



STAINED GLASS CONSERVATION REPORT

Date received: w/c 12th June 2018

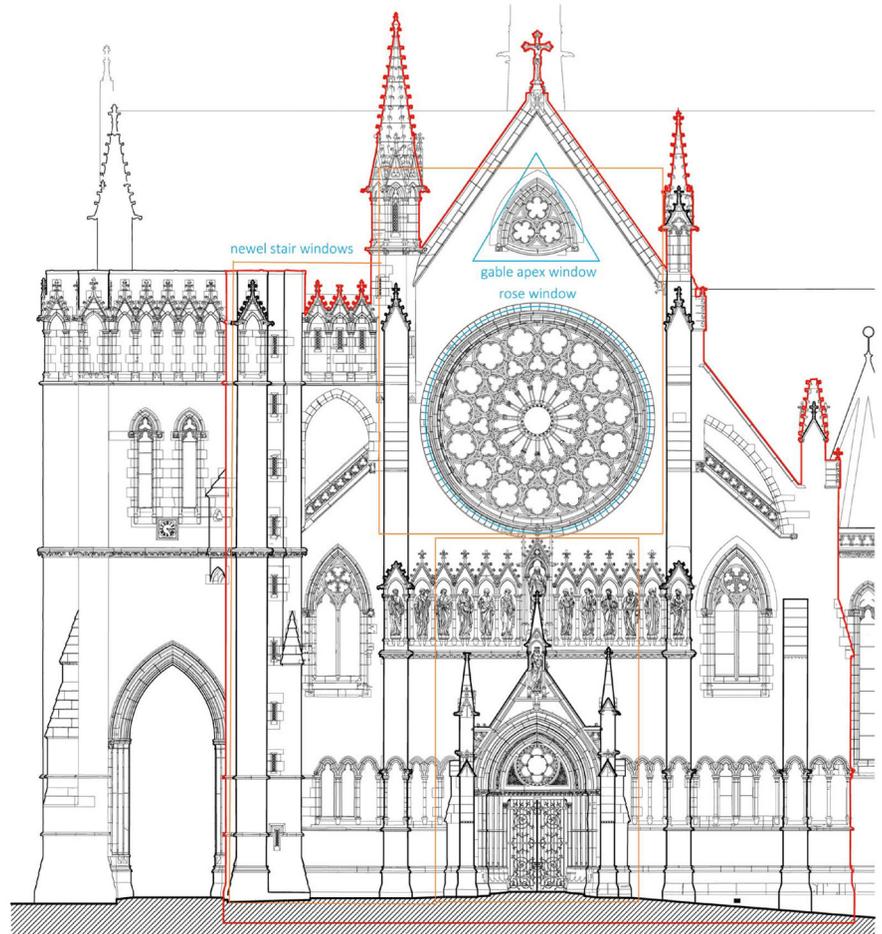
Date returned: w/c 4th March 2019

Conservators: Steve Clare ACR, Jack Clare, Sarah Knighton ACR, Gemma Curtis, Shane Toomey, Helen Bree, Helen Bower, Stuart Low, Clare Mardall, Connor Dors, Chris Elliott, Dan Hearn, Jon Pullen, Samantha Peacock

INTRODUCTION:

After winning a competitive tender, Holy Well Glass was asked to carry out conservation works at Arundel Cathedral. Main works comprised of re-leading and/or partial re-leading and repair of the Great Rose Window on the West Front. Ancillary works included repairs and re-leading to the plain glazing of the Gable Apex Window, and two narrow windows on the newel staircase turret, both on the West Front. Basic cleaning to surrounding masonry was carried out, and for the gable apex window, further brush cleaning was necessary to remove the 'beard' of moss and lichen below it. The relevant windows are marked on adjacent diagram.

