Advanced Topics in the Science and Technology of Concrete
Chloride threshold testing using linear polarization resistance (LPR) and electrochemical impedance spectroscopy (EIS)

Hi this is Shreepriya I am a research scholar in IIT Madras. I am going to explain corrosion related testing how to do first, corrosion is a major detonations mechanism and most of the structures so we need to understand the corrosion mechanism and the materials which are used whether it is corrosion resistant or not. For that we have to test with advance techniques such as LBR EIS.

So I am going to explain how to do the testing when these techniques have to be employed first I will explain the instrumentation and next I will go explain the corrosion accessories that are required for the experiment.

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This is a potentiostat and this a frequency response analyzer this potentialstat is capable of measuring voltage in the test specimen this is required for doing a conducting experiments such as linear polarisation resistance, cyclic voltammetry etc. And frequency response analyzer is capable of transmitting waves and record the response signal so this is used for electro chemical impedance spectroscopy.

This instrument should be coupled with this to do the experiment but nowadays we have a inbuilt FRA in potentiostat itself so we can have single instrument which is capable of doing both the experiments.

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So moving on to the corrosion cell, this is the corrosion cell. It is has three electrodes first is the reference electrode I have used saturated calomel electrode here you can see this is the saturated calomel electrode and then we have a nichrome mesh this is the counter electrode when we choose the counter electrode it should be corrosion resistant because we don't want a response from the counter electrode to affect the reading when the working electrode that is the test specimen is connected here this is a.

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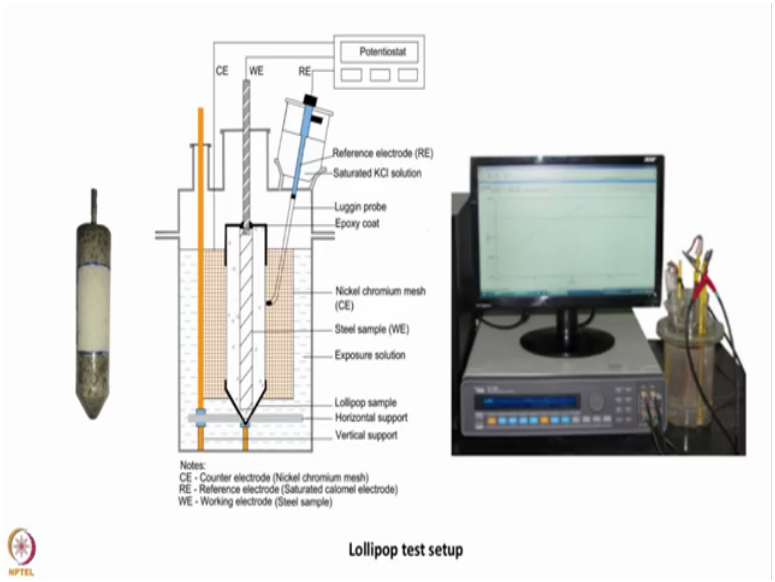

All put it in a beaker. The whole setups forms the corrosion cell.

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Here I have used lollipop specimen this is the type of specimen here a steel rod is embedded in water it is cast with this kind of plastic mould and after twenty-four hour it is demoulded and the specimen is prepared now in this experiment I have subjected the specimen to chlorides depending on your specimen and the type of exposure condition you want you can change the condition of the testing.

So first I will explain linear polarisation resistance techniques as corrosion is a equilibrium process we cannot directly measure the corrosion rate from the test specimen so what we have to do is we have to measure the inherent potential of the test specimen and slightly disturb the specimen by applying a small voltage and record the response back so in linear polarisation resistance we apply a DC voltage we measure the OCP first that is the inherent potential of the specimen.

And then we apply a small voltage plus or minus 10 millivolts over the OCP and then record the response now I will show how to do the testing with the help of the software that comes with that an instrument.

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This is the carver software that comes with the instrument here I have chosen open circuit impedance and polarisation resistance open circuit is the inherent potential of the specimen and then we do a EIS test because EIS is the AC signal it doesn't offer the specimen much and then we do a polarisation resistance because we need to have some time lapse to come back to the inherent potential in polarisation resistance.

So we order the testing in this sequence and we usually do open circuit potential for 60 to 120 seconds we will start the experiment now.

