albertfry associates
albert fry associates ltd.
125 ormeau road
belfast
bt7 1sh

t: +(0) 28 9032 2025
f: +(0) 28 9032 2057
w: www.albertfryassociates.com
e: office@albertfryassociates.com

Our Ref: MSW/10692.L01/JK/JS

25th August 2022

Ms. Gillian Corbett
Ards and North Down Council Planning Department
2 Church Street
Newtownards
BT23 4AP

Dear Madam,

Re: Royal hotel, 22-28 Quay Street, Bangor, Co. Down

Further to your instruction we have reviewed the current planning application documents and have undertaken visual inspection of the exterior of the building (on 26/07/2022) and of the interior (on 11/08/2022). The purpose of this review and inspections is to assess the feasibility of retaining the existing façade of the Royal Hotel Building.

Figure 1.0 – Royal Hotel Quay Street Facade

The current application includes a proposal, to demolish the façade, based on the recommendations set out in the 'Steelwork Condition Report – Executive Summary' report prepared by Design ID Structural & Civil Engineers. This report discusses two options; Option1 – Replacement of External Columns and Option 2 – Demolition and re-construction.

The report recommends demolition and re-construction on the basis that Design ID consider this approach to be less risky, to require less maintenance and to be less complex and less expensive compared to the column replacement option.

Our visual inspections confirmed that the structure of the building comprises a five-storey steelwork frame of columns and beams supporting poured in-situ concrete floor-slabs. Our observations confirmed that corrosion of the steelwork varies from minor (at the drier interior locations) through moderate (at areas affected by water ingress/leaks etc) to severe (on steelwork embedded in the façade).


Figure 2.0 Interior Dry Area Corrosion


Figure 3.0 Interior Wet Area Corrosion


Figure 4.0 Façade Steelwork Corrosion

These observations are consistent with the findings of the Design ID report and we agree that the absence of effectual protection on the façade steelwork and the adverse changes (to the plaster coating and mortar covering the steel) caused by the aggressive marine environment of the building's location have led to the severe corrosion.

With respect to options to address the severe corrosion of the façade columns we recommend that consideration should be given to a Cathodic Protection (CP) approach. There are precedents (e.g., Shelbourne Hotel, Dublin and Parker Street, Liverpool) for successful use of Cathodic Protection of embedded steelwork in historic facades, involving the use of embedded, discrete hybrid-anodes with initial application of an impressed current, from an external electrical source, to render the steel passive followed by anode self-generated galvanic-current to maintain passivity in the long term.

The approach could be detailed with enclosures to allow access to the installed system from inside the building. Since the external cover to the façade columns is a relatively thin render the system would need to incorporate a high-specification coating to the outer face of the façade columns allowing the embedded anodes to provide protection to the other, embedded, faces of the columns.

Should the present loss of column cross section, to corrosion, have significantly compromised the loadbearing capacity of the columns it would be possible to supplement capacity by introducing additional columns (e.g., RHS steel sections minimising interior projection) placed against the internal face of the façade below each floor beam location.

This approach would allow the steelwork to remain in place, it would involve minimal disruption to the façade and it would provide a means to extend and manage the design life of the building.

I have attached information on the Shelbourne Hotel and Parker Street examples along with 'Technical Note 7, Cathodic Protection of Early Steel Framed Buildings' published by the Corrosion Prevention Association for your information.

I trust this response is sufficient for your purposes for now, please let me know if you require any clarification or wish to discuss.

Please note that this report relates to specific purpose noted and that no opinion is offered or is to be inferred with respect to other matters (such as damp, building services, timber condition, finishes etc) which we assume are subject to a separate assessment, if required by other specialists.

Should you require any clarification or further information please contact the undersigned.

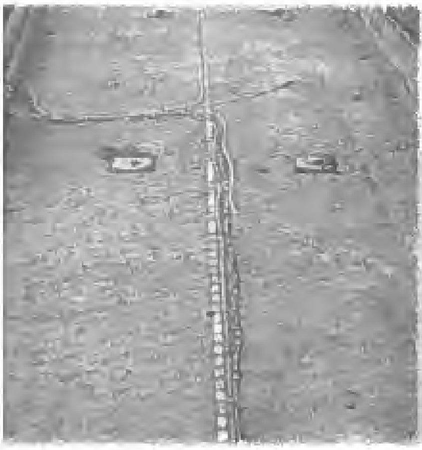
Yours faithfully
for ALBERT FRY ASSOCIATES LTD

[redacted]

James P Kerr
B.Sc. (Hon), M.B.A., C.Eng., M.I.C.E., F.I.Struct.E., M.C.M.I.
CARE Accredited Conservation Engineer

Encl.