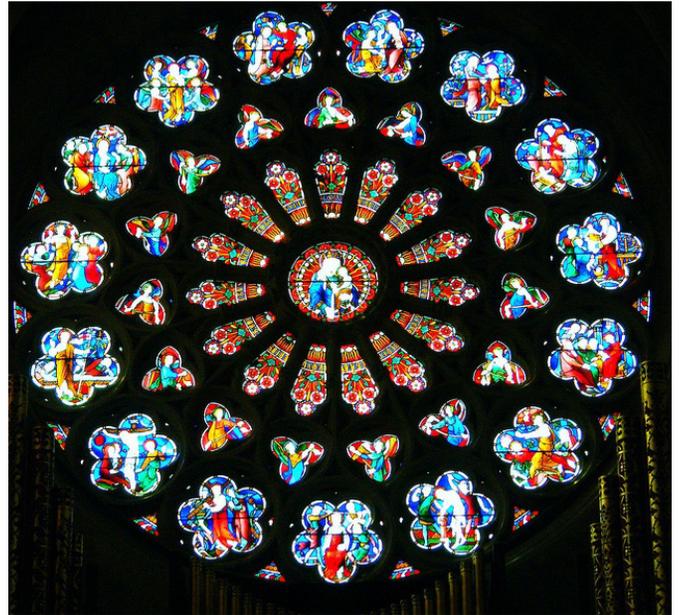
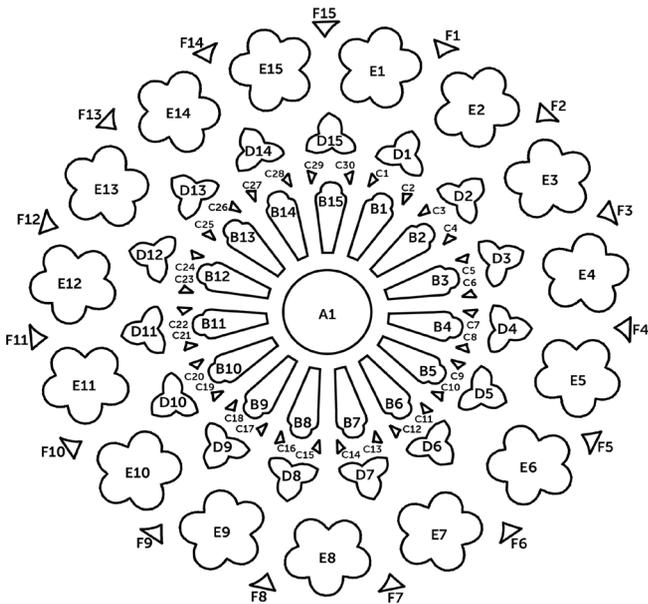
The Great Rose Window on the west façade sits above the organ gallery. The stained glass was made for the Victorian French Gothic cathedral in 1873 by the esteemed C19th stained glass workshop Hardman's of Birmingham. The window contains 15 outer cinquefoils, 15 inner trefoils, 15 smaller trefoil headed lights, and 1 central circular light. There are also numerous 'eyes' between the tracery elements. In the centre is the Blessed Virgin with the Holy Child around her, and angels bearing incense in the inner trefoils. In the outer circle are the fifteen Mysteries of the Rosary. The gable apex window contains three lights within an overall opening. One newel stair turret window is a single rectangular light on the spiral staircase, removed to allow works to the stone, the other a narrow two panel rectangular light with a trefoil head, located above a ladder at the top of the turret.



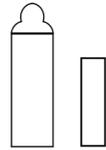
CONSERVATION RECORD: ON SITE

Access on site gained via a fixed scaffold internally and externally. Organ fully wrapped against dust and water ingress. Apart from the small eyelets in the Great Rose Window, all the traditional stained glass and plain glazed panels were removed from the stonework; hard Portland cement mortar was removed by hand, with dummy and tungsten tipped chisel, from around the perimeters of the lights. Copper ties were released, and the stained glass panels/leaded lights freed from

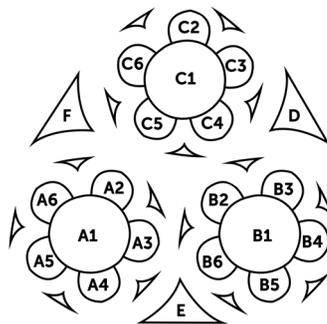
GREAT ROSE WINDOW



NEWEL STAIRCASE
TURRET WINDOWS



GABLE APEX WINDOW



A heavy concentration of moss & lichen below the Gable Apex Window

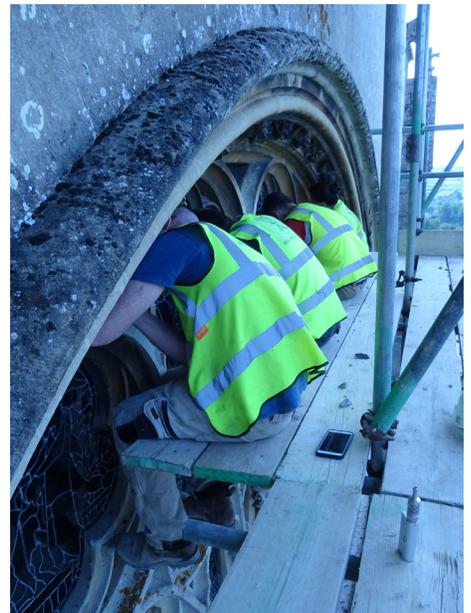
the openings. All panels removed from church, stacked securely with bubble wrap and boards, and transported to workshop for conservation. The narrow cusped turret window was removed externally as there was no internal access. All sills were checked for glass fragments, after which debris was removed from openings and sills with a vacuum cleaner. Templates were made of the stone openings and measurements taken. All spaces glazed temporarily with a mix of twin wall polycarbonate and boards, supported on battens, and silicone sealed. Boards were used to ensure security of the larger openings. Site left clean.



