Port and Harbor Structures
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Module-04 Lecture-27
Mechanical Handling System

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This lecture, we will discuss about this mechanical handling system. What you are seeing is a conveyor belt, supporting structure with tall steel towers which attach here. And this is under construction, so then they will add the belt over this. Mechanical handling system is an important component of port development. If you assume that 1,000 crores is spent on developing a port, maybe 600 to 700 crores will be spent on civil, marine civil works. The balance will be mechanical and electrical works.

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So we nowadays go for fully mechanized handling systems. Because of its inherent advantage, these systems will give you good throughput. Throughput means when a vessel of 60,000 dwt comes, you would like to handle the cargo within about 24 hours. That means we have to handle about 3,000 tons per hour. So we will have two independent system handling about 1,000 to 2,000 tons per hour, two cranes. So this is for a particular berth, a particular multipurpose berth. So we want to use a common bulk handing system. We will discuss about this.

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So this (mechanic) mechanized ship unloading and loading system for bulk or ore carriers, this consist of the following components. You can have either a ship unloader or a ship loader. Suppose you want to evacuate the cargo, then you use ship loader. Or when you are bringing your cargo, then you use a ship unloader. For example, many of the thermal power plants receive coal from coal fields in Jharkhand and other locations.

So in Paradip, they load the cargo into the ship using a ship loader and when it comes to Tuticorin or Chennai or any other coastal power station location ports, they use a ship unloader to unload the coal. Once you unload the coal, then you connect it to conveyor system and take it to a yard which is called as a stackyard. They do not directly take it to the power land, power plant. They will keep it on a separate land. Typically about 5 hectares of land is required. For handling 1 million tons, you need about 1 to 1.5 hectares. So if you want to handle, any berth will handle about 4 to 6 million tons. That means you need about 5 to 7 hectares.

“Professor-student conversation starts.”

Professor: What is a hectare?

Student: (())(03:19) meter.

Professor: 100 meters by 100 meters is 1 hectare.

“Professor-student conversation ends.”

Then after it is stacked, then you use a wagon loading system. Either through rail or through road, you transport it to the power plant. But if the power plant is nearby, you can use a conveyor system directly to the power plant. This is what is being planned in Ennore for Tamil Nadu Electricity Board Power Plants. Directly it will go by a conveyor system, there is no stacker or reclaimer within the port area, will directly go to the power plant.

Clear now? Mechanical student should be comfortable with this class. But we have to have lot of components, civil and mechanical components for this. You have to design the structure also for this as well as you have to design the mechanical handling system. Typically a ship loader or unloader will cost about 25 crores to 40 crores. That is the cost of that. We need at least two such

systems, sometimes three. That means about 100 crores we have to spend on this mechanical handling system.

Then conveyors are there. Conveyor cost is about 1.5 to 2 lakhs per running meter, that is the cost of the conveyor system. Some of the conveyor systems can run into minimum 1 or 2 kilometers but maximum it can go any number. But about 10 to 15 kilometers we may have to provide this. Stacker and reclaimers are other special equipments which is used to, see once the conveyor system drops at a particular place, then you need a stacker and reclaimer to arrange it in order. For that we need a stacker and reclaimer.

That means you will have about 6 meter high or 10 meter high of this cargo kept. For that you need a stacker and reclaimer to take the cargo and place it accordingly.

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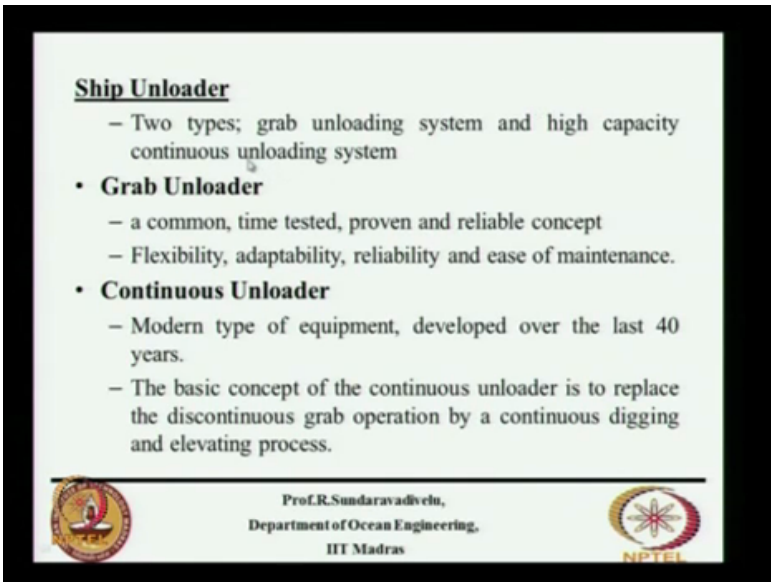

We have typically two types of ship unloaders. One is called as a grab unloading system and other one is continuous unloading system. The grab unloader is a proven and reliable concept. It is flexible, adaptable, reliable and it is ease of maintenance. Whereas continuous unloader, these are modern type of equipment, developed over the last 40 years. So we replace the continuous, discontinuous grab operation by a continuous digging and elevating process.

For example, grab means there will be a grab which will pick the cargo and drop it. Then it, the grab again will come, go inside the ship, grab it and then put it back. This continuous unloader

means continuous bucket will be there. Bucket will be going from the ship hole to the top, then it will continuously unload. Most of the people would like to have a grab unloader only.

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Then coming back to ship loader, the ship loader will come by railway wagon. Mostly these cargoes come by railway wagons and some places they are replaced by road, but generally railway is better. So you need to have good system, transport system to bring the cargo to the plant. So we have railway wagon coming and there is a platform, wagon tripling platform or which the wagons dump the cargo.

So this Indian Rare Earths Limited, we are using this arrangement. Then there will be a stockpile yard. From the stockpile yard, it will be conveyed by a connecting conveyor system to the ship loader. It is the reverse process.

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So what we do is there is a wagon unloading system, stacker, reclaimer, conveyor system and ship loader. Other option is ship unloader, conveyor system, stacker, reclaimer and wagon loading system. So loading is this side and unloading is from this side.

“Professor-student conversation starts.”

Professor: Which will be faster? Loading will be faster? Unloading will be faster?

Student: Loading.

Professor: Loading will be faster. Unloading depends on where your cargo is.

“Professor-student conversation ends.”

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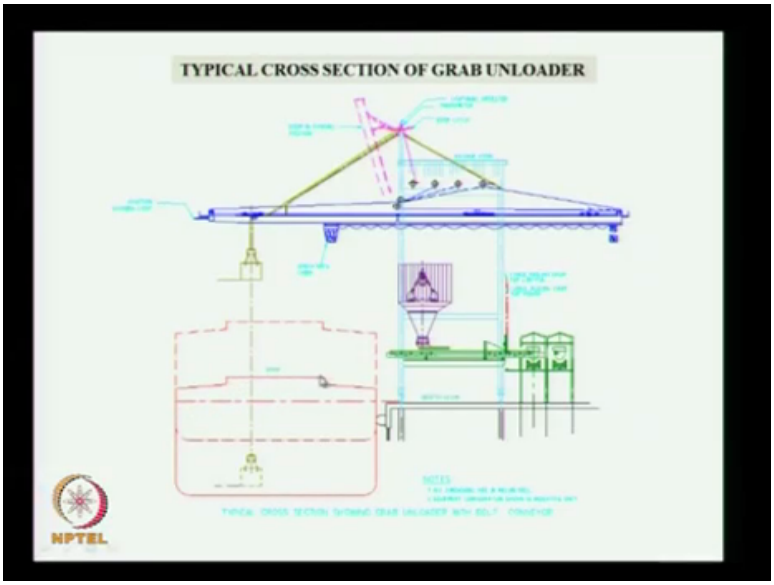

What here we are showing is this is the vessel which is loaded fully or it may be because of the tidal variation it goes up and down. But when cargo is there at the top, we can grab and it will go faster. The cargo is at the bottom, the hold is having a shape like this, it is very difficult to pick up the cargo. The rate of unloading, it depends on where your cargo is. The cargo is there at the top, it will be very fast.

Suppose the hold height is let us say about 9 meters. Top 3 meter it will be fast, then 3 to 6 meter it will be slow. 6 to 9 meter, it will be much slower as grabbing will become a problem. The bucket size itself will be about 1.5 to 2 meters. So the height of the cargo is only half a meter. The grab will not pick up that so fast. In addition you should take care of the tidal variation also. Draft also will change.

“Professor-student conversation starts.”

Student: We have to unload the simultaneously, so….

Professor: That is why we need two cranes. So this is one crane. What he is telling is we cannot unload at a particular point. So if the ship is there, we need two unloaders simultaneously removing. Sometimes three also is used. One at the middle, two at the ends.

“Professor-student conversation ends.”

