

The background of the page is a vibrant red. It is decorated with several abstract geometric shapes: a large teal semi-circle in the top-left corner, a blue semi-circle in the top-right corner containing a white circle, a dark blue horizontal bar in the top-right corner, a teal semi-circle in the bottom-right corner, a blue semi-circle in the bottom-left corner containing a white circle, and a dark blue semi-circle in the bottom-left corner containing a white circle. The text is positioned on the left side of the page.

Appendix P
Templeogue Arch –
Structural Appraisal and
Outline Recommendations
for Repair

Templeogue Arch, Templeogue, Co. Dublin



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Structural Appraisal and outline recommendations for repair

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1 Introduction

1.1 Outline of brief and report

CORA Consulting Engineers were requested by Arup on behalf of National Transport Authority to undertake a structural condition survey of the freestanding masonry arch on the former grounds of Templeogue House, Templeogue, Dublin 6W.

The requirements from CORA were to provide a Structural Condition Survey report and outline the schedule of repair works to make the arch safe and secure structurally. It is intended that the arch will become part of the public realm as part of the Bus Connects project, with a bicycle lane and pedestrian path at either side of the arch structure. Details of path proposals and public realm landscaping are outside the scope of this report. Please refer to reports and drawings by others.

This report contains a high-level structural appraisal of the condition of the arch inspected on site visits by Triona Byrne and Lisa Edden for CORA Consulting Engineers in March 2022. Poval Conservation Ltd. had cleared the substantial volumes of vegetation from the arch in advance of the structural appraisal and the scaffolding remained in place in order to access all parts of the arch.

This report is limited to the Structural Engineering appraisal of the arch and outline recommendations. For historical reference and archaeological matters please refer to reports by others.

1.2 Description of Structure

The Templeogue Arch is a ruinous folly, that directed and framed part of the water features within the Templeogue House demesne. It is currently surrounded by palisade fencing on all sides, with the R137 Templeogue Road running adjacent.

The large semi-circular rusticated arch has a clear internal span of the arch is approximately 5m with a clear internal height from current ground level to the underside of the arch of 6.8m. The height to the springer of the arch was measured at 3.1m. The arch thickness is approximately 1.1m.

The arch is formed from large pieces of stone; a mixture of granite, limestone, river cobbles, some bricks and Tufa stone, with some artificial stone also evident (formed of aggregate and a lime based mortar). The large tufa stones extend across the full width of the arch, whereas the granite and limestone pieces are smaller.

There is a flanking wall on each side, formed of rubble masonry (predominantly limestone) approximately 600mm thick, with the walls running south-westwards from the arch toward a central point; though they do not fully meet. It is understood from historic maps that the two flanking walls originally funnelled a water course towards and under the arch.

The arch was built in the early/mid-eighteenth century. It is on the Record of Protected Structures (RPS No.244).



Figure 1 – Arch and flanking walls during vegetation removal



Figure 2 – C18th portrait of Sir Compton Domville showing arch with water flowing through it in the background (Malins, 1976)

1.3 Method of Appraisal and limitations of report and Investigations

The arch was visited in March 2022 by Triona Byrne and Lisa Edden of CORA Consulting Engineers.

The inspection involved a visual inspection from the ground and from a scaffold that had been erected on each side of the arch. The vegetation had been clipped back hand by Povall Conservation during March 2022.

No invasive works were carried out or samples taken or tested.

2 Observations and Commentary

2.1 Arch structure

The Arch structure appears very ruinous and indeed there has been some stone loss but the arch must be viewed in the context of being a rusticated ruinous folly. It was constructed originally with a rough raked finish and recessed mortar joints.

The arch is largely intact and structurally stable. However several stones of the rusticated capping have fallen from the top of the arch; most of these were present on the ground at the base of the arch and were visible once the vegetation had been cleared. This loss of overburden stone is compromising the arch structure, which relies on an even distribution of weight from above in order to act as a 'true arch'.

There were ivy roots growing on and around the arch stones. The majority of these were removed during vegetation removal works however the roots deeply embedded in joints were left until such a time as masonry works are commissioned. There were some large joints between stones exposed once the vegetation was removed. The joint at the left hand side of the key stone, which can be seen in Figure 4, was particularly wide, and so this was pinned and repointed immediately following the vegetation removal works.

There is significant mortar loss on the underside of the arch, where mortar has washed out over time.



Figure 3 – Underside of arch



Figure 4 – Stone missing above arch keystone can be seen in the northeast elevation of the arch



Figure 5 – Historic photo of arch, prior to stone falling from centre of arch (*Rustic Gothic Arch*) Templeogue, by Patrick Healy, 1987, South Dublin County Council, URI: <https://hdl.handle.net/10599/2696>)



Figure 6 – Arch during vegetation removal



Figure 7 – Top of arch after vegetation removal

2.2 Flanking walls

The walls flanking either side of the arch are in reasonable condition. However there has been some stone and mortar loss from the wall tops and there are several vertical cracks in the walls. These cracks were likely caused by the large ivy roots growing within the masonry. The wall tops were covered in vegetation until recently, which has dislodged the top stones. These are now loose and allowing water ingress into the core of the flanking walls.