Great Rose Window external scaffold



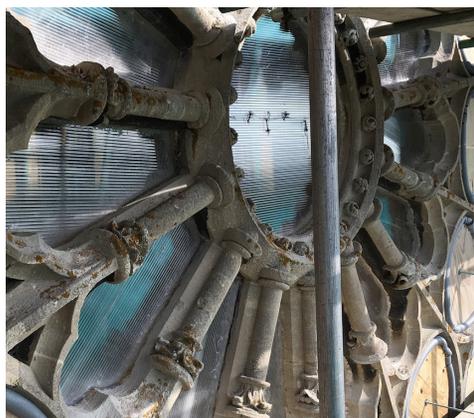
Great Rose Window internal scaffold



On-site removal



On-site removal, hard Portland cement mortar



On-site removal, protective boards & polycarbonate sheet



On-site removal, moss & lichen growth visible on the window masonry

IN WORKSHOP:-

Photography

All the panels were digitally photographed, including before and after pictures, processes, and site work. Images and conservation diagrams are stored as JPEGs and are included in the digital copy of this conservation report (on USB).

Assessment

Once in the workshop the panels were assessed for damage prior to works. The glass was assessed to determine the glass types, bonding methods, and cleaning methods, and the lead was assessed to determine if it was structurally sound or failing. The stained glass panels in the **Great Rose Window** were very unstable. Some had fallen apart upon removal, with many broken solder joints, and substantial bowing to panels. There was much loss of cement externally, and leaching of cement internally. Some sections of glass had pulled away from the lead structure to reveal light gaps, and historic mortar repairs were evident. The glass was stable but there were often multiple breaks throughout, and occasional holes. There was severe paint loss throughout, generally occurring to the clear/green tinted glass used mainly for the faces, hands, and robes. In some case only the pale 'ghost' image remained, only discernible on close inspection. On-site Hard Portland cement had been used previously around the perimeter of the panels. The larger 'A' and 'E' panels were fitted with 1/2" square bronze bars, which were sound. The masonry was generally good, though some parts were covered with moss and lichen. The **Gable apex window** was structurally weak, with brittle leads. Internally there was general surface dirt and grime, and spider's webs. There were a number of cracks to border glass pieces. The stonework below was heavily covered in moss and lichen. **Turret windows**; the rectangle window on spiral staircase was weak, with brittle lead, and the perimeter lead was cracked and failing. The panels with cusped head were in poor condition, with distorted lead and broken glass. The internal ferrous bars were in poor condition and hugely expanded, severely damaging the stonework. The perimeter mortar was very hard Portland cement.

Rubbings

Before the panels were dismantled three rubbings were taken of the lead matrix and lead profiles noted. First rubbing used to lay glass pieces on after removal from leads, second rubbing as a guide for re-leading, and third for annotation with Church Building Council (CBC) conservation symbols.

Dismantling

It was necessary to dismantle fully or partially, some panels that were not structurally sound, and some areas to facilitate repairs to the glass. Presumed in favour of renewing leadwork where weakness was evident, as future opportunities will be limited due to the extreme inaccessibility of the window.



Panel E14 during dismantling

PRE-CONSERVATION CONDITION ASSESSMENT



Broken leads and solder joints



Weak panel coming apart naturally



Leaching cement internally



Lead coming away from the glass, external view



Painted border glass & perimeter lead



Remains of hard Portland cement mortar on perimeter lead



Multiple cracked piece, external



Single crack, internal



Hole in glass & historic putty repair, internal



Hole in glass & historic putty repair, external



Historic strap lead repair, internal



Moderate paint loss, internal



Severe paint loss, internal



Total paint loss, internal



Varying thicknesses of glass internal, after removal from leads



C19th lead, internal

Cleaning

The painted surface of the glass was monitored with a binocular microscope. Each piece of glass was cleaned using a 50/50 mixture of ethanol and de-ionised water on cotton buds and soft brushes. Leaded light cement was removed with a scalpel. Panels not dismantled were also cleaned, as above, but within the lead matrix.

CONSERVATION OF GLASS:-

Edge-bonding

Impact breaks, single/double breaks and small gaps repaired using Araldite 20:20; a conservation grade two-part epoxy resin. Silicone used where a more flexible mend was required, and where glass was too thin to work with resin.

Some cracked sections or simple breaks of glass were repaired employing the copper foil method, whereby the break edges of the glass are coated with a thin adhesive strip of foil. The pieces are brought together and the foiled sections soldered to make one re-united piece.



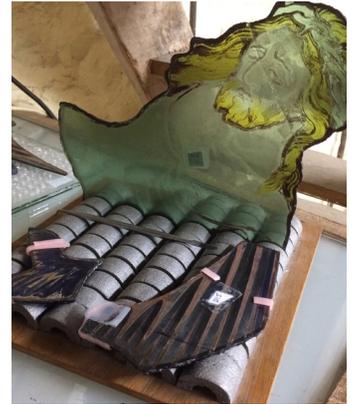
Glass pieces laid on rubbing after cleaning



Newly soldered copper foil edge-bond



Copper foil edge-bond dulled with Black patina to blend with the lead came



Two stage vertical & horizontal epoxy resin edge-bonding in progress

Cold Painting

For edge-bonded areas, glass with stable paint was then cold coloured for legibility.

