

Corrosion Testing



- Half-Cell Potential
- Surface Resistivity
- Corrosion Rate
- Linear Polarization Resistance
- Electrical Impedance Spectroscopy
- Galvanic Anode Performance Test
- hr-ACT
- pcd-ACT
- cs-ACT
- Coating Thickness Gauge
- Pit Depth Measurement Tool

Half-Cell Potential

Working Principle

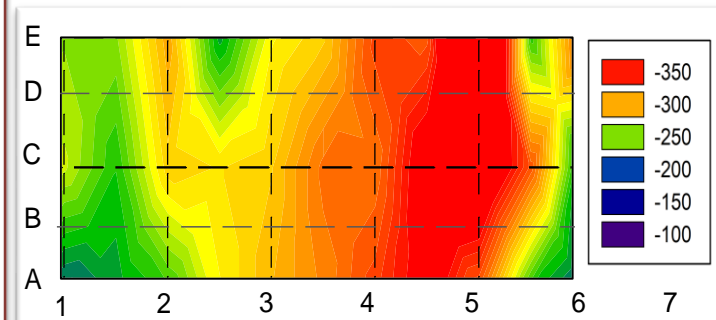
Half-cell potential refers to the potential developed at the electrode of each half cell in an electrochemical cell. In this method, potential difference between the half-cell of the embedded steel reinforcement and the half-cell of a known electrode (reference) is measured.



Canin half-cell potential equipment

Application

The half-cell potential value can help in determining the probability of corrosion within the rebar in reinforced concrete structure.



Half-cell potential contour mapping

Surface Resistivity

Working Principle

The pore solution in concrete facilitates a conductive path for the movement of ions and the average (surface) resistivity of the concrete sample can be evaluated based on the current and potential applied.



Wenner resistivity meter

Application

The resistivity value can be used as a rough guideline to estimate the probable occurrence of corrosion.

Classification of corrosion rate based on resistivity (ACI 222R, 2001)

Resistivity (k Ω .cm)	Corrosion rate
> 20	Low
10 to 20	Low to Moderate
5 to 10	High
< 5	Very High

Corrosion Rate

Working Principle

The polarization resistance of steel reinforcement in concrete is measured using the modulation confinement technique.

Application

The rate of corrosion of steel reinforcement can be obtained.



Corrosion rate meter

Table 1 - Ranges of corrosion current values related to the significance in terms of service life of the reinforcement

I_{corr} ($\mu\text{A}/\text{cm}^2$)	Corrosion level
≤ 0.1	Negligible
0.1 – 0.5	Low
0.5 – 1	Moderate
> 1	High

Electrochemical Interface - Linear Polarisation Resistance

Working Principle

The working electrode is polarized (typically on the order of ± 10 mV with respect to its OCP) to obtain the corresponding current measurement.

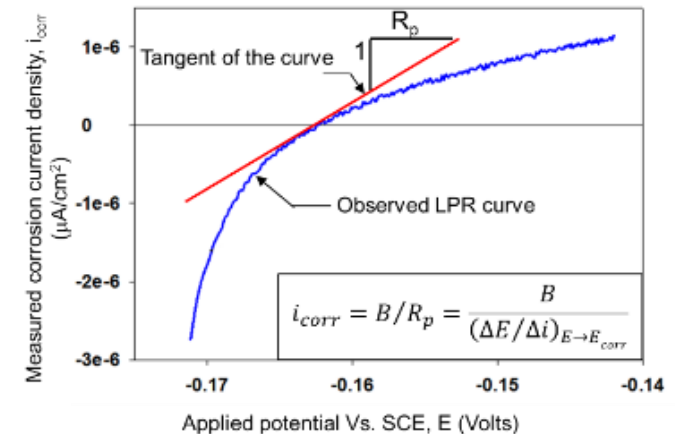


Potentiostat-cum-frequency response analyser

Application

Can be used as potentiostat or galvanostat with selectable control loop bandwidth to ensure stable operation for various types of cell.

Can provide accurate DC polarization to establish the rate of ionization in the cell.



Typical linear polarisation resistance response



Electrochemical Interface - Electrochemical Impedance Spectroscopy

Working Principle

When a sinusoidal potential perturbation is applied to the working electrode at different frequencies, the resulting current will have an amplitude that is inversely proportional to the impedance of the interface.

