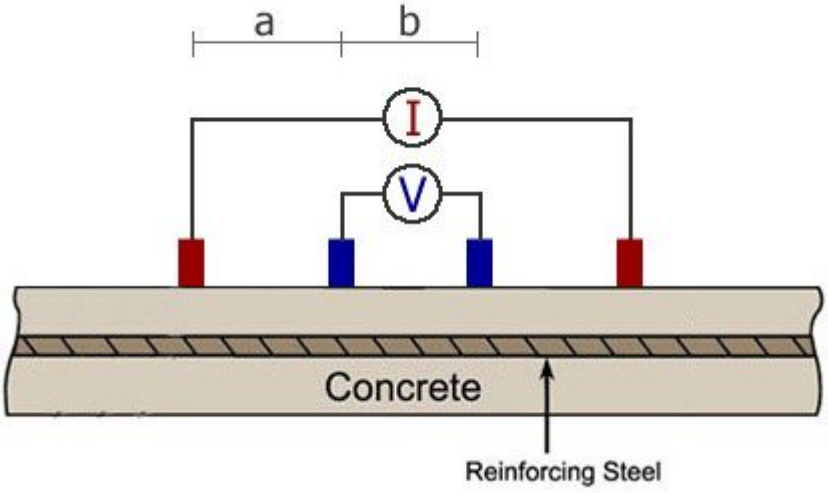
Corrosion of Steel in Concrete

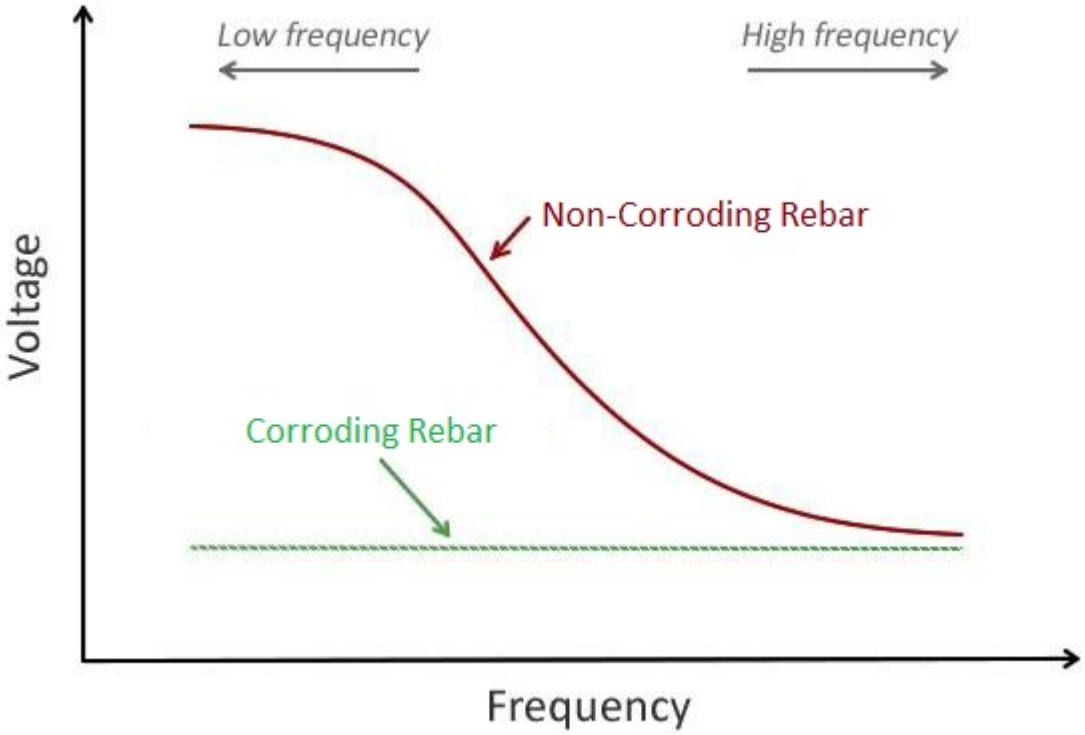
The rebar corrosion in concrete structures and the NDT techniques for corrosion rate measurement were previously discussed in another post. In the current post, the details of the recently developed CEPRA technology by Giatec for connection-less corrosion rate measurement is presented.

The Concept

The electrical response of rebar embedded in the concrete can be determined from the surface of concrete using the four-probe Wenner array configuration (as shown in the following figure) by applying a constant AC current between the outer probes and the measurement of voltage between the inner probes.



