



HOTEL GOTHAM, MANCHESTER

CATHODIC PROTECTION CONCEPT DESIGN REPORT

For:

MARSHALL COMMERCIAL DEVELOPMENT PROJECTS LIMITED

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HOTEL GOTHAM, MANCHESTER
REVISION RECORD
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CONTENTS

1	INTRODUCTION	1
1.1	PROJECT PARTICULARS	2
1.2	TERMS OF REFERENCE	2
1.3	SITE ARCHITECTUAL AND DESIGN DETAILS	3
1.4	SCOPE OF CONCEPT DESIGN PACKAGE	3
2	CONSTRUCTIONAL DETAIL & BACKGROUND	4
3	SCOPE OF SYSTEM	6
4	OUTLINE DESIGN	7
4.1	INSTALLATION [EXTERNAL / INTERNAL]	9
4.2	SYSTEM ZONING	10
4.3	CONTINUITY	10
4.4	ANODE ARRAY	10
4.5	NEGATIVE AND TEST NEGATIVE CONNECTIONS	12
4.6	MONITORING ELECTRODES	12
4.7	CONTROL EQUIPMENT AND CABLE MANAGEMENT	13
5	DETAILS REQUIRED FOR DETAILED DESIGN	18
6	SUMMARY	19
7	QUALITY STATEMENT	20
APPENDIX A.	STEEL MEMBER QUANTITIES	
APPENDIX B.	CONCEPT DESIGN SKETCHES	

1 INTRODUCTION

Corrosion Engineering Solutions [CES] have been commissioned by Commercial Development Projects Limited to produce a Concept Design [roughly equivalent to Stage 3 of the Royal Institute of British Architects [RIBA] project guidance] for a Cathodic protection [CP] system. The CP system is to arrest on-going corrosion of the steelwork embedded in the stone clad facades of Hotel Gotham, Manchester.

The purpose of this document is to describe the context of the project and to communicate the concept design via text and sketches in sufficient detail to allow for planning and coordination in the context of the wider repair works. The other main purpose is to provide details of the CP design to inform listed building consent, as the structure is on the National Heritage List of England.

It is understood that this document will be shared with Manchester City Council to offer insight into the works to protect this historic building from deterioration and corrosion. The intention of the CP is to protect and preserve the structure for a period of 50 years, but it is predicted that the major components of the system will last 100+ years.

The document has been prepared such that the principal concepts are accessible by anyone with a basic understanding of buildings and engineering. The nature of CP does, however, require an understanding of some specific technical concepts and it is expected that any persons using this document for pricing purposes have an understanding commensurate with that expected of persons certificated to BS EN ISO 15257:2017, Level 3 in the reinforced concrete application sector.

1.1 PROJECT PARTICULARS

1.1.1 THE PROJECT

Below is a list of the parties involved in the refurbishment project at the design stage:

1.1.2 CLIENT

Marshall Commercial Development Projects Limited
Huddersfield Road
Elland
West Yorkshire
HX5 9BW



Main Contract: Mr Marlon Chetty

1.1.3 CATHODIC PROTECTION SPECIALIST [DESIGNER]

Corrosion Engineering Solutions Ltd

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64-66 Akeman Street,
Tring,
HP23 6AF



Main Contact: Chris Wozencroft

1.2 TERMS OF REFERENCE

The design of this scheme has been carried out in accordance with the following contract documents, standards and guidance notes:

- i. BS EN ISO 12696:2022, "*Cathodic Protection of Steel in Concrete*" – N.B. although this structure is not universally constructed of concrete, this standard/sector can be applied to masonry clad early 20th Century Buildings.
- ii. BS EN ISO 15257:2017 "*Cathodic Protection – Competence levels and certification of cathodic protection personnel*".
- iii. BS 7671:2018 "Regulations for Electrical Installations – The IET Wiring Regulations 18th Edition" and associated guidance notes.