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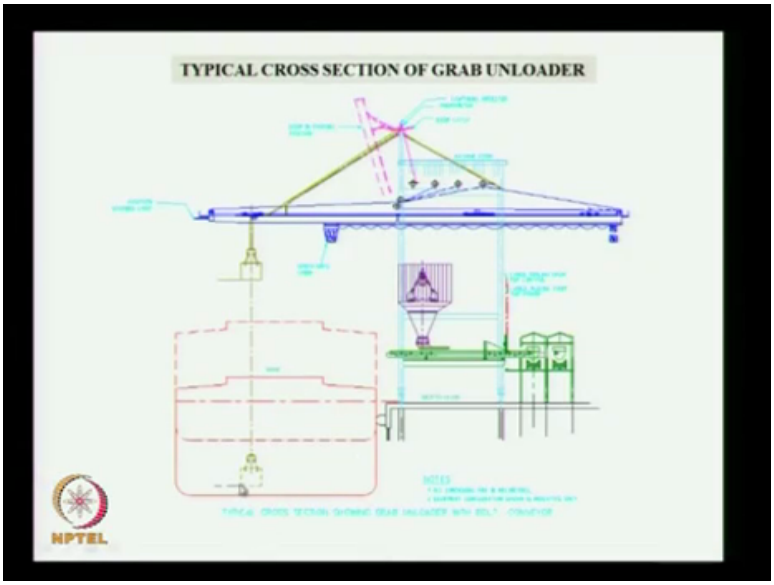

So this is a grab bucket which picks up the cargo, then moves here, drops it through a chute. From here it goes to these two conveyor belts. One conveyor belt for one crane, other conveyor belt for the another crane, I said two cranes are there. So it drops onto the conveyor, the conveyor takes to the stackyard. This is the operation, so this is called as unloading operation. We just pick up the cargo, moves here, drops it, goes to the conveyor belt and from here (())(09:42). This conveyor is generally in a slope. One intern slope, so it is not horizontal and it cannot go for a long distance, maybe every 500 meters we will have what is known as transfer towers.

So conveyor goes like this, drop out of 500 meters to another conveyor, then it goes like that. And then you are seeing this pink color, so when the conveyor is not operation, the crane will be kept in this position. Not in the horizontal position because if it is kept in the horizontal position, force will be very high. And when the storm comes, they stop the operation, they keep the crane in this position. This horizontal position becomes vertical, then take it to a location, then properly anchor it. Typically the weight of the crane is about 800 tons and it will have about 16 wheels or 24 wheels.

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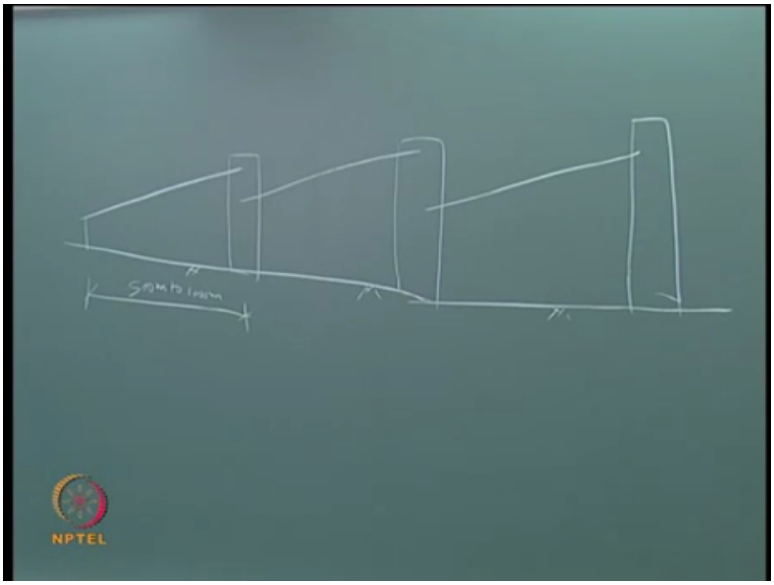

What I was telling about conveyor is suppose this is your ground level. There is one conveyor, it goes here. Then we have a transfer tower, then it drops here and then goes to another place, drop here. It goes here and drops other place. So this is your ground level. This distance vary from 500 meters to 1 kilometer also. Suppose you want to, for 3 kilometers if we start this end and goes 3 kilometer, the power consumption will be very high and the height also will be very high. Once the height goes up, wind forces will be very high, so they do it.

Suppose you want to change the direction, you need a transfer tower. So from here if you want to come like this, you put a belt in this direction so that it goes there. Right? These transfer towers also are very important. Typically the width of the conveyor is about 1.6 meter.

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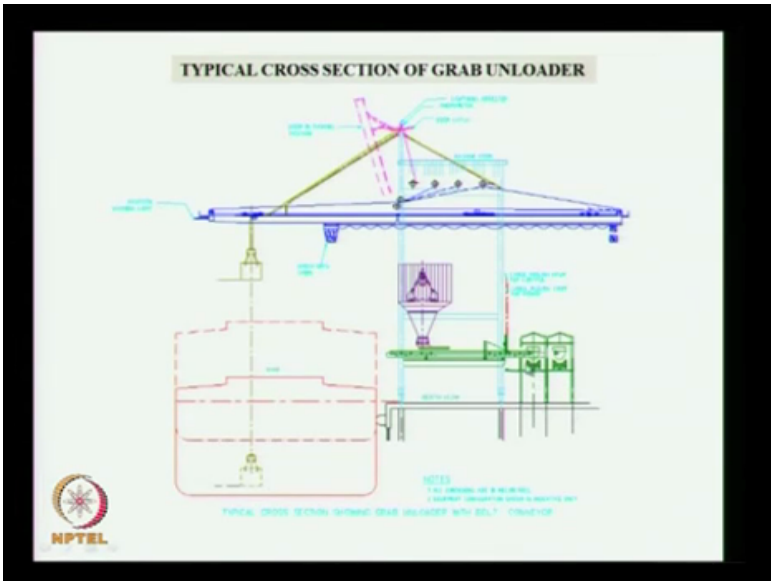

Sometimes you put a single tower. Here we have shown two towers. Sometimes you put a single tower with two conveyor belts. Mostly that is what is used. Then we used to cover the conveyor also. Because of the pollution control norms, this will be completely covered.

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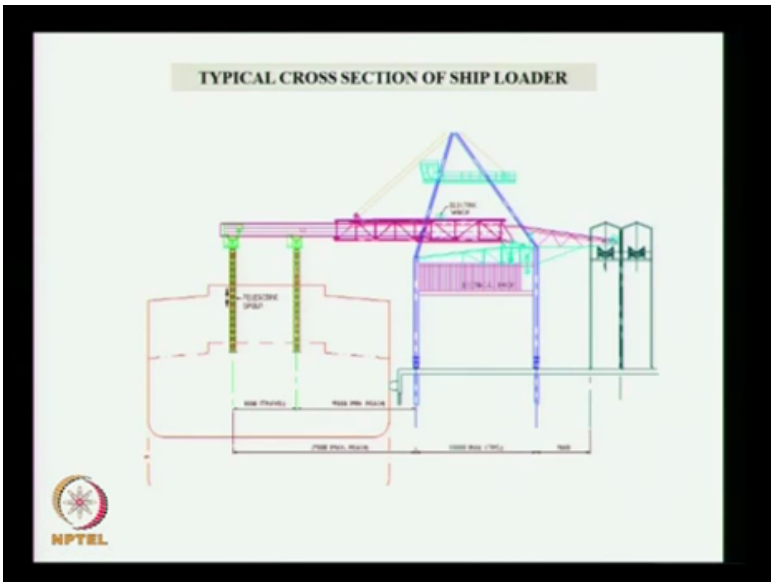

Then this reverse process, how to do it on a ship loader. Ship loader, it does not depend on the draft of the vessel, it depend on where your loading or unloading are done. So there will be a conveyor which will come. From here you take the cargo, take it to this place. And there are two telescopic spouts through which you drop the material. This is what we do. Ship loader also, two

numbers are required for each ship. Otherwise what you have to do is you have to load some portion and then move the crane to the other end but that takes time. So that is why we provide two cranes.

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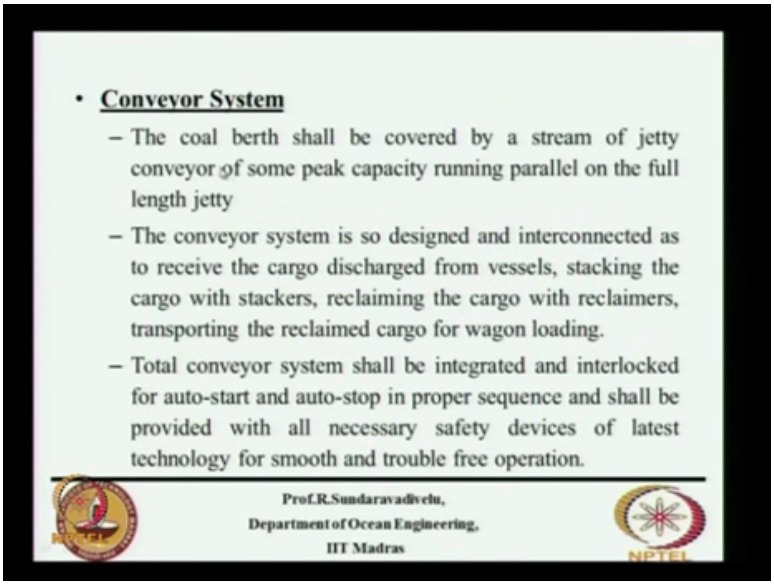

So normally the conveyors are used, designed for some peak capacity and this will be parallel to the jetty. It is for a full length. So this has to be designed and interconnected between the jetty to the stacker area and there you have to reclaim the cargo with reclaimers and transporting the reclaimed cargo for wagon loading. So there should be an auto-start and auto-stop option. Proper sequence should be there. You should also have necessary safety device for smooth and trouble free operation. Normally we provide a standby conveyor system, we do not do with two.

