required and depth required. So the point here is if the draft is more the depth required is more, once the depth require is more the cost of the berthing structure also will be increase. So the cost is not directly proportional to the water depth. It is proportional to the cube of the water depth, whereas if you see the basic principles of bending moment and (())(21:54). Bending moment is proportional to the square of the span whereas here the force which is act (())(22:01) pressure also depends on the depth of soil which is retaining. So your bending moment in the case of this type of water depth is proportional to the cube that means the cost will increase enormously that is why you have to see what type of vessels which will be handle at a particular port.

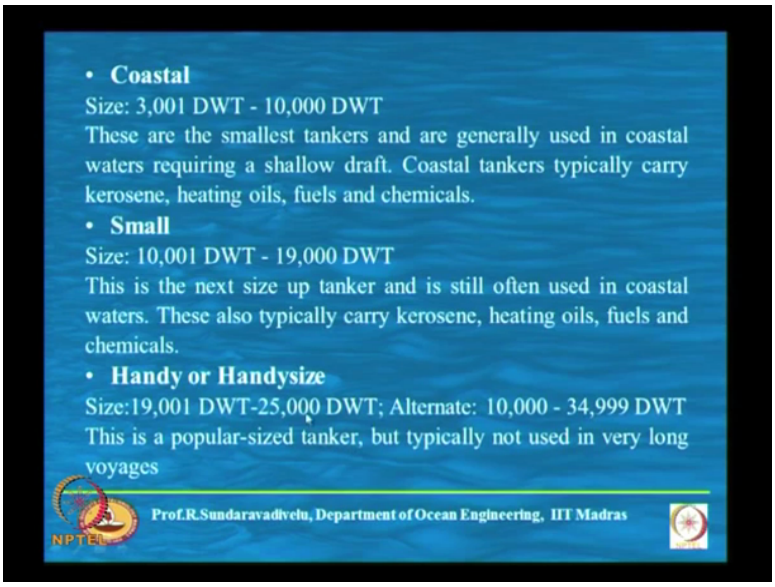
(Refer Slide Time: 22:25)



Then we have very large Ore Carriers. This very large Ore Carrier is typically about 200,000 DWT. These vessels are the largest bulk carriers and also cannot pass through either the panama or Suez Canals. So depending on the requirement, you can go for either very large ore carrier or Capsize or panamax size. Then we have the tankers earlier what we have given is bulk carriers then we have the tankers. These vessels carry refined petroleum products in numerous bulk tanks for safety and in order to carry a number of different products in a single voyage. So if the tanker will have compartments you can have a different products also and they are refined petroleum products. This tankers which is less than 100,000 DWT, they are referred to either clean or dirty. The clean tankers carry refined petroleum products or the

so-called dirty vessels. They transport heavy fuel oils or crude oil and larger tankers greater than 100,000 DWT, they carry only crude oil. So you have in tankers also you have two classification. One is clean, other is dirty. The clean cargo is refined petroleum products and dirty cargo is the heavy fuel oil as well as the crude oil.

(Refer Slide Time: 23:52)



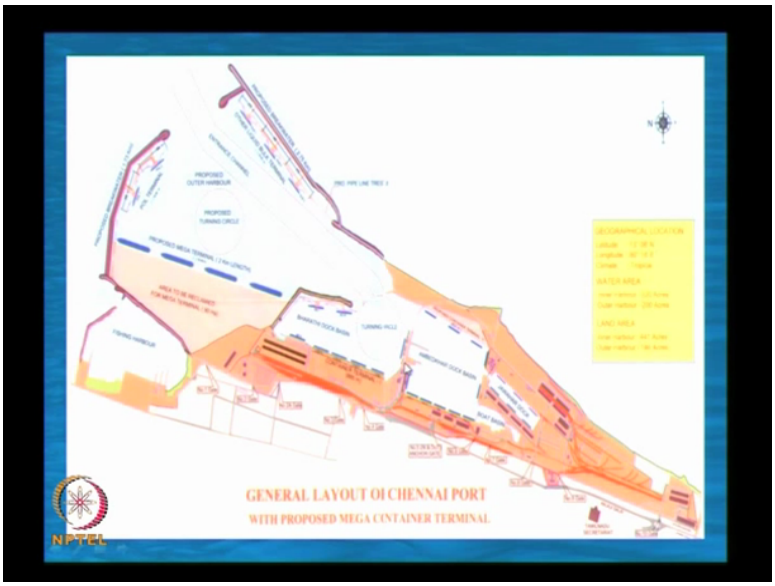
The just like earlier we have classified handysize (())(23:55) and here we have less than handysize we have two small size vessels which is called as coastal tanker and the small tanker. This vary from 3000 to 10,000 DWT. They are used in coastal waters requiring a shallow draft. They carry kerosene, heating oil, fuels and chemicals. So kerosenes are household purpose, the heating oils are used industries; the fuels can be used in some coastal powerplants and chemicals which are used for various industries. These are all small size tankers which will go only along the coast.

