Port and Harbor Structures
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Module-05 Lecture-28
Single Buoy Mooring and Open Sea Jetty- Part 1

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This class, we will discuss about single buoy mooring and open sea jetty. As you see this in the figure, this is called as a single buoy mooring system. The cylindrical buoy, typically about 10 meter in diameter and 4 meter in height. This is connected to the mother vessel. This is called as mother vessel. There is one more vessel standing here, this is called as daughter vessel. So there can be oil field here from where the oil will come to the single buoy mooring system. From there it will go to the mother vessel.

Continuously oil will be pumped continuously, that is why it is staying here. From there it will be pumped to the shuttle vessel, this is called as daughter vessel. This shuttle tanker will take it to the shore. So this is the way in which this operates. This is a loading terminal and in open seas for very big vessels, very big means 300,000 dwt vessel, this type of systems are adopted. I think India we have about 12 SBMs operating. Then we have open sea jetty's permanent facility, that also we will discuss in this class.

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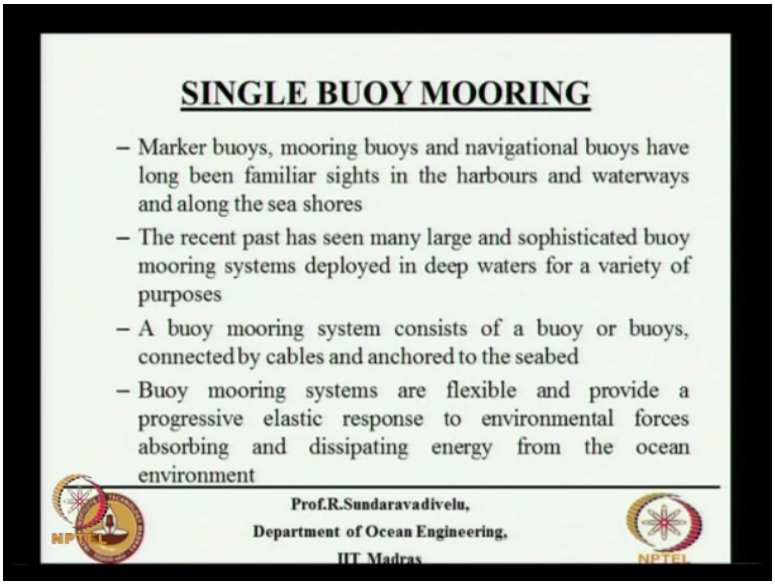

The single buoy mooring system, this can be used as a marker buoy for navigation channel and mooring buoys and navigation buoys. These are in harbors and waterways and along the sea shore. So nowadays we are seeing large and sophisticated buoy mooring systems. These are deployed in deep waters for variety of purposes. This buoy mooring system consists of a buoy or buoys connected by cables and anchored to the seabed.

The buoy mooring systems are flexible and they provide a progressive elastic response to environmental forces absorbing and dissipating energy from the ocean environment. What we mean by this is this is not a rigid system, is a flexible system and there is a flexibility. This will absorb the energy in better manner. So we will see one figure showing the single buoy mooring system.

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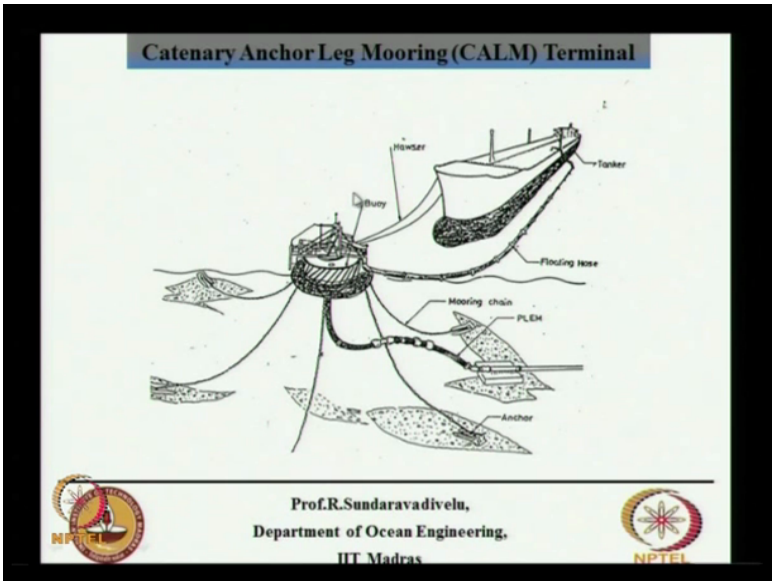

This is a single buoy mooring system. What you see here is an attachment to the single buoy mooring system which is used to connect the anchors. So in this figure we have, there are about 6 anchors. These anchors, I am sorry, 6 chains, mooring chains. These are the anchors. I am sorry, these are the anchors, this one, this one and this one. So this is a mooring chain connected to an anchor.