By sweeping the frequency of the AC current from low frequency to high frequency, the voltage response of the system changes. The variation of the voltage response of the corroding rebar is different from that of the non-corroding rebar. As show in the figure below, the measured voltage when rebar is not corroded increases in the low frequency zone of the spectrum, but it is almost invariable for the corroded rebar. This basic concept can be applied for the detection of the corroding areas of the reinforced concrete structures from the surface without the need to have an electrical connection to the rebar inside the concrete, unlike other existing non-destructive corrosion measurement devices.



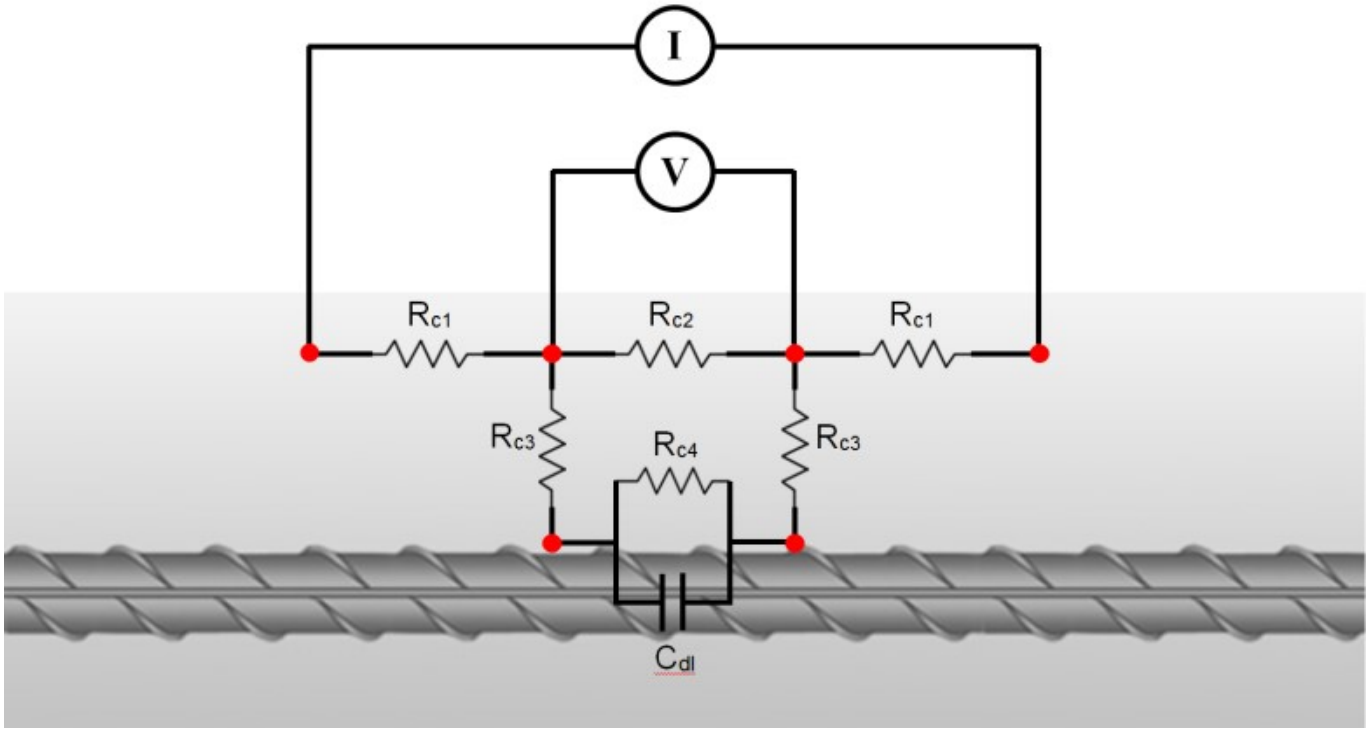
Although the low-frequency impedance response of reinforced concrete can be correlated to the corrosion state of rebar in concrete, its direct measurement is very time-consuming and vulnerable to noise interruption; hence, it is not practical to use it in the field to measure the corrosion rate of rebar inside the concrete.

A Practical Approach

In the CEPRA technology developed by Giatec, the low-frequency behavior of reinforced concrete system is determined by applying a narrow current pulse or a step voltage/current for a short period of time (in a couple of seconds) and simultaneously recording the voltage of the system with a high sampling rate. Using the recorded voltage and the applied current the low-frequency impedance response of rebar in concrete can be extracted, which can be used to determine the state of corrosion in reinforced concrete structures. This patented technology is called **Connection-less Electrical Pulse Response Analysis (CEPRA)**.