Where the walls abut the arch, there is some stone and mortar missing.

The southwest end of the walls are unravelling, with loose unstable stones.

The ground level between the flank walls is higher than the general site, with earth banked against the base of the walls putting the walls into a retaining situation. There has likely been some mortar loss behind this banked earth.



Figure 8 – Top of southeast flanking wall



Figure 9 – Arch and flank walls after vegetation removal



Figure 10 – Inner face of southeast flanking wall



Figure 11 – Vertical crack in southeast flank wall due to roots



Figure 12 – Stone missing where wall abuts arch



Figure 13 – Inner face of northwest flanking wall

2.3 Materials

As noted in Section 1.2, there are a variety of stone types used in the arch construction and flank walls. These include granite, limestone, river cobbles, brick and tufa.

There are also large blocks of reconstituted stone, formed of large aggregates and a lime mortar to look like a conglomerate.



Figure 14 – Artificial stone (limecrete)

There are a variety of mortar types present in the wall, generally lime-rich, with some sandier than others.



Figure 15 – Sandy mortar



Figure 16 – Lime-rich mortar

3 Recommendations

3.1 Proposed repairs

Recommended repairs to the arch and flanking walls in suggested order of works is as follows:

- i. Arch to be consolidated by replacing fallen stone on top of arch, bedded in an appropriate lime-based mortar. The placement of this stone should be informed by careful interrogation of the historic photographs.
- ii. Joints between stones to be repointed, ensuring a self-draining surface. Any large joints between arch voussoirs to be packed tightly with slithers of stone/natural slate. However, joints should be recessed to respect the original intention of a weathered appearance.
- iii. All algae and lichen growth on stones to be cleaned off using an appropriate biocide.
- iv. Banked earth/debris against base of flanking walls to be carefully removed to give a level surface between the walls at a similar level to the outside face of the walls.
- v. Flanking walls to be rebuilt to full height at the west end where stone has fallen to form wall ends that are not easy to climb and are structurally secure.
- vi. Flanking walls to be repointed in an appropriate lime-based mortar. Any remaining roots in the wall to be treated and removed as masonry works proceed. Once roots are removed, vertical cracks to be stitched using long stones across the crack.
- vii. Flanking wall tops to be flanché to shed water. Exact wall top detail to be agreed once exemplars of options presented during works on site.



Figure 17 – Base of arch with various stone types and algae/lichen-stained stone

3.2 Materials to be used in the repairs

All repair works should be designed to use traditional materials of a close match to the original excepting where a more extensive structural repair is required, where the use of long lasting durable modern materials may be appropriate. Here it is envisaged that the majority of the repairs will use the stone as found on site with a small amount of supplementation set in a lime-based mortar.

Recommended mortar mixes for the repairs are indicated in the specification drawings.


All works should be preceded by exemplars, and mock ups in the case of the Arch top, to be agreed with the Design team prior to execution of works.