We will be defining what is known as a scope. Scope is nothing but the length of the mooring line to the water depth. That is defined as the scope. Typically the length of the mooring line is about 3 to 10 times the water depth depending on the condition of the sea. Normally the water depth is about 30 meters to 50 meters. That is the water depth, this will be adopted mainly because of the vessel size.

Vessel will have a draft of about 22 meters. We need more clearance because it is open sea. So minimum depth required is about 30 meters. Sometime they put even for 50 meters. That means the length of the chain will be about 300 meters. This figure shows that the chain is directly connected to anchor. That is for small scope, that is about 90 meters. It is a long scope, there will be some portion of the line which will be lying on the seabed, then only the anchor will be connected.

“Professor-student conversation starts.”

Professor: What you are seeing here is PLEM. Ocean engineering students, what is PLEM? Nothing big about it, they may ask you in the interview. So if you do not know, they will say you do not know this. You have never heard of this PLEM? Uhh, it is not plum fruit. What is it? What can be? What is offshore structural context you know for P and L and M? P stands for what? Short for P, P stands for what?

Student: (())(05:02)

Professor: The word should start with P.

Student: Yeah.

Professor: Pipeline? E, email or no? What is M stands for? M stands for manifold. E for End. Pipeline End Manifold. So you will have offshore, you drill and you get the oil and it may come from different pipelines. And you have a manifold here. This manifold is collecting all the oil. Then you have the riser pipe. This is called as riser pipe. Riser pipe is not directly vertical, it has some, some buoys are attached here so that it will be horizontal or it will be not applying tension to the pipeline end manifold.

"Professor-student conversation ends."

Okay. The buoys are giving certain buoyancy so that this configuration, typically this is called as step configuration. This is not a style, but generally there is a step configuration given. That is why in the introduction we said there are a lot of buoys. This is the main buoy but you may have additional buoys here. Then we have a floating hose. This floating hose also is longer length and this floating hose transmits the oil from the buoy to the tanker, so permanent tanker or a mother tanker.

So from the offshore field underwater we get the oil. From there it comes to this. From here it goes to the buoy, from the buoy by floating hose it goes to the tanker. This tanker is connected to the buoy by means of again by chains or some steel structure. This is called as a hoser. So when I ask you to draw the single buoy mooring system, you have to draw the buoy, you have to draw the anchors, you have to draw the riser pipe, pipeline end manifold, mooring chain, floating hose, tanker, hoser. This facility is called as weather weaning. Weather weaning means suppose the wind is acting in this direction, the ship will be in this direction.

Suppose the wind acts like this, this will rotate and go to other direction so that ship is always in the (())(07:52) condition not on the whimsy condition. Automatically it will transmit. Mostly all these things are in the purvey of mechanical engineers not civil engineers. Civil engineers should design the anchor, mooring chain and that. Whereas there are so many mechanical components which will be designed by mechanical engineering students.

All this, this rotation takes place because of forthcoming the friction on this connection. All those things are belonging to mechanical engineers. Similarly the pipeline end manifold, the pressure with which the oil comes, the floating hose, all these details are with the mechanical engineers. Any doubt in this? If you see more than or between 40 to 60 percent of our cargo, international cargo is liquid cargo only.

"Professor-student conversation starts."

Professor: For economy to go up, what are the risk factors? What is a risk factor for India to grow? General question here, you have to answer immediately. India has to grow, if India is not growing, what are all the risk factors? Tell me but identify the risk. India has to grow, there may be some positive things, there may be some negative things. What is the risk associated with…?

Student: The economic instability.

Professor: That is a general. Why should the economic instability should come?

Student: Because the inflation keeps…..

Professor: No, no. All are general. Risk is, inflation why should it increase? And I will go on ask the question.

Student: The industries will not invest.

Professor: Why they will not invest? They are already investing. Why will they not invest? What is our growth? I will say CAGR, annual CAGR. What is our CAGR? Compounded annual growth rate, what is that? How much is our growth rate?

Student: 6.7.

Student: 6.7.

Professor: What is the growth rate of US, Europe?

Student: Europe is some 1.5.

Professor: What about China?

Student: China, 10 percent.

Professor: Okay. What is meant by BRIC countries? You are only answering, others will answer. BRIC, what is BRIC? BRIC countries.

Student: Britain, Russia, Indonesia.

Professor: Britain, Russia….?

Student: India and China.

