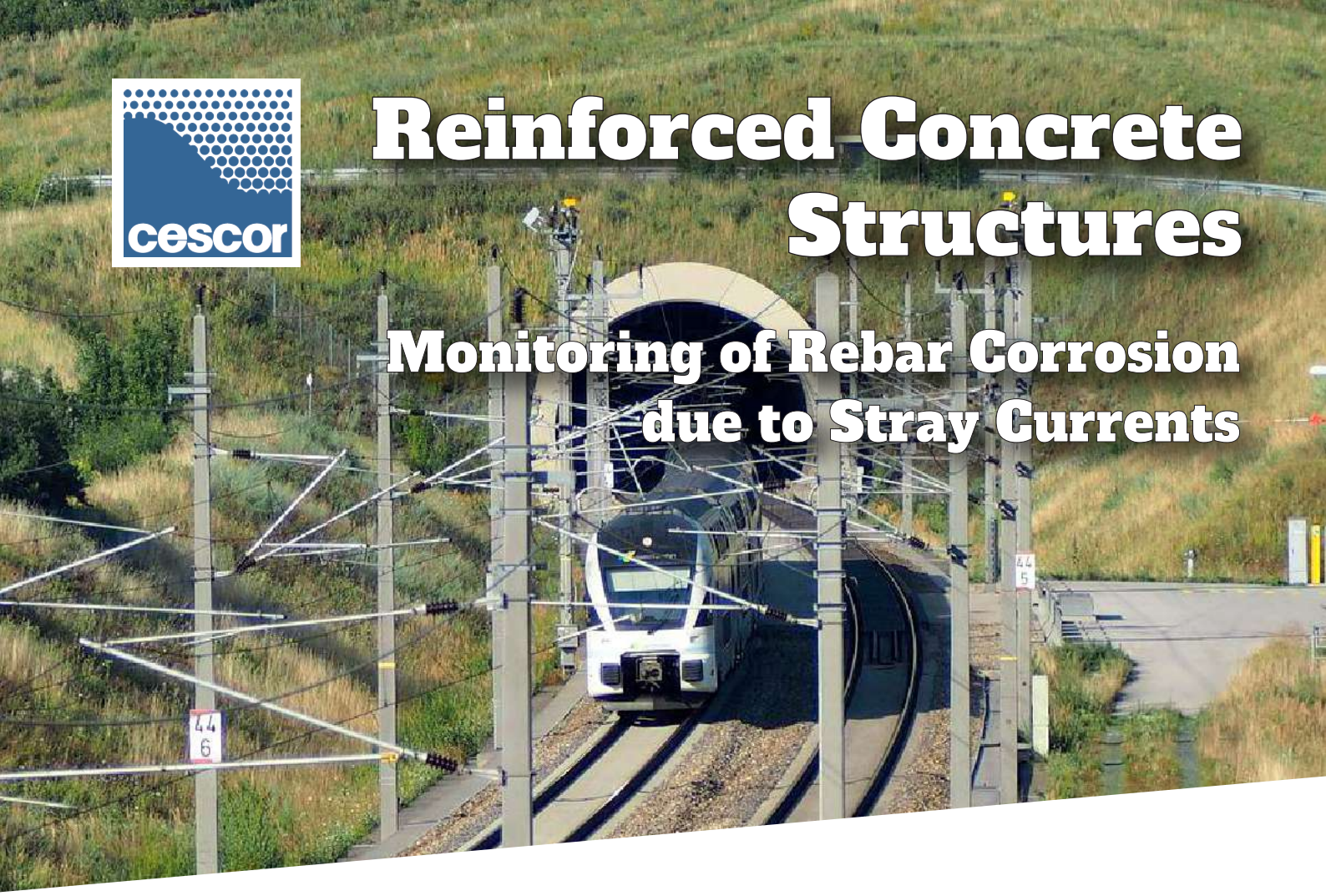


Reinforced Concrete Structures

Monitoring of Rebar Corrosion due to Stray Currents

Rebar Corrosion

Steel reinforcements embedded in concrete structures are naturally protected by the alkalinity of cement that allows to establish and maintain passive conditions. However, there are a number of specific but recurrent situations where passivity can be destroyed, and corrosion can initiate and propagate. These are:

