Port and Harbour Structures
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Module No 07
Lecture 36: UPV, Half cell potential, Low high Integrity Test

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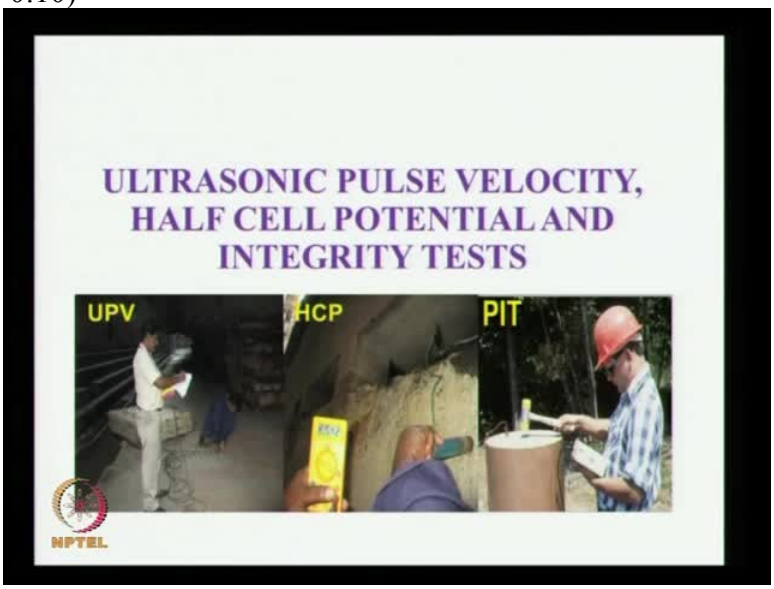

This lecture we will discuss about 3 type of tests which can be done either during construction or any failure as when observed due to ship hit on the berthing structure or failure of the structure due to corrosion and other effects. So in 3 stages we can do, one is during construction, 2nd is due to failure ofcertain elements in the structure due to corrosion, 3rd is if there is any accident that has taken place.

There are 3 tests which we can do. One is called as the UPV. UPV means ultrasonic pulse velocity test. The 2nd one is HCP, that is called as half cell potential and the 3rd one is Pile integrity test. Any berthing structures, we will be using the piles, the integrity test on pile during construction has become a requirement nowadays. These tests are not very expensive compared to the cost of the pile. A 1000 mm dia pile, 20 metre long may cost around 10 lakh rupees whereas the pile integrity test on these piles will be only about Rs. 25,000.

So earlier, we used 5 percent of the piles for doing the pile integrity test. Nowadays, we carry out even up to 100 percent because it gives a confidence level to the owner, the client, the contractor

who does the construction as well as the designer, sufficient information to know whether the pile is in good condition or not. There are some restrictions for doing pile integrity test. As you see here, this is the pile and if you see a small hammer, and there is a pick up here.

This can be done only before construction of the deck system. So once the deck is completed, you cannot do the test. So generally, this is used during construction. Whereas the other 2 tests can be done at any stage.

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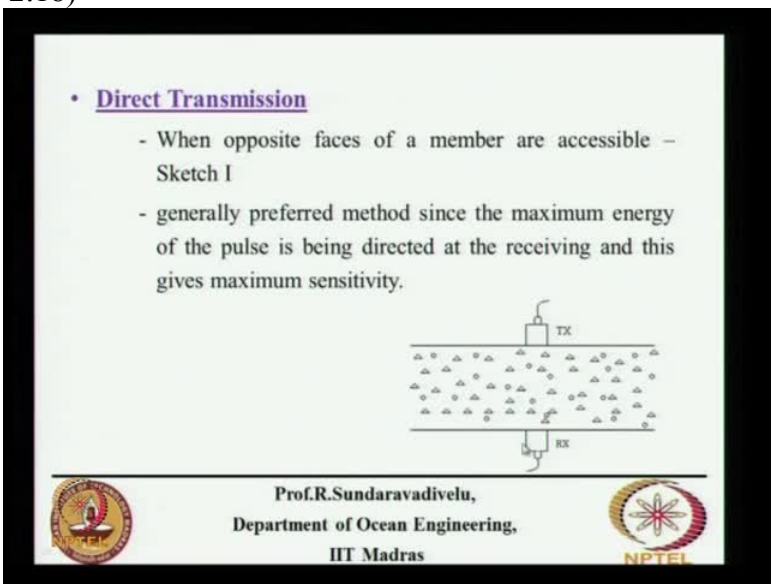

1st we will see ultrasonic pulse velocity UPV test. This test is a wave propagation test. It consists of transmitting ultrasonic pulses, this is of 50 to 60 kilohertz frequency is through a concrete medium and we measure the travel time of ultrasonic pulses for known or measured length. Suppose you know the length or you can measure the length. Then from this you can find out whether the quality of the concrete is good or otherwise. The velocity, that is the speed at which the waves travel is indirectly correlated to concrete quality.

There are 3 ways of measuring pulse velocity. One is called as the direct transmission, this is preferable. The 2nd one is semi-direct transmission, the 3rd one is indirect or surface transmission. Mostly we adopt these 2 methods. I will explain about these 2 now. In direct transmission, we have 2 transducers that are being used here. So one is the transmitting transducer, another is a receiving transducer.

So if we have a tie beam which can have a suppose surface on both top and bottom, then you can have a transmission transducer here and receiving transducer here. That is when both opposite faces are accessible, this is the sketch 1, then you can use direct transmission. This method is generally preferred since the maximum energy of the pulse is being directed at the receiving and this gives maximum sensitivity.

So the sensitivity is very important. For this reason, it is most preferable but normally, we do not have both the surfaces accessible. In piles and columns, it is accessible whereas in beams, you may have a slab on top of it. It is not accessible. Whereas in a slab, it is possible both top and bottom of the slab.

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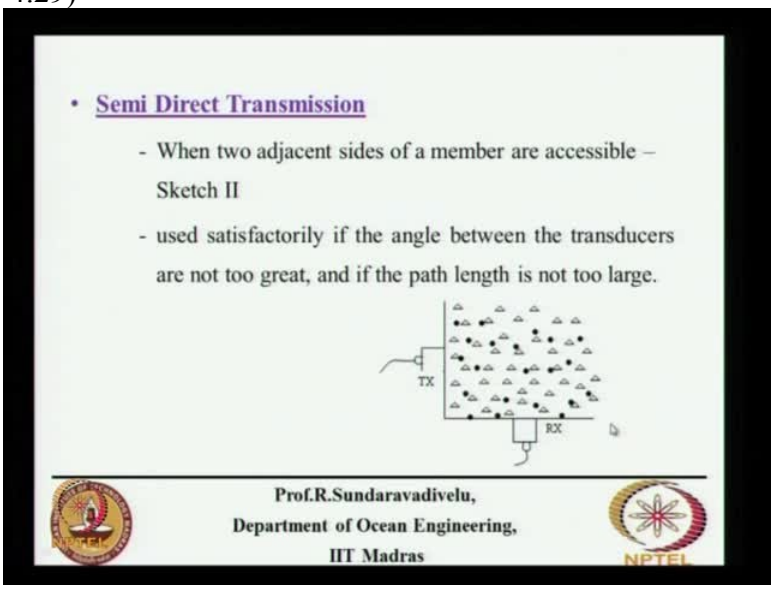

In beams, we use semi-direct transmission where you have these adjusts available at the corner. This is sketch 2. This is satisfactory if the angle between the transducers are not too great, this angle is not too great and the path length is not too large. You cannot take(())(4:51) where the length is very large.

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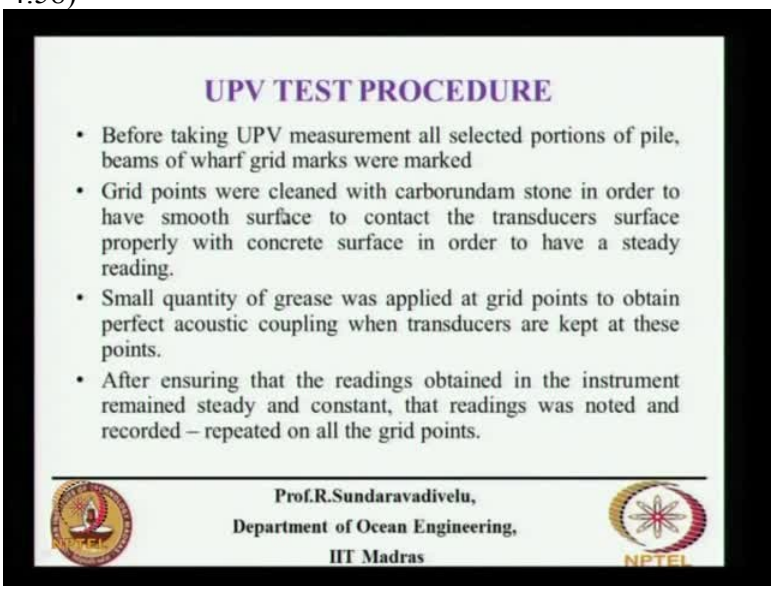

This procedure for doing the UPV test is to select the portions in the pile, beam or slab and we mark the grids. These grid points, we have to clean it using a carborundum stone so that we have a very smooth surface for the contact of the transducers and this concrete surface we have a very smooth surface so that we have a steady reading. This is the reason why we need this smooth surface. We apply a small quantity of grease at grid points, this is to obtain perfect acoustic coupling when transducers are kept at these points.

After we ensure that the readings obtained in the instrument remains steady and constant, the readings were noted. That is, as soon as you get the steady reading and constant reading, then only you note down. Initially you may not get a steady and constant reading. You have to repeat for all the grid points. These are done at least 5 by 5 grid or something like that, not one point alone it is measured.

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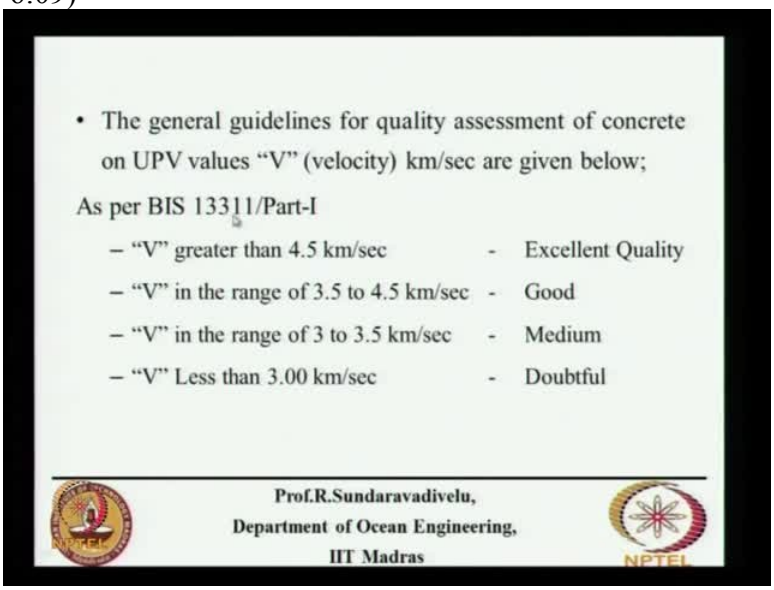

There is a standardbureau of Indian standards, 13311/part 1, this gives what should be the value of UPV we have to get. This is measured in kilometre per second. This Ultra pulse velocity we what we measure is greater than 4.5 kilometre per second, then we can classify this as excellent quality but if it is in the range of 3.5 to 4.5, you can make it as good. 3 to 3.5 is medium, less then 3, it is doubtful. So this Ultra pulse velocity, generally it will measure, it will give an indication of any honeycomb that is formed, any poor quality of the concrete which they offer and things like that.