1.3 SITE ARCHITECTUAL AND DESIGN DETAILS

The design has utilized the following details and investigations:

- i. BUILDING MANAGEMENT SERVICES LTD – Elevations drawings M2731-112 and 113
- ii. ARP – Masonry crack locations – Drawings 1506/44-SK01 and SK02
- iii. JPG - 1st Floor Duct Cleaning Access Gantry - 4078-1-100A (A2)
- iv. JPG - 2nd Floor Layout Structural Alterations - 4078-2-100C (A0)
- v. JPG - 3rd Floor Layout Structural Alterations - 4078-3-100C (A0)
- vi. JPG - 4th Floor Layout Structural Alterations - 4078-4-100C (A0)
- vii. JPG - 5th Floor Layout Structural Alterations - 4078-5-100C (A0)
- viii. JPG - 6th Floor Layout Structural Alterations - 4078-6-100B (A0)
- ix. JPG - 6th Floor Alterations To Head Of Proposed Goods Lift Layout - 4078-6-101A (A1)
- x. JPG - 7th Floor Layout Structural Alterations - 4078-7-100B (A0)
- xi. JPG - Structural Alterations To New 7th Floor Staircase - 4078-7-101B (A2)
- xii. JPG - 7th Floor Staircase Beam Connection Details - 4078-7-102B (A0)
- xiii. JPG - 7th Floor Roof Terrace Plinth Layout and Details - 4078-7-103B (A1)
- xiv. JPG - 8th Floor Structural Alterations - 4078-8-100E (A0)
- xv. JPG - Goods Lift and Service Riser Steelwork Layouts - 4078-100B (A0)
- xvi. JPG - Sub Basement Plant Support Plinths - 4078-SB-100B (A1)

1.4 SCOPE OF CONCEPT DESIGN PACKAGE

The concept design work for the CP system is intended to provide:

- i. A description of the structure and elements requiring protection.
- ii. The scope and extents of the proposed CP scheme.
- iii. Reasoning in support of the selected system and materials and identification of any which may be inappropriate.
- iv. An outline of the proposed CP scheme.

The CP scheme design does not include detailed drawings, calculations, or materials specifications as these will need to be developed as part of the Stage 4 works in conjunction with the wider project team.

2 CONSTRUCTIONAL DETAIL & BACKGROUND

The Hotel Gotham building was designed by Edwin Lutyens in 1928 in the Art Deco style. Due to the architecture and historic significance, it is a Grade II listed structure on the National Heritage List of England. The building was created in Portland stone with diminishing floors with a total of eight stories with the 8th being the dome atop the building.

The building is located on 100 King Street as a standalone building with four main facades with multiple balconies and returns. Figure 1 shows the structure of Hotel Gotham.



Figure 1 - Hotel Gotham

The building is a steel framed structure with the external beams and columns tightly clad in Portland stone masonry and the voids filled with concrete/cement, or the members are cast in concrete casings.

For the purposes of the project, the building is divided into four sections: Spring Gardens [SG], Chancery Lane [CL], Brown Street [BS] and King Street [KS] each being its own façade.

Alterations were made in 2013, and these are detailed in the JPG drawings listed in Section 1.3. A new 1st floor duct was built along with cleaning access. New beams were constructed on the 2nd, 3rd, 4th, 5th and 6th floor to enclose the central lightwell and enable additional risers and a freight/goods elevator. The 7th floor had additional beams constructed to support an additional staircase.

ARP investigated the condition of the stonework of Hotel Gotham around November 2022. Subsequently they found locations of cracked masonry which were believed to be indicative of expansive corrosion, also known as Regent Street Disease [RSD]. Therefore, CP was suggested as a potential option for preventing further deterioration.

Further to the above investigations, CES conducted a rope access investigation finding further cracking. This external investigation was conducted over the 11th-22nd September 2023.

CES were contracted to devise a concept CP design roughly equivalent to the RIBA Stage 3 for the project.

The structure is to remain in use in its current form throughout the works, therefore, any CP system must be minimally intrusive to the internal spaces. All external metallic components must be considered to maintain their integrity. For example, the flagpoles may need to be removed and replaced during the works.

3 SCOPE OF SYSTEM

The scope of the CP system is to protect all embedded steel beams and columns in the external perimeter facades. These are shown as the red highlighted areas in sketches CN23-016-J712-R1468-SK016-017 in Appendix B.

