Cathodic Protection of Early 20th Century Steel Framed Buildings

By

Dr John Broomfield, CEng, FICorr, FIM³, FNACE
Some of our most prestigious landmark buildings of the early 20\textsuperscript{th} century are steel framed

Major department stores, hotels civic buildings etc. in London, Birmingham, Manchester and elsewhere

Now suffering from corrosion of steel frame
Principles of Conservation

- Rule 1 – There are no rules! A flexible approach is required, not adherence to rules.
- Rule 2 – If you’ve done it before, doesn’t mean you can do it again.
- Rule 3 – Just because you don’t like a building doesn’t mean you don’t need to care for it.
Principles of Conservation

• All historic fabric is precious
  – NOT JUST THE ORIGINAL
• Intervention should be avoided if at all possible
  – THEREFORE MINIMUM INTERVENTION
• Necessary intervention should be reversible
• It should be in addition to the existing structure not replace it
• Intervention should be carried out with sympathetic materials (good engineering)
• Avoid destroying historical evidence
• Make clear modern changes while being sympathetic
Guidelines for satisfying the ideals of Conservation

- Grade 1 and 2* it is compulsory to involve EH
- Grade 2 is responsibility of Local Authority, although they often include EH in the process.
- Older buildings (pre 1840) are deemed potentially of historic interest hence EH will often be consulted even if not listed.
- The above applies to England & Wales. Other countries may have different categories and authorities, but principles are broadly the same.
Guidelines for satisfying the requirements of conservation

• Pre application meeting with Regional staff.
• Historic Buildings Inspector.
• Historic Buildings Architect.
• Conservation Engineer
• Consider having a project “Conservation Steering Group” of experts & stakeholders
Don’t say
“It’s only the façade that’s listed”

Current regulations list the building without categorising what part. Each building is unique and listed for its own unique reason.

Forthcoming listing procedures will identify more clearly why the building is listed.
Cathodic Protection for Masonry Buildings
Incorporating Structural Steel Frames

Technical Notes No: 20

By:
NACE International Task Group 329 and CPA Technical Committee

Price: £5.00

Corrosion Prevention Association
Corrosion Assessment Methods for Steel Frames

- Reference Electrode (Half Cell) Potential Mapping
- Corrosion Rate (Polarisation Resistance)
- Electrical Resistivity
- Carbonation Depth
- Chloride sampling & profile
- NOTE – PERMISSION REQUIRED FOR DESTRUCTIVE EXAMINATION OF LISTED BUILDINGS
Investigation Methods

- Radar
- Infra Red
- Ultrasonics
- Displacement measurements
- Crack monitoring
- Defect Monitoring
Cover Meter used to find depth of steel band which was jacking up brick courses

Problem was cover depth and failed drainage
LPR Meter for steel in concrete or mortar
• From a total of 186 readings
• Assume 1 μm/year section loss
•  = 7 μm/year brick movement
• 6% of readings showed >1 mm brick movement in less than 50 years
• High rates concentrated near parapet/roof level and north elevation
Resistivity Meter
4 probe Wenner

CONCRETE
> 20kohm.cm
  = Low Corrosion
10 - 20kohm.cm
  = Low - Mod Corrosion
5 - 10kohm.cm
  = High Corrosion
<5kohm.cm
  = Very High Corrosion
Most masonry materials have resistivities that exceed 1 MΩ.cm when moisture content falls below 2% and in the range 100 to 300 kΩ.cm at higher moisture content.
Repair Options

- Exclude the water
  - Drainage
  - Flashings
  - Repointing
- Strip cladding, treat steel and reclad
- Apply impressed current cathodic protection
Impressed Current Cathodic Protection

- Connect all steel together or isolate it
- Only repair where there is damage
- Divide into zones
- Apply anodes and reference electrodes
- Wire to 10-20V DC power supply
- Apply approximately 5mA/m$^2$ of surface
- Design and operate according to BSEN12696:2000
Impressed Current
Cathodic Protection Components

• Anodes –
  – Ribbons in joints or probes in holes
  – Different zones to control different conditions
• Reference electrodes
  – Measure the steel potential to ensure it is protected
• Cables
  – From anode zones, steel, and reference electrodes
• Power Supply
  – Typical 12-20V, 1A DC multizone supply
• Monitoring System
  – Local logging or remote control and monitoring
# Impressed Current Cathodic Protection Pros & Cons

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Wide Range of Anodes</td>
<td>• Requires a continuous power supply</td>
</tr>
<tr>
<td>• Well Established Technique</td>
<td>• Requires continuous monitoring</td>
</tr>
<tr>
<td>• Well Established Standards</td>
<td>• High first cost</td>
</tr>
<tr>
<td>• Many expert UK Contractors/consultants</td>
<td>• Highly technical</td>
</tr>
<tr>
<td>• Continuous monitoring to show it works</td>
<td>• Can be hard to hide anodes</td>
</tr>
<tr>
<td></td>
<td>• Must bond all steel together</td>
</tr>
<tr>
<td></td>
<td>• Possible staining</td>
</tr>
</tbody>
</table>
Corrosion Prevention Association

Positive Connection to anodes (All external cables in joints)
Reference electrode Voltage measurement
Negative Connection to steel

Control and Monitoring System
Modem or broadband link for remote access

Exterior of Building

Interior of Building

Anode in Joint
(Reference Electrode at higher level in joint)

Terracotta Block
Mortar
Steel Frame
Failure to bond the discontinuous metal may result in either (i) cracking of the terra cotta modillion unit, or (ii) accelerated corrosion of the J hook support and potential spalling to ground level.
Contaminated ribbon slots. Iron filings used to simulate deposits from slot cutting tools.
St Martin’s Lane
In Conservation Area

Corrosion Prevention Association
36 St Martin’s Lane London
Originally part of the Coliseum next door – now flats above a coffee shop
Built 1904 Architect Frank Matcham

Ribbon Anodes
In joints between stones
Conclusions I

- Each Historic Building is unique
- Each will require unique assessment and treatment
- Cathodic Protection can be
  - Less invasive
  - More reversible
  - Have lower visual impact
  - Very long life (>100 years)
  - Continual assurance of effectiveness
- 53 cases 1999-2008 listed in CPA Tech Note 20
Conclusions II

• If cathodic protection is the preferred solution
• Ensure there is adequate expertise in the design team
• Use an experienced contractor with qualified staff
• Undertake sufficient investigation to quantify the risks