

TEM LAB

Remote monitoring of concrete corrosion

by **geoLAB**

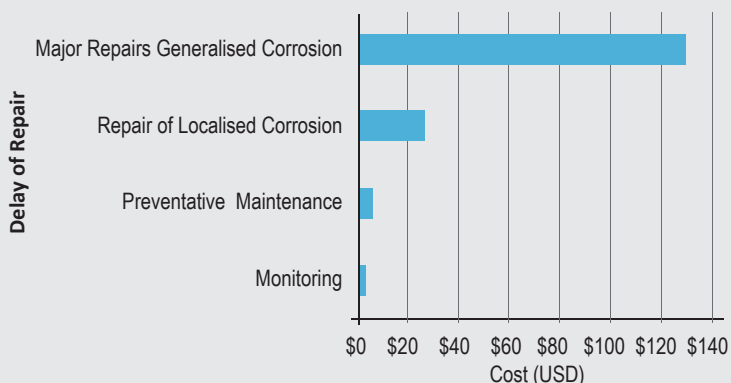
Detecting and reporting in detail reinforced concrete decay for a fraction of the cost



THE SYSTEM

- TEM LAB is an intelligent, non-destructive and minimally invasive system for in situ monitoring of the chemical and physical parameters of concrete, structural concrete, cement conglomerates and building stones.
- It provides real-time measurement of pH, chloride concentration, conductivity, temperature and humidity of the materials to determine the conservation conditions and the status of the relative degradation process.
- The output data is transmitted wirelessly to a remote server for processing and analysis.

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MAIN BENEFITS

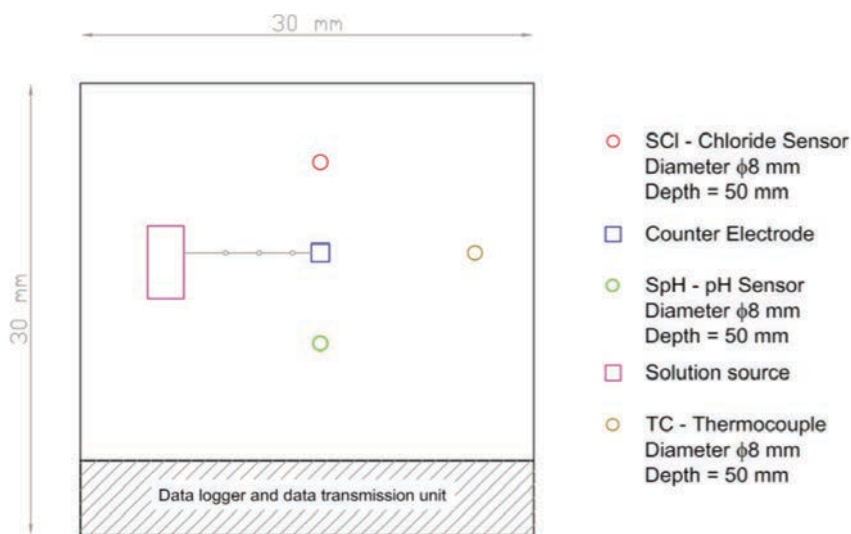
- Substantial savings in collection of information without the need of mobilising assets to conduct surveys on site.
- Continuous and reliable monitoring of the degradation and rate of corrosion of structural materials.
- Detailed information and easy interpretation of the data on corrosion damage, optimising planning, budgeting and execution of maintenance works.
- Non destructive procedure for collection of information with a minimum impact on the structure being monitored.
- Quick installation and low maintenance cost.

WHY CONCRETE DECAYS

- Deterioration rate of structures depends on the exposure conditions and extent of maintenance. Corrosion, a result of chemical or electrochemical actions, is the most common mechanism responsible for deterioration of reinforced concrete structures.
- Two major factors cause corrosion of rebars in concrete structures, carbonation and ingress of chloride ions. When chloride ions penetrate in concrete more than the threshold value or when carbonation depth exceeds concrete cover, then it initiates the corrosion of reinforced concrete structures.
- If the corrosion is initiated in concrete structures, it progresses and reduces service life of the structures and rate of corrosion affects the remaining service life of reinforced concrete structures.



HOW DOES THE TEM WORK?



The TEM is based on electronic measurement of chemical reactions that reveal the penetration of corrosion inside the concrete.

The TEM sensor inserted into the concrete structure through a small hole, injects a solution and measures the half-cell potential with respect to a counter electrode of liquid junction of the type Cu/CuSO₄ (sat. sol).