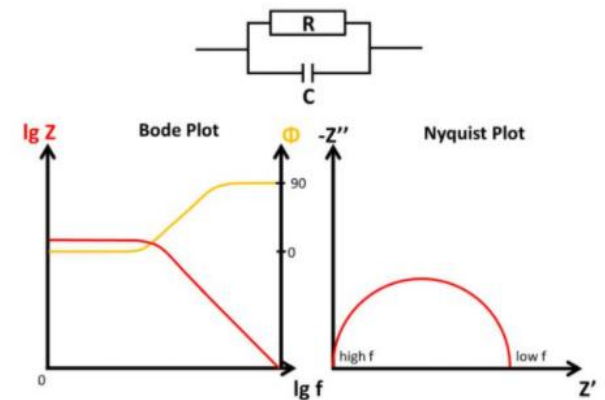


Potentiostat-cum-frequency
response analyser

Application

To obtain polarization resistance of steel to understand its rate of corrosion.

To obtain resistance, capacitance, and inductance of various components of the system.

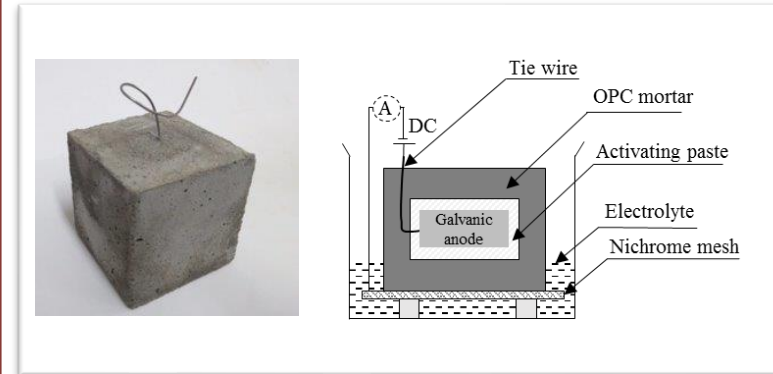


Schematic of a typical Bode and Nyquist
plot

Galvanic Anode Performance (GAP) test Method

About the test

A short-term laboratory test method for assessing the long-term performance of galvanic anodes for cathodic protection of reinforced concrete structures

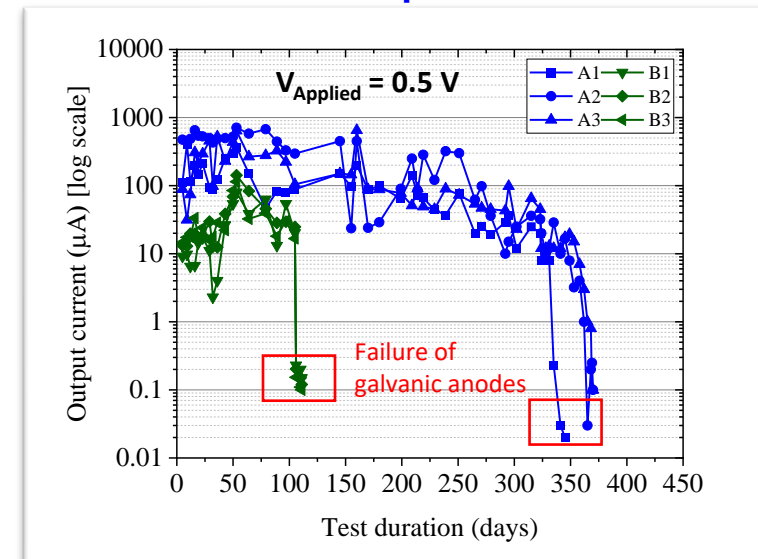


GAP test specimen and experimental setup

During service life of anode:

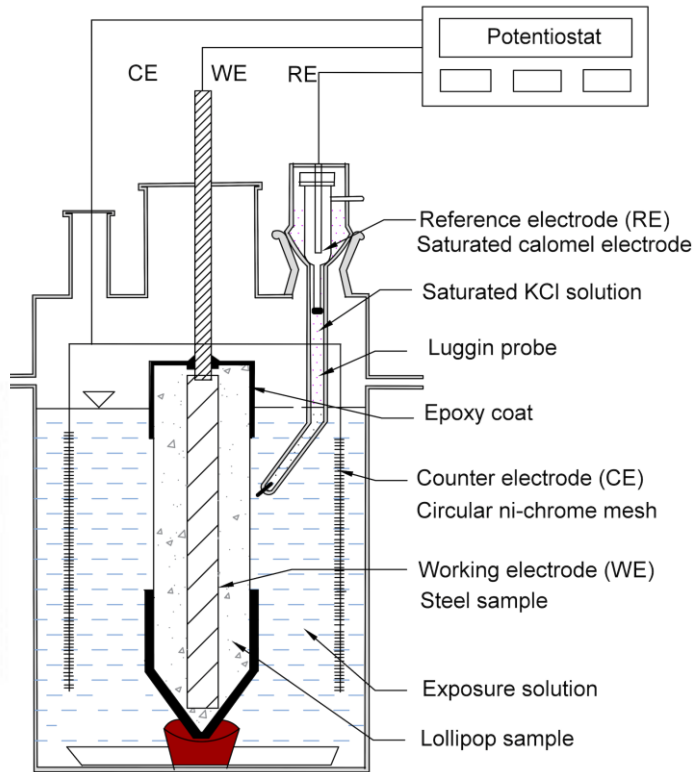
The charge passed during the GAP test should be equal to the total charge passed in concrete structure

$$i_{GAP} \times t_{GAP} = i_{required} \times t_{min\ service\ life}$$

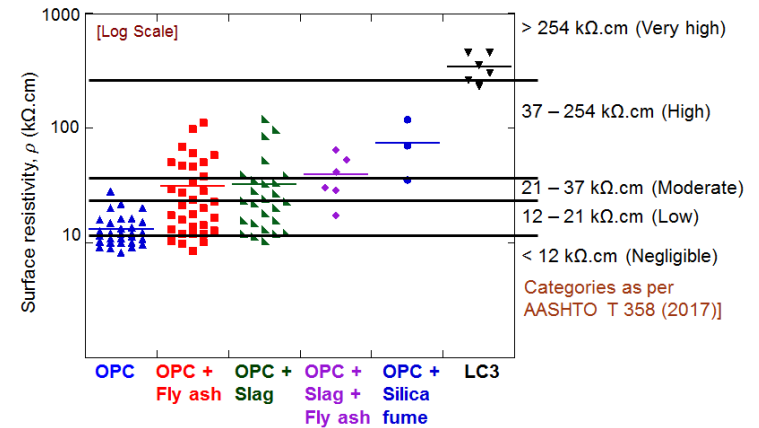


Output current supplied by the anodes in GAP test

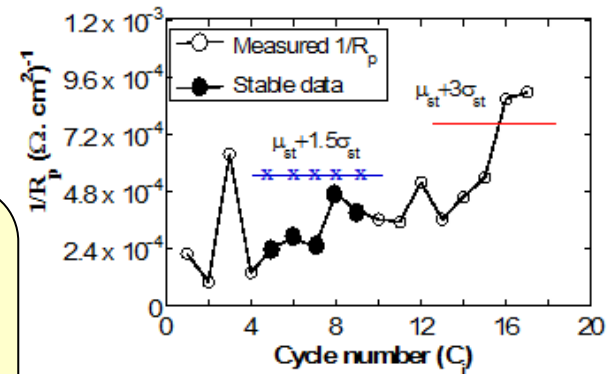
hr-ACT for highly resistive (HR) steel-concrete (S-C) systems