- CPA Cathodic Protection of Early Steel Framed Buildings
- CPT-Case-Study-Parker-Street - brickwork surround
- CPT-Case-Study-Shelbourne-Hotel-Dublin



Cathodic Protection of Early Steel Framed Buildings

Technical Note 7

Peter Gibbs

February 2016

The voice of the concrete repair and refurbishment industry

INTRODUCTION

Corrosion problems associated with early 20th century masonry clad steel framed buildings have become increasingly evident over the past two decades.

Buildings affected by corrosion were generally constructed during the first half of the 20th century and many are now 'listed' or designated within conservation areas. These buildings often have ornate stone or masonry façades, which provide the impression of traditional solid load bearing construction.

The problems of corrosion in early 20th century steel framed buildings are related to the original designs. Unlike modern buildings utilising cavity wall construction techniques, these buildings have thick masonry or stone units tightly built about the structural steel frame. As the facing masonry and masonry in-fill materials are often porous this method of construction allows moisture entering the structure to come into contact with the steelwork. Sufficient levels of moisture for corrosion can enter the structure through a variety of routes the more common of which include: open joints, cracks, directly through porous masonry facings, or through inadequate or poorly maintained rainwater protection details

Steel framed buildings are located in most major towns and cities of the UK. The most widely recognised steel framed buildings of the UK are probably those found in Regent Street, London (see front page) where the problems of corrosion have been so common that steel frame corrosion is commonly referred to as 'Regent Street Disease'.

Steel frame corrosion problems are common throughout the UK and are not just confined to the Capital. For example, in Manchester, steel frame corrosion problems are well recognised and the local term 'The Deansgate Disorder' is often used to describe the corrosion problems.

Reports of steel frame corrosion problems have risen steadily over the past two decades and the number of reported cases can only be expected to increase as this important stock of buildings continues to age.

ORIGINAL CORROSION PROTECTION MEASURES

Steel frames were rarely adequately protected against corrosion with typical corrosion protection measures including one of the following treatments (London Building Act 1930):

- Mortar in-fill
- Red lead paints
- Tar treatments
- OPC wash
- Application of boiled oil

It is now known that the above methods of corrosion protection would have provided protection for a period of not more than 30 years.

TREATMENT OPTIONS

Only two practical methods of treatment are available to prevent steel frame corrosion:

a) treating the steel and changing the environment, or

b) halting the corrosion process electrochemically.

(Note: Waterproofing measures and novel treatments such as the application of corrosion inhibitors are not 100% effective and should always be viewed with caution.)

The former is often impractical and expensive due to the necessity to remove large sections of masonry to allow access to the steel frame. The removal of masonry is also of particular concern where Listed buildings are involved and a conservation strategy must be adopted for the facade.

Recent developments have exploited the latter option to provide a cost effective and non-invasive remedy to steel frame corrosion.

Cathodic Protection (CP) offers many benefits over traditional repairs, including substantial cost savings, minimal disruption to the building occupants and conservation benefits that are of particular importance in Listed buildings.

CATHODIC PROTECTION

The theory and application of CP is not new. The first system was developed by Sir Humphry Davy in 1824 to prevent the corrosion of copper anti-fouling cladding applied to timber hulled war ships. CP has developed considerably since these early systems and is now applied to protect large engineering structures such as pipelines, bridges and concrete buildings as well as common every day items such as hot water cylinders.

The most recent application of CP has been for early 20th Century masonry clad steel framed buildings with the first system being installed in 1991. The technology of Cathodic Protection is well proven and its development to steel framed buildings is described below:

- 1824 First CP system for marine applications.
- 1920s CP applied to buried pipelines.
- 1973 First CP system for reinforced concrete in USA.
- 1984 First UK CP system for reinforced concrete.
- 1991 First CP system for the protection of steel 'I' sections in Portland stone.
- 1992 First CP system for the protection of corroding iron cramps in Bath stone.
- 1995 Extensive laboratory and site trials on the application of CP to masonry clad steel framed buildings.
- 1997 First CP system for a faience clad steel framed underground station using discrete rod anodes.
- 1997 First CP System for a faience and brick steel framed building using ribbon anodes in jointing.
- 1998 First CP system installed on a sandstone-clad steel framed building.

Early CP systems such as those used by Humphry Davy and early pipeline engineers are comparable in theory to those used to protect reinforced concrete and masonry – but are very different in operation.