Suppose we have two cranes, we do not do only two conveyor systems, we provide one more conveyor. Redundancy is there, so we provide one more conveyor so that in case of any maintenance we can use the other system. So we are experiencing power cut because the power stations are not built. One of the reason the power stations are not built in time is not having sufficient port infrastructure. So it is very expensive, time consuming and getting any clearance for port operation as well as power plant operation is very difficult. Whether it is coal thermal based power plant or LNG based power plants or nuclear power plants, one is transportation of cargo, another is getting the required water for cooling purposes.

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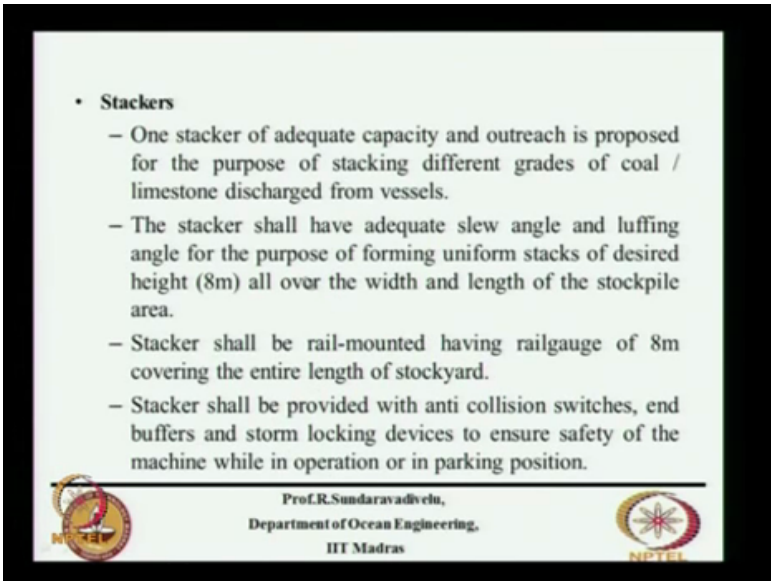

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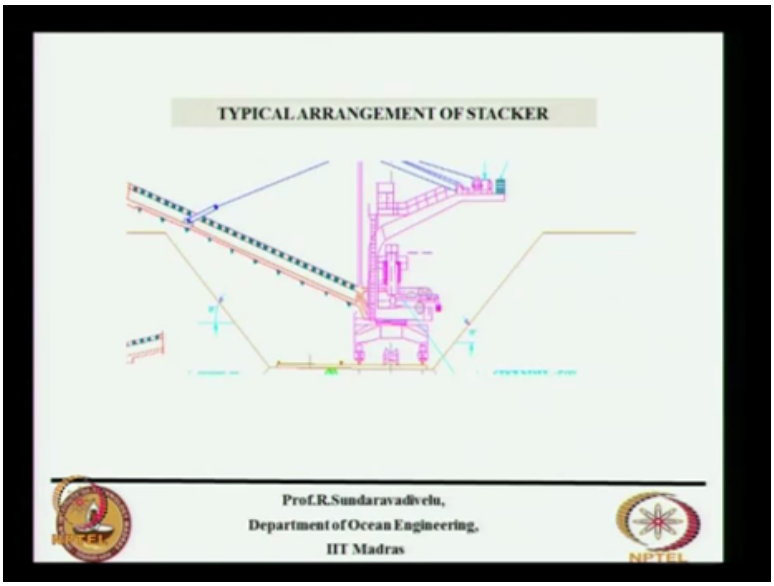

The stacker and reclaimer will be generally on a, like this, so this is called as stacker. Sometimes the same machine can perform the operation of both stacking as well as reclaiming. So it is nothing but there are two wheels are here. Normally this is about 8 meter spacing, so what you do is wherever the cargo is there, just using some kind of a JCB you just push it and stack it to a height. Here we have given the angle of repose as 30 degrees. So you stack it properly in this profile, for this the stackers are being used.

Beside the 1 hectare is about 100 meter by 100 meter, 5 hectares means it may be 500 meter by 100 meter. So in 500 meter direction, 500 meter is one side, then you are, this stacker will go in the 500 meter direction. This boom length will be about 30 meters or 40 meters, so we may provide two stacker reclaimers or one stacker reclaimer.

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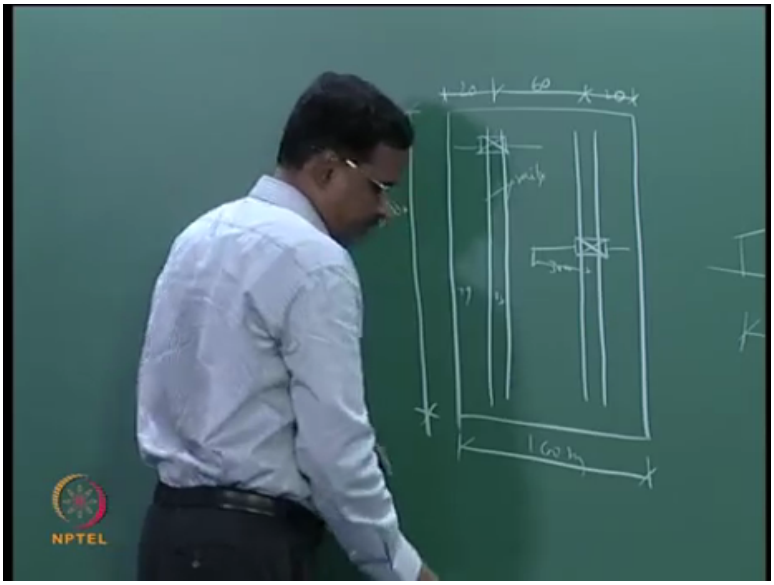

Suppose this is your stackyard area. I am giving a typical dimension, it can change. This is 100 meters, this is 500 meters. You provide two rails here and provide two rails here. Then you provide one stacker here. Another I am putting in this position, it can move anywhere. So from here it should reach at different points, here it is. So let us say the center to center distance is about 60 meters, center to this side is about 20 meters and 20 meters.

The stacker reaches about 30 meter let us say, so it will reach 30 meters and then take the cargo. Is it clear? Accessibility should be there for the stacker reclaimer to pick up the cargo from one side and keep it in a arranged position, just like container cranes we are doing now, same thing only we are doing here. And this level let us say generally is about plus 3 level. When you are stacking, this can go up to plus 9 level. And you need a compound wall all around this.

Then there will be a system here where we load the wagon and take the cargo. So this is the (()) (17:18), these are the two rails.

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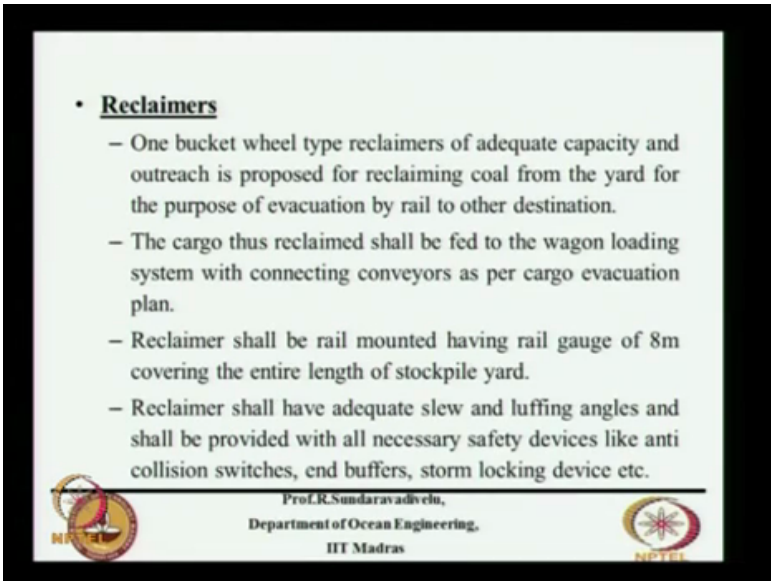

So reclaimer generally they are having some bucket wheel and they have to reclaim the coal from the yard for the purpose of evacuation by rail to other destination. So from the reclaimer what we do is we get the cargo and put it in the wagon loading system. So stacker is to stack the cargo, reclaimer is to take the cargo from the stackyard and put it into the what is called as wagon loading system.

So stacker stacks the cargo, reclaimer picks up the cargo from the stackyard and put it into the wagon loading platform. Just like a loading system, so it will have anti-collision switches, end buffers, storm locking devices. End buffer means you should not go beyond that end of the rail, so you put some end buffers. Then we will have some storm locking devices also will be provided.