Lollipop test setup



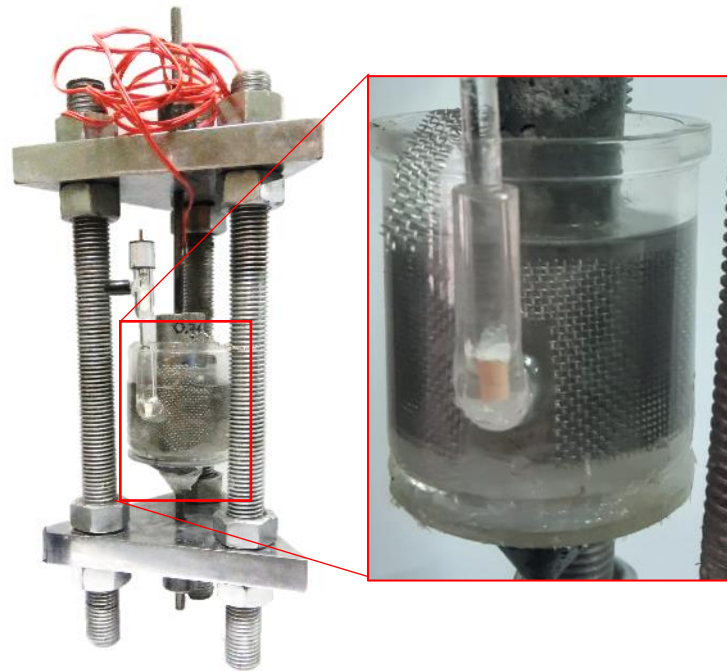
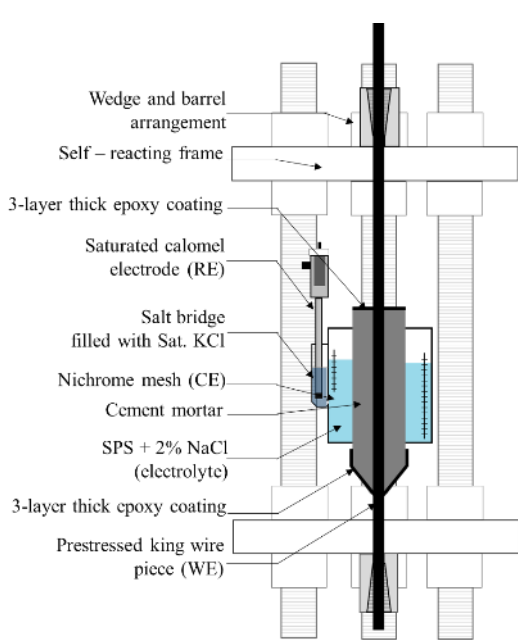
HR, S-C system --> Surface resistivity > 37 kΩ.cm



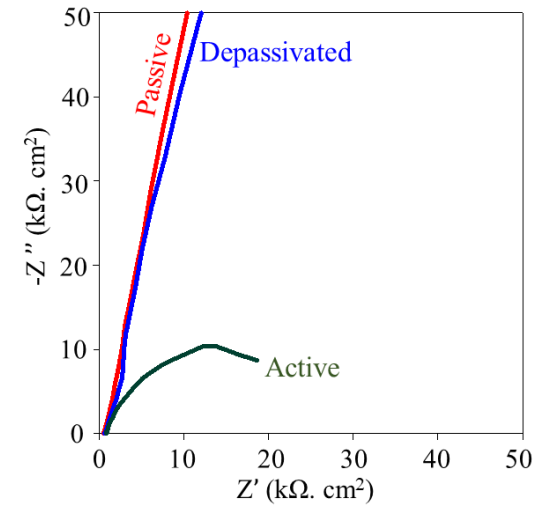
Initiation Criteria

Chloride threshold of HR, S-C systems can be determined with the help of hr-ACT test method using Electrochemical Impedance Spectroscopy technique and adopting the initiation criteria

