Corrosion of reinforced concrete structures

Corrosion of reinforcement is one of the major deterioration mechanisms in concrete.

- In 2014, the direct cost of corrosion in India was Rs. 4 lakhs crores/year!
- ~ 3 to 4% of GDP

We have huge tasks of maintaining the aging infrastructure and constructing new, durable infrastructure systems

A corrosion prevention strategy to minimize the repair and maintenance costs is a MUST

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Half-cell potential mapping

- Onsite half-cell potential (HCP) contour can be mapped using rod, or telescopic rode, or wheel electrodes. Allows to a measure potential of ± 999 mV.
- The probability of chance of corrosion is interpreted using ASTM C876 manual (Table 1).

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Half-cell potential (mV vs. CSE)	Corrosion condition
< − 500	Severe corrosion
< − 350	High (< 90% risk of corrosion)
− 350 to − 200	Intermediate corrosion risk
> − 200	Low(10% risk of corrosion)

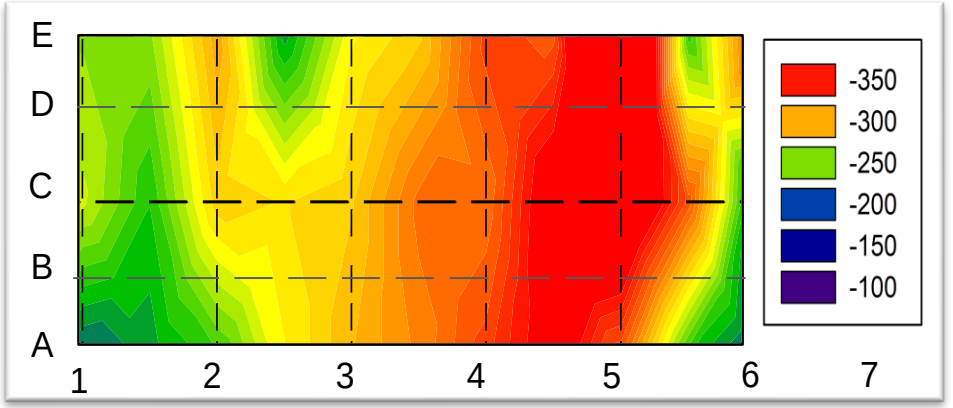

Figure 1: HCP contours mapped on a 5 x 2 m concrete sunshade

Concrete Surface Resistivity Meter

Surface Resistivity

- This instrument operates on the principle of Wenner 4 - probe
- It a non-destructive on-site condition assessment tool
- The resistivity values can be correlated to durability parameters such as corrosion rate, chloride permeability, etc.

Wenner Resistivity Meter

Classification of concrete quality based on resistivity (RILEM TC 154-EMC, 2004)	
Resistivity (kΩ.cm)	**Concrete quality**
> 100	Good
50 to 100	Normal
10 to 50	Poor
< 10	Very Poor

Classification of corrosion rate based on resistivity (ACI 222R, 2001)	
Resistivity (kΩ.cm)	**Corrosion rate**
> 20	Low
10 to 20	Low to Moderate
5 to 10	High
< 5	Very High

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Onsite-corrosion rate

- Uses modulation confinement technique for measuring the polarization resistance of the steel reinforcement in concrete
- Three types of sensors are available to conduct tests in both wet and submerged conditions
- The level of corrosion in the structure is interpreted using the criteria given in RILEM TC 154 –EMC (Table 1)

Efficiency of Cathodic protection

- By analyzing the electrical impedance obtained from an alternating current applied with modulated confinement

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

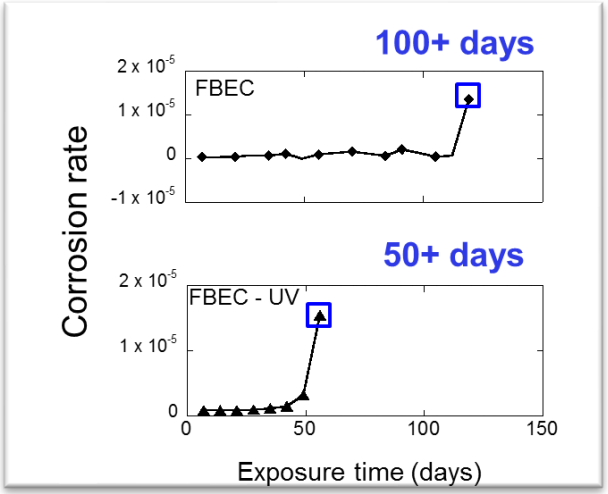
I_{corr} (µA/cm²)	Corrosion level
≤ 0.1	Negligible
0.1 – 0.5	Low
0.5 – 1	Moderate
> 1	High

Electrochemical Interface

Electrochemical Characteristics

- Can be used as Potentiosat 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
- Can be coupled with a frequency response analyzer for AC tests to study the cell impedance characteristics
- Electrochemical characteristics of bare, coated steel rebars and prestressing steel strands are being studied

Potentiostat cum Frequency Response Analyser



Corrosion initiation determined using Electrochemical Interface