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4.0 Appendix

Proposed repair works drawings and specifications

22548 – Sk01 Location and Plan

22548 – Sk02 Arch Outline Repairs 1 of 2

22548 – Sk03 Arch Outline Repairs 2 of 2

22548 – Sk04 Flanking Walls Outline Repairs 1 of 2

22548 – Sk05 Flanking Walls Outline Repairs 2 of 2

22548 – Sk06 Vegetation Control

22548 – Sk07 Mortar Specification 1 of 2

22548 – Sk08 Mortar Specification 2 of 2

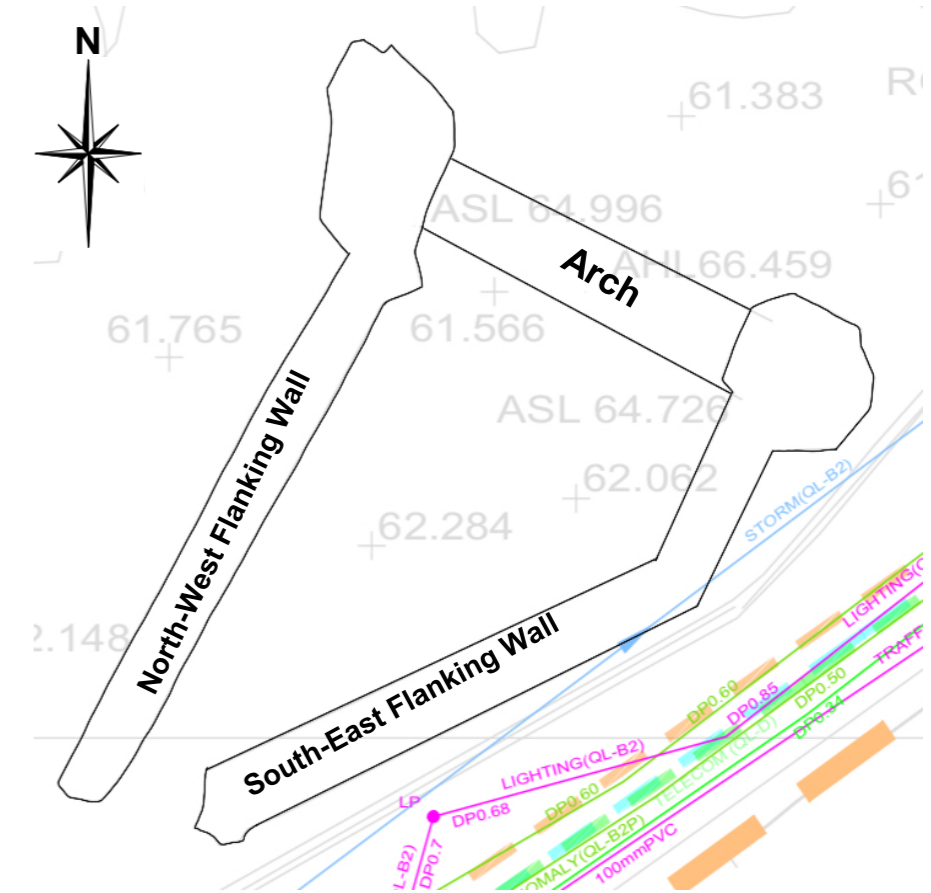


Arch during vegetation removal viewed from South-West

Vegetation which had grown around the arch has been removed early 2022. Removal of vegetation exposed large joints around the arch - a significantly large joint was pinned and repointed promptly. Tops of the flanking walls show significant loss of stone and mortar and several vertical cracks likely due to vegetation growth. Remaining vegetation will require further treatment as per vegetation control specification prior to masonry repairs.



Arch and Flanking Walls viewed from South-West



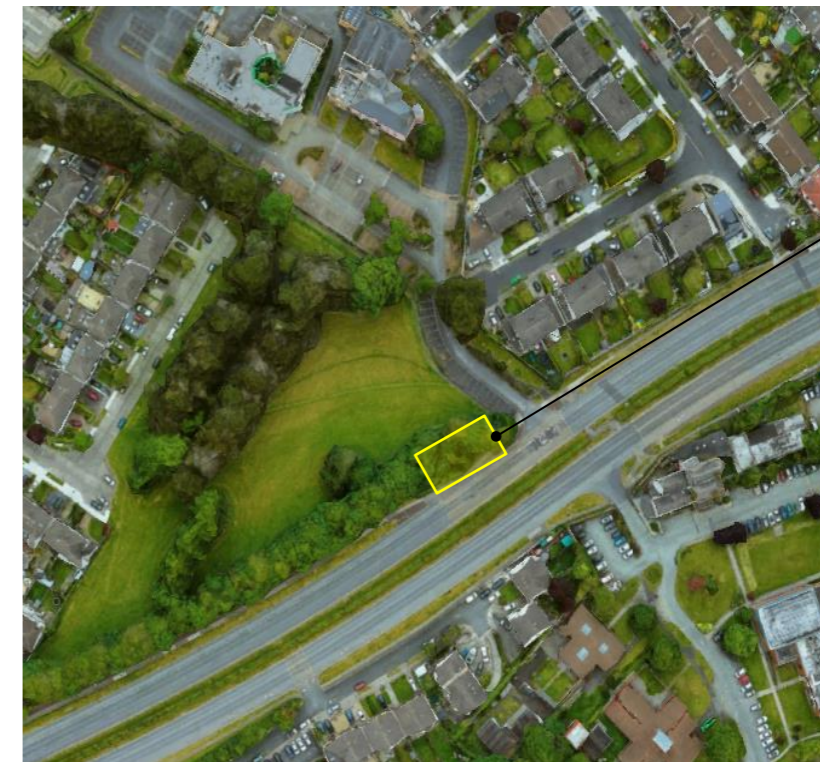
Extract from Apex Surveys

Assumed General Sequence of Works

Refer to Drawing Sk02 - Sk05 for specific works and Specification drawings Sk06 - Sk08.