Is there is a corrosion that affects that concrete quality, that also can be measured by this. This is a very good method and they can have a co-relation between the V value and the grid of concrete also, that is also possible.

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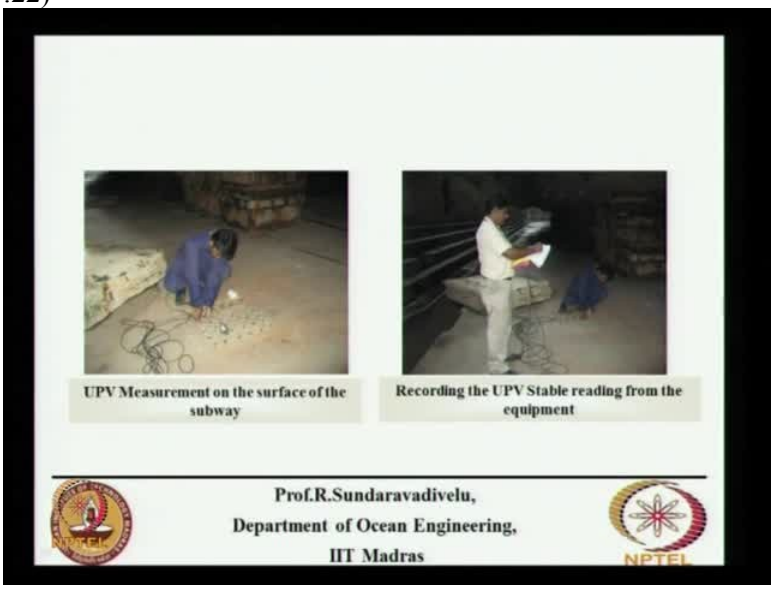

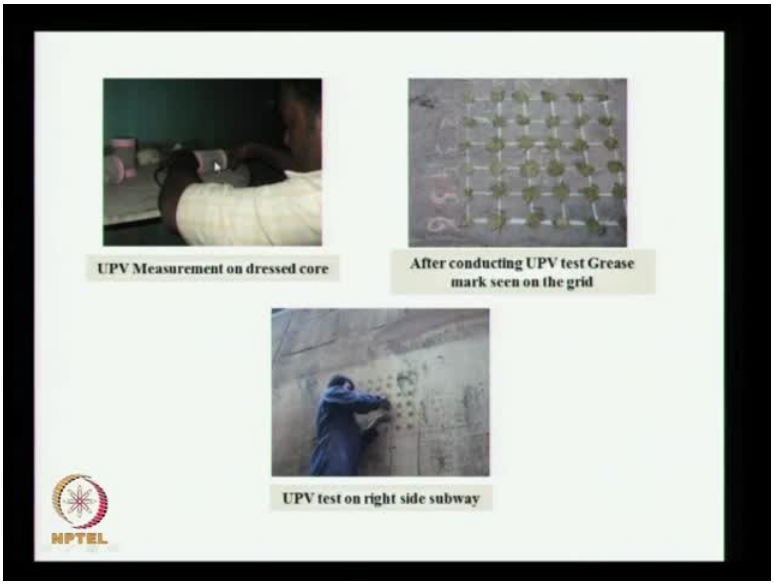

So these are the grid points which are marked, this is on the surface of a subway, then there is a instrument which is used to measure when the reading becomes stable andwe can take a core. This photograph is not very clear but you can take a core. Suppose we are not able to take the

UPP measurement because we are not getting the accessibility or the distance is too large, then what we do is, we take a core. Recently, we have done this for (())(7:54).

We have taken a core and after taking the core, we can bring it to the laboratory. Then we can use a direct method and we can find out what will be the Ultra pulse velocity. Normally, the core is a cylindrical core. We can take the core and then measure the velocity.

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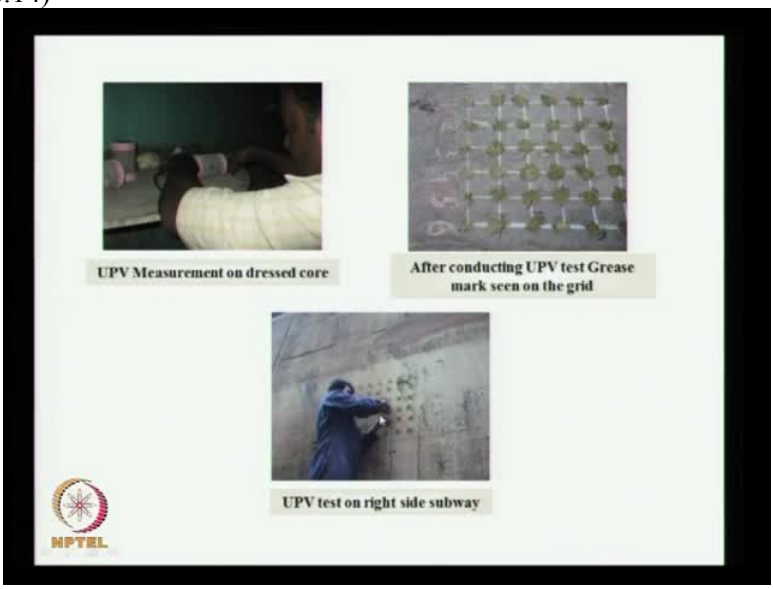

So these aremarkings from the grid. This is the bottom of the slab. Side of the slab also we can do these measurements.

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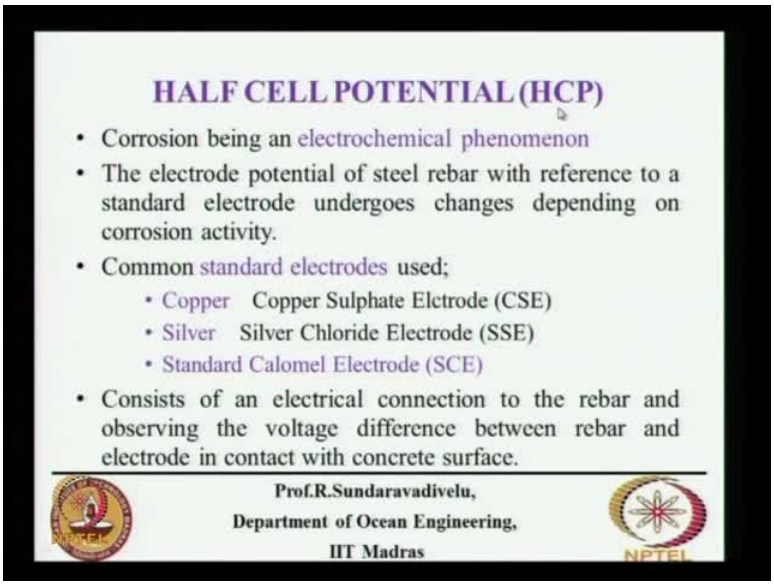

Next we will move on to half cell potential. These concrete structures, we have to measure the quality of the concrete. Quality of the concrete is grid of the concrete. The grid of the concrete is N30, 35, 40, like that.That is correlated to the Ultra pulse velocity. The 2nd information what you need to get is what is the corrosion rate that is taking place in the reinforced concrete structure.

So you have reinforcement in the concrete and if there is a corrosion that is taking place, whether we have to do the repair immediately or it can be postponed, that can be obtained by carrying out this half cell potential test. Normally the concrete corrosion takes place after 4 or 5this visible or the damage we can find out, we can observe only after 4 or 5 years. The contractors who are building the structure, the warranty period is only 1 year or maximum 2 to 3 years.

So this corrosion takes place after 4 or 5 years. So we cannot fix the responsibility with the contractor. So if the construction is done properly, no corrosion will be expected even after 30-40 years. We provide adequate cover, put durable concrete. If not, then we get this corrosion effect on the structure.

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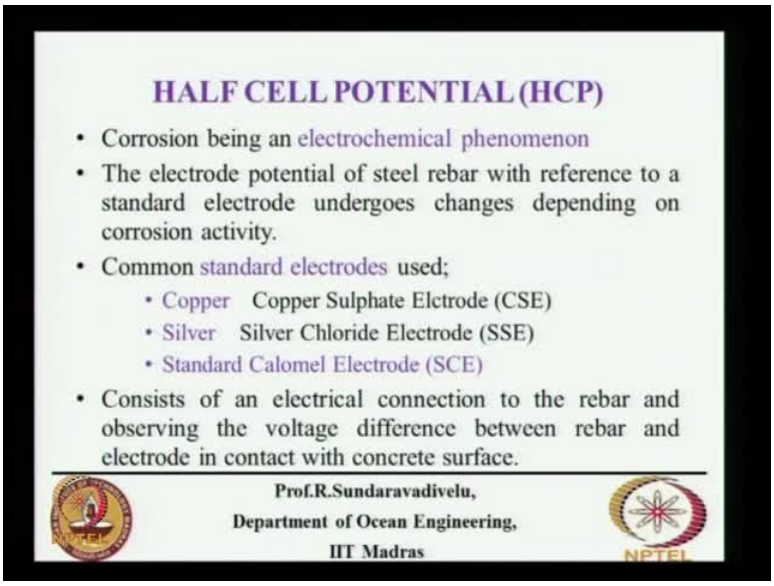

UPV test is used to generally find out the grade of concrete. Half cell potential is used to find out the corrosion activity that is taking place in the reinforced concrete. This corrosion we can define this as a electrochemical phenomenon, so we can measure the electrode potential of the steel Rebar with reference to a standard electrode and this undergoes changes depending on the corrosion activity. So there iscertain values of this potential with reference to a standard electrode.

If we measure that value, we can quantify whether the corrosion is taking place or otherwise. The common standard electrodes are copper, silver, standard calomel electrode. The copper is copper sulphate electrode. It is called as CSE, silver is silver chloride electrode, this is called as SSE. This consists of an electrical connection to the Rebar and observing the voltage difference between the Rebar and electrode in contact with concrete surface. This is what we measure.

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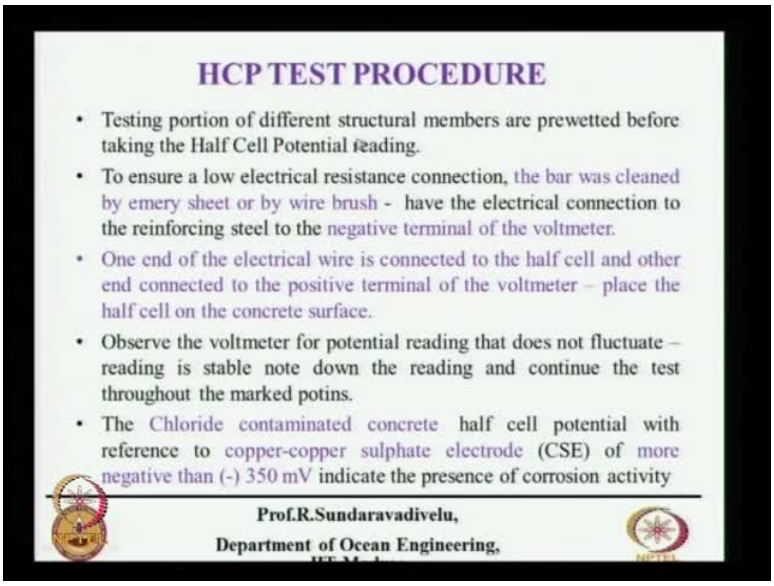

We are testing portion of different structural members and they are prewetted before taking the half cell potential reading. We have to wet the surface. To ensure alow electrical resistance correction, the bar was cleaned. That means you have to expose the bar. If you are measuring thehalf cell potential measurement, if the bar is already exposed you have to clean it. If it is not expose, you have to expose one of the bars, clean it and take the measurement.

