

Essential Repairs including Replacement Wagon Arch Glazing

1830 Warehouse

Science & Industry Museum

Design and Access Statement



Prepared by:
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February 2023

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SECTION 01 / INTRODUCTION:

- This Design & Access Statement report has been prepared on behalf of the Science and Industry Museum (SIM) Manchester for proposed works which are part of a large capital spend by the museum on their estate of historic buildings. This includes an important programme for inspection, repairs and maintenance to bring the buildings back to where they should be and to ensure their continued enhancement and long term well being as an important part of the visitor experience.
- As part of this programme Studio Downie Architects LLP have been working with SIM and coordinating a team of experienced consultants and specialists to provide a series of Conditional and Measured surveys for the Grade 1 1830 Warehouse. The team has developed a detailed understanding of the historic building through their history, construction details and current maintenance/defect issues and its importance within the wider context of Manchester's townscape setting.
- Studio Downie's varied experience includes historic buildings on challenging landlocked city sites and sensitive protected landscapes.
 - The Grade 1 Parker Library, Corpus Christie College, Cambridge
 - The Grade II* Royal Geographical Society, London
 - The Cass Sculpture Foundation, South Downs National Park.
 - The Grade 2 Lyme Regis Museum, Unesco World Heritage Site
 - The Grade II Stanley Building, Kings Cross, London awarded best Heritage-led project, London Planning Awards.

Executive Summary

- There is a priority for essential conservation works during the Summer of 2023. From October 2023, the 1830 Warehouse will be used for staff offices and temporary events and so repairs are needed for staff and visitor safety.
- The design team have undertaken a review of the client ‘as built’ information, client records, client surveys; a visual record of what’s there now; an assessment of historical significance focused on the specific alterations, and including identifying repairs to the fabric.
- The client liaison with internal stakeholders, e.g. operations, commercial events and parallel works activities is important to the successful project delivery.

The Scope of Works

- Replace the large glazed screens to the Wagon Arches in Bay 1, Bay 2 and Bay 3 in the south elevation. Single glazing system of toughened and laminated glazing installed as part of an aluminium framed glazing system to provide weather protection and reduction in air leakage. Glazing requires UV reduction interlayer. Limited thermal improvement.
- Replace and re-profile wood sills to base of cargo doors on south elevation.
- External brick and stone repairs primarily to north and south elevation with inspection of west and east elevation during the works.
- Internal brick and timber repairs.
- Localised strengthening works to increase the floor load rating to approx. 2.5kN/m2 across most of the floor areas.
- Redecorate rainwater downpipes (appropriate railway livery colours to be confirmed following analysis of historic paint colours).
- Metalwork repairs.
- The intention is to avoid the need for full scaffolding. The works to the south elevation will require scaffold access. Work to the north elevation from the Lower Yard level would be undertaken without the use of scaffolding and works to the upper levels below the cornice line would be undertaken via mobile elevated working platform (MEWP). East and West elevation external repairs – minor work will be inspected by MEWP, then works to be undertaken by MEWP.

Process

- This application for Listed Building Consent brings forward the scope of works to the Wagon Arches and straightforward repairs.
- HCUK attended the pre-application meeting on the Wagon Arches and the preliminary walkround on the essential repairs. They visited the archives and have reviewed proposed scope of works as part of their preparation of the heritage assessment.
- MCC planners have been engaged with early discussion on site (09/08/22 and 17/01/23) with MCC Conservation Officer to establish their understanding of the defects and how the situation will be improved with the new installations and repairs, to help identify what is of special interest to inform the level of detail of the proposals before going too far.

WAGON ARCHES:

- A preliminary meeting was held on site on 09/08/2022 with MCC Planning Officers and the Conservation Officer to give an overview of the defects and the general approach.
- Feedback from the meeting established the need for additional baseline information:
 - Report 1: photographic analysis of all Viaduct level openings on the south elevation of the 1830 warehouse as a visual record of what’s there now and to provide a reference document.
 - Report 2: heritage analysis to bring together the history of the openings and to establish special interest and to review the options under consideration.
 - Report 3: condition survey of the fabric to identify what are the issues, reasons for structural failure and why it is not possible to replace like for like with the existing installation.
 - The team agreed that (ultimately) there should be consistency across all large openings in the façade as a family of details.

- SDA developed the design approach which was issued to MCC in preparation for a pre-application meeting on 29/11/22. Following feedback from the pre-application meeting, an updated report was prepared and submitted to Historic England which received positive feedback 03/01/23. The updated report was submitted to MCC for review and they have confirmed that the proposals can be submitted for LBC without further pre-application meetings.
- The application brought forward is to replace the large structural glazed screens to the original wagon arches overlooking the viaduct in Bay 1, Bay 2 and Bay 3.
 - To remove existing temporary structural safety bracing and safety film and structural glazed panels including fins and associated channels.
 - Review design parameters for replacing the structural glazing to Bay 1 and Bay 2 and Bay 3 as a ‘family’ of details. (visual design of structural glazing; integrate UV protection to the glazing for museum object conservation)
 - Associated repairs to the fabric.

ESSENTIAL REPAIRS:

- A preliminary meeting was held on site on 17/01/2022 with MCC Planning Officers and the Conservation Officer to give an overview of the defects and the general approach.
- Feedback from the meeting established:
 - Cargo door sills to viaduct - research is being carried out into the historic detailing of the sills
 - Timber/brickwork repairs (included in this document) would come forward with Wagon Arch glazing replacement application.

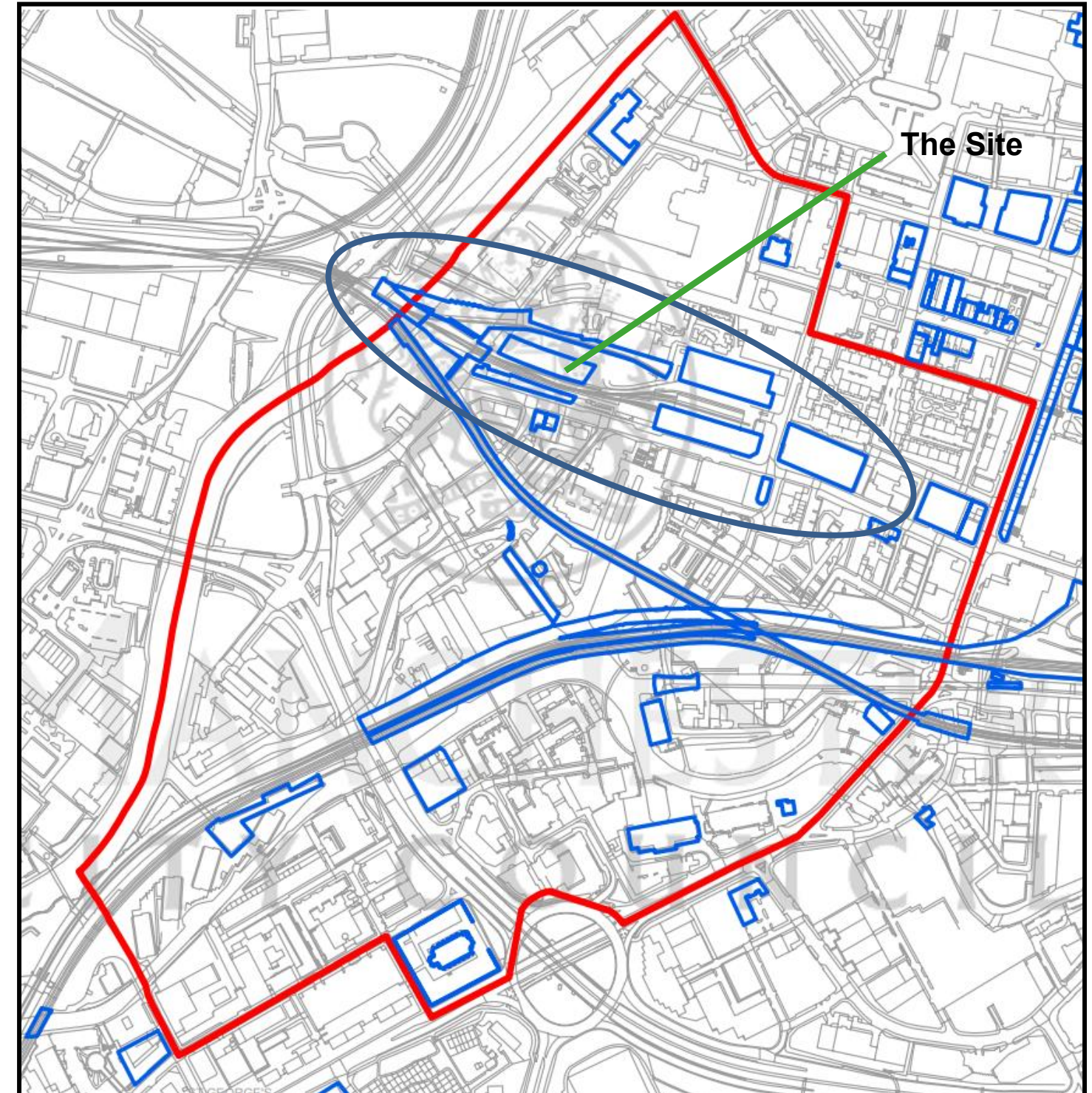
SECTION 02 / THE SITE AND ITS CONTEXT:

The buildings and the site

- As the world's oldest surviving passenger railway station and the world's first railway warehouse, the western end of the site has been extensively researched.
- Located within the Castelfield Conservation Area the large and complex former "Liverpool Road Railway Station" site contains a significant collection of Grade I and Grade II listed buildings.
- A Conservation Management Plan commissioned by the Museum, who are the owners of the site sets out policies which form a framework of philosophy and priorities for repair and conservation.

Planning, Heritage & wider context

- The 1830 Warehouse is a Grade I listed building, it sits within the Castelfield Conservation Area and is close to a number of other listed buildings and structures including the former Liverpool Road railway station and station masters house (Grade I) and the elevated track and viaduct between those two that links the bridge over the River Irwell to the Station and Warehouse.
- The building has a brick envelope with timber frame internally, reinforced at basement level with steel and iron columns. The elevation has several types of opening which are explained in the HCUK heritage assessment: e.g. cargo doors, wagon arches, triple windows, lunettes.
- There have been phases of alterations to the 1830 Warehouse born out of a necessity to adapt to the needs of changing warehousing methods to transfer goods from track into the building. The most recent phase of the adaptation relates to changes brought about by its change of use to a museum. These changes include glazed infills to the wagon arches.
- The Bays are numbered 1 – 5 from west to east on plan. Defects were previously found to be present to the former wagon openings at Bays 1 and 2, requiring temporary support and shatter proof film to be applied to the glazing. Further investigation has been undertaken and preliminary liaison with MCC Planning Authority and Conservation Officer to understand the scope for replacement. With the risk of further movement in the glazed infills to Bay 1 and Bay 2 it is important to replace the glazing as soon as possible.
- A separate element of work relates to completing the installation to the roof access to Bay 2 and Bay 5. These have listed building consent, and the logistics of the installation of the final elements is included within the scope of this study.



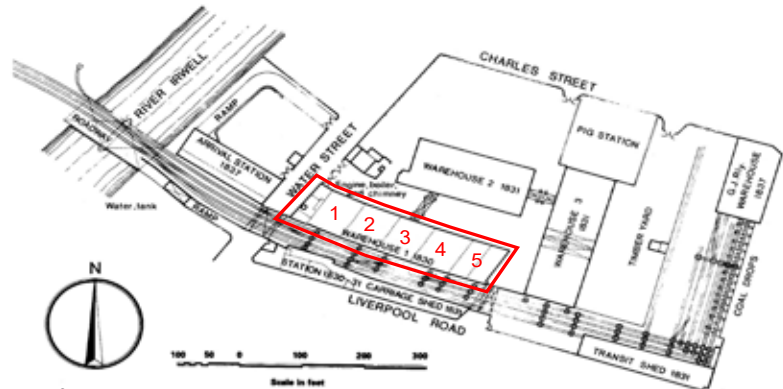
Castelfield Conservation Area

Bays to the building

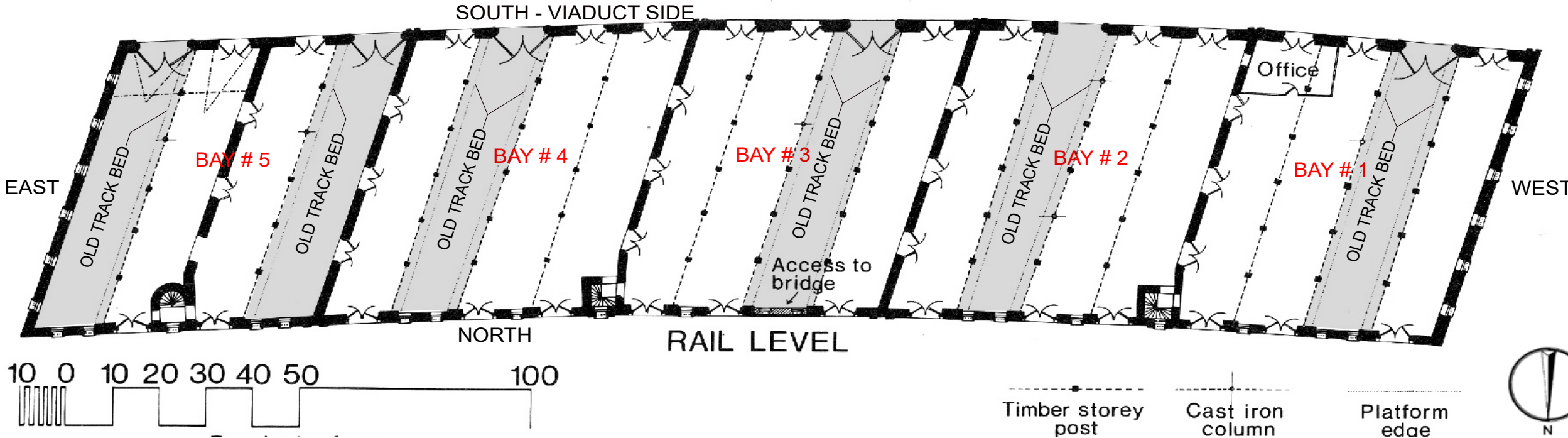
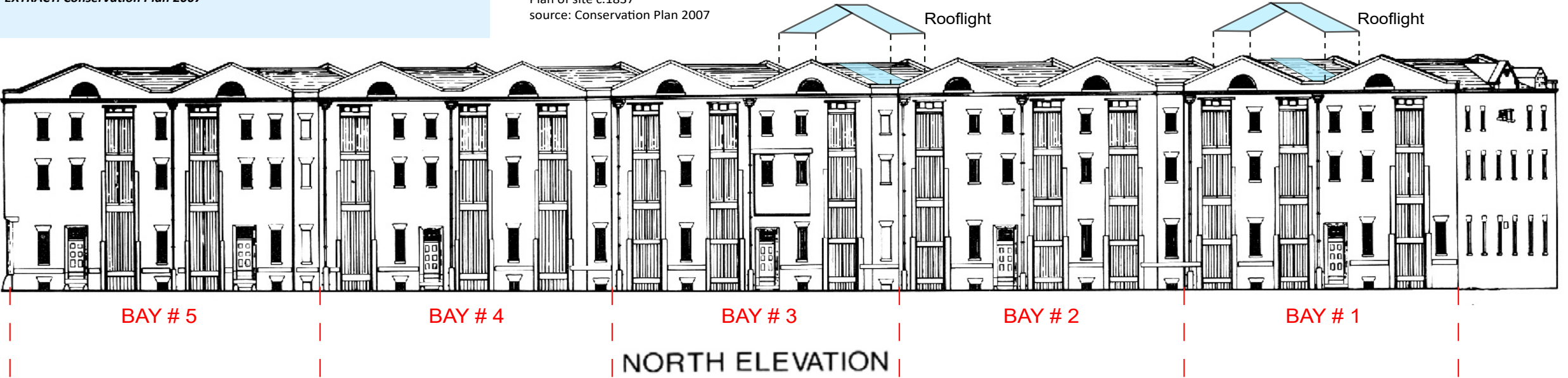
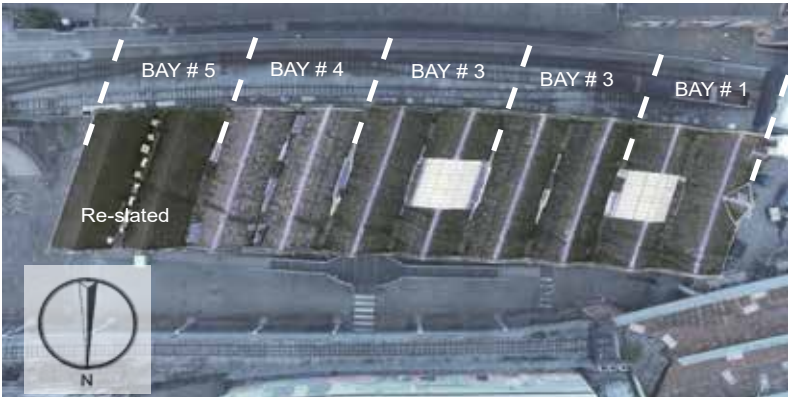
Description of 1830 warehouse

It is timber framed (with cast iron columns in the basement) with brick walls and a slate roof (with some glazing). Stone is used for the sills and lintels, cornice and coping blocks for the gable ends. It is of five storeys (including the basement), but presenting only two to the southern (rail) elevation. The main northern façade is characterised by the strong vertical lines of the brick pilasters and the vertical lines of the loading doors. The transverse gable roofs end in gables with stone copings, linked by short flats; the gables are accentuated by lunettes above the moulded cornice. The loading bays are surmounted by openings for the hoist jibs, which remain in varying degrees of repair.

EXTRACT: Conservation Plan 2007



Plan of site c.1837
source: Conservation Plan 2007



Heritage Category: Listed Building.

Grade: I. List Entry Number: 1282991. Date first listed: 08-May-1973.

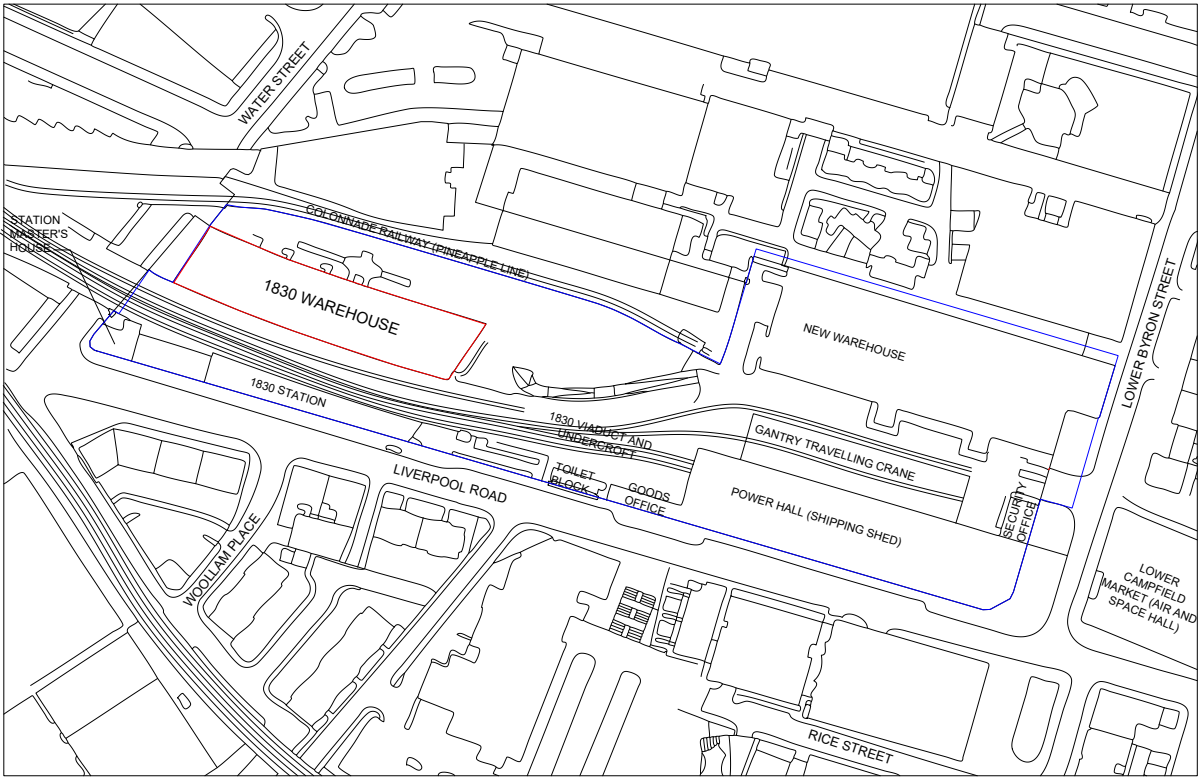
Statutory Address:
OLD WAREHOUSE TO NORTH OF FORMER LIVERPOOL ROAD RAILWAY STATION, LIVERPOOL ROAD.

Details MANCHESTER

SJ8297 LIVERPOOL ROAD 698-1/18/208 (North side) 08/05/73 Old Warehouse to north of former Liverpool Road Railway Station

GV I Listing NGR: SJ8299097886.

Railway warehouse. c.1830, together with Liverpool Road Railway Station (q.v.), by George Stephenson and his son Robert; altered. Red brick in Flemish bond, with sandstone dressings and slate roofs. Long slightly curved plan, convex to the railway line and concave to the rear. Three storeys but presenting only 2 storeys to the raised level of the track, 10 individually gabled bays arranged in pairs, with slotted pilasters between each pair and at both ends, a moulded stone cornice (carried round the whole), a small lunette on the cornice in the centre of each bay, and stone gable copings linked by short flats. In each pair of bays (except the 5th pair, at the right-hand end), one bay has a segmental-headed wagon archway with stone surround, 3 small segmental-headed barred windows above the archway with linked sills and wedge lintels (except the 4th bay where the wagon entrance has been raised so as to leave only the heads of the windows) and one 2-stage loading slot to left or right, and the other bay has 2 loading slots. The last pair of bays both have the wagon-archway form. The right-hand loading slot in the 3rd bay has a hoist pulley over the lintel, and apparently altered brickwork over the other loading slots suggests that all were formerly equipped with similar hoists. The left hand return wall has (inter alia) a small pediment to the centre, with an oculus; the 3-storey 6-window right-hand return wall has a doorway with stone surround at the left end of the ground floor, 2 segmental-headed doorways at 1st floor level, and narrow rectangular windows diminishing in the height. The 3-storey rear, with cornice and lunettes like the front, and pilasters which have small windows, has 3-stage loading slots arranged singly or in pairs corresponding to those at the front, with hoists over all except one at the west end and 2 at the east end, doorways with stone surrounds next to the single slots, and small rectangular barred windows with wedge lintels. Interior: timber construction visible.



Location Plan

Photogrammetric survey of the existing elevations



South Elevation



East Elevation



North Elevation



West Elevation

SECTION 03 / ANALYSIS AND APPROACH:

This section sets out the proposed scope of works.

3.1: Wagon Arch Glazing

3.2: Cargo Door Sills

3.3: Brickwork Repairs (internal and external)

3.4: Stonework Repairs

3.5: Timberwork Repairs

3.6: Metalwork Repairs

3.1: Wagon Arch Glazing

Methodology

- The design team have undertaken a review of the client requirements which has included a review of the client records, client surveys, a visual record of what’s there now, an assessment of historical significance focused on the specific alterations, and an assessment of the condition of the fabric (including identifying repairs to the fabric). In depth assessment and analysis is included in Appendix 4.

- There is an urgent need to repair the two structurally defective glazed bays to Bay 1 and to Bay 2 as a priority (to Bay 3 as preventative measure, and we have considered the wider elevational approach to inform the design and detailing of the proposals.

• Understanding the group of windows to the southern facade only

- The 1830 Warehouse has two principle long elevations, the elevation to the north originally handled goods from the warehouse on to carts for road distribution via the Lower Yard, whereas the south elevation handled the unloading from train wagons on the viaduct (originally the whole wagon!) into the warehouse while the central Bay 3 originally featured a continuous train line passing through the building and over the Lower Yard. The east and west elevations do not have this active history of transition through openings, primarily because the structure of the five bays were assigned to specific commodities resulting in cargo transfer on a north-south axis. The south elevation abuts the viaduct (a key part of its historic function) and appears shorter in height than the north elevation which opens to the lower yard.

- The wagon arches on the viaduct side are a visual reminder of this industrious activity connecting the warehouse to the railway. Since the museum’s phase of ownership, the museum has glazed four of these wagon arches. Though there are adjacent cargo doors and triple windows, the wagon doors themselves are a unique group of historical elements relating specifically to the viaduct. Curatorial decisions in the 1990s when the warehouse was restored led to a light weight touch as far as glazing, with limited slender frames and large sheets of glass to preserve as much of the sense of an open arch as possible. A similar approach was made to other window openings higher in the façade which were not historically glazed, but were infilled in this period. The cargo doors were never glazed, only the wagon arches and selected higher level windows in bays 1-3 and 5. Bay 4 was deliberately left with unglazed openings as a way of using the building as an exhibit and illustrating the ‘original’ format of the building.

- With the 1830 Station open to the public, the museum route takes visitors along the old platform alongside the viaduct with a view across to the south elevation. The platform side setting for visitors (in historic times, ‘would-be’ passengers) retains the relationship of the south elevation of the warehouse to the railway and to the 1830 Station.