Early systems relied on the protective current being created by the dissolution (corrosion) of a sacrificial piece of anodic metal such as zinc attached to the structure in a low electrical resistivity medium such as soil or seawater. In the case of reinforced concrete and masonry the current is produced from an external power supply and the current is impressed towards the corroding metal via inert anode materials embedded within the structure. The two forms of CP system are now generally termed either 'Sacrificial' or 'Impressed Current' Cathodic Protection. The important major differences between these two forms of CP are that the anode is not consumed and the current output is fully controllable under an Impressed Current CP system. Both these qualities are generally essential for the successful operation of a masonry or concrete CP system.

PRINCIPLES OF MASONRY CATHODIC PROTECTION

The corrosion of steel in masonry and cement-based materials is an electrochemical process (Figure 1). Dissolution of steel (oxidation reaction) liberates electrons and forms anodic sites. In order to maintain charge neutrality, a reduction reaction occurs in an adjacent area called the cathode. Both oxidation and reduction reactions occur simultaneously and the corrosion rate is reduced and / or stopped when one of these reactions is controlled and/or ceased.

Cathodic protection forces a current towards the steel surface (Figure 2) and effectively arrests the corrosion process by:

I. lowering the steel potential sufficiently in the negative direction to prevent the oxidation reaction

II. lowering the electrical potential difference between the anodic and cathodic areas

III. generating alkalinity at the steel surface as a result of reduction reactions passivating the steel

IV. removing aggressive ions, such as chloride, from the steel surface.

A more simplistic view of cathodic protection is that reversal in the direction of corrosion current occurs by forcing an ionic current to flow on to the steel surface.

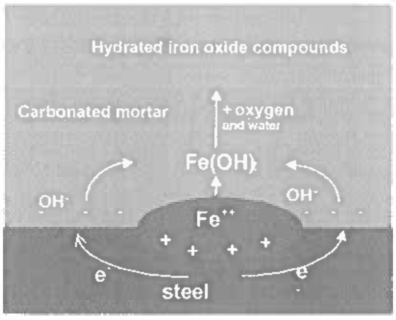


Figure 1: Electrochemical corrosion

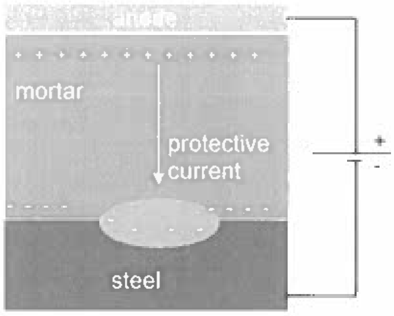


Figure 2: Schematic representation of a CP system

PRACTICAL CONSIDERATIONS

Making cathodic protection work in practice is a specialist skill. Before concluding that CP is a viable option for a steel framed building it is essential that the following factors are assessed:

- continuity of the steel frame, fixings and other metallic elements
- level of contact between the steel and masonry facing
- current distribution (controlled by mortar and stone resistivity
- the impact of anode location and type
- aesthetic considerations (installation details).

ELECTRICAL CONTINUITY

Early 20th century steel framed buildings contain a large variety of metallic elements and often include two or more of the following:

- steel beams and columns
- fixings that are either bronze, iron, steel or galvanised steel
- iron, steel, galvanised steel or bronze cramps between stone elements
- steel reinforcement bars of concrete floors hooked over the top flanges of spandrel beams
- small steel reinforcement wires used to form a cage for the concrete encasement of the internal faces of the steel beams and columns
- chicken wire meshes to aid internal works such as concreting and plastering
- cast iron rain water downpipes and copper water pipes.

Failure to ensure the electrical continuity of all metallic elements in a steel framed building can result in stray current interactions between the various elements of the structure, resulting in the accelerated corrosion of the discontinuous items. The importance of electrical continuity is well established in marine, pipeline and concrete CP and site trials have proven its importance in steel framed buildings. CP designers and engineers involved with steel framed buildings should always be fully acquainted with all common design details, historical methods of construction and testing and inspection methods for the identification of discontinuous metallic elements.

ELECTROLYTE

The CP of steel framed buildings is possible since the protective current can be passed through the stonework or masonry to the steel via the mortar/masonry contact. However, although details often exist of the steel and masonry layout, knowledge of the connection between the two elements is not always easy to ascertain. The quality and consistency of mortar in-filling between the frame and facade is often highly variable, frequently containing large voids. In some cases in-fill is completely absent. Expert knowledge of steel frame construction is required to make an accurate and rapid risk assessment of voidage.

As a rule of thumb it has been found that the following can be applied:

- large cavities and voids greater than 25mm may not require grouting as corrosion rates are low in large cavities
- small voids less than 10mm do not require grouting since the formation of subsequent corrosion products will fill the void with minimal steel loss at which point contact is made and CP is achieved.
- voids between 10mm and 25mm should be considered risk items and grouting considered.