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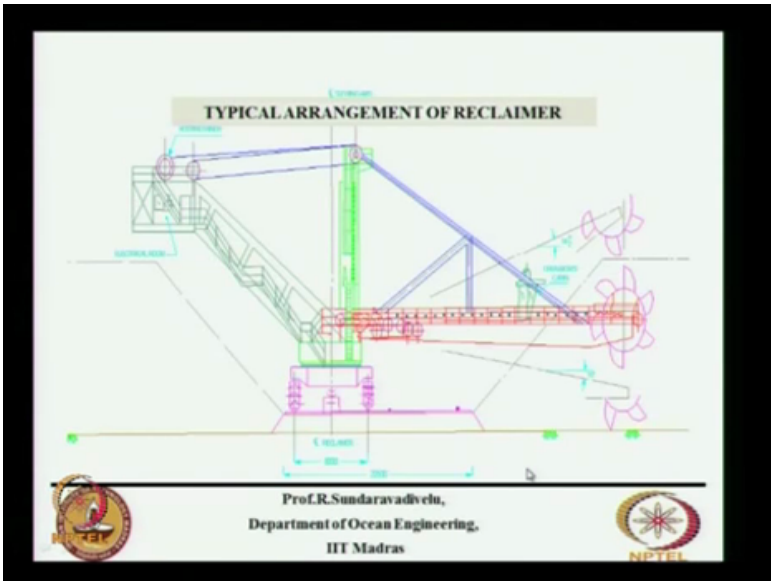

This is the general arrangement of the reclaimer at different positions where it will reclaim the cargo and put it into a conveyor belt and take it to the other places. This space is about 8 meters. We have put 22.5 meters to take care of one more stacker here and one reclaimer here.

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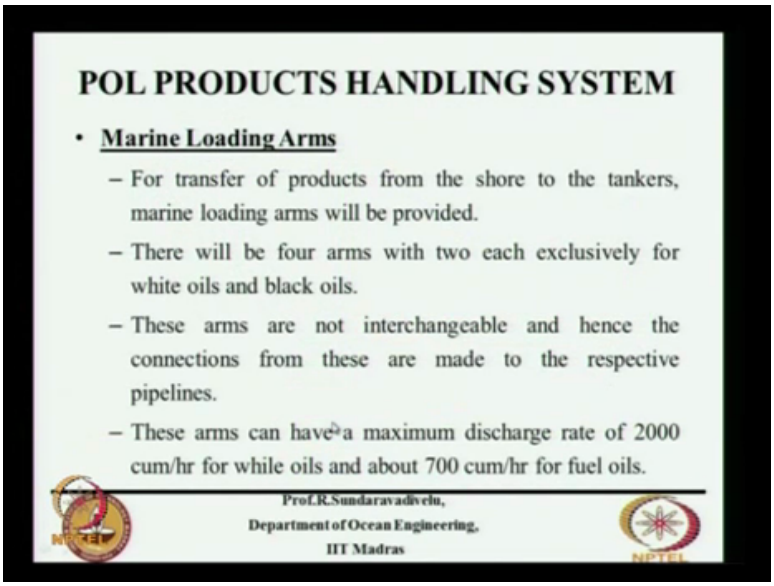

Then there are three types of cargo which we are going to see for mechanical handling. One is the bulk cargo like ore or coal. Another is the POL cargo, third one is the container cargo. So we normally provide marine loading arms for POL products, it can be loading or unloading. One of

the advantage of this marine loading or unloading arms is these are very fast method. Typically they will have 4 arms and 2 will be for white oil and 2 will be for black oil.

The type of cargo which is coming into a POL system, POL berth will be different types, so we need different things. So the pipelines also are different. Some of the pipelines which are carrying white oil cannot carry black oil because of the pressure as well as because of the contamination. So each loading arm is connected to each pipeline. The discharge rate can be 2,000 cubic meter per hour for white oil and 700 cubic meter per hour for fuel oil. We have the fuel oil density is higher, viscosity is more, the rate will be much lesser coming to, compared to white oil.

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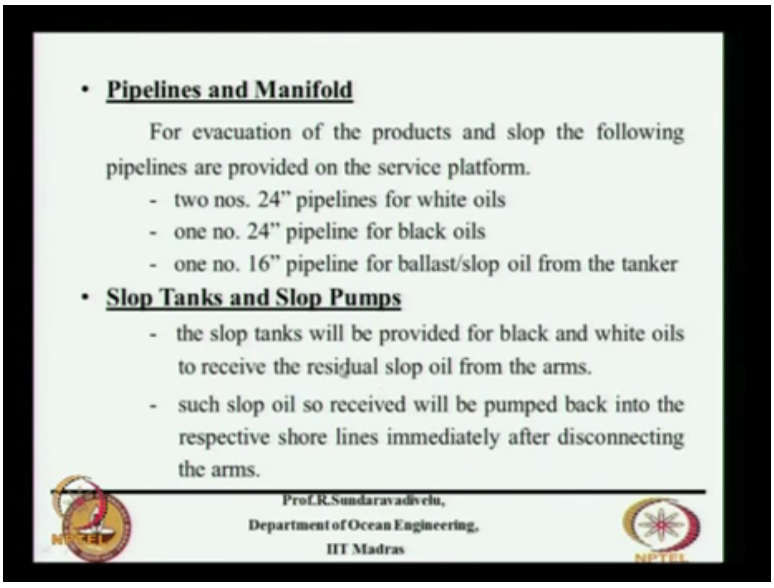

There will be a pipeline manifold and this also has to be provided to control. The slop tank is to collect the residual oil. Once you pump the oil and once they stop the operation, there will be some oil which will be there in the pipeline which you have to remove. For that these slop tanks and slop pumps are required.

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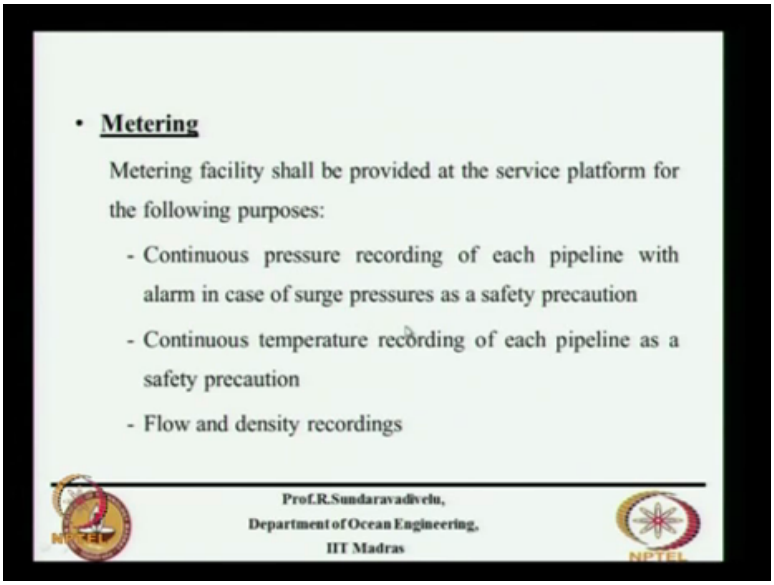

And we should also have the metering facility. Just do not think that I am just giving this metering facility, it is very important. This will be monitored continuously. So suppose there is a place, for example in Chennai port we have the cargo which has come in a tanker and the cargo is going up to CPCL finally maybe around 20 kilometers away, they will meter at the point of discharge as well as at the receiving point. So they should get the correct quantity of oil which is discharged. This is for safety.

And there is what is called as surge pressure, you know what is meant by surge pressure? What is surge pressure? Maybe you would have studied in pipeline transport. Suddenly the due to some reason there is pressure of some walls or something happens and what the, oil is flowing with a particular pressure and it has stopped at one location, then there will be some pressure that will build up. This is called as surge pressure.

And you should also note the temperature and density also and flow velocity also. These are the things which are to be carried out. It is very important that to take care of this discharge of pure products very carefully.

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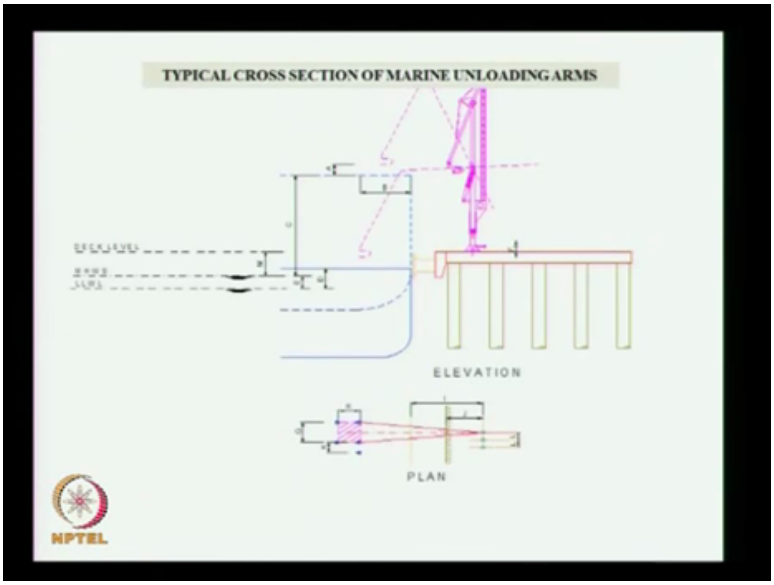

So this shows the sketch of the marine unloading arm. There will be a flexible house which will be connected to the ship. This is the marine unloading arm which is fixed to the jetty. This is the plan which shows how it is connected at different locations. These dimensions are given for each marine unloading arm, whatever we have shown, what is the reach and how much that it can go, all those things are given. The separate catalog is available using which we can decide.