• Assessment of the Wagon Arches

- The glazing installed in the 1980’s and 1990’s is a result of the recent phase of use as a museum. Defects have rendered two of the four glazed openings inadequate with a risk of further movement and further potential damage to the fabric and potential harm to users. The detail to Bay 3 is similar to Bay 1 and ultimately this detail will fail in time as Bay 1.

- The two wagon arches with timber doors are different and will be retained.

- The timber door to Bay 4 is a recreation of the original alignment of the early doors before function and use changed and the doors to the wagon arches were set back within the arch with short platforms projecting out towards the track through the archways, as a result of changes in floor level to reflect changing operational needs in line with technological developments. The door to Bay 4 serves as reminder of the origins of the wagon arches.

- The timber door to Bay 5 is reduced in height as part of the substantial remodelling of Bay 5 in the 1980’s to accommodate the museum’s curatorial needs which included a change to the original structural system of timber floors to concrete floors, and the detail inside at the lower level has been filled in with the result that the external detail is now a brick faced wall below the raised sill which itself sits in line with the internal floor level. The door to Bay 5 would require substantial rebuilding of Bay 5 to change it back to an original detail and would serve only to reveal the substantial internal changes of the 1980’s alterations to Bay 5.

- The eastern most wagon arch to Bay 5 has replica doors reinstated to hang externally, similar to Bay 4, however the infill to Bay 5 is a large glazed sliding door. This unique detail was part of the specific design of this bay which was substantially remodelled with new internal concrete floors to accommodate the very large object display internally. The concrete floor is level with the trackside with an internal arrangement of fire stairs and lobbies.

We have set out below a series of considerations which have emerged from the design team studies and feedback from the Conservation Officer. These considerations respond to the client brief and the ongoing and future use of the 1830 Warehouse.

Considerations for type of glazing:

- 1 No glazing. Reinstatement of timber doors (reduces weather protection and reduces internal environmental control). Not viable.
- 2 Replace as is (like for like) with planar glazed system. Not recommended due to defects/condition, does not adequately manage rainwater away from weak interfaces which will lead to future decay in historic fabric. Not viable.
- 3 Build masonry upstand to Bay 1. This has no historical precedent.
- 4 Build brickwork spandrel panel to Bay 1. This reflects previous historical interventions. It reduces legibility of the original wagon openings.
- 5 Replace glazing with alternate approach (there are sub-options):
 - a. Single glazing system of toughened and laminated glazing installed as part of an aluminium framed glazing system to provide weather protection and reduction in air leakage. Limited thermal improvement. Glazing requires UV reduction interlayer.
 - b. Double glazing system of toughened and laminated glazing installed as part of an aluminium framed glazing system to provide weather protection and reduction in air leakage. Glazing requires UV reduction interlayer. Improved thermal environment but limited by the fact that many openings are not glazed.
- 6 Secondary glazing. This could be a future approach to some or all openings but will add a new layer of intervention throughout the building. Not recommended.

The like for like installation is not feasible without further harm to the stonework. The frame system provides adaptability to future adaptation and ease of long term maintenance, and is a more sustainable approach with an aluminium frame to provide a better long term weatherproof detail and lower maintenance.

Following consideration of the above, the preferred approach is to replace glazing as 5a above with single glazed system as part of an aluminium framed system. This approach would be applied to wagon arches with existing structural glazing, Bay 1, Bay 2, Bay 3.

The museum does not propose to install glazing to wagon arches with wood doors in Bay 4 and Bay 5 nor to replace the sliding glass door to Bay 5.

• Developing the preferred approach

- The approach is to replace the structural glazing as a family of details which respect the legibility of the history of the building, and its multiple phases but don’t replicate or directly mimic existing details and creates a consistent contemporary vocabulary to these wagon arches to render these interventions clearly legible and honest interventions, building on earlier intervention strategy and also to have all structurally glazed openings as clear and light weight as possible.

- The proposals for replacement glazing requires the repair of structural defects and associated fabric repairs.

- The proposed structural glazing system is an aluminium frame with new sill and integrated upstand details. The interface design will manage rainwater away from interfaces.

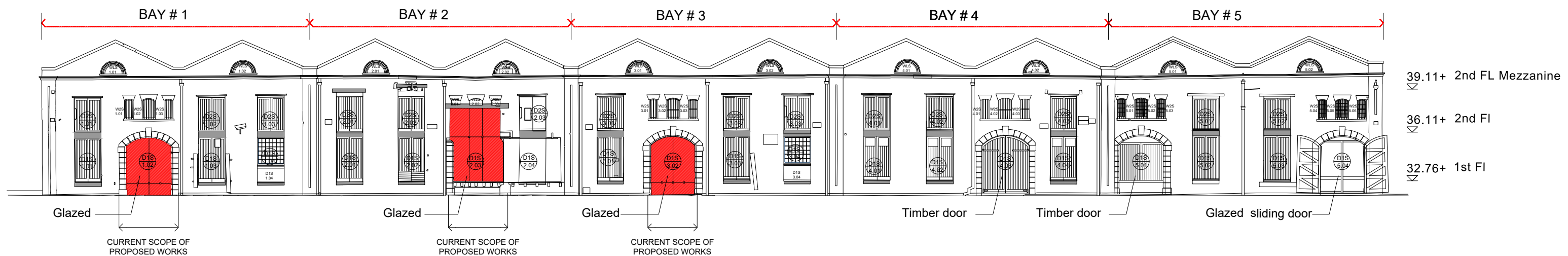
- The following pages provide an overview of the appraisal of the existing before setting out the design approach.

Design Approach

- A more sustainable approach with an aluminium frame to provide a better long term weatherproof detail and lower maintenance, smaller panels to ease replacement for long term maintenance.
- Design a legible modern intervention, respecting old levels, modern materiality that reflects the quality of the industrial fabric.
- Simple glass shapes, respecting the robustness of the brick and stone framed archways.
- Keep the wagon arches legible and distinct as glazed 'openings'. Avoid matching the vertical lines of cargo doors.
- Thin vertical elements, the metal frame to the reveal set back from the external face to retain the depth to the elevation and to maximise visibility of masonry details in stone and brick at the openings and remaining historical details e.g. pintels. The thin line in the mullion refers to the meeting line between wagon doors.
- The uniqueness of the larger Bay 2 opening which is offset at the upper level, has led us to consider the alignment of the new glazing elements within the glazed opening itself to balance the new intervention and to define it as an honest intervention while maintaining the family of details at the lower level.
- Use of subtle colour changes to emphasise geometries within the opening, distinct from the original.
- High quality powdercoated metal frames.
- The new sill on Bay 1 and Bay 3, with a metal upstand below, as part of the metal framed system provides the waterproofing detail and interfaces to the historic fabric.
- A metal floor plate internally to link wood floor to back of glazing box.
- The low level transom follows the existing internal floor level and could be a capless silicone joint with the internal frame box for the bracing to retain the visual height of the wagon arch when viewed externally (de-emphasising the joint and reinforcing the height of the wagon archway from track level).
- The following pages summarise the schedule of works.



Overlay of key elements of the elevation



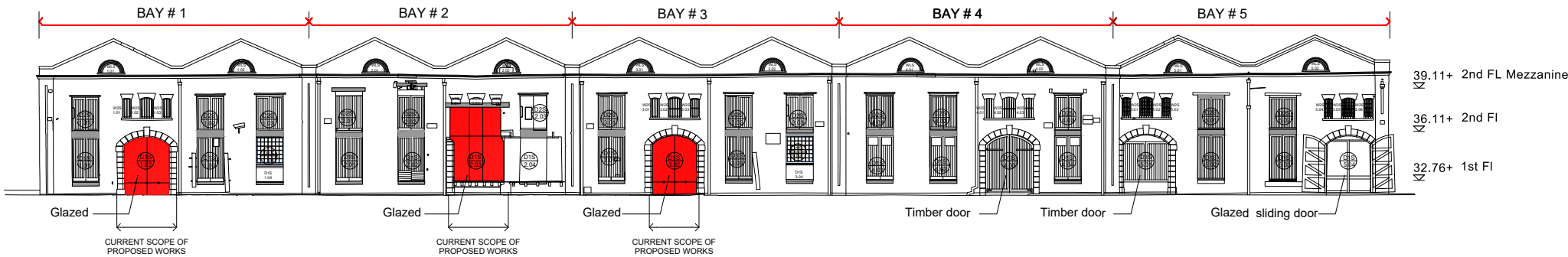
South Elevation

KEY

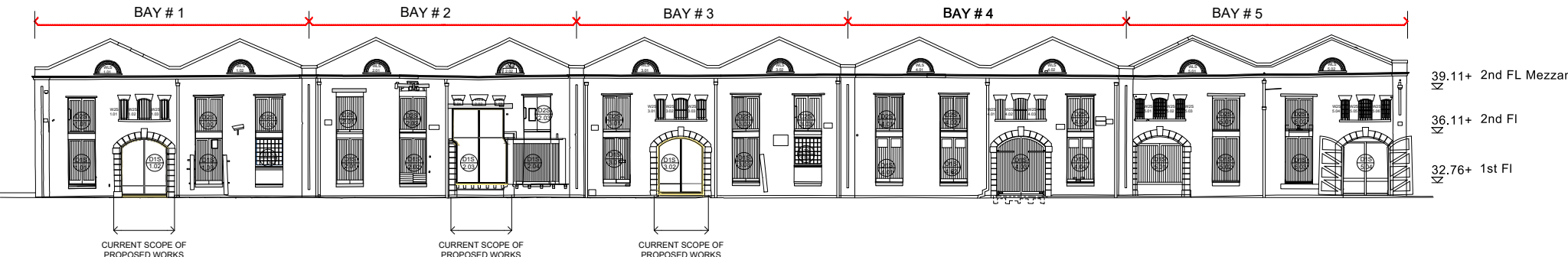
Glazing to be removed

SCHEDULE OF WORKS

- Aluminium framed glazing system, capless joints / capped system components with powdercoated finish.
- Toughened and laminated glass with UV protection using standard PVB interlayer of about 95% reduction between the wave length of 280 – 380 nm as defined by EN 410.
- Repairs to structural timber
- Repairs to adjacent stonework and brickwork
- Repoint stonework and brickwork locally with lime mortar.
- All carried out by a competent operative with careful protection of surrounding original fabric.



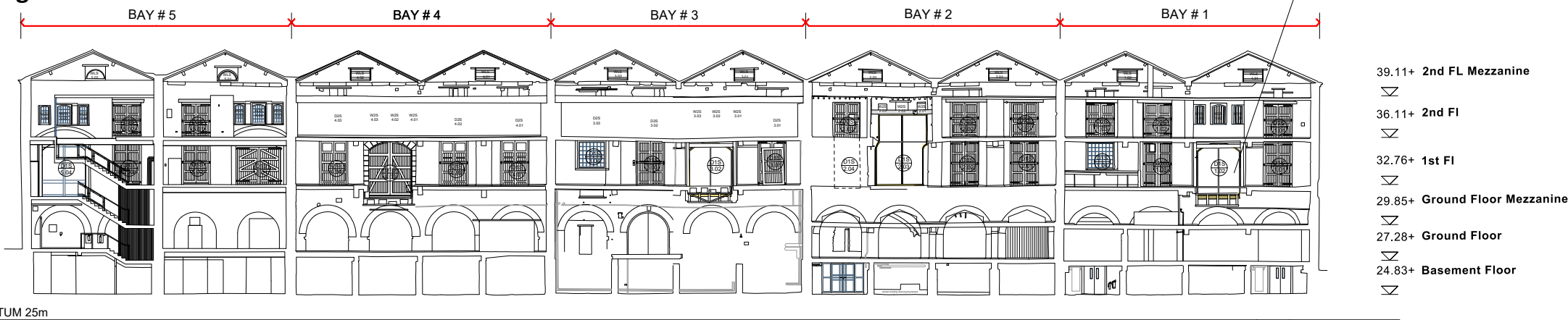
Existing south elevation



Proposed south elevation concept



Existing internal south elevation



Proposed internal south elevation concept

FABRIC REPAIRS

SCHEDULE OF WORKS TO THE FABRIC

Bay 1 Wagon Arch

- Clean and treat iron hinge posts
- Repoint arch stonework

Bay 2 Wagon Arch

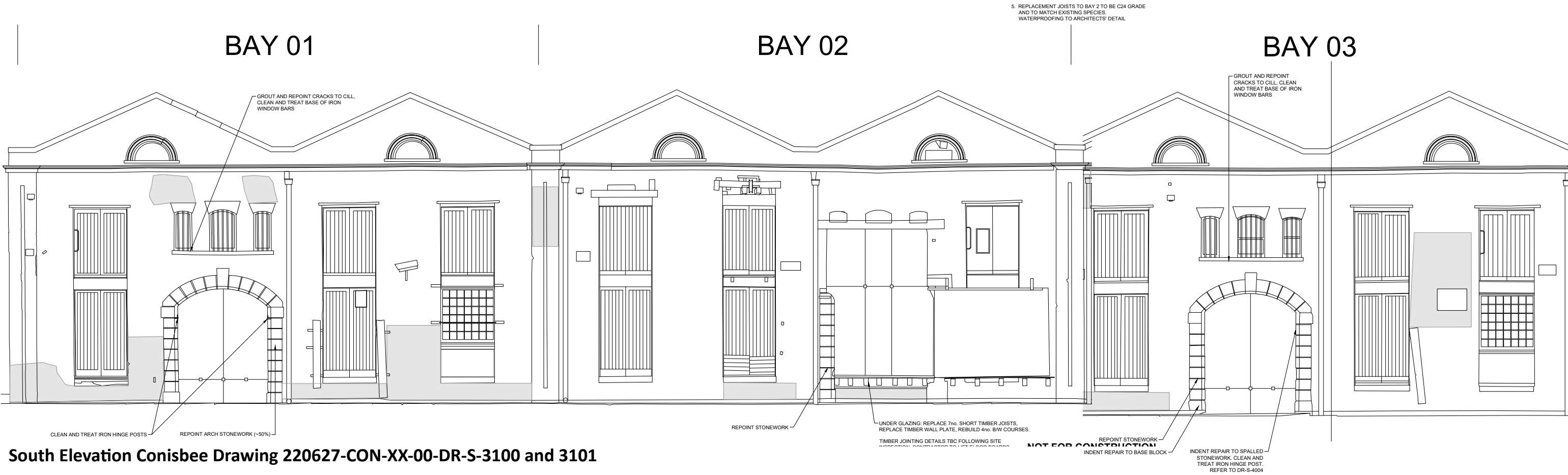
- Under glazing: replace 7no. Short timber joists, replace timber wall plate, rebuild 4no. B/w courses
- Repoint stonework

Bay 3 Wagon Arch

- Indent repair to base block
- Clean and treat iron hinge post
- Indent repair to spalled stonework
- Repoint stonework
- All stone indent repairs to match existing types and profiles.

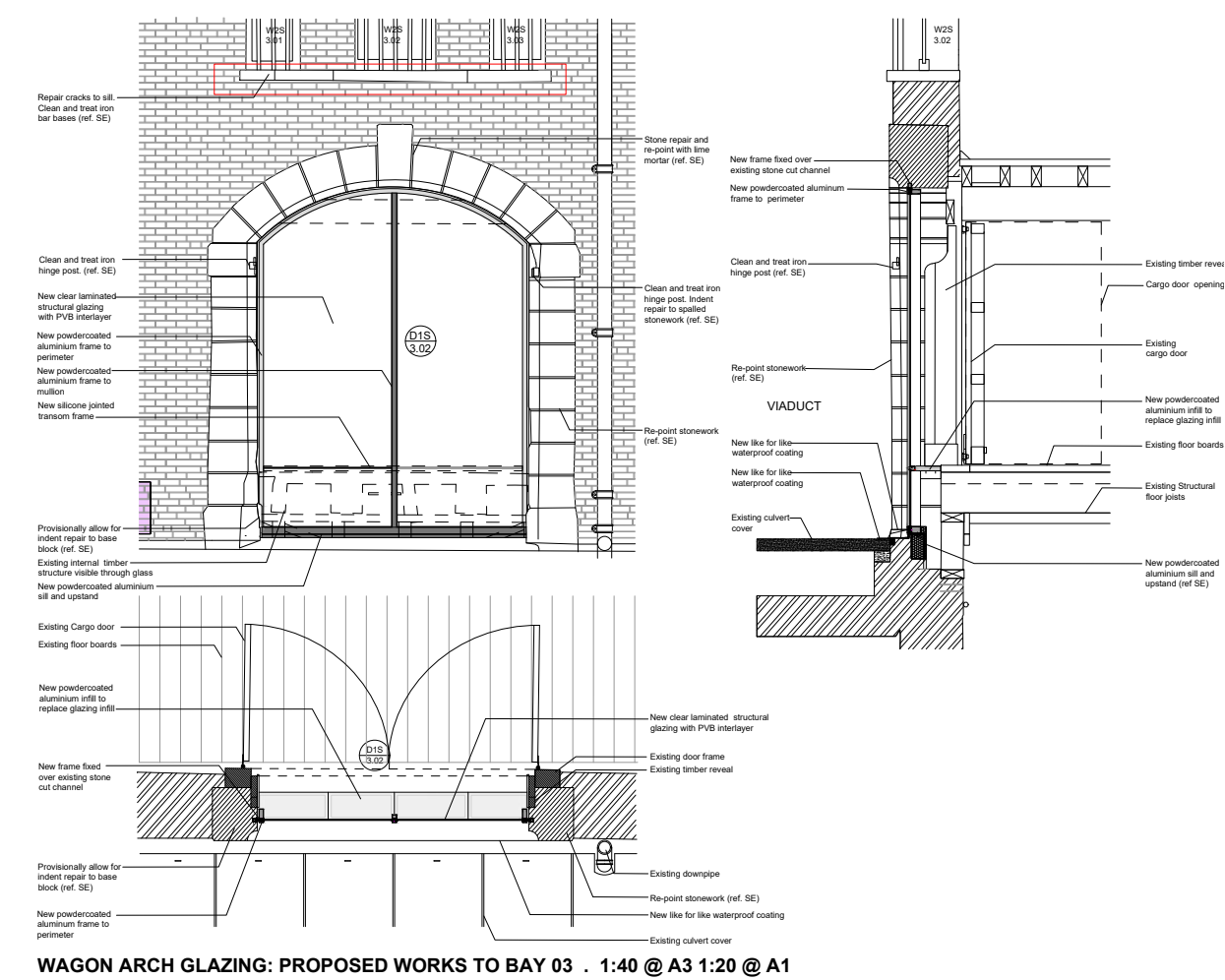
Note drawings illustrate repair required to wider elevation:

- Significant areas of spalled brickwork and eroded pointing are shown in grey hatch. Smaller isolated patches and individual damaged bricks are not highlighted but are Included in the work scope
- All redundant non-historic ferrous fixings (Nails, bolts, eyes etc.) To be removed and Holes infilled with colour matched mortar
- Triple windows above bay 1 and bay 3: Repair cracks to sill. Clean and treat iron bar bases

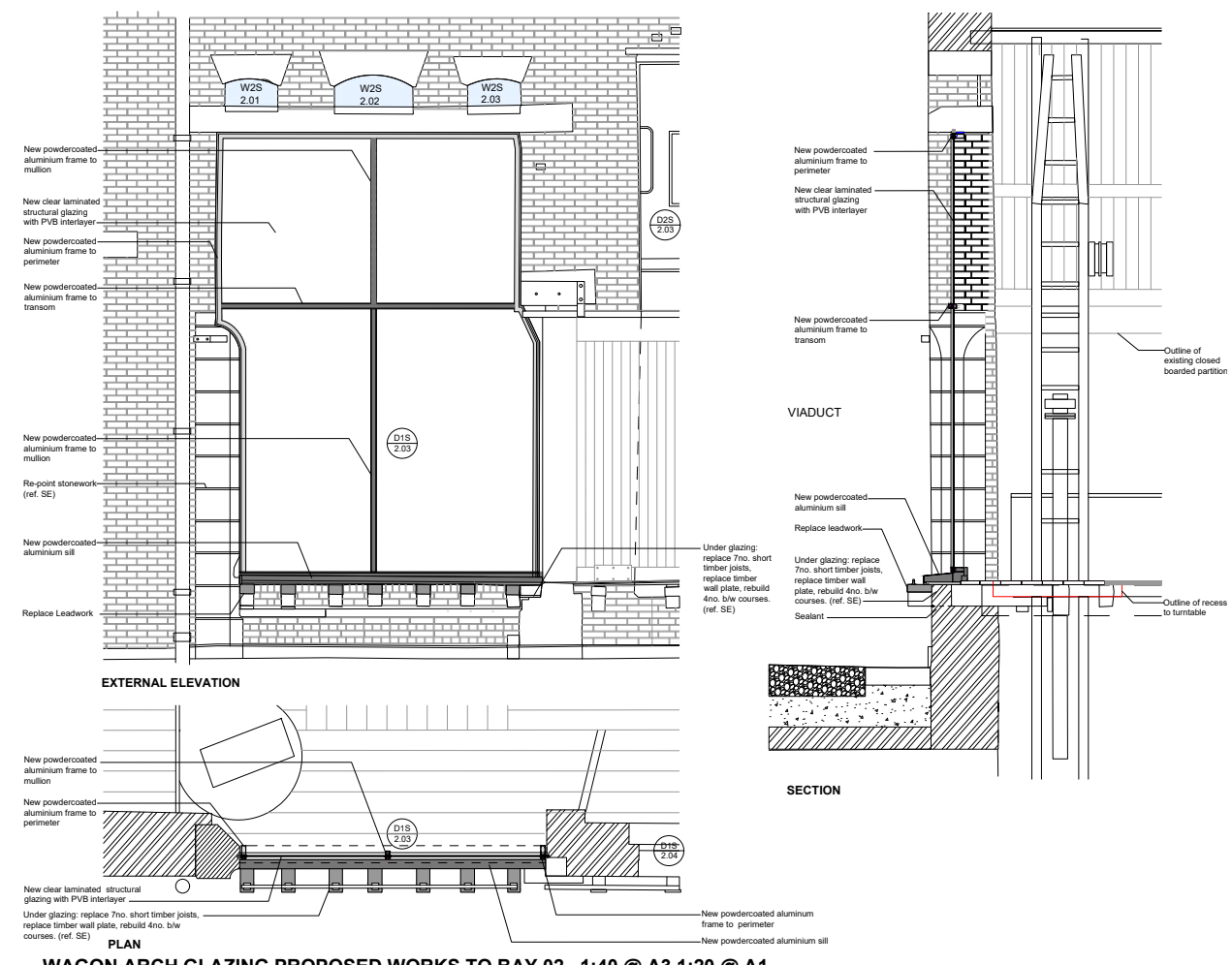


PROPOSAL

- Considering MCC’s feedback, we recommend the propsoals developed from Option 1a. Reasons to support the revised proposal:
 - High quality aluminium framed system with toughened, laminated glass panels with PVB interlayer to protect the interior.
 - Maximises size of glass and reduces framed elements and associated air paths. Energy efficient solution.
 - Perimeter frame detailed with a capped detail to maintain simplicity. Cap to the central vertical joint enhances vertical height.
 - Frames have a non-invasive interface detail to stonework and conceal scar.
 - System can be positioned to fix through existing channel without damage to historic fabric.
 - Option to install double glazing in future.
 - Maximises size of glass and reduces framed elements.
 - Cap to the central vertical joint enhances vertical height.
 - High quality aluminium framed sill and upstand below provides better long term weatherproof detailing.
 - A solution which is as clean, simple and invisible as possible.



WAGON ARCH GLAZING: PROPOSED WORKS TO BAY 03 . 1:40 @ A3 1:20 @ A1



WAGON ARCH GLAZING PROPOSED WORKS TO BAY 02. 1:40 @ A3 1:20 @ A1

3.2: Cargo Door Sills

External Cargo Bay Sills to Viaduct

Summary of existing condition

- The existing sills are set flush in the wall with no drip and the square profile means that there is no fall to discharge lying water resulting in ongoing cause of decay to both timber sills and the brickwork below. The existing wood is primarily pine used during the 20th century replacements.