Psd-ACT

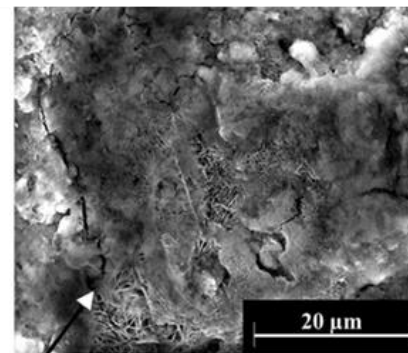


Test setup

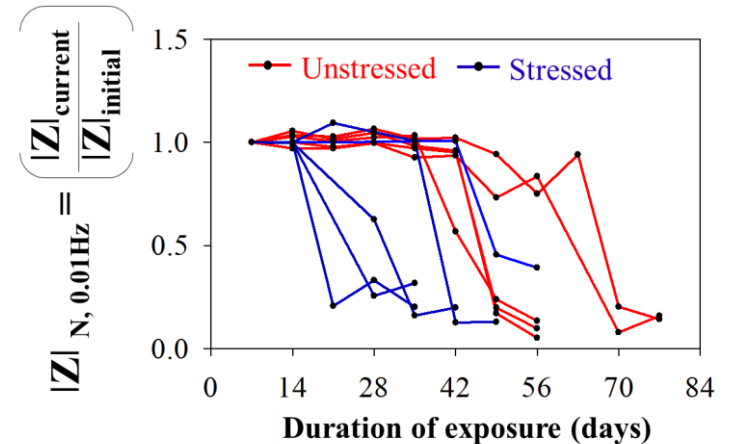


Passive-to-Active transition

Chloride threshold of prestressed S-C systems can be determined with the help of Psd-ACT test using Electrochemical Impedance Spectroscopy technique and adopting the initiation criteria



Passive film cracking

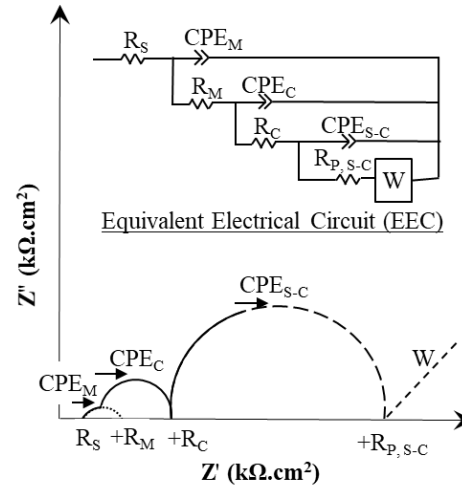


Initiation criteria

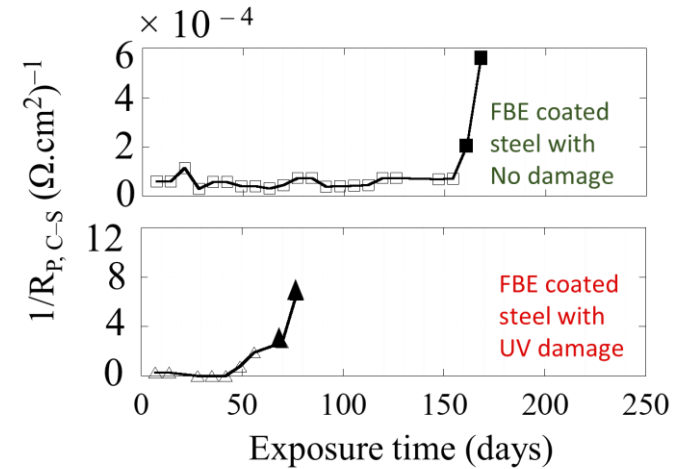
Cs-ACT



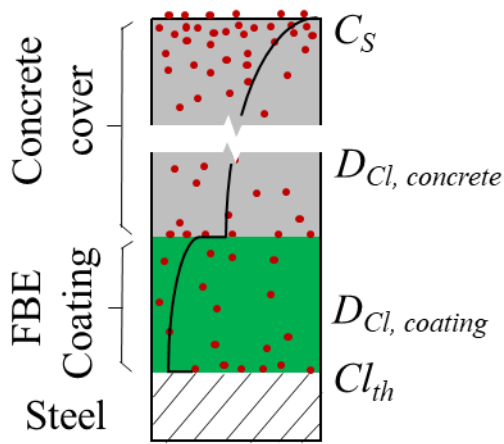
Corrosion cell



Typical Nyquist plot and equivalent electrical circuit



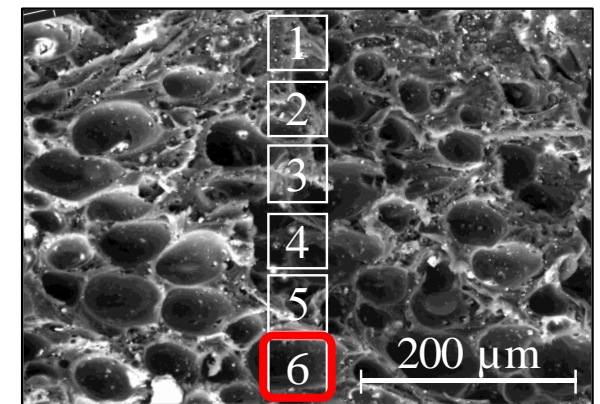
Initiation criteria



Service life model

- $D_{cl, coating}$ (diffusion coefficient of coating)
- Cl_{th} (at steel-coating interface)

