Connectionless Electrical Pulse Response Analysis (CEPRA)

Corrosion Measurement Techniques

**Corrosion Potential**
- Half-cell Potential - (ASTM C876)

**Corrosion Rate:**
- Linear Polarization Technique (LPR)
- Galvanostatic Pulse Technique
- AC Impedance Analysis (Lab Technique)
- Potentiation Pulse Technique
- NEW METHOD: Connectionless Electrical Pulse Response analysis (CEPRA)

Challenges of the Existing Measurement Techniques

- Area of Polarization, Ap?
- Electrical Connection to Rebar
- Time of measurement
- Data logger
- Size
CEPRA- Measurement Concept

AC Impedance Spectrum

Reinforcing Steel

Concrete

Non-Corroding Rebar

Corroding Rebar

Low frequency

High frequency

Voltage vs. Time

Voltage

Frequency
CEPRA- Measurement Concept

**Curve Fitting Parameters:**

- $R_{c1}$: Contact Resistance
- $R_{c2}$: Bulk Electrical resistance of concrete
- $R_{c3}$: Electrical resistance of concrete cover
- $R_{c4}$ ($R_p$): Polarization Resistance or Rebar
- $C_{dl}$: Double Layer Capacitance

**Equivalent Electrical Circuit Modeling**

**CEPRA- Measurement Concept**

Corrosion Rate ($i_{corr}$) from $R_p$:

$$i_{cor} = \frac{B}{A_p R_p}$$

Concrete Electrical Resistivity ($\rho_c$) from $R_{c2}$:

$$\rho_c = 2\pi a R_{c2}$$

**Unique Features of CEPRA - Advantages**

- No need for an electrical connection to reinforcement
- Fast: Measurement within seconds (max 10 seconds)
- Directional measurements
Comparison With Other Techniques

<table>
<thead>
<tr>
<th></th>
<th>Half-Cell</th>
<th>LPR</th>
<th>Galvanostatic Pulse</th>
<th>CEPRA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrosion Rate</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Concrete Resistivity</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>No Repair Connection</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
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<tr>
<td>Directional Meas.</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Localized Meas.</td>
<td>No</td>
<td>?</td>
<td>?</td>
<td>Yes</td>
</tr>
<tr>
<td>Meas. Time</td>
<td>Short</td>
<td>Long</td>
<td>Medium</td>
<td>Short</td>
</tr>
<tr>
<td>Maintenance Req.</td>
<td>High</td>
<td>Very High</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

Lab Verification
- 16 reinforced concrete blocks
- 300 mm (L) x 300 mm (W) x 100 mm (H)
- 0%, 1.5%, 3% and 6% admixed chlorides by weight of cement
- 10M rebar was used at cover depth of 2 cm, 4 cm, or 7 cm
- 20M rebar with 4 cm cover depth

Field Verification
Field Verification

Giatec iCOR™

- Wireless connectivity (Bluetooth)
- User friendly Android application
- Contour map display
- Online software upgrade
- Online data sharing
- Verification unit

Question?

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