Newly painted /replacement glass

Missing areas replaced with newly painted and kiln-fired inserts. Glass matched from stock of handmade tints (Lamberts Restoration Glass). Paint and stain tests conducted to achieve correct match. Detail repainted using evidence within panel. All new painted insertions clearly date marked with kiln-fired glass paint. For the Gable Apex Window a matching machine rolled glass was found, and the central section re-made to follow the pattern of the south transept gable rose window.

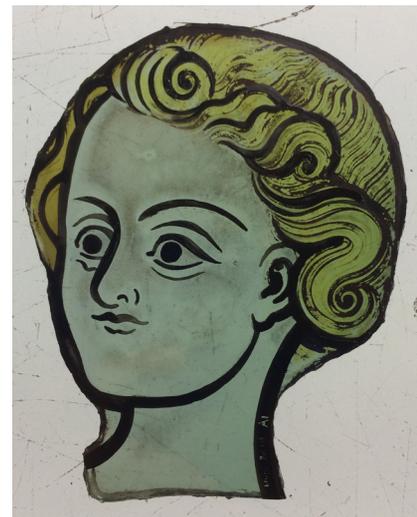
Paint enhanced plates

Plates were produced to reinforce lost painted detail from iconographically important areas of The Great Rose Window. The larger central 'A' panel and the large cinquefoil 'E' panels in the outer rose were selected for this treatment. They were felt to benefit most significantly; it was in these larger panels the white glass was particularly glaring where the paint had been lost, drawing the eye from the design intent of the window. Plates were clear 1.2mm thick optical glass, painted with kiln-fired glass paint, and heat formed to the contours of the original pieces. Paint and stain tests were conducted to achieve a correct match. The detail was hand-painted to match the original design intention, using evidence within the existing pieces. For areas of total paint loss, a full repaint was applied to the plates following the 'ghost' image on the original glass, whereas those pieces with less paint loss were only partially repainted. Once kiln-fired the paint enhanced plates were fitted with copper foil around the perimeter, in readiness for fitting to the conserved panels during site-refit.





Original piece, left, with paint loss, & new paint enhanced plate, right



Original piece, with paint loss, below, & new paint enhanced plate, atop



Applying copper foil to perimeters of paint enhanced plate



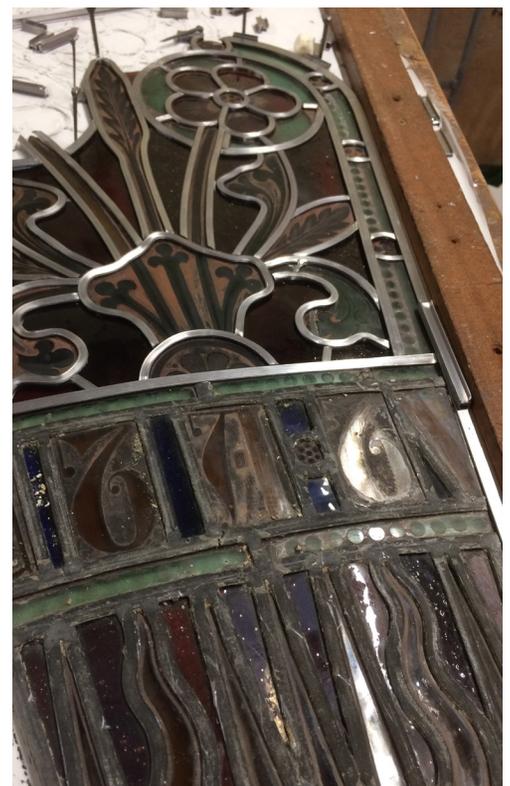
Newly re-leaded panels, ready for waterproofing



Pattern of lead came sizes for 'B' panels, based on original lead profiles



Re-leading



Part new lead, part C19th lead, during re-leading

Re-leading

Panels have been leaded with commercially available lead comes, in profiles matching the original lead width and depth; 3/8" flat perimeter, 1/4" flat bead, 3/16" flat, and 5/16" flat internal leads. The soldering

technique has been mirrored, soldered with 60/40 lead/tin solder. String leads have been employed where historic repairs were leaded in the same manner, where breaks were unsuitable for edge bonding, or to separate modern inserts from original glass.

Waterproofing

Areas with unstable paint hand puttied with linseed oil putty stained with lamp black pigment. All others cemented with traditional leaded light cement, to the following recipe: - 4 white spirit, 1 boiled linseed oil, 1 raw linseed oil, 5% gold size, calcium carbonate and lamp black pigment.



