Port and Harbor Structures
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Module-05 Lecture-29
Single Buoy Mooring and Open Sea Jetty- Part 2

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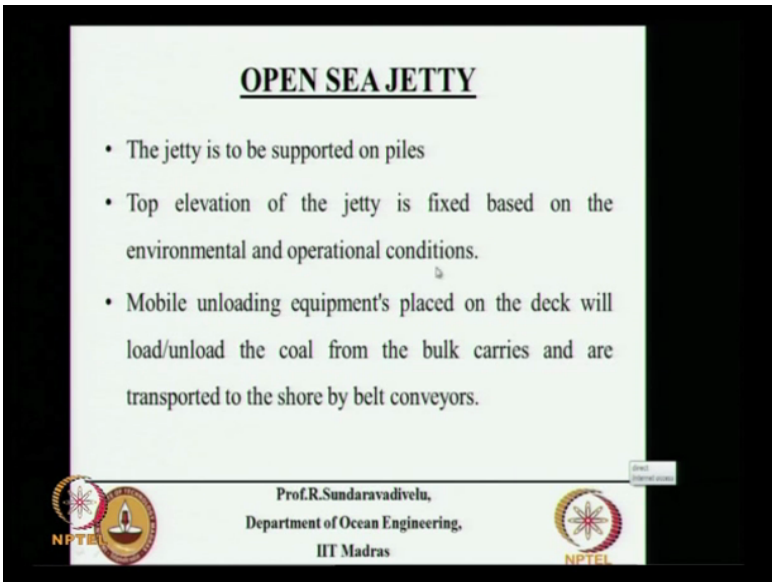

We will continue discussion on open sea jetty. This open sea jetties are generally supported on piles mainly because we do not want to obstruct the environment by providing a solid structure. The top elevation of a jetty is based, fixed based on the environmental and operational conditions. Environmental means what will be the high water level, this can be due to high tide level plus surge or due to tsunami. Classical example is two jetties, open sea jetties. One is near Nagapattinam, another is in Gulf of Cambay, that is near Dahej.

Dahej, the top level is plus 20 meters. Plus 20 meter is, the top level of the jetty will be about 6 floors above the water level because the tidal variation is very high, 6 meter and wave height is also about 8 meters. That is why they have fixed the top level of the jetty as plus 20. Nagapattinam it is plus 11 meters, they have the tidal variation is not there but we have waves breaking and surge is there, plus tsunami is also there. Tsunami wave heights may go up to 7-8 meters, so the recent tsunami, this jetty was constructed before tsunami. When the recent tsunami, the top level was not touched but there is an operational requirement.

Operational means if the ship is at lower level and jetty is at higher level, you cannot tie the vessel. So the mooring dolphin, berthing dolphin and all those things you should provide slightly at a lower elevation or provide some mooring outfits so that you can tie the vessel. This point is clear now. You cannot keep the top level very high. Then the vessel has to come and berth. So there should be some fenders that is to be provided at low water level. So you have to provide the fender and mooring outfits at a lower elevation.

Normally this open sea jetties are used for single type of cargo not multiple type of cargo and again this is for large quantities. So this open sea jetties are being built in abroad. So far we do not have any such facility in India for bulk, that is coal or iron ore. And the transportation will be by belt conveyors. Recently you would have seen in Tamil Nadu budget, there is told (())(02:51) there will be a power plant for 8,000 crores.

For that power plant, we have designed open sea jetty. So we can unload the coal from 60,000 dwt vessel Panamax size. Whereas abroad these open sea jetties are used for very big vessels. Very big vessel means capsize which is about 1, 20,000 dwt vessels. The transportation is by belt conveyors, so the loading and unloading rate will be very high with this belt conveyor, about 2,000 tons per hour for coal and 4,000 tons per hour for iron ore.

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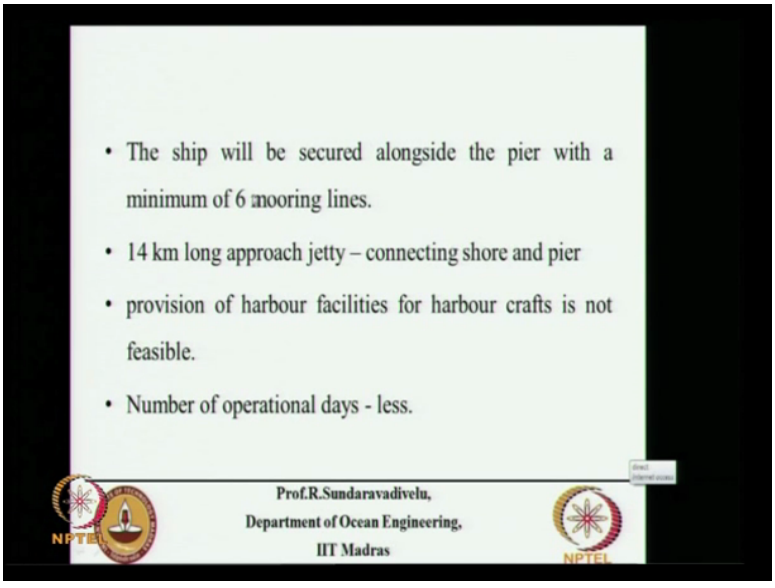

So we need about 6 mooring lines to secure the ship minimum. Approach jetty can be very long, it can be even 14 kilometer. In Nagapattinam it is very less, maybe about 1 kilometer. Whereas in

some places where we want to use bigger vessels, the seabed contour is very flat, then the approach jetty will be very long. One of the disadvantage is whenever we want to operate port facility, we need harbor crafts. Harbor craft means tugboats and other things to bring the vessel inside. But that possibility is not there when you have open sea jetty because harbor crafts cannot stay in open sea condition.

Another aspect is number of operational days will be less. Open sea jetty, it cannot operate on 365 days, it will be less. Less means it may be between 275 days to about 300 days. In Nagapattinam it operates for 300 days.

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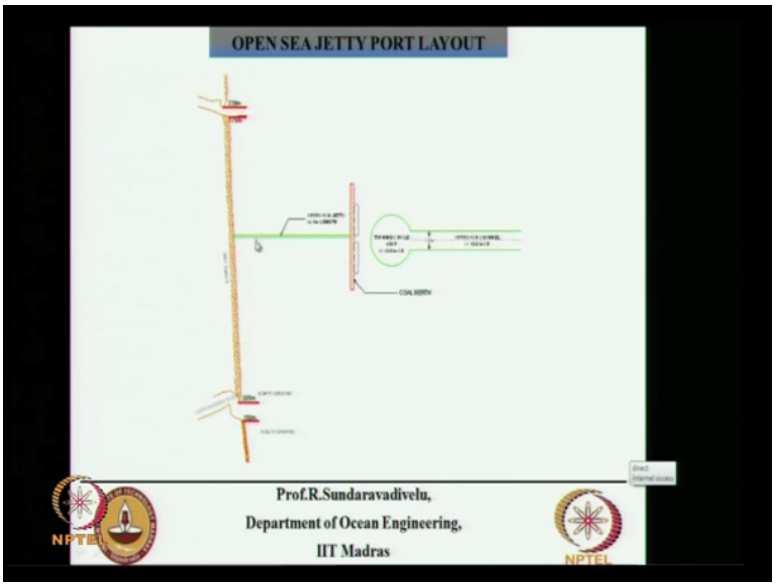

So this is your shore line which we have seen. There will be an approach jetty. There will be mine coal berth. Typically designed for two vessels, you will have an approach channel and a turning circle. And a basin, dock basin here so that the vessel will come here, then berth here. There are two rivers which are draining. So to bring the water flow properly, we have constructed two training walls.

Though this approach jetty supported on piles will not have any impact on the shore line, CSR, CSR means corporate social responsibility, we want to build the groins or training walls and dredge this area so that this water will drain and it will save lot of paddy fields from end.

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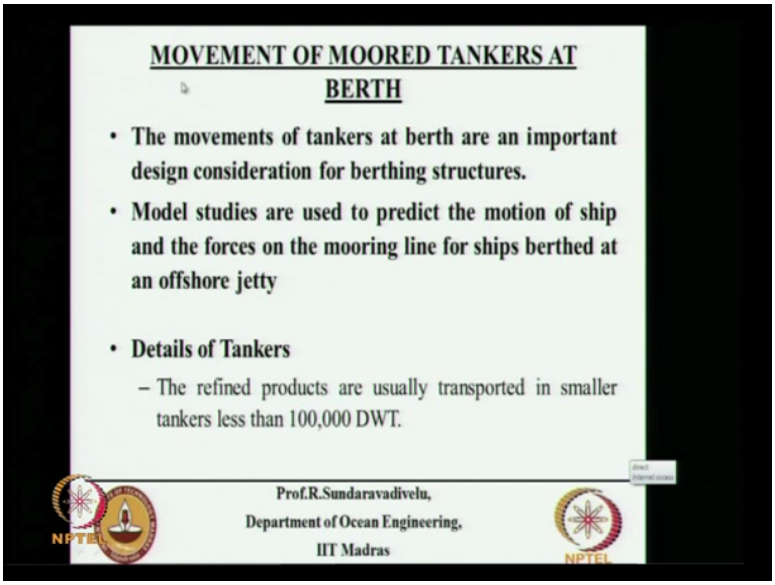

One of the main requirement of this open sea facility is what is a movement of moored tankers at berth, this I have given only for tankers. It is different for different type of vessels. It is different for container vessel, is different for bulk carrier. It is different for smaller size vessels, is different for bigger size vessels. So I will not be able to cover the entire thing but I will tell you for tankers what will be the permissible movements.