The CEPRA technology is implemented in a portable wireless device called Giatec iCOR™. This novel NDT tool employs a complex electrical circuit model for predicting different properties of concrete materials, and steel reinforcement. This electrical circuit is

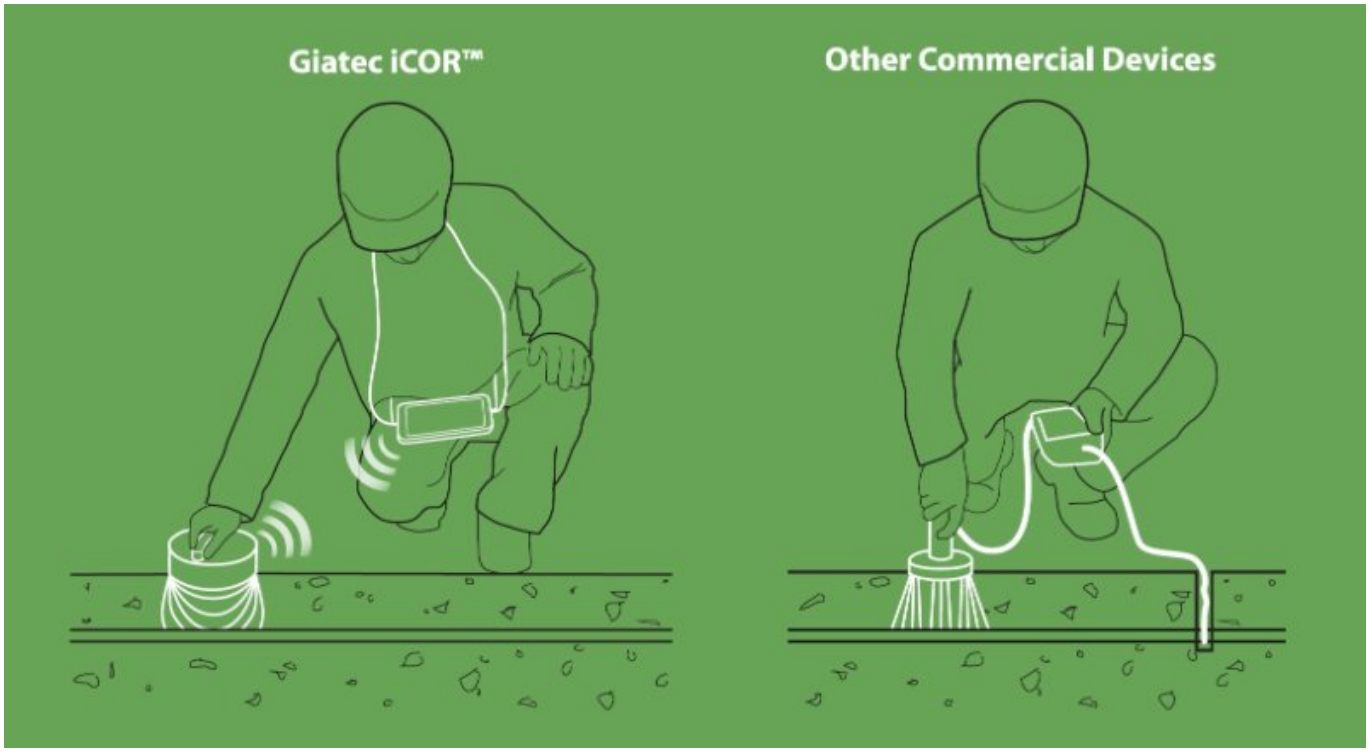
schematically illustrated as shown below. An advanced mathematical algorithm is implemented in the core software of the device. This software processor is responsible for the analysis of certain characteristics of reinforced concrete structure such as the polarization resistance of embedded reinforcement and the ‘real’ electrical resistivity of concrete.



Knowing the polarization resistance, one can easily calculate the corrosion rate from the Stern-Geary equation.

CEPRA vs. Other NDT Devices for Corrosion Detection

The CEPRA technology makes it possible to detect corrosion and measure corrosion rate in concrete from the surface without the need to have a rebar connection. This is great advantage as it allows to perform onsite condition assessment quickly and efficiently. The CPERA technology offers an accurate method of corrosion rate measurement as it confines the polarization area and does not get affected by the surrounding environment.