Then we have small tankers which are between 10001 to the 19000 DWT. These are also used in coastal waters. Similar size of cargo similar type of cargo is used here. Then we have the handy or handysize and (the) this is a popular size tanker. They are not used for long voyage long voyages, typically bigger size vessels are used for long voyages.

(Refer Slide Time: 25:05)

This shows the photographs of the bulk carrier, ore carrier, barge carrier as well as the container ship. So here we have the gears here. So these gears can be used for loading or unloading the cargo. So some typical photographs for different types of vessels.

(Refer Slide Time: 25:26)

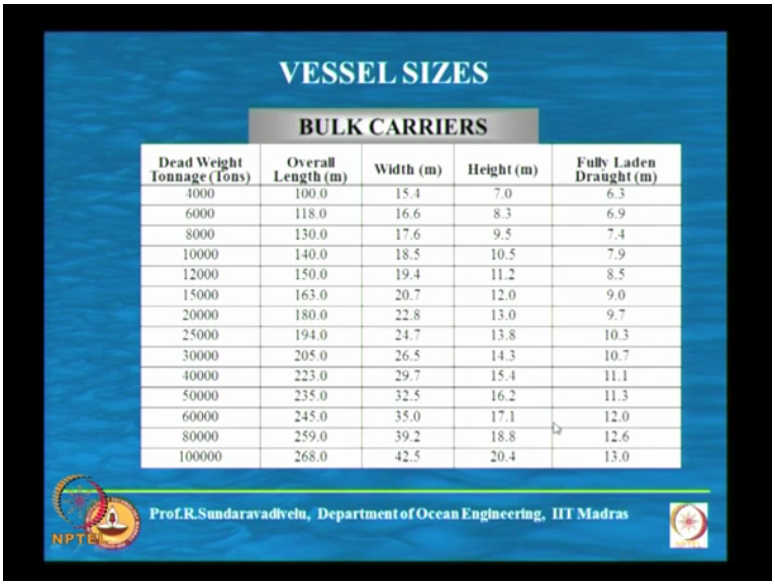


So one of you ask me what is the water depth in the port. The water depth in a port is not constant. So in a harbour for Chennai harbour we have this layout adjacent to that we have a fishing harbour. Typically fishing harbour (the water) the size of the a fishing crafts that will enter is typically about 1 meter to 2 meter draft that is what will come here. We have a what is called as a catamaran that also can come inside which has very less draft may be 0.3, 0.4,

0.6 meters. Then we have a jawahar dock. The jawahar dock is originally designed for about 9 meter draft.

Now we are improving this to 12 meters and we have a second container terminal here. This can handle vessels upto 12.5 meter draft and we have the tankers here can go upto 14-15 meter draft and now we are proposing the mega terminal you can handle upto 18 meter draft, when I say draft of the vessel, the depth will be about 10 percent more than this. Here we can bring the VLCC also in phase to which will have a draft of about 21 meters. So the navigation channel will be designed for the biggest vessel. The biggest vessel will come and it can be used only at these locations you cannot go to this harbour. Then here the next medium size vessel will come and we will get berth. The smaller vessels will go here; much smaller vessels will go to this place called as a boat basin. The water depth is not constant in a port, it is different at different places.