Need for repairs

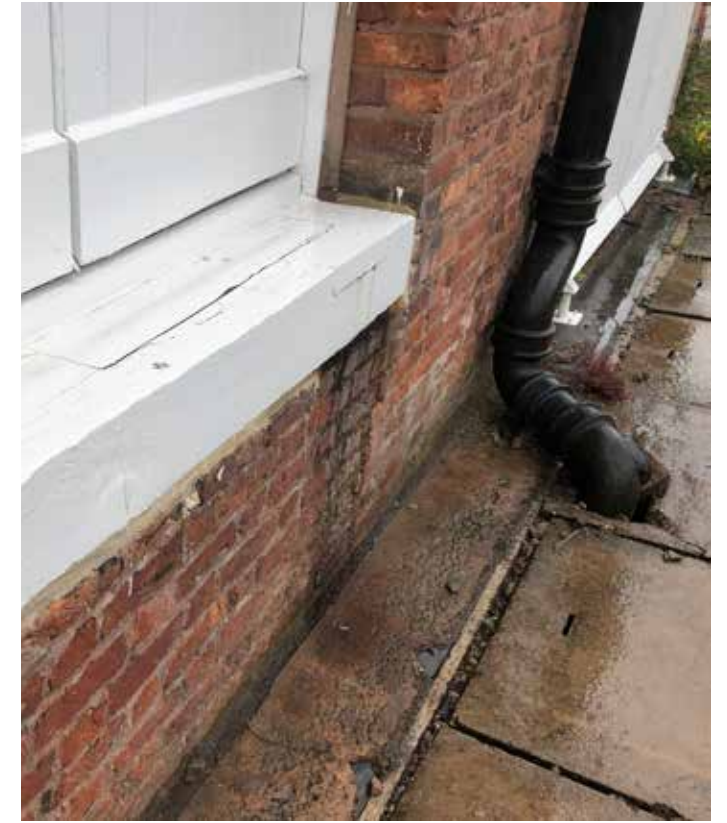
- Without further action, the brickwork fabric below the sills will become saturated

Proposed solution

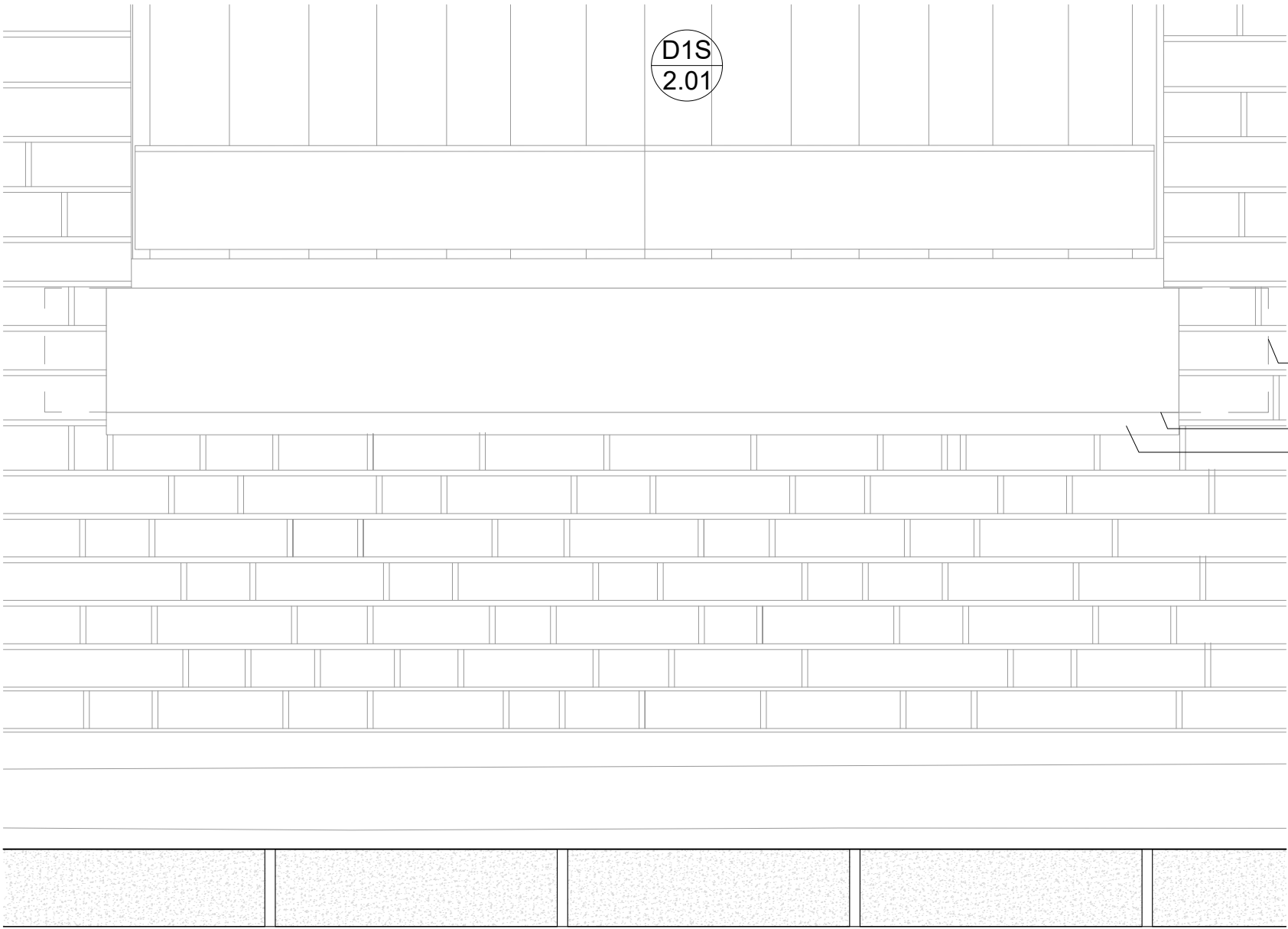
- Works will involve carefully cutting out and completely removing the entire wood sill. Specialist craftsman will carefully template the existing and cut a new sill using hardwood/oak matching the profile of the existing section with the adapted profile to include the fall to the top surface and the protruding drip detail with grooved throat to the underside to prevent capillary rainwater tracking under the sill. Lime Putty seals will interface with the brickwork.
- Apply preservative and decorate the new hardwood sills.



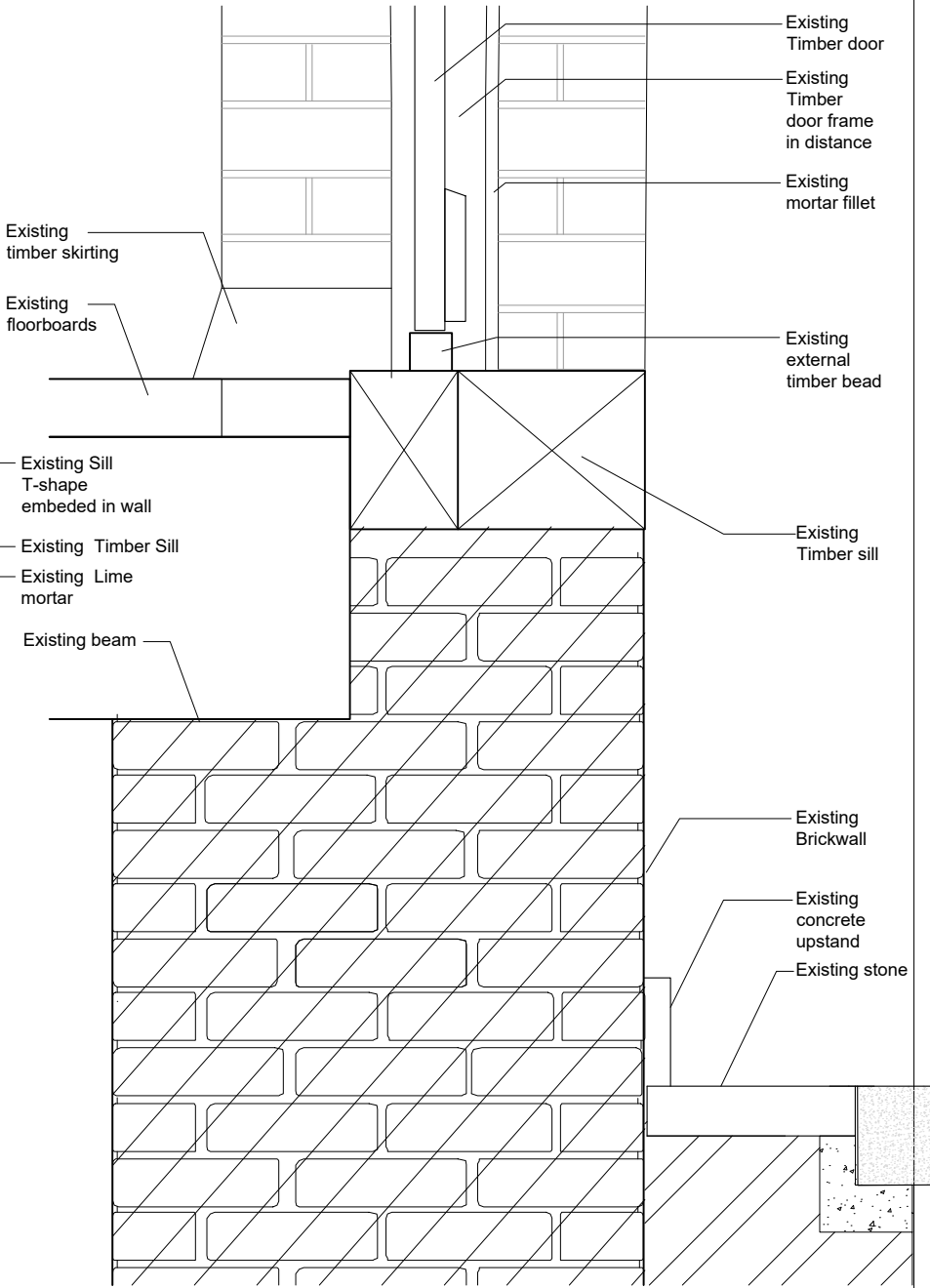
Visible staining to brickwork due to absence of any drip.



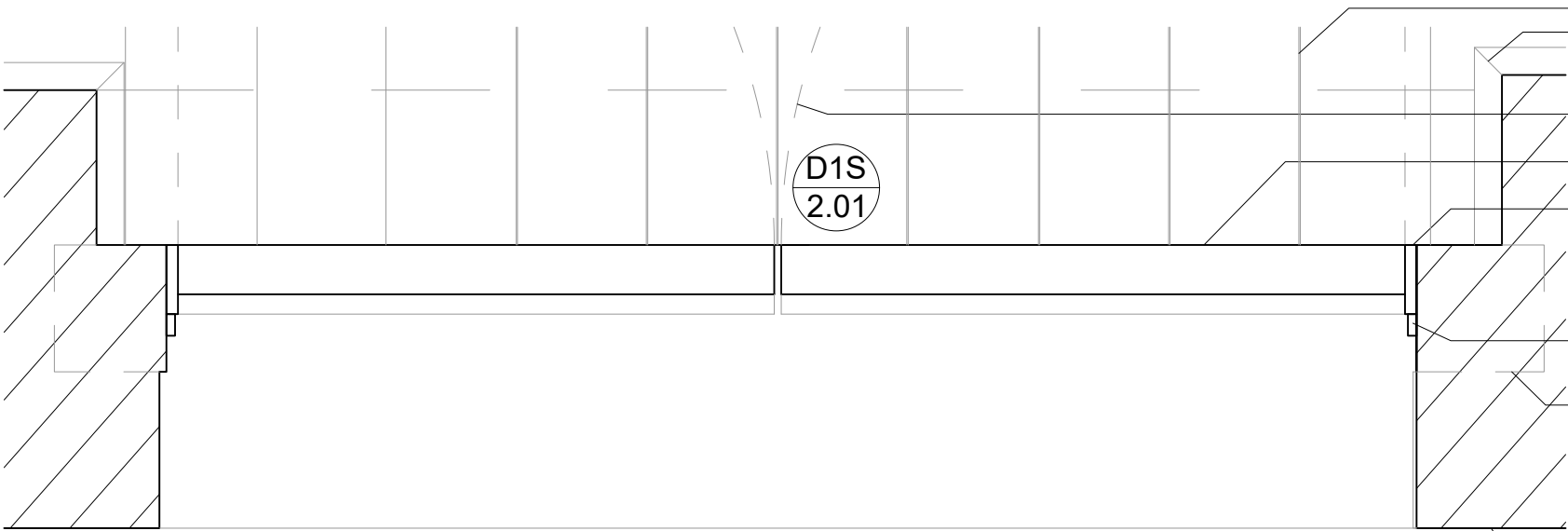
Sitting water as a result of the absence of any fall to the top surface of the sills. The scope is to replace and to reprofile with fall and drip.



ELEVATION



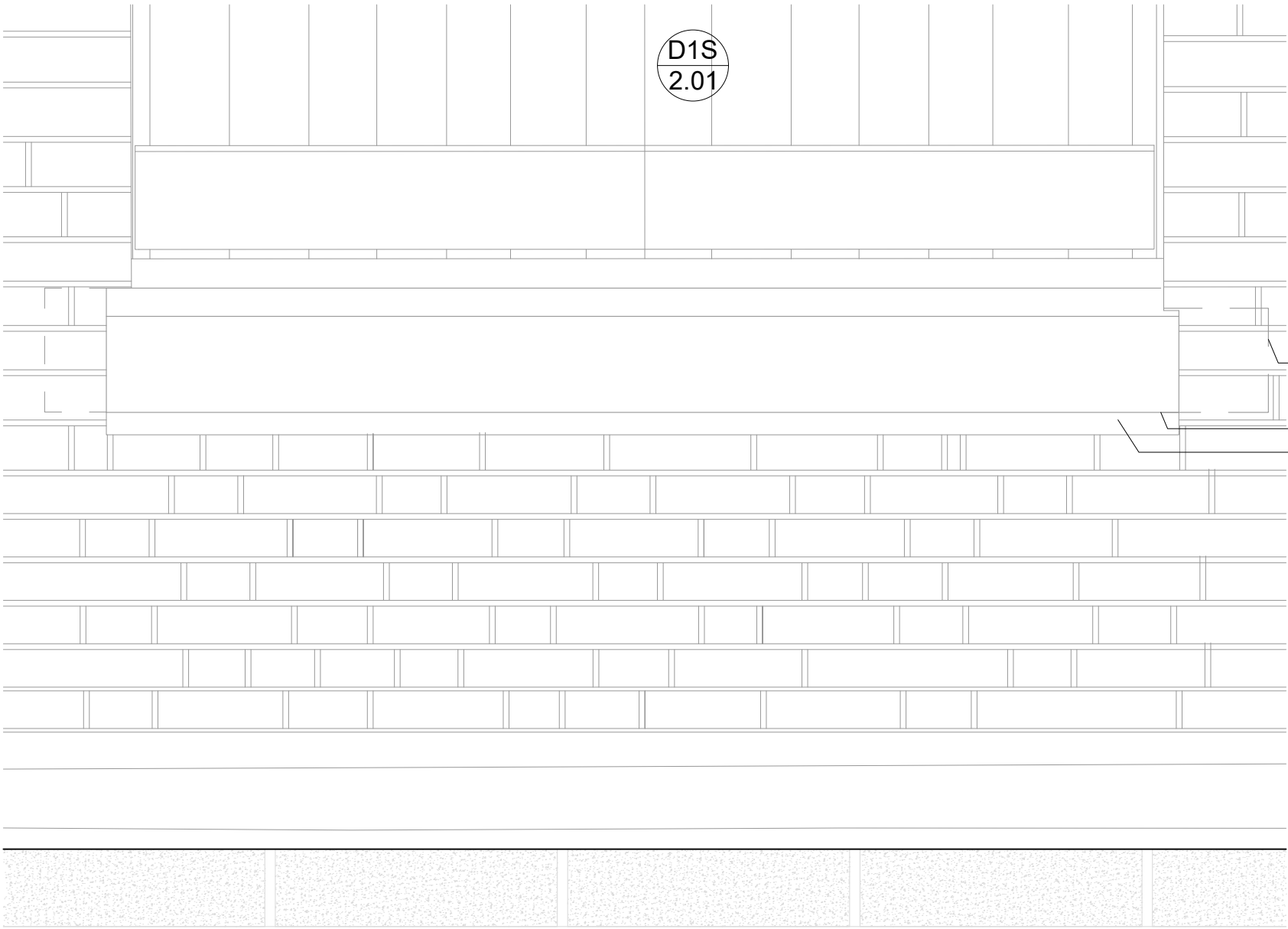
SECTION



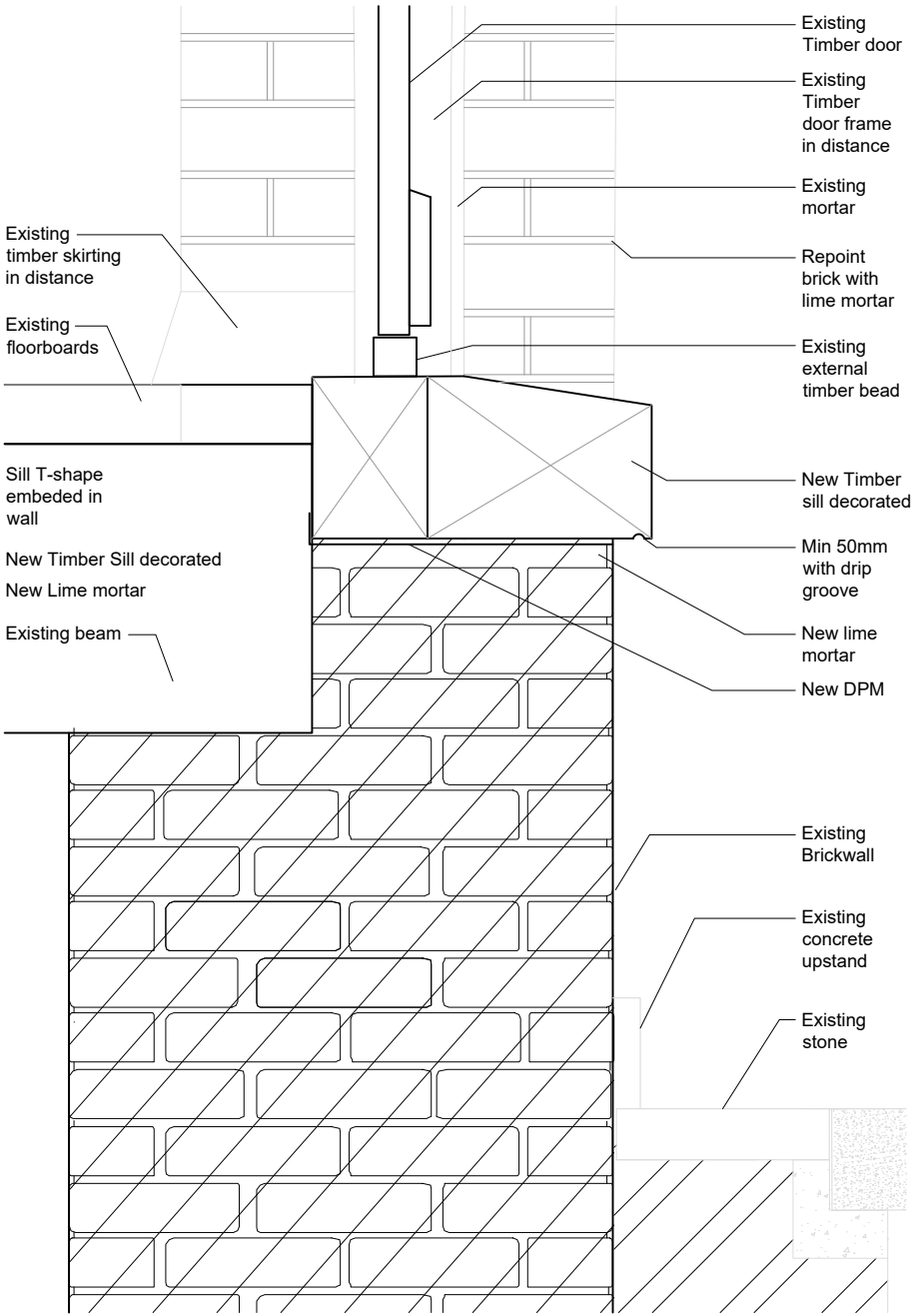
PLAN
CARGO DOOR SILLS: EXISTING DETAIL 1:5 @ A1 / 1:10 @ A3

- Existing floor boards
- Existing Skirting
- Existing door swing
- Existing Timber doors
- Existing Timber door frame
- Existing mortar
- Existing Sill T-shape embeded in wall
- Existing Brickwall

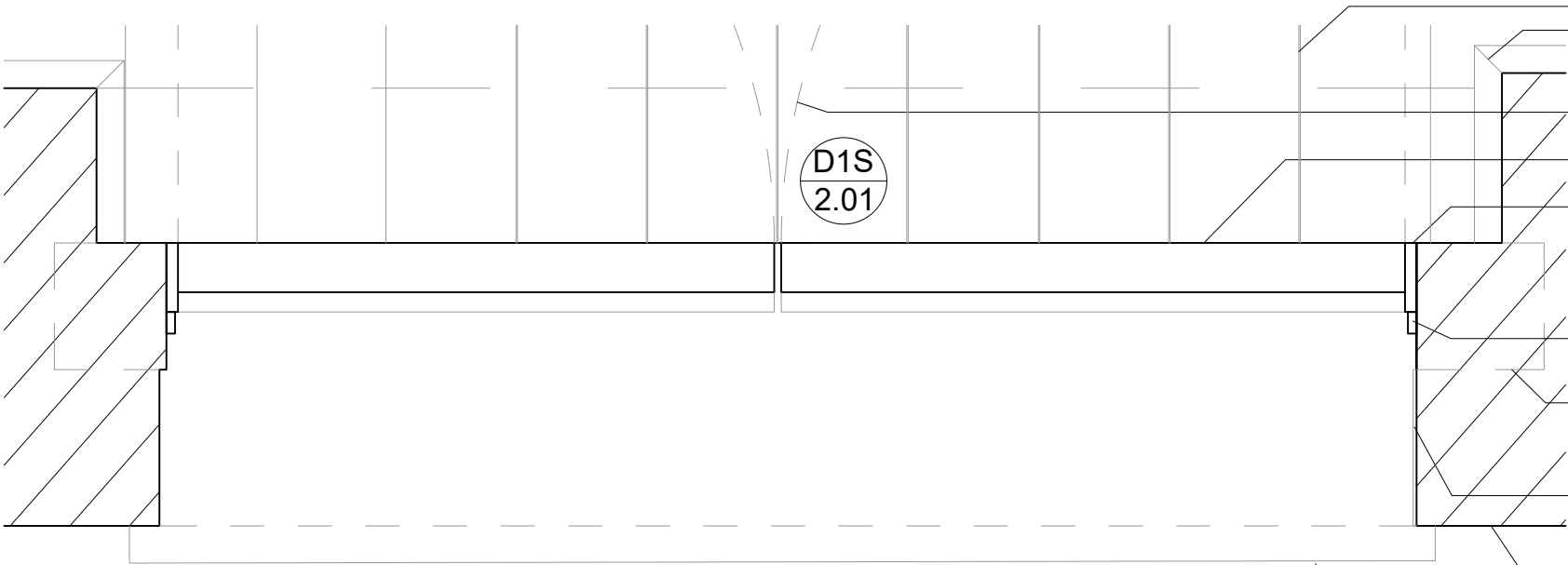
BASED ON MEASURED SURVEY BY "SITECH SURVEYING SERVICES"					
JOB TITLE Essential Repairs 1830 Warehouse, Science & Industry Museum. MS-RFP	JOB NO. 275	DRWG. TITLE Cargo door sills: Existing detail	STATUS Planning		
		DRWG. NO. 275 / PD / 140 (A1 ORIGINAL FORMAT)	REV:	SCALE: 1:5@A1 1:10@A3	
Studiosdownie ARCHITECTS LLP	TEL: +44 (0) 20 7299 7766 info@studiosdownie.com	All dimensions to be checked on site by the Contractor and confirmed with the Architect prior to construction. Do not scale off this drawing.	Drawn by: JP	DATE: 03/02/23	



ELEVATION



SECTION



PLAN
CARGO DOOR SILLS: PROPOSED WORKS 1:5 @ A1 / 1:10 @ A3

- Existing floor boards
- Existing Skirting
- Existing door swing
- Existing Timber doors
- Existing Timber door frame
- Existing mortar
- Sill T-shape embedded in wall
- Lime mortar
- Existing Brickwall
- New Sill decorated

BASED ON MEASURED SURVEY BY "SITECH SURVEYING SERVICES"					
JOB TITLE Essential Repairs 1830 Warehouse, Science & Industry Museum. MS-RFP		JOB NO. 275	DRWG. TITLE Cargo door sills: Proposed works	STATUS Planning	
			DRWG. NO. 275 / PD / 340 (A1 ORIGINAL FORMAT)	REV:	SCALE: 1:5@A1 1:10@A3
Studio Downie Architects LLP		TEL: +44 (0) 20 7299 7766 info@studiodownie.com	All dimensions to be checked on site by the Contractor and confirmed with the Architect prior to construction. Do not scale off this drawing.		Drawn by: JP DATE: 03/02/23

3.3: Brickwork Repairs (internal and external)

External Brick Repairs

Summary of existing condition

- The previous phase of works focused on repairs to brickwork above the cornice. Below the cornice, areas of spalled brickwork and eroded pointing, smaller isolated patches and individual damaged bricks and these are to be attended to in this phase of works.
- There are isolated metalwork embedments which are corroding into brickwork and causing spalling, principally to the east elevation.

Need for repairs

- Stabilise and preserve the historic brickwork and stonework.

Proposed repairs

- Brick repair or replacement & re-point with lime mortar where repairs undertaken. Corroded metalwork will be cleaned and treated. All redundant non-historic ferrous fixings (Nails, bolts, eyes etc.) to be removed and holes infilled with a mix of colour matched mortar and brick dust.
- Bay 2 South: rebuild 4no. brickwork courses in conjunction with timber replacements under wagon arch.
- Bay 3 North: Repair vertical crack to brick quoin.
- Bay 4 North: Remove corroded fixing. Repair crack.
- Lime mortar will be as previously agreed with MCC and used during the Phase 1 and Phase 2 works as CDN/21/0140: Discharge of Condition 4b (samples and specifications of materials) of Listed Building Consent ref:124068/LO/2019.
 - 25% St Astier NHL 2 (Lime)
 - 10% Nosterfeild washed river sand
 - 20% Ash/Black grit
 - 45% Leighton buzzard sand

Methodology

- The methodology is summarised in Appendix 3.1 and illustrated on the following pages.



Spalled bricks. Cut out and replace bricks where erosion exceeds 15mm depth. Repoint using lime mortar.



Patches of eroded pointing. Repoint using lime mortar.



Metal duct frame is corroded. Cut out and brick in the opening. Material loss/spall. Indent repair to stone cill.