Coating-cementitious interface



Steel-coating interface

SE micrograph of the Coating-cross section

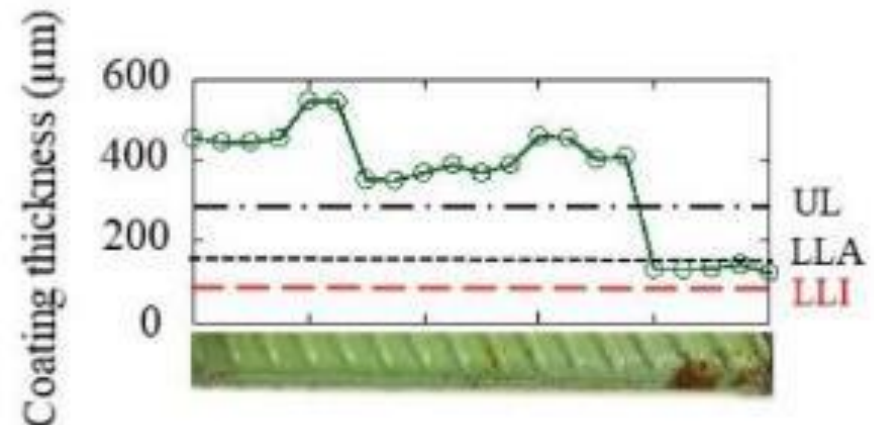
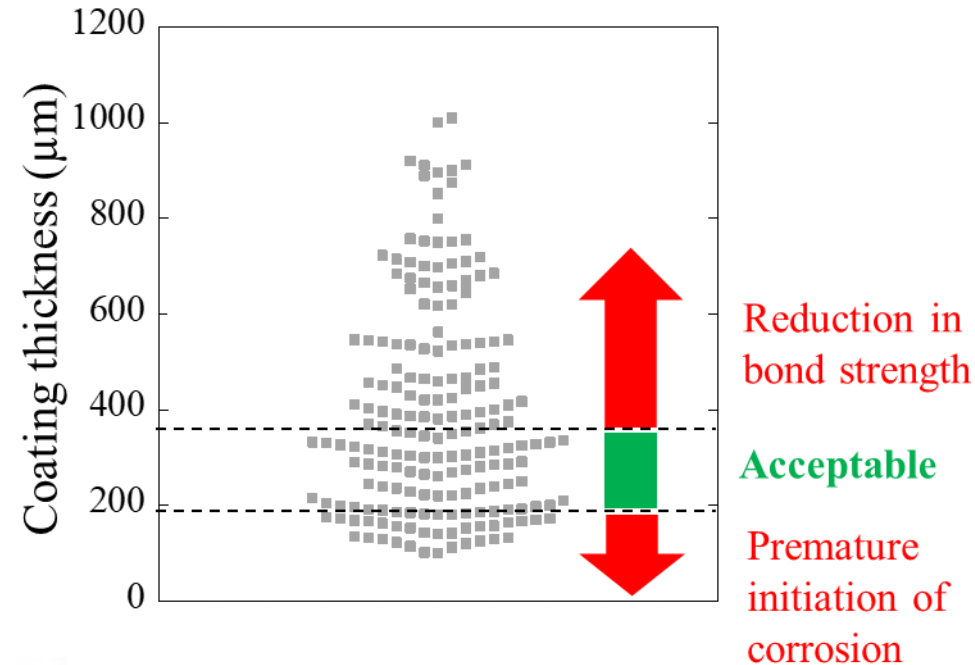
Coating thickness gauge

About the instrument

The Elcometer 456 coating thickness gauge is used to measure dry film thickness on ferrous and nonferrous metals.



Measurement of coating thickness of fusion-bonded-epoxy coated steel rebar



Pit depth gauge

About the instrument

The Caltech CPG-1021 pit depth gauge designed with a digital vernier caliper can measure the pit depth with a resolution of 1 micron

Applications

They are used to measure the surface pits, dents, peak to valley heights, undercuts etc.



Pit depth gauge