



## Connectionless Electrical Pulse Response Analysis (CEPRA)



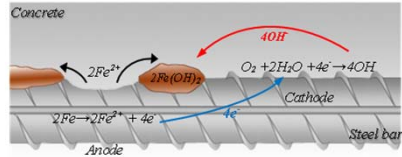
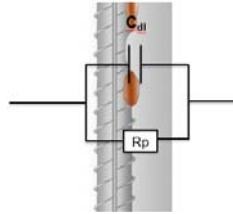
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## Corrosion Rate

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



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## 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)**



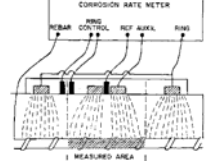
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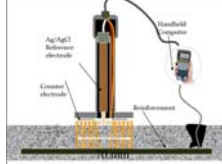
## Challenges of the Existing Measurement Techniques


- Area of Polarization,  $A_p$  ?
- Electrical Connection to Rebar
- Time of measurement
- Data logger
- Size

Linear Polarization Technique



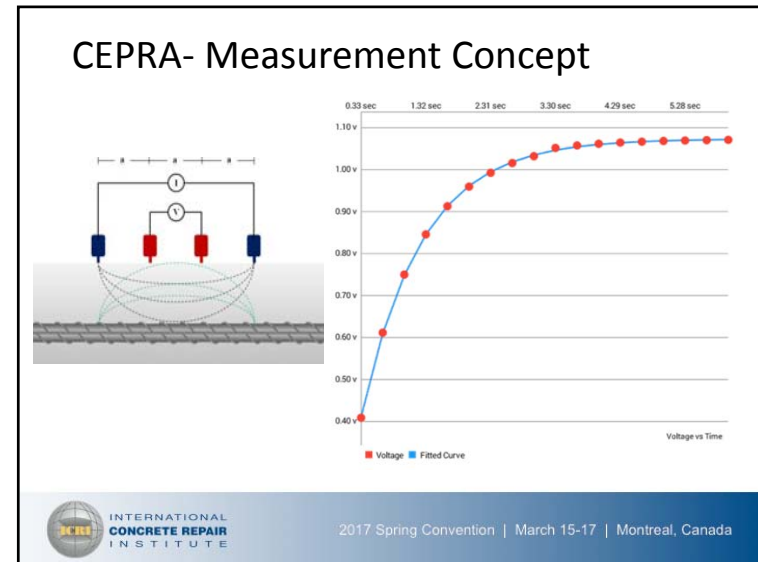
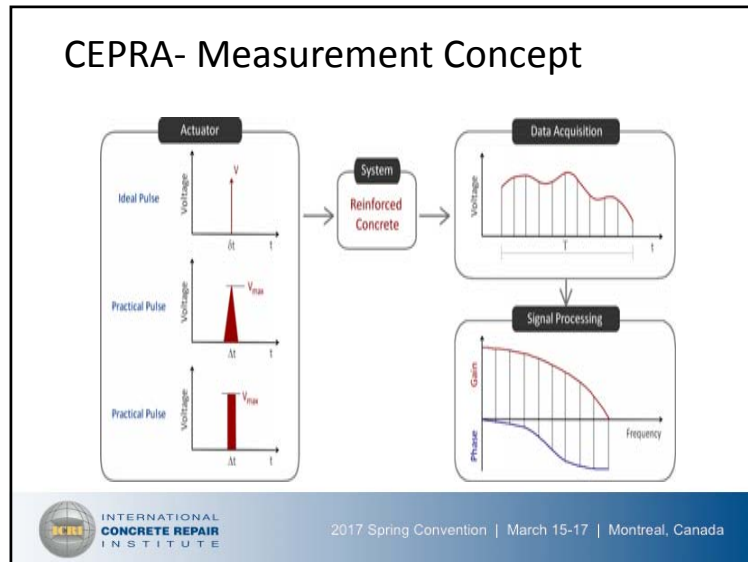
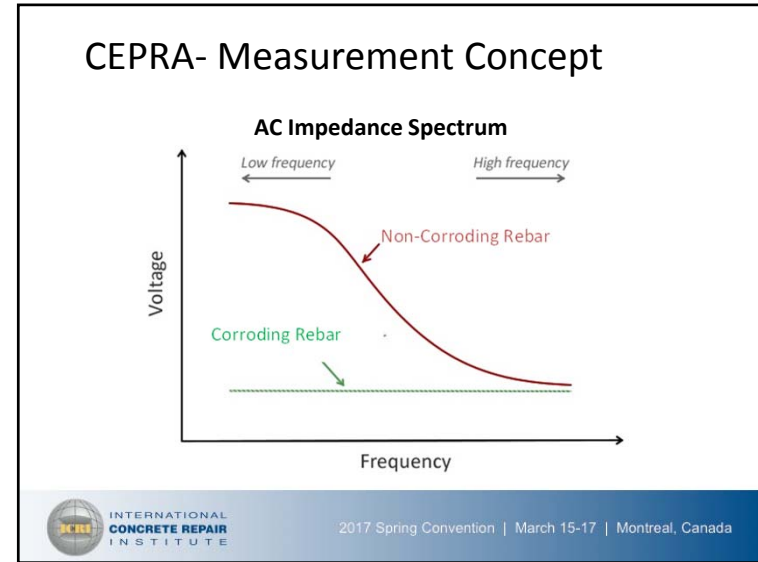
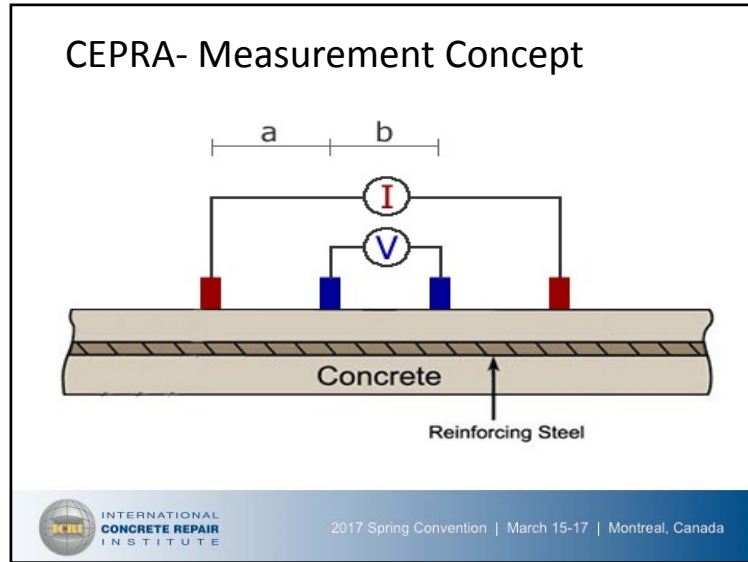
Galvanostatic Pulse Technique