Do not leave it as it is. After taking the measurement, you have to do some kind of plastering so that the reinforcement is not exposed to water. So thereis a precaution you have to do. So the bar has to be cleaned by emery sheet or by wire brush, have the electrical connection to the reinforcing steel to the negative terminal of the voltmeter. We use a voltmeter to measure.

This reinforcement bar is connected to the negative terminal. One end of the electrical wire is connected to the half cell and the other end is connected to the positive terminal of the voltmeter. Place the half cell on the concrete surface. That is the other terminal is on the concrete surface. Observe the voltmeter for potential reading that does not fluctuate. This is very important. When you just connect it, it may fluctuate.

You have to keep it for some time to measure or you have to reconnect andtill the fluctuation is not there. If it is becoming stable, you note down the reading and you continue the test throughout the mark points. This is also done for different points. One point to another point, you can mark and measure it. The chloride contaminated concrete half cell potential with reference to

the copper-copper sulphate electrode of more negative than minus 350 millivolts indicates the presence of corrosion activity.

That means when you are measuring when the concrete is contaminated with chloride, that means it accelerates the corrosion. The half cell potential reading if it is more negative than minus 350 millivolts, that is minus 500, minus 600, like that, then it indicates the presence of corrosion activity. If it less than minus, if it is more positive than minus 350 millivolts, minus 250 or minus 200 or minus 150, there is no corrosion activity.

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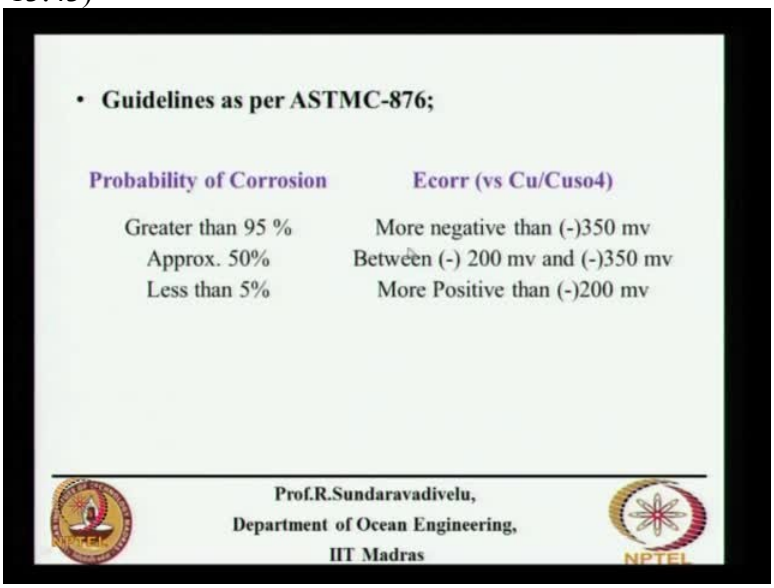

There is ASTM standard. It gives the probability of corrosion vs the measured potential. Probability of corrosion is more than 95 percent if it is more negative than minus 350, that means you have to do immediately pair. if approximately corrosion is about 50 percent if it is between 200 and 350, that is minus 200 and minus 350, this also you have to do repair but not urgent. And maybe 1 or 2 years, you can wait and measure for 1 or 2 years and then see whether it is increasing or otherwise. But definitely, we have to do some repair.

But if it is more positive than minus 200 millivolts, the probability of corrosion is less than 5 percent, that means you do not have to do any repair. That is what it shows. This is a very useful measurement technique.

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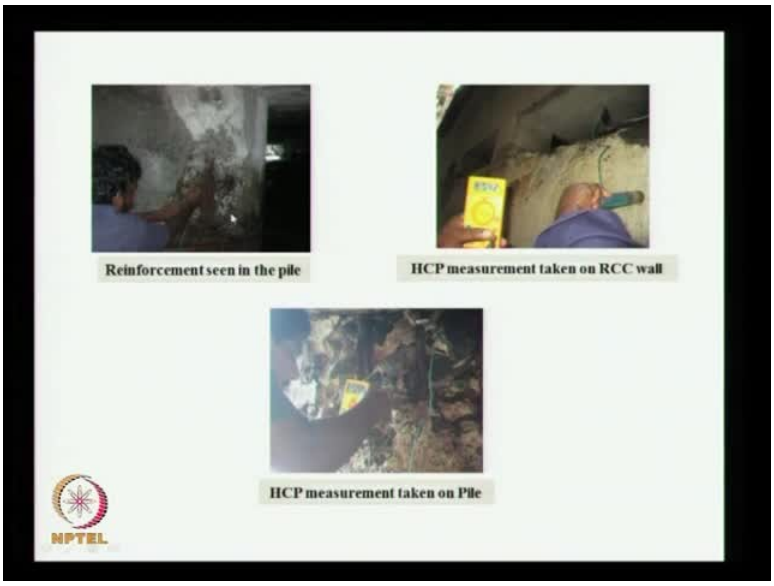

So this shows some reinforcement on the pile, then how you are using the half cell measurement, this also we take the reinforcement on the pile and we are taking the measurement.

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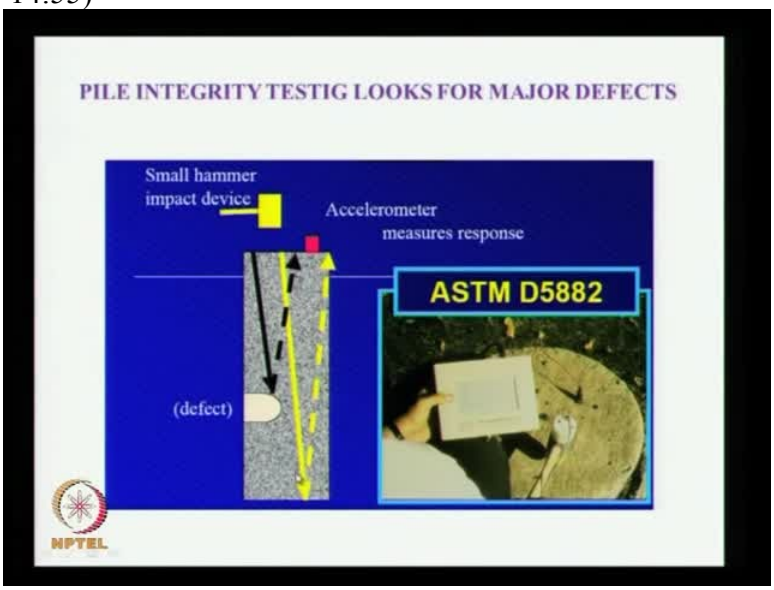

So we have seen 2 types of tests. One is the Ultra pulse velocimeter test, another is half cell potential. The next important test is pile integrity test. The pile integrity test is normally done during construction site. The main purpose of the pile integrity test is all of you know when you do the pile underwater, you may use liner and we do some boring and we pour the concrete from the top using a semi-pipe.

When you do this type ofconcreting with bentonite slurry inside the pile reinforcement cage, if there is a bulging that is taking place in the pile or there is a honeycomb, suppose you are doing the pile, concreting is done from the top and this is the water level, there may be some liners here after some depth, below that you may put bentonite slurry and core through this and remove the soil or rocks, then you may have a undulated surface like this, there may be some bulging that also can take place here because the soil may collapse when you are pouring the concrete.

There can be some defect like this. Sometimes the concrete what you are pouring will be more than the theoretical quantity. You know the diameter, you know the length. So pi D square by 4 will give the area of cross-section into length will give the theoretical quantity. But actual quantity what you are pouring can be measured. Our IS code says if the actual quantity is more than 5 percent, it is not acceptable.

Sometimes we have seen that thequantity, actual quantity what is poured in the concrete, when you pour the concrete is more than 40 percent. We have seen that because of poor quality of, pour type of soil, specially soft clay which collapses. In those cases, we can very well see wherever there is a bulging, here it has shown a defect, if there is a bulging also, there will be a reflection coming from in between place where there is a bulging.

Otherwise normally, we use a hammer and tap it. It goes right up to the bottom and comes back. And we use an accelerometer to measure the response and we find out the time difference between the 1st signal. The 1st signal comes, when does the 1st signal comes in the accelerometer. Accelerometer will measure the signal twice. When does the 1st signal come?

Professor-student conversation starts.

Student: Deflect.

Professor: Hmm?

Student: Deflect.

Professor: what is it?

Student: Deflect response (())(18:08).

Professor-student conversation ends.

The 1st signal will come when you are tapping. Using a hammer when you are tapping it, there will be some disturbance, vibration will be there. That will be measured 1st by the accelerometer. The 2nd signal will come when it goes down and comes back. Suppose there is a defect, you will have a signal in between the 1st signal and the 2nd signal. That is, it goes here and then comes back. So you will have 3 signals.

If we have more defects along the length, you will have more number of responses. From this we can find out whether there is adefect in the pile or otherwise. So this is a hammer, this is a accelerometer, this is a measuring device. So once you 1st tap it, then you will get the 1st peak. Then when the goes down and comes back, then you will get the 2nd peak.

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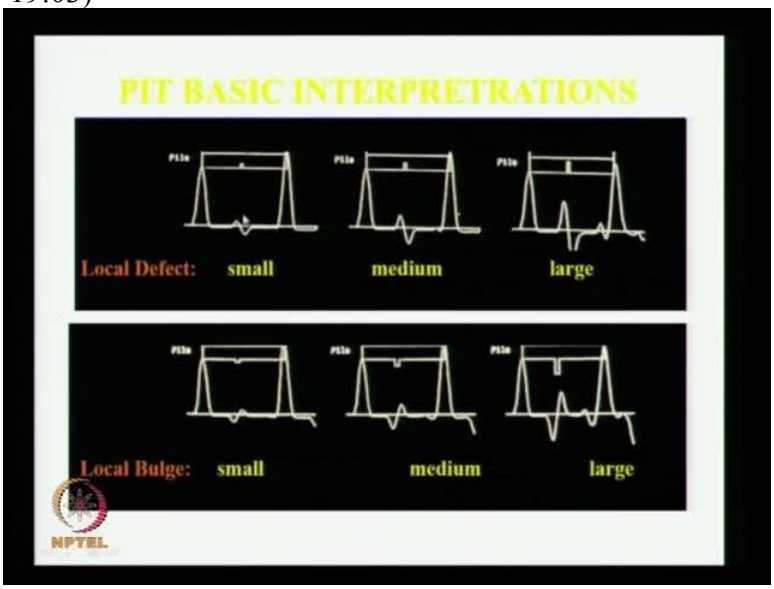

You can see here. This is the 1st measurement what you are taking, this is the 2nd measurement what you are taking. It goes to the full length of the pile and comes back. But there is a defect, small defect, you will get one more response here. Clear no? When you measure the accelerometerresponse, if we have only 2 signals, then there is no damage.