Based on site visit observations, and the existing/historic information the quantities of members for the structure of Hotel Gotham are estimated in Appendix A, [Hotel Gotham Column & Beam Quantities]. Please note that no measured survey of the façades exists, and one is being planned presently. These figures are to allow outline planning only and are subject to change during the detailed design.

The areas of masonry repair, and their positions, have been marked up on sketches CN23-017-J729-SK003-006, presented in Appendix B. The position of the columns and beams has been based on the CES site survey and the historic architectural drawings. The historic drawings are extensive and detail all the column and beam positions and dimensions. Whilst the position and dimensions of the beams/columns are detailed in the historic drawings, these will need to be confirmed via local and discrete mortar joint drilling during the installation stage.

Usually, due to inaccurate or unknown positioning and dimensions of members their locations would be determined by metal detector survey and two targeted breakouts. It is assumed that these breakout locations would be representative for the whole structure. However, due to the extensive historical information no additional breakouts would be required to confirm the above. During the masonry repairs it is recommended that exposures of the steel occur in limited areas, at which point sizing and positioning confirmation can take place.

The scope for protection excludes the roof dome along with the former lightwell within the interior of the dome. Additionally excluded are the internal members of the structure, the basement/sub-basement and the window frames.

Some form of safe access will be needed to enable the masonry repair works. The exact form and phasing of the work is still being decided at the time of writing.

4 OUTLINE DESIGN

The structure should be protected by an Impressed Current Cathodic Protection System [ICCP].

The system will likely utilise titanium mesh ribbon anodes. An image of a segment of typical ribbon anode is given in Figure 2. These anodes will likely to be 10/20 mm wide and 1 mm in thickness. The titanium is coated in mixed metal oxide [MMO]. The benefits of this material are, that it is flexible to fit into the masonry joints, can be used to form rod anodes installed into drilled holes, and, when properly managed, is robust and long lasting with an extensive track record. These anodes have a design life of 100 years.

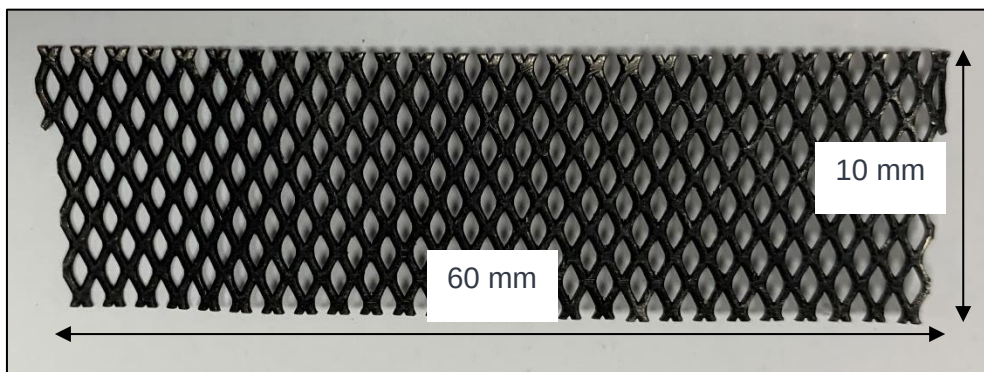


Figure 2 – Typical segment of MMO titanium ribbon anode. Approximately 60 mm in length, 10 mm in width, and 1 mm in thickness. Note that installed lengths will be cut to suit the required situation.

- i. The high resistance of masonry structures drastically reduces the effectiveness of galvanic anodes, below the minimum protection requirements, due to their limited drive voltage – this results in a greater number of anodes being required and additional cost.
- ii. Galvanic anodes are made of high purity zinc, the cost of mining and refining this material has significantly increased and the carbon cost is significantly greater than the equivalent ICCP systems on a whole-life basis.
- iii. Galvanic anodes are consumed during the life of the CP system and typically only have a 15-year design life due to size and space limitations in the façade.
- iv. The size and geometry of the galvanic anode presently available on the market result in unnecessary damage to a façade and would be visible once the works were complete – one of the principal aims of CP to buildings is that the installation be as indistinguishable as possible from the surrounding original detailing.