Spalled bricks. Cut out and replace bricks where erosion exceeds 15mm depth. Repoint using lime mortar.



West elevation. Multiple vertical cracks in brickwork.Repair using helical bar stitching. Repoint using lime mortar.



Decayed embedded timber. Remove timber and brick-in void.

External Brick Repairs - previously approved mortar sample

- There are varied mortar types across the building. Samples taken for mortar analysis are bedding mortar (analysed by RSK). Only S1 was possible to determine mix proportions using petrographical method and modal analysis. The calculated results suggest the original mix proportions of binder to aggregates may have been approximately 1:3. Evidence for dry slaking implied that the original mortar production comprised air lime – powdered quicklime – rather than hydrated lime putty. The comparatively high presence of sandstone in S1 and S3 can be attributed to the large particle size, rather than specific number of particles.
- RSK-S1: Bay 4 GF North, Centre exterior wall
 - Binder: 42.5% Lime binder, with common overburnt and unhydrated lime particles.
 - Aggregate: 57.5% (adjusted for voids)
 - >34% quartzite,
 - >3% Industrial waste (slag/ clinker, charcoal), >6% Sandstone, >4% Opaque minerals, >2% Chert, >1% Crushed ceramics (probably brick fragments)
 - >1% Feldspar grains
 - Other inclusions: Sporadic wood fragments, Rare hair fibres
- RSK-S3: Bay 1 1F South, Exterior face of wall
 - Binder: Lime binder, with common overburnt and unhydrated lime particles.
 - Aggregate: (overall % based on assumed 57.5% aggregate volume as S1)
 - >34% quartzite, >8% Industrial waste (slag/ clinker, charcoal), >8% Sandstone,
 - >5% Chert, >5% Crushed ceramics (probably brick fragments).
 - >1% Feldspar grains
 - Other inclusions: none observed
- APPROVED Mortar Sample 2 mix ratio (applied 07/04/21) as CDN/21/0140: Discharge of Condition 4b (samples and specifications of materials) of Listed Building Consent ref:124068/LO/2019 - see photo:
 - 25% St Astier NHL 2 (Lime)
 - 10% Nosterfeild washed river sand
 - 20% Ash/Black grit
 - 45% Leighton buzzard sand



West elevation bedding



Approved Mortar Sample as CDN/21/0140: Discharge of Condition 4b (samples and specifications of materials) of Listed Building Consent ref:124068/LO/2019

External Brick Repairs - previously approved tooling sample

Sample of Raking out mortar:

- We progressed sample areas to test the methodology of raking out the brickwork, ready for re-pointing. The use of hand tool to remove the cementitious mortar was challenging and impossible in places. It was not clear if they had been able to rake out sufficient depth. Raking out the perpend joints had been more successful. See photo (A). The arbor saw could not make any impact for the strength of mortar encountered. An alternative low percussion drill fitted with a chisel bit was successful with good control, there are various widths of chisel available and the slow speed enables manual control by a highly skilled operative in limited and careful use where necessary. See attached photo (B). A hand held thin diamond disc cutter is an option, to score a line in the centre of the hardest mortar joint and then allow hand tools to chip away mortar close to the arris of the brick.
- To summarise key observations/discussion points based on site observations 25/03/21 with architect, structural engineer, heritage consultant:
- Hand tools.
 - Insufficient depth. Perpend joints seems more successful. A low percussion masonry drill could also be used to create a line of holes along the centre of the joint and make it easier to break up the mortar with a hammer and chisel.
- Arbor saw.
 - Noted that the arbor saw was reported to be unsuccessful and abandoned, so the alternative low percussion drill was used.
- Low percussion drill with chisel bit.
 - Successful with good control but a couple of skips. Careful selection of the width of the chisel bit will reduce risk of skipping and slipping.
- Conclusion and the AGREED way forward:
 - The use of hand tools was specified. However, the hardness of the mortar in this case is challenging. Limited, careful use of power tools where necessary combined with traditional methods using hand tools for perpend joints and chipping out close to arris of bricks in the horizontal mortar joints seems to be the approach which will least damage the bricks.



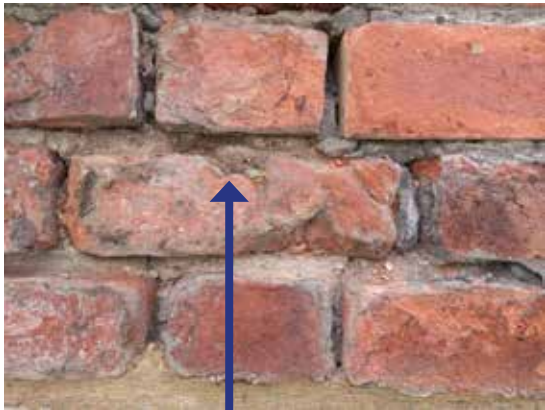
A: Hand tools



B: Low percussion drill

External Brick Repairs - previously approved repair sample

- Images illustrate the careful approach approved previously.



Failed brick identified.



Failed brick removed. Remaining adjacent masonry is not disturbed, marked or damaged during this process. All joint surfaces to be left in a suitable condition to receive the replacement brick.



Salvaged brick from client stocks on site. The replacement brick has been set out and aligned carefully to ensure interfaces and junctions with existing masonry is maintained. Joint widths have been maintained and replicated. The salvaged brick has been laid will be laid and sighted on a full bed of mortar with all joints filled.



Example of hole repair to brick after removal of redundant fixing, Filled with brick dust and mortar mix to blend with adjacent brick colour.

Internal Brick Repairs

Summary of existing condition

- Localised areas of brickwork and stonework joints at the inside face have been repointed using a modern conventional sand and cement mortar.
- Various ‘fine’ to ‘moderate’ vertical and diagonal cracks were noted at the cross walls of the building, particularly beneath lintel bearings at door penetrations. Some of these cracks have been filled with a cementitious grout mix.
- Vertical and diagonal cracking was noted at various locations up the inside face of the piers either side of the tall doors at the north elevation, which possibly suggests high localised stresses. Historic crack filling was evident suggesting that the issue may be ongoing.
- Damaged, loose or missing brickwork.

Need for repairs

- Stabilise and preserve the historic brickwork and timber. Various brick piers at basement level displayed vertical cracking adjacent to timber beam bearing, which possibly suggests high localised stresses. Historic crack filling is evident in some locations. Whilst the brick piers do not appear to be at risk of progressively failing, diagonal and vertical cracking reduces the robustness of the structure and bearing capacity, providing re pointing and reinforcement across the cracks will tie the piers into the perimeter walls re-establishing the robustness of the structure.
- Where additional capacity is needed in the floor structure, providing horizontal bed joint reinforcement and re-pointing should be carried out in the brick piers.

Proposed repairs

- Brick repair or replacement & repoint with lime mortar where repairs undertaken.
- Second floor - Bay 2: Helical bar repair to crack in brickwork.
- Second floor - Bay 2: Helical bar repair to crack in brickwork.
- Ground floor mezzanine - Bay2: Helical bar repair to crack in brickwork.
- Ground + Basement: Grout Cracked Bedjoint. Tie In Pier Using Cemties.
- Ground - Bay 2:
 - Locally rebuild cracked brickwork at corner bearing.
 - Locally rebuild loose brickwork at corner of reveal.
 - Helical bar repair to crack in brickwork.
- Basement - Bay 1:
 - Cut out and replace cracked bricks at beam bearing.
 - Rebuild cracked brickwork at pier top.
 - Tie in separated brickwork panel with helical bars.
 - Dry-pack/grout padstone bedjoint.
 - Grout cracked bedjoint. Tie in pier using cemties
- Install monitoring devices across the cracks.



A full height photo of a ground floor pier at the inside of the north elevation, showing the extent of vertical cracking evident through bricks.



Brickwall crack. Brick repair required.



Missing masonry. Masonry repair required.



Vertical cracking through a primary beam support pier at the South wall at basement level.

3.4: Stonework Repairs

External Stone Repairs

Summary of existing condition

- Damaged stonework and embedded metalwork.
- Damaged steps due to settlement
- Damaged window sills due to embedded ironwork

Need for repairs

- Stabilise and preserve the historic brickwork and stonework.

Proposed repairs

- All stone indent repairs to match existing types and profiles. Re-point with lime mortar where repairs undertaken.
- South Bay 1, Bay 3, Bay 5: Clean and treat iron hinge post. Indent repair to spalled stonework to Bay 3 an Bay 5.
- South Bay 3, Bay 5: Allow for indent repair to base block.
- South Bay 1, Bay 2, Bay 3: Re-point stone to wagon arches with lime mortar
- East Elevation: Clean and treat iron duct liner.
- North Bay 2, Bay 5: Repair crack in stonework sill.
- Dismantle stone steps. Reconstruct on new foundation.
- North Bay 4: indent repair to spall on tread.
- Repair cracks in stone cill. Clean and treat iron bar base. Re-point with lime mortar where repairs undertaken.

Methodology

- The methodology is summarised in Appendix 3.2.



Material loss to keystone. Indent repair to stone block. Repoint using lime mortar.



Corrosion of iron bar ends and cracks to cill. Cut out around bar embedments and treat iron. Repoint cracks using lime mortar.



Crack/spall to block at hinge fixing. Treat ironwork, indent repair to stone block.



Vertical crack, c7mm width.Repoint using lime mortar.



Material loss/spall. Indent repair to stone block.



Settlement of steps. Dismantle and rebuild on new foundation.

3.5: Timberwork Repairs

Internal Timber Repairs

Summary of existing condition

- Damaged timber or loss of support due to shrinkage and settlement. Throughout the building there are locations where initial design, shrinkage and frame racking has resulted in floor joists with minimal bearing. This is exacerbated at column locations, where the full depth bearing of the columns from above further reduces the bearing of the floor joists. The timber floor framing at in the old platform locations at ground and 1st floor, typically uses a single bolt side fixed plate / corbel onto which the 1st floor primary beam dead-bears. In various locations shown on the observation plans, shrinkage and frame racking has reduced the bearing of timber beam, with very little contact remaining in some locations.
- Various timber joists and isolated timber beams are noted to show cracking at ground, mezzanine and first floor level. The majority of locations the beams do not appear to be at risk of progressive failure, however the capacity of the beam remains limited by the reduced cross section.
- Timber decay due to moisture ingress and damp observed in isolated instances.

Need for repairs

- The concern resulting from the shrinkage and supplementary repairs focuses on the limited bearing area of many of the timber beams and joists. In most cases the limited bearing does not appear to result from progressive movement, a repair in multiple locations to enhance the bearing would be recommended to enhance the load capacity and robustness of the structure.
- To stabilise and preserve the historic brickwork and timber, the broad approach of the repair recommendation work is to attempt to prevent future deterioration based on a minimum intervention approach in line with sound conservation principles. The aim is to retain as much of the existing fabric as possible and to incorporate good conservation maintenance, by repairing currently defective elements using compatible techniques and materials that will not compromise the long-term health of the building structure and decorative features.
- For the small number of locations at ground, mezzanine and first floor level where deterioration due to moisture is apparent, Hutton & Rostron have inspected and reported on the timber condition.

Proposed repairs

- Timber repairs and strengthening details (mainly in Bays 1-3).
- All floors: Install new steel brackets at short beam bearings
- First floor - Bay 3: Bolt/resin repair to cracked floor beam.
- Ground floor mezzanine - Bay 1 & Bay 2: Install supplementary M20 bolts (approx. 6no. per column).
- Ground floor mezzanine - Bay 2: Resin & bolt repair to split joist.
- Ground, mezzanine, & first floors: Suspected timber decay to beam or column. Provisionally allow bolted splice repair. H&R to confirm.
- Install new steel bracket to short beam bearing at Mezzanine soffit.
- Basement - Bay 2, Bay 3: Install new steel bolted overplate to reinforce beam butt joint over column head.



View from ground floor mezzanine of east west beams with limited bearing on vertical plate. Vertical plate bolted to column using single M20 bolt. Shrinkage and frame racking has pulled the timber off this bearing and it now very little contact remains.



Floor beam 'but' connection off centre overcast iron columns. floor beam eccentrically loading cast iron plate.



Loose floorboard. Re-fix, repair , make good.



.Check stability. Review with Structural engineer. Reinforce

Methodology

- The methodology is summarised in Appendix 3.3.

3.6: Metalwork Repairs

Metalwork Repairs

Summary of existing condition

- At basement level, there was moderate surface corrosion noted in Bay 1 where diagonal iron beams are embedded in the corners to support the primary timber floor beams. This corrosion is to be expected as the masonry at this level retains the damp earth beyond. This has resulted in some minor spalling of brick faces in these areas. It appears that no significant section loss was evident, however this should be cleaned down to expose the degree of corrosion.
- A heavily corroded downpipe penetrates through the inside face of the south wall at basement level. There is no evidence of salt deposits or tide marks around the opening which may suggest the penetration does not pass through the full thickness of the wall, but the pipe itself is exhibiting moderate to high levels of corrosion and further investigation is warranted to determine its functionality.

Need for repairs

- Repair and conserve metalwork through careful cleaning of the corroded elements at basement is recommended to assess to extent of section loss and confirm if measures are required to limit progressive corrosion.

Proposed repairs

- Clean back corroded metalwork and cast iron beam. A paint analysis will be undertaken and reviewed with client’s fire strategy to ascertain the requirement of intumescent coatings to be re-applied.
- Investigation of downpipe in south wall.

Methodology

- The methodology is summarised in Appendix 3.2.



Looking at the southwest corner. corrosion in corner support to ground floor timber floor beam

External Downpipe Redecoration

Summary of existing condition

- There are two gabled pitched slate roofs per bay and the valley gutters occur between each roof situated either above a valley beam or above a brick cross wall (the cross walls divide the bays). The rainwater sheds down the slope of the slate roof and is collected in the valley gutter. Each valley gutter has a high point in the middle and drains to both the north and south via a catchpit to a chute through the external brickwall and outflows above and into external hopperheads above the rainwater downpipes which drain to the ground drainage system. Bay 5 is slightly different in that the chutes have been replaced with two drain pipes flowing above into the hopperhead.

Need for repairs

- The downpipes have not been redecorated for a very long time. Their visual condition contributes to the tired appearance of the elevations of the building. The downpipes are overdue their need for redecoration.
- Redecoration will help preserve the material and will improve the visual appearance of the building,

Proposed redecoration

- The client has instructed Crick Smith to undertake analysis of historic paint colours. The client will then make a curatorial decision on the appropriate colour of the livery of the railway company.
- Temporary works will consist lightweight decorators platforms or a truck based mobile platform.
- The downpipes will be lightly rubbed down and cleaned to prepare a key for the new colour finish in an appropriate paint.

Methodology

- The methodology is summarised in Appendix 3.4.



Heavily weathered rainwater downpipe



Hopperheads to be included within decoration scheme

SECTION 04 /
SUMMARY OF PROPOSED SCHEDULE OF WORKS:

Proposals

- The following pages provide a summary of the scope of works and general arrangement drawings.

4.1 Wagon Arch Glazing

	DEFECTIVE CONDITION	PROPOSED SOLUTION
	Defects have rendered two of the four glazed openings inadequate with a risk of further movement and further potential damage to the fabric and potential harm to users.	To Wagon Arches in Bays 1, 2, and 3, to install a high quality aluminium framed system with toughened, laminated glass panels with PVB interlayer to protect the interior. Associated repairs and repointing to stonework and brickwork and to the pin-tel detail embedded in the stonework.

Conclusions

- Remove unsafe glazing and replace with a high quality, elegant solution to protect the collections and to provide better weaherproofing.
- Stabilise and preserve the historic brickwork and stonework.

Key Drawings:

Wagon Arches Bay 1, Bay 2 & Bay 3

275/PD/101 Wagon Arch Glazing: Existing external & internal elevations

275/PD/110 Wagon Arch Glazing: Existing Bay 01

275/PD/111 Wagon Arch Glazing: Existing Bay 02

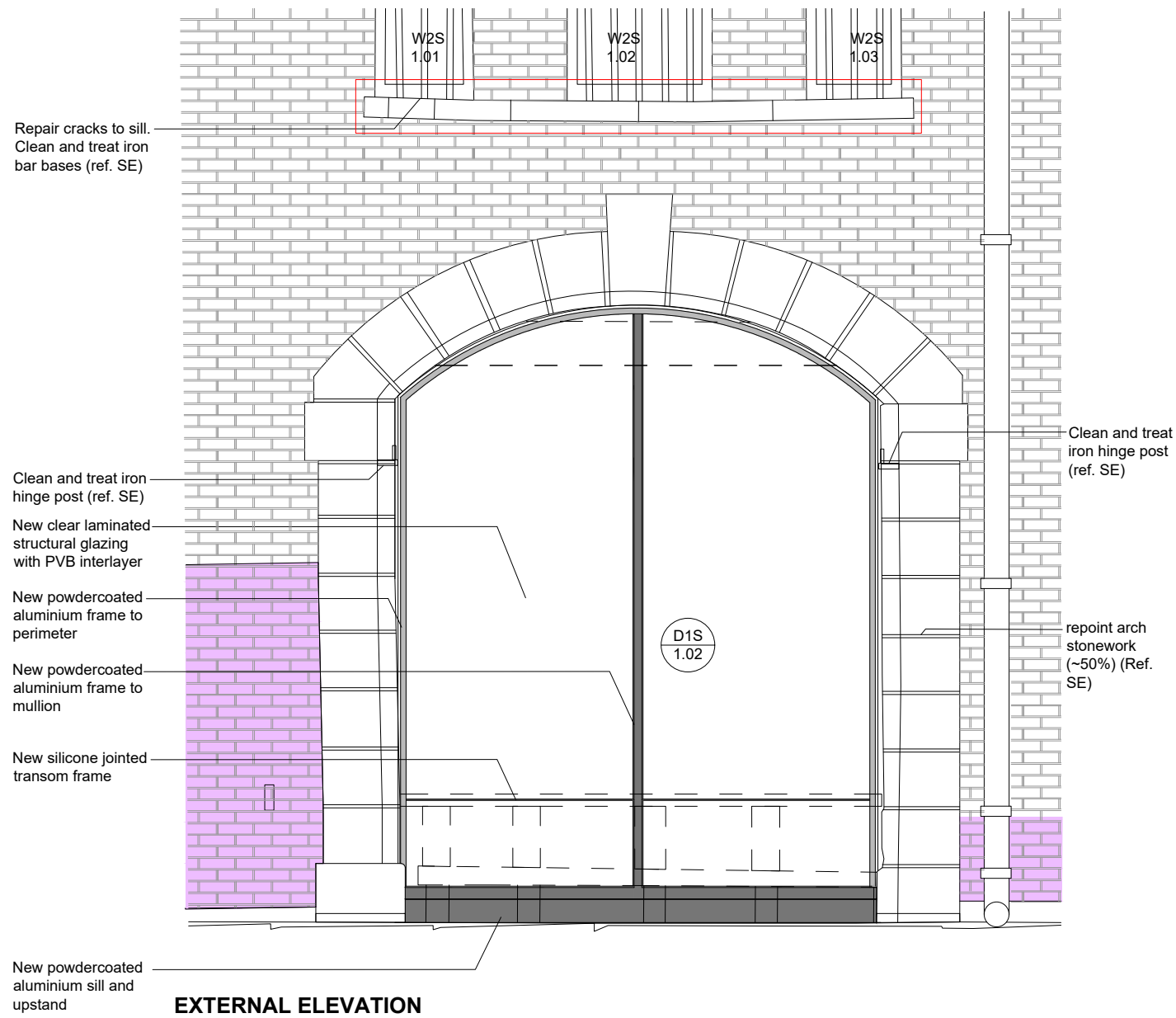
275/PD/112 Wagon Arch Glazing: Existing Bay 03

275/PD/201 Wagon Arch Glazing: Proposed external & internal elevations

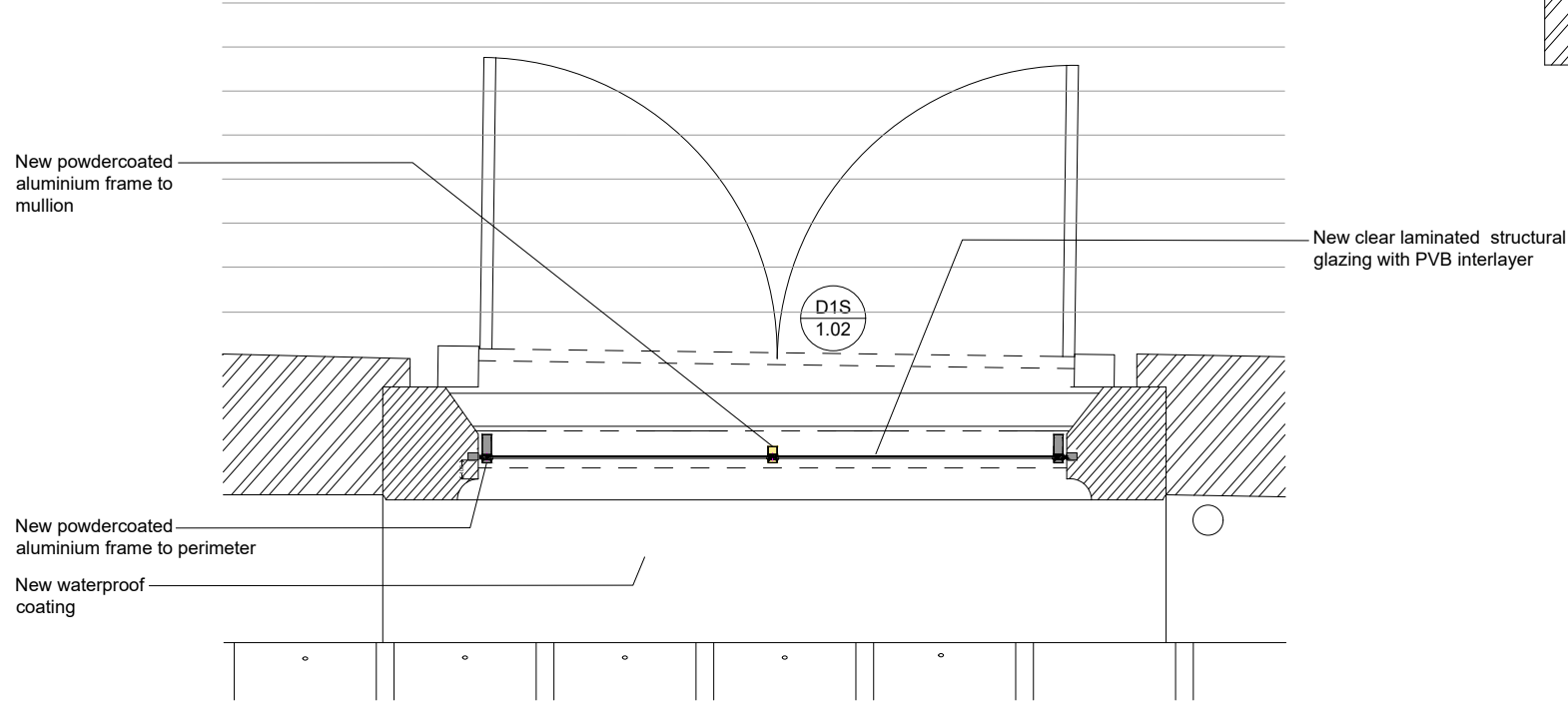
275/PD/210 Wagon Arch Glazing: Proposed Works to Bay 01

275/PD/211 Wagon Arch Glazing: Proposed Works to Bay 02

275/PD/212 Wagon Arch Glazing: Proposed Works to Bay 03

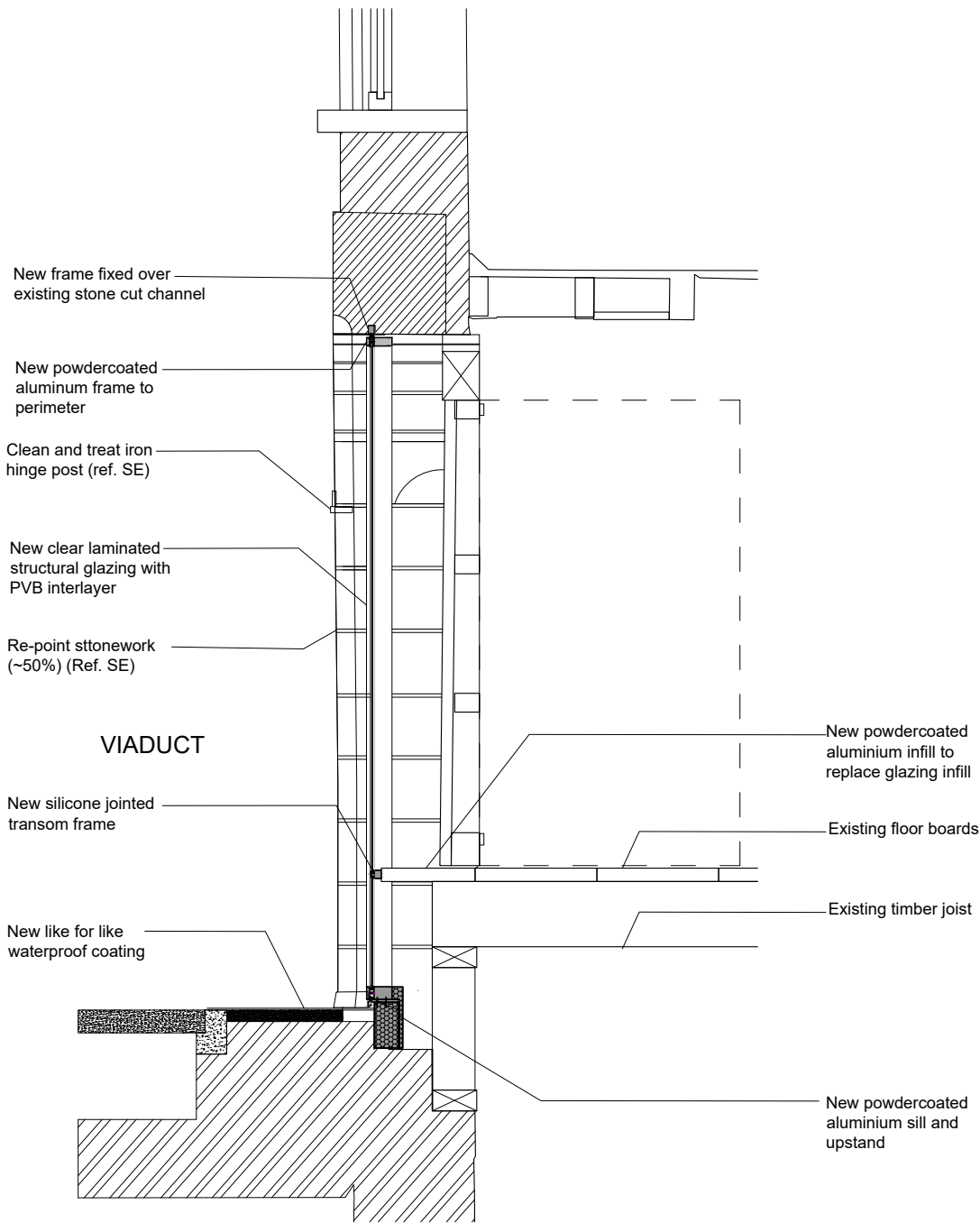


EXTERNAL ELEVATION



PLAN

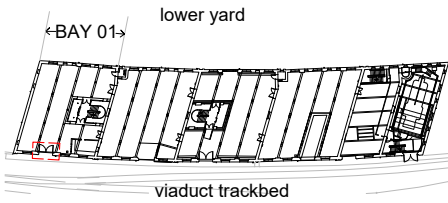
WAGON ARCH GLAZING: PROPOSED WORKS TO BAY 01. 1:40 @ A3 1:20 @ A1