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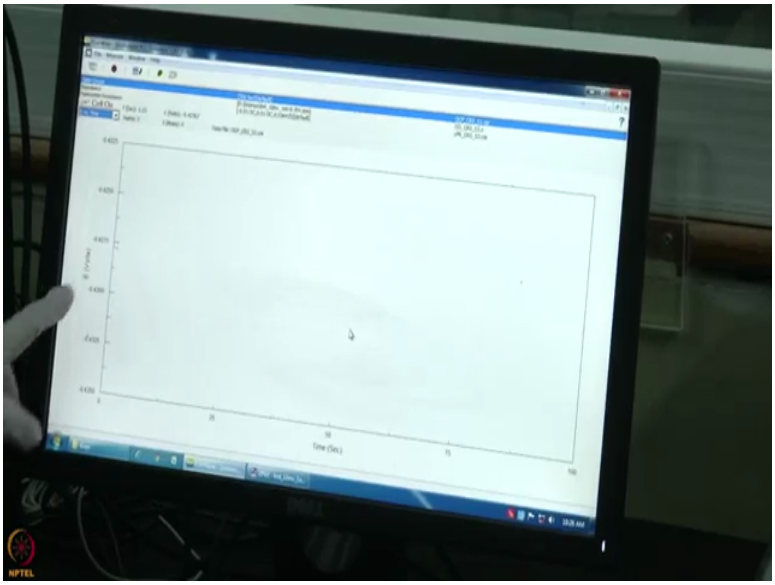

So the first the open circuit potential is measured so it will go on for 120 seconds if you can see there are four digits in this so it is more or less very stable so when you have a stable OCP our measurements will get better in LPR and EIS measurements. Now the experiment is over the next experiment is impedance spectroscopy.

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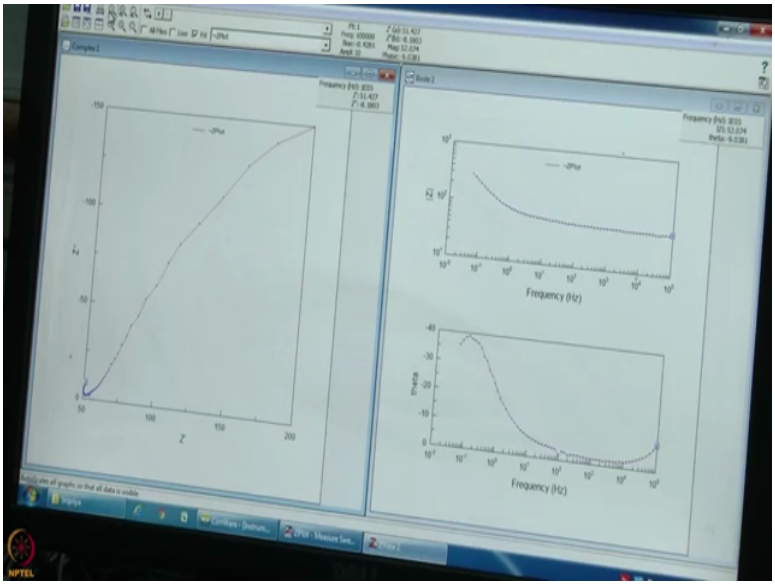

This is the typical EIS curve that is obtained from the test specimen first plot shows the (()) (5:14) plot where we have Z dash and Z double dash these are real and imaginary impedance and then we have second graph the two graphs both of them together called as board A plot. Here we have modulus of Z where is a its frequency. And second is face angle that we get from the specimen.

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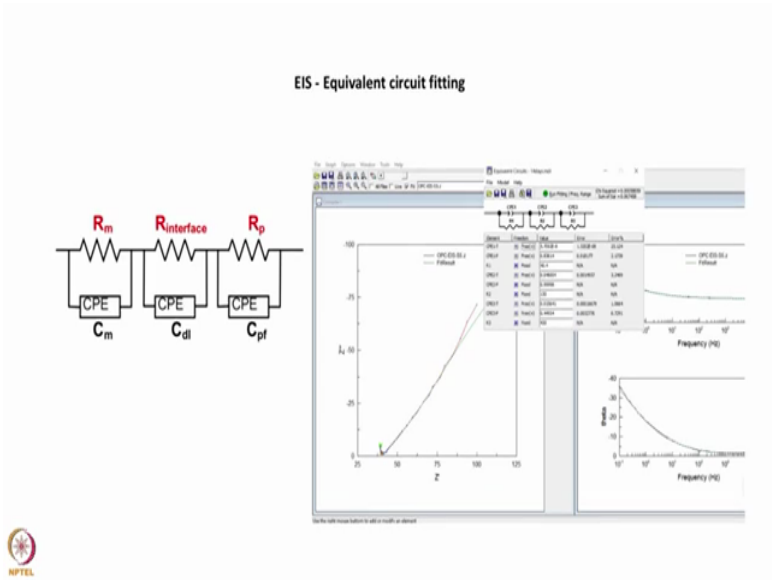

So we have to use a equivalent circuit to fit the spectra and get the polarisation resistance this equivalent circuit depends on the type of specimen for example we cannot use the same equivalent circuit for coated steel and uncoated steel. We have to use depending on the type of the test specimen and the physical reaction that is going on.