Hybrid anodes have not been considered for multiple reasons. Some of these reasons are listed below:

- i. The cost of hybrid anode installation is typically 10% to 30% greater than ICCP when considered on a like for like basis but the system lacks many of the long-term benefits of ICCP.
- ii. Hybrid anodes are also larger than galvanic anodes and significantly larger than ICCP anodes. Therefore, their installation is more expensive and requires the removal of far more material than is necessary for ICCP. This also means that they cannot be installed in an architecturally sympathetic manner and evidence of their installation will be noticeable for the life of the system and building.
- iii. For a period of the hybrid anodes design life, they function identically to galvanic anodes. The high resistance of masonry structures indicates that during this phase the structure would be poorly protected without the installation of far more anodes than is necessary for the equivalent ICCP system.
- iv. Hybrid anodes are proprietary products, therefore, the tendering process [in the UK] is between only two suppliers [many suppliers of high-quality ribbon anodes are available].
- v. The propriety nature of hybrid anode products has resulted in little third-party verification having taken place. Therefore, an estimation of a hybrid anode CP design life or performance cannot be made accurately.

Correctly installed and properly managed ICCP systems have been found to be the cheapest and most effective CP option for masonry structures. They are typically designed for a 50–60-year design life but with proper maintenance could function for 100+ years.

Based on the design life, ICCP is likely to be a more environmentally friendly option for the structure as it does not require the mining and refining of high purity zinc. If properly managed, it is likely that an ICCP system will also require less maintenance with only reference electrodes and control systems needing to be replaced within the service life, as opposed to the entire system.

Typically, Ag/AgCl reference electrodes will need replacement every 10 to 15 years and the control equipment will require replacement approximately every 20 years.

4.1 INSTALLATION [EXTERNAL / INTERNAL]

It is envisaged that the system be installed predominantly from the external aspect but elements such as cable management and infrastructure will need to be installed within risers, the internal soffits and walls.

The installation will be largely externally installed [probably completely – except for some electrical installation works]. This limits disruption, noise, mess and internal refurbishment. .

It is, therefore recommended that an external installation of the CP system be undertaken with anodes chased into the masonry joints of the facades. The masonry joints will need to be widened in many locations. The existing joint widths are approximately 5mm to 12mm. To accommodate the CP anodes and wiring, all joints around protected members will need to be 8mm to 12mm.

The anodes will be embedded into the joint, the mortar reapplied, and the finished aesthetics will appear as in Figure 3a and 3b which are previous examples of CP in Portland stone. For further information and details of CP works conducted onto the masonry see sketch CN23-016-J712 SK011.



Figure 3a and 3b – Examples of previous installations finished product of cabling chased into mortar joints

The work described above is to be applied to all areas highlighted red in sketches CN23-016-J712-R1468-SK016-017.

4.2 SYSTEM ZONING

For the CP system to run as effective as possible the structure shall be divided into a series of zones. The zoning division has been based on the perceived exposure conditions in each part of the building/façade.

Each façade shall contain at least four zones. This for a total of 16 zones for structure.

The zoning has been detailed in the sketches [CN23-016-J712-SK012-015].

It should also be noted that there remains scope for further division of the structure into more zones to account for specific details and conditions such as prevailing winds and sun exposure. The precise zoning shall be determined during detailed design.

4.3 CONTINUITY

For a CP system to function it is essential that all components, intended to be protected, are electrically continuous. Given its construction and the period to which it was constructed, it is highly likely, that the steel frame of Hotel Gotham building is electrically continuous within the zoning that has been described in the previous section.

Externally mounted metallic components, within 0.5m of any anode, e.g. flag poles or window fixings/mountings will require a protection strategy to prevent the CP from damaging these components. These strategies include bonding the component to the steel frame [or the D.C. negative terminal at the TR] thereby including the component for protection. Alternatively, these components can be isolated from the system via the use of non-metallic mountings or surrounding their mountings in electrically resistive resin [blocking the CP from the component].