Hand putting internal side of panel, after re-leading

Ties

For 'A' and 'E' panels only on the Great Rose Window, new copper ties were applied to the inside using 1.4 mm soft copper. Copper ties were also applied to both turret panels internally.

Ferramenta:-

Great Rose Window – only 'A' and 'E' panels have bars. The extant bars were in good condition and remained untouched.

High Apex Window – there were no bars.

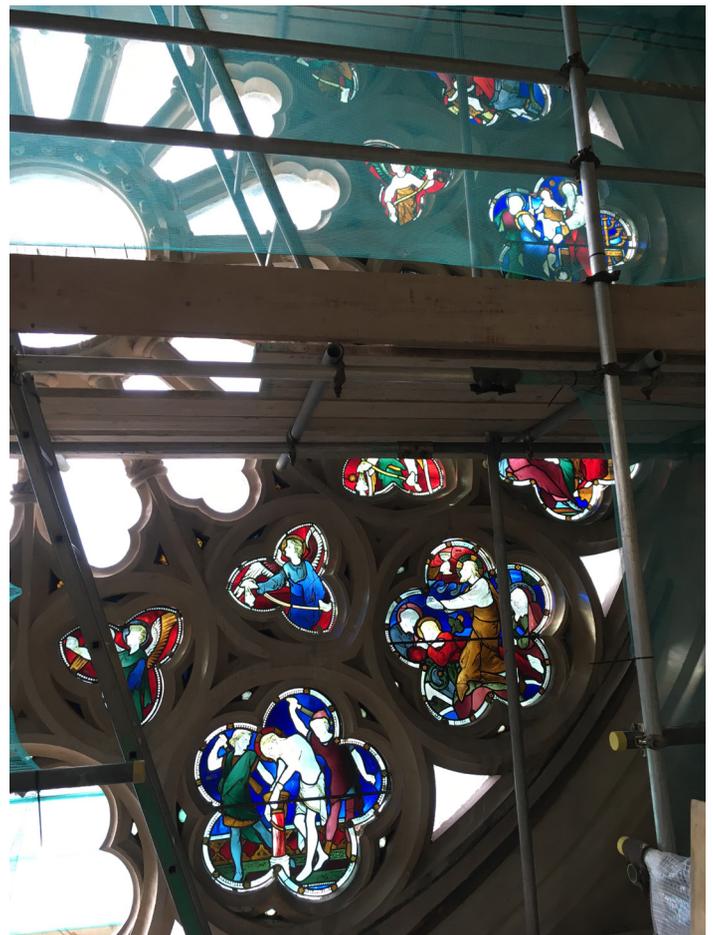
Turret Windows - the rectangle window on the spiral staircase, and the two panels with cusped heads were fitted with new stainless steel bars, supplied by the stonemasons.

SITE INSTALLATION/RE-FIT



Refitting 'E' panels, external view

The windows were returned to the building w/c 4th March 2019. For the Great Rose Window access was gained via a fixed scaffold both internally and externally. Stained glass and plain glazed panels were delivered to site. The temporary twin wall polycarbonate sheet and boards were removed. Panels refitted into stone grooves, and copper ties tied to bars where necessary. The windows were sealed to the building around the perimeter of the lights with traditional lime-mortar - 1 St Astier lime NHL3.5: 3 aggregate (2 Sut Sharp sand: 1 w60).



On-site refit in progress, internal view



A 'D' panel fitted, wedged, and ready to point around perimeter, external view



Pointing in progress, external view



An 'E' panel fitted, wedged, and ready to point around perimeter, internal view

Fitting paint enhanced plates for the Great Rose Window

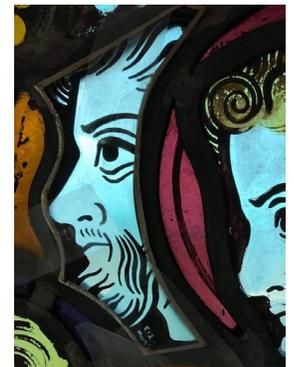
The workshop-prepared paint enhanced plates with copper foil perimeters were tack-soldered into position internally, once the stained glass panels were fully installed.

