Corrosion Protection for Reinforced Concrete Highway Structures

Sam Beamish – Mouchel
Track Record of Electrochemical Corrosion Protection Systems

- **1824** Sir Humphry Davy reports galvanic CP of ships’ hulls.
- **circa 1910** Impressed current CP of buried steel structures.
- **late 1940s** Impressed current system to pipeline in Africa.
- **mid 1950s** CP of buried reinforced concrete structures.
- **late 1970s** CP of reinforced concrete bridge decks in US.
- **mid 1980s** First Building - conductive coatings used as anodes.
  First UK Bridge: Midland Links - Spaghetti Junction.
  Titanium mesh anodes with sprayed concrete overlay.
- **early 1990s** Meshless conductive overlay anodes introduced.
  Desalination and realkalisation in the UK.
- **early 1990s** CP used to protect steel framed buildings.
- **mid 1990s** CP using discrete anodes.
- **late 1990s** Galvanic CP systems.
Midland Links Viaducts - Spaghetti Junction
Midland Links Viaducts
Typical Sub-structure Arrangement

- Hard Shoulder
- Carriageway - 3 Lanes
- Reinforced Concrete Shear Walls
- Deck Slab
- Expansion joint
- Steel Beams
- Reinforced Concrete Columns
- Reinforced Concrete Crossbeam

Section A-A
Deterioration Due to Chloride Attack
Cathodic Protection

- Repair of physical defects only (e.g. spalling, delamination, etc)
- Contaminated concrete can remain.
- Structural impact is reduced.
- Minimal disruption to travelling public.
Midland Links - Site Trials
Site Trials – Two Stages

- Two different conductive paint systems.
- Conductive polymer mesh anode with sprayed cementitious overlay.
- MMO coated titanium mesh in cementitious overlay.
- Sprayed zinc.
- Discrete surface mounted titanium oxide tile system.
- Instrumented controls.
Site Trials

Conductive Paint Systems
Site Trials

Mesh and Overlay System
Site Trials – Evaluation

- Physical condition.
- Review of monitoring and performance data.
- Review of secondary effects.
- Comparison of anodes.
- Choice of anode(s).
First Full Scale Cathodic Protection System
- Anode System
First Full Scale Cathodic Protection System
Cathodic Protection – Zoning Arrangements
Cathodic Protection
Cathodic Protection – Monitoring and Control Regime

- Operational checks.
- Performance monitoring and adjustment of control parameters (where required).
- Anode inspections.
- System reviews and reports.
Cathodic Protection – Remote Monitoring

Benefits

- Reduced visits to site
- Better quality data
- Potential for automated monitoring and control
- Alarms
- Less susceptible to vandalism
Cathodic Protection – Remote Monitoring
Cathodic Protection – Different Anodes

Anodes used on the Midland Links:

- Conductive paint.
- Mesh and overlay.
- Discrete anodes.
- Sacrificial anodes.
A13 Pitsea Flyover
A13 Pitsea Flyover
A13 Pitsea Flyover
A9 Cromarty Bridge
Area 5 - M25 Sphere

- M4 Elevated – discrete anode/mesh and overlay
- M1 Bunns Lane - mesh and overlay
- M1 Brockley Bridges - mesh and overlay
- M1 Scratchwood Railway Bridges - mesh and overlay
- M1 Deans Brook Viaduct - mesh and overlay
- M1 Berry Grove - mesh and overlay
- A1089 Dock Road – discrete anode/mesh and overlay
Sacrificial Anodes - Galvashield
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Area 13 M6 Bridges - Desalination
Area 16 M6 Bridges - Desalination
Re-alkalisation
Multi-storey Car Parks
Multi-storey Car Park – Contamination Mechanism
Multi-storey Car Park Deck
Half-cell Potential Mapping

Less used bays

Popular parking bays

Up ramp

Up ramp

Increasing -ve half-cell potential

Corrosion Prevention Association
Multi-storey Car Park – Cathodic Protection Installation
Corrosion Prevention Association

Standards

Highways Agency Guidance Note and Specification

Table 1 – Impressed Current Anode Types and Characteristics

<table>
<thead>
<tr>
<th>Anode Type</th>
<th>Typical Long Term Anode Current Density per m² of anode</th>
<th>Supplier’s Typical Anode Life Estimate Note 2</th>
<th>Suitable for Wet Structures</th>
<th>Suitable for Burring Surfaces</th>
<th>Dimensional &amp; Weight Impact</th>
<th>Installation</th>
<th>Other Performance (Overhead Specialist Advice)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductive Organic Coatings</td>
<td>20mA/m²</td>
<td>20mA/m²</td>
<td>Max</td>
<td>Up to 15 years</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Syphoned zinc</td>
<td>20mA/m²</td>
<td>20mA/m²</td>
<td>Max</td>
<td>Up to 25 years</td>
<td>Possibly</td>
<td>No</td>
<td>No</td>
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<tr>
<td>Mixed metal clad cathode; (MMCT) mesh and grid in cementitious overlay</td>
<td>10mA/m²</td>
<td>15-40mA/m²</td>
<td>varying grades</td>
<td>Up to 120 years</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>MMO1/100 Inhibition anodes</td>
<td>110mA/m²</td>
<td>Cira 10-110 mA/m² subject to distribution</td>
<td>Up to 120 years</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Discrete anodes in reinforcement unwind. MMO 1/10; or Conductive anodes</td>
<td>800mA/m²</td>
<td>Cira 10-110 mA/m² subject to distribution</td>
<td>Up to 50 years</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Cored/concrete rebars; incorporating wire/taped carbon fibre strands</td>
<td>30mA/m²</td>
<td>30mA/m²</td>
<td>Max</td>
<td>Up to 25 years</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Standards

European Standards

BS EN 12696 Cathodic Protection of steel in concrete.

DD CEN/TS 14038-1&2
Electrochemical re-alkalisation and desalination treatments for reinforced concrete.
Standards

Concrete Society Technical Reports TR 36 and 37