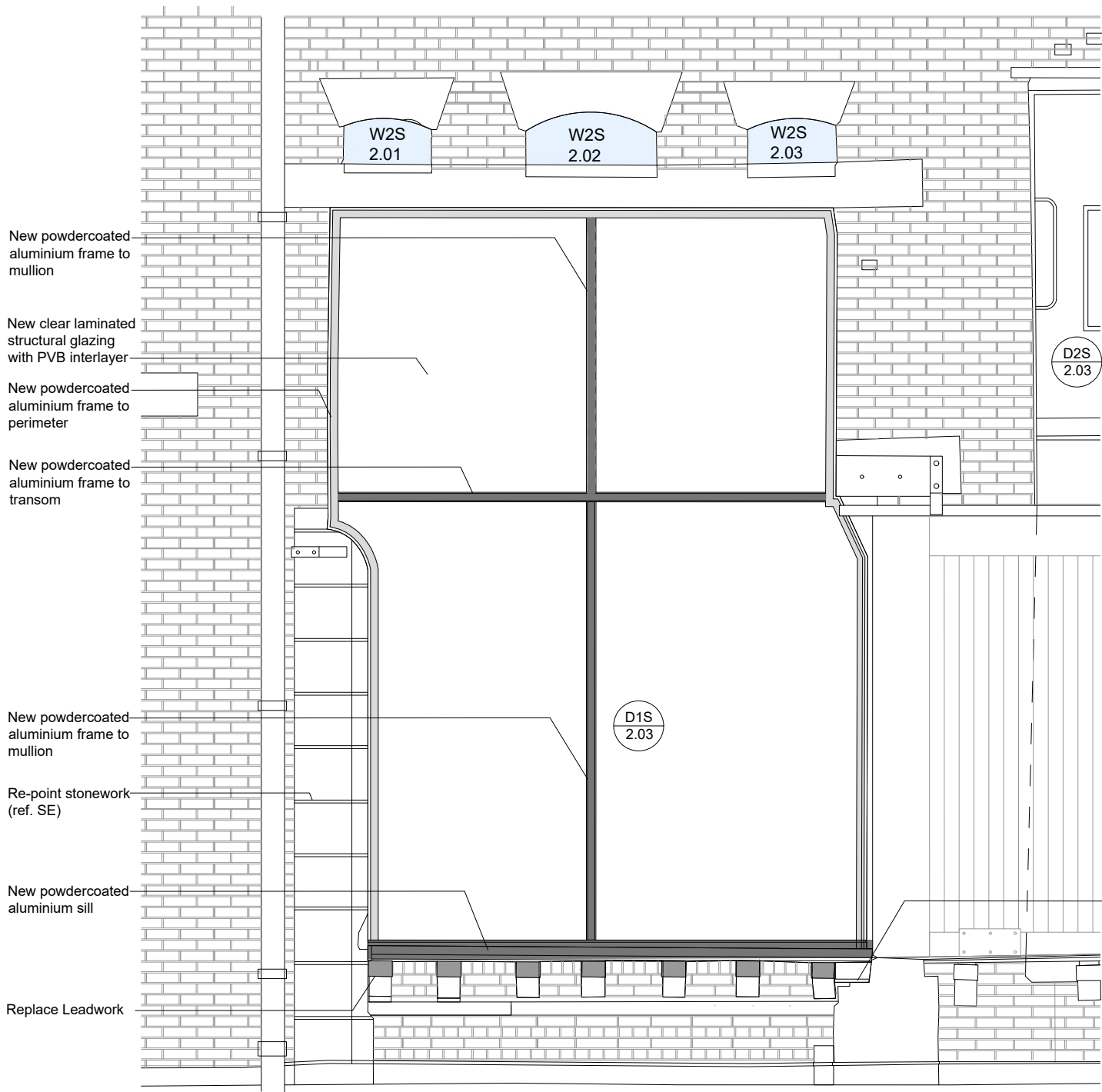
SECTION

KEY

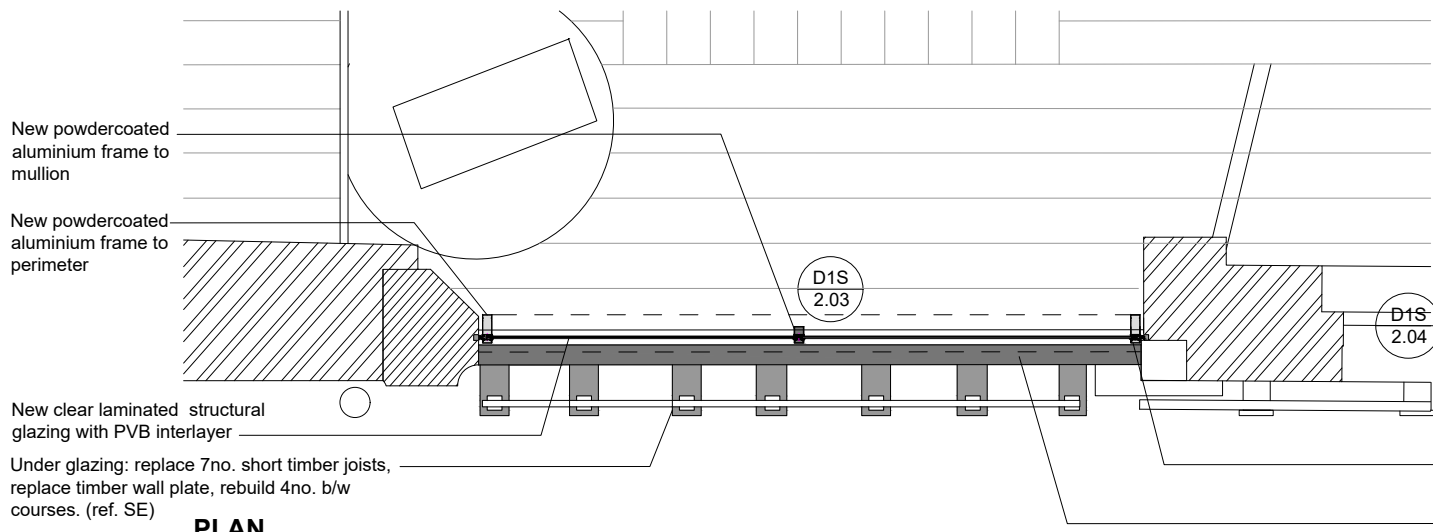
 Re-pointing zone (ref.SE)



BASED ON MEASURED SURVEY BY GREEN HATCH					
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		DRWG. NO. 275 / PD / 210 (A1 ORIGINAL FORMAT)	REV: 22	SCALE: 1:40@A3 1:20@A1	DATE: 03/02/23
Studiodownie ARCHITECTS LLP	TEL: +44 (0) 20 7299 7766 info@studiodownie.com	All dimensions to be checked on site by the Contractor and confirmed with the Architect prior to construction. Do not scale off this drawing.			



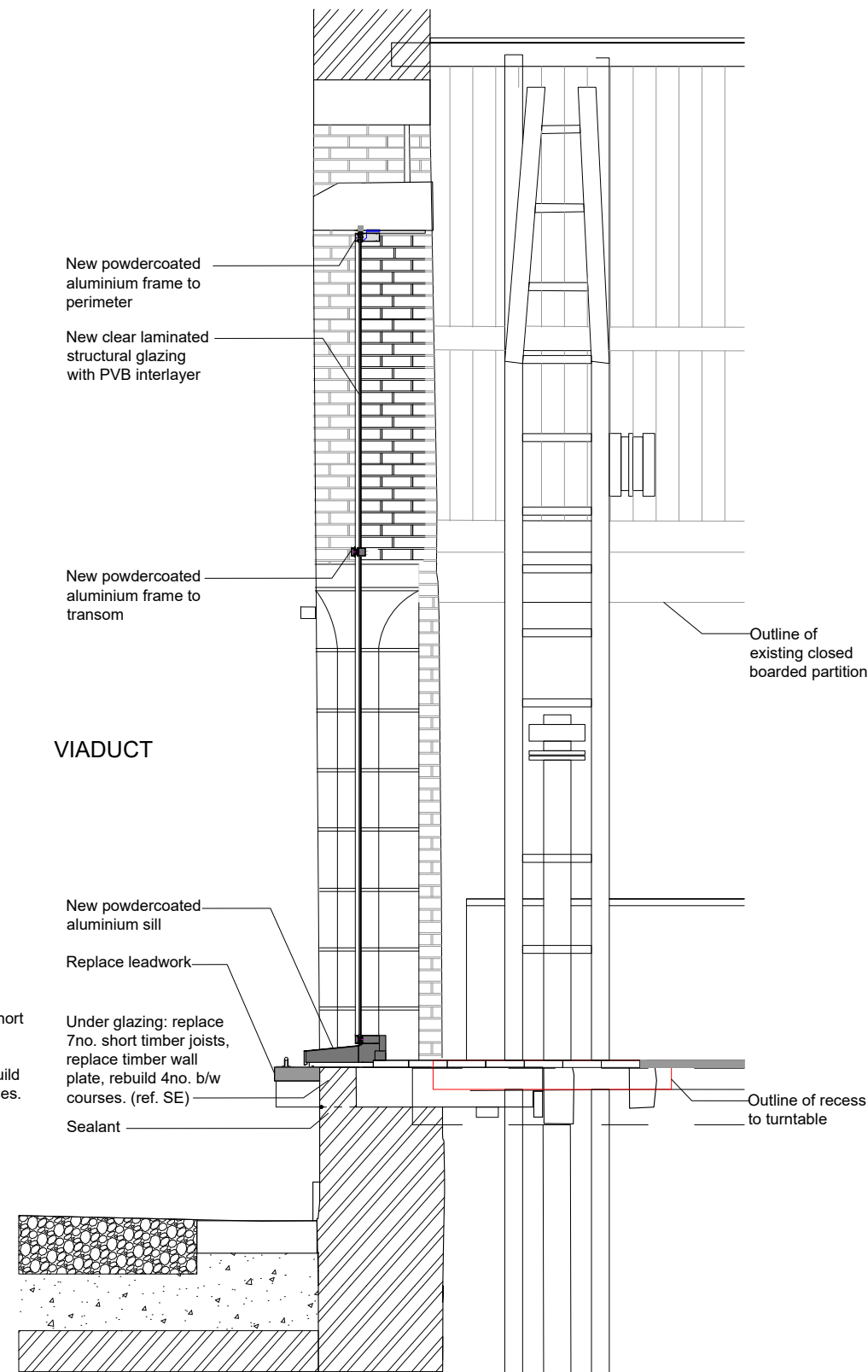
EXTERNAL ELEVATION



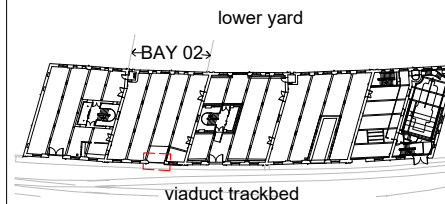
PLAN

WAGON ARCH GLAZING PROPOSED WORKS TO BAY 02. 1:40 @ A3 1:20 @ A1

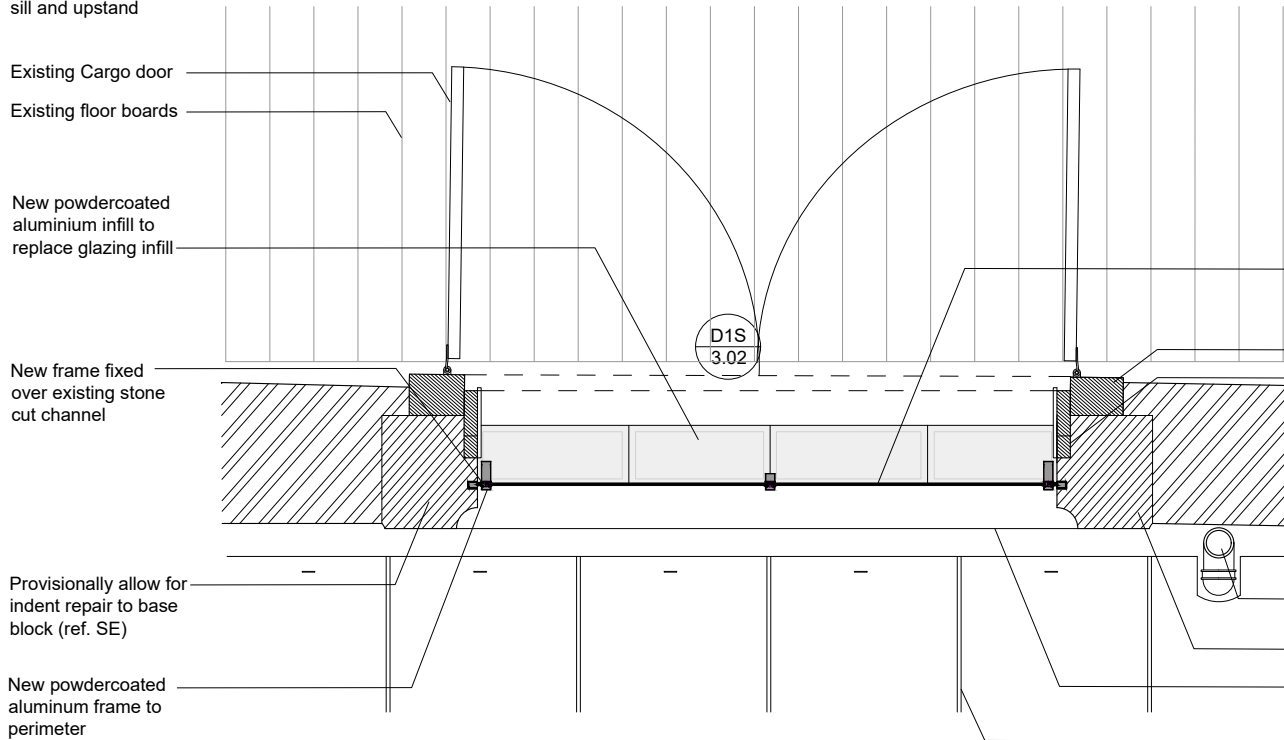
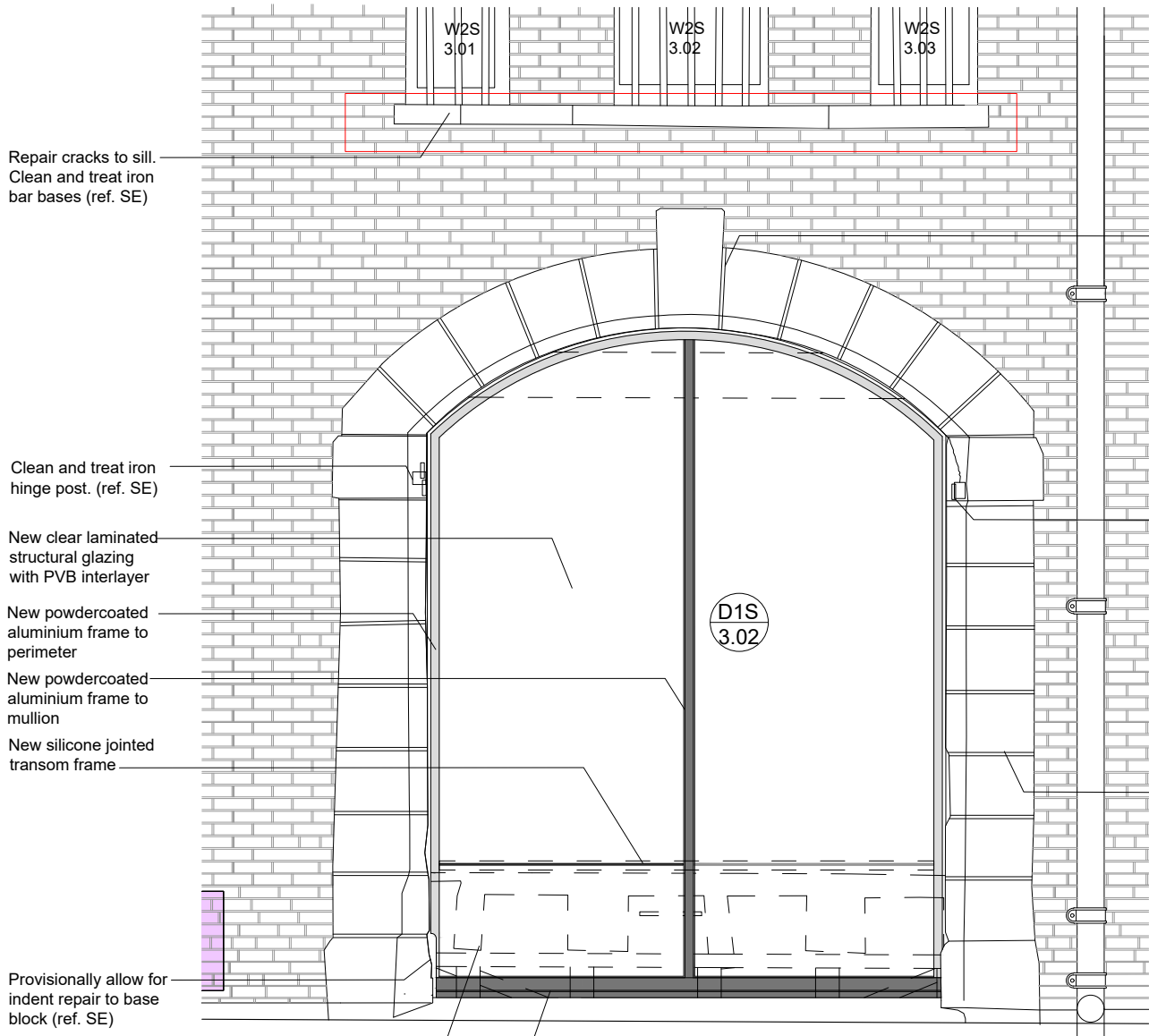
Page 34



SECTION



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		DRWG. NO. 275 / PD / 211 (A1 ORIGINAL FORMAT)	REV. 22	SCALE: 1:40@A3 1:20@A1
Studiosdownie ARCHITECTS LLP	TEL: +44 (0) 20 7299 7766 info@studiosdownie.com	All dimensions to be checked on site by the Contractor and confirmed with the Architect prior to construction. Do not scale off this drawing.	Drawn JP	DATE: 03/02/23



Stone repair and re-point with lime mortar (ref. SE)

Clean and treat iron hinge post. Indent repair to spalled stonework (ref. SE)

Re-point stonework (ref. SE)

New clear laminated structural glazing with PVB interlayer

Existing door frame
Existing timber reveal

Existing downpipe

Re-point stonework (ref. SE)

New like for like waterproof coating

Existing culvert cover

New frame fixed over existing stone cut channel

New powdercoated aluminium frame to perimeter

Clean and treat iron hinge post (ref. SE)

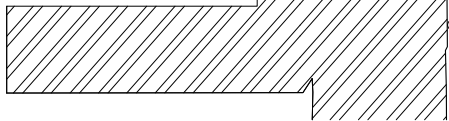
Re-point stonework (ref. SE)

VIADUCT

New like for like waterproof coating

New like for like waterproof coating

Existing culvert cover



Existing timber reveal

Cargo door opening

Existing cargo door

New powdercoated aluminium infill to replace glazing infill

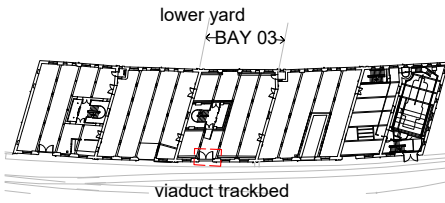
Existing floor boards

Existing Structural floor joists

New powdercoated aluminium sill and upstand (ref SE)

KEY

Re-pointing zone (ref.SE)



WAGON ARCH GLAZING: PROPOSED WORKS TO BAY 03 . 1:40 @ A3 1:20 @ A1

BASED ON MEASURED SURVEY BY GREEN HATCH					
JOB TITLE Essential repair 1830 Warehouse, Science & Industry Museum M3 4FP	JOB NO. 275	DRWG. TITLE Wagon Arch Glazing: Proposed Works to Bay 03	STATUS Planning		
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Studiodownie	TEL: +44 (0) 20 7299 7766 info@studiodownie.com	All dimensions to be checked on site by the Contractor and confirmed with the Architect prior to construction. Do not scale off this drawing.		Drawn by: JP	DATE: 03/02/23

4.2 External Repairs

[illegible]

Conclusions

- Stabilise and preserve the historic brickwork and stonework.
- Replace wooden sills to provide a sustainable long term solution.
- Redecorate rainwater goods.