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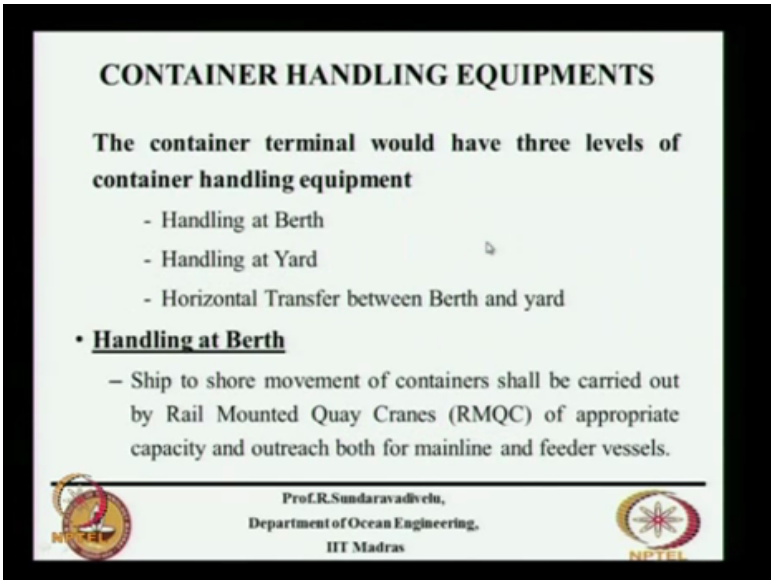

The next system that has to be considered is container cargo. So we have seen ore or coal cargo, then POL products, then we are now looking into container handling equipments. These

container handling equipments are very important. Some of the ships prefer certain ports mainly because of the handling operation. Singapore, the berth is ready, available anytime for a vessel. When a vessel comes to Singapore waters, immediately the berth will be allocated, it will go there. Then they will provide 4 cranes or 6 cranes. In India normally they provide 2 cranes, now they are improving to 4 cranes.

And this operation also is very important, that is handling at the berth, handling at the yard, then horizontal transfer between the berth and yard. These three operations are important, that is one is to unload or load the cargo container at the berth from the vessel, then you horizontally transfer between the berth and the yard or yard and the berth. Berth and the yard for unloading, yard and the berth for loading. Then you again handle at the yard. So if you are going for interview, they will ask what is RMQC. RMQC is nothing but rail mounted quay cranes. These cranes cost about 40 crores.

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So this is the crane what you are seeing. This is the container, you can see the number of stacks in the container, 1, 2, 3, 4, 5, 6. And there may be containers below the deck also. Maybe there are 7 stacks and maybe 4-5 stacks below this. You see how close the ship is to the crane. So normally we provide a clear gap of 2.5 meters between the face of the berth to the central line of the vessel, central line of the crane. And afterwards fender is there. But sometimes when there is a rolling, then the ship may hit the crane. It has happened in Chennai port.

When the ship is rolling now, rolling means it is rotating, it will go and hit the crane and damage the crane. It happens, that is why we have to provide sufficient clearance and rolling should be reduced. So what here we do is the container, the operator will be sitting somewhere here, there are series of cranes here. So for a vessel I think there are 3 cranes here and this center to center spacing between the crane rails, normally we use about 30 meters, JNPT we have 22 meters.

Some of the modern facilities this is 40 meters. So if you want to reach more, your center to center spacing should be more. That is the basic concept. If you have 22 meters here, typically it can reach only 22 meters. It is 30 meter, you can reach 30 meters. If this is 40 meter, you can reach 40 meter. So width of the ship varies from 22 meters to 40 meters. It is not that 30 meter cannot be used, here 22 meter crane, you can do it. But the load coming onto the crane will be higher. That is the reason. You see the car here, car looks so tiny. In photograph normally we take all these with some small objects just to see how big it is.

These are the trucks, so pick up the cargo and put it into this and then take it out. You need some space behind the berth also because once you remove the cargo there will be, the cover will be there, deck cover will be there. So we have to remove the plate and keep it, then go below and take the cargo. This is the operation of rail mounted quay crane for unloading or loading from the vessel at the berth. Since rail mounted quay crane, we can also use mobile harbor crane. That I will show it in the last slide about the mobile harbor crane.

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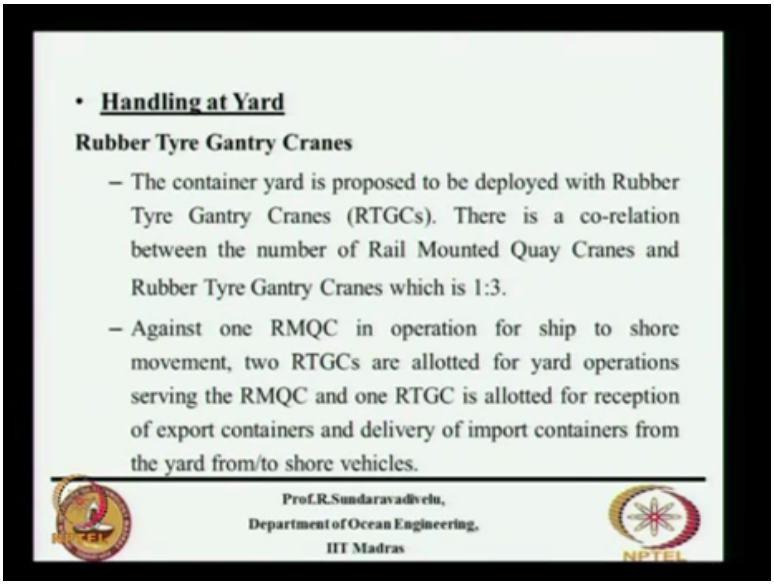

Then we have this RTGC. So when they ask RMQC and if you answer correctly, then they will go to next question, what is RTGC? RTGC is Rubber Tire Gantry Cranes. So once you have a rubber tire gantry crane, just like a car the tire is rubber, it can go anywhere, only you need a finished surface over which the cranes can go.

And there is correlation between the rail mounted quay crane and rubber tire gantry crane, that is 1 is to 3. Suppose you have 1 RMQC, we need 3 RTGC. This RTGC is in the yard not in the berth. So you have your berth where we have RMQC and transport the cargo by trucks and take it to the yard. Yard, you use the RTGC for arranging the cargo. So once 1 RMQC, we need 2 RTGCs for yard operation serving the RMQC. And the one more is allotted for reception of export containers and delivery of import containers from the yard from to shore vehicles. That is how this 3 is mentioned.

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So this photograph shows the RTGC, there are rubber tires. So there is civil, mechanical and electrical engineers are required for this operation. Civil people are required to design the yard, mechanical people are required for this, electrical people are required for operation. Then we need IT sector also. So we have to identify each container. Suppose you want to take the container somewhere here, it is better that you take the top two containers first and then the third container. So when you are stacking itself, you arrange like that.

So when each container will be taken, your operation will be less. Otherwise if somebody has to pick up your container somewhere interior and remove some containers and then lift it, it will be very difficult. See one of the reason is this about 1 million TU, we need about 30 hectares of container yard. 1 million TU is about 14 million tons. So it is about 2 hectares per million tons of container. 1 million TU, we need about 30 hectares for this operation.

So this is stacked like this, maybe they will use 5 stacks. So we want to pick up one container here, the vehicle will not come here, so you pick up the container and take this. After picking up this RTGC will move to one end, then load it into the truck. For that operation this will be used. Or when your truck comes, this RTGC will go, pick up the container and stack it at appropriate place.

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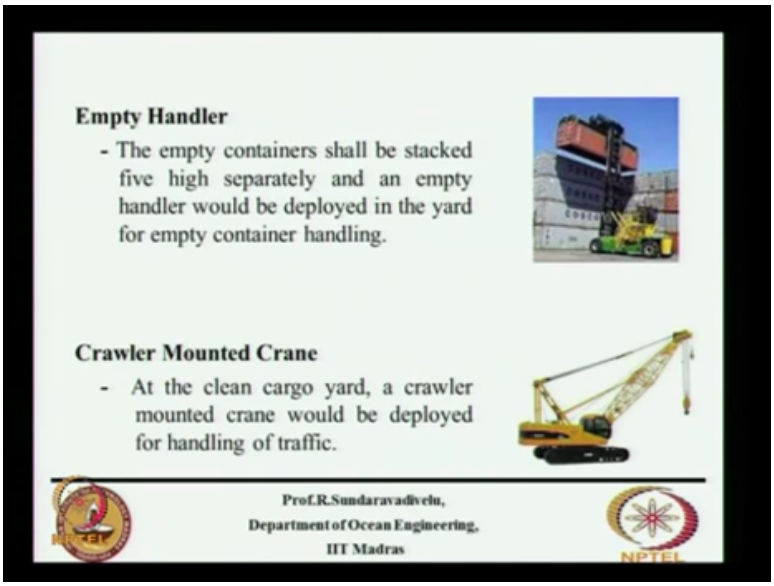

Then this empty handler also is very important. Once the container is disturbed, sometimes after so many operation this becomes very weak, then we have to use the empty. This is called as forklift truck which is used to handle this. Then we have this crawler mounted crane. These are called as crawler, typically this is about 5.5 meter in width, length and width may be 0.9 meter or 1.8 meter. There are two crawlers, this will sync 360 degrees. This can move with the container. This also can move with the container.

So these are the various things required. We need RMQC, rail mounted quay crane, RTGC, then we need this forklift truck or empty handler. Forklift truck is slightly different, we have some more version also there. Then we need this crawler mounted crane.