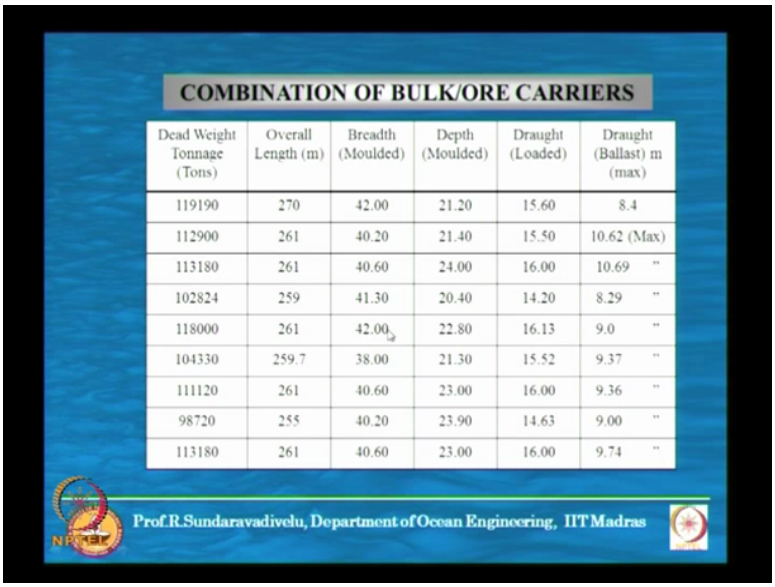
(Refer Slide Time: 27:13)



Now we will see the bulk carriers. Bulk carriers has said only handysize, but there are certain barge carriers for handling the cargo. The typical size is about 100 meter in length, width is 15.4 meter, height means moulded depth that is the top of the vessel to the keel and the fully laden draft is 6.3 meter that means the freeboard is only about 0.7 meter that is about 10 percent of the height that is a freeboard. So freeboard is less for a smaller size vessel and this type of vessels are being used in large numbers, ONGC uses this offshore supply vessels. They are also typically of this size and the many tugboats and the many costal vessels are of this size, we have a size less than this also, but this is the maximum size that will be used and for design purpose we take this dimension.

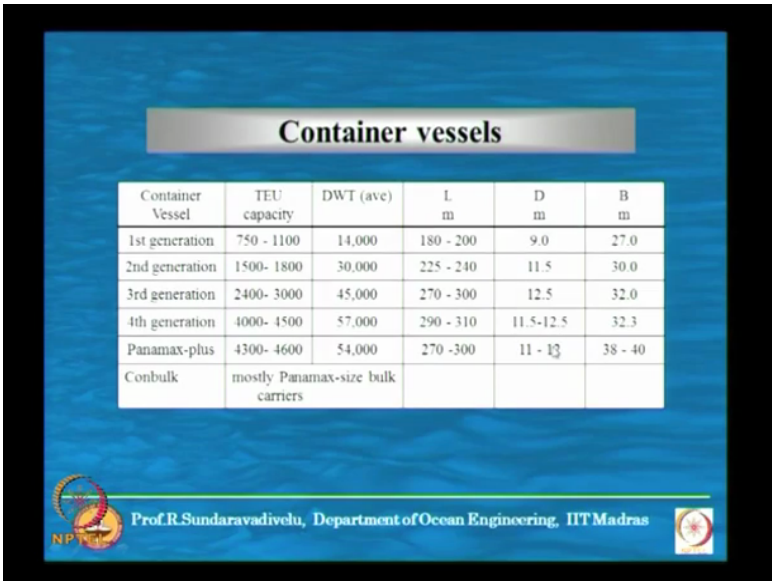
The next size normally we use it for design is about 30,000 DWT vessel which is 205 meter long, 26.5 meter wide, 14.3 meter in height and 10.7 as the fully loaded draft . Nowadays we do not use this size for the design no longer, but most of the structures which were design may be 20 years back they have used this as a size. Now we want to use there is some what about 60,000 DWT vessels which is called as a panamax size vessel. The length is 245 meters, width is not 35 sometimes it is 32.3, becuise this is used for Panama Canal and the total height is 17.1 and fully loaded draft is 12 meters. So most of the structures what we are designing is for about 12 meter draft and may be 90 percent of the ports they will be able to handle this 12 meter draft vessel. Here you can see the freeboard is about 5 meters, because with this point ocean going vessel, this will not be a ocean going barge, but this will be a ocean going vessel, we need the good freeboard.

(Refer Slide Time: 29:37)



Then we have the combination of bulk or ore carrier. It is a typically about 100,000 DWT vessel in the there we have given the moulded depth as well as the loaded draft and the this may be the light draft the typical size is given.