Phase 1 - 2022

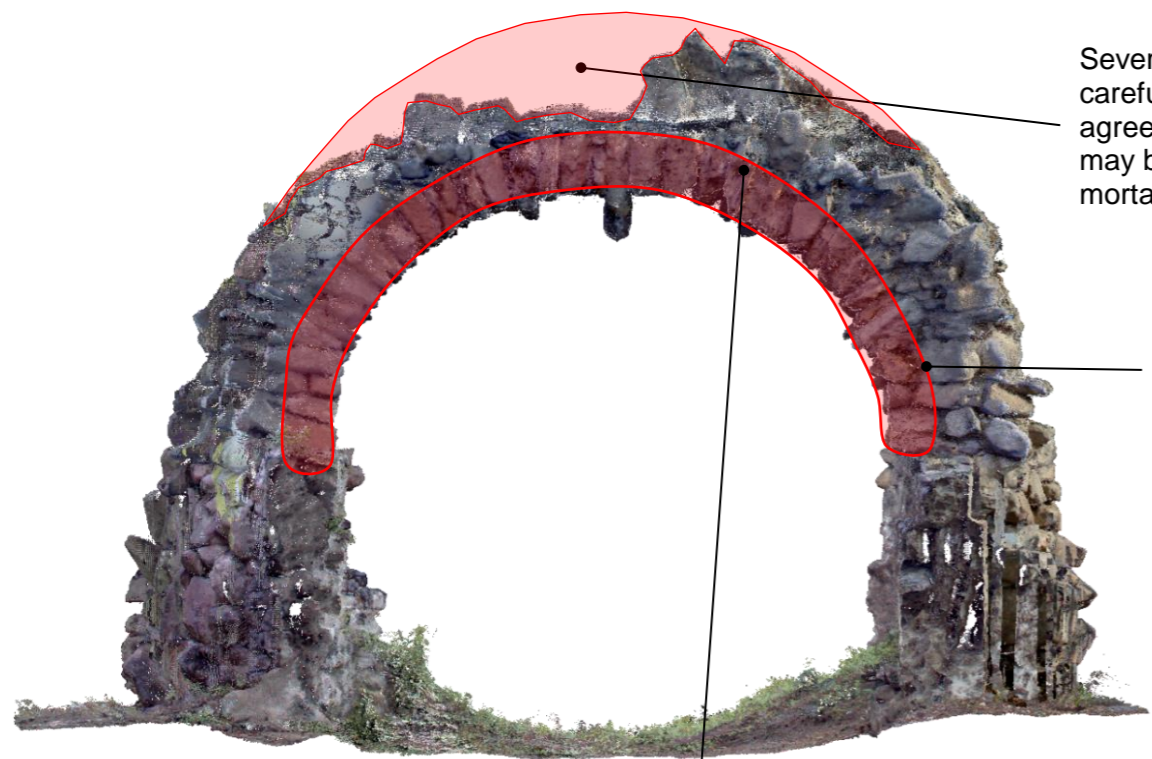
- i) Erect working platforms local to works.
- ii) Spray any vegetation growing on wall top, wall faces or local to work areas. Refer to Sk06.
- iii) Carefully cut back large roots/trees growing on walls. Any remaining root to be drilled and plugged again. Refer to Sk06.
- iv) After 2-3 weeks start to take off ivy very carefully from wall tops, wall faces and around any door/window reveals or special features.
- v) Repoint and stabilise loose stone as indicated on drawings Sk02 - Sk05.
- vi) Consolidate wall top as indicated on drawings Sk02 - Sk05, ensuring wall top is rough raked to give a self-draining surface. Refer to Sk07 - Sk08 for lime mortar specifications. Exemplars to be provided prior to works commencing and agreed with design team.



Location of Templeogue Arch.

Extract from Google Earth (Easting: 312365, Northing: 228497)

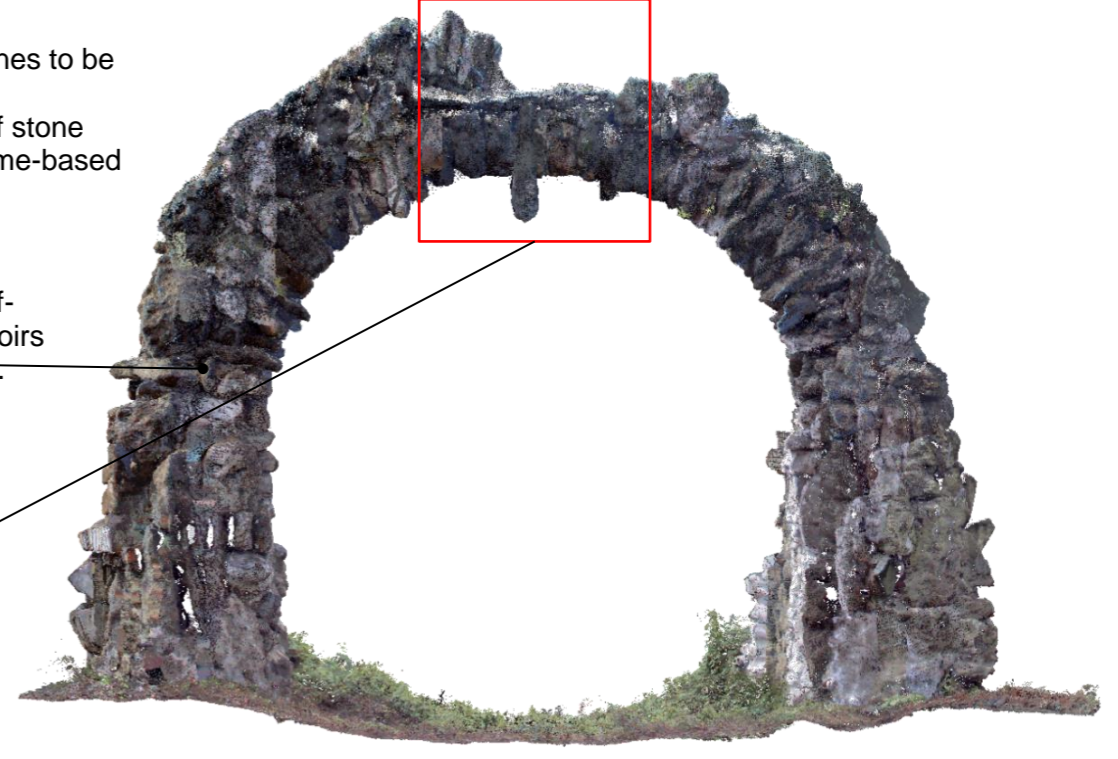
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PRELIMINARY					NM	TB	LE	05/07/2022									
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					Structural Condition Survey												
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Architect:	HHCA	REV. No.	REVISION DESCRIPTION	DATE	ISSUED BY	Location and Plan			22548						SK01		P1