Unique Features of CEPRA:

1. Directional measurement of corrosion rate, concrete electrical resistivity, and electrical resistance of concrete cover
2. Fast measurement within seconds
3. No need to have electrical connection to reinforcement

Giatec iCOR™

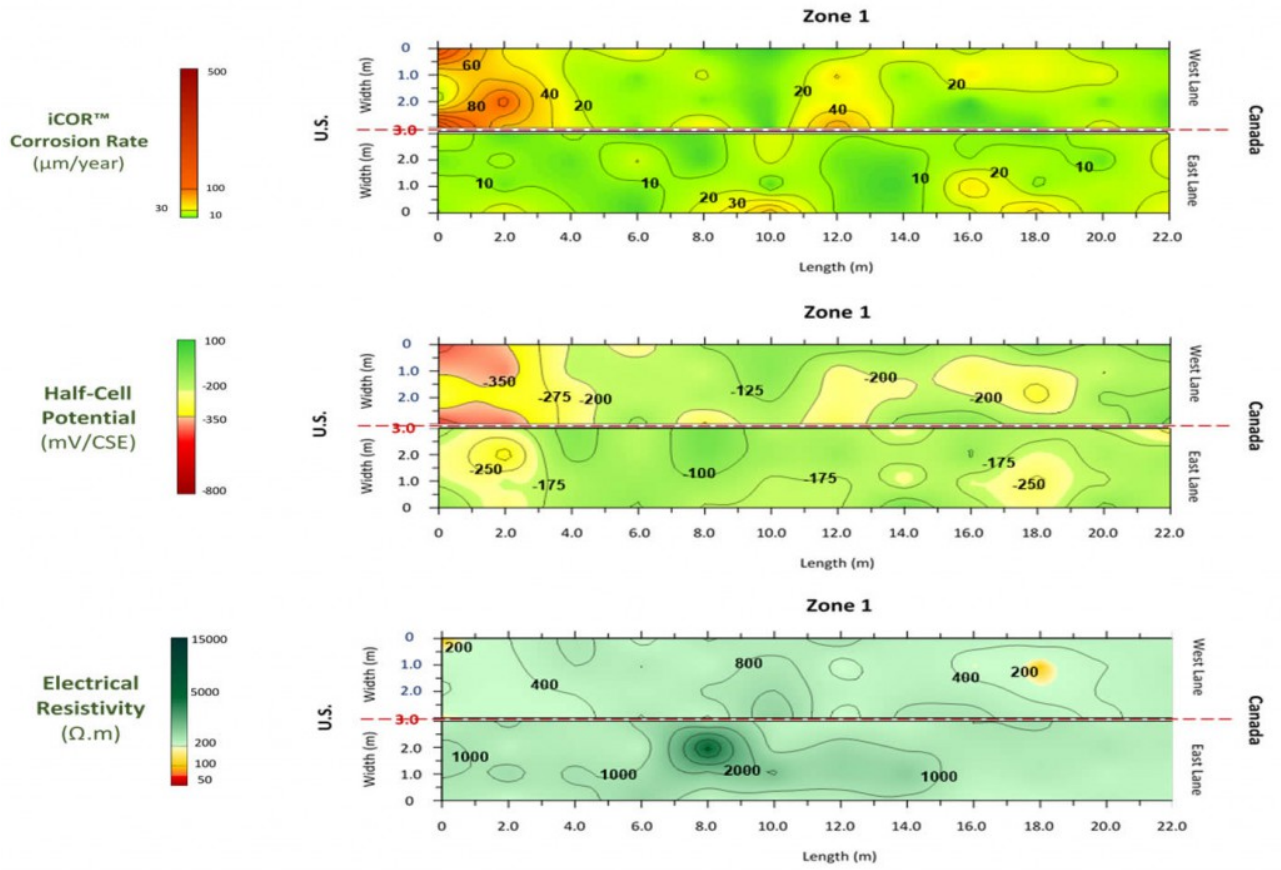
The sophisticated technique and the advanced algorithms behind the CEPRA technology are embedded in a hand-held device called iCOR™. The novel NDT tool also utilizes wireless communication along with a tablet-based application for easy data collection and real-time data analysis and corrosion mapping.

Using the communication tools in iCOR™'s Android app, the data, reports and corrosion maps can be easily shared. Here is a quick walk-through video on the iCOR™ device setup and field testing:

Case Studies

Giatec iCOR™ has been successfully utilized in the condition assessment of various bridges, precast concrete slabs, columns, and parking garages deteriorated as a results of rebar corrosion.

Here is a typical corrosion rate map as obtained by iCOR™ along with the half-cell corrosion potential measurement and concrete resistivity values. As observed, iCOR™ provides more details and localized information on the corrosion activity. This corrosion rate map can be used by infrastructure owners and operators to optimize the prioritize the repair and maintenance schedules and allocate their limited budget more efficiently depending on the stage of deterioration.



For more information on this new rebar corrosion rate measurement technique, please click here.