Stonework Repairs

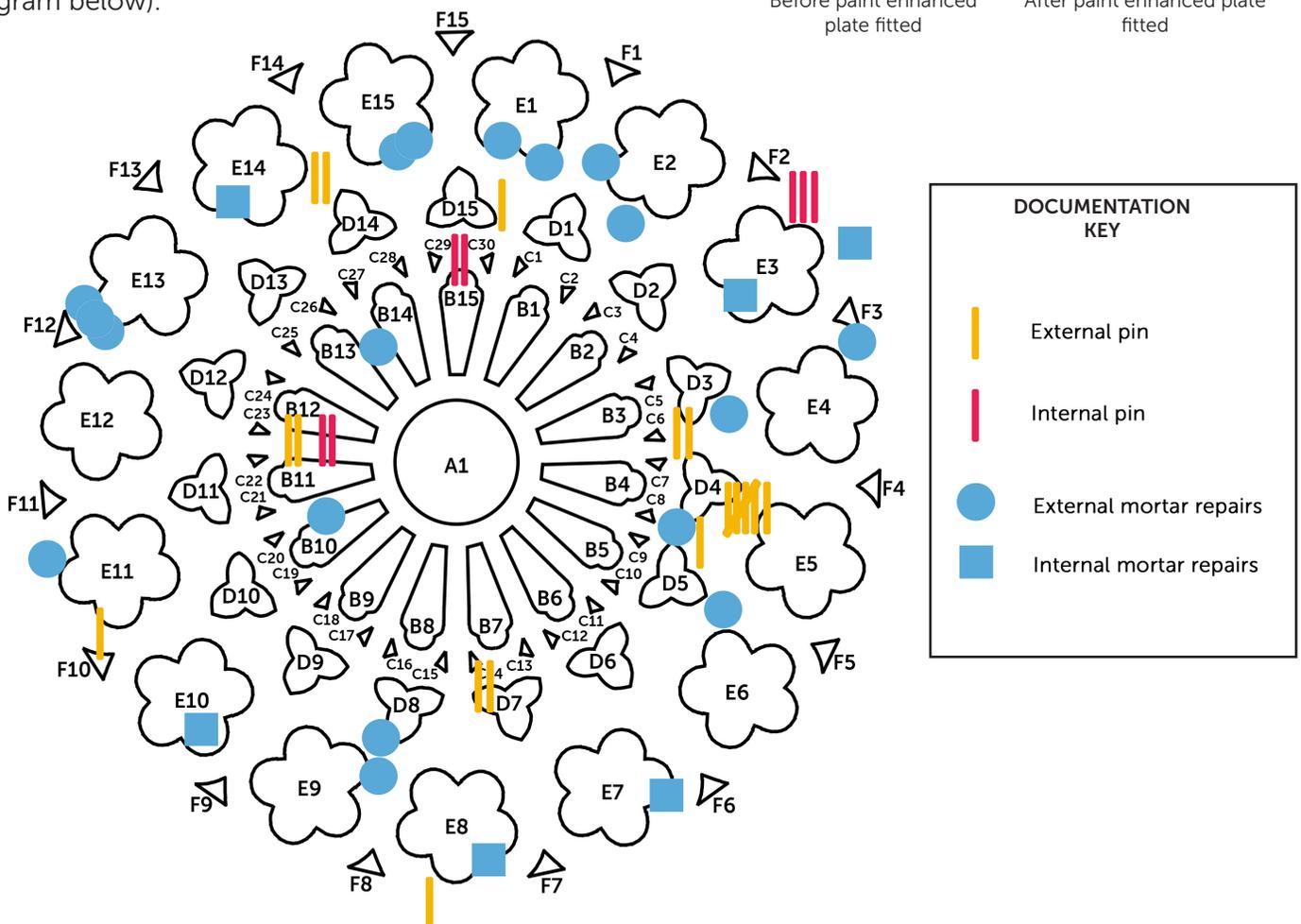
External and internal mortar repairs and fixing of pins were applied to strategic sections of the Great Rose Window (see diagram below).



Before paint enhanced plate fitted



After paint enhanced plate fitted

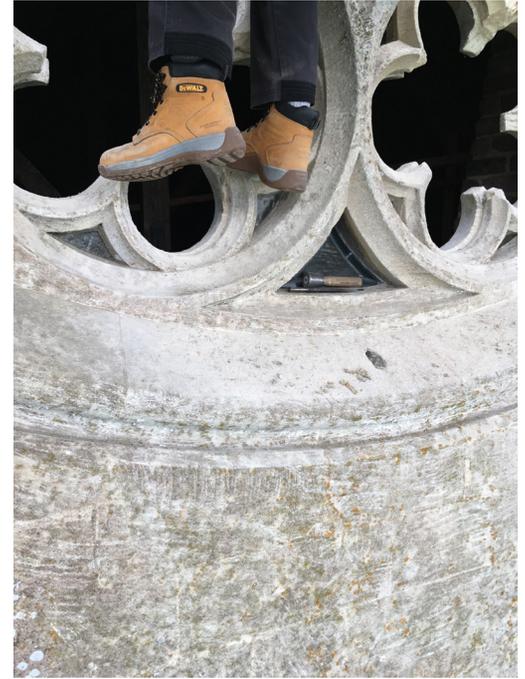


On-site/in-situ cleaning

During site removal of glass panels, before conservation, basic cleaning to masonry was carried out on the Great Rose and Turret windows, and heavy moss and lichen growth to ashlar walling below Gable Apex Window, cleaned off stonework with brushes. Left site clean.