Second I will show you now the linear polarisation resistance now this experiment is over we move on to the next experiments linear polarisation resistance.

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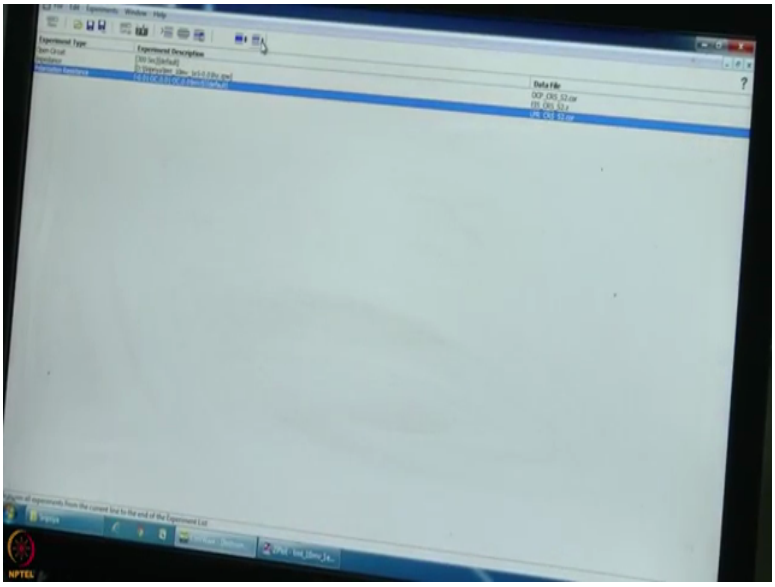

Now I will start the polarisation resistance experiment from the OCP measured there will be DC potential that is applied plus or minus 10 millivolts and then we will get a curve that is E versus I curve the curve is obtained we will measure the slope of the curve near to the OCP that will give the polarisation resistance of the steel. When this curve crosses this is the near to the open circuit potential what we measured initially.

So we want to get the slope near to this point so once the experiment is over we will get a slope of this curve then take that as a polarisation resistance value. Now we are done with the measurements of the polarisation resistance with this equipments we need to do repeated measurements of polarisation resistance to get to know the product threshold. Product threshold is the minimum amount of chlorides that are required to initiate corrosion.

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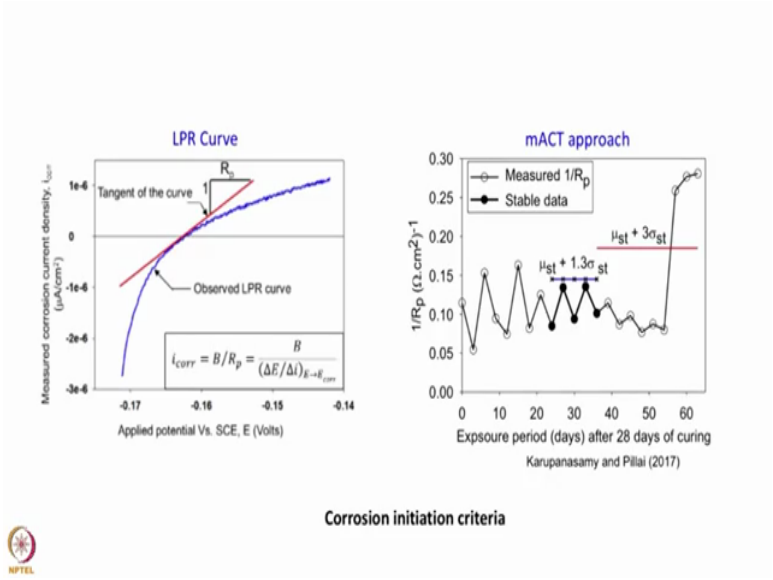

You can see in this graph that one by RP is plotted against the exposure days you can see there are ups and downs in the reading it is because the corrosion process is dynamic process and down going corrosion may influence the reading so we have to have a statistical analysis you can see that the stable data has been marked so we do subjected to some statistical analysis of the mean.

And then when it crosses some certain value that is Mu plus 3 sigma then we consider the specimen to be initiated once we identify the initiation that happen with the specimen we have to open the specimen and collect some powder from the interface and with the help of chloride sensing probe we can find the amount of chloride that has been at the interface this amount of chloride is reported as chloride threshold value why do we need this threshold value because lot of materials are available in the market.

So to enhance the service life that is without any repair durable structure if you want to have we need to have material which are corrosion resistance and many materials are coming to the market climbing it to be durable to measure whether it is really durable or not we need to do this kind of testing and find the chloride threshold.

And then compare it with other material that are available and choose the material wisely with this we have come to the end of the experiment thank you for watching.