The most suitable strategy for each component will be determined & coordinated as part of the detailed design.

4.4 ANODE ARRAY

The Portland stone clad steel columns are likely to be protected via the use of MMO ribbon anodes chased in the masonry joints. The chased anode shall only be positioned on the horizontal joints with titanium wiring joining each ribbon chase together as per Figures 4 & 5.

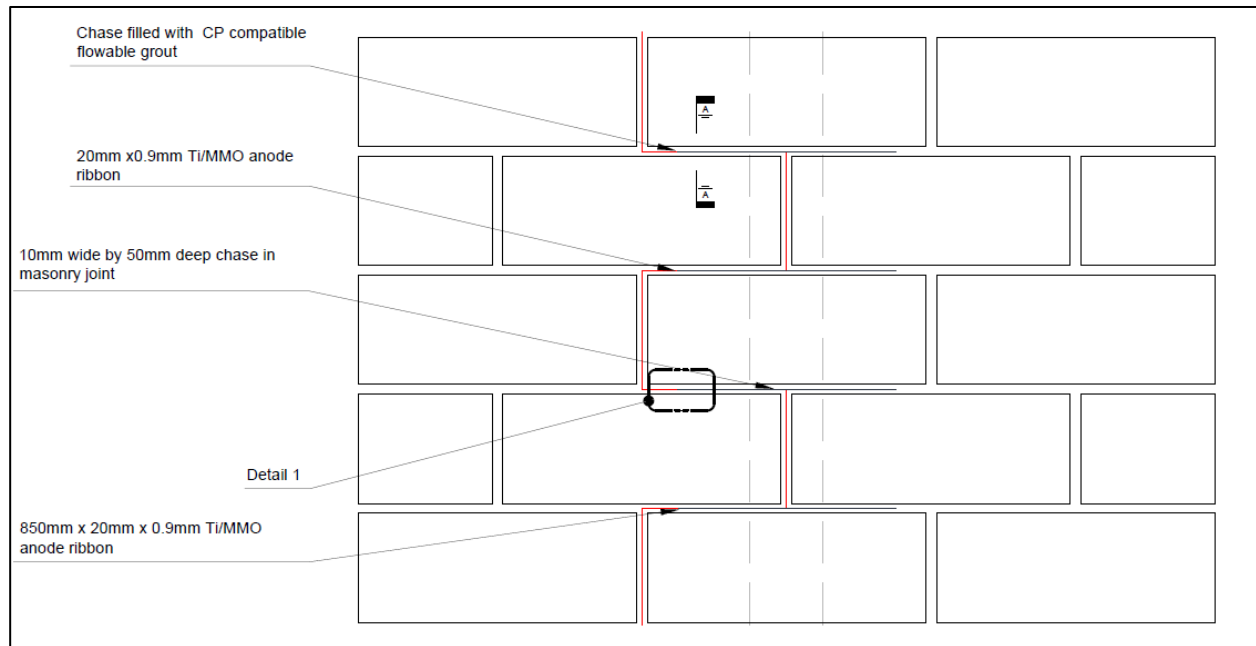


Figure 4 – Suggested horizontal ribbon anode arrangement, with vertical titanium connection wire between anodes.

Portland stone clad steel beams are also likely to be protected via the use of MMO ribbon anodes chased in the masonry joints. The chased anode shall only be positioned on the horizontal joints running in parallel to the beams position.

The exact length of each ribbon anode and the spacing required between them shall be determined during detailed design and is dependent on the size of the member to be protected and its exposure.

For corner columns the exposure of the column is larger [both side of the corner] therefore a slightly difference anode arrangement is required. This is shown in Figure 5, with approximately 500mm of anode [250mm either side of the corner] at every bed joint. This is an example; the actual arrangement will be determined during the detailed design.