This is one of the design consideration for berthing structures. So what we do is we find out what is the movement of the tanker for particular wave heights. If the wave heights are exceeding the permissible movement, then we de-moor the ship, that is what we do. That is how the number of operational days will come down. We may use model studies also, numerical studies also can be done. We have excellent facilities in our department. I will show in one of the class what are the facilities we have in our department where we can perform this model studies.

So to make it in context of these model studies, international level there are only very few institutions, maybe two or three academic institutions where the facilities what we have in our department exist. Most of the other facilities that also is not very big in number. Maybe 10 facilities may be there in the (())(06:58) similar to what we have in our department, is by industry. That is the testing cost will be much much higher than what we normally charge for doing the test.

Normally these tankers are used for this open sea jetty for smaller tankers less than 100,000 dwt. I remember that I have told you in one of the class, the crude oil comes by bigger vessels. For that we put a single buoy mooring system. That is also in open sea. That is what we discussed in the last class. Then the finished product also goes by open sea jetty but that vessel size is smaller. Vessel size is smaller means water depth requirement is less. So open sea jetty need to go only up to 14-15 meter water depth where the for tankers. Whereas for single buoy mooring system it has to go up to 30 meter water depth so that you have your bigger tankers moored together.

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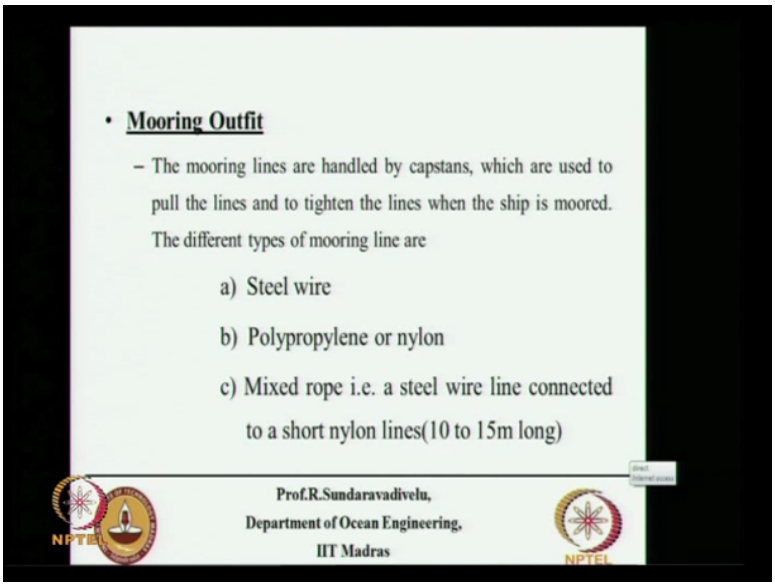

Like this moored tanker's permissible motion, for single buoy mooring system also there is a permissible motion. Typically it is about 4 meter wave height along with the wave period also, about 10 second wave period. And mooring outfit means we have basically the mooring line and bollards, capstones and mooring ropes. We have three types of ropes. One is a steel rope. Another is a polypropylene or nylon ropes. Mostly this polypropylene or nylon ropes are used. Or we have a mixed rope, combination of steel and nylon ropes.

Mostly this mooring outfit will be carried by ship. It is not available in the berth. Each ship will have its own mooring lines along with them. Each mooring line will have its own properties. At I think one class I already discussed.

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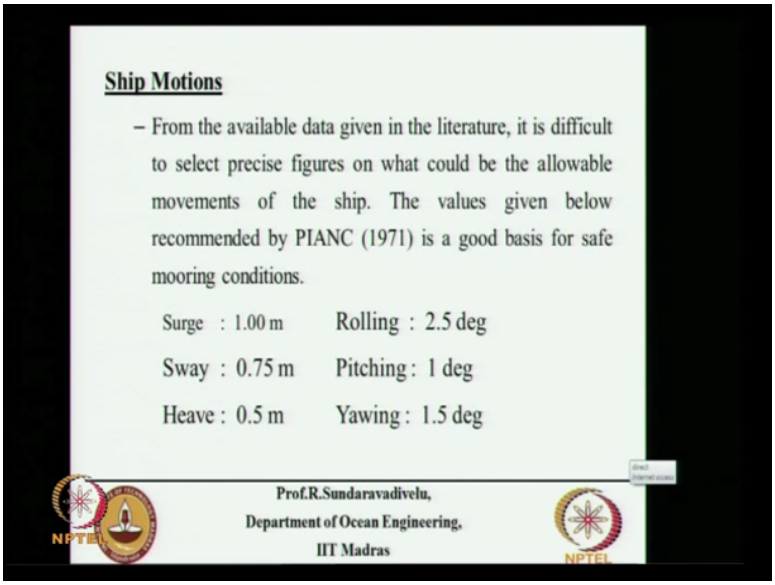

So this is very important. This is what we want to discuss today, what is the permissible motions. There are three translational motions, three rotational motions. The permissible motions for heave that is going up and down is very less, that is only 0.5 meters. Related to this if it is a smaller vessel, it relates to 0.5 meter wave height only, very small vessels. Whereas very big vessels may be even 2.5 meter, 3 meter, will produce a heave motion of 0.5 meter.

What I am saying is if the wave height is 2 meters, the ship motion heave will be only about 0.5 meters for a vessel of about 60,000 dwt. Bigger vessels will have lesser motions. Sway motion permissible is 0.75, surge is 1 meters. Similarly yaw motion is 1.5, pitch is 1 degree and roll is 2.5 degrees. So these are the permissible motions. So what we have to do is for a particular wave condition, you have to find out what is the ship motion and limit the wave height within which we can do the operation.

There are certain procedures that are followed. So the vessel is already berthed, the wave height is suddenly increasing. It is in operation, that means you are connected the hose pipe to the ship and it is pumping the oil. At that time the wave height increases. Normally what they do is they will disconnect the loading arm. They will not remove the ship, they will wait for some time and if it still continues for a longer duration or the wave height further increases, then they will remove the vessel and take it outside, berth it, moor it in open sea in a deeper water depth.

Then when the wave subsides, they will come back and then they will unload or load the cargo as the case may be. They will not take the vessel away because for a particular location you want to discharge about 10,000 tons of crude oil, I am sorry, 10,000 tons of product, then they will do it. After 7,000 ton it comes, they will not go away with 3,000 tons. They will come back and then they will continue the operation.

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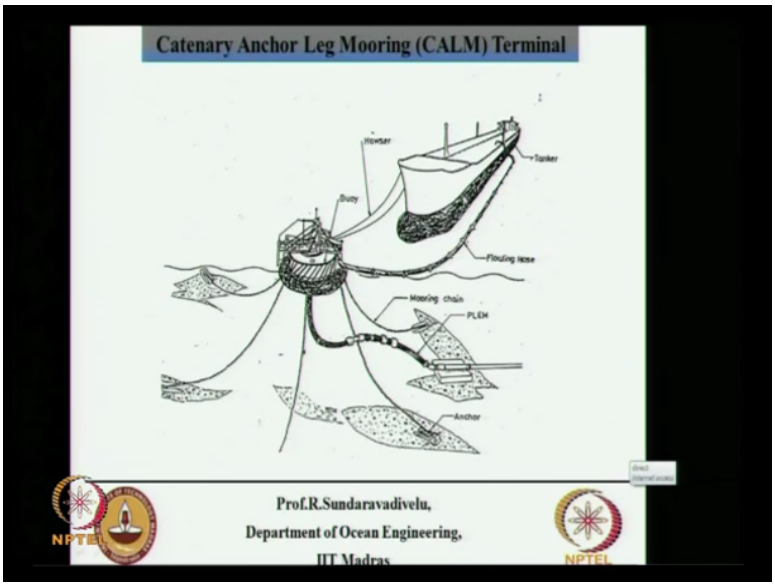

So this to summarize this is the type of facility that is used for bigger vessels, a single buoy mooring system.