Student: Britain, Russia, India, China and…

Professor: Why China is higher than India?

Student: Better infrastructure.

Professor: They say there is, I do not know the technical things, technical jargons in the financial terms. In terms of GDP, they are borrowing more money than what they can sustain. In the long-term, they will suffer. Whereas our Prime Minister Manmohan Singh from the finance minister for last 20 years, he goes for good economic policy. We do not borrow more money, I think we borrow only 40 to 50 percent of GDP. You can spend more, government can print money and spend.

They do not spend it so much as China is spending. Now coming back to the risk, what are all the risk? Oil security is a big risk. What is meant by oil security?

Student: We are depend on other nation's oil (())(11:43).

Professor: And what is security coming into the oil security?

Student: We do not have good resources.

Professor: Oil security means even if you have money you may not able to buy because US is not allowing Iran to, US is not allowing any country to buy oil from Iran. Do you know that or not?

Student: Yes.

Professor: Why they are not allowing? Some reasons. What is the impact of that?

Student: Oil prices will….

Professor: Oil prices will shoot up. We are getting oil from Iran. And many international trade we have to buy from foreign currency not Indian rupees. You have to pay in US dollar to buy. So this is one risk what we have, oil risk. Our per capita consumption of oil is much less than US but it is growing. So the demand is growing because of China and India, both consumer goods as well as these infrastructure goods like oil and construction materials and things like that. So that is to take care of this risk for oil, I do not know, (())(13:04) student must be knowing.

There is insurance component whenever you transport the oil. How US can stop us to buy the oil from Iran? How can they stop? Iran has accepted to get the money from Indian rupees.

Student: They can stop you….

Professor: So we have Indian rupees, they accepted or we can sell them goods. Then how US can stop us, US or Europe can stop us to buy the oil from Iran? How can they stop?

Student: They have imposed trade sanctions.

Professor: They do not even have to impose trade sanctions. There is a very simple method for them. They can stop the tankers to supply oil to India. How can they stop?

Student: They block the naval channels.

Professor: They do not even block the naval channel. They do it very simple way. They do not give insurance to the tankers. Tankers are operated by certain companies and they want to transport the oil from Iran to India by the tanker, they will not give insurance. If you do not give insurance, tankers will not play the oil. The most of the insurance is given by foreign companies. Even if there is Indian company which gives the insurance, this will be plowed back to foreign countries.

There are foreign international companies only are there to give insurance. So very simply they will block insurance. So no tanker will transport the oil, that is the whole problem. This is a security threat to us. It is not blocking the navigation channel, they do not do it. Either we have to transport by land by laying pipelines or we should have our own insurance companies or there is one more way we can do. You can transport the oil from Iran to Dubai and then mix the oil and send it as oil originating from Dubai.

See oil means it is not, all oils are not same. There are different types of oil. Even crude oil, there are different types of oil and the oil from Iran would be supplied by land, road to some companies, bogus companies in Dubai. They will mix it or they will process it and they will show that it is originating from Dubai and then they will send it to India. That also they can bypass. These are the various permutation and combination we can do. One of the ways in which we can have the oil security is to have the blocks, oil blocks in foreign countries like Vietnam, Nigeria. These are the places where we can buy the oil blocks and then get the oil.

China is opposing us to have any exploration to be done in South China Sea which belongs to other countries not in the China block. They say that India should not come and invest money to do exploration. Same way on Indian coast also we are opening our exploration fields to many foreign players, sell so many companies. They can invest, they can do the exploration also in Indian waters.

Why we are not able to explore in India? Why not we do it? Why ONGC cannot explore in India? What is the problem?

Student: We do not have the technical.

Professor: We do not have…..?

Student: Technical expertise.

Professor: What is it?

Student: We do not have enough technical expertise in that.

Professor: You can buy. You are going and exploring Vietnam. You are going and exploring in Nigeria. Why not we do it in India?

Student: Exploration cost.

Professor: It is not the (())(17:09). There is a risk in that also.

Student: Policy.

Professor: When you do the exploration, if you do not get back the oil, then it is going as a waste. So if it is potential oil field is not there in India, so if the more potential is there in foreign oil fields or Indian companies invest more there because the risk factor is low. Our population is a risk, yes or no? Yes, our population risk for our growth. We are keeping (())(17:43), yes or no?

Student: Yes.

Professor: Yes sir. No, it is not. Everybody is telling that our population is a risk. Our population growth is not a risk. We are growing because of our population. Why foreign country's growth rate is less?

Student: Because they have already…..

Professor: What is the reason? Many reasons are there.

Student: Growth rate reduces after they have grown now.