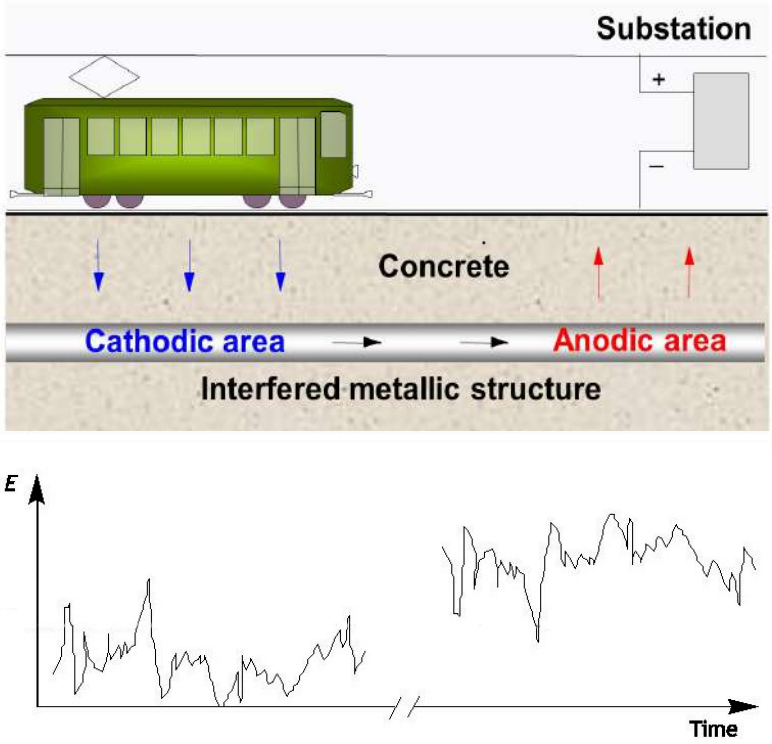
- Penetration of chloride ions
- Carbonation
- Stray currents.

In all these cases, corrosion starts after an initial period where the corrosion rate is negligible, and could then potentially propagate at an increasingly high rate, subject to local concrete conditions and macrocell establishment (Fig. 1).

Fig. 1 - Example of corrosion attack on a rebar

Electrical Interference

Steel reinforcements are embedded in a medium (concrete) having ionic conductivity. In case of electrical interference due to the circulation of direct current and the consequent creation of an electric field, the rebar can undergo corrosion attacks.



Non-stationary interference phenomena are encountered when the electric field is variable: this is the classic case of interference deriving from stray currents dispersed by direct current traction systems (railways, tramways, undergrounds, etc.).

Fig. 2 shows the example of an interfered metallic structure, embedded in a concrete structure located parallel to an electrified tramway line.
Electrical interference can cause the corrosion of the reinforcement in the anodic areas of the structure, where the current flows in the direction from the reinforcement to the concrete. From this tangible risk, it arises the need to adopt specific interference prediction criteria for the case of civil works and infrastructures in reinforced concrete (railway galleries, tunnels, motorway viaducts, etc.), in support of EPC contractors and Operators of electrified lines.

Fig. 2 - Interference scheme from non-stationary continuous stray currents in case of a metallic structure embedded in concrete

Interferences due to direct current railway and tramway traction systems generally have the following characteristics:

- During the day the electrical condition of the structure changes, and the extension and position of the interfered areas change in relation to traffic variation
- Potentials of the structure vary according to the position of the train along the line and the current absorbed by the structure at a given time.

Monitoring of Rebar Corrosion due to Stray Currents

CESCOR is able to monitor the presence or occurrence over time of interference conditions, with consequent corrosion damage on reinforced concrete structures, by using a permanent monitoring system based on data acquisition units and permanent reference electrodes (Fig. 3 and Fig. 4) in activated titanium (Ti-MMO).