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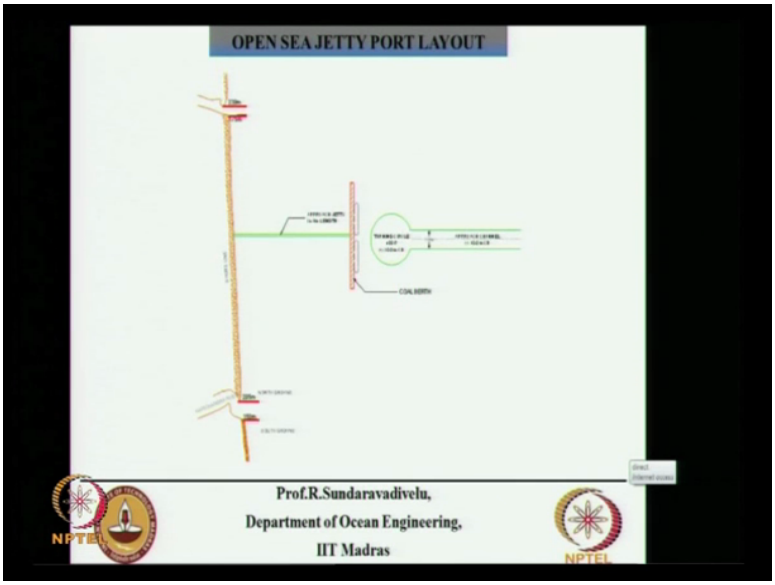

And for a product tanker this is a type of open sea jetty which is used. The previous one is for crude oil and this is for the product tanker.

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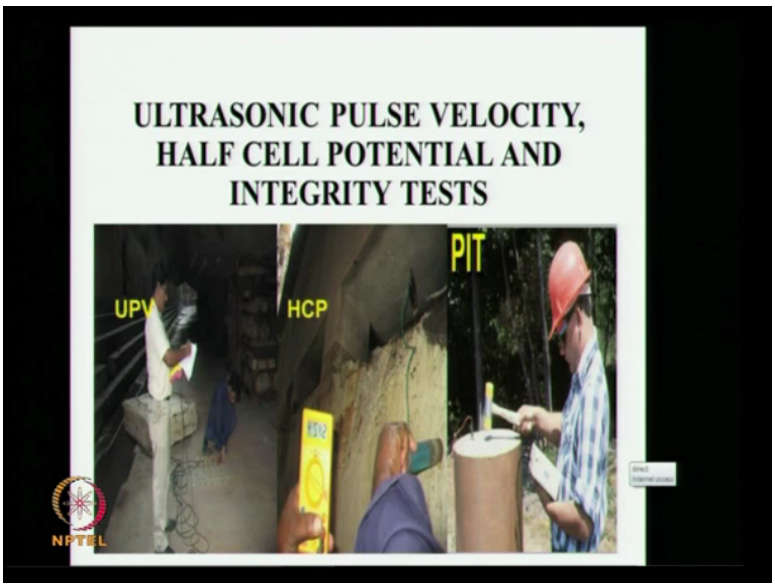

So we have people from different, students from different background. But any field whether it is medical field or engineering field, you should know the equipments, instrumentations that are required to perform certain test so that you find out the integrity of the system what is being studied. This is for health monitoring of structures, marine structures. We use three type of test.

One is called as ultrasonic pulse velocity. The second one is called as half cell potential. The third one is called as integrity test.

PIT means pile integrity test. So you have a pile which is built. What you are seeing is above the seabed or above the land, what the pile goes right down. So he is having a hammer and he is having a transducer. Then we have a recorder. This hammer is used to give some vibration. It travels down and it comes back. The signal is picked by this transducer. We may have an amplifier to amplify the signal. In nowadays we have the built-in amplifiers.

“Professor-student conversation starts.”

Professor: Have you see any transducer so far in IIT? What transducer? Any instrument you have seen till date? Ocean engineering laboratory you would have seen what transducers they use. Load the…

Student: Precedence uses.

Professor: And? You are not telling what I wanted. You have not used acceleration transducers? This is an acceleration transducer pickup. What about other student? Mechanical students, have you seen any acceleration transducers, pressure transducers? You have used it, have you used it in the laboratory?

Student: (())(14:08) meter.

“Professor-student conversation ends.”

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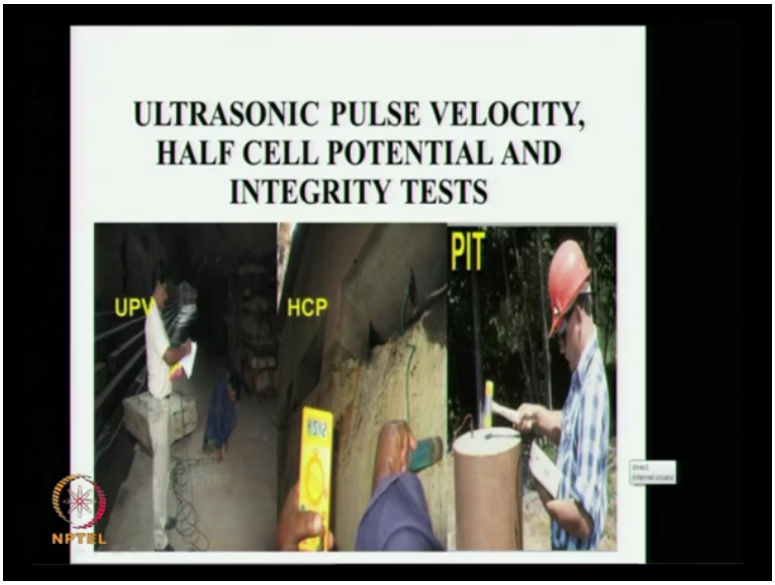

This is the recorder and another thing is this person standing is wearing a helmet. Normally if you go to any civil engineering construction site, they insist that you wear a helmet because this requirement. This is another test which is called as half cell potential meter. So here also we have a recorder or reader. And there is a cap which is used to find out the potential. This is ultra-pulse velocity test. You can see the grid here where they use a pickup, then make the measurement.

We normally use all these three test once in 5 years after about 20 years of service life of the structure just to find out what is the condition of the structure. This pile integrity test nowadays is being used routinely during construction because this test does not cost very much, this cost only about 1,000 or 1,500 rupees. Whereas each pile the cost will be about 10 lakhs. So whenever we install a pile whether it is offshore pile or onshore pile, nowadays minimum 50 percent of the piles are tested using a pile integrity test just to ensure that the quality of the concrete is good.

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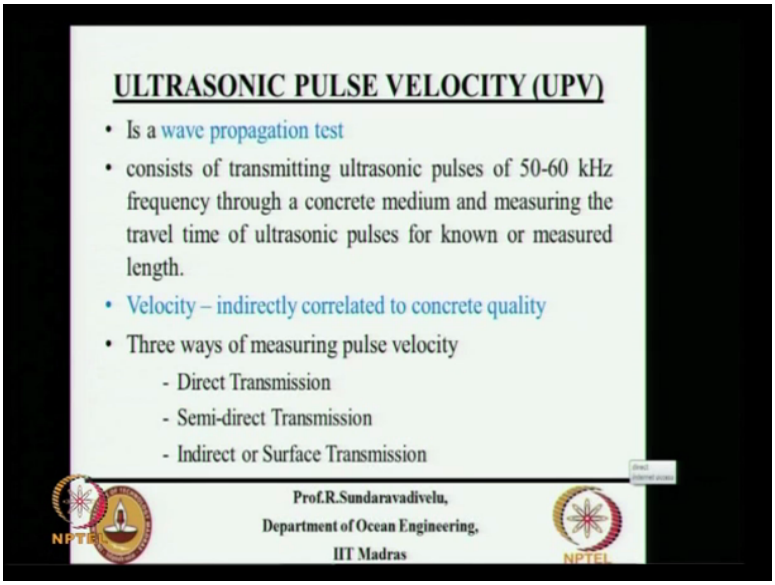

So we will see one by one what are the different types of test, what is the procedure. This is a wave propagation test. What we do in this, we transmit the ultrasonic pulses in this frequency, 50 to 60 kilohertz frequency and we pass it through a concrete medium. Generally this is used for concrete structures and what we basically measure is the travel time of ultrasonic pulses for known or measured length. So we should know the thickness of the concrete specimen.

You send the pulse and then you measure the time. Is it clear? Time taken for the velocity to pass through the known length of concrete, known thickness of concrete is what we do at this. And this velocity is indirectly correlated to concrete quality. You find out the velocity and once you find out the velocity, then you can get the concrete quality. Anybody knows what should be the velocity for good concrete quality? Can you tell me how much will be the speed, velocity with which the pulse will go? No idea. It is between 3 kilometer to 5 kilometer per second. That is the velocity it will travel.