Gable Apex Window before stone cleaning



Gable Apex Window after stone cleaning

TREATMENT MATERIALS USED

CLEANING AND FIXING

- Ethanol TS DA (DEB)
- De-ionised water
- Acetone 99.5 % BP APC
- Silicone adhesive (Silcoset 153 ACC Silicones Ltd)
- Linseed oil putty (Hodgeson)
- Abrasive block Garyflex (Garryson, coarse grit)
- Amino silane primer A-1100
- Araldite (20:20 Huntsman) Epoxy resin
- Orasol dye various colours (Ciba)
- Windsor & Newton acrylic paints various
- Lamp Black pigment (L Cornelisson & son)
- Cotton wool
- Black Patina Art - Nr 5011103
- Edco copper foil tape 7/32 5B

GLASS

- Handmade cylinder glass
- 1.2mm thermoformed optical backing glass
- Machine rolled glass

GLASS PAINTING

- Fine flux 44C2 (Cookson Matthey)
- Gum Arabic
- Reusche 401, 402,
- Silver stain Reusche 1382
- Debitus Brun XIII 3980

GLAZING

- Lead came - Heaps Arnold and Heaps
- Tallow
- 60/40 lead tin solder (k grade)
- Soft gauge copper wire 1.4mm

WATERPROOFING

- White spirit
- Boiled linseed oil
- Raw linseed oil
- Gold size
- Calcium carbonate
- Lamp black pigment

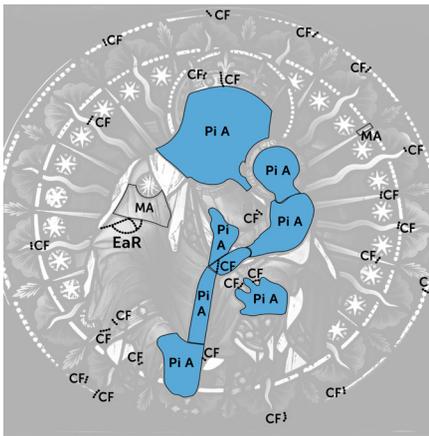
SITE FIXING MATERIALS

- Linseed oil putty
- Lamp black pigment
- Hydraulic Lime NHL 3.5
- Lead skirts
- Sharp sand
- Black silicone sealant

DOCUMENTATION KEY

••••	Edge bond	T	Historic glass transferred
EaR	Epoxy resin edge bond	M	Unpainted modern glass
EaS	Silicone edge bond	MA	Painted/stained modern glass
FR	Epoxy resin infill	Pi A	HWG paint enhanced internal plate
CF	Copper foil edge bond		Old Victorian lead retained
Gr	Piece reversed historically		

PHOTOGRAPHIC CONSERVATION RECORD EXAMPLE, Panel A1:-



Panel A1, conservation diagram



Panel A1, before conservation, transmitted light



Panel A1, before conservation, reflected light

Post Conservation Condition

Panels are stable, clean, fixed sound, and weatherproof. Important design detail has been restored to the Great Rose Window, employing a fully reversible method.

Future Care

It is important for the glass to be regularly monitored in the usual quinquennial inspection by the architect. Due to the delicate nature of the surface glass paint on the Great Rose Window, any future cleaning should be carried out by a specialist.



Panel A1, after conservation, transmitted light



Panel A1, after conservation, reflected light



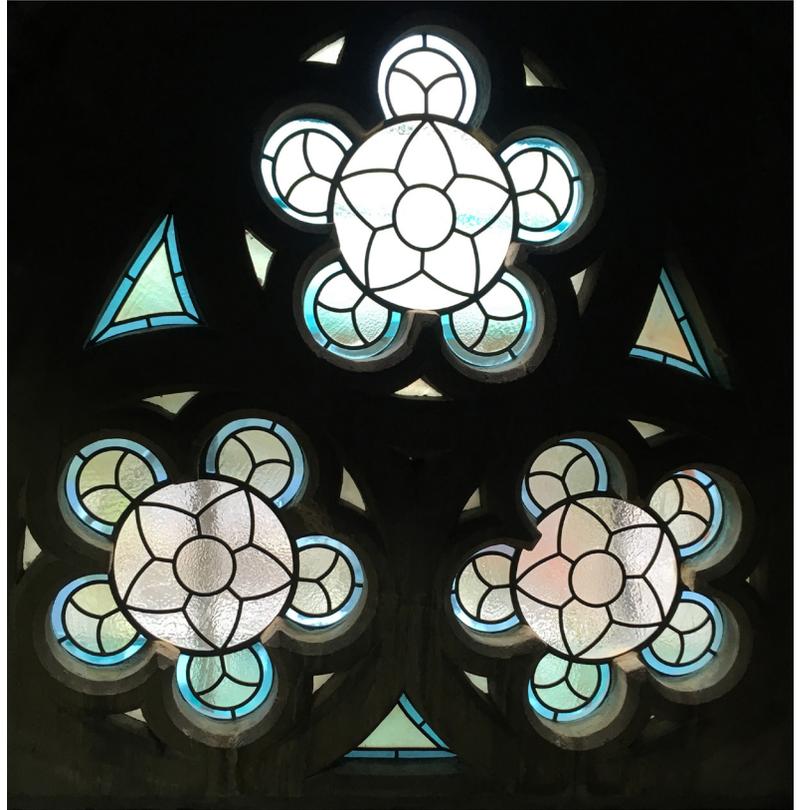
Panel A1, after conservation refit, prior to fitting of paint enhanced plates, transmitted light