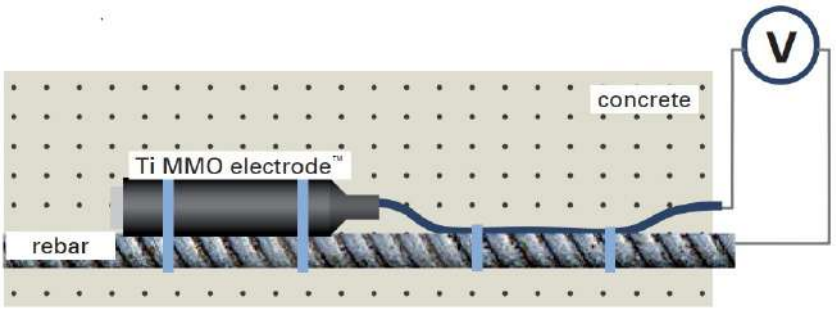


Fig. 3 - Ti-MMO installation on new structures

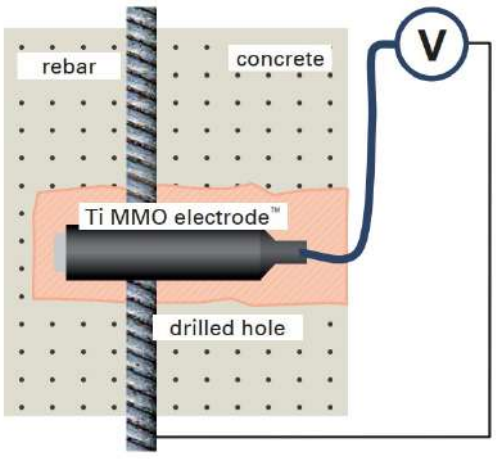


Fig. 4 - Ti-MMO installation on existing structures

The automated system is designed to continuously monitor the potential of rebar embedded in a concrete structure. For example, in the case of railway applications, in correspondence with the points where the Ti-MMO reference electrodes are installed, the system is able to monitor both the electrochemical potential and, eventually, the longitudinal ohmic drop.

The data acquisition unit can be optionally equipped with an internal computer and lighting with proximity sensor for switching on/off when the door is opened/closed (Fig. 5).

Fig. 5 - Internal components' overview of a data acquisition unit

The autonomous control panel system of the data acquisition unit can be connected to a central acquisition computer. The dedicated software can acquire and save the data, also visible in a graphical form, and transmit them via the Ethernet cable to the central computer (Fig. 6). The Ethernet network, which branches parallel to the entire length of the railway line to be monitored, can be copper or fiber optic, possibly configurable with daisy chaining cabling, with inputs and outputs from each data acquisition unit.

It is also possible to communicate directly with the data acquisition unit via an external PC/laptop, which can control and manage the dedicated software and the recorded data.