Professor: Reference to the population, there is a risk factor. What is that? Most of the countries, European….

Student: Their average age group….

Professor: Average age is higher. If you take the population, more than 70 percent will be above maybe 60 or 50 of age. So they are not productive. What about India? Our population is very young, more than 50 percent are in between 30 and 40 age group. They are productive.

"Professor-student conversation ends."

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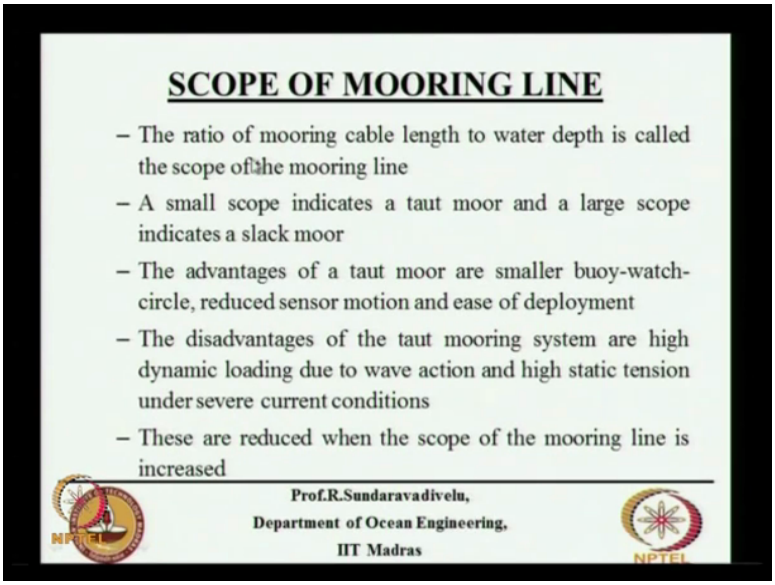

So this I already discussed, ratio of mooring cable length to water depth is called as scope of the mooring line. It is a very small, then it includes taut mooring and if it is a large scope, it indicates a slack mooring line. Advantages of taut moor are smaller buoy-watch-circle, reduced sensor motion and ease of deployment. So when there is a buoy, the buoy will move. The movement if it is less, it is better for certain applications. That will happen if it is a taut moor.

Disadvantages of taut mooring system are high dynamic loading due to wave action and high static tension under severe current condition. Suppose this is a buoy, if you allow the buoy to move for a longer distance and if you see that this is a mooring line, the mooring line is very taut. This will not allow it move, it will allow it to move like this only. If it is a very slack mooring line, this can move like this.

Okay. So if it is very taut like this, when the wave comes it moves up and down, tension will be very high. That is what is given here. So these disadvantages are reduced when the scope of the mooring line is increased.

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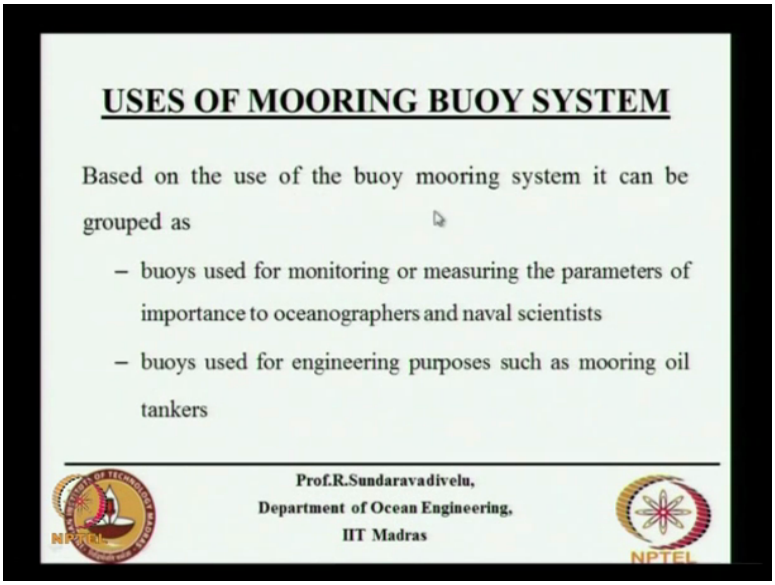

So we can group this buoy mooring system into two categories. One is for scientific purpose, another is for engineering purpose. Scientific purpose is for monitoring or measuring the parameters of importance to oceanographers and naval scientist.

"Professor-student conversation starts."

Professor: What are the things you want to measure using a buoy mooring system? Ocean engineering students.

Student: Wave height.

Professor: Wave heights.

Student: And tsunami warning.

Professor: Scientist, they do not need all these things. What do the scientist need? Salinity.