If it is very much less, the quality is bad. About 4, 4.5 kilometer per second is really good. Very simple. You have to go to any concrete column, you send the pulse velocity, then measure the time taken. You know the thickness, you know the time taken, from which you can find out the velocity of travel by this pulse. And if it is between 3 and 5, it is good. Depending on the grade of concrete, this velocity will change.

We have three ways of measuring the pulse velocity. One is called as direct transmission. Another is semi-direct transmission. Another is indirect or surface transmission. These different types depends on what kind of accessibility you have while doing the measurement.

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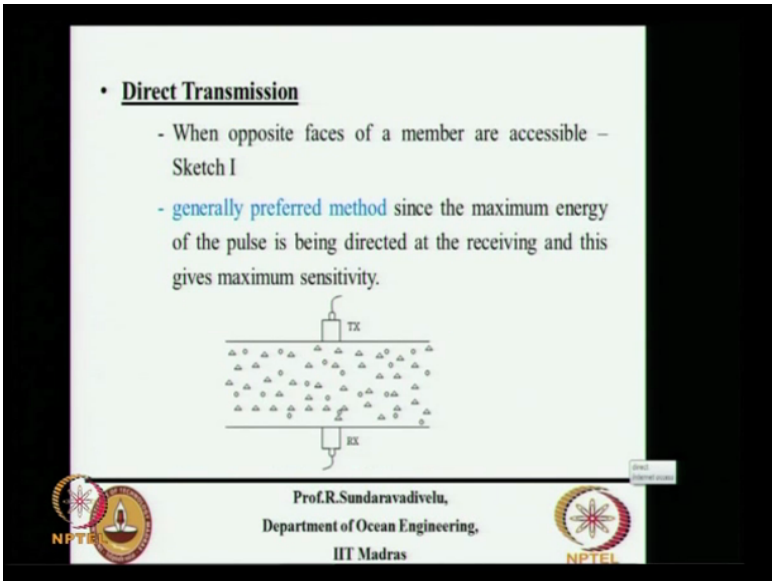

So when both the, specimen is available on both the sides, then we use the direct transmission. So this is the transducer which sends, transmit the signal TX and this is the one which receive the signal. You know the thickness and find out. So this is possible when opposite faces of a member are accessible. We have accessibility on both the faces, then you can do it. This is the most preferred method because the maximum energy of the pulse is being directed at the receiving and this gives maximum sensitivity. Whenever you use the instrument, sensitivity is important. The signal should not be having any noise and it should have sufficient amplitude to measure.

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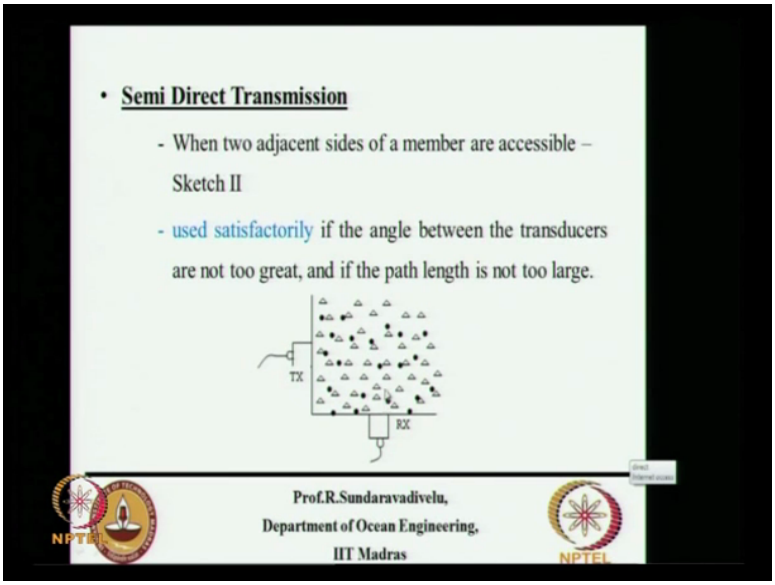

The semi-direct transmission means you have accessibility only at two rectangular faces not on the opposite face mainly because this thickness will be very large, other face may not be accessible. In that case we do, you do this. And this is used when two adjacent sides are accessible. This is where you transmit, this is where you receive. If the path length is not large and the angle between the transducers are not great, this angle is not great, then we use this method.

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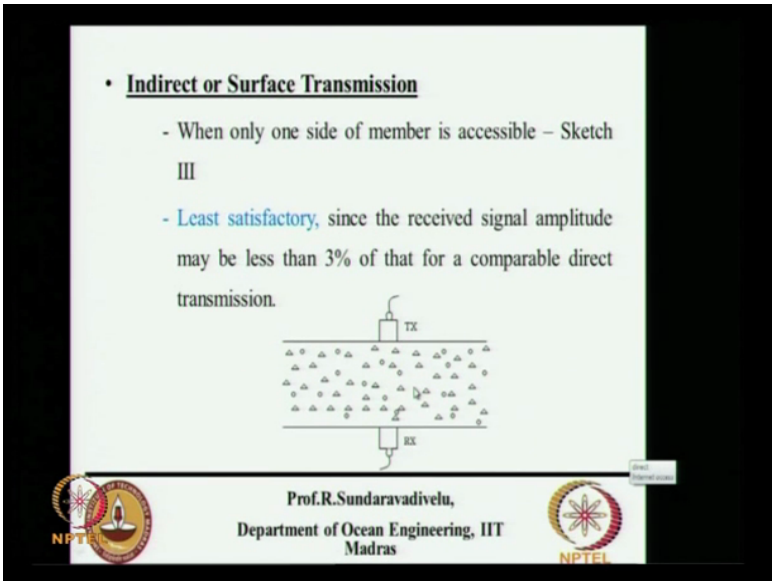

Indirect or I think this figure is wrong. Only one side of the member is accessible. You do not go by this figure, this is wrong. This is least satisfactory since the received signal amplitude may be less than 3 percent of that for a comparable direct transmission. Actually it is you have only the transducer, transmission signal and receiving signal are at the same phase.

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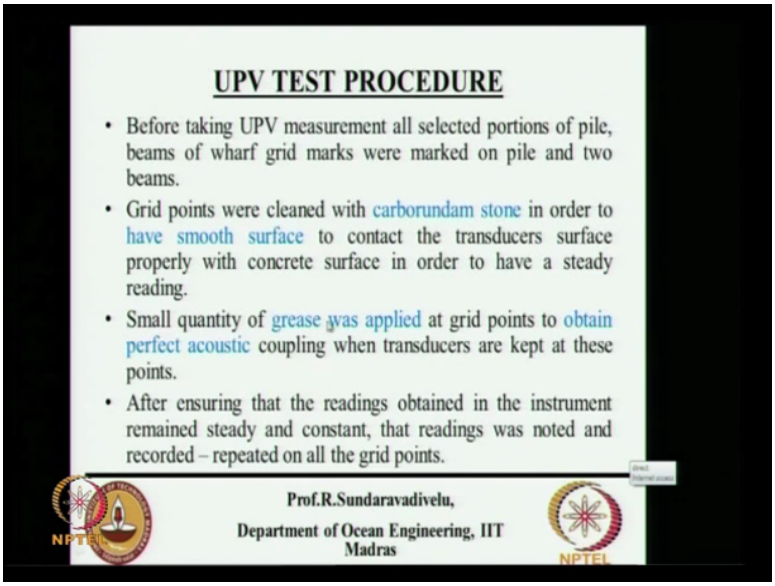

So what is a procedure that has to be followed for UPV test? So we have to before taking the measurement, we have to make a grid marking, that you should do on the pile or beams. And you have to, at the grid points we have to clean it with stone called as carborundum stone to have a smooth surface. The surface preparation is very important. We do not prepare the surface, the signal transmission or receiving will be difficult.

So this is to ensure the transducer's surface are properly fixed with the concrete, so to have a steady reading. Otherwise we will have unsteady reading. You apply a small quantity of grease at grid points to obtain perfect acoustic coupling. After ensuring that the readings obtained in the instrument remain steady and constant, that reading was noted and recorded—repeated on all grid points. Just to keep the instrument and then immediately you should not take the reading. We keep it for minute or so, see that the reading is steady, then you take these values.