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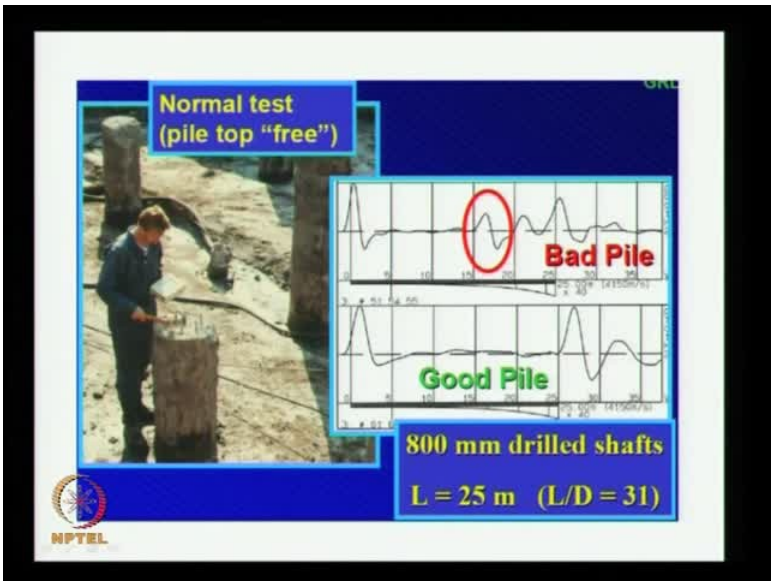

That you can see it here. This iscalled as a good pile, this is a normal test when the pile top is free. And we cannot do the test when the pile is connected with the deck system, I told earlier. So it should be a freestanding pile to do the tests. When there is a good pile, this is the length of the pile which is about 25 metres, this is 0 to 25 metres. There is a 1st signal when you tap it and then the 2nd signal comes somewhere here.

So this distance is about 25 metres. Find out what isthis is intimescale as well as in the length scale. You can find out what will be the speed based on the length of the pile as well as the time taken for measuring these 2 points. It is coming 4150 metre per second. This is similar to what we have got using a UPV test also. UPV test also, you are measuring the Ultra pulse velocity. I have shown you two methods.

What are the methods I told for UPV test? I told 2 methods. There are 3 methods. I explained to methods. Hmm? One of you tell.

Professor-student conversation starts.

Professor: Shashibindu, what are the 2 methods I explained?

Shashibindu: Direct and semi-direct.

Professor: semi-direct. What I have not explained?

Student: Ashwin, what did I not explain?

Student: Indirect.

Student: Indirect.

Professor: This is indirect method.

Professor-student conversation ends.

What we are doing is indirect method. Sowe are getting the signal somewhere. It cannot be classified as a UPV but pile integrity test is somewhat similar to a indirect method. Correct? Indirect method means youraccelerometerthat transmission and receiving transducer will be at the same location. Whereas in the pile integrity test, you have only one accelerometer which measures signal while tapping as well as while receiving.

It is different from UPV but the UPV test indirect method, you will have both the transmission and receiving accelerometers at the same location, okay? So what happened to a bad pile? This is a bad pile. Because we know the distance 25 metre, so you have one signal here, you have at the end you have another signal and you have 2 signals here in between. This shows, there is a failure. I will show some test results which we have done Jaigad ship lift system where one of the dredging barges, dredging vessel has come and hit, recently it has happened.

There it is very clearly shown that there is a crack. That I will show it later. What is written here is a L by D ratio. L is 25 metres, D is 800 millimetre. So L by D ratio is about 31. So generally around 30 or less than 30, thismethod is applicable but people have done even a pre L by D equal to 60 also. There are some limitations for doing the test. Generally most structures, L by D will be between 20 and 30.

You may not go anything more than 30. Maximum, you may go up to 40 and things like that because these piles are lateral loads are very heavy in these piles. Another thing what we can see is this speed will not be different between the good pile and the bad pile. The speed will remain the same4150 meter per second. It will be the same. If the speed is the same, the velocity is the same, it does not mean the pile is good. There is a crack just taken place.

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You can see a pile for which the test has been done and then excavated. The length of the pile is a model pile which is 6 metre long. This is the initial signal, this is a X signal. There is a defect that has taken place at a distance of about 6 metre. I think the pile length is more I think. It is about 12 metre or so. So at 6 metre you can see there is no concrete. So the signal has come back from this particular location.

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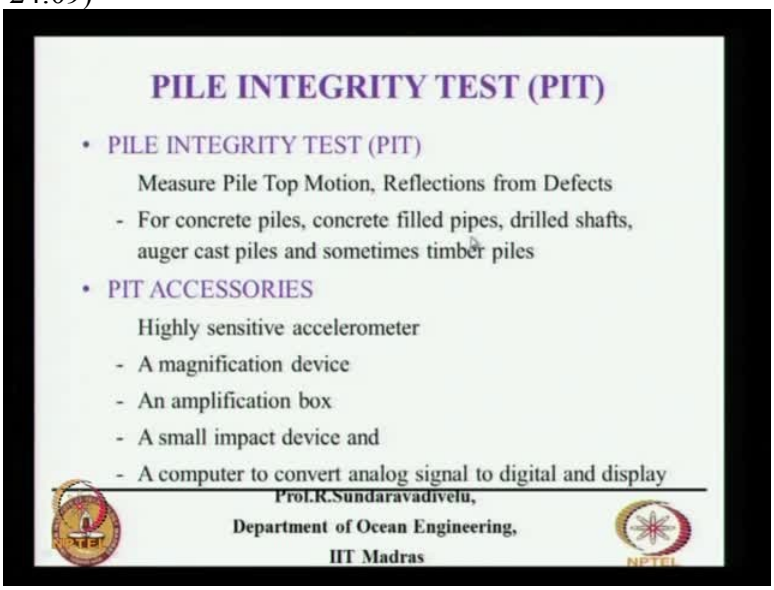

So once again we will go from the beginning, pile integrity test in short form it is called as PIT. This measures the pile top motion, reflections from defects. That is what it measures. This can be used for concrete piles, concrete filled pipes, drilled shafts, auger caste piles and sometimes timber piles also. What are the accessories required for pit? We need a highly sensitive accelerometer. Normally when you do any type of tests, we need 3 basic requirement.

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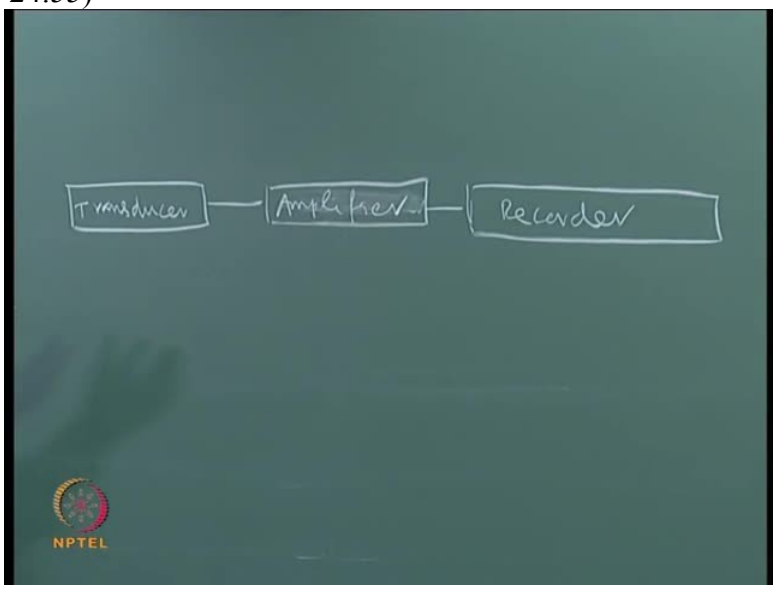

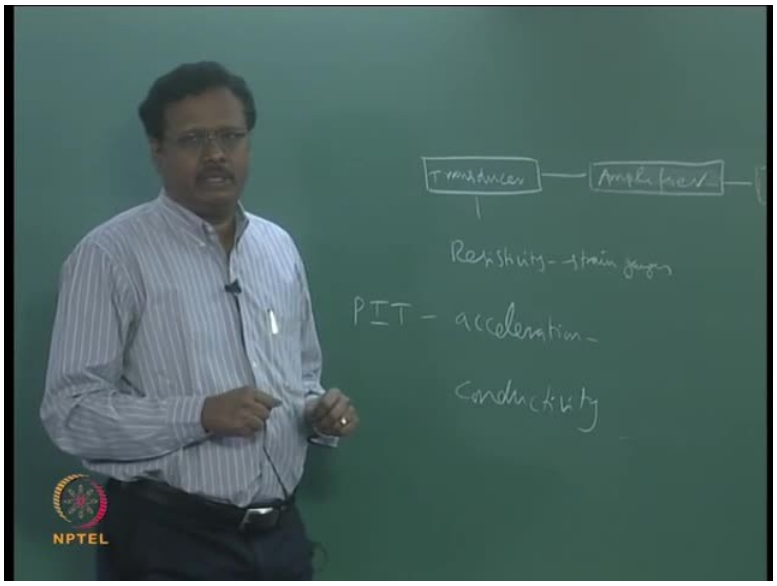

One iscalled as a transducer. Another, what we need is a accelerometer, 3rd one what we need is a recorder. So when we want to do any test, we need a transducer. I am sorry, this is not accelerometer, this is amplifier. The 3rd one is recorder. These are the 3 instruments that are required. The transducer means, itis attached to the structure, this transducer. Transducer can measure the resistivity, it is used in strain gauges.

It can measure the acceleration, it can measure the conductivity also. This acceleration is a acceleration transducer that is what we are using in pile integrity test. So we measure the acceleration. That is when you heat the pile top, then you get somesome vibration that you are measuring the acceleration. Then conductivity is generally used to measure the in wave probes, we use all this.

So if the signal what you are measuring is not possible to record because the value what you are measuring is very low then we use an amplifier. Amplifierwhat does it do is it amplifies the signal what you are measuring. There is some disadvantage in using amplifier. What will be the disadvantage? If you use an amplifier, there can be some disadvantage. It may pick up some noise.

Noise also will get amplified. So if you use a very high sensitive transducer, you do not have to amplify too much. Supposethis transducer if you have to measure 0.01 g where g is the acceleration due to gravity, the sensitivity of that order, then you may not even need an

amplifier.Directly you can record. This recorder, there are various types are there. We have what is called as the strip chart recorder.

We can also have an oscilloscope. Now we have a data acquisition system where you can use a computer directly to measure the readings.

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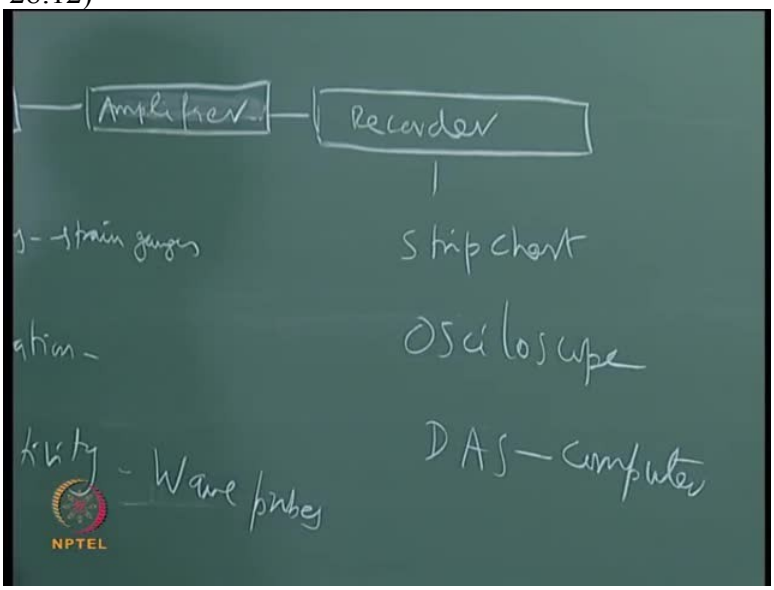

This oscilloscope and the strip chart, you will get the analog reading where as this computer you will get the digital readings. So you have to store this, then bring it back for process, that is what we do. So that is what is written here.