South-West Elevation of Arch

Several stones have fallen off the top of the arch. Fallen stones to be carefully identified and mock up of reinstatement created for agreement with design team. Note some supplementation of stone may be required. Stone to be re-bedded in an appropriate lime-based mortar.

Joints between stones to be repointed, ensuring a self-draining surface. Any large joints between arch voussoirs to be packed tightly with slithers of stone/natural slate. However, joints should be recessed to provide a weathered appearance.



North-East Elevation of Arch



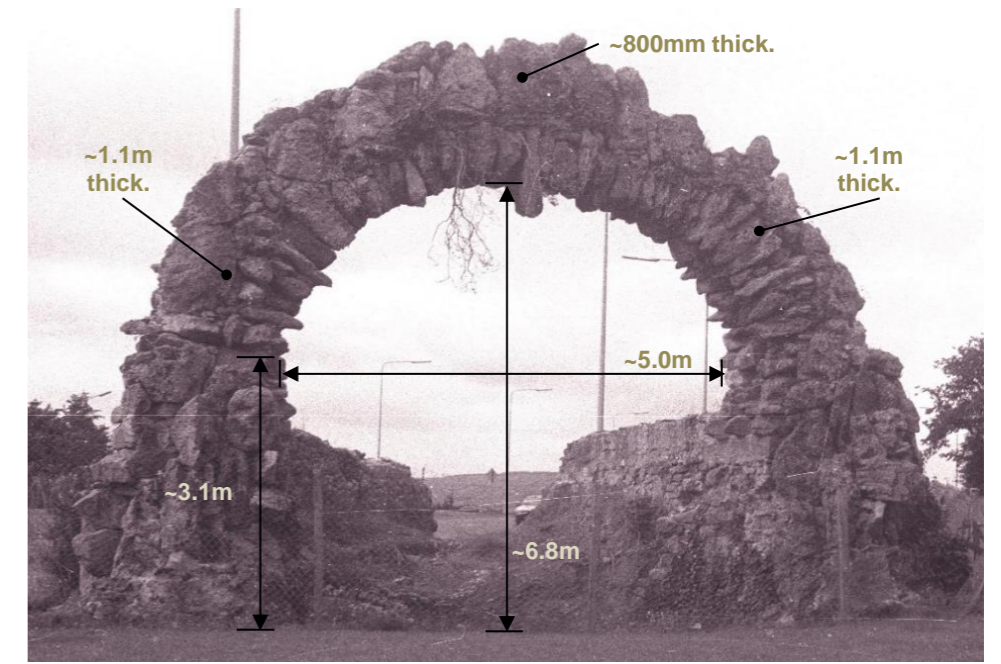
Significant mortar loss from the underside of the arch. Deep repointing required.

Underside of South-East side of Arch




Joint located at the left hand side of the key stone was pinned and repointed right after the removal of vegetation.

Image of missing stone on top of Arch



[Rustic Gothic Arch] Templeogue by Patrick Healy, 1987, South Dublin County Council, URI: <https://hdl.handle.net/10599/2696>

All masonry works to be carried out with materials to match existing, i.e. local stone as retrieved from site, slithers of natural slate used for packing structural joints, pinning stones in joints larger than approx. 30mm. All mortars to be lime based as specification on Sk07 to Sk08. Exemplars to be provided for all works at beginning of works.

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Architect:	HHCA	REV. No.	REVISION DESCRIPTION	DATE	ISSUED BY	Arch Outline Repairs 1 of 2			22548						Sk02		P1

All masonry works to be carried out with materials to match existing, i.e. local stone as retrieved from site, slithers of natural slate used for packing structural joints, pinning stones in joints larger than approx. 30mm. All mortars to be lime based as specification on Sk07 to Sk08. Exemplars to be provided for all works at beginning of works.