(Refer Slide Time: 29:56)



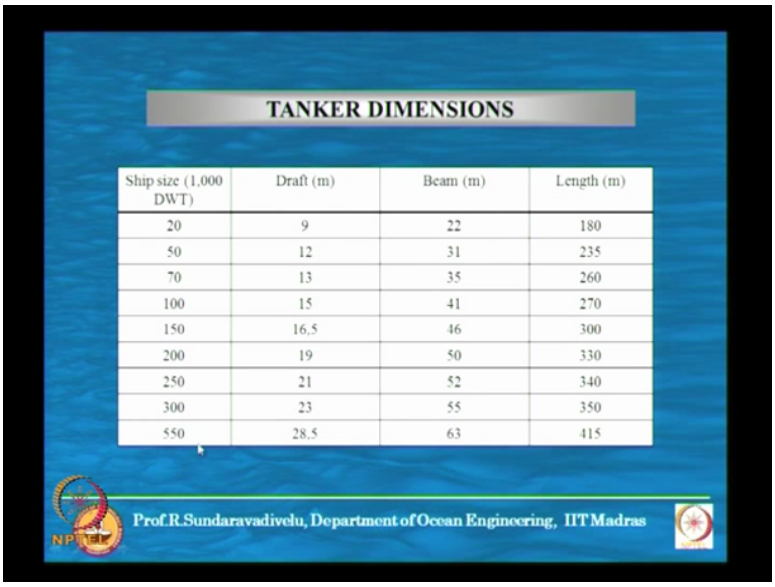
Next class of vessel is a container vessel. This classification is important about 30 percent of the cargo that is transported is by container. If you want the classification of cargo the liquid cargo will be very large may be about 40 to 50 percent. Then we will have the container which will be about 30 percent. The balance will be the other cargo. Is it clear? Liquid cargo is maximum. This container vessels can be classified as first generations, second generation, third generation, fourth generation. Fourth generation is the panamax size vessel then we have the panamax plus, then we have Conbulk.

The conbulk is nothing but bulk carrier. This is a panamax size bulk carrier. This is a terminology which is being used for container vessels. Then we have a bigger size vessels. This 4300 to 4600 we have upto 10,000, 12000, 15000, 18000 TEU vessels. Here the not being, there will be only very select destinations about 5 or 6 ports where they contain. So we will talk about the 1st generation. This first generations vessels are used from a transshipment port to a nearby neighboring port. The capacity is about 750 to 1100 TEU. The average deadweight tonnage is about 14000 tons, the length is between 180 to 200 meters, depth is 9 meters, breadth is 27 meters.

The most commonly used vessel is this panamax-plus about 54000 DWT, the average size is about 4300 to 4600 T EU, length is 270 to 300 meters. The draft is about 11 to 12 meters, then breadth is about 38.4. So the difference between the 4th generation which is a panamax vessel and the panamax-plus is in the last column here, 4th generation vessel as a width of 32.3 whereas panamax-plus vessel will be about 38 to 40 meters. When you have the larger width, number of containers across the width of the vessel can be more, but it cannot pass

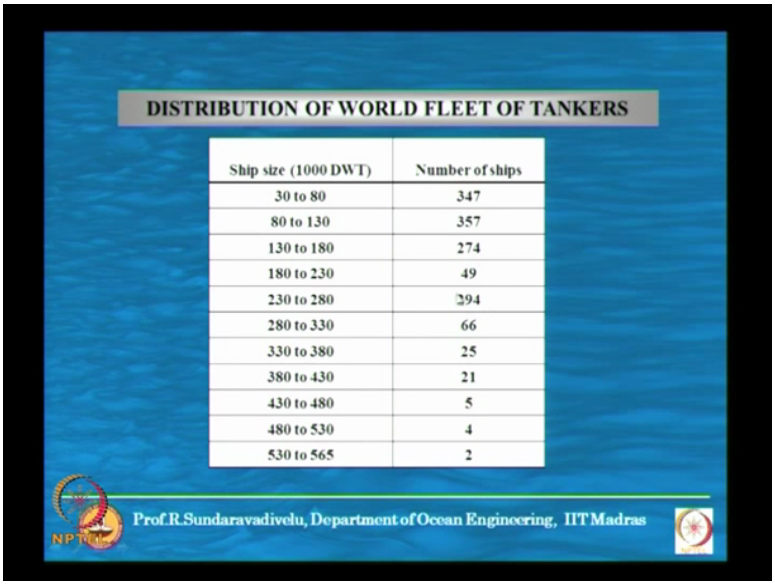
through the panamax canal. When you have a crane to lift the panamax-plus cargo from panamax-plus then the reach of the crane also should be larger, whereas for panamax is to 0.3 for panamax-plus it will be 40 meters. Draft is typically between 12 to (())(32:38) of meters you have to cat up for equivalent of meters.