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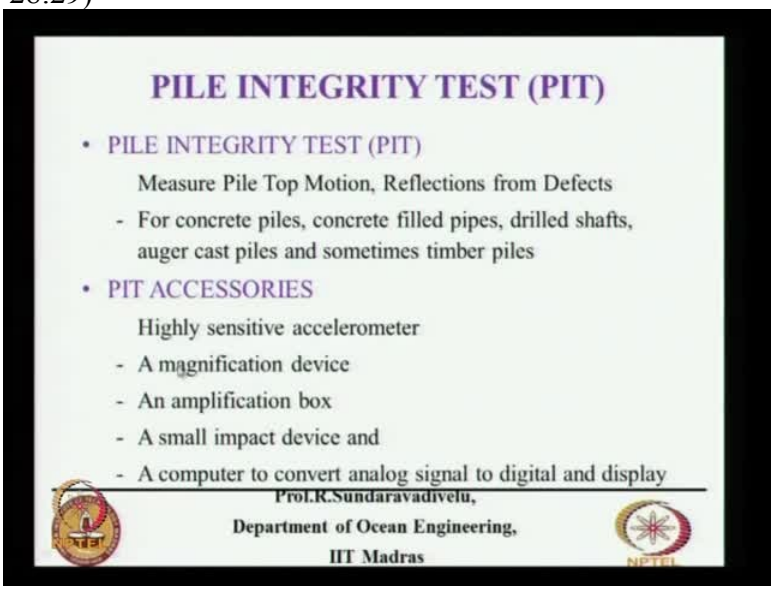

What is written here is, we need a highly sensitive accelerometer, then we need a magnification device, then we need a amplification box. These 2 are together termed as an amplifier. Then we need a small impact device to give thevibration or some signal. Then we have to have a computer, means the recorder to convert analog signal to digital and display. This is what we need.

So this is the transducer, these 2 are amplifiers, this last one is the recorder, this impact device is to give the impact the structure. We need a smallhammer. So when we talk about this pile integrity test, we have 2 types of tests.

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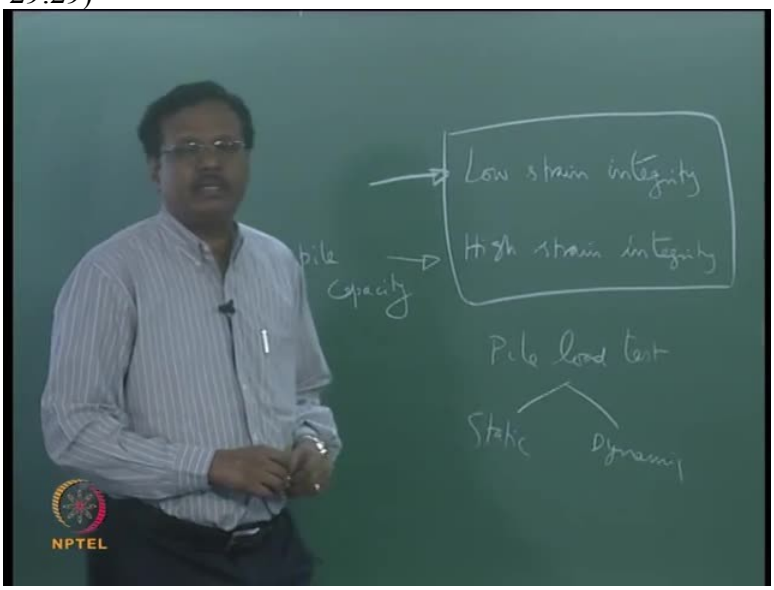

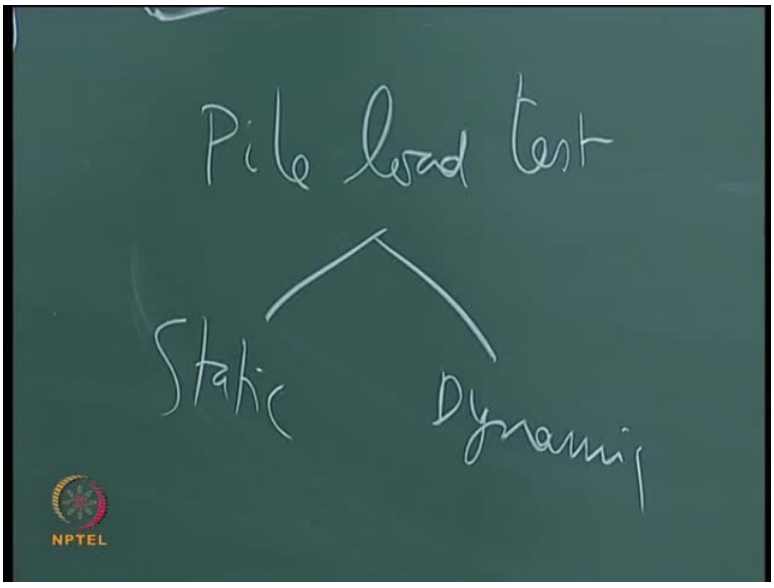

One is called as low strain integrity test, another is called as high strain integrity test. Now when we talk about the pile integrity test, we can classify into 2 types. One is low strain, another is high strain. What I am discussing now is only the low strain integrity test. High strain integrity

test, I will discuss in some other class. The low strain integrity test you cannot find what is the capacity of the pile.

We are talking only about pile integrity test. You cannot fight on the capacity of the pile in low strain integrity test whereas if you do a high strain integrity test, you can get the pile capacity. So we had already a lecture where we said how to do the pile load test. So this pile load test can be 2 types. One is static, another is dynamic. Thishigh strain integrity test is a part of dynamic test, is not very expensive compared to a static test, that we will be using.

So a low strain means you use a hammer to give an impact. So it doesn't create very high strain in the member. That is why, it is called as a low strain integrity test. Whereas in high strain integrity test, we will be giving at least some percentage of the capacity of the pile as a hammer weight and it will drop from 3 to 4 m height. Okay? In that case, the strain level in the pile will be higher. That is why we call it as a high strain integrity test. That we will discuss separately.

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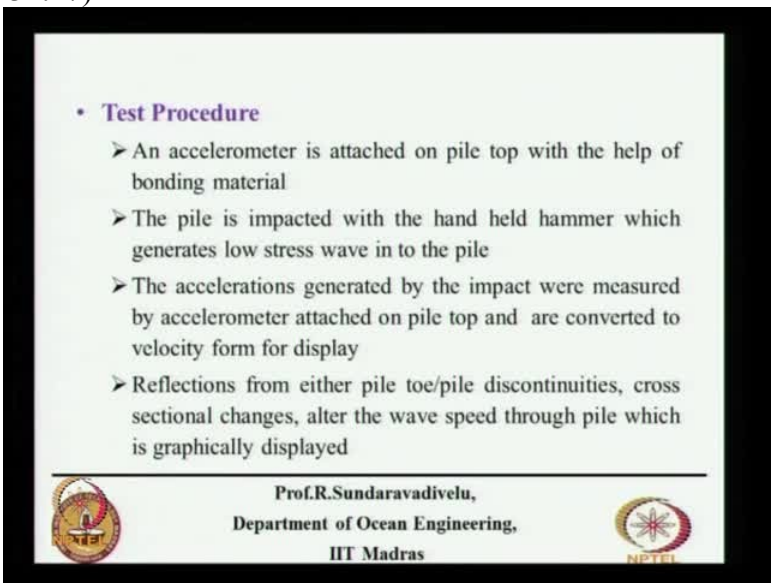

So what is the test procedure? There are basically 4 steps in this procedure. You have to attach an accelerometer on pile top with the help of a bonding material. Then you have to impact the pile with the handheld hammer which generates low stress wave into the pile. The acceleration generated by the impact were measured by accelerometer attached on the pile top and are converted to velocity from for display.

We don'tdisplay the acceleration. Whenever we do any measurement using an accelerometer, you can plot as an accelerometer or a velocity or a displacement. How to get velocity from acceleration?

Professor-student conversation starts.

Professor: Suppose we measure acceleration. How do you get the velocity?

Student: (())(32:29)

Professor: Hmm?

Student: Multiply into a time duration

Professor: Multiply but what is the correct mathematical term? From acceleration to velocity you have to get, what do you have to do?

Student: Differentiate.

Professor: Hmm?

Student: Differentiate.

Professor: what is it?

Student: Differentiation.

Professor: Differentiation? I am asking acceleration to velocity.

Student: Integration Sir.

Professor: Integration?

Student: Integral of…

Professor: So if you integrate acceleration, you will get velocity. If you integrate velocity, you will get displacement.

Professor-student conversation ends.

In oscilloscope, the analog device, it can be used online also. Normally for many experiments, we use an oscilloscope which gives the picture correctly and you can also integrate and see the values. The reflection from the either pile toe suppose there is no defect, the reflection will come only from the pile toe. Otherwise, where there is a discontinuity of the pile, discontinuity of the pile can be due to some cracks that is formed in the pile or due to some honeycombs or cross-sectional changes.

Cross-sectional changes is bulging of the pile all through the wave speed through the pile which is grasphically displayed. That's what we do so whenever we do a pile.

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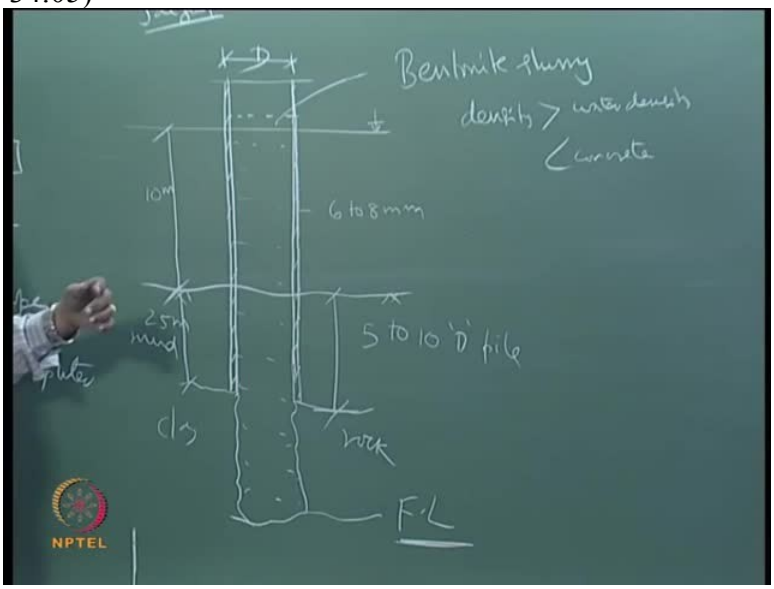

So this is your water level, this will be your seabed. You have a gantry that I am not drawing it, then you will be having a liner called a steel liner. What is the thickness of liner normally we use?

Professor-student conversation ends.

Student: (())(34:30)

Professor: Hmm?

Student: (())(34:32)

Professor: How much?

Student: (())(34:33)

Professor: I am not hearing.