ELECTRICAL RESISTIVITY

The electrical resistivities of most masonry materials are in a suitable range for the application of CP when containing more than 2% moisture by weight. However, as with any porous material it is important to understand the behaviour of moisture content on resistivity. Most masonry materials have resistivities that exceed 1MΩ cm when moisture contents fall below 2% and therefore the placement of anodes and rating of power supply voltages must be correctly chosen to ensure adequate protection of the steelwork.

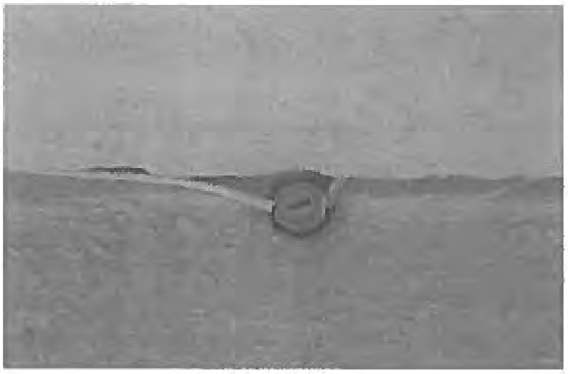
The external cladding material should be carefully considered. Particular care is required with materials such as terracotta, faience and glazed bricks where the glazing or fire skin layer acts as insulator making it difficult to distribute protective currents to the steel surface. However, protection is possible in the majority of cases if, for example, the anode materials are in contact with the underlying porous material beyond the surface layer.

ANODES

With regard to steel framed buildings, there are two main choices of anode: mixed metal oxide coated expanded titanium mesh ribbon anodes (see pic 2) and discrete rod anodes (see pic 3). Expanded mixed metal oxide coated mesh anodes have several distinct advantages in that:

- the anodes are not visible in mortar joints
- the anodes can be installed using standard masonry pointing techniques at the time of external repairs
- the anodes can often be situated parallel to beams and columns
- they cause minimal internal disturbance.

Photograph 2: Ribbon anodes in ashlar jointing



Photograph 3: Discrete anode in Portland stone ashlar

Discrete rod anodes can be installed externally, however, careful consideration is required in relation to their positioning and resultant disturbance on the façade. However, discrete rod anodes do have the following unique advantages in that they can be inserted internally and require no external access; furthermore, anodes can be placed deep within the structure making them less susceptible to wetting and drying cycles on the building surface.

TRACK RECORD

The first CP system for the prevention of steel corrosion in a masonry structure was installed in 1991. This system protects the entrance colonnade at the Royal College of Science, Dublin; a limestone structure containing two parallel structural 'I' beam members. Regular remote monitoring and annual visual inspections have confirmed that corrosion has been arrested.
Further applications in the early 1990s included two Grade I Listed sites with the protection of iron cramps in the Inigo Jones Gateway, Chiswick House, London, and iron

Staircase supports embedded in the brickwork of Kenwood House, Hampstead.

The full-scale application of cathodic protection to complete building facades took place in 1996. Typical examples of these early systems include the faience facade of Gloucester Road Underground Station, which is protected by a discrete rod anode system, and the Joshua Hoyle Building, Manchester; a brickwork and terracotta facade protected using expanded MMO coated titanium mesh ribbon anodes inserted in the mortar jointing.

Photograph 4: Royal College of Science, Dublin, Eire

Photograph 5: Joshua Hoyle Building, Manchester, UK

These systems have shown the possibility of protecting full building facades and the versatility of CP systems for listed buildings In the case of Joshua Hoyle, the use of CP to protect two five storey facades was found to have a cost saving in excess of 50% in comparison with traditional approaches involving the removal of masonry, painting of the steel followed by the reinstatement of the masonry.

Cathodic Protection systems are continuing to generate interest in the steel framed building area and over 20 systems were completed or initiated by July 2001. Examples of typical projects include: Lloyds Bank, Lombard Street London (Portland stone); Blackfriars House (Carraraware faience), London; Arkwright House, Manchester (Portland stone); St Andrews House, Edinburgh (Darney sandstone) and Putney Boathouse (calcium silicate brickwork).

FURTHER INFORMATION

In 1995, Historic Scotland, Lloyds/TSB and The Department of the Environment (now the DETR) recognised the maintenance problems associated with early steel framed buildings by funding a three year research project. The final report 'Technical Advice Note 20' is available from Historic Scotland.