(Refer Slide Time: 32:45)



This shows the size of the vessel tankers and the draft is given here, beam is given here and the length is given here. The ship size is in 1000 DWT that means 20 means it is 20000 DWT, mostly for crude oil we use 300,000 DWT vessel that is 3 lack DWT vessel. the draft is about 23 meters, beam is 55 meters, length is about 350 meters we may also use this 250 meter vessel, (250,000) 250,000 DWT where the draft is 21 meters, beam is 52 meters, the length is 340 meters. The biggest tanker that is available is 550, 000 DWT vessel dimensions are given.

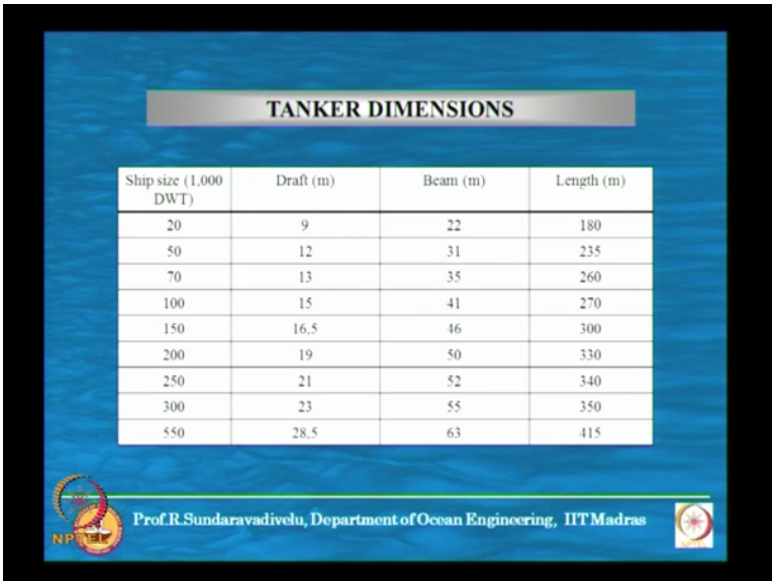
(Refer Slide Time: 33:34)

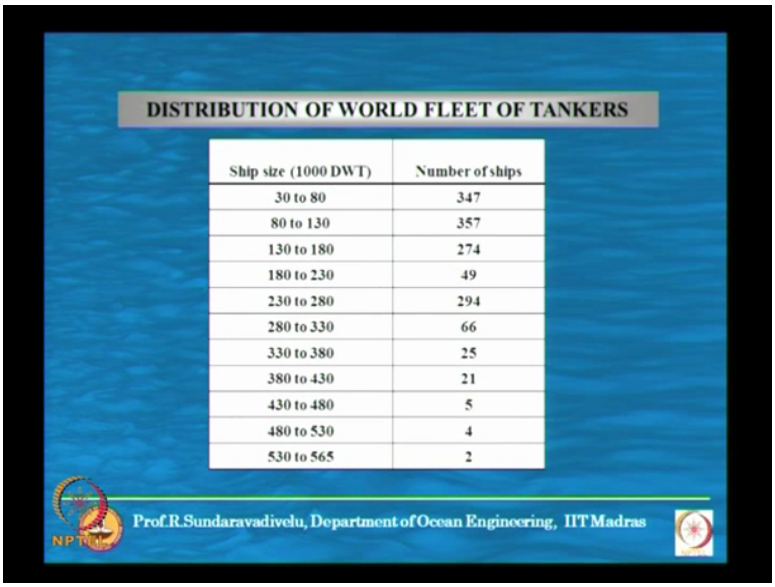


Whenever a vessel is being used, you should know what is the distribution. This is a one of the old data which is used for the tankers. So we have so many number of vessels if we see here between 30 to 80 thousand DWT vessel, our number of ships of 347, 80 to 130 thousand also it is a almost same number around 357. 130 to 180 is 274 then this size is very small 49 whereas 230 to 280, this is the size 230,000 to 280,000 which are used for transporting crude oil from where the oil is being drilled to the place where the refineries are located, we use this 230,000 to 280,000 DWT vessel. It is about 300 numbers which are being used to transport the crude oil from the locations where the oil is available to the location where the refineries are located.