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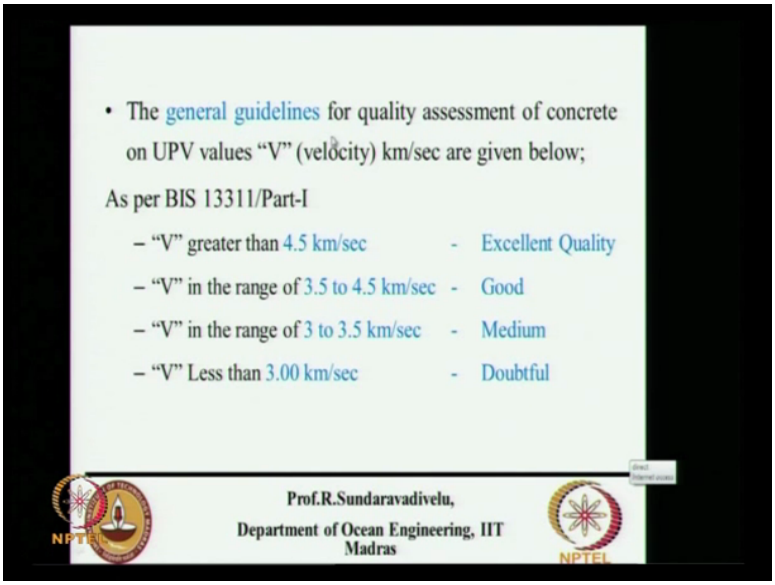

The general guidelines for quality assessment of concrete on UPV values in kilometer per second is given below. According to BIS 13311 Part-I, is a bureau of Indian standards, velocity greater than 4.5 kilometer per second is excellent quality, 3.5 to 4.5 is good quality, 3 to 3.5 is medium and 3 kilometer is doubtful. So once you measure, then you know what is the quality of concrete, so very simple test. So deterioration of concrete may take place because of corrosions, falling and even while placing the concrete you would not have compacted properly. All these reason the quality will be deteriorating.

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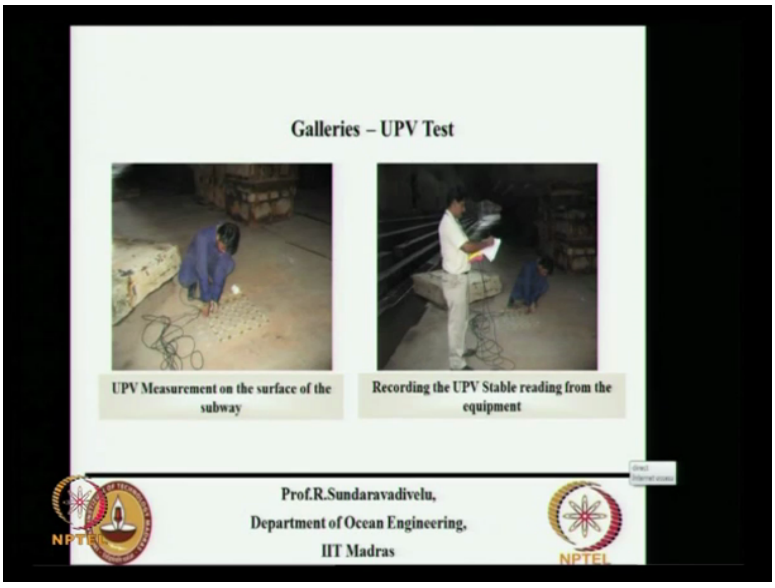

The second test which normally used, this is some more photograph showing the grid points where they have used and how they are recording the stable reading. This is done on a dry dock facility in Mumbai.

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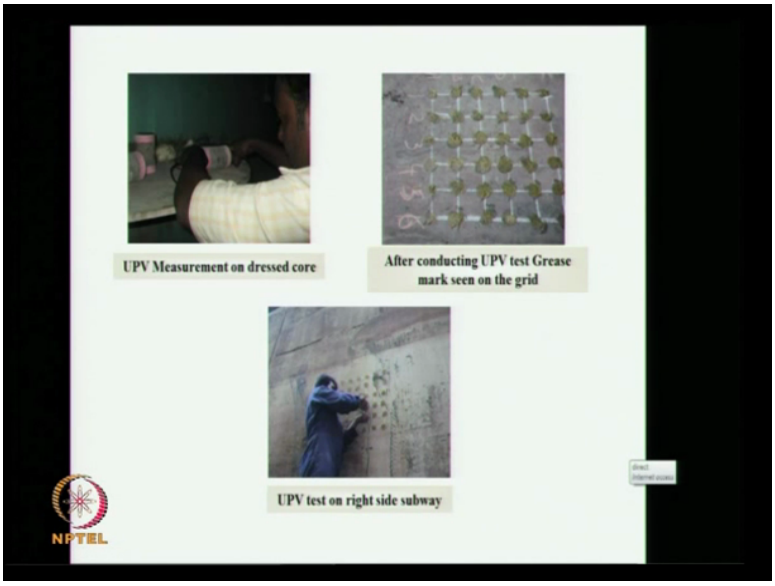

They are also doing on a core, they have taken a core here, they are putting one transmission signal here and receiving signal here and they are finding out. We can see the grease marks, this is on the floor. This is on the side. How they are taking the measurement, this side for a subway.

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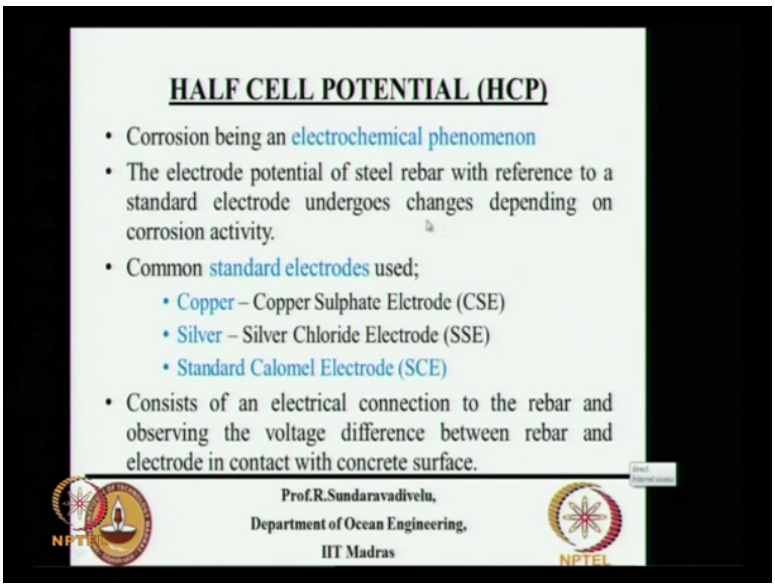

See what we have, there are the concrete consists of two components, reinforced concrete structures. One is the concrete, the second one is the reinforcement. Mostly the failure of the structure or durability of the structure is affected by the corrosion in reinforced steel. So to find out the corrosion in reinforced steel we use this half cell potential. This corrosion being an electrochemical phenomenon, we find out the electrode potential of steel rebar with reference to a standard electrode and this undergo changes depending on corrosion activity.

That means you have a standard electrode and you connect it to another electrode which is connected to the steel bar. You find out the difference in potential between these two, that will give you the corrosion activity. I will tell what indicates the corrosion potential. The common electrodes that are being used are copper, silver and standard calomel electrode. These are the electrodes which are being used.

For doing this we need an electrical connection to the rebar. That means you have to expose the rebar. Whenever we go to the site, we do not have any problem in exposed rebar. Whenever they call us, already the rebar is exposed. So we do not have to expose the rebar. In some cases where the rebar is not exposed, we chip the cover portion and expose the rebar. That also is not difficult. Whenever they call us, our cover concrete is so bad even you can remove with your hand. Otherwise you use a hammer and also it can be removed. In only very few cases we need a stone cutter to go and remove the cover.

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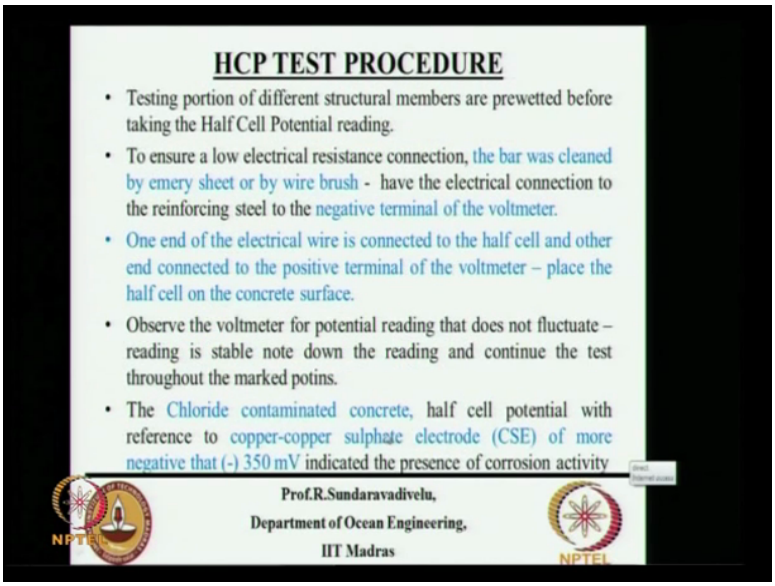

So we have to prewet the testing portion before taking the reading. We have to clean the bar with emery sheet or a wire brush. This will be the negative terminal of the voltmeter. One end of the electrical wire is connected to the half cell and other end is connected to the positive terminal of voltmeter and you place the half cell on the concrete surface. So you observe the voltmeter for potential reading that does not fluctuate. You note down the reading. So if the value what you are measuring that is half cell potential reading, it is more negative than minus 350, then it indicates presence of corrosion activity.