Underside of North-West side of Arch

All algae and lichen growth on stones to be cleaned off using an appropriate biocide.




Fallen stones from Arch top lying to North-East of Arch



Any remaining roots in arch to be treated and removed.



Top of North-East side of the Arch

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Area between Flanking Walls viewed from the top of the Arch

Stone and mortar loss from on top of flanking walls. Vegetation caused stones of top of walls to become loose and dislodged allowing water to seep into the core of the wall. Top of flanking walls require flaunching after masonry repairs and flanking walls are rebuilt to full height at the west end.

Banked earth/debris against base of flanking walls to be carefully removed to give a level surface between the walls at similar level to the outside face of the walls.



Area between Flanking Walls viewed from the top of the Arch

All masonry works to be carried out with materials to match existing, i.e. local stone as retrieved from site, slithers of natural slate used for packing structural joints, pinning stones in joints larger than approx. 30mm. All mortars to be lime based as specification on Sk07 to Sk08. Exemplars to be provided for all works at beginning of works.

All algae and lichen growth on stones to be cleaned off using an appropriate biocide.



Arch and Flanking Walls viewed from North-West

Flanking walls to be repointed using an appropriate based mortar.



Inner face of North-West Flanking Wall


Missing stones in west end of the flanking walls. West end of flanking walls to be rebuilt to full height where stone has fallen ensuring that the walls are not easy to climb and are structurally secure.



Inner face of South-East Flanking Wall



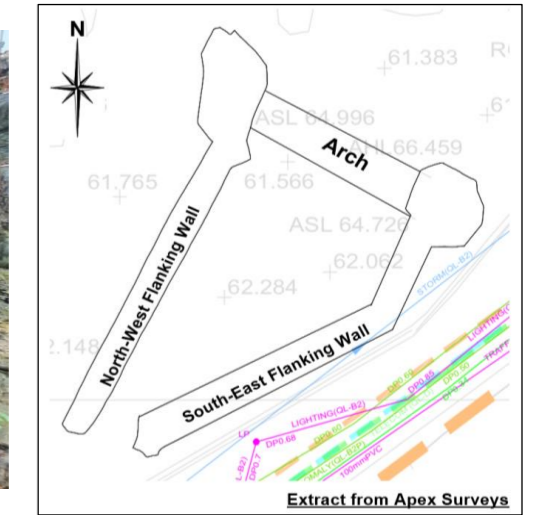
Arch and Flanking Walls viewed from South-West

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Inner face of South-East Flanking Wall

Key Plan



Vertical cracks in the flanking walls caused by the vegetation roots - after removal of roots, stitch vertical cracks using long stones across the crack.



Outer face of South-East Flanking Wall showing vertical cracks




Outer face of North-West Flanking Wall

Missing stones from wall where wall joins with the base of the arch due to vegetation - require masonry works and repointing.



Inner face of North-West Flanking Wall

All masonry works to be carried out with materials to match existing, i.e. local stone as retrieved from site, slithers of natural slate used for packing structural joints, pinning stones in joints larger than approx. 30mm. All mortars to be lime based as specification on Sk07 to Sk08. Exemplars to be provided for all works at beginning of works.

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Specification for repair mortars

Note final mix designs to be a result of consultation with Lime suppliers; CORA Engineers; Architect and appointed Contractor and will be based on exemplars and a more thorough understanding of the previous construction obtained during masonry works preparation.

Lime mortar works can be affected by excessive wind, rain, sun or low temperatures. If these conditions prevail the working areas must be kept moist by spraying and protection using polythene or hessian sheets sprayed with water at regular intervals. Spray hoses can be used for large areas or for damping down hessian sheets but should be used with caution to avoid jet action of water washing out mortar or over saturating a wall. Thus a bottle spray, sprayer back pack or similar is an essential part of the equipment. No works to be carried out if below 5 degree Celsius temperatures forecast within 48 hours unless temperature control methods such as tented enclosures deployed. Full discussions regarding mortar mixes and methodologies to be undertaken with Engineer prior to commencing works. Exemplars will be required for each pointing / rebuilding type and are to be agreed with the design team before undertaking any work.

Mortar Binder

The use of Portland Cement shall not be permitted for this work. All mortars for repairs to the historic masonry including rebuilding of new sections of traditionally constructed walls will be lime and sand mixes as specified in this section.

Lime for structural repairs should be Naturally Hydraulic Lime NHL or indigenous quicklime.

There may be instances such as work in areas where a quick set is desirable because of the inherent wet conditions and the need to work in times outside of the ideal temperatures for lime because of the programme. Prompt Natural Cement may be sourced for these situations with the approval of the Engineer.

Metastar 501 pozzolan will be permitted for situations such as exposed wall tops.