Student: Salinity.

Professor: Temperature, current, all these things. Sometimes we want to measure the acoustic signals also. This for navy it is very much important. Buoys used for engineering purpose such as mooring oil tanker, that is what the second. We are interested in the second part of it.

"Professor-student conversation ends."

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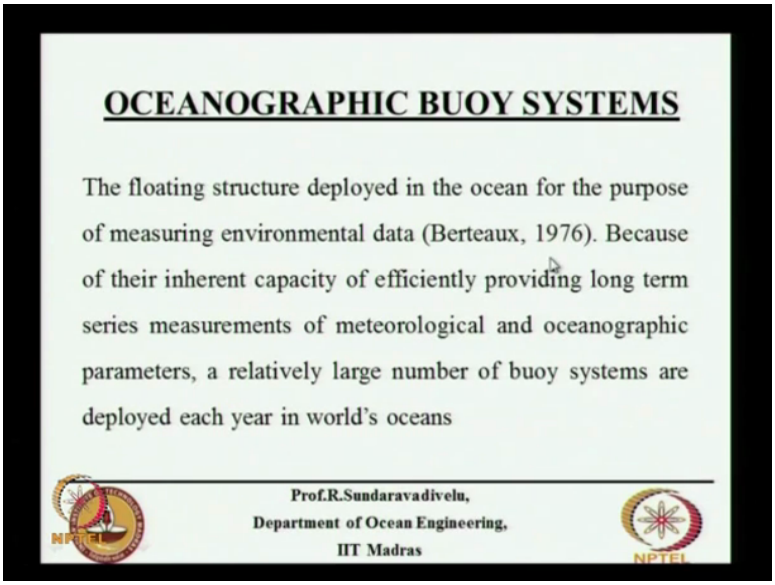

So there is a book called Berteaux, 1976. How many of you are aware of this book? Ocean engineering students, have you seen this book? Have you heard of this book?

Do you know the institute called Woods Hole Oceanographic Institute? You do not know that also. Better know all those things. And this book is a classical book. So now the, is like a Bible for buoy mooring system. It is available in our department as well as in the main library. Very old book, I think there is updated edition is there.

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Then we will talk about this single point mooring system. We call it as offshore floating storage system because we are storing the oil in the mother vessel or permanent tanker. We call this as SPM. This enables economic transport of crude oil where pipeline, use of pipeline is not technically or economically feasible because of rough seabed, topography or long distances from shore. So sometimes we use SPM with pipeline also but in general for a loading terminal we do not use with pipelines.

Whereas for unloading terminal, in India we have the unloading terminal, there we place only the single buoy mooring system and lay the pipeline to the shore. Is it clear? You know what is loading and unloading terminal. Suppose we load the oil from Dubai or some Arabian countries from the offshore location, it is called as loading terminal. We get the oil in the seabed immediately connected to the riser pipe to the mother tanker and shuttle tanker. And the shuttle tanker moves from Dubai to India. It either comes to east coast or west coast.

When it comes to one of these places, there also it is connected to the single buoy mooring system. But from the single buoy mooring system, you can lay a pipeline and then take it to the nearest land based terminal. In Paradip port, we have a terminal for, I think it is for, I do not remember whether it is BPCL or IOCL, there is a terminal there. So what they do is they lay a pipeline from the offshore location 30 meter water depth to Paradip port.

The oil comes to the refinery, then they refine the products and send it by, abroad or send it by coastal transport or send it by land transport. That laying of pipeline depends on type of seabed. Rough seabed means where it is stones or the rocky seabed is there, topography gradient is not flat or the distance is very long. Mainly this has two functions. One is to offer safe mooring to the vessel. Secondly, it can form a link in the transport of oil.

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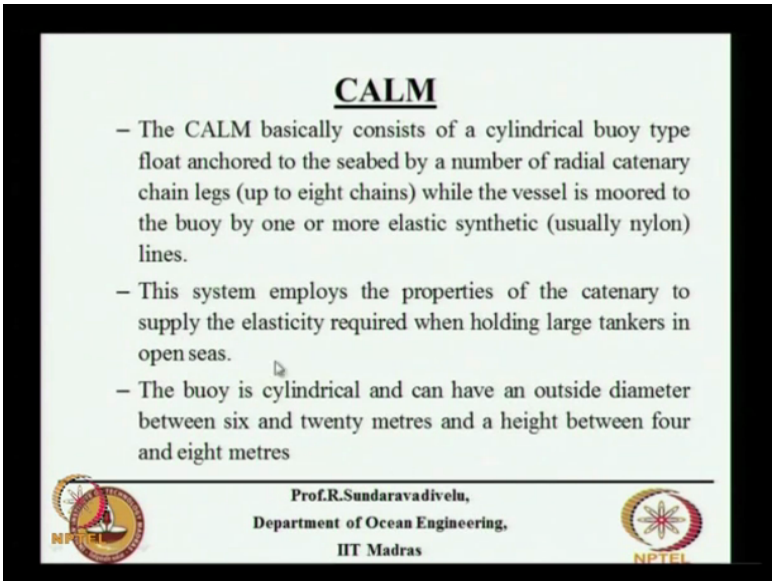

We have CALM. They may ask you this question also if you go for interview.