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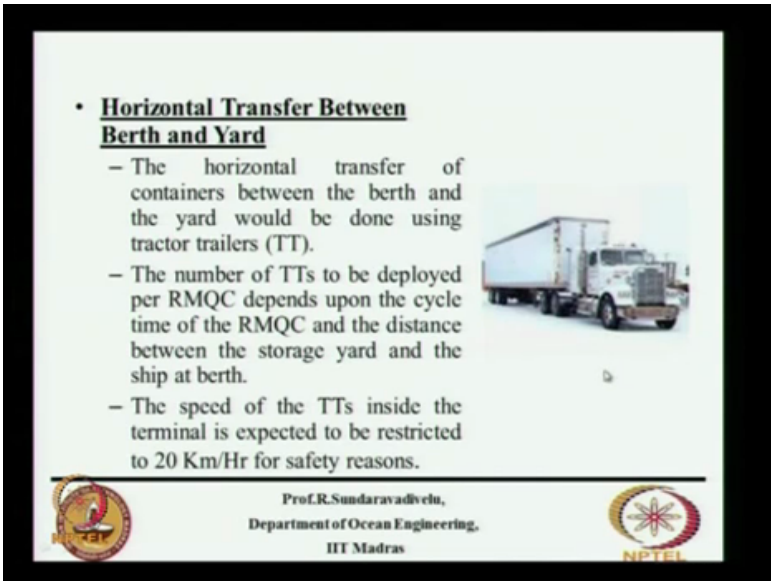

Horizontal transfer between the berth and yard is by these tractor trailers. So there are number of tractor trailers to be deployed, it depends on the distance between the yard and the storage. And the tractor trailer, you have to restrict the speed to 20 kilometer per hour for safety.

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This is the other mobile harbor crane which are deployed for handling steel, grains, even containers. These are smaller one. This moves on tires here like this. Once it goes to the location, you drop these pads and these pads give some reaction and lift the tires. So then it will be resting on the four pads. Using that they will be doing this operation. Many people nowadays prefer this mobile harbor cranes instead of rail mounted quay cranes for temporary facilities or even for permanent facilities mainly because these are cheaper and it is versatile and can be used for any type of cargo.

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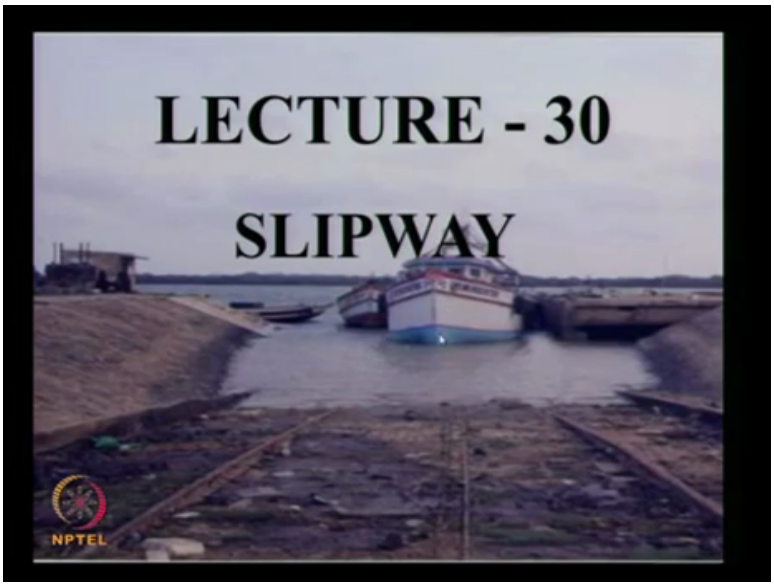

Maybe I will take 5 more minutes and complete this slipway. The slipways are used for construction of vessels or for repair of vessels. So this shows the photograph of the slipway where we haul the vessel inside. This is a sloping platform. These are the rails, these are the ropes which are hauling it.

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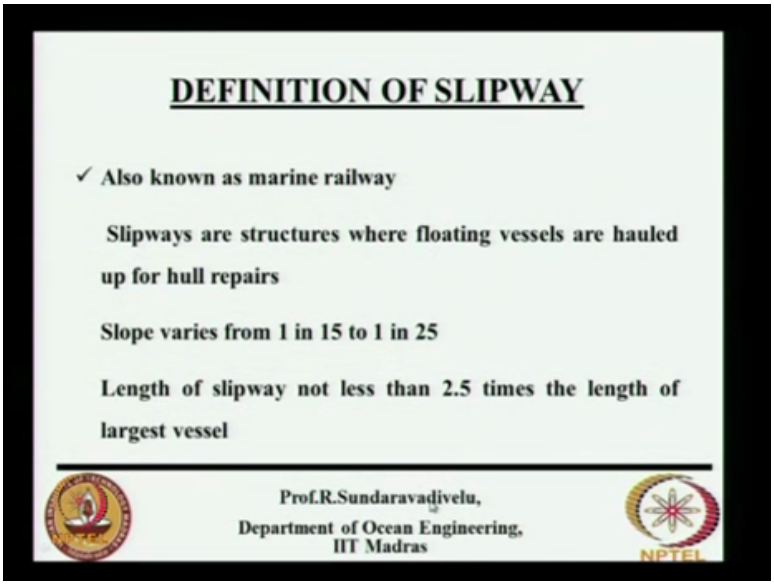

Normally the slope varies from 1 in 15 to 1 in 25. The length of slipway is 2.5 times the length of largest vessel.

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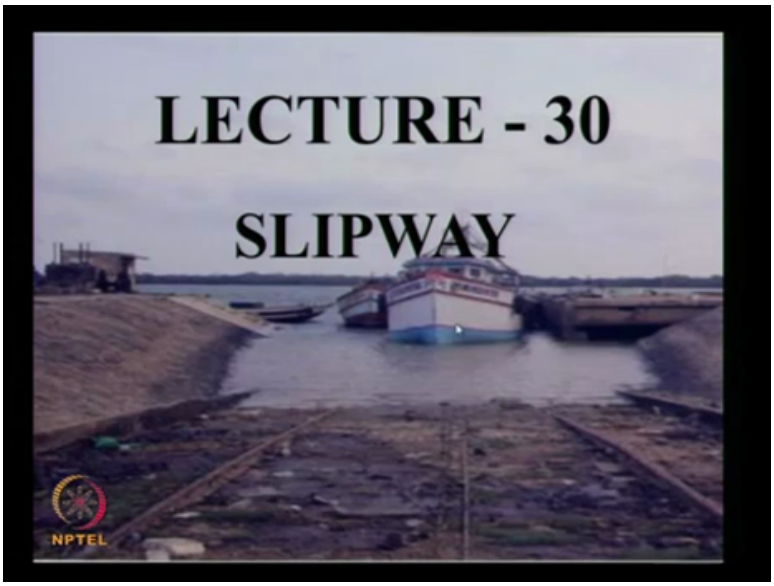

This for a small fishing boat, this can be used for bigger vessels also. So this will be the length of the ship and length of slipway will be 2.5 times.

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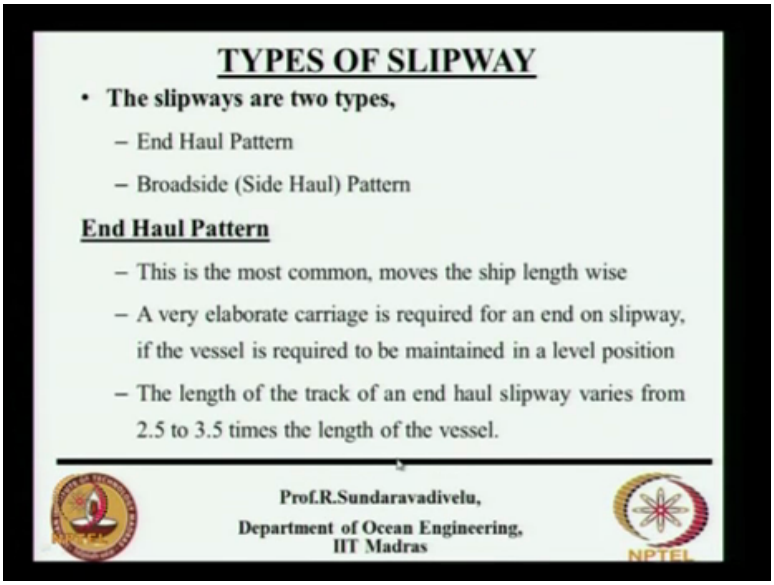

So we can have two types of slipways. One is from the end side, another is from the broadside. The end haul pattern is generally used.

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Suppose this is the ship, you can just haul the ship like this or you can haul the ship like this. This is the end pattern, this is the broadside pattern.