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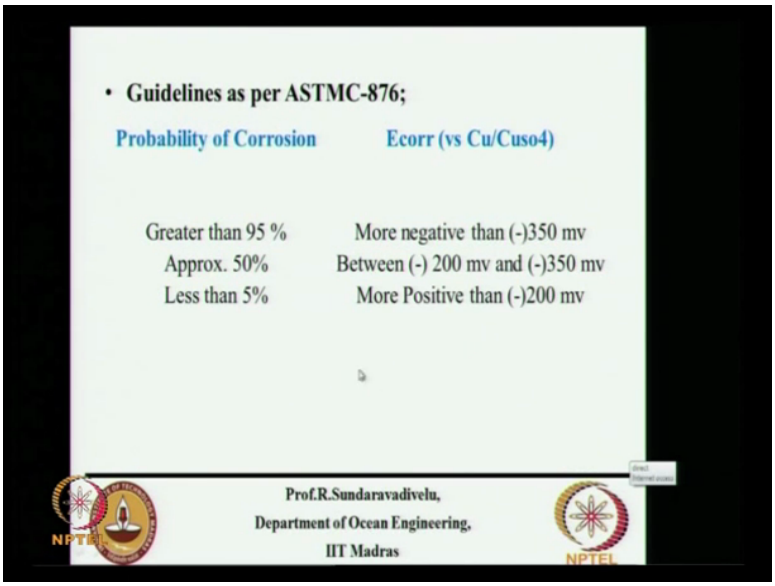

So this is the guidelines as per ASTM standard. So the probability of corrosion will be greater than 95 percent. We measure the values more negative than minus 350 millivolts. This we have observed in many cases. In some of structures where we are suggesting the repair work, most of the places we have measured greater than 95 percent probability of corrosion when it is negative than minus 350.

But if the client is very careful and if he calls us as soon as he feels that there is some problem with the structure, we are in between minus 200 to minus 350. This also we have measured. We have seen in the same structure some places we have less than 5 percent corrosion, 5 percent probability when we have more positive than minus 200. We have recorded values from minus 50 to minus 550, that is a range we have recorded so far whenever we have measured.

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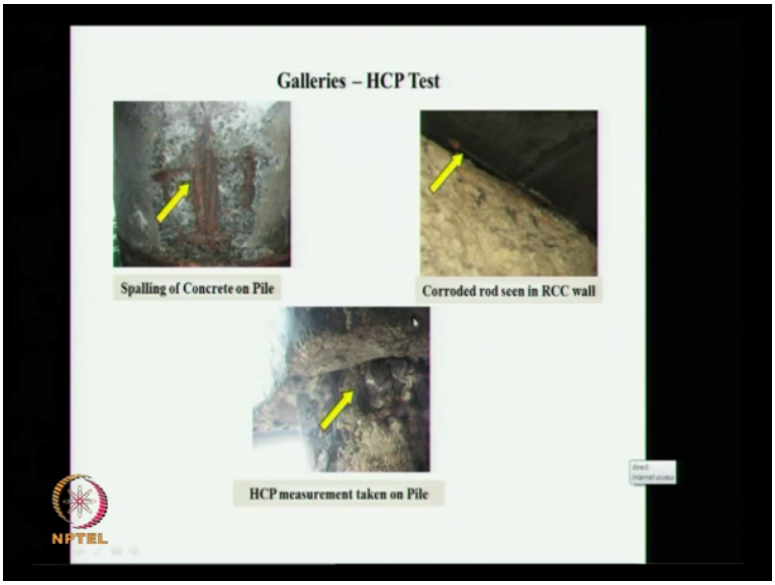

So this is the place, you can see the corrosion that is already there. There is falling of concrete has already taken place. We do not have to expose the reinforcement. This is on one of the piles. This is some more reinforcement, here also we are seeing some corroded rod.

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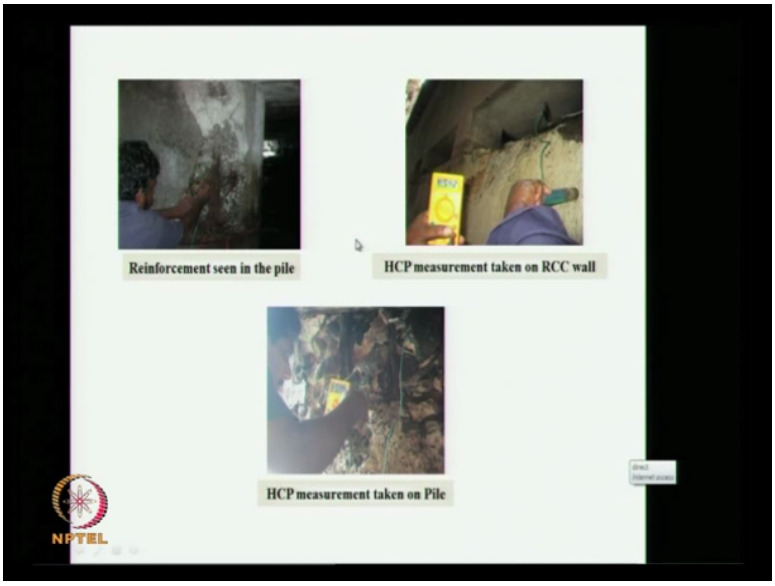

So you have to keep one wire to the reinforcement and another wire to this instrument, then you have to find out the reading here. It shows some reading here, it has to be recorded.

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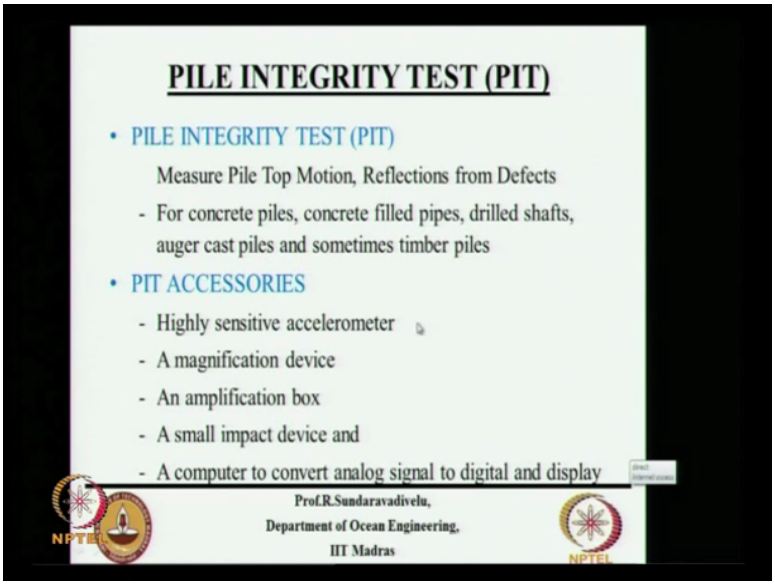

The third type of test what we do is called as pile integrity test, is called as PIT. So you measure the pile top motion, the reflections from defects will be measured. So whenever you send a signal from the top, if there is any defect it will reflect in between. There is no defect, it will go right up to the bottom and come back. So for concrete piles, concrete filled pipes, drilled shafts, auger cast piles and sometimes timber piles, we can use the pile integrity test.

So here the transducer which is used as an accelerometer. The signal is not having enough sensitivity, we use the magnification device and you have an amplification box. And you need a small impact device to send the signal and you need a computer to convert the analog signal to digital and display. These are the various accessories. Basically you need an accelerometer, you need amplifier, you need a device to give the signal, input signal and you need a recorder. These are the four components that are mainly required to do the test.