"Professor-student conversation starts."

Professor: Can you guess, what is CALM? At peace of mind.

Student: Name of mooring system.

Professor: What is it? What is, M is for mooring, C is for catenary and?

Student: Anchor linked mooring.

Professor: This is not here, anchor linked mooring. Catenary, what is catenary?

Student: It is a parabola shape. It is a shape of parabola.

Professor: Yeah. Why that particular name came?

Student: If you plan a (())(24:52).

Professor: Have you seen the spiders? Spiders when they are making a web, it is also of a shape of the catenary, it is a natural shape which it will take. Any natural shape will have lesser problems. If it is deep water and you lay a chain, the chain will take the shape of a catenary. It is a parabola only. The equations are slightly different. If you are ocean engineering student, you

better know what is the equation for catenary. It is available in Berteaux books or any standard textbooks it is there.

“Professor-student conversation ends.”

And what is called as a stiffened catenary also? Stiffened catenary means at the ends the shape will be slightly different because of the change in boundary condition. The CALM basically consists of a cylindrical buoy type float, is a cylindrical buoy type, is a float. This is anchored to the seabed by a number of radial catenary chain legs. This can be up to 8 chains or even 12 chains while the vessel is moored to the buoy by one or more elastic synthetic, usually nylon lines.

This system employs the properties of the catenary to supply the elasticity required when holding large tankers in open seas. The tanker is connected to the buoy and buoy is connected by catenary chains. So the chain is not holding only the buoy, it is also holding the tanker. We have done some experimental studies on single buoy mooring system connected to the tanker with mooring chains. Some PhD work also has been done.

The buoy is cylindrical and can have an outside diameter between 6 and 20 meters and a height between 4 and 8 meters. In engineering you should know what is the range of all these parameters. You should know what should be the, what will be the approximate diameter of the buoy and what will be the height.

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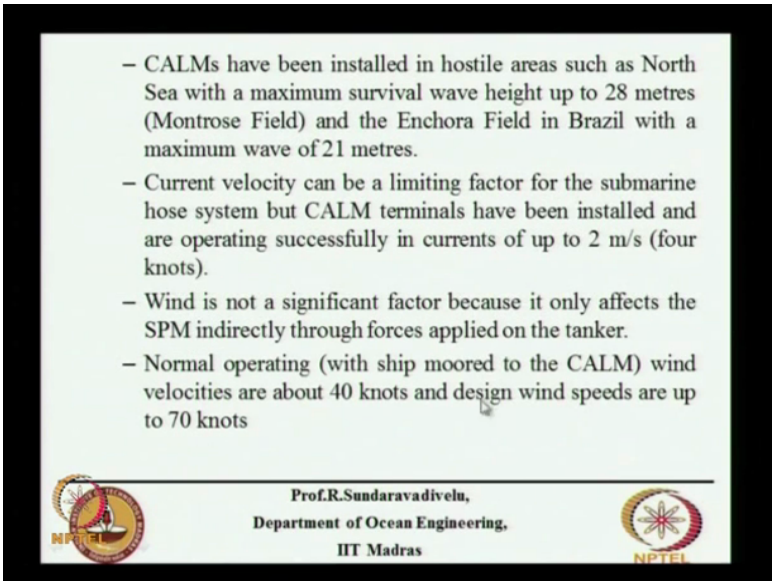

So they have installed this in North Sea where the wave height is 28 meters and there is another field in Brazil, the maximum wave of 21 meters. The Brazil is growing because they have lot of oil potential. China also has self-sufficiency in oil. Russia also has lot of oil. We have all things except oil. Only problem for us is we do not have sufficient oil. That is a very big risk for us. The current velocity can be a limiting factor. You see 28 meters and 21 meters. Imagine what is 28 meters and 21 meters.

28 meters is 9-storey building and 28 meters come, I have also done some work for ONGC with a buoy mooring system. When I generate 28 meters of wave in the floam, 1 is to 30 scale or something like that, what I have seen is the buoy simply goes up 28 meters and comes down. 28 means 14 meters it will go up and 14 meters it will come down. When it is going up by 14 meters, the mooring chain which is laying on the seabed it will get lifted up. It will not get completely lifted up. I was wondering why they are giving for 30 meter water depth 300 meter chains.