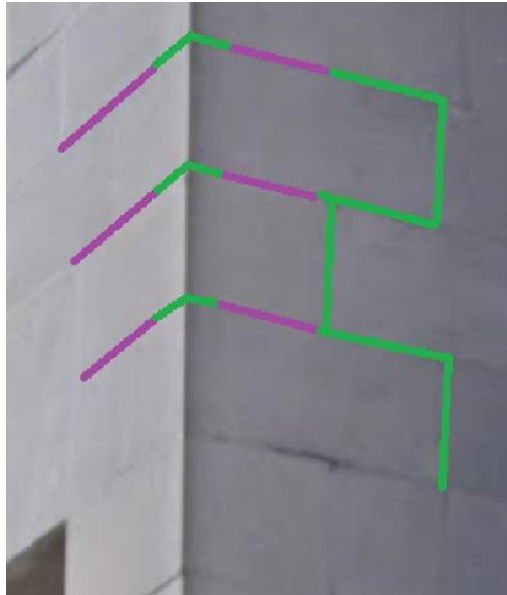


Figure 5 – Corner column Anode [purple] position with Ø2mm Ti wire [green] connecting the lengths together every bed joint.

4.5 NEGATIVE AND TEST NEGATIVE CONNECTIONS

The relevant standards require a minimum of two of each type of connection per zone. However, the nature of a steel frame and need to minimise disruption to the façade means that a more pragmatic and considered approach can be accommodated.

The control cabinet shall have its own negative and test negative connections. These connections shall be made in close proximity to the control cabinet, so as to minimise the need for excessive cabling. These connections shall be made inside the buildings. A minimum of two negative and two test negatives will be required for the structure in its entirety.

4.6 MONITORING ELECTRODES

It is envisioned that monitoring of the CP system will be performed by both reference electrodes and decay probes. Reference electrodes, while giving a precise measure of the potential of the steel structure, tend to lose their accuracy after 10-15 years in service and at this point, they may

require replacement. To address this potential vulnerability, decay probes will also be specified. Decay probes do not lose their accuracy and can report valid results to the end life of a CP system.

In order to offer additional redundancy an equal number of two types of reference electrode shall be used these will be located in different zones to maintain an equal distribution:

- i. Silver/silver chloride [Ag/AgCl 0.5M KCl].
- ii. Manganese/manganese Dioxide [Mn/MnO₂]

No other reference electrode chemistries shall be accepted.

The decay probes shall be made from short lengths of MMO coated titanium ribbon anode.

4.7 CONTROL EQUIPMENT AND CABLE MANAGEMENT

4.7.1 CONTROL EQUIPMENT

Hotel Gotham shall have a single dedicated transformer rectifier [TR] incorporating all necessary monitoring and control. This shall be installed in an appropriate plant room possibly on the ground/basement floor.

The exact location of the TR will be confirmed during detailed design and will need to be carefully coordinated with the hotel's existing mechanical and electrical system.

The TR shall be housed in a suitable GRP IP65 rated cabinet, with all cabling entering the bottom of the cabinet. The cabinet should be of suitable size and weight to allow for installation without additional lifting equipment.

An example of a TR cabinet for a similar building is shown in Figure 6.



Figure 6 – Example of a TR cabinet for a similar structure – also located in a back-of-house/plant room area.

The TR shall be specified for a minimum of 16 zones and approximately 70 monitoring electrode channels.

The equipment shall provide suitable terminations for the 16 zones. Actual quantities of terminations will be stated in the detailed design.

Each zone shall have a minimum output of 12V and 500 mA. The equipment shall allow the output current to be set in 1 mA increments with an accuracy of ± 1 mA in constant current

control. Each output channel shall be capable of having its output independently adjusted without affecting the output of any other output channel.

The equipment may provide functionality to arbitrarily limit the output via current or voltage.

The control equipment shall be capable of remote access and shall allow for remote monitoring and adjustment of current/voltage outputs.

It is currently envisioned that the control cabinet shall have the following dimensions 1400 × 1000 × 400 mm.

The Cabinet shall also incorporate any and all equipment required to facilitate remote access to the system via a 4G/5G SIM card. This will require an aerial to be run from the TR to a level where there is suitable mobile phone signal. Remote access shall offer access to the full functionality of the equipment.

