In situ atmospheric corrosion assessment of weathering steel structures

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Weathering steels or high strength low alloy steels are a group of steels that form a dense and tightly adherent oxide barrier as they corrode under specific conditions. This oxide layer seals out the atmosphere and protects bulk metal from further corrosion. Due to the nice colour of the corrosion products layer, weathering steels are extensively used for artistic and architectural purposes in outdoor sculptures, as well as in exterior buildings facades and for bridges.

Weathering steel structures are generally exposed to the atmosphere as is, leading the corrosion products layers to naturally grow on the surface after the interaction with the environment; however, in some cases, artists decide to artificially corrode the metallic surface before exposing their creation outdoor to immediately give it an antique and rustic appearance.

In this study, in situ electrochemical impedance spectroscopy (EIS) measurements have been performed to assess the atmospheric corrosion behaviour of the weathering steel structures of a residential building, known as 25-Green, a tree-house designed by the architect Luciano Pia and located in Torino (Italy). Several measurement campaigns have been performed in the last two years to investigate the atmospheric corrosion mechanisms occurring on the weathering steel structures as a function of the exposure time to the weather, and to assess the protective effectiveness of the naturally grown corrosion products layers.

Moreover, EIS measurements have been performed on a set of artificially aged COR-TEN (trade mark of a series of weathering steel alloys) steel specimens to compare the corrosion-retarding effect of corrosion products layers developed and regenerated continuously when exposed to the atmosphere, with the protective properties of those artificially grown very fast when the metal has been exposed to chemical reagents.

EIS measurements have been performed employing a portable commercially available electrochemical interface and some specifically designed measuring probes realised through a 3D printer. The measurements have been performed in Na_2SO_4 0.1M solution, in the frequency range of 0.01Hz to 100kHz, by stimulating the sample with a small alternating voltage, in the range from 10 mV to 100 mV, while compensating the open corrosion potential (E_{OCP}).

EIS results highlighted the different corrosion behaviour of naturally and artificially grown corrosion product layers, as well as the different electrochemical behaviour of the weathering steel structures in dependence of the chemical composition of the bulk alloy and the different alloy manufacturing processes.