I have physically seen that up to 280 meter the chain will get lifted. Nothing will happen to the system. You see it, it is a tie. If you see the buoy, the buoy is only 4 meter in height and 10 meter in diameter and you are generating wave of 28 meter. The buoy simply goes up and down. Nothing happens to it. But at that time the tanker will not be connected. There are two position for this operation. One position is survival, another position is operating condition.

This 28 meter (())(28:42) is survival condition. 28 meter your tanker will not be connected to the buoy, tanker will be disconnected and will be taken elsewhere. Up to 4, 4.5 meter only you will connect the tanker to the buoy mooring system. Once it is more than 4, 4.5 meter, the tanker has to be disconnected and it will go elsewhere nearby only. It has its own anchors and it will get connected. Otherwise that floating hose will get detached and oil spill will take place. That is why for survival we do not do it.

And current up to 2 meter per second we can use. Wind is not a very significant factor because wind affects only the tanker, the force of the tanker. Normal operating with ship moored to the CALM wind velocities are about 40 knots and design wind speeds up to 70 knots can be used.

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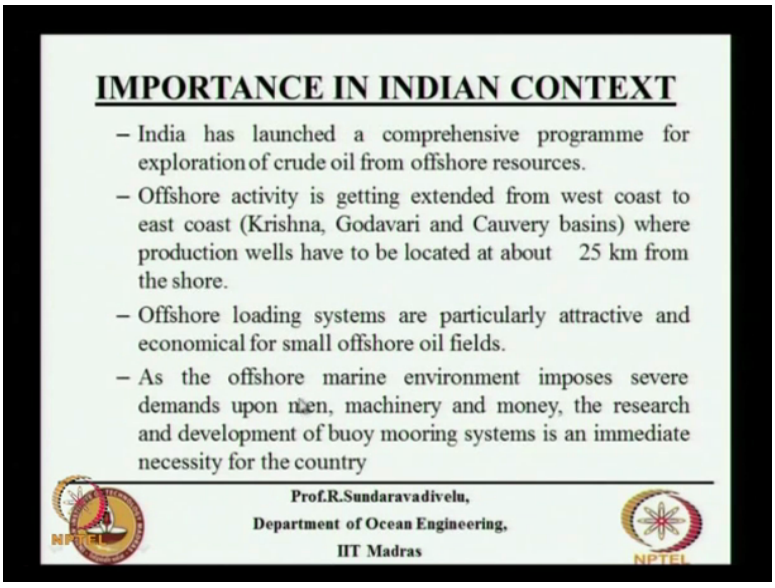

So we have large comprehensive program for exploration of crude oil from offshore resources. So we have this Krishna, Godavari and Cauvery basins where these production wells have to be located about 25 kilometer from the shore. So for this type of system, offshore loading systems are particularly attractive and economical for small offshore fields. So if you have big offshore fields only, you can lay the pipeline because the pipeline cost is very high.

As the offshore marine environment imposes severe demands upon men, machinery and money, the research and development of buoy mooring system is an immediate necessity for the country. One of the area in which we are working is to fabricate the buoy mooring system. So if you do it

yourself, it will be always better. L&T has facility in Hazira where they have started manufacturing this buoy mooring systems. In Kattupalli also they may start doing it.

Only thing is the design of ships as well as the design of buoy mooring system, so far it has not percolated into Indian market. For a bigger ship design, is not done in India. Even a smaller ship design is not done in India. I will tell you later why it is not done like that.

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The movement of the ships and tankers at berth, this is important consideration. This is moored tankers at the berth, this is not related to single buoy mooring system. Even inside the harbor if you have the mooring, I think maybe I will discuss this in the next class.

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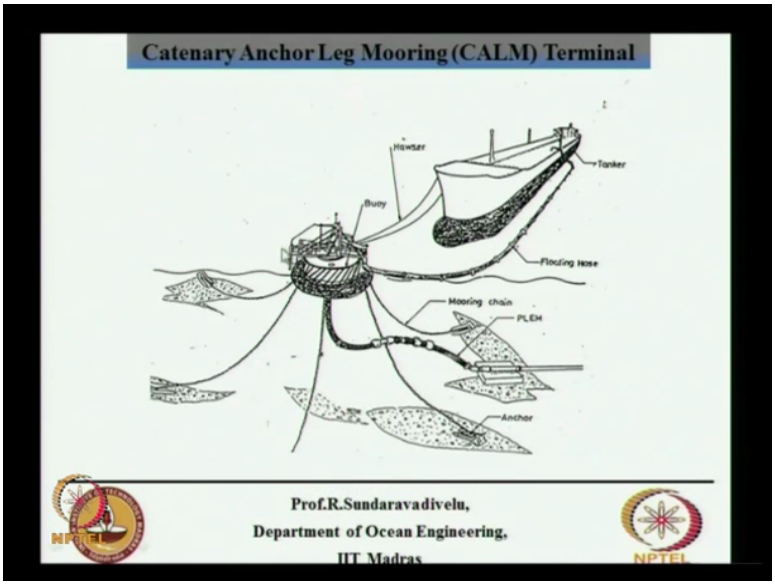