Key Drawings:

Cargo Door Sills

275/PD/140 Cargo Door Sills: Existing detail

275/PD/340 Cargo Door Sills: Proposed Works

Repairs to exterior

275/PD/720 Proposed Works to Existing Building: External Elevation

275/PD/820 Photo Reference: Essential Repairs GA External Elevation

Conisbee Drawings - structural repairs

220627-CON-XX-00-DR-S-3100 SOUTH ELEVATION BAYS 1 & 2 STRUCTURAL REPAIRS

220627-CON-XX-00-DR-S-3101 SOUTH ELEVATION BAYS 3 & 4 STRUCTURAL REPAIRS

220627-CON-XX-00-DR-S-3102 SOUTH ELEVATION BAY 5 STRUCTURAL REPAIRS

220627-CON-XX-00-DR-S-3103 EAST ELEVATION STRUCTURAL REPAIRS

220627-CON-XX-00-DR-S-3104 NORTH ELEVATION BAYS 5 & 4 STRUCTURAL REPAIRS

220627-CON-XX-00-DR-S-3105 NORTH ELEVATION BAY 3 & 2 STRUCTURAL REPAIRS

220627-CON-XX-00-DB-S-3106 NORTH ELEVATION BAY 1 STRUCTURAL REPAIRS

220627-CON-XX-00-DB-S-3107 WEST ELEVATION STRUCTURAL REPAIRS

220027 CON XX 00 DR 3 3107 WEST ELEVATION STRUCTURAL REPAIRS

Conisbee Drawings - stonework repairs

220627-CON-XX-ZZ-DR-S-4003 TYPICAL STRUCTURAL REPAIRS DETAILS SHEET 3

220627-CON-XX-ZZ-DR-S-4004 STONE REPAIR DETAILS

2nd FL Mezzanine
Ref: SDA Drwg No.275/PD/713

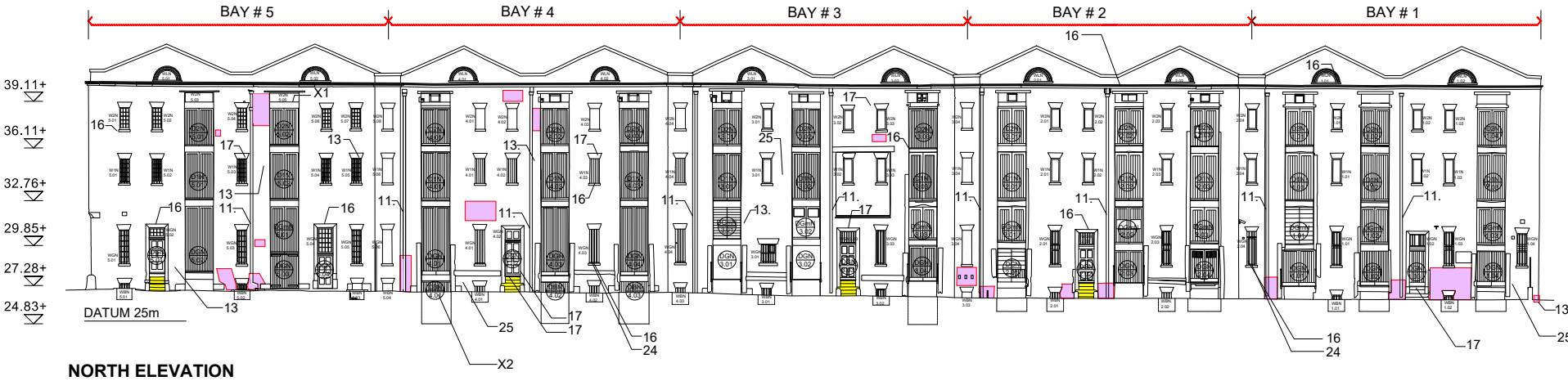
2nd FI
Ref: SDA Drwg No.275/PD/713

1st FI
Ref: SDA Drwg No.275/PD/712

GR FL Mezzanine
Ref: SDA Drwg No.275/PD/711

GF FI
Ref: SDA Drwg No.275/PD/711

BS FI
Ref: SDA Drwg No.275/PD/710



2nd FL Mezzanine
Ref: SDA Drwg No. 275/PD/713

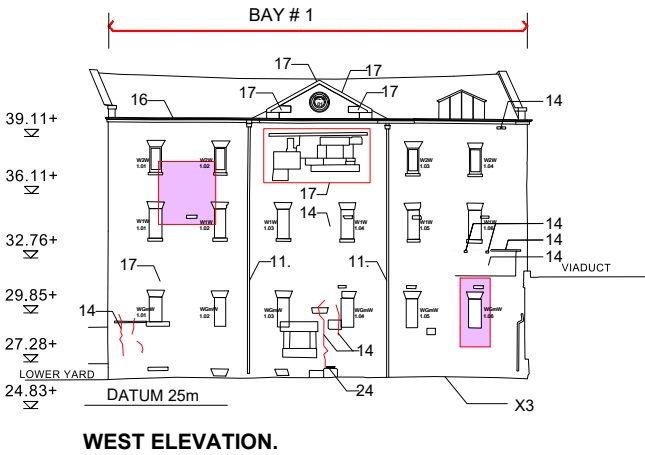
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1st FI
Ref: SDA Drwg No. 275/PD/712

GR FL Mezzanine
Ref: SDA Drwg No. 275/PD/11

GF FI
Ref: SDA Drwg No. 275/PD/711

BS FI
Ref: SDA Drwg No. 275/PD/710



2nd FL Mezzanine
Ref: SDA Drwg No. 275/PD/713

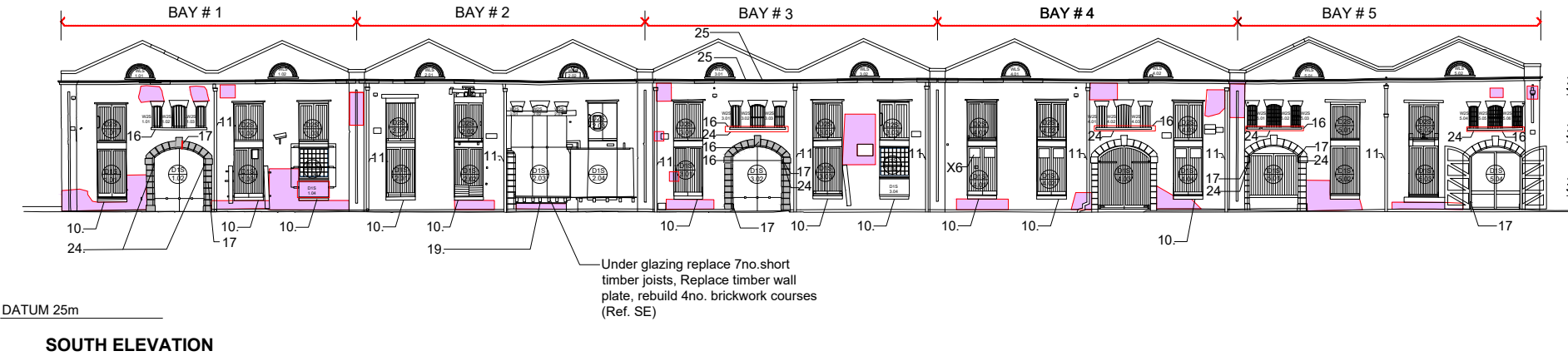
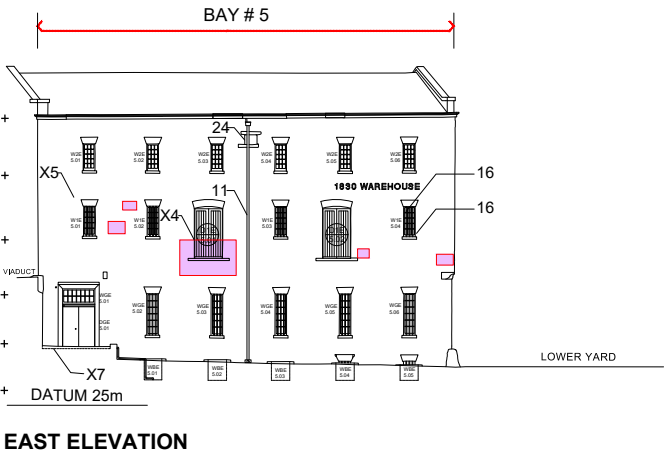
2nd FI
Ref: SDA Drwg No. 275/PD/713

1st FI
Ref: SDA Drwg No. 275/PD/712

GR FL Mezzanine
Ref: SDA Drwg No. 275/PD/711

GF FI
Ref: SDA Drwg No. 275/PD/711

BS FI
Ref: SDA Drwg No. 275/PD/710



SCHEDULE OF WORKS

EXTERNAL WORKS TO WOOD SILLS TO CARGO DOORS:

10. Remove existing wood sills, template and fabricate new hardwood timber sills with surface to fall and drip detail proud of wall. Lime mortar detail to sides and rear.

EXTERNAL DECORATIONS:

11. Redecorate rainwater goods (hopperheads downpipes) - heritage colour to be confirmed by paint analysis.

EXTERNAL BRICK REPAIRS:

12. South Elevation access from localised scaffolded working platforms which must not be tied to the existing brickwork. Brick repairs & repoint with lime mortar where repairs undertaken (ref SE).

13. North Elevation access from wheeled MEWP for upper areas and from mobile working platform to lower areas. Brick repairs & repoint with lime mortar where repairs undertaken (ref SE).

14. Inspect West Elevation brickwork from wheeled MEWP, localised repairs & repoint with lime mortar where repairs undertaken (ref SE).

15. Inspect East Elevation brickwork from wheeled MEWP, localised repairs & repoint with lime mortar where repairs undertaken (ref SE).

EXTERNAL STONE REPAIRS:

16. Crack repair to stone sills/lintels/cornice & repoint with lime where repairs undertaken (ref SE).

17. Stone repair & repoint with lime mortar where repairs undertaken (ref SE).

18. Re-set and stabilise existing steps (ref SE).

EXTERNAL METALWORK REPAIRS

24. Carefully clean and treat corroded metalwork (ref SE)

25. Remove metal fixed to wall and repair (ref SE)

WORKS TO BE CONFIRMED

X1. Allow to remove metal hooks from timber (as SDA A1005)

X2. Allow to re-level grating (as SDA A1009)

X3. Allow to clean or replace RWP to viaduct as A1022.1

X4. Allow to replace concrete sill (as SDA A1026)

X5. Allow to redecorate east elevation windows (as SDA A1023)

X6. Replace glass (as SDA A1038)

X7. ACO drain to fire escape to be changed from solid cover to slotted grille and cleaned out and new metal pipe to connect to below ground drainage.

- Works as items 12,13,14,15 in schedule of works
- Works as items 17 in schedule of works
- Works as items 17 in schedule of works
- 50% re-pointing to Bay 01 arch stonework only
- Works as items 18 in schedule of works

PROPOSED WORKS TO EXISTING BUILDING: EXTERNAL ELEVATION 1:400 @ A3 1:200 @ A1

BASED ON MEASURED SURVEY BY GREEN HATCH, 2018				
JOB TITLE Essential Repairs 1830 Warehouse. Science & Industry Museum M3 4FP	JOB NO. 275	DRWG. TITLE Proposed works to existing building External elevation	STATUS Planning	
		DRWG. NO. 275/ PD / 720 (A1 ORIGINAL FORMAT)	REV: 1:400@A3 1:200@A1	SCALE: 1:400@A3 1:200@A1
Studio Downie	TEL: +44 (0) 20 7299 7766	All dimensions to be checked on site by the Contractor and confirmed with the Architect prior to construction. Do not scale off	Drawn By: J22	DATE: 20/09/2018

4.3 Internal Repairs

	DEFECTIVE CONDITION	APPROACH TO PROPOSED REPAIR SOLUTION
	Damaged, loose or missing brickwork.	Brick repair or replacement & repoint with lime mortar where repairs undertaken. Second floor - Bay 2: Helical bar repair to crack in brickwork. Second floor - Bay 2: Helical bar repair to crack in brickwork. Ground floor mezzanine - Bay2: Helical bar repair to crack in brickwork. Ground + Basement: Grout Cracked Bedjoint. Tie In Pier Using Cemties. Ground - Bay 2: Locally rebuild cracked brickwork at corner bearing. Locally rebuild loose brickwork at corner of reveal. Helical bar repair to crack in brickwork. Basement - Bay 1: Cut out and replace cracked bricks at beam bearing. Rebuild cracked brickwork at pier top. Tie in separated brickwork panel with helical bars. Dry-pack/grout padstone bedjoint. Grout cracked bedjoint. Tie in pier using cemties.
	Timber decay due to moisture ingress and damp. Damaged timber or loss of support due to shrinkage and settlement.	Timber repairs and strengthening details (mainly in Bays 1-3). All floors: Install new steel brackets at short beam bearings First floor - Bay 3: Bolt/resin repair to cracked floor beam. Ground floor mezzanine - Bay 1 & Bay 2: Install supplementary M20 bolts (approx. 6no. per column). Ground floor mezzanine - Bay 2: Resin & bolt repair to split joist. Ground, mezzanine, & first floors: Suspected timber decay to beam or column. Provisionally allow bolted splice repair. H&R to confirm. Install new steel bracket to short beam bearing at Mezzanine Soffit. Basement - Bay 2, Bay 3: Install new steel bolted overplate to reinforce beam butt joint over column head.
	Corroded metalwork.	Clean back corroded metalwork and treat downpipe. Basement - Bay 1: Clean and treat cast iron beam.

Conclusions

- Stabilise and preserve the historic brickwork and timber.
- Repair and conserve metalwork.

Key Drawings:

Repairs to interior and exterior

- 275/PD/710 Proposed Works to Existing Building: Basement
- 275/PD/711 Proposed Works to Existing Building: Ground Floor & Ground Mezzanine
- 275/PD/712 Proposed Works to Existing Building: First Floor
- 275/PD/713 Proposed Works to Existing Building: Second Floor & Second Floor Mezzanine
- 275/PD/750 Proposed Works to Existing Building: Internal Elevation GA

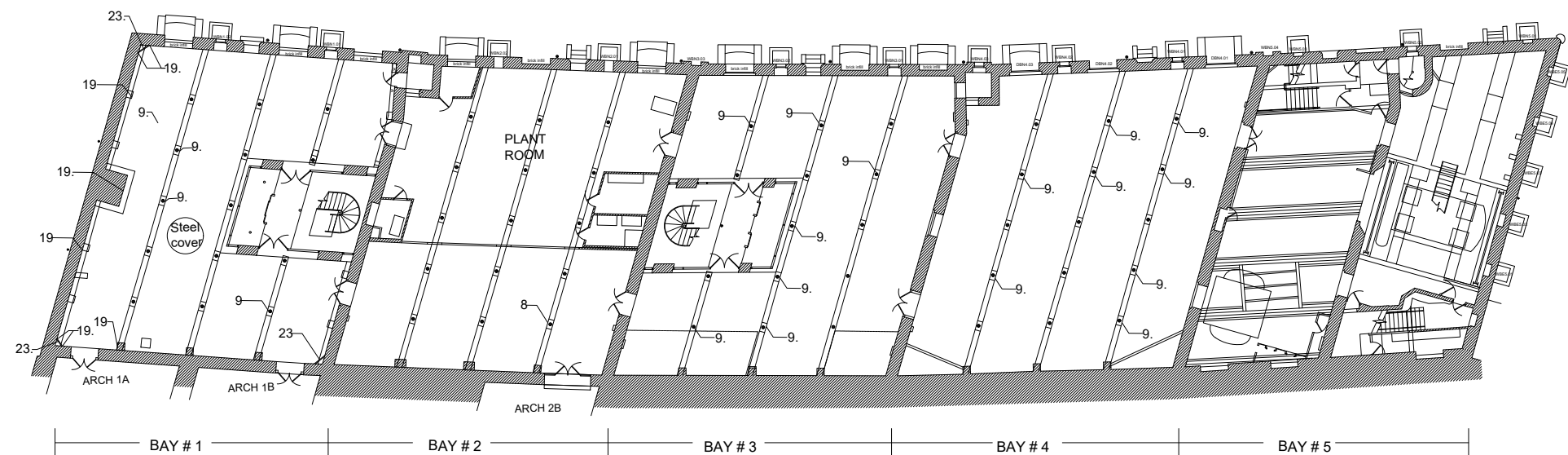
- 275/PD/811 Photo Reference: Essential Repairs to Ground Floor & GFL Mezzanine
- 275/PD/813 Photo Reference: Essential Repairs to Second Floor & 2FL Mezzanine
- 275/PD/850 Photo Reference: Essential Repairs GA Internal Elevation

Conisbee Drawings - structural repairs

- 220627-CON-XX-00-DR-S-1099 BASEMENT PLAN STRUCTURAL REPAIRS
- 220627-CON-XX-GF-DR-S-1100 GROUND FLOOR PLAN STRUCTURAL REPAIRS
- 220627-CON-XX-M0-DR-S-1101 GF MEZZANINE PLAN STRUCTURAL REPAIRS
- 220627-CON-XX-01-DR-S-1102 FIRST FLOOR PLAN STRUCTURAL REPAIRS

Conisbee Drawings - timberwork repairs

- 220627-CON-XX-ZZ-DR-S-4001 TYPICAL STRUCTURAL REPAIRS DETAILS SHEET 1
- 220627-CON-XX-ZZ-DR-S-4002 TYPICAL STRUCTURAL REPAIRS DETAILS SHEET 2



- SCHEDULE OF WORKS**
- INTERNAL TIMBER REPAIRS:**
8. Timber repair (ref SE).
9. New strengthening details (ref SE).
- INTERNAL BRICK REPAIRS**
19. Brick repair or replacement & repoint with lime mortar where repairs undertaken (ref SE).
- INTERNAL METALWORK REPAIRS**
23. Carefully clean corroded metalwork (ref SE).

PROPOSED WORKS TO EXISTING BUILDING: BASEMENT 1:400 @ A3 1:200 @ A1

INDICATIVE NORTH

NORTH

EAST

WEST

SOUTH

BASED ON MEASURED SURVEY BY GREEN HATCH, 2018

JOB TITLE Essential Repairs 1830 Warehouse, Science & Industry Museum M3 4FP	JOB NO. 275	DRWG. TITLE Proposed works to Existing Building: Basement	STATUS Planning
		DRWG. NO. 275/ PD / 710 (A1 ORIGINAL FORMAT)	REV: SCALE: 1:400@A3 1:200@A1
Studiownie ARCHITECTS LLP		TEL: +44 (0) 20 7299 7766 All dimensions to be checked on site by the Contractor and confirmed with the Architect prior to construction. Do not scale off this drawing.	Drawn by: DATE: 03/02/23

SCHEDULE OF WORKS

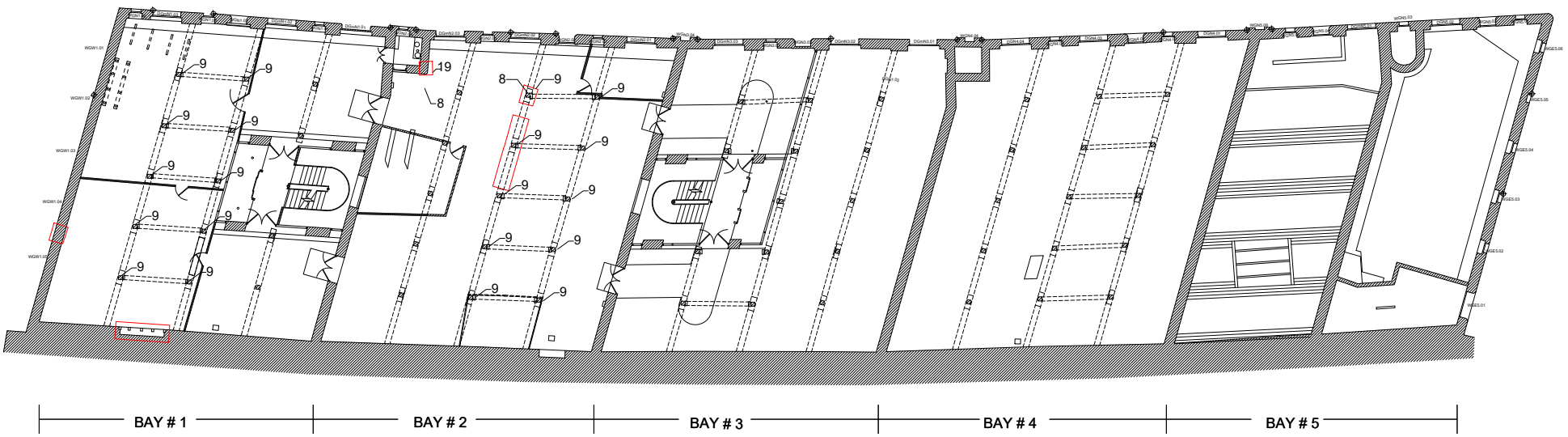
INTERNAL TIMBER REPAIRS:

8. Timber repair (ref SE).

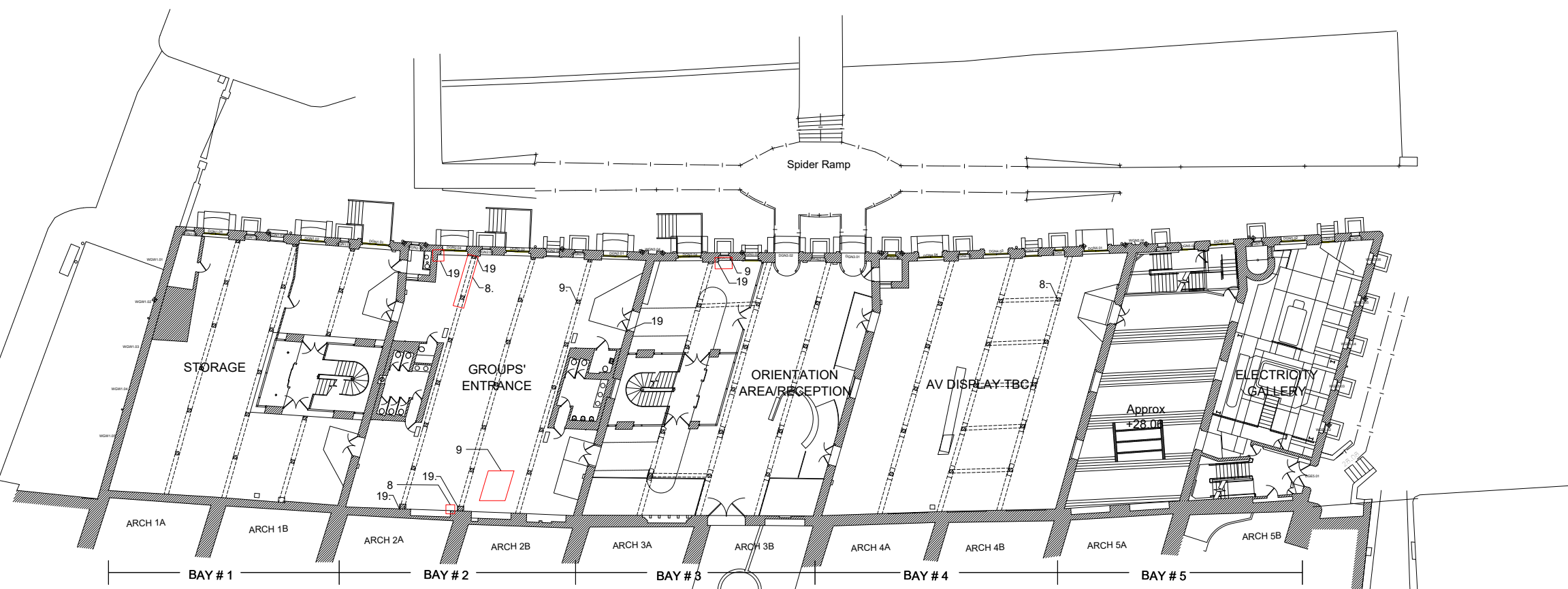
9. New strengthening details (ref SE).

INTERNAL BRICK REPAIRS

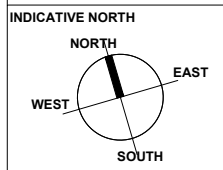
19. Brick repair or replacement & repoint with lime mortar where repairs undertaken (ref SE).



GROUND FLOOR MEZZANINE

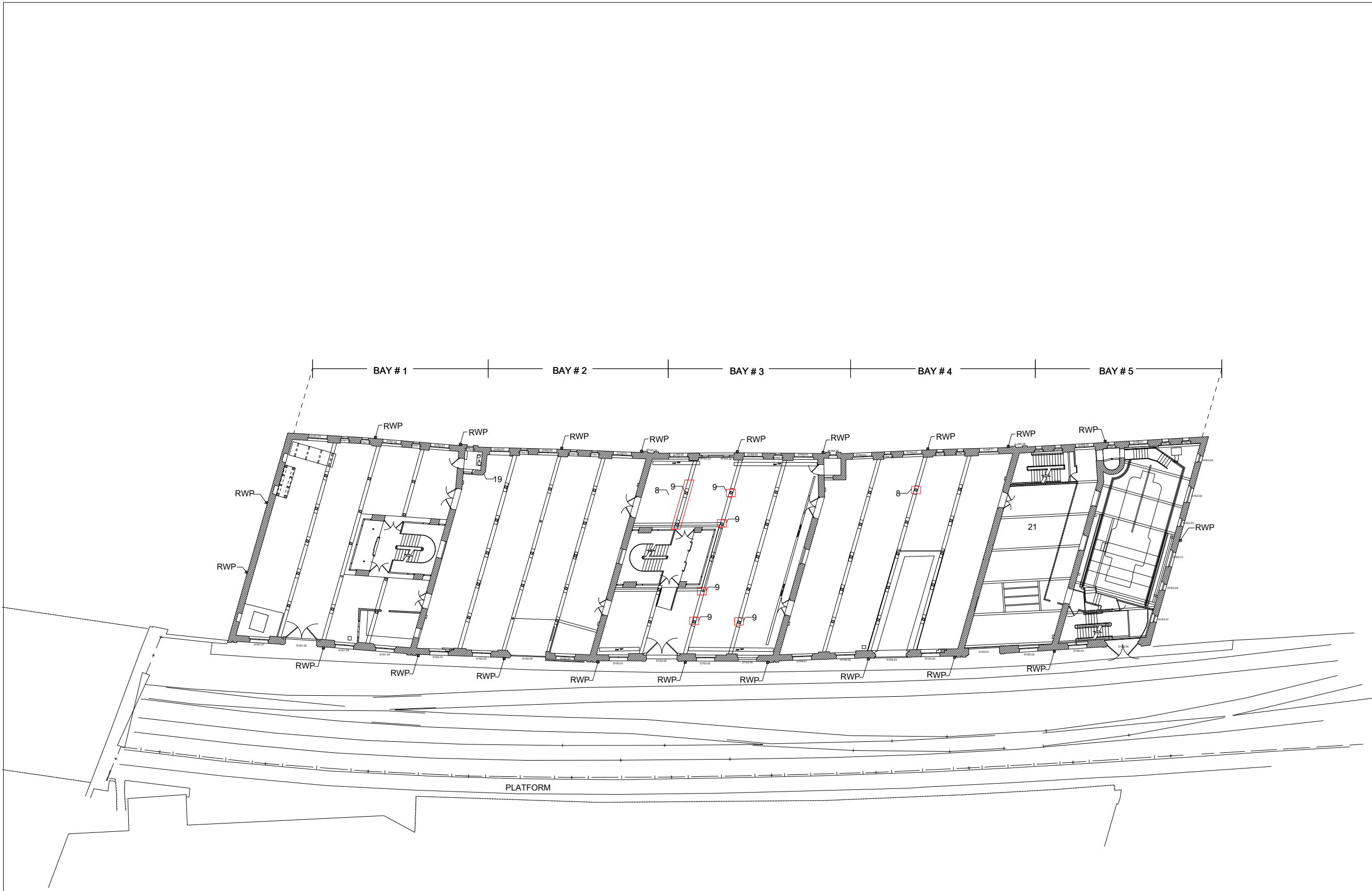


GROUND FLOOR



BASED ON MEASURED SURVEY BY GREEN HATCH, 2018				
JOB TITLE Essential Repairs 1830 Warehouse, Science & Industry Museum M3 4FP	JOB NO. 275	DRWG. TITLE Proposed works to Existing Building: Ground Floor & Ground Mezzanine	STATUS Planning	
		DRWG. NO. 275/ PD / 711 (A1 ORIGINAL FORMAT)	REV: 1:400@A3 1:200@A1	SCALE: 1:400@A3 1:200@A1
Studiodownie	TEL: +44 (0) 20 7269 7769	All dimensions to be checked on site by the Contractor and confirmed with the Architect prior	Drawn by: 2.2	DATE:

PROPOSED WORKS TO EXISTING BUILDING: GROUND FLOOR & GROUND MEZZANINE 1:400 @ A3 1:200 @ A1



SCHEDULE OF WORKS

INTERNAL TIMBER REPAIRS:
8. Timber repair (ref SE).
9. New strengthening details (ref SE).