4.7.2 CABLE MANAGEMENT, INFRASTRUCTURE AND ROUTING.

4.7.2.1 Multicore cabling

Multicore [MC] cabling, for Zones 9-16, will be required from the TR to a suitable location on the roof of the building. These cables shall be installed within the main building and run from the TR equipment situated on ground floor/basement area, to the roof where they will terminate in a Junction Box.

It is anticipated that each protected façade will have a dedicated junction box and multicore.

Multicore cables shall be 12 core 2.5mm² XLPE/LSZH/SWA/LSZH coloured black. The conductors shall be Class 2 or Class 5 stranded / flexible copper conductors. Appropriate cable management shall be utilised, for instance flexible conduit.

The size of the junction boxes shall be confirmed during detailed design, however, shall be IP65 rated. For the purposes of scheme design the project should assume that all junction boxes will be approximately 250 x 250 x 200mm. The location junction boxes for the middle zones will be approximately on the balconies.

The precise route and form of the MC cable management utilised will need to be determined at detailed design stage and coordinated with the existing M&E management. The CP cabling

should be independent of other services and must be separated or otherwise protected from mains and high voltage AC sources. Detailed information on available risers to route the cabling through the building will be required for the detailed design.

4.7.2.2 Single Core cabling [Field Cables]

For Zones 1-8, the single core cabling shall exit the TR directly and shall transition to their relevant facades as a bundle in suitable cable trays or trunking.

For Zones 9-16 the single core cabling shall penetrate the parapet of each on the roof using suitable weather and fireproof materials to ensure the integrity and safety of the structure and façade. These penetrations should be located as close as possible to the junction box positions.

A small number of holes shall be drilled during this installation to facilitate cable penetrations through the façade – this will typically be covered by a similar type to the original materials.

Field cabling shall **not be visible externally**, all external cables shall be chased into masonry joints of the stone facades.

Cabling subject to change during the detailed design.

4.7.3 CABLE PENETRATIONS

At various positions [yet to be agreed], the cabling that is installed/hidden in the external masonry joints needs to be connected to the internal multicore cables and junction boxes.

The system will be designed such that the number of cables at any one penetration will be limited, thus reducing the width of the masonry joint required and disruption to the façade. It is important that these penetration points are not visible, and their impact on the heritage is minimised.

The proposed detail will be to drill a small [approximately 18mm Ø] hole through the masonry at a bed and perp joint intersection. The cables will pass through this hole and be laid into the masonry joints. The edges of the blocks around the hole will then be repaired.

If a larger penetration is needed, then one corner of a block [preferably in a location where repair is required regardless] will be locally removed to create a larger aperture [up to 50mm x 50mm]. This will then be repaired using matched materials in the same manner that the existing damaged blocks are to be repaired [e.g. a mortar based indent repair].

An example of a cable penetration in a Portland Stone building is provided in Figure 7.