It analyses two parameters:

- Chlorides concentration and distribution
- Concrete pH and carbonation depth

$$\begin{cases} AgCl + e^- \rightarrow Ag + Cl^- \\ E = E_{AgCl/Ag}^0 - \frac{2.303RT}{nF} \ln[Cl^-] \end{cases}$$
$$\begin{cases} IrO_2 + H^+ \rightarrow \frac{1}{2} Ir_2O_3 + \frac{1}{2} H_2O \\ E = E^0 - \frac{RT}{F} \ln[H^+] = E^0 - 0.0592 pH \end{cases}$$

The measurements of potential (mV) are translated into concentration values through calibration curves, specific for each sensor, obtained from laboratory measurements of standard reference.



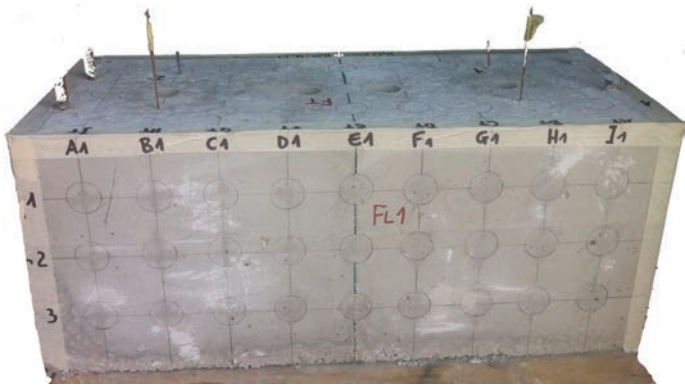
INSTALLATION METHODS

There are two options for installation of the TEM in a concrete structure:

Non-Destructive Installation during the concrete casting procedure while the structure is being built. The sensors are immersed into the concrete and the reference electrode is placed when the fluid solidifies.

Minimally Invasive Installation in hardened structures after concrete casting, or even years after completion of the construction works. The sensors are inserted into small holes that are drilled in the concrete and sealed afterwards.