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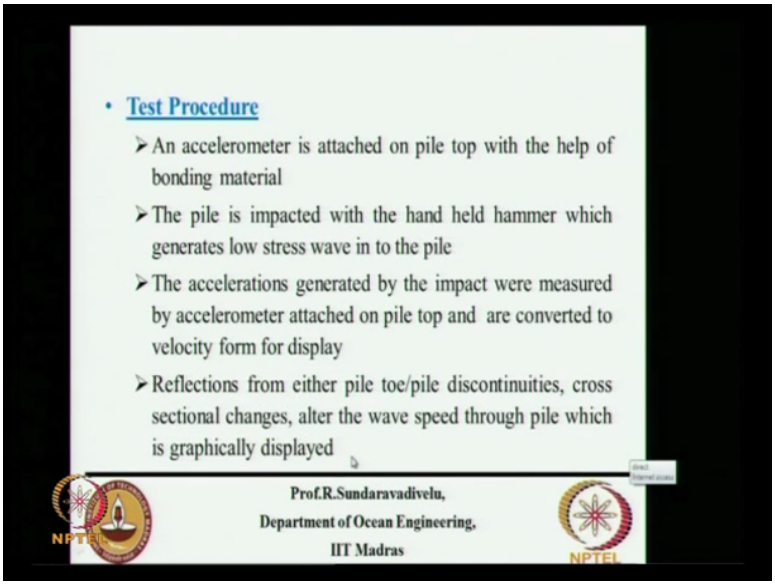

So you have to attach the accelerometer on the pile top with the help of bonding material and you have to give the impact on the pile with hand held hammer which generates low stress value. We have two types of test. One is called as low strain integrity test, the pile integrity test. Another is called as high strain integrity test. I will discuss high strain integrity test in another class. This is low strain because you are using a hammer and giving the signal. That is why it is called as low strain. So the acceleration generated by the impact were measured by accelerometer attached on the pile top and are converted to velocity form for display.

Reflection from either pile toe or pile discontinues, cross sectional changes, alter the wave speed through pile which is graphically displayed.

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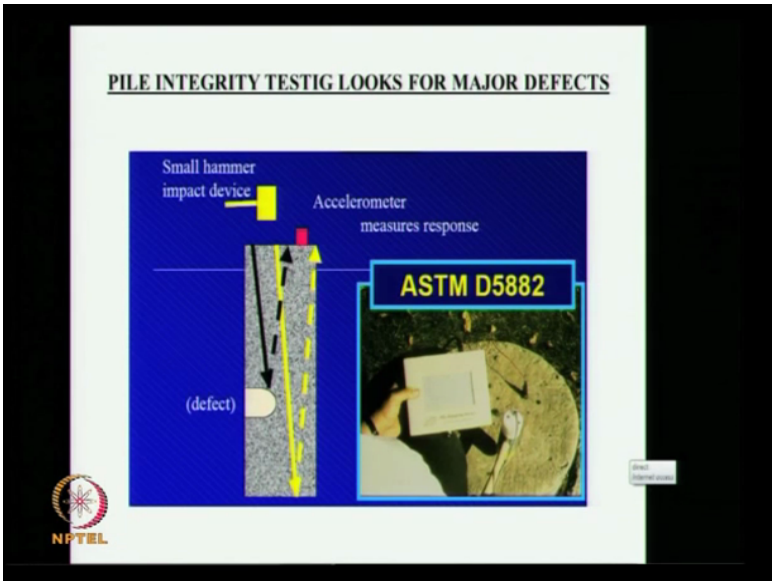

I will come back to this.

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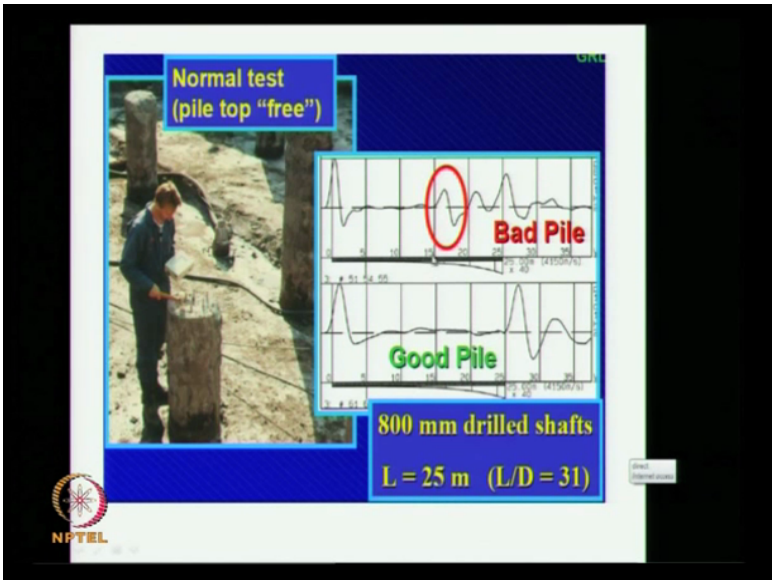

You see here he is doing the test here. You are seeing some reinforcement out, this is for providing the lab. So this is the reinforcement, this is a hammer and I think somewhere here he has put the accelerometer. This is the kind of signal you get. This is for a bad pile. This is for a good pile.

"Professor-student conversation starts."

Professor: Can you tell me why this is good and this is bad? What is it?

Student: (())(29:53)

“Professor-student conversation ends.”

See, this is the point of impact. When you give the signal, you receive the point of impact. The length of the pile is 25 meters. After 25 meter, you get one more signal, right? Because the signal goes right up to the bottom and comes back. You have to get only, normally the signal is weaker than this signal. Here it is not shown. But generally the signal is, amplitude is higher than this. Then subsequently you can have some more signal. This relates to the change in soil stratum. Okay. You know the length, length is 25 meters. What is marked here is the speed of the wave, that is about 4,150 meter per second.

In both the cases speed is the same. That means the concrete overall quality is good. But once you know the 4,150 meter per second, this can be a time scale or it can be a length scale. This is your accelerator, accelerometer reading. This is acceleration level. This is your time scale. Time scale once you know the speed, you can convert into a length scale. So once you receive the signal from the impact point, this is the point of impact, you receive the signal, the second signal you will receive only after 25 meter. If you are receiving the signal somewhere in between, that shows it is bad.

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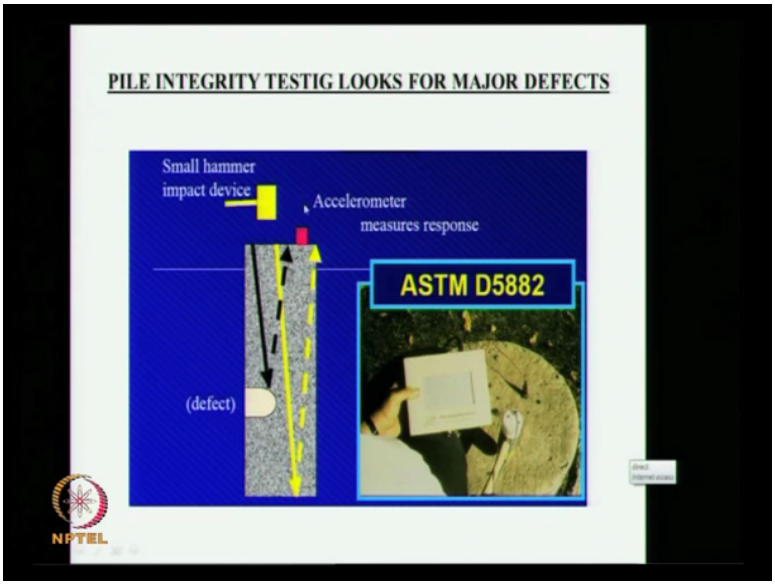

So this is displayed by this facility. You have a small hammer, is shown here. This is accelerometer. This is a recorder. So when you give a small hammer pulse here, immediately it records, then it goes down all the way, then it comes back. And from that you can find out what is a record. Actually if it is 25 meter, it will travel for 50 meter. The earlier slide I said 25 meter, 25 meter is not the length of the pile. It may be 12.5 meters and 12.5 meters. 25 meter is the length of the pile and you will get the second signal.

Suppose there is a cavity is here. Cavity may happen because when you are pouring the concrete, there are some weak points you did not pour or compact or the quality is not good, there is a defect. Defect means the concrete may be very porous, the quality may not be good. Sometimes there can be voids also. That time the black line, the same signal, one signal goes here and then comes back. Other signal also will go right up to the bottom and then come back.

But instead it goes here and then it touches here and then it comes back. It comes back earlier than the other signal. Some more signal what you are seeing is when it passes down, then comes back. That is when the soil layer changes, other things are coming.