So I will just complete this figure. This is for the single buoy. This is a hose. So when the big waves comes, this buoy will go up and down. When the buoy is going up, all the chains will go up along with the buoy. This riser pipe also it has this shape, this will also go up. The floating hose if it is connected, it will get detached. So there is a risk, so they will remove the hoser and take the ship away. The floating hose also they will seal it and leave it along with the buoy mooring system.

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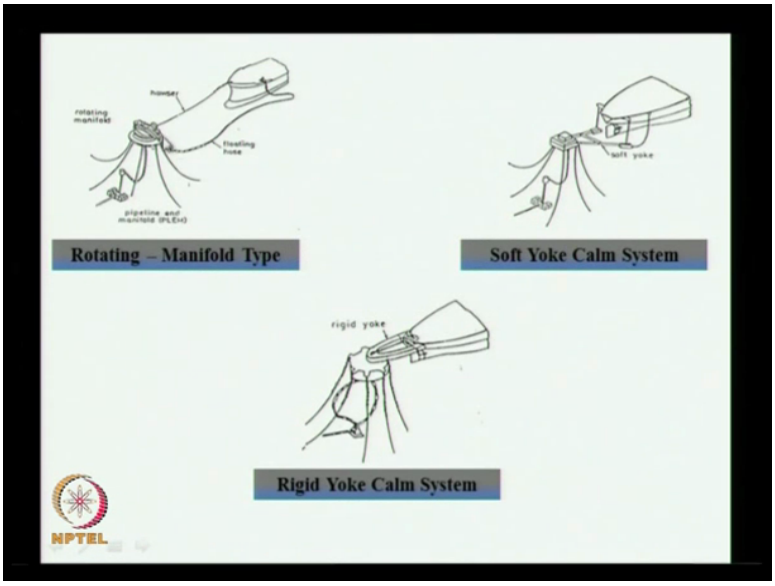

We have different types of yoke. This is called as manifold type. This is called as soft yoke. This is called as rigid yoke and these are certain classification. This is a submersible buoy, this is the hose, this is a riser pipe and this is going down vertically so that no tension is applied at this particular point. So this is normally how it is done in a riser pipe.

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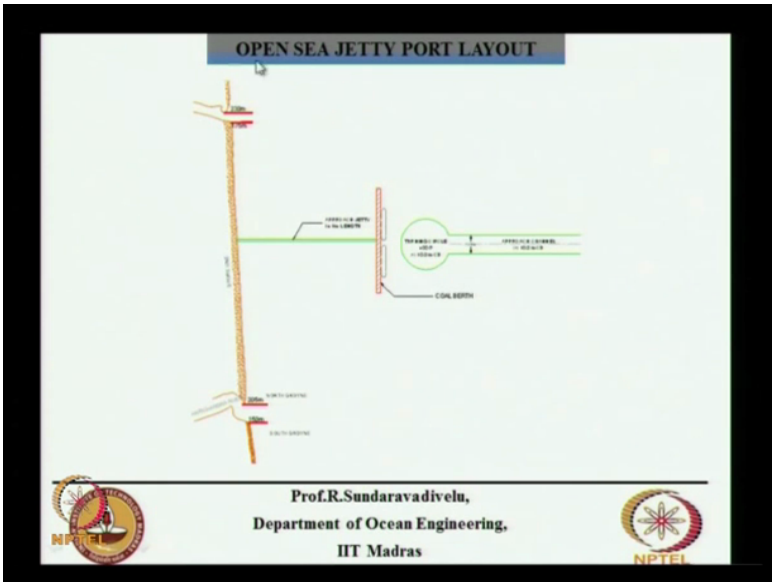

So this open sea jetty and open sea jetty is like this. You have the shore line, we provide an approach, then we will have this jetty. You have the vessels here. You have an approach channel, and turning circle. And you transfer the oil like this. This we have similar jetties and CPCL jetty, Dahej in Gujarat, CPCL jetty at Nagapattinam we have this type of facilities.