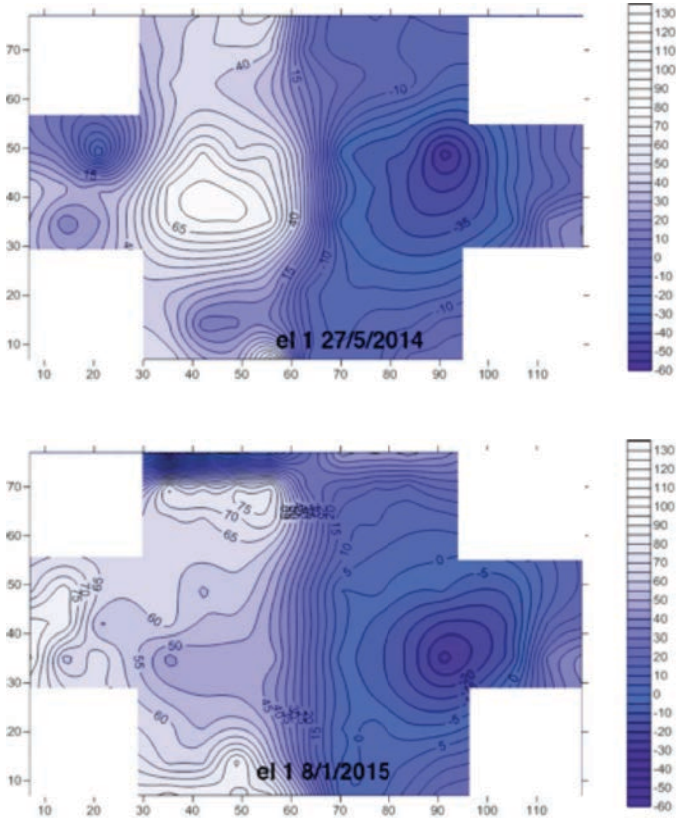
VISUALISATION OF RESULTS



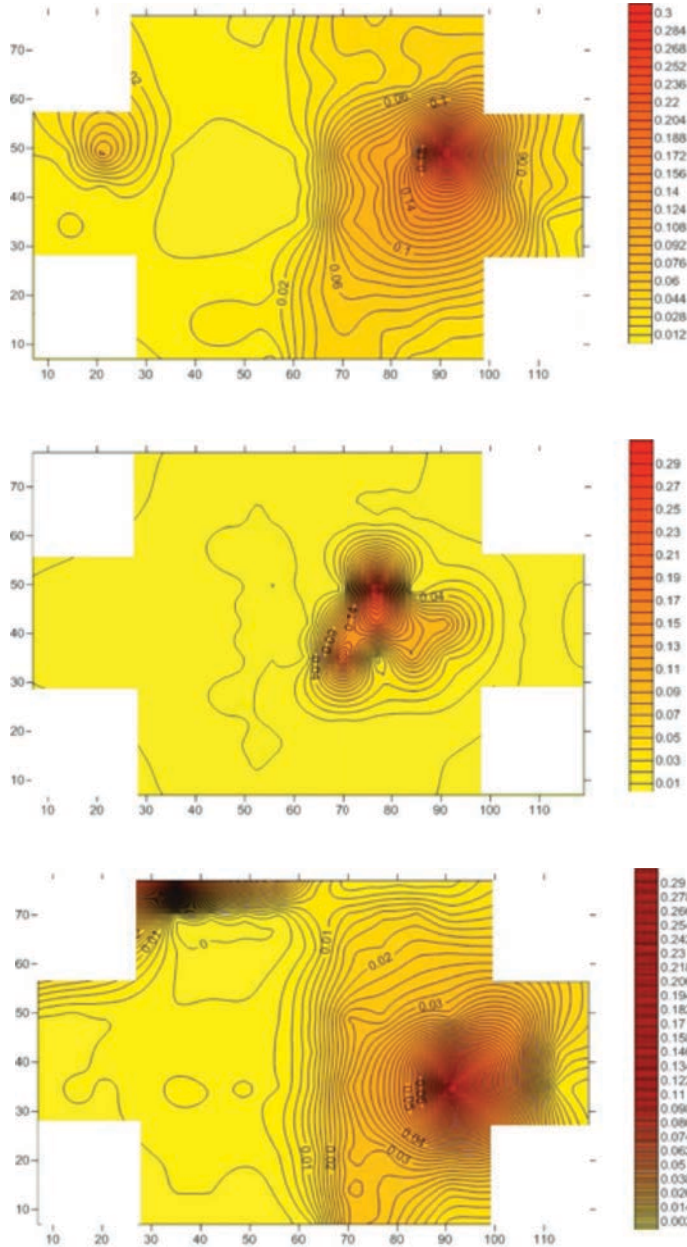
The data, which can be acquired on data loggers with an adjustable time frequency, are transmitted to the portal that records the information and manages the alerts, via a GSM or WIFI modem, or directly through a USB serial port

CHLORIDES THEMATIC MAPS

Potential [mV]



Chlorides Concentration [mol/l]



TIME

These images show some of the **distribution maps of the potential values (mV) and of the corresponding concentrations of chlorine ions.** The maps, made using commercial software (eg Matlab, Surfer, Arch GIS) or open source (Q Gis), refer to measurements made on a block of concrete made for one half of the volume with distilled water and for the other half with saturated NaCl solution. The maps show quite clearly the evolution over time of the phenomenon of migration, by diffusion, of the chloride ions in the capillary pores of the cement matrix, triggered by the initial concentration gradient.

WHO WE ARE



Geolab is a leader in the field of materials technology, quality control on construction products and geotechnical tests.

Geolab is registered with the European Commission as a notified body for the certification and quality control of structural materials and authorised to award the CE marking.

GeoLab, in collaboration with the University of Palermo, developed and patented the TEM System for measurement of key physical and chemical parameters in structural materials with intelligent sensors.

This is currently the only existing system in Europe with these capabilities and functionality.

OUR EXPERTISE

- Diagnosis of structural and chemical integrity in concrete.
- Research of the causes of deterioration in concrete through applied chemistry and mineralogy, X-ray fluorescence, X-ray diffractometry, reflected and transmitted light fluorescence microscopy, scanning electron microscopy.
- Physical and mechanical testing of construction materials.
- Diagnosis and study of the decay of buildings and materials.

MAIN CUSTOMERS

- ANAS
- RFI - Italian Railway Network
- INVITALIA - Ministry of Economic Development
- Sicilian Austradia Consortium
- Regional Service of Sicily
- Astaldi S.p.a.
- Impregilo S.P.A.
- SACYR
- FIP Industriale S.p.a.

SCIENTIFIC COLLABORATION

- University of Palermo
- University of Tuscia
- Accademia di Belle Arti di Palermo
- Consorzio INSTM



EXPERIENCE IN THE MIDDLE EAST

In 2014, GeoLab obtained approval by the Ministry of Public Works of the UAE for a pilot project intended to test the TEM under the extreme climatic conditions of the desert. The Ministry chose to install the sensor in a pillar of the tallest road bridge in the Middle East, under construction at the time at what was known as the National Paints Roundabout, between Sharjah and Dubai.

The two-year pilot project was completed successfully in September 2016 and a presentation of the results was given to the top authorities and the management of the Roads Department. The engineering team in charge of road maintenance highlighted the value of the information collected, the reliability of the system and the great difference in cost compared to the effort it would require to obtain similar information through conventional methods.

As a result the Ministry included the TEM within its plans for infrastructure maintenance across the country in the immediate future.