INTERNAL BRICK REPAIRS
19. Brick repair or replacement & repoint with lime mortar where repairs undertaken (ref SE).

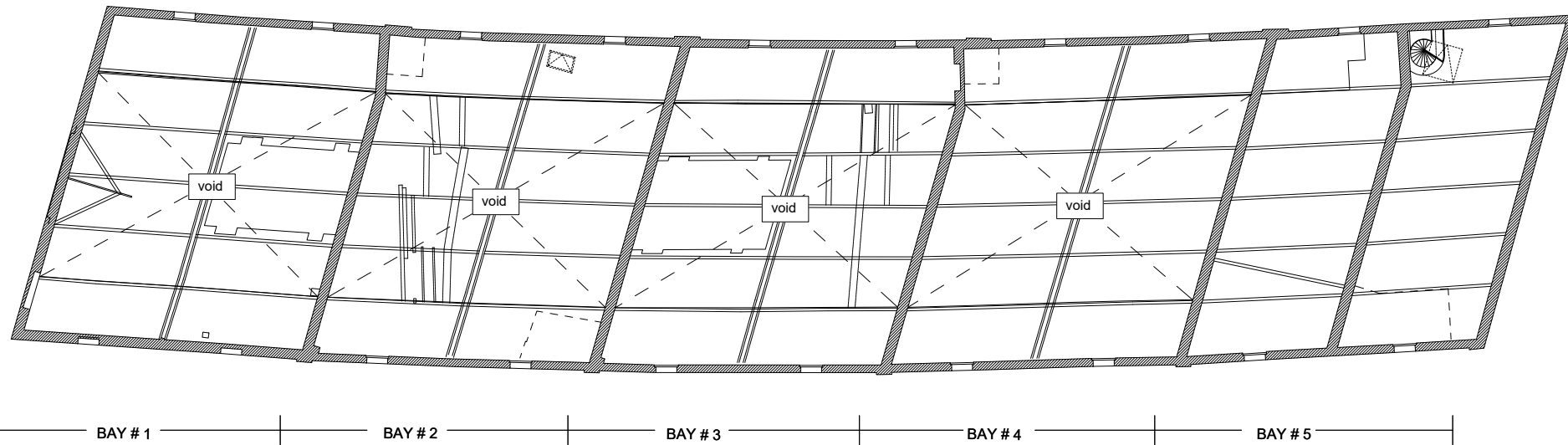
INTERNAL PRE-CAST CONCRETE REPAIRS
21. Initial investigation to SE scope - subject to client instruction.

PROPOSED WORKS TO EXISTING BUILDING: FIRST FLOOR 1:400 @ A3 1:200 @ A1

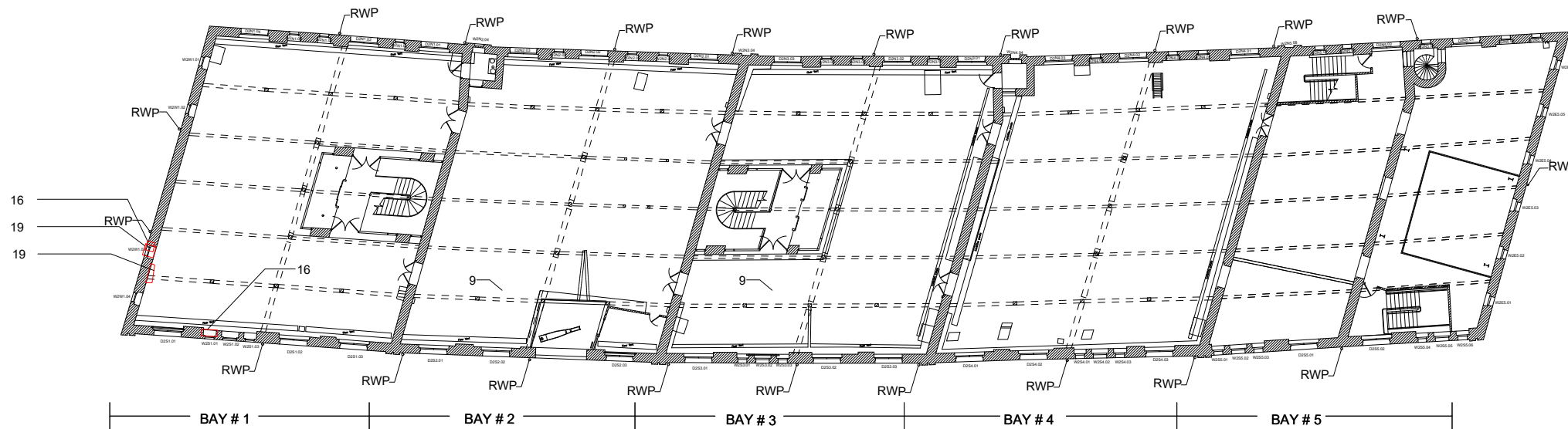
INDICATIVE NORTH

BASED ON MEASURED SURVEY BY GREEN HATCH, 2018

JOB TITLE Essential Repairs 1830 Warehouse. Science & Industry Museum M3 4FP	JOB NO. 275	DRWG. TITLE Proposed Works to Existing building: First Floor	STATUS Planning
DRWG. NO. 275/ PD / 712 (A1 ORIGINAL FORMAT)		REV: 2	SCALE: 1:400@A3 1:200@A1
Studiowdownie ARCHITECTS LLP	TEL +44 (0) 20 7299 7766 info@studiowdownie.com	All dimensions to be checked on site by the Contractor and confirmed with the Architect prior to construction. Do not scale off this drawing.	Drawn by: JP DATE: 03/02/23



SECOND FLOOR MEZZANINE



SECOND FLOOR

PROPOSED WORKS TO EXISTING BUILDING: SECOND FLOOR & SECOND FLOOR MEZZANINE 1:400 @ A3 1:200 @ A1

- SCHEDULE OF WORKS**
- INTERNAL TIMBER REPAIRS:**
- 8. Timber repair (ref SE).
 - 9. New strengthening details (ref SE).
- EXTERNAL STONE REPAIRS:**
- 16. Crack repair to stone sills/lintels & repoint with lime where repairs undertaken (ref SE).
- INTERNAL BRICK REPAIRS**
- 19. Brick repair or replacement & repoint with lime mortar where repairs undertaken (ref SE).

INDICATIVE NORTH

BASED ON MEASURED SURVEY BY GREEN HATCH, 2018

JOB TITLE Essential Repairs 1830 Warehouse, Science & Industry Museum M3 4FP	JOB NO. 275	DRWG. TITLE Proposed works to existing building: second floor & second floor mezzanine	STATUS Planning
DRWG. NO. 275/ PD / 713 (A1 ORIGINAL FORMAT)		REV: 2023	SCALE: 1:400@A3 1:200@A1
Studio Downie ARCHITECTS LLP TEL +44 (0) 20 7299 7786 info@studiodownie.com		All dimensions to be checked on site by the Contractor and approved with the Architect prior to construction. Do not scale off this drawing. Drawn by: DATE: 03/02/23	

2nd FL Mezzanine 39.11+
Ref: SDA Drwg No.275/PD/713
2nd FI 36.11+
Ref: SDA Drwg No.275/PD/713
1st FI 32.76+
Ref: SDA Drwg No.275/PD/712
GR FL Mezzanine 29.85+
Ref: SDA Drwg No.275/PD/711
GF FI 27.28+
Ref: SDA Drwg No.275/PD/711
BS FI 24.83+
Ref: SDA Drwg No.275/PD/710

NORTH INTERNAL ELEVATION

2nd FL Mezzanine 39.11+
Ref: SDA Drwg No.275/PD/713
2nd FI 36.11+
Ref: SDA Drwg No.275/PD/713
1st FI 32.76+
Ref: SDA Drwg No.275/PD/712
GR FL Mezzanine 29.85+
Ref: SDA Drwg No.275/PD/711
GF FI 27.28+
Ref: SDA Drwg No.275/PD/711
BS FI 24.83+
Ref: SDA Drwg No.275/PD/710

WEST INTERNAL ELEVATION

2nd FL Mezzanine 39.11+
Ref: SDA Drwg No.275/PD/713
2nd FI 36.11+
Ref: SDA Drwg No.275/PD/713
1st FI 32.76+
Ref: SDA Drwg No. 275/PD/712
GR FL Mezzanine 29.85+
Ref: SDA Drwg No.275/PD/711
GF FI 27.28+
Ref: SDA Drwg No.275/PD/711
BS FI 24.83+
Ref: SDA Drwg No.275/PD/710

EAST INTERNAL ELEVATION

39.11+ 2nd FL Mezzanine
Ref: SDA Drwg No.275/PD/713
36.11+ 2nd FI
Ref: SDA Drwg No.275/PD/713
32.76+ 1st FI
Ref: SDA Drwg No. 275/PD/712
29.85+ GR FL Mezzanine
Ref: SDA Drwg No.275/PD/711
27.28+ GF FI
Ref: SDA Drwg No.275/PD/711
24.83+ BS FI
Ref: SDA Drwg No.275/PD/710

SOUTH INTERNAL ELEVATION

SCHEDULE OF WORKS

EXTERNAL STONE REPAIRS:

16. Crack repair to stone sills/lintels & repoint with lime where repairs undertaken (ref SE)

INTERNAL BRICK REPAIRS

19. Brick repair or replacement & repoint with lime where repairs undertaken (ref SE)
20. Localised repointing with lime mortar (ref SE)

WORKS TO BE CONFIRMED

XX1.Remove timber and make good (as SDA A0067)
XX2.Remove timber and make good (as SDA A0035)
XX3. Remove white stains to brick wall (as SDA 0059)
XX4. Remove white stains to brick wall (as SDA A0069)

BASED ON MEASURED SURVEY BY GREEN HATCH, 2018				
JOB TITLE Essential Repairs 1830 Warehouse, Science & Industry Museum M3 4FP	JOB NO. 275	DRWG. TITLE Proposed works to existing building: Internal elevation GA	STATUS Planning	
		DRWG. NO. 275/ PD / 750 (A1 ORIGINAL FORMAT)	REV: 22	SCALE: 1:400@A3 1:200@A1
Studiodownie	TEL: +44 (0) 20 7299 7766	All dimensions to be checked on site by the Contractor and confirmed with the Architect prior to construction. Do not scale off		
		Drawn JP	DATE: 03/02/23	

APPENDIX:

- **Appendix 1 Photographs of location of works, cross referenced on plan.**
- **Appendix 2 Structures Report**
 - 2.1: Conisbee 220627 - SMG-1830 Warehouse Glazing - Structural Report
 - 2.2: Conisbee 220626_1830_Warehouse_Structural_Appraisal
 - 2.3: 220627- 1830 Warehouse - Structural Design Summary
- **Appendix 3 Method Statements**
 - 3.1: Methodology for Brickwork Repairs
 - 3.2: Methodology for Stonework & Associated Metalwork Repairs
 - 3.3: Methodology for Timberwork Repairs
 - 3.4: Methodology for Decorations
 - 3.5: Methodology as General Summary
- **Appendix 4 Visual Assessment & Analysis of Wagon Arch Glazing**
- **Drawings**
 - Studio Downie Architects Drawings - architectural and general arrangement
 - Conisbee Drawings - structural repairs

Essential Works & Repairs, 1830 Warehouse

Science & Industry Museum

APPENDIX 1

Photographs of location of works, cross referenced on plan

Prepared by:
Studio Downie Architects LLP
February 2023

APPENDIX

Visual Summary of essential fabric repairs

- The following pages include the photographs from the visual condition survey.
- ALL necessary repairs will be be carried out with sensitivity and to a high standard of workmanship.

PHOTOGRAPHS OF EXAMPLES OF EXTERNAL WORKS



S1001: Patches of eroded pointing. Repoint using lime mortar.



S1002: Spalled bricks. Cut out and replace bricks where erosion exceeds 15mm depth. Repoint using lime mortar.



S1003: Open joint at keystone. Repoint using lime mortar.



S1004: Patches of eroded pointing. Repoint using lime mortar.



S1005: 7no. Decayed timber joists below glazed opening. Replace with new timber to match.



S1006: Corroding metal pipe & material loss to cornice. Remove pipe and undertake indent repair to cornice.



S1007: Bolt shell. Remove bolt shell.



S1008: Bolt shell and adjacent spall. Remove bolt shell and undertake indent repair to cornice.



S1009: Spalled bricks. Cut out and replace bricks where erosion exceeds 15mm depth. Repoint using lime mortar.



S1010: Corrosion of iron bar ends and cracks to cill. Cut out around bar embeddings and treat iron. Repoint cracks using lime mortar.



S1011: Material loss to keystone. Indent repair to stone block.



S1012: Open joints at keystone. Repoint using lime mortar.



S1013: Crack/spall to block at hinge fixing. Treat ironwork, indent repair to stone block.



S1014: Material loss/spall. Indent repair to stone block.



S1015: Crack through drainage channel at wall base. Further investigation required as part of viaduct drainage strategy.



S1016: 2no. Bolt shells. Remove bolt shells.



S1017: Material loss/spall. Indent repair to stone block.



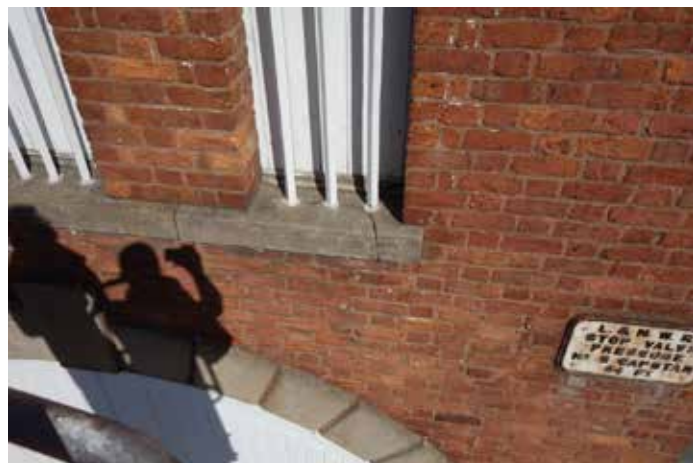
S1018: Material loss/spall. Indent repair to stone block.



S1019: Spalled bricks. Cut out and replace bricks where erosion exceeds 15mm depth. Repoint using lime mortar.



S1020: Patches of eroded pointing. Repoint using lime mortar.



S1021: Corrosion of iron bars and cracking to sill. Cut out around bar embedments and treat iron. Repoint cracks using lime mortar.



S1022: Open joint at arch block. Repoint using lime mortar.



S1023: Fairing coat to RC beam is delaminating. Reapply with concrete repair mortar.



S1024: Corrosion of iron bar ends and cracks to cill. Cut out around bar embedments and treat iron. Repoint cracks using lime mortar.



S1025: Spall at hinge fixing. Indent repair to stone block.



S1026: Spall at hinge fixing. Indent repair to stone block.



S1027: Patches of eroded pointing. Repoint using lime mortar.



S1028: Delamination at cornice block. Indent repair to stone block.



S1029: Material loss/spall. Indent repair to stone block.



S1030: Spalled bricks. Cut out and replace bricks where erosion exceeds 15mm depth. Repoint using lime mortar.



S1031: Metal duct frame is corroded. Cut out and brick in the opening.



S1032: Material loss/spall. Indent repair to stone cill.



S1033: Various redundant metal bolts and fixings. Remove and infill holes using lime mortar.



S1034: Vertical crack, c7mm width. Repoint using lime mortar.



S1035: Vertical crack, c1-2mm width. Repoint using lime mortar.



S1036: Settlement of steps. Dismantle and rebuild on new foundation.



S1037: Patches of eroded pointing. Repoint using lime mortar.



S1038: Spalled bricks. Cut out and replace bricks where erosion exceeds 15mm depth. Repoint using lime mortar.



S1039: Previously repaired crack to door head, c6mm width. Rake out cementitious mortar, repoint with lime mortar.



S1040: Spalled bricks. Cut out and replace bricks where erosion exceeds 15mm depth. Repoint using lime mortar.



S1041: Vertical crack due to corroded fixing. Remove fixing and replace with stainless steel. Repoint crack with lime mortar.



S1042: Vertical crack/fissure in stone architrave. Pin fissure using stainless steel dowels, Infill with colour matched repair mortar.



S1043: Large spall to step tread. Indent repair to stone tread.



S1044: Settlement of steps. Dismantle and rebuild on new foundation.



S1045: Vertical crack, 1-2mm width Pin bricks with Cemties. Repoint crack with lime mortar



S1046: Corrosion of iron bar ends and cracks to cill. Cut out around bar embedments and treat iron. Repoint cracks using lime mortar.



S1047: Various redundant metal bolts and fixings. Remove and infill holes using lime mortar.



S1048: Vertical crack, 1-2mm width to RHS quoin. Pin bricks with Cemties. Repoint crack with lime mortar.



S1049: Bolt shells in cornice blocks. Remove and infill holes using lime mortar.



S1050: Open joints to stone architrave blocks. Repoint using lime mortar.



S1051: Settlement of steps. Dismantle and rebuild on new foundation.



S1052: Bolt shells in cornice blocks. Remove and infill holes using lime mortar.



S1053: Spalled bricks. Cut out and replace bricks where erosion exceeds 15mm depth. Repoint using lime mortar.



S1054: Patches of eroded pointing. Repoint using lime mortar.



S1055: Settlement of steps. Dismantle and rebuild on new foundation.



S1056: Crack in stone architrave. Pin crack with SS dowel. Repoint using lime mortar.



S10057: Open joints to cornice. Repoint using lime mortar.



S1058: Open joints to cornice. Repoint using lime mortar.



S1059: Corrosion of iron bar ends and cracks to cill and lintel. Cut out around bar embedments and treat iron. Repoint cracks using lime mortar.



S1060: Patches of eroded pointing. Repoint using lime mortar.



S1061: Spalled and eroded step treads. Indent repairs to 2no. treads.



S1062: Corroding metal pin. Remove pin and repoint crack using lime mortar.



S1063: Open joints to cornice. Repoint using lime mortar.



S1064: Delamination of LHS pediment block face. Indent repair to restore lost section.



S1065: Delamination of coping blocks (2no.). Indent repair to restore lost section.



S1066: Missing pointing at lead capping. Repoint using lime mortar.



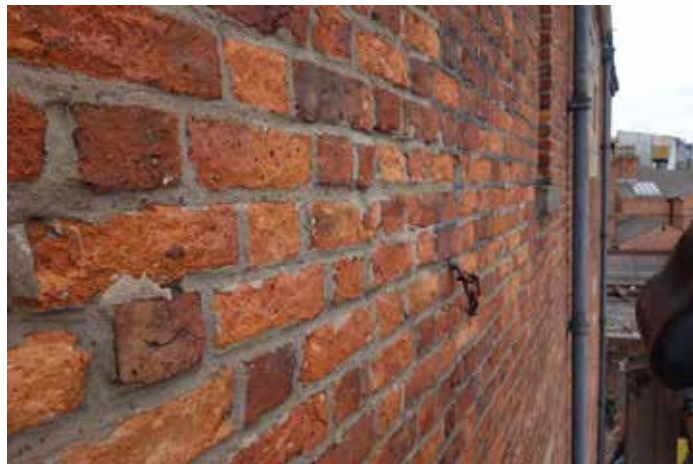
S1067: Delamination of RHS pediment block face. Indent repair to restore lost section.



S1068: Decayed embedded timber. Remove timber and brick-in void.



S1069: Area of delamination of stone block faces and loose pointing. Defrass stone and repoint joints using lime mortar.



S1070: Various redundant metal bolts and fixings over elevation. Remove and infill holes using lime mortar.



S1071: Diagonal cracks, 2mm width. Repoint using lime mortar.



S1072: Eroded pointing over whole elevation. Repoint using lime mortar.



S1073: Multiple vertical cracks in brickwork. Repair using helical bar stitching. Repoint using lime mortar.



S1074: Previous surface repair failing. Indent repair to restore lost section.



S1075: Multiple vertical cracks in brickwork. Repair using helical bar stitching. Repoint using lime mortar.



S1076: Corroding emdedded iron duct. Clean and treat where accessible. Repoint around using lime mortar.



S1077: Spalled/missing bricks. Cut out and replace bricks where erosion exceeds 15mm depth. Repoint using lime mortar.



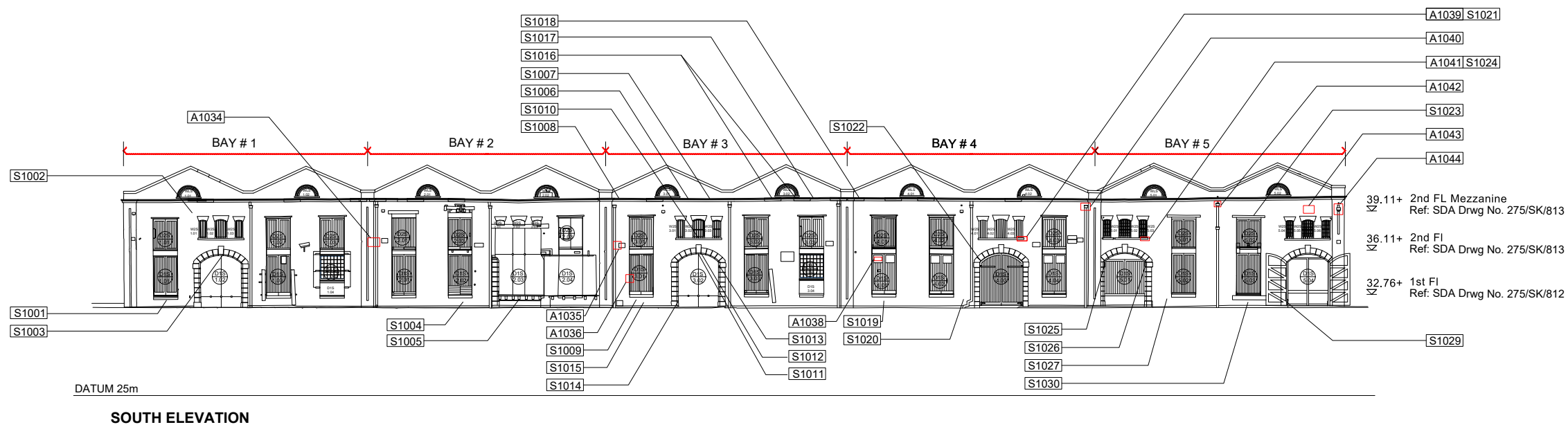
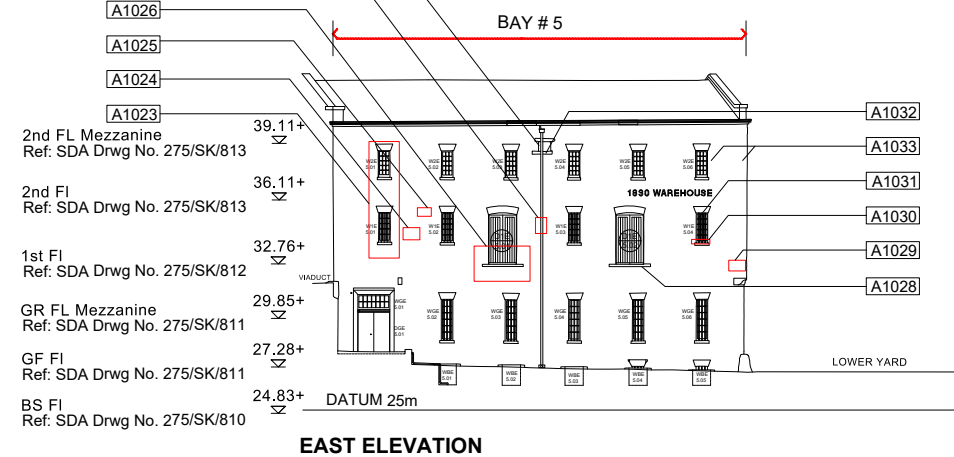
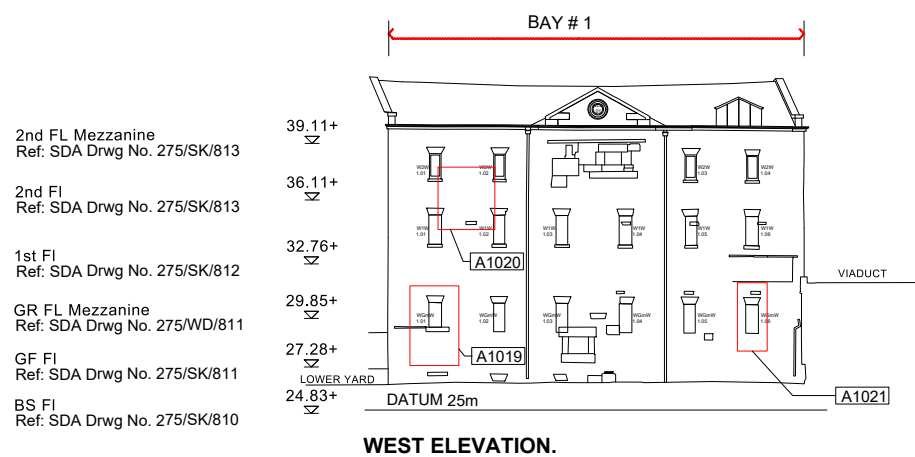
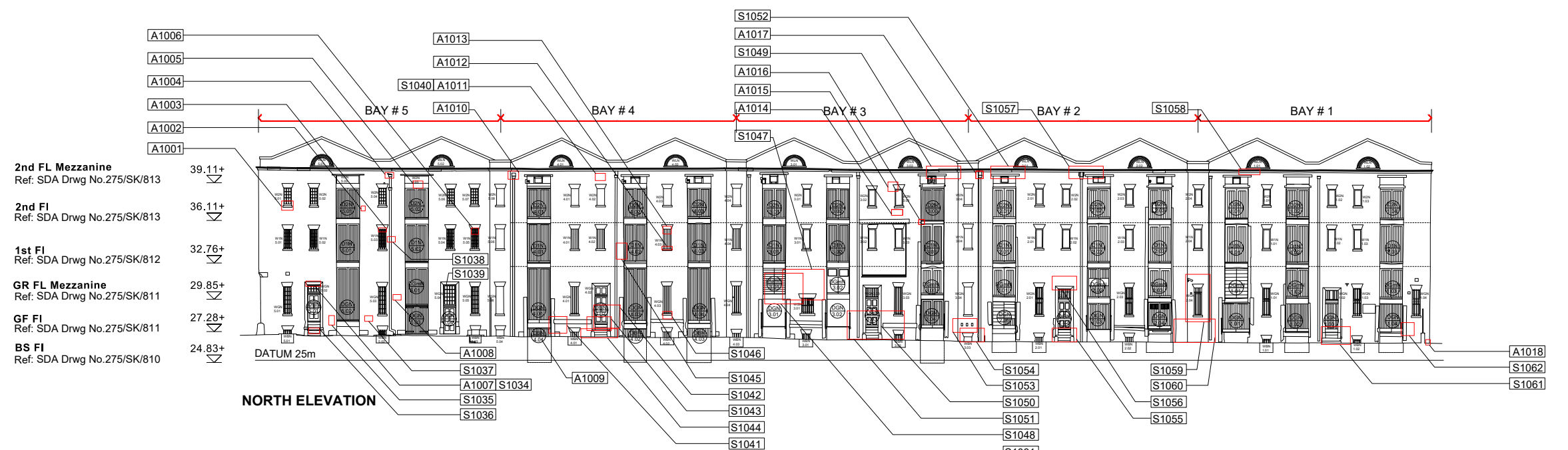
S1078: Decayed embedded timber. Remove timber and brick-in void.