Hot Mixed Lime mortars using indigenous quicklime as manufactured by Clogrennane, Co. Carlow should be considered for rebuilding. For masonry wall re-building it is proving a much quicker, more robust way of rebuilding rubble stone masonry and the expansion during slaking will be inherently useful in tightening up the arch voussoirs. The document "Hot Lime Mortars - HLM Project - TECHNOLOGY TRANSFER & APPLIED RESEARCH" should be consulted (see references).

Naturally Hydraulic Lime; Metastar; Prompt and quick lime for hot mixing are all supplied by the following (not exclusive list)

Stoneware Studios, Youghal www.stonewarestudios.com

Traditional Lime Co., Carlow www.traditionallime.com

All lime mortars should be prepared and mixed as recommended in manufacturer's printed guidelines. Bags of lime hydrate, natural cement, etc. must be stored off the ground in a clean, dry place and not used outside of the dates recommended on the bags. Quicklime should be stored in weatherproof air tight bags/containers.

Sand

Shall be clean, coarse, well-graded sharp sand.

Particle sizes should range from 3mm to fine dust for any ashlar repointing and 5mm to fine dust for repointing larger joints in stonework.

The sand colour is important in achieving a good visual match to the existing mortar.

Mixing

Lime and sand should be carefully measured by volume, using batching boxes (shovels are not sufficiently accurate to be used). A conventional cement mixer may be used.

Add lime and sand dry and mix thoroughly. Lime hydrate and sand must be mixed dry in a mixer for a minimum of 20 minutes prior to the addition of water, to encourage air entrainment and improved workability.

Add water carefully until mixture starts to run. It should be a little dryer than a cement-sand mix. After water is added allow a full twenty minutes further mixing. The long mixing period helps improve workability.

The mortar should be damp but not too wet. Mortar for re-pointing needs to be dryer than that used for original bedding because it is being placed in small quantities in a vertical situation.

Use mixed mortar within a few hours and do not moisten to extend the working life. Mortar when mixed must be used within the time scale recommended by the manufacturer.



Existing lime-rich mortar on site

Exemplars of all proposed works provided at start of contract.

This should include the following at minimum:

- i) Mortar for wall tops, underside of arch and consolidation of reveals
- ii) Mortar for repointing wall faces
- iii) Sample wall top detail both regularised and rough raked (see next page)

Mix proportions

A typical Hydraulic mortar for structural repairs and wall tops:

Mix proportions may need to vary depending on the lime + sand but are to be in the range:

Structural repairs: 1 part NHL 3.5 lime to 2.5 – 3.0 parts graded sharp sand.
 Wall tops and slopes: Gauge NHL3.5 with Metastar according to manufacturers' instructions.
 Wall faces: A softer Hot-mixed or gauged Hot-mix (NHL 2) mortar to be used.

A typical Hot-mixed mortar for bedding work and repointing:

1 part quicklime (Clogrennane kibbled or powder):
 3 parts coarse sand (If a silica sand as opposed to a calcareous sand is to be used then substitute 0.5 part for limestone dust). Gauging by (level) bucket.

Gauged Hot Mix Mortar - for bedding work and repointing

1 part Hydraulic lime (NHL5 St Astier or NHL3.5 Roundtower grey):
 1 part quicklime (Clogrennane kibbled or powder):
 5 parts coarse sand (If a silica sand as opposed to a calcareous sand is to be used then substitute 0.5 part for limestone dust). Gauging by (level) bucket.

Moisture resistant Mortar - works at/or below ground level

1 part Naturally Hydraulic Lime NHL3.5 (upper band width NHL3.5 spec)
 1 part Prompt Natural Cement
 2 parts 5mm down washed sharp sand + addition of up to 10% 10mm aggregate

Note. The Prompt Natural Cement in these ratios will give an initial set in approximately one hour of placing without dramatically


Re-laying Masonry

All loose stones are to be laid on a full bed of mortar, spread on a carefully cleaned and wetted upper surface of the underlying masonry. Slate or small stone pinnings may be used to level the stone and all horizontal and vertical joints are to be completely filled with mortar well packed in so that the loadings of the structure are distributed evenly.

Think of mortars as soft beds to provide cushions between stones. Lime does not glue things together or create a hard, impervious skin like cement-based mortars and coatings.

Where new stones or bricks are to be inserted, allow for "dry packing" joint over with barely wet mortar.

The new mortar joints of the rebuilt stone and brickwork are to match exactly the existing joint depth and are to be struck flush, brushed off diagonally across joint in both directions and sponged off carefully to match exactly the re-pointing works to the remainder of the masonry. Care must be taken to ensure that mortar or grout splashes do not stain the existing masonry faces. See also note below re: beating back of mortar once stiff.