CORROSION PREVENTION ASSOCIATION

CATHODIC PROTECTION ● REALKALISATION ● CHLORIDE EXTRACTION ● GALVANIC ANODES ● CORROSION INHIBITORS

Kingsley House, Ganders Business Park, Kingsley, Bordon, Hampshire, GU35 9LU

Tel: 01420 471614

www.corrosionprevention.org.uk

Registered in England 3167864

ISBN

Case Study

Parker Street

The Parker Street building is a six floor steel framed structure in the centre of Liverpool. The building was suffering from cracking and displacement of the brickwork cladding to the steel frame. In addition leakage through the degraded waterproofing and drainage had led to water damage. The upper section of the roof was refurbished and individual steel I beams suffering corrosion damage were replaced.

Location
Liverpool, UK

Client
Colliers

Completed
January 2015

Structure
Steel Frame Building

The Problem Identified

The rear brickwork face of the building was exhibiting cracks and some bulging. Exposure of the steel frame indicated corrosion in numerous sections had occurred, leading to formation of expansive corrosion products which in turn was applying disruptive pressure to the brickwork.

The Solution Developed

In order to stop ongoing corrosion and prevent further damage at the Parker Street Building CPT designed a DuoGuard™ hybrid anode system. Initially the bulging brickwork was removed to expose some of the steel I beams. DuoGuard anodes were then installed into the mortar surrounding the beams to deliver a protective current to the steel. Using an external power source, an impressed current was applied to stop active corrosion and render the steel passive. The DuoGuard anodes were then disconnected from the power source to self-generate a galvanic current, sufficient to maintain steel passivity and control corrosion.

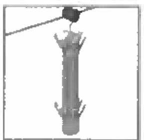
A series of discrete enclosures allowed access to the installed system from inside the building to check the system operation and monitor steel corrosion rate.

The Benefits Provided

Corrosion related deterioration of the Parker Street Building has been halted. After the initial power up period using an external power source the DuoGuard system is self powered thus minimising future maintenance requirements and associated life costs.

Corrosion found on the rear brickwork face of the building

CPT Products Used



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1 Palmer Business Court, Manor House Road, Nottingham, UK, NG10 1LZ
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Shelbourne Hotel Dublin

Opened in 1824, the Shelbourne Hotel, Dublin is one of the most prestigious and well known hotels in Ireland. In 1901-1902 an extra floor was added to the hotel comprising concrete encased structural steelwork with a brick facade.

Location
Dublin, Ireland

Client
McFarland Associates Ltd.

Completed
Summer 2015

Structure
Heritage Building (Hotel)

The Problem Identified

During external work to the Shelbourne Hotel façade it was noticed that the structural steel work was corroding and causing cracking to the encasement material. The material surrounding the structural steel was identified as a clinker concrete by its dark colour and extensive voids.

The Solution Developed

Testing found that all corrosion rates were above the threshold for passive steel. In addition, the fully carbonated concrete was providing no protection against corrosion. A DuoGuard™ hybrid anode system was designed to halt the ongoing corrosion and prevent future damage. Using an external power source, an impressed current was applied to stop active corrosion and render the steel passive. The DuoGuard anodes were then disconnected from the power source to self-generate a galvanic current, sufficient to maintain steel passivity and control corrosion.

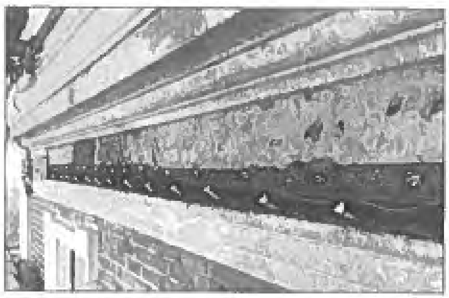
A trial was done before the full system installation to ensure compatibility with the clinker/steelwork arrangement and to collect on site data to aid design. During the impressed current phase, the clinker concrete let current freely pass between the anode and steel. In phase two the galvanic current output was effective at maintaining steel passivity at a spacing of 300mm between installed anodes.

A monitoring system was installed on the roof to provide continuous feedback on the system's performance, using a remotely accessed datalogger powered via an attached solar panel.

The Benefits Provided

Corrosion related deterioration of the Shelbourne Hotel was halted. After the initial power up period, the self-powered DuoGuard hybrid anodes minimise all future maintenance requirements and associated life costs.

Traditional methods of repair to 20th century steel framed structures are often costly and disruptive with only short to medium term results expected. DuoGuard hybrid anodes offer a long term and minimally intrusive alternative solution to managers of heritage assets.



Shelbourne install

Shelbourne complete

CPT Products Used

DuoGuard™

DuoCrete SD Mortar

ISO 9001 Cert No. 10159