Student:(())(34:38)

Professor: Normally we use suppose 6 to 8 millimetre thickness of the liner plate. How much depth it has to go below the seabed?

Student: (())(34:52)

Professor: Hmm?

Student: (())(34:54)

Professor: Below the seabed, how much depth it has to go?

Student: (())(34:59)

Professor-student conversation ends.

Normally, it depends on the type of soil. Generally we take 5 to 10 times the diameter of the pile where D is the diameter of the pile. Suppose 1 metre is the diameter of the pile. We go about 5 to 10 meter. Whether it is 5 metres or 10 meter, depends on what is the type of soil here. If the soil is sandy soil or stiff clay, we can shaft it 5 meters. If it is a loose sand or soft clay, it has to go to 10 meter. If it is a dense sand and stiff clay, 5 meter.

Sometimes they take it up to the suppose the rock is available here, they take it up to the top of rock. In many places, it has been done. For oneone particular project in Jaigad where we are designing a shift lift as well as a berthing structure, the water depth maybe around 10 meter or so whereas we have gone up to 25 meters when it is all mud, not even clay. mud is flowing here.

We have taken the liner right up to the top of rock, then we have done. So now this is the problem. Suppose you are not having rock or even if you have a rock, then you will be having this boring that is taking place. So you will bore through the rock and this is your level which is called as the founding level. This is called as the founding level. When you are doing this boring, suppose it is not rock, suppose it is a very soft clay, even if you put bentonite slurry, bentonite slurry will be filled up to this level.

So you fill this with bentonite slurry so that the borehole will not collapse. This bentonite slurry what we are using, this density will be controlled. This density should be greater than water density and it will be less than concrete density. So this bentonite slurry density is slightly more than water density and less than the concrete density. That is what we fill up this.

Suppose this clay collapses, then we may have a bulging like this. That means, the cross-section area will increase where there is a bulging. So this bulging take place if we suspect that there is a clay which is very soft, then you have to take the liner right up to the place where the soil is very bad. Do not go by this 5 times the diameter and 10 times the diameter of the pile and all. Sometimes we take the liner right up to the founding level also. That is what is written here.

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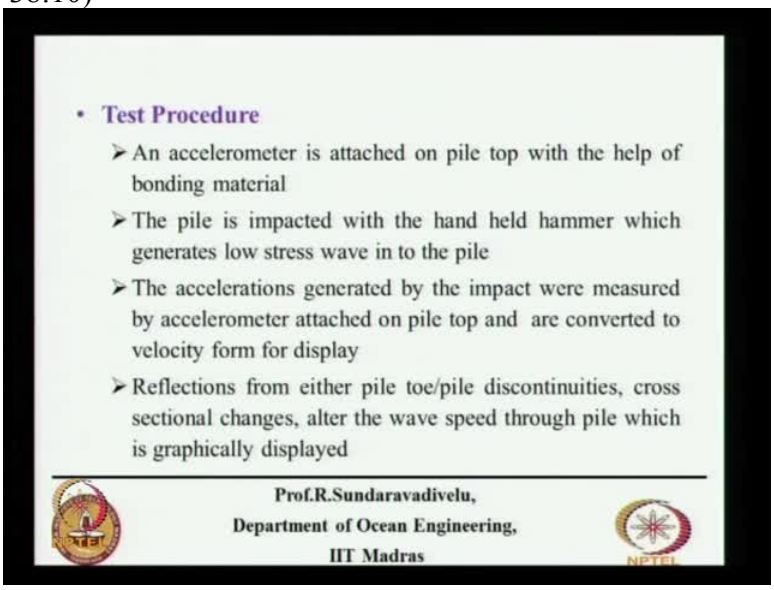

The reflection from either pile toe or pile discontinuity, cross-sectional changes, alter the wave speed through pile which is graphically displayed. What about the pile discontinuity? Suppose I

told in Jaigad, there is a dredger which is nearby, it has come and hit the pile like this. Then there is a crack which has formed somewhere here. Maybe, there is a crack which has formed somewhere here. So this is called as the discontinuity.

That also can be measured. So the cross-sectional changes because of the bulging, what happens is when the bulging takes place here, there is, the bentonite slurry goes here but still, there is a mix of soil and concrete here. That is why, the quality of the concrete will not be very good. What do we do if the pile integrity test shows there is a discontinuity but there is abulging?

So what normally we do is easiest thing is to discard that pile, drive another pile nearby. Otherwise, we assume wherever the discontinuity is there, wherever the bulging is there, we assume that point to be a hinge and that is the moment of inertia and cross-sectional area, 250 percent of the original pile, redo the analysis and find out whether neighbouring piles are taking the additional load. In that case, we do not have to put additional pile.

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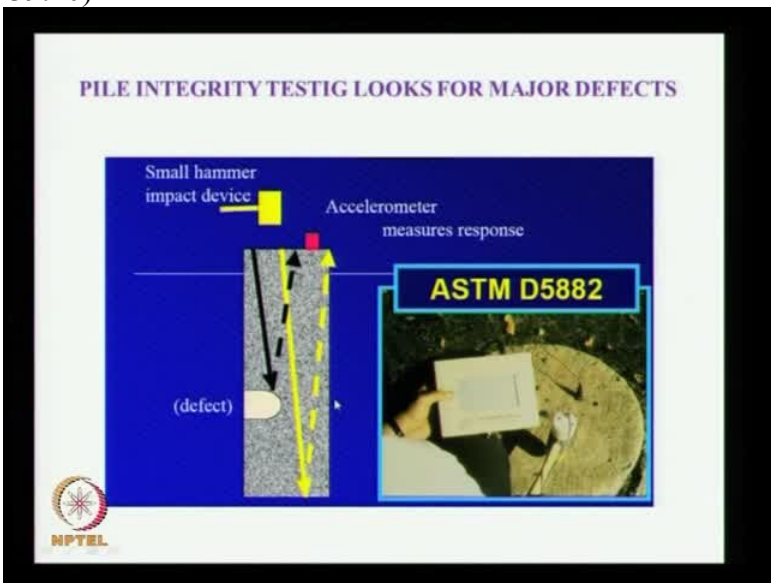

This I already explained, if there is a defect or if there is a bulge somewhere here, you will get the 1st reflection from here. The speed with which it is travelling is constant. That is the speed what we know. So the distance is twice the distance at which you have the defect. So you know the speed at which the waves are travelling depending on the type ofdepending on the quality of concrete which I already explained, about 4000 to 3500 metre per second.

So based on which we can find out at what time interval your signal which is going here comes back? So if you know it is 4000 metre per second and if the length is around 20 metres is the length of the pile, when it will come back, after how many seconds it will come back?

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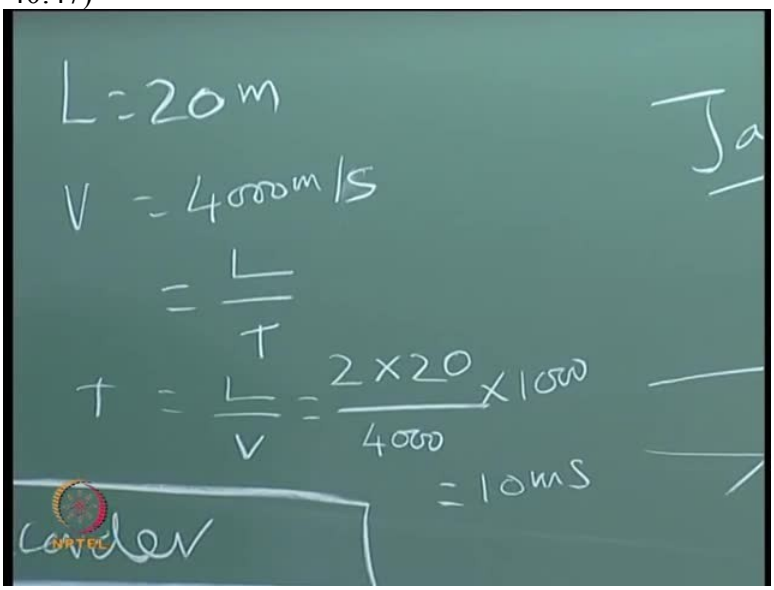

Supposelength of the pile is 20 metres, plus it is about 4000 metre per second, V is equal to L by T. I want to find out T.

T will be is equal to capital L by V. So here L we have to take 2 into 20, twice the length you have to take. Suppose 20 metres is the length of the pile, you have to take twice the length because the signal goes down and comes back. It goes on in an inclination and comes back. Do not worry about that. You take twice the length provided by V is 4000.

To convert into milliseconds, you make it as 1000, so this becomes 10 milliseconds. This 40,000 divided by 4000, that means, it is coming back in 10 milliseconds. Here, we assume that the velocity with whichthis acceleration travels is at about 4000 metre per second. Depending on the grade of concrete, we can assume this value, 4000 metre per second or 3000 metre per second. You know the length of the pile because you know the top-level and founding level from which you know the length of the pile. So you can find out what distance it has to come.

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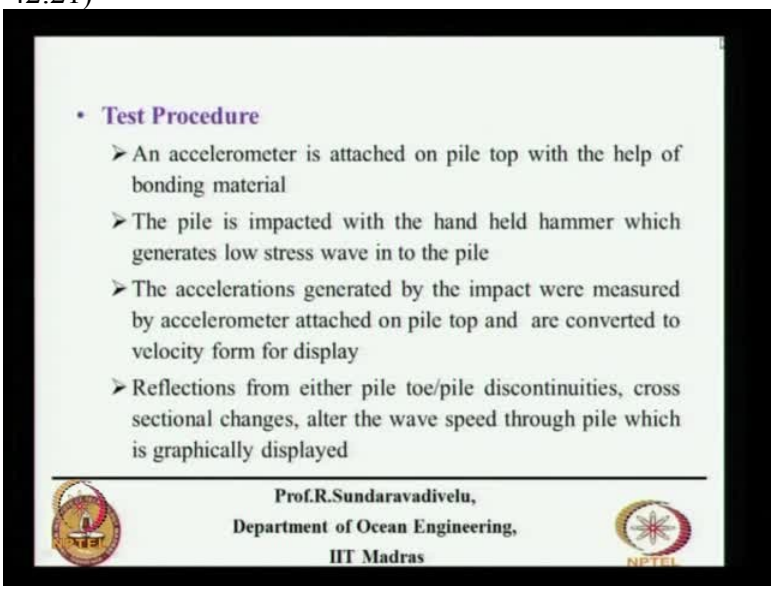

So when you see the result, you will know what is the length you are getting. So the accelerometer is attached on file top with the help of bonding material and we are measuring the reflections.

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42:35-43:07

So this is a 10 millisecond I was talking about, it should come. If the defect is very small, this signal is very small, intermediate signal. If it is very big crack, then it is a medium signal. Very large crack, it will be like this. There will be one more pic like this. Sometimes you can see it much more than this also. This is for the local defect, a crack and similarcan be seen for the local bulge also, how much it is happening like this. This is a theoretical thing.