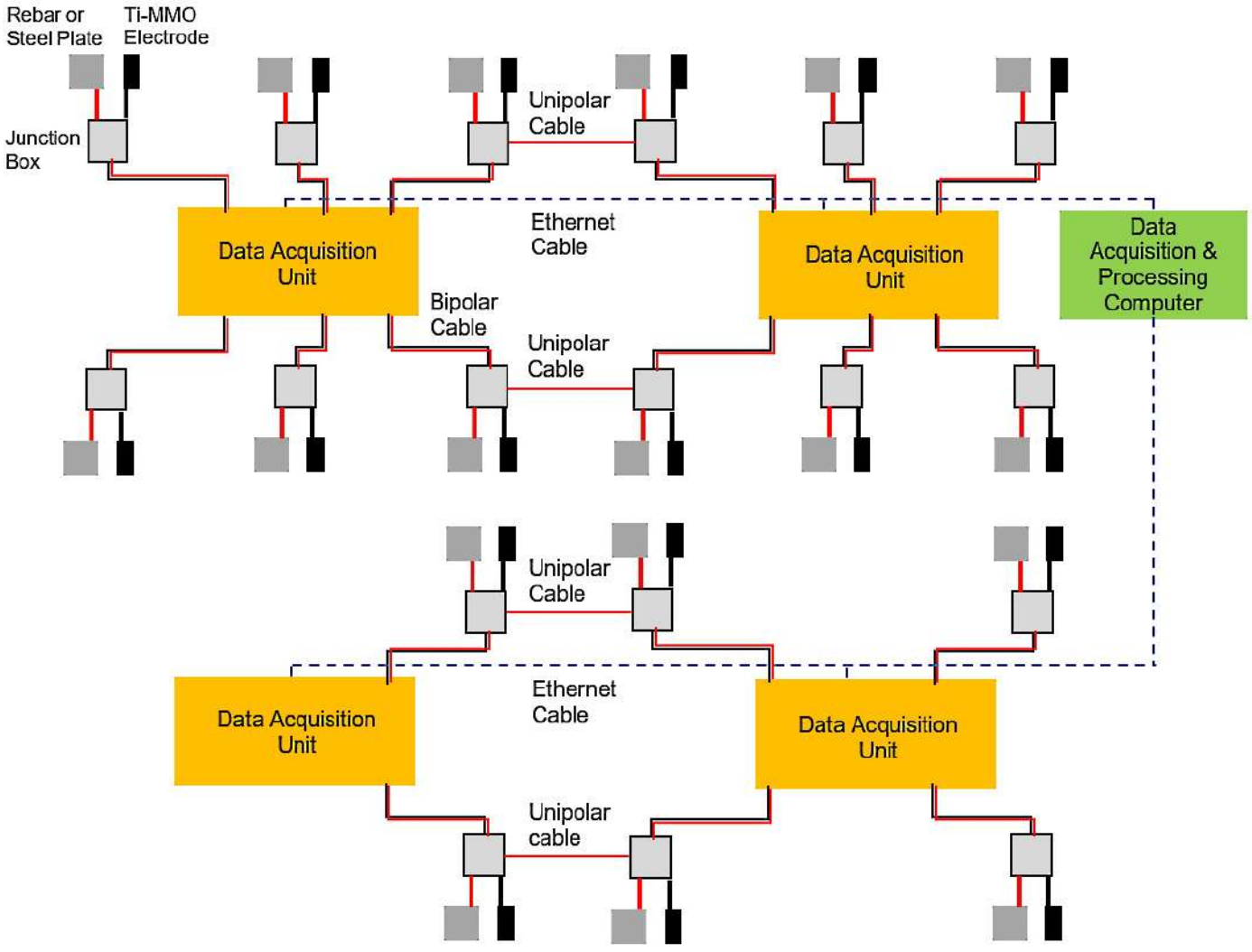


Fig. 6 - Schematic example of connections between data acquisiton units and central control computer

On the basis of the criteria defined by the current regulations and standards, the reference electrodes will allow checking whether the rebar will be interfered or not, by monitoring the electrochemical potential of the steel reinforcements, and the acquisition system will record and process the potential difference data, generating alarms in the event of exceeding certain standardized thresholds.

The example graph reported below in Fig. 7 clearly highlights the difference between the period of absence of traffic and the period of greater railway traffic, and it allows to evaluate if the potential remains constant over time (no interference), or if the potential varies over time, with a significant risk of electrical interference.

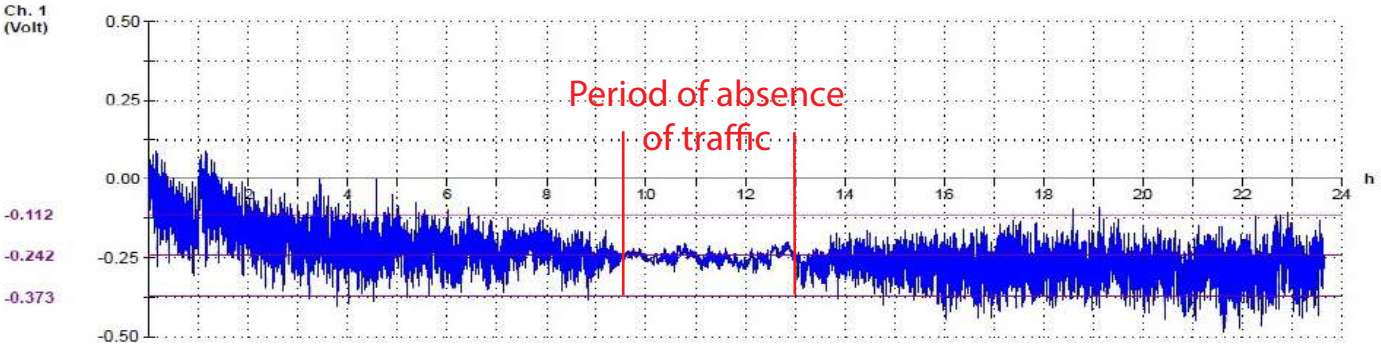


Fig. 7 – Graphical visualization of the period of absence of traffic, with no electrical interference

The interface software is also equipped with a real-time viewer that allows at any moment the operator to constantly control the status of the monitoring system and the monitored structure, and any diagnostic information relating to data acquisition units.

To periodically check the absence or presence of interference, the permanent monitoring system can perform:
- Measurement of the structure potential with respect to permanent Ti-MMO reference electrodes in concrete
- Processing of the recorded potential measurements for the evaluation of the structural conditions and eventual interference phenomena
- Storage of all recorded measurements within a database.

In addition, the permanent monitoring system is also able to monitor the operating status of the equipment installed inside the data acquisition units, as follows:
- Display of system configuration for measurements, with a management interface
- Calculation and memorization of characteristic parameters necessary for diagnosis
- Calculation of the diagnostic status, based on current regulations and standards
- Record of the diagnostic status, and also self-diagnosis
- Generation of alarms/warnings.

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