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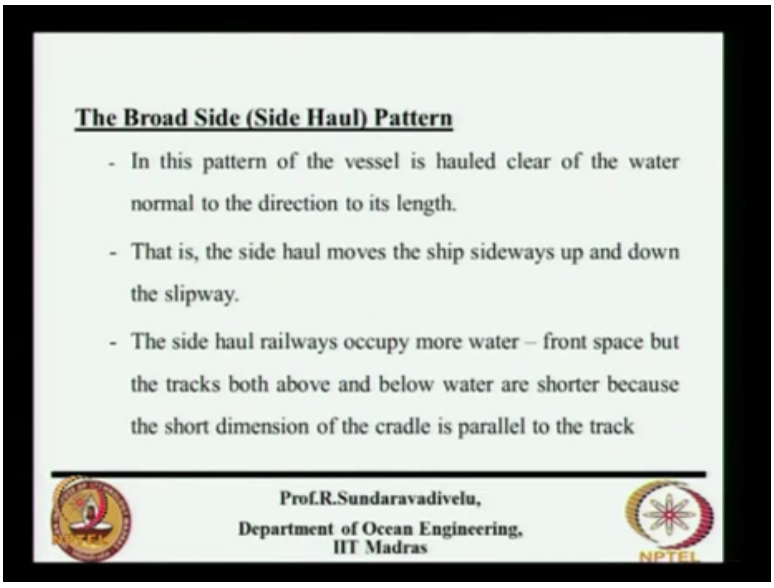

This broadside pattern hauled clear of the water normal to the direction of its length. So we can move the ship sideways and this occupy more water but the tracks are shorter.

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We have three components in a slipway. One is called as sloping concrete platform, cradle and roller and hauling machinery. So we need a platform, we need a cradle. Cradle is supported on a roller. To haul the vessel we need the machinery, that is some inches are required.

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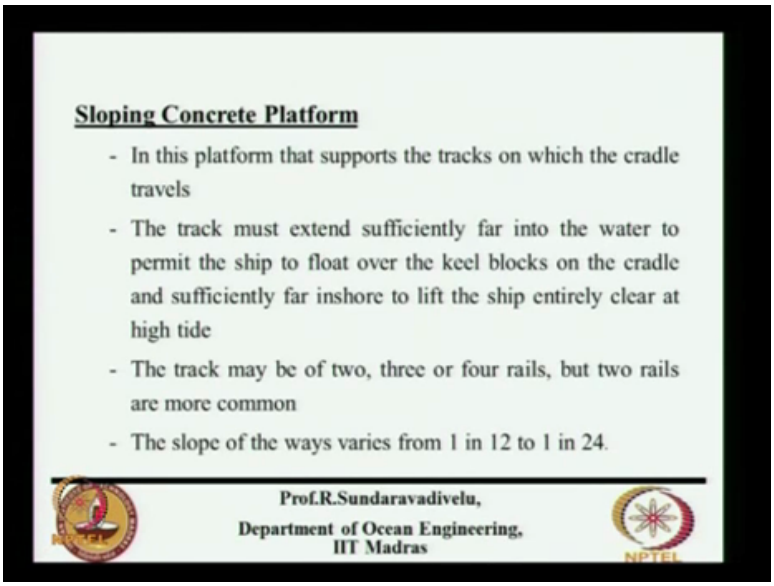

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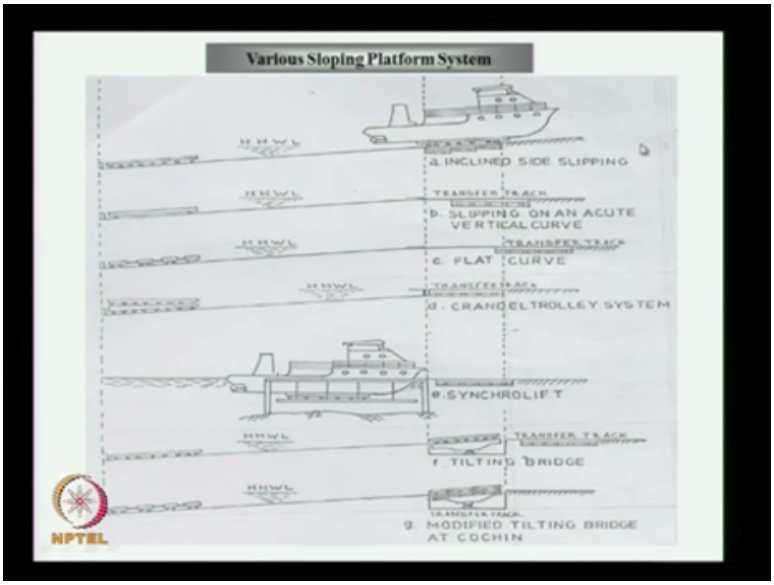

We have different type of platforms. I will show here. This is inclined side slipping. So this is called as the cradle. The ship comes and sits on the cradle, then you haul the vessel like this. This slope is told as 1 is to 12 to 1 is to 24. Then when it comes here, then you can take the ship into the land. Normally we provide some transfer track, this is for horizontal track transfer. So once you bring the vessel here, you can put it on either side.

Then we have what is called as shiplift or syncrolift system in which you bring the vessel here, there is no sloping platform like this, the ship sits here. Then you raise the platform above the water level, bring this cradle at this level, then push it inside. Just you lift it. This being built in Kattupalli for L&T and other facility what we have is dry docks.

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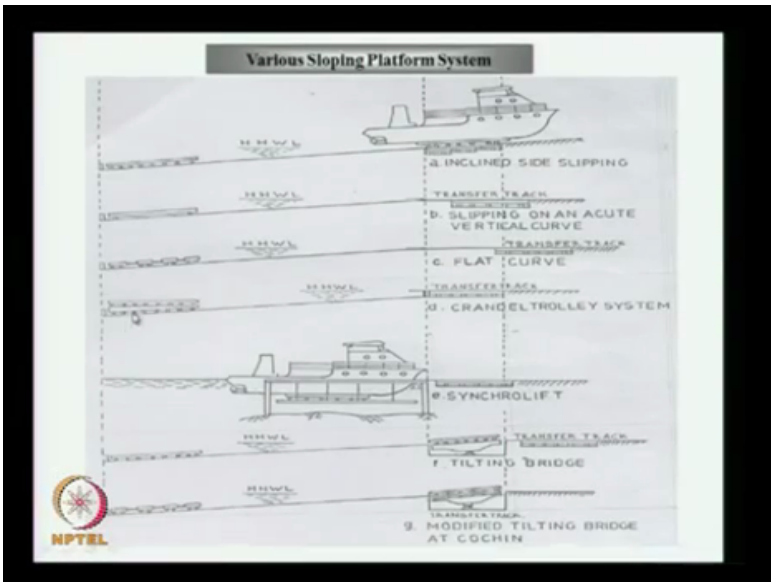

The cradle, there are different types. That is this cradle. We have rigid cradle, semi-rigid cradle and telescopic cradle.

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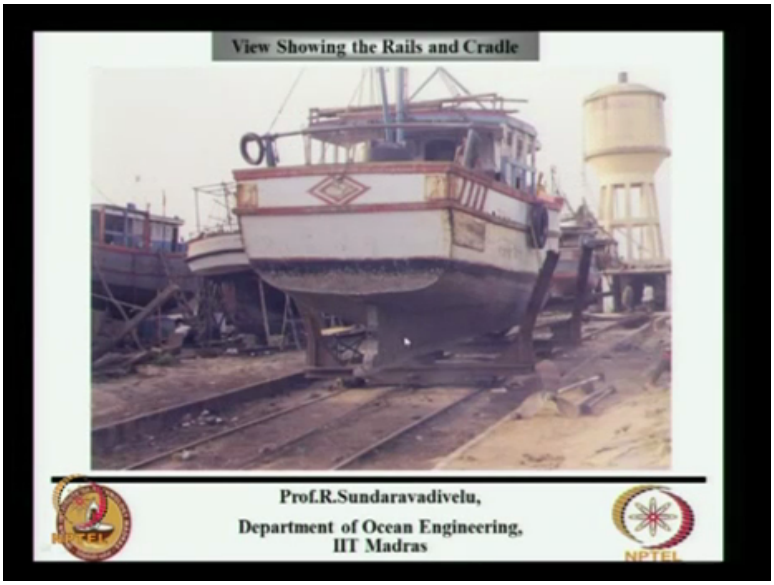

So this is simple cradle what we have given as a rigid cradle.

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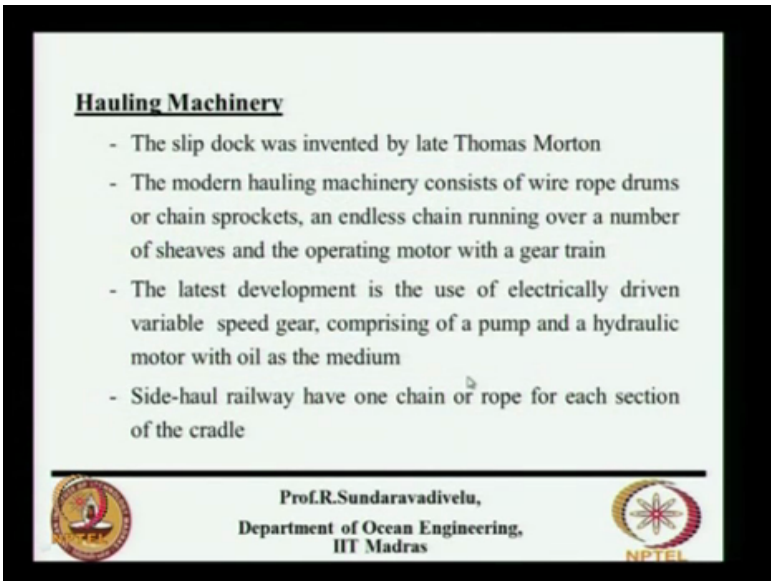

The hauling machinery is nothing but some chains and some electrically driven speed, variable speed gear, comprising of a pump and a hydraulic motor. And side-haul railway have one chain or rope for each section of the cradle. When you do the side-hauling, we need more cradles and simultaneously you have to pull it.

