

EVALUATING CORROSION PROPAGATION IN STEEL WITH DAMAGED PROTECTIVE COATING

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Corrosion remains a predominant factor in the deterioration of steel bridge infrastructure, particularly under aggressive atmospheric and marine environments. Protective coating systems, including organic, metallic, and duplex layers, are widely utilised as a primary defence mechanism to isolate the steel substrate from corrosive agents such as oxygen, moisture, and chloride ions. However, during critical phases such as fabrication, transportation, lifting, welding, and installation, these protective systems are frequently subjected to mechanical distress, resulting in coating discontinuities like scratches, cracks, or localised delamination. These defects compromise the barrier properties of coatings, enabling electrochemical interactions that initiate corrosion at the exposed metal surface. Although a variety of high-performance coatings are employed in infrastructure applications, there exists a substantial research gap in understanding how different coating systems behave when deliberately damaged. The absence of comparative studies focusing on corrosion propagation from artificially induced defects under controlled laboratory conditions presents a significant limitation in current maintenance and design practices.

This study aims to evaluate the corrosion propagation kinetics in steel plates with uniformly damaged coatings, simulating real-world exposure scenarios in steel bridges. Specimens were prepared with five representative coating systems: Hot-Dip Galvanising (HDG), Thermal Spray Metalising (TSM), marine-grade epoxy paint, and two types of duplex systems, which are hot-dip galvanising + marine-grade epoxy paint and thermal spray metalising + marine-grade epoxy paint, each applied according to manufacturer specifications and standardised surface preparation. Controlled scribing techniques were used to introduce uniform defects of consistent thickness. Accelerated corrosion testing were conducted per ASTM G85 Annex A5, a modified cyclic corrosion procedure involving alternating fog/dry phases and a dilute electrolyte solution of sodium chloride. Corrosion initiation and propagation were carried out using visual inspections and Half-Cell Potential (HCP) measurements.

The study found that duplex coatings (Hot-Dip Galvanising + Marine Paint and Thermal Spray Metalising + Marine Paint) outperformed only marine paint coatings, showing less corrosion propagation due to the sacrificial protection of the metallic layers. Although HCP measurements for Hot-Dip Galvanising and Thermal Spray Metalising alone did not yield HCP results, visual inspections confirmed their superior performance. The research highlights the effectiveness of duplex systems for steel infrastructure exposed to mechanical damage and emphasises the need for alternative electrochemical testing methods, such as Electrochemical Impedance Spectroscopy (EIS) for sacrificial coatings. These findings provide insights into material selection and coating strategies, contributing to long-term durability and reduced maintenance costs in steel bridge applications.

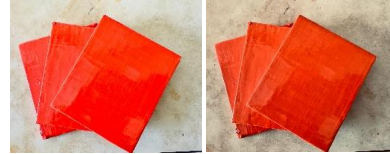
Keywords: Accelerated corrosion testing, ASTM G85 Annex A5, Coating performance evaluation, Electrochemical analysis, Steel bridges

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Commonly Used Protective Coatings

- Hot Dip Galvanizing
- Thermal Spray Metalizing
- Marine Painting
- HDG + Marine Painting
- TSM + Marine Painting



Prepare Specimens and Perform Experiments to Evaluate Corrosion Propagation

Prepare Specimens for the Experiment

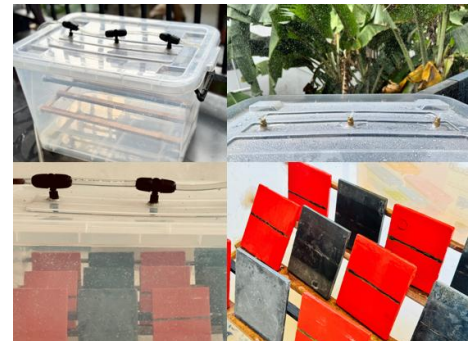
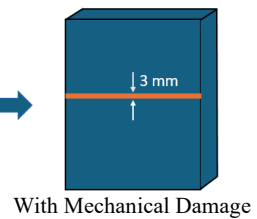
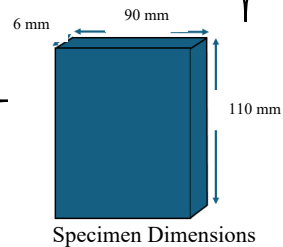
Construct a Salt Spray Machine

To analyse corrosion propagation using an electrochemical method

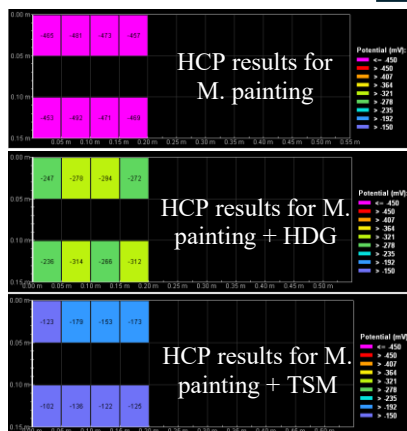
Perform Half-Cell Potential Tests

Visual Inspection

Marine Painting Specimens after 70 days



Accelerated Corrosion Test According to ASTM G85 Annex A5 (Cyclic Wet/Dry, 5% NaCl)



Conclusion

Alternative testing methods are recommended for Galvanizing and Thermal Spray Metalizing coatings for more reliable results

Corrosion Propagation

M. Painting + TSM

< M. Painting + HDG

< M. Painting