Panel A1, after conservation refit, after fitting of paint enhanced plates, transmitted light

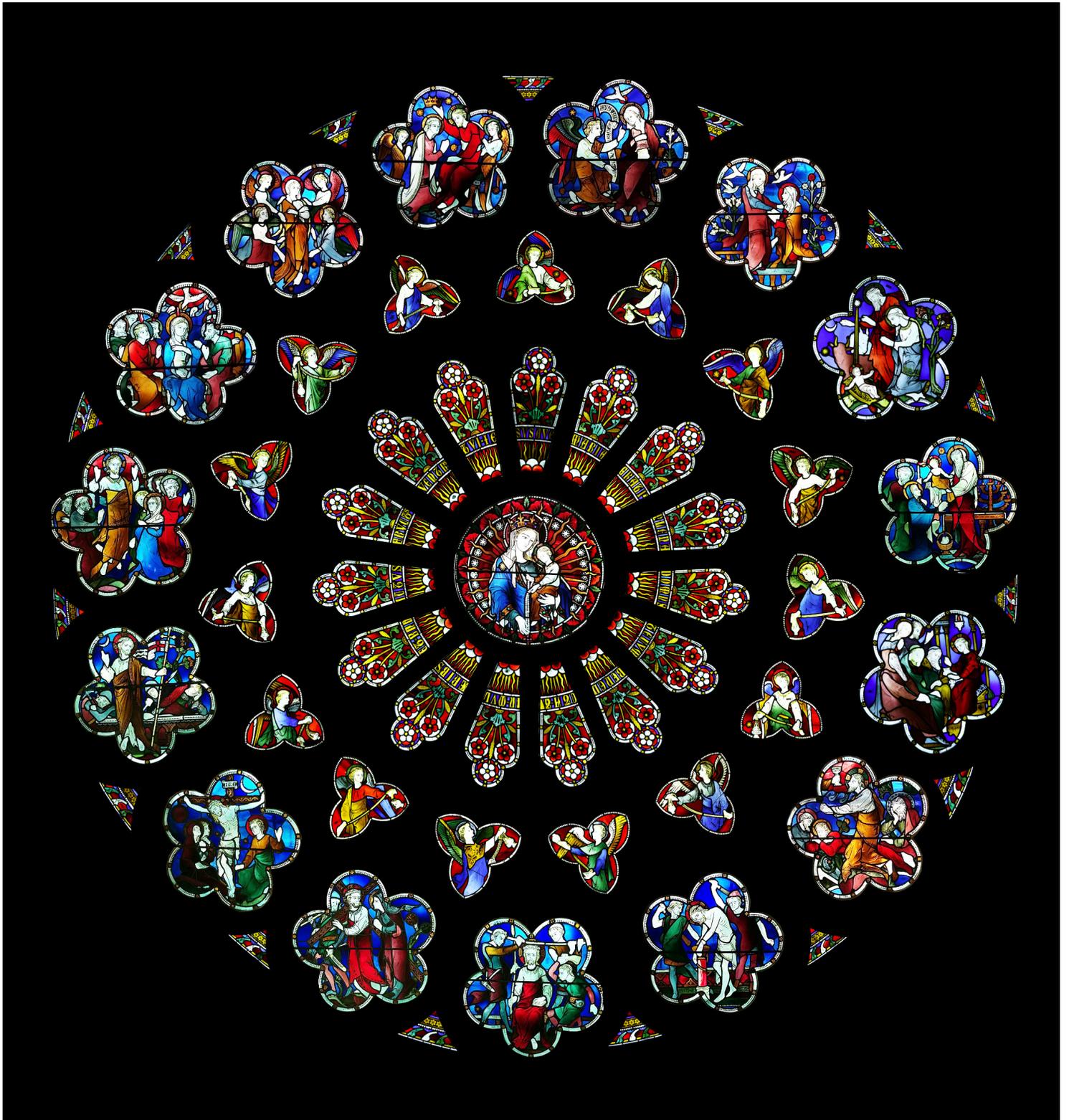


Great Rose Window, centre 'A' panel, fully refitted and pointed, external view



After site refit, internal:- Below, Great Rose Window, above right, Gable Apex Window.





Great Rose Window, after-conservation digital diagram, internal view