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### CEPRA- Measurement Concept

**Equivalent Electrical Circuit Modeling**

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### 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

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### CEPRA- Measurement Concept

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

$$i_{corr} = \frac{B}{A_p \cdot R_p}$$

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

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

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### Unique Features of CEPRA - Advantages

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

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## Comparison With Other Techniques

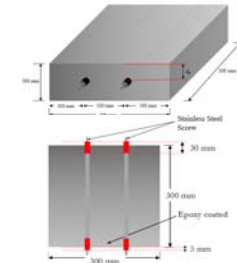
	Half-Cell	LPR	Galvanostatic Pulse	CEPRA
Corrosion Rate	No	Yes	Yes	Yes
Concrete Resistivity	No	No	No	Yes
No Rebar Connection	No	No	No	Yes
Directional Meas.	No	No	No	Yes
Localized Meas.	No	?	?	Yes
Meas. Time	Short	Long	Medium	Short
Maintenance Req.	High	Very High	Low	Low



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## 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

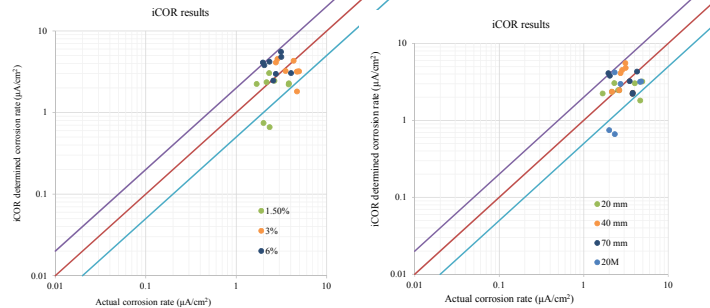


- Mass loss testing



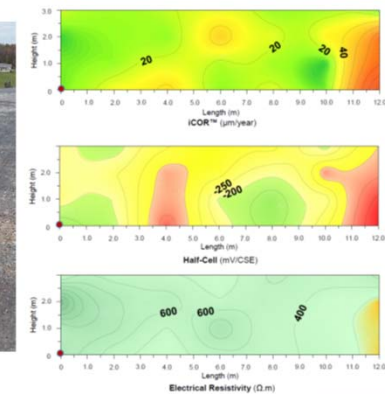
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## CEPRA vs. Actual Corrosion Rate



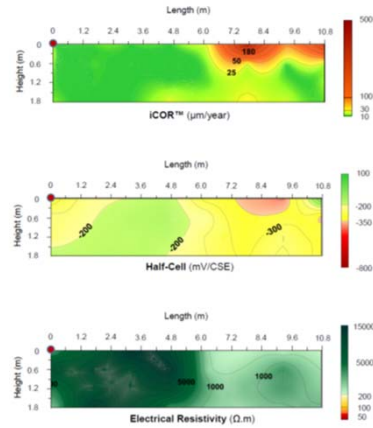
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## Field Verification



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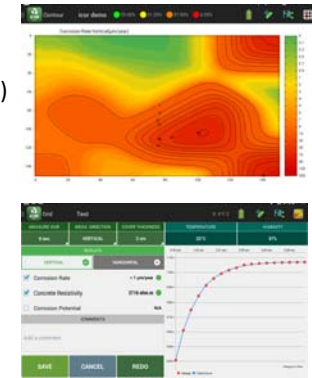
## Field Verification



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## Giatec iCOR™

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



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## Question ?



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