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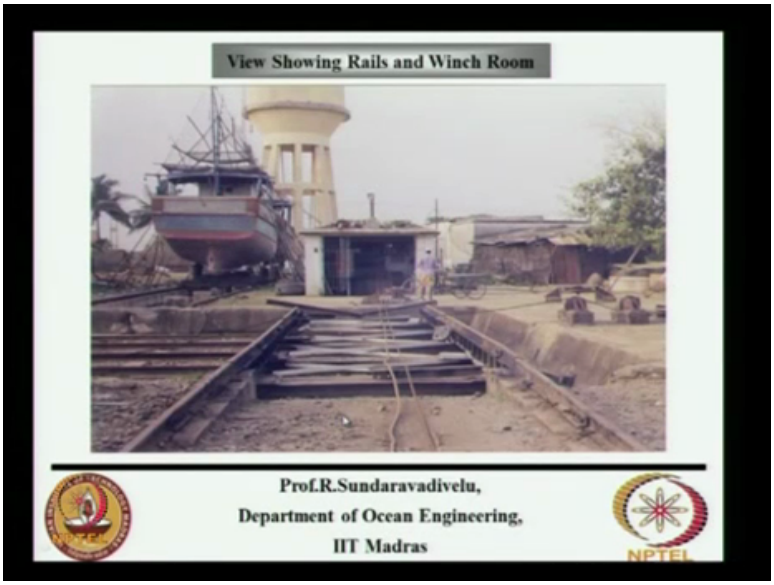

This is the motor room where the ropes are coming. They are doing it.

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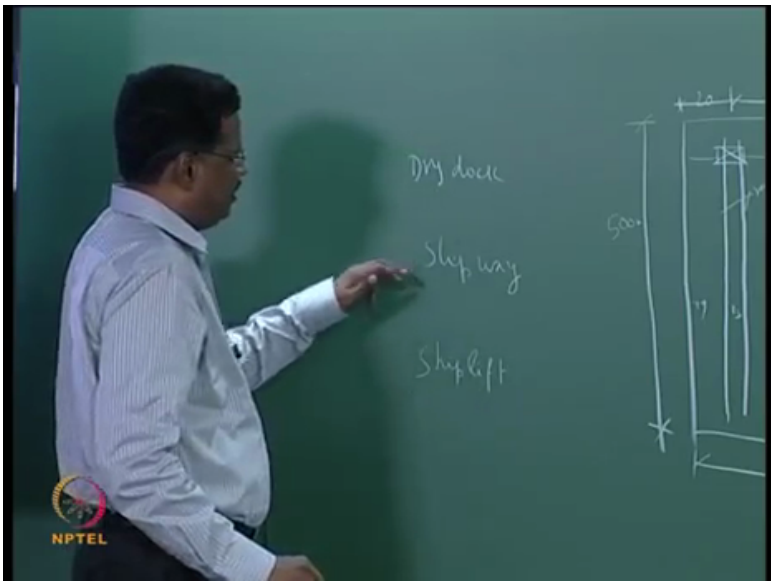

To summarize these slipways we have three types of systems. That is to be studied. One is the dry dock. Another is a slipway. Another is a syncrolift or a shiplift system. So I explained about shiplift and slipway.

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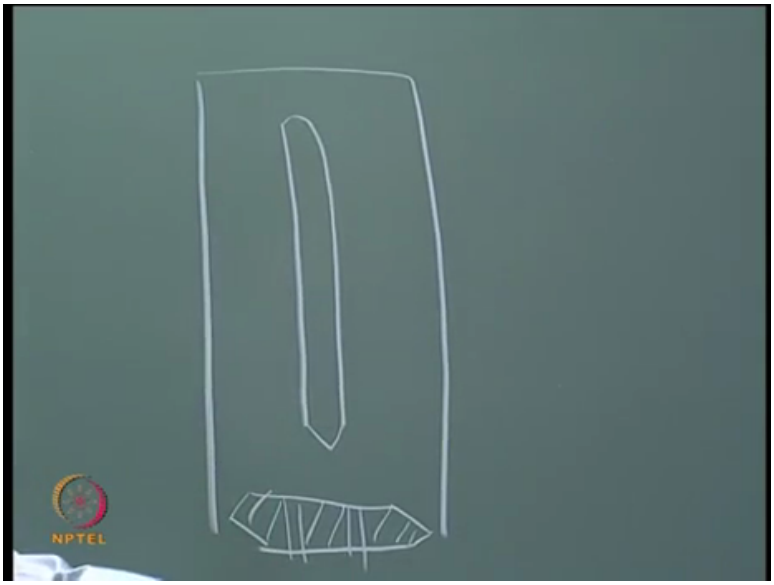

Dry dock is nothing but we have enclosed basin like this with a gate at the front with some arrangement for pumping allowing the water inside also. So the vessel will be kept somewhere here. So you remove the gate. Once you remove the gate, the vessel can go inside and rest here. Then you can close the gate. Then afterwards you pump the water outside so that you can have the bottom portion of the vessel sit. Afterwards you can allow the water inside through this, so the water level is same between inside and outside. Then you remove the gate, then take the vessel outside. This is for repair as well as for building.

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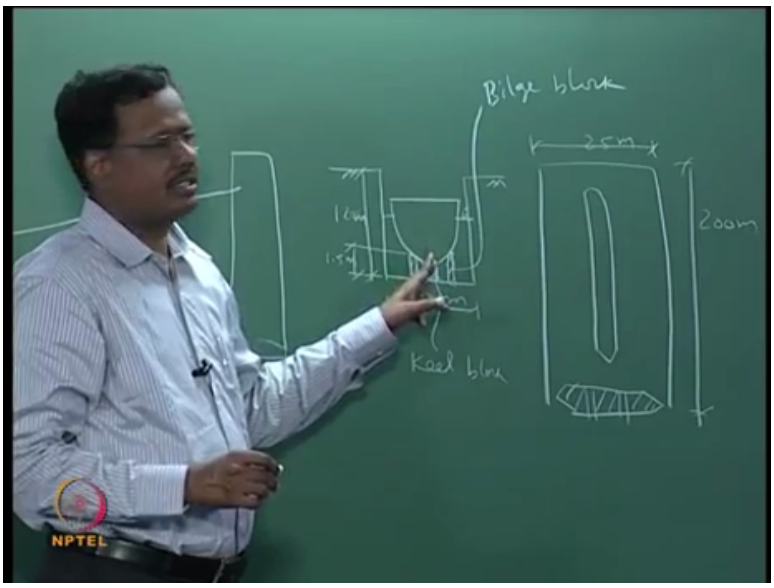

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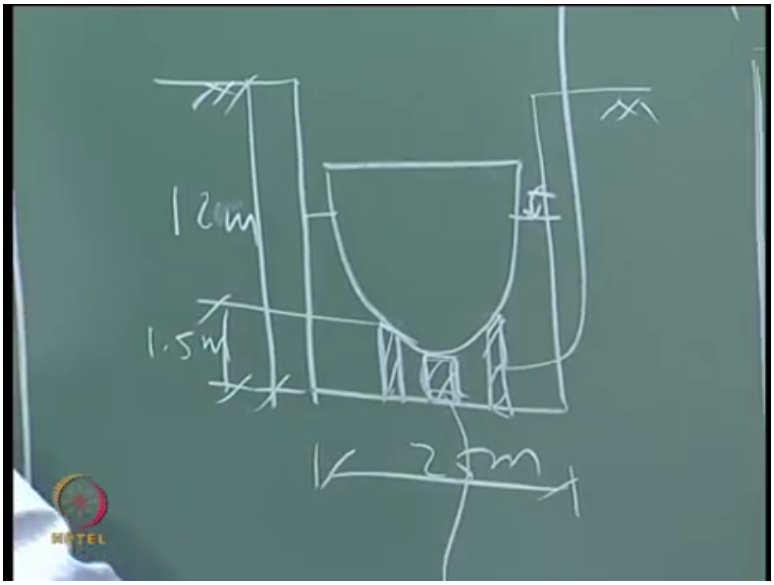

One of the important facilities required for naval purposes, so this will be your top level of the dry dock. Suppose this is the width, generally it is about 20, 25 meters for naval vessels. The length will be around 200 meters. This depth will be around 15 or 12 meters. We have what is known as some blocks here so that the vessel will come and sit on top of it. This is called as keel block, this called as bilge block. So you can bring the vessel with this water level. It will come and sit here. Typically this height is about 1, 1.5 meter. This much height is required.

After the vessel is kept here, you somebody wants to go inside, paint and all, somebody should go inside, do the painting and see some welding, some stone blasting and things like that. Then this is the water level at which it may come. Then you close the gate and pump the water out. Then the water level will go to the bottom. Then you can repair the vessel, then do it.

Once in 5 years it is recommended to dry dock the vessel. If it is a bigger vessel, you have to do it in a dry dock. It is a smaller vessel, you can do it in a slipway. That is the purpose. For building ships also we need. Cochin, we have the biggest dry dock. Okay.