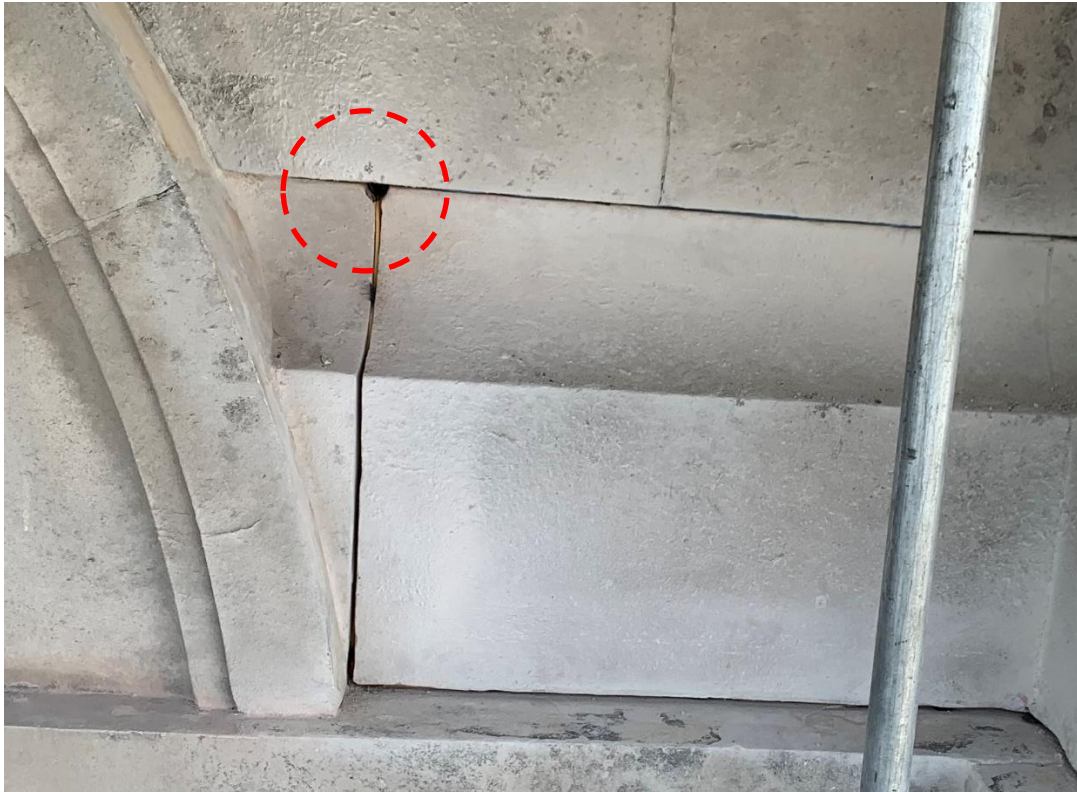


Figure 7 – Example of cable penetration in Portland Stone façade

This method shall result in repairs at these locations that are indistinguishable from other, incidental repairs.

5 DETAILS REQUIRED FOR DETAILED DESIGN

Before the detailed design more details are required from the hotelier. The hotelier should provide information on the existing M&E scheme prior to any work on the detailed design. This information is required as it details available cabling routes through risers and will inevitably affect placement of junction boxes, the TR unit, cabling routes and penetration points. Without this information manual investigation of the internal working of the hotel will need to be conducted which would cause major disruption and expense.

It is understood that listed building consent will be granted [at least progressed] based on this concept design prior to detailed design being completed.

6 SUMMARY

Full details of the proposed CP system are yet to be determined. However, the following summary details a framework to which a more detailed design can be derived.

- i. The structure shall be protected by an Impressed Current Cathodic Protection system.
- ii. The scope of the protection shall include the beams and columns on all the façades.
- iii. The location of the columns/beams is understood from the historic information. Only limited intrusive work will be required during the installation phase to confirm details, and these will be limited to areas which require substantial repair.
- iv. Each façade shall comprise of at least four CP zones as shown in CN23-016-J712-SK012-015.
- v. The beams & columns shall likely be protected by lengths of 10/20mm wide MMO ribbon anode embedded in external masonry joints.
- vi. Many of the masonry joints will need to be widened to accommodate the CP installation which will be embedded in the mortar and then over-pointed with heritage matched mortar such that the CP installation is completely concealed.
- vii. Each zone shall be monitored by a series of Ag/AgCl 0.5M KCl and Mn/MnO₂ reference electrodes and, MMO coated titanium decay probes.
- viii. The CP installation is to be undertaken in conjunction with an extensive masonry repair package, which is likely to include repointing and cleaning of much of the cladding.
- ix. A control cabinet shall be positioned in an appropriate plant room in the basement/ground floor of the building to enable servicing without disruption to the tenant/guest operations.
- x. This control equipment shall be capable of remote access, so as to minimise disruption to the hotel's operations.
- xi. Multicore cabling will be installed between TR control equipment and upper elevation junction boxes utilising existing service routes.
- xii. Details of the hotel's existing M&E scheme are required before the detailed design can be completed.

7 QUALITY STATEMENT

We confirm that we have exercised reasonable skill and care in the preparation of this report, which has been produced for and on behalf of Corrosion Engineering Solutions Ltd.

The information contained within this report is based upon information available at the time of writing. If further information becomes available, we reserve the right to review the content provided.

APPENDIX A. STEEL MEMBER QUANTITIES

APPENDIX B. CONCEPT DESIGN SKETCHES



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