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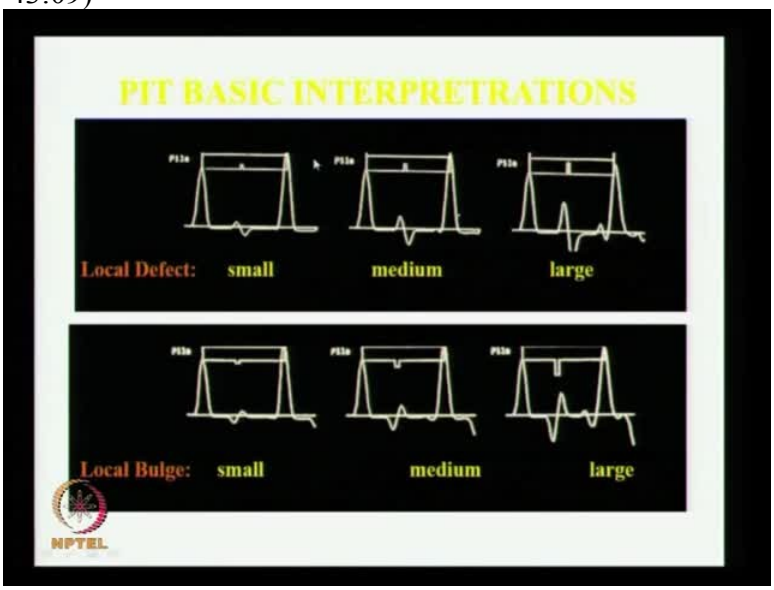

But actual measurement is shown here. So respecting the signal after 10 milliseconds but in between in a bad pile, you have got one more signal. So this shows that the signal is not, there is some defect in the pile.

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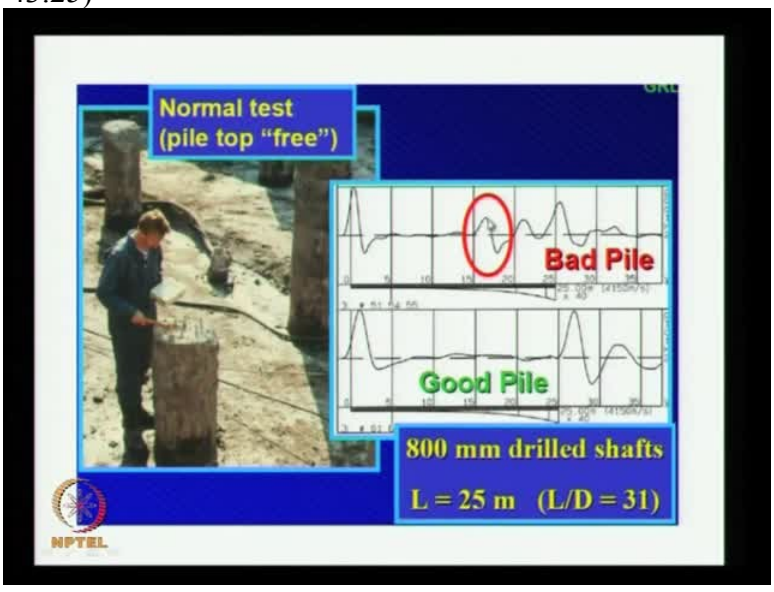

This is already explained, when there is a local defect. This can take place when you do not do the concreting properly.

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That is, normally when you do the concreting in offshore structures like berthing structure, what we do is, we put a drummy pipe from the top with a funnel at the bottom and then we pour the concrete from the top. Then you withdraw the drummy pipe as the concrete is being filled up slowly. So if you do not do this process properly, then also the bulgethis concrete will not get filled up to the entire hole.

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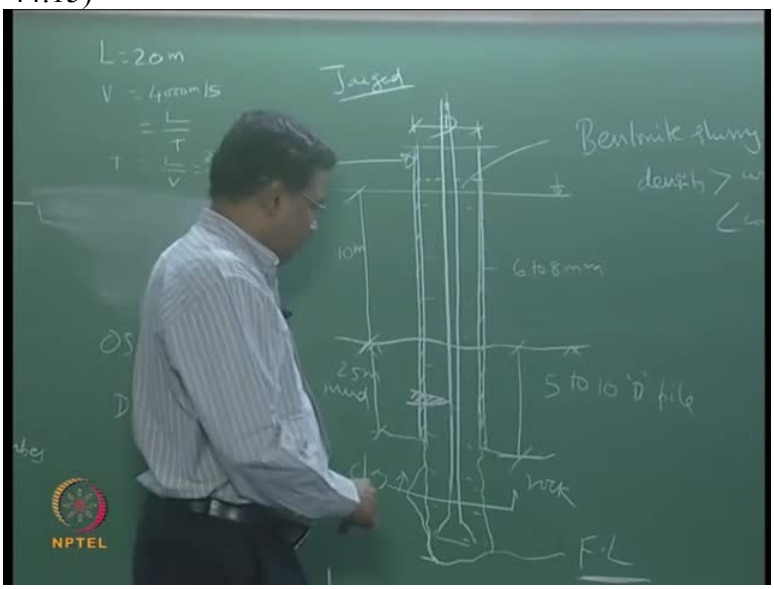

Whenever you do the tests and we get the response, we classify this into 4 categories. The 1st category is a good pile, 2nd category is a bad pile, the 3rd one is a possible defect. The last one is

a inconclusive data. So if there is a inconclusive data, that means that whatever pile integrity test what you are using, is not able to clearly say whether the pile is good or bad. That case you have to go for some other type of test only.

So this can cap and if there is a poor pile top quality or there are no reflection due to strong soil, the soil is very strong or if the pile quality is not good, then you will have inconclusive data. But generally it comes into these 3 categories. When you do the construction by a good quality contractor, with proper management control, thenyou will see the clear toe response, no obvious defect and you will have a sound shaft. So a good pile, you can classify that.

The bad pile means is a clear identification of a serious defect. There may not be any toe signal, needs contingency test or corrective measures. Possible defect, you have to do re-test, other tests, reduce capacity or replace the pile. That is what I told, you have to replace the pile or you have to reduce the capacity, 250 percent or something like that, depending on the type of failure that is taking place.

So this possible defect, they will identify where the defect has taken place, what depth the pile is not good, all those things you can get. It is only qualitative but it clearly shows that there is a defect in the pile.

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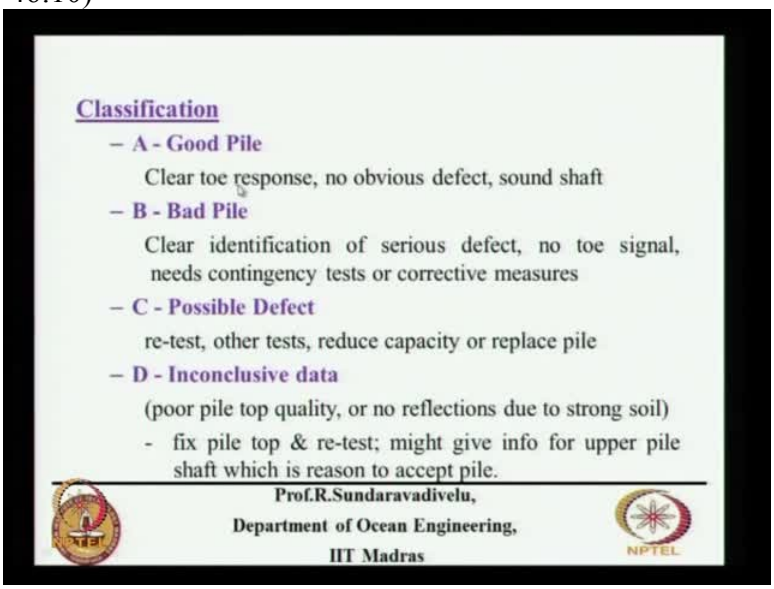

The pit conclusions, the pile integrity tests, finds major defects, very low-cost. I said it costs around 20 to 25,000 rupees whereas the cost of the pile is 10 lakhs to 50 lakhs, depending on the diameter. So we can test every pile. It does not take much time also. Once you complete the piling, after 28 days, you can start doing the tests. The cracks or gaps limit transmission of wave and there is no information about capacity. So we do not use it for getting the capacity of the pile. Thank you.

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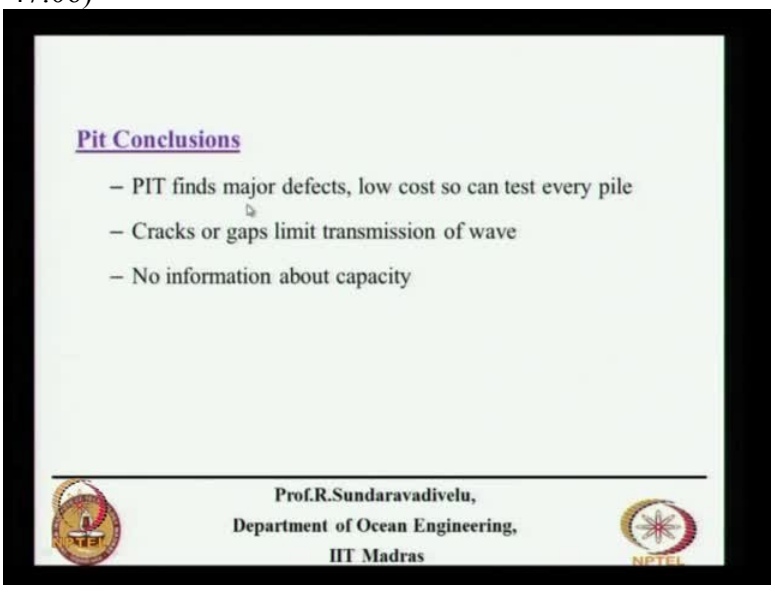

So if some questions have to be asked for this particular lecture, we will ask you what is meant by the procedure for Ultra pulse velocity meter, half cell potential and pile integrity test, this is one of the question which can be asked. Then we can ask whether pile integrity test will it estimate the capacity of the pile? That we can ask. Then there is one more slide which shows the different test procedures.

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ULTRASONIC PULSE VELOCITY (UPV)

- Is a wave propagation test
- consists of transmitting ultrasonic pulses of 50-60 kHz frequency through a concrete medium and measuring the travel time of ultrasonic pulses for known or measured length.
- Velocity – indirectly correlated to concrete quality
- Three ways of measuring pulse velocity
  - Direct Transmission
  - Semi-direct Transmission
  - Indirect or Surface Transmission

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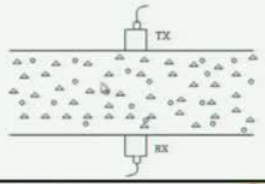
Department of Ocean Engineering,
IIT Madras

- **Direct Transmission**
  - When opposite faces of a member are accessible – Sketch I
  - generally preferred method since the maximum energy of the pulse is being directed at the receiving and this gives maximum sensitivity.



Prof.R.Sundaravadivelu,
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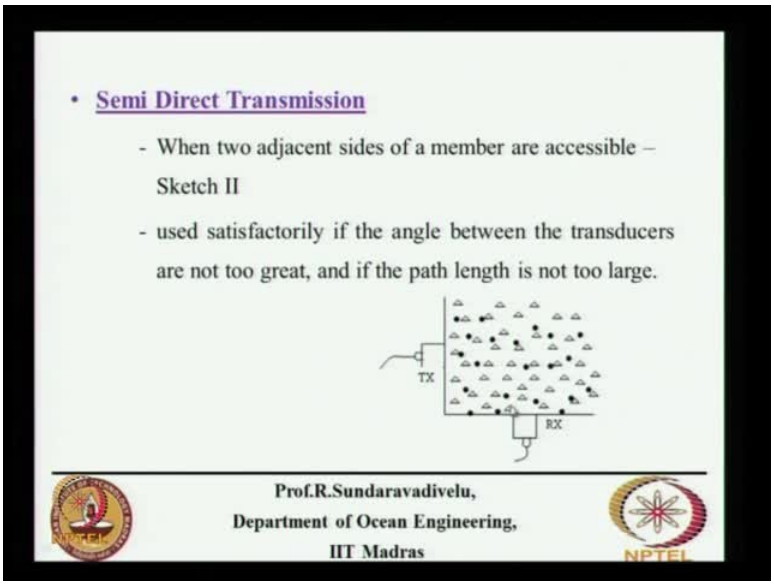
IIT Madras



So we can explain with sketch, what are the 3 different methods for measuring the pulse velocity, direct transmission, semi-direct transmission and indirect or surface transmission. So I have shown the sketch only for direct and semi-direct. Indirect means only one surface will be exposed. You will have both TX and RX at the same place.

