CONNECTION-LESS ELECTRICAL PULSE RESPONSE ANALYSIS (CEPRA) TEST METHOD FOR CORROSION RATE MEASUREMENT

Measurement Concept

The electrical response of rebar inside the concrete can be determined from the surface of concrete with four probes as shown in the Fig. 1. A constant AC current is applied between the outer probes and the voltage between the inner probes is measured.

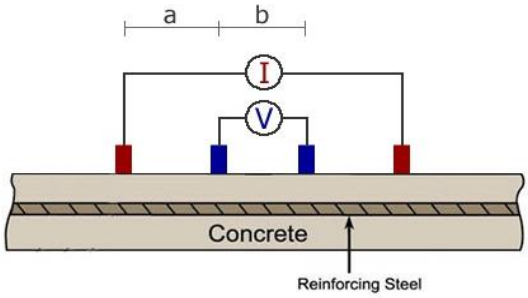

Figure 1. The configuration of 4 probes on the surface of concrete for corrosion detection of rebar inside the concrete

By sweeping the frequency of the AC current from low frequency to high frequency, the voltage of the system is recorded as illustrated schematically in Fig. 2.

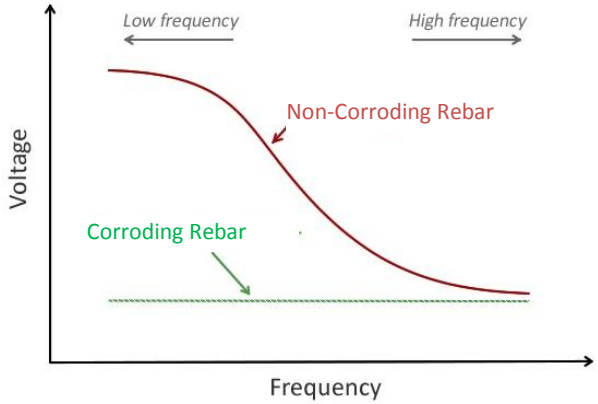

Figure 2. The schematic illustration of the voltage-frequency response of the corroding rebar compared to the non-corroding rebar

The voltage response of the corroding rebar is different from that of the non-corroding rebar. The voltage of the non-corroding rebar increases in low frequency zone of the plot, but it is almost invariable for the corroding rebar. This basic concept has been utilized in the iCOR™ technology 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.

iCOR™ Measurement Technique

As mentioned above, the low-frequency impedance of rebar in concrete can be correlated to the corrosion state of reinforcement in concrete. However, direct measurement of the low-frequency impedance of rebar in concrete is very time-consuming and vulnerable to noise interruption; hence, it is not practical to use this technique in the field to measure the corrosion rate of rebar inside the concrete. In Giatec iCOR™, 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 recoding 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 that has been developed by Giatec Scientific Inc. is called Connectionless Electrical Pulse Response Analysis (CEPRA).

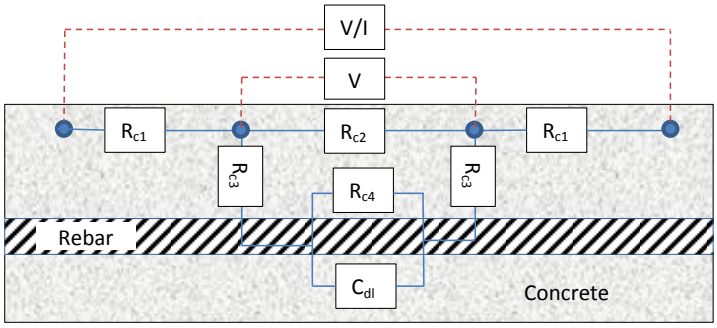

Figure 3. Electrical circuit of reinforced concrete system in non-contact four-probe measurement

Giatec iCOR™ employs a complex electrical circuit model for predicting different properties of concrete materials, and steel reinforcement. This electrical circuit is schematically illustrated in Fig 4. 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.

POLARIZATION RESISTANCE OF REBAR (R_P):

This parameter is related to the corrosion rate of rebar in concrete. One can calculate the corrosion rate (i_{cor}) from Rp using the following well-established equation:

$$R_p = A.R_{c4}$$

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

where A is the area of rebar, R_{c4} is the charge transfer resistance of rebar in Fig. 3, B is a constant parameter determined experimentally.

ELECTRICAL RESISTIVITY OF CONCRETE (ρ):

The intrinsic electrical resistivity of concrete can be calculated from R_{c2}, R_{c3} and R_{c4} in Fig. 4 using the following equation:

$$\rho = 2\pi a \times R$$

where a is a constant parameter determined from the geometry of the measurement probes, R is the equivalent resistance of concrete calculated from R_{c2}, R_{c3} and R_{c4}.

It should be noted that the effect of rebar, unlike other concrete surface resistivity measurement devices, would be minimized using this approach. Other AC techniques have inherent error in the measurement of concrete resistivity due to the rebar effect.

ELECTRICAL RESISTANCE OF CONCRETE COVER:

As shown in Fig. 3 the value of R_{c3} can be used to determine the electrical resistance of concrete cover.

UNIQUE FEATURES OF CEPRA TECHNIQUE:

- Directional measurement of corrosion rate
- Directional measurement of concrete electrical resistivity
- Directional measurement of electrical resistance of concrete cover
- Fast: Measurement within seconds
- No need to electrical connection to reinforcement