From the refinery location we refine the crude oil and distribute to other locations this will be about 1000 ships smaller size vessels, because this is big size vessel 230 to 280, 300 vessels and for 300 vessels which are coming by crude oil, you are distributing in it almost 3 times the number of vessels for distribution. Some of the distributions from these refineries can go by pipeline also or by tankers also and these are bigger size vessel. They are all less in numbers, so we do not have many ports that will cat up to this. Many of the ports will cat up this size, these two sizes actually this size only many ports will cat whereas we need special ports to use this.

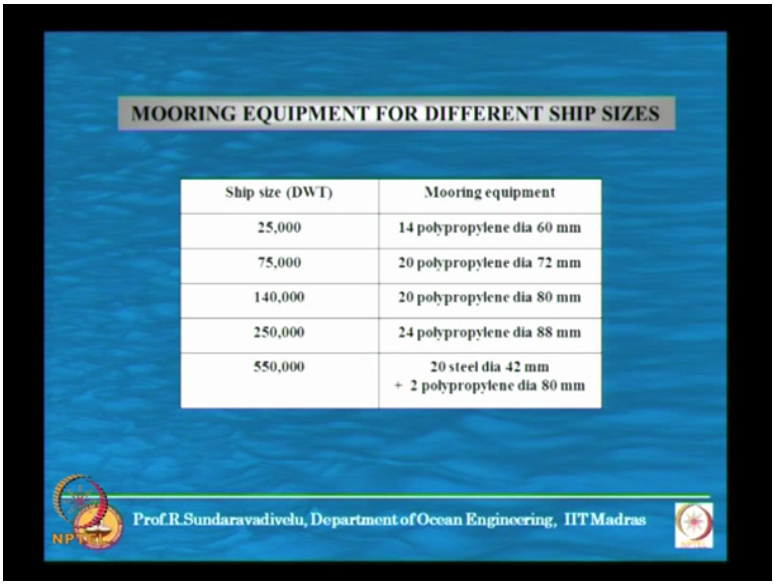
(Refer Slide Time: 35:33)





If we see this draft requirement for this 200 to 300 is about 19, 21 and 23 meters. Normally we have another facility which are used for this type of vessels which is called as a single by mooring system, which will be done in a open sea and they do not need breakwater or things like that. To handle this type of draft sometimes we may need upto 30 meter of water depth. So it is very difficult to provide, because it is open sea, open sea 20 percent of the draft would be given as keel clearance that is why we need about 30 meter water depth.

(Refer Slide Time: 36:14)



Then there are different equipments that are being carried whenever a ship is coming to the berth they have to Moore the vessel. So they will not ask the port authorities you give me the mooring rope per travel (())(36:29). So they have to carry. So a 25,000 DWT vessel. There are two different types of ropes that are normally used one is called as a polypropylene rope, another is called as a steel rope. The polypropylene rope (we) they have to carry about 14 ropes, the diameter of rope is about 60 millimeter in diameter. This is called as a mooring equipment what is writturn here.

This is the mooring equipment which the ship will carry and 14 ropes are there means they may use 2 rope to the same bollard on the berthing structure, it is not the you need 14 bollards even if the 6 bollards are there, they may use the 14 robes 2 ropes to 1 bollard they will connect and for 75,000 we need 20 ropes, 140,000 they need 20 ropes but the diameter is bigger 80 millimeters, 250,000 they will carry 24 ropes diameter 88 millimeters, then they will have the steel ropes. These are normally which they carry. There are certain locations in India like the (())(37:41) in gulf of Kutch and the some places in gulf of Khambhat I think the gauge (())(37:50) is gulf of Khambhat.

in this location the current velocity is very high the current velocity is typically about 1 knot or less than 1 knot whereas in this location gulfs the current can go upto 3 knots and all. So where the current is more the number of ropes are required is also more, in that time when they want to call a particular port they will carry additional equipments. These are the different sizes of ships that will be carrying these different types of mooring equipments. So

with this we will conclude this lecture we will see the next lecture that will be on port planning in the next class. Thank you.