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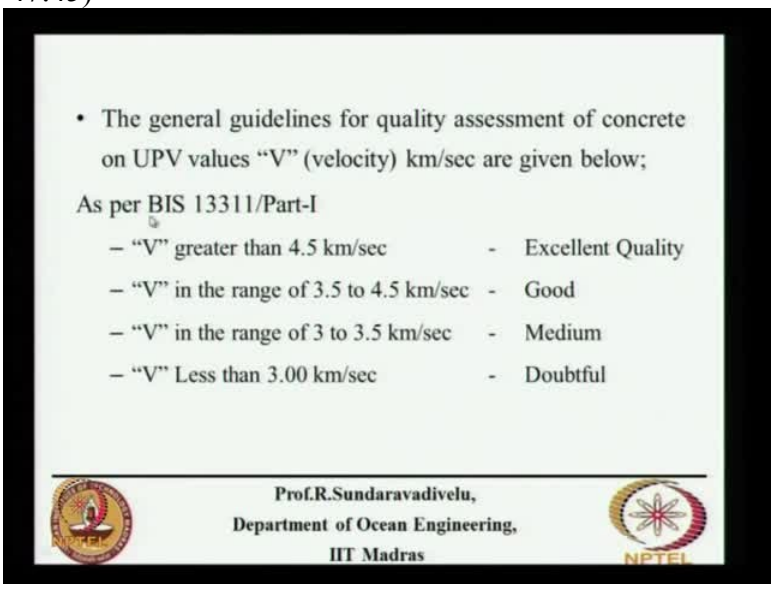

Then this particular table, you should remember the value, that is the measured value will be in between 3 to 4.5 kilometre per second. We have measured even very close to 4.85 of 4.95

kilometre per second and if the quality is very bad, we have measured even 2700, 2.7 or 2.6 kilometre per second. So you should remember this value.

The UPV tests measured value should be between 3 to 4.5 kilometre per second. In any engineering discipline, you should remember these values. Suppose you are getting 200 kilometre per second, that means something is wrong. The calibration of instrument is not good or things like that. You will never get. You will get anywhere between 3 to 4.5 kilometre per second. Maybe 4.5 can increase by 10 percent. You may not get anything more than that.

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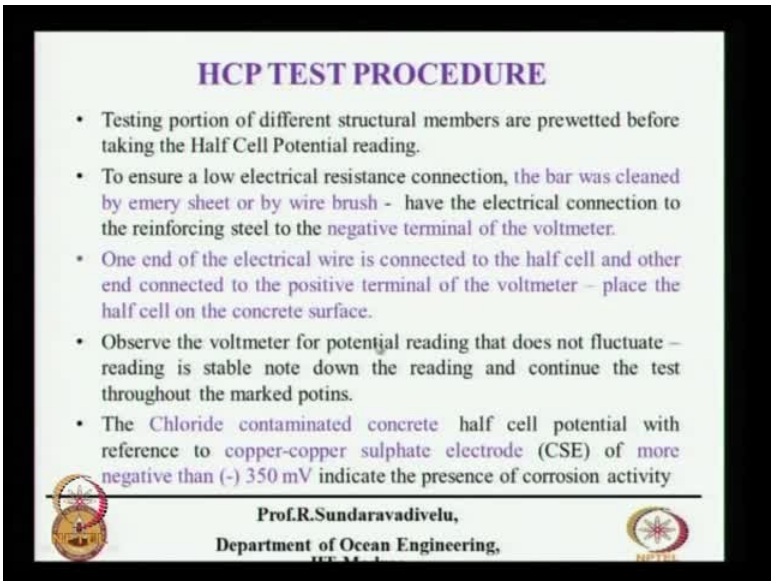

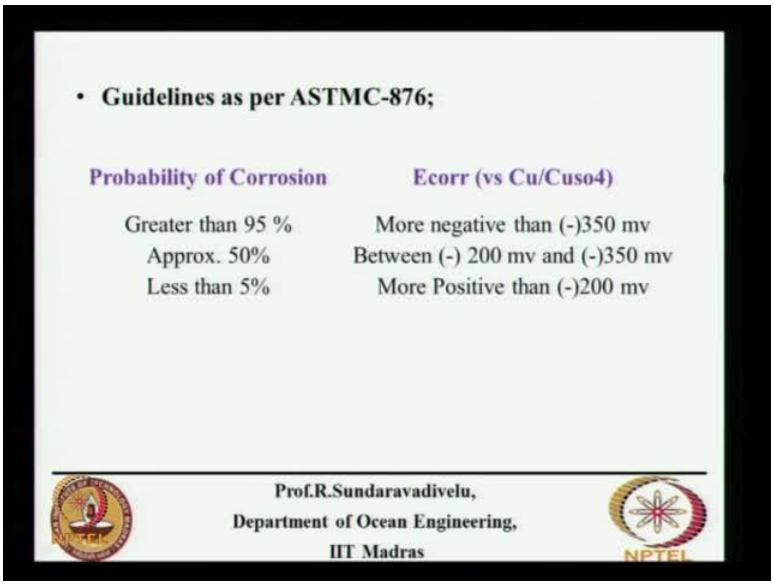

When you talk about half cell potential method, you have to write what are thedifferent procedures to be followed and this table is very important. So when you measure the value more negative than minus 350, we have measured even minus 500, minus 600 and all. So this value is

very much important. So more positive than minus 200. You always get a negative potential, you may get minus 100, minus 50, minus 150.

In that case, the probability of corrosion is less than 5 percent, you do not have to do any corrective methods. Otherwise, you have to do some procedure for repair. This also I will discuss in one of the classes, how to do the repair when you have more negative than minus 350 millivolts. So these values also you have to remember, values are between minus 200 to minus 350 but you can get minus 600, minus 800, the corrosion potential is very high.

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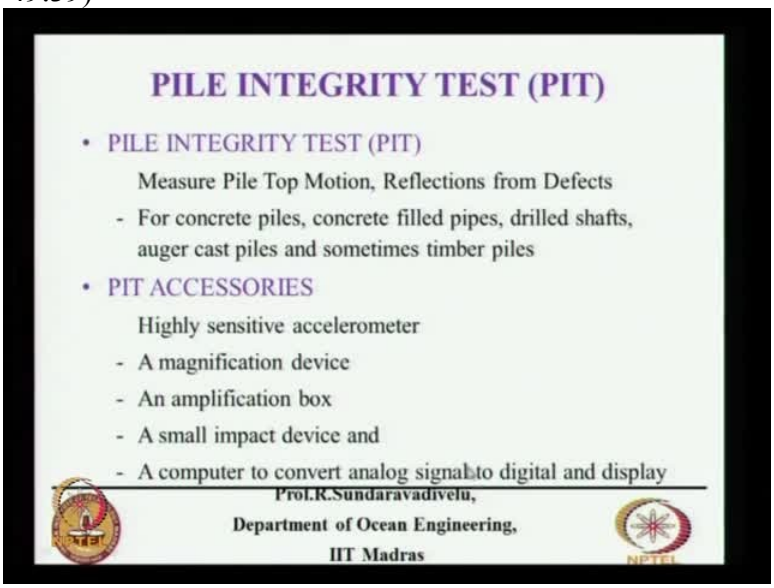

Then talking about pile integrity tests, one of the main question that will be asked is what are all the accessories required. You need a accelerometer, identification device, and amplification box, then a small impact device and a computer to store the signal. What the computer does is it converts the analog signal into digital and it will display. And you have other type of recorders also like strip chart recorder which is nobody uses nowadays after the advent of computers. But still people use oscilloscope.

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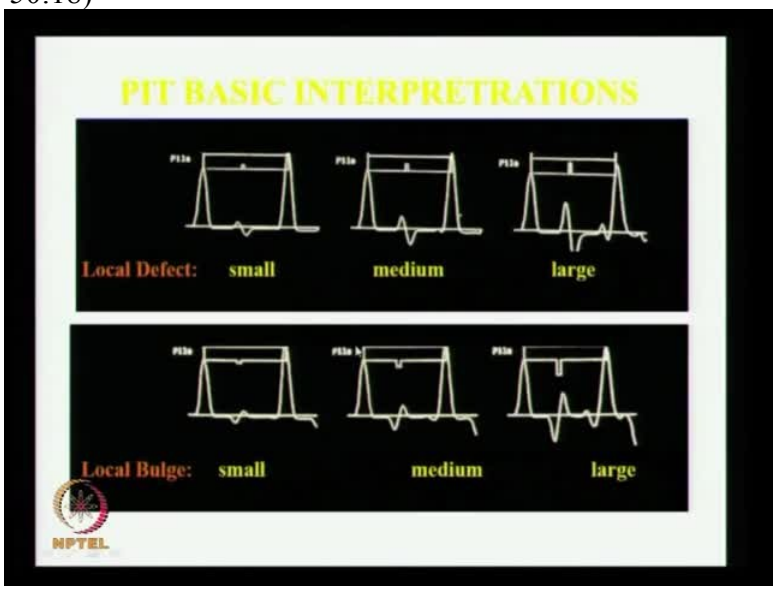

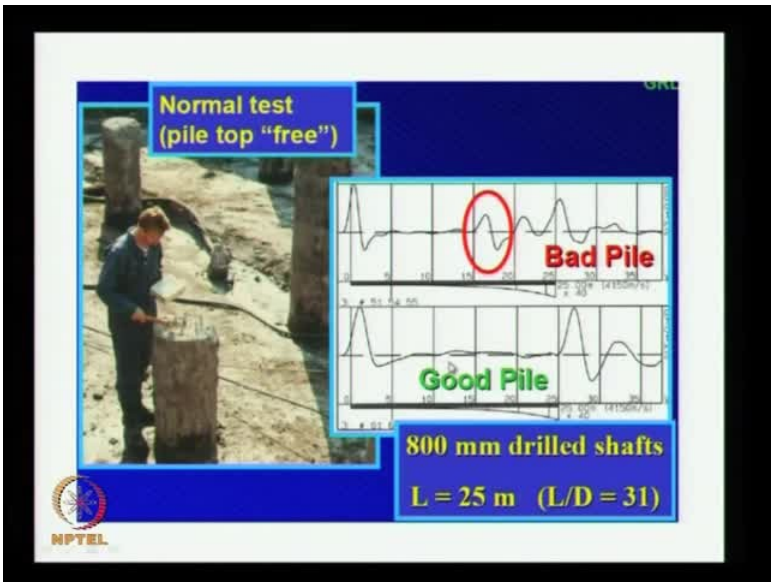

Then this figure you can put and explain how the measurement comes and this figure also very important. What will be the signal difference between a good pile and a bad file? And how many milliseconds? I have done one problem here, a 20 metre long pile, how much time it takes if there is a clean shaft. We have calculated this as 10 milliseconds if the speed is 4000 metre per second. Okay, thank you.