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Architect:		HHCA		REV. No.		REVISION DESCRIPTION		DATE		ISSUED BY		Mortar Specification 1 of 2		22548										SK07				P1	

Specification for repair mortars continued

Preparation for Re-pointing and initial build-out

Prepare areas for re-pointing using small hand-held tools and by removing all the very friable mortar saving any small stones (“gallets” or “pinnings”) that come loose for re-use.

Good preparation is essential for all lime works and a brush is an essential piece of equipment for cleaning out joints, wall surfaces and for brushing pointed joints.

Do not use large blobs of mortar to fill in voids or loose areas; build up with pieces of stone. If the voids are large, bed in the small filler stones in the normal way. If smaller then fill void with mortar and then drive in a stone wedging it in tightly to tighten up loose masonry.

Re-Pointing

Carefully rake out joints to depth of twice the joint width. Face of raked out mortar to be cut back square and not sloped or V-shaped. Brush out joints to clear of all debris.

Wet down joints and adjoining masonry to be pointed thoroughly, on dry or windy days spraying may be needed several times and also occasionally during the pointing process and after the work is completed. The wetting is to stop the bed joints from drawing water out of the pointing mortar that would make it dehydrate and fail to set. Lay the pointing mortar on a hawk to a depth equal to the depth of the joint and square off the front edge. Using a pointing iron of similar depth to the joint, cut off thin strips of mortar and offering the hawk up to the joint press well in with the pointing iron.

Make sure the joint is well filled and the front face brushed off lightly once the mortar has become stiffer. Beating back the mortar with a churn brush (as supplied by lime supply companies above) once stiff also assists with compaction of the mortar into the joint and reduction in shrinkage cracks.

Protection & Follow up Work

All finished work must be protected by plastic sheeting or damp hessian sheeting to prevent the joints or coatings from drying out too quickly or conversely becoming saturated

Some slight cracking may occur to the joints and this should be pressed back by hand/churn brush. Brushing up of finished pointing is essential to roughen the finish and clean up drips and splashes from adjoining areas.

All masonry works should be carefully planned such that proper protection can be included or scheduled for the warmer months of the year.

Precautions of suspending operations until the temperature reaches 6° C on a rising thermometer or 8° C on a falling thermometer shall be strictly observed. Also frost protection and protection from saturation by rain is essential.

The horizontal surfaces of masonry are particularly vulnerable to saturation and thus frost damage in the weeks immediately following rebuilding/ pointing and should therefore be protected from excesses of water. The vertical elevations can be protected by draping with hessian

Consideration should be given to insulating and /or applying heat to wall faces if cold weather is forecast in the two months during or after masonry works are completed.

Care must also be taken to protect applied work from rapid drying conditions i.e. exposure to direct sunlight or drying winds. In these conditions it should be kept evenly damp for up to 30 days, depending on ambient conditions and the rate of set, by lightly spraying periodically with clean water. In areas exposed to direct sunlight, the possibility of a "greenhouse" effect must be avoided, either by shading the polythene or by substituting woven cloth materials.

Polythene, hessian or other approved sheeting that is used during curing should be arranged to hang clear of the face of the wall in such a way that it does not form a tunnel through which the wind could increase the evaporation of water. The polythene or hessian sheeting must not have intermittent contact with the pointing / render as this may cause a patchy appearance.

Recommended Reading / useful references:-

“Lime Works - using lime in traditional and new building” Patrick McAfee 2010

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Hot Lime Mortars - HLM Project

Technology Transfer & Applied Research Scotland & Ireland May 2015

available on Building Limes Forum Website www.buildinglimesforumireland.com



Exemplar provided of flush pointing in stonework beaten back to expose aggregate

Stone Identification process - numbering and recording

Any part of a wall that is to be dismantled or stones that need to be removed must follow strict protocol.

All stones to be numbered using removable chalk / paint; photographed and layout mapped using clear mona flex or similar before dismantling.


After dismantling apply same number in indelible ink / paint to hidden face and store stones in reverse order on scaffold or pallets etc ready for reassembly.



Example of appropriate protection to allow wall to dry out yet not become saturated by rain on upper surfaces



Sample of regularised (left) and rough-raked (right) wall top finish

Drawing Stage:						Drawn By:		Checked By:		Approved By:		Date:		 <p>Behan House, 10 Lower Mount Street, Dublin 2. D02 HT71 Tel: +353 (0)1 661 1100 e-mail: info@cora.ie web: www.cora.ie</p>															
PRELIMINARY						NM		TB		LE		05/07/2022																	
Project Details:						Project Name:		Scale:		Project Number:																			
Site Address:		Templeogue, Dublin 6W				Structural Condition Survey		NTS		22548																			
Client:		P1		Issued for inclusive in report		08/07/2022		TB		Drawing Title:		Project:		Originator:		Zone:		Level:		Type:		Discipline:		Drawing No.:		Stage:		Revision:	
Architect:		HHCA		REV. No.		REVISION DESCRIPTION		DATE		ISSUED BY		Mortar Specification 2 of 2		22548										Sk08		P1			