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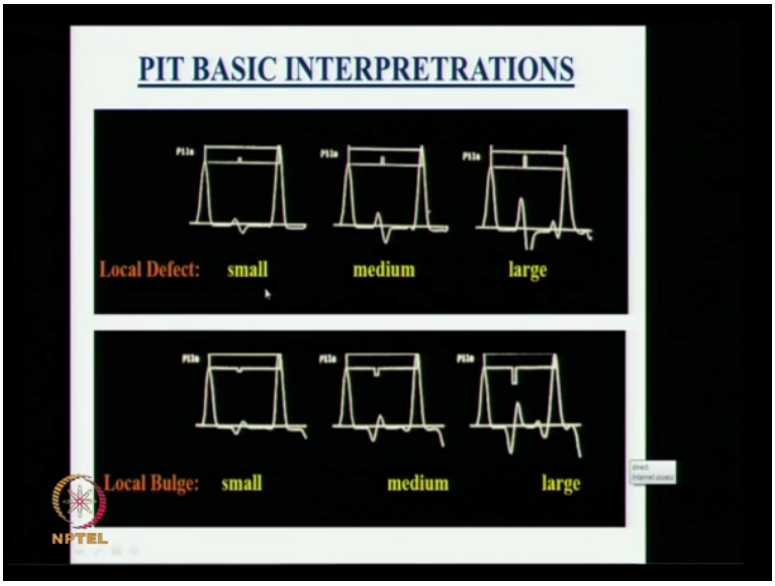

So here you are seeing that these are the two signals which you have to receive. There is small defect you will get like this. There is a medium defect you will get like this. It is a large defect, you will get a signal like this. And if there is, defect means if there is a gap or there is void in the concrete. Bulge means the concrete will bulge. Once it bulges, the grade of concrete goes down.

If it is small bulge, you will see like this. And a medium bulge and large bulges you will see, this type of reading.

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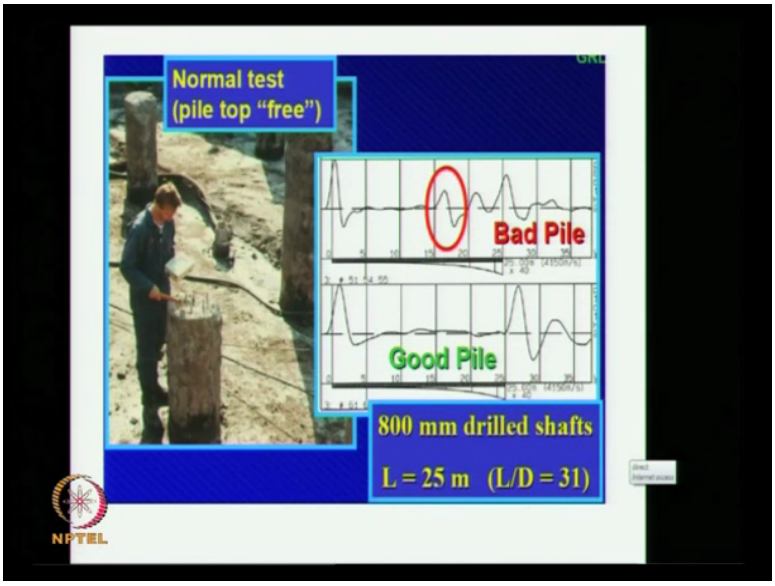

So this is for a bad pile and this is for a good pile. So this L by D ratio I have written here because mainly these tests are limited. Length is the length of the pile and D is the, L is the length of the pile and D is the diameter of the pile. There are some restrictions I think it is coming in the next slide up to what point you can find out.

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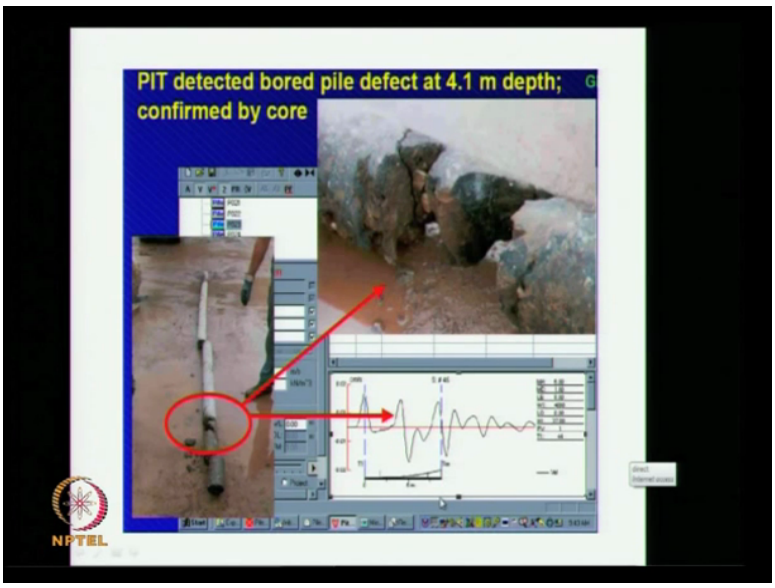

So this shows one pile which was tested. This is the total length of the pile and this will be the first signal, this should be the second signal. So you are showing the problem somewhere here in the record and they have excavated the pile. Then you are seeing how the pile is. So this defect is very big defect. So you can see how much is the signal what you are getting.

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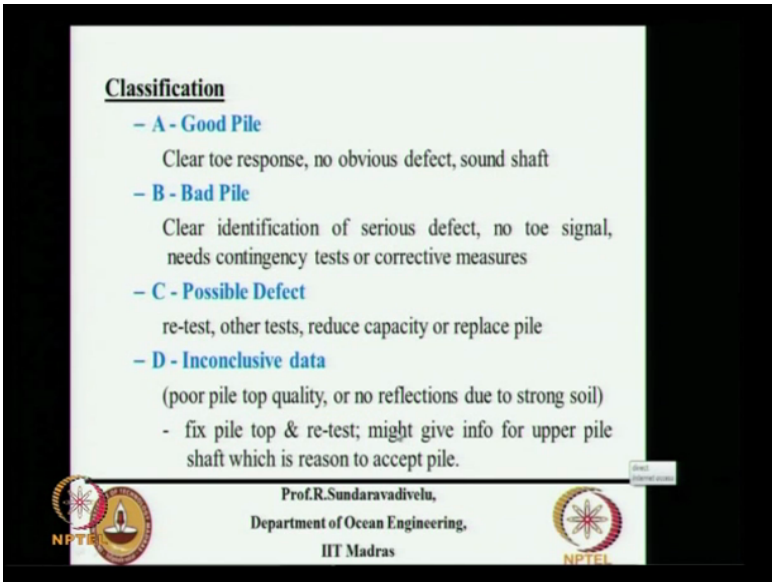

So these are the various classification. Clear toe response, no obvious defect and it is a sound shaft, we can classify like this. Bad Pile: clear identification of serious defect, no toe signal, needs contingency test or corrective measures. Then there is possible defect. I am giving all these details because you can either pass the pile or fail the pile. So one is good pile you can easily say, bad pile you can say. But sometimes you may have possible defect.

In that case you have to do retest and you have to do other type of test or you have to reduce the capacity of the pile or you have to replace the pile. For this you have to necessarily do corrective measures. Sometimes you have inconclusive data, your measurement may not be always perfect, there may be poor pile top, pile top is not good, you may not get good reflections. Then you have to do retest.

Sometimes this test may not be able to conduct but once you construct the pile with the drop deck structure, you cannot do this test. Yesterday I was telling Napier bridge, they wanted us to do some testing of the new bridge which they have built, CBI investigation. They have come to

you and asked us to do. We said it is not possible. Because once you complete the deck structure and concrete it, this cannot be done. Only when the pile is free standing, we can do the test.

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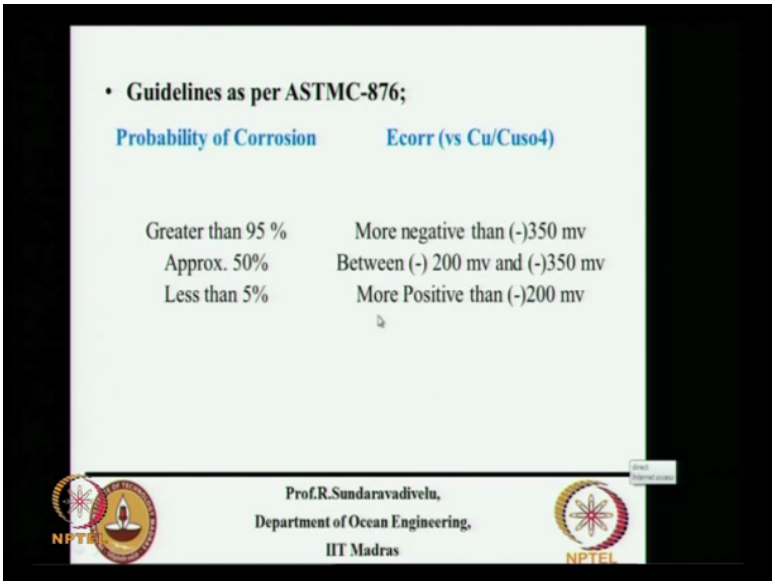

We have to use that L by D ratio up to 30 but sometimes they say it can be done up to 60 also. And it does not give any information about the capacity of the pile, that is a low strain integrity test. It is a low cost, it finds major defects, so you can test every pile. Initial stage itself we can do it, that is what I told in the beginning.