S1079: Failing area of render over brickwork. Remove and replace with new lime render.



S1080: Timber lintel has poor bearing. Extend bearing.



GA PHOTO REFERENCE: ESSENTIAL REPAIRS GA TO EXTERNAL ELEVATIONS 1:400 @ A3 1:200 @ A1

BASED ON MEASURED SURVEY BY GREEN HATCH, 2018				
JOB TITLE Essential Repairs 1830 Warehouse, Science & Industry Museum M3 4FP	JOB NO. 275	DRWG. TITLE GA Photo Reference: Essential Repairs GA External elevations	STATUS Planning	
		DRWG. NO. 275/ PD / 820 (A1 ORIGINAL FORMAT)	REV: 1:400@A3 1:200@A1	SCALE: 1:400@A3 1:200@A1
Studiowdnie	TEL +44 (0) 20 7299 7766	All dimensions to be checked on site by the Contractor and confirmed with the Architect prior to construction. Do not scale off this drawing.		Drawn by: JP2021
ARCHITECTS LLP	www.studiowdnie.com	DATE: 03/02/23		



A1001: Loose sill. Check sill stability/replace sill



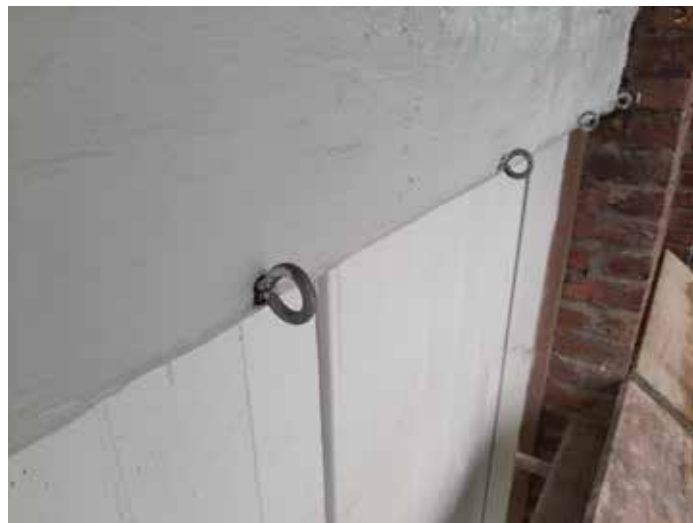
A1002: Damaged Brick. Brick repair required



A1003: Lintel damaged. Lintel repair required, associated anti corrosion works to security bars.



A1004: Rainwater goods. RWP outlet to replaced with Catchpit and chute.



A1005: Metal hooks in wood. Remove metal hooks



A1006: Lintel damaged. Header head repair required



A1007: Lintel damaged. Structural engineer to review



A1008: Poor repair. Repair brick repairs with brick dust



A1009: Stone step worn, grating is not level. Level grating



A1010: Rainwater goods. RWP outlet to replaced with Catchpit and chute.



A1011: Metal hooks fixed to wall. Remove hooks and repair



A1012: Sill damaged. Sill repair required



A1013: Lintel damaged. Header brick repair required



A1014: Movement in brick. Brick repair required



A1015: Lintel movement. Structural engineer to review



A1016: Loose sill. Check sill stability/replace sill (historic detail)



A1017: Damaged leadwork. Replace lead lining to chute (generally)



A1018: Damaged brick: Loss of brickwork at base. Loss of corners



A1019: Extensive movement to brickwork, loss of mortar under timber lintel. Check lintel stability and repoint



A1020: Vertical line of metal brackets, poor pointing in brick. Remove metal fixed to wall and repoint



A1021: hole at lower right of GFL infilled window, extensive cracking to brickwork, loss mortar, mid-left iron protruding. Brick repair required



A1022.1: Forecourt area hardcore - rough surface with vegetation, water leak damp from overflowing (hopper blocked by vegetation). Clean/ replace RWP to Viaduct.



A1023: East elevation frames to be redecorated.



A1024: Hole in brickwall. Brick repairs correctly with brick dust



A1025: Modern brickwork. Replace with salvaged brick



A1026: No drip detail to concrete sill, stain to brick below. Replace concrete sill.



A1027: Damaged RWP. RWP to be redecorated or replaced



A1028: Metal fixed to wall. Remove redundant metalwork and fill hole with brick dust



A1029: Metal sockets inserted to wall. Remove sockets



A1030: Sill damaged. Sill repair required. Associated anticorrosion works to security bars, rub down and redecorate)



A1031: Lintel damaged: Header repair required. anticorrosion works to security bars, rub down and redecorate)



A1034: Damaged brick. Brick repair required



A1035: Damaged brick. Brick repair required



A1036: Broken brick. Brick repair required



A1038: Cracked glazing. Replace glass or coat in anti-shatter film.



A1039: Defective pointing: Repoint



A1040: Rainwater goods. RWP outlet to replaced with Catchpit and chute.



A1041: Sill damaged. Sill repair required



A1042: Defective pointing. Repoint



A1043: Modern brickwork. Replaced with salvaged brick



A1044: Defective pointing: Repoint



A1052: Valley gutter poor damp and friable. Timber repair required and make good. Slate battens or pegs to underside could be decay

PHOTOGRAPHS OF EXAMPLES OF INTERNAL WORKS



A0004: Loose floorboard. Re-fix / Repair / Make good



A0005: Check stability. Review with Structural engineer- Rein-force



A0012: Damage timber. Repair sill (historic detail)



A0013: Damaged brick. Repair brick required



A0015: Brickwork damaged. Brick repair required



A0016: Damaged timber or deteriorate. Repair sill (historic detail)



A0025. Brick wall crack. Brick repair required



A0026: Defective pointing. Re-point



A0028: Brickwork damaged. Brick repair required



A0029: Brickwork damaged. Brick repair required



A0031: Missing masonry. Masonry repair required



A0032. Brickwork damaged. Brick repair required



A0035: Wood piece below. Remove batten



A0036: Defective pointing. Re-point



A0038: Brickwork damaged. Brick repair required



A0040: Poor pointing. Brick repair required



A0043 Defective pointing. Re-point



A0044: Brickwork damaged. Brick repair required



A0046 Brickwork damaged. Brick repair required



A0047: .Damaged timber or deteriorated.



A0050: Brickwork damaged. Brick repair required



A0051 Defective pointing. Re-point



A0052: Brickwork damaged. Brick repair required



A0053 Brickwork damaged. Brick repair required



A0054: Brickwork damaged. Brick repair required



A0055.1: Defective pointing. Re-point



A0059: Wall stains. remove stains



A0060: Stone lintel damaged. Repair lintel



A0061 Brickwork damaged. Brick repair required



A0067: Wood piece fixed to wall. Remove and replace with salvaged brick



A0068: Wood blocks inserted to wall. Remove and replaced with salvaged bricks



A0069: Wall stains. Remove white stains to wall



A0070: Loose sill. Check sill stability and repair.



A0071: Brickwork damaged. Brick repair required



A0072: Brickwork damaged. Brick repair required



A0073: Brickwork damaged. Brick repair required



A0076: Defective pointing. Re-point



A0077: Brickwork damaged. Brick repair required



A0078: Brickwork damaged. Re-point check brick movement and repair



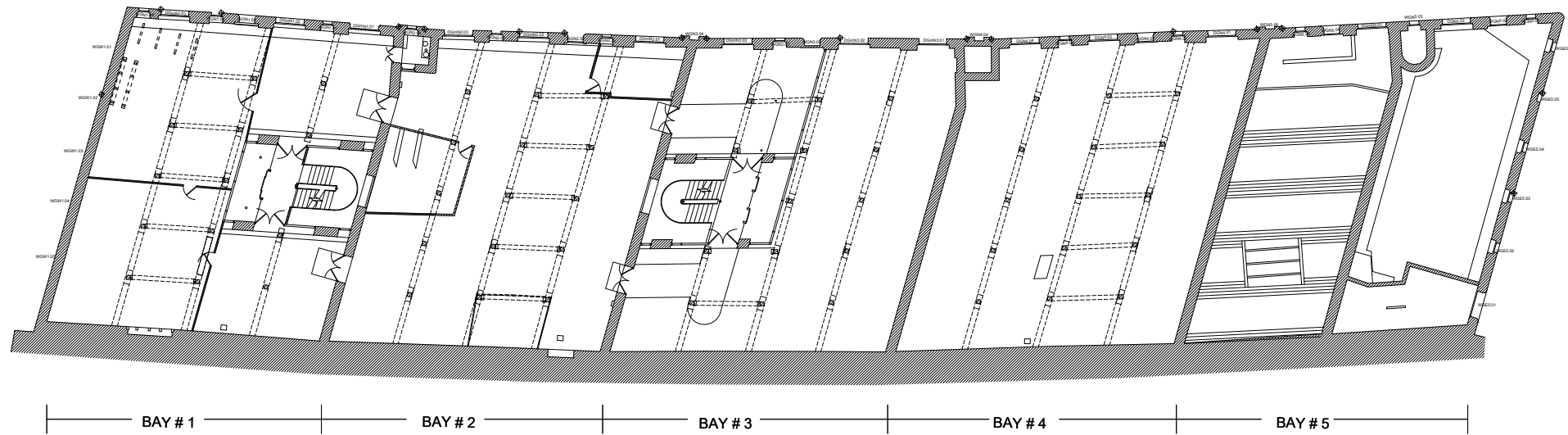
A0080: Damaged window reveal. Repair window reveal.



A0082. Defective pointing. Re-point



A0083. Defective pointing. Re-point

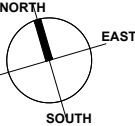


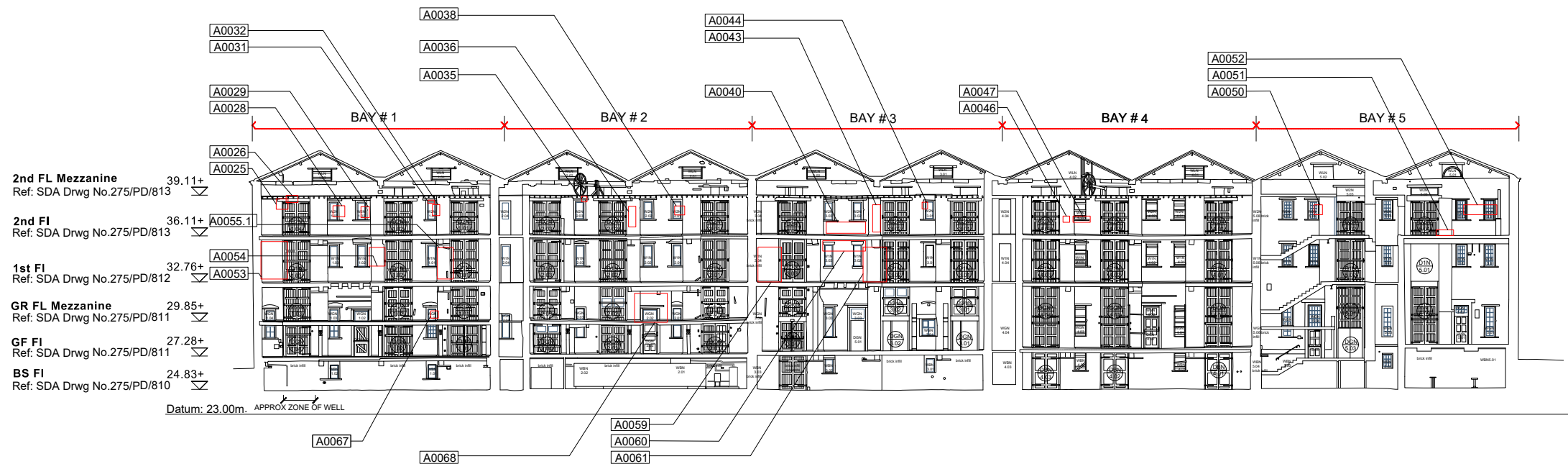
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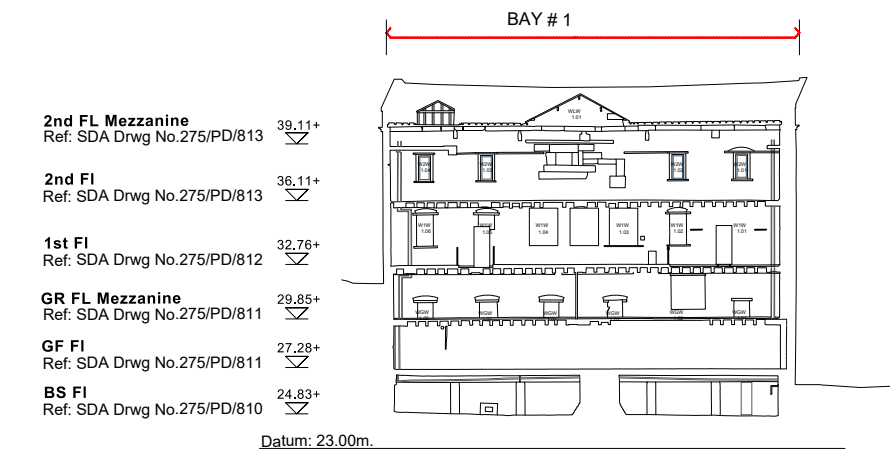
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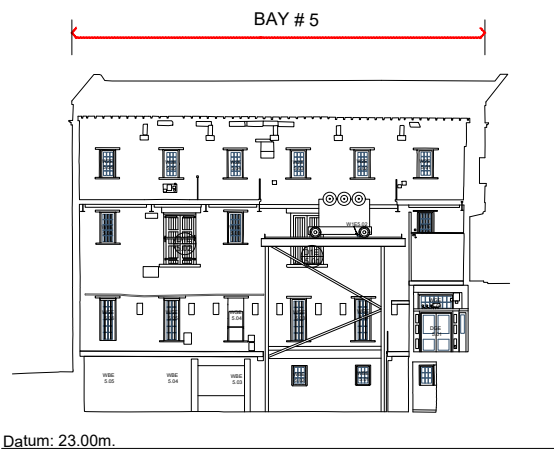
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BASED ON MEASURED SURVEY BY GREEN HATCH, 2018			
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		DRWG. NO. 275 / PD / 811 (A1 ORIGINAL FORMAT)	REV. 1:400@A3 1:200@A1
Studiowdownie ARCHITECTS LLP	TEL: +44 (0) 20 7299 7766 www.studiowdownie.com	All dimensions to be checked on site by the Contractor and confirmed with the Architect prior to construction. Do not scale off this drawing.	Drawn by: JP DATE: 03/02/23



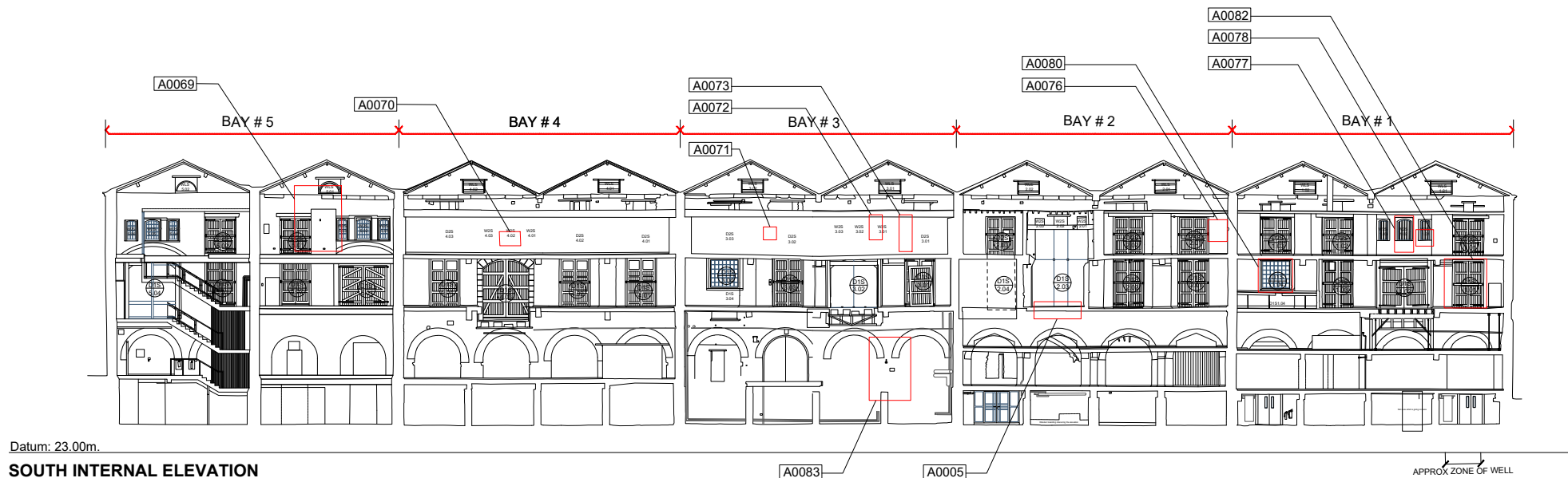
NORTH INTERNAL ELEVATION



WEST INTERNAL ELEVATION



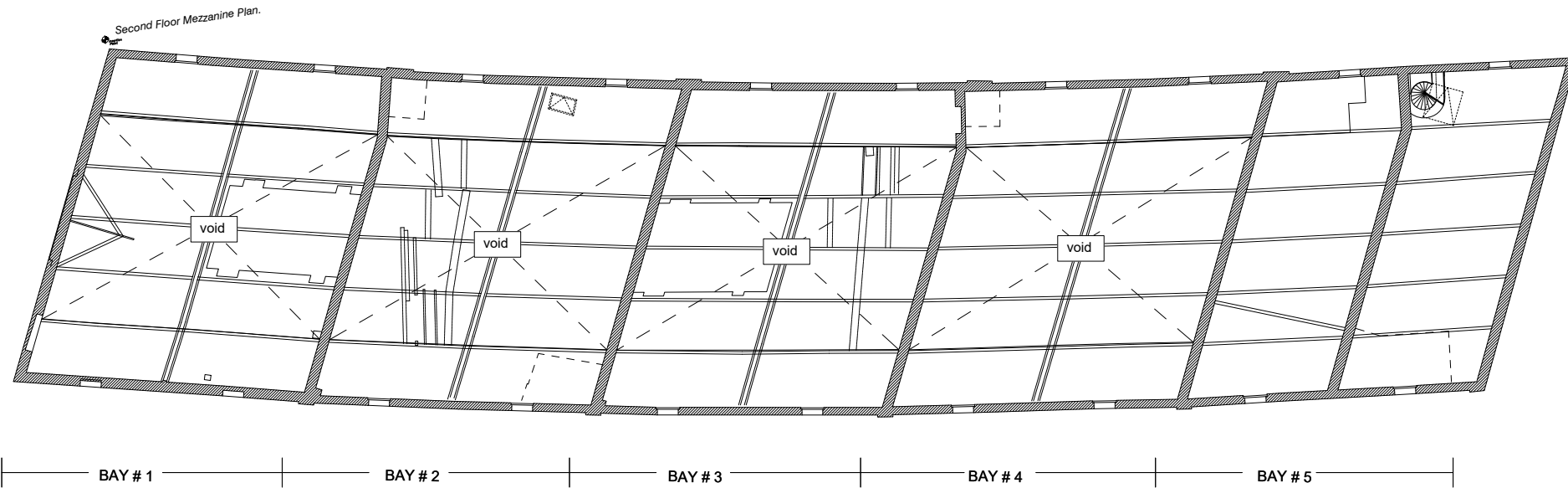
EAST INTERNAL ELEVATION



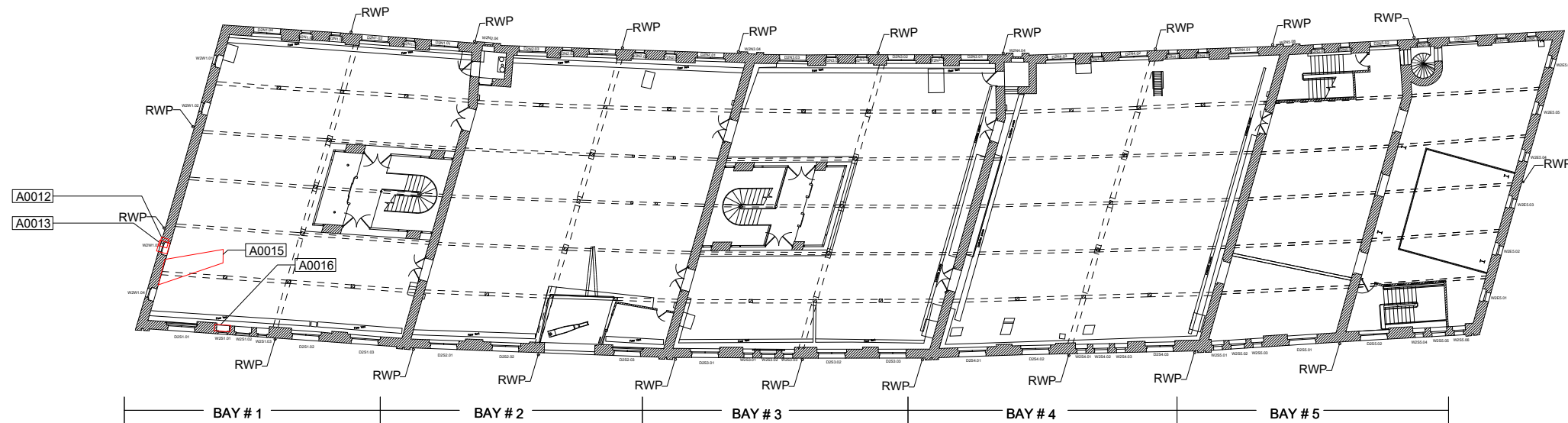
SOUTH INTERNAL ELEVATION

GA PHOTO REFERENCE: ESSENTIAL REPAIRS GA INTERNAL ELEVATIONS 1:400 @ A3 1:200 @ A1

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Studiownie ARCHITECTS LLP	TEL: +44 (0) 20 7299 7798 info@studiownie.com	All dimensions to be checked on site by the Contractor and confirmed with the architect prior to construction. Do not scale off this drawing.		Drawn by: DATE: 03/02/23

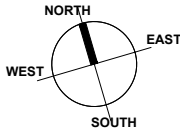


SECOND FLOOR MEZZANINE



SECOND FLOOR

PHOTO REFERENCE: ESSENTIAL REPAIRS TO SECOND FLOOR & SECOND FLOOR MEZZANINE 1:400 @ A3 1:200 @ A1

INDICATIVE NORTH			
			
BASED ON MEASURED SURVEY BY GREEN HATCH, 2018			
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		DRWG. NO. 275/ PD / 813 (A1 ORIGINAL FORMAT)	REV: 1:400@A3 1:200@A1
Studiowdownie	TEL +44 (0) 20 7299 7766	All dimensions to be checked on site by the Contractor and confirmed with the Architect prior to construction. Do not scale off this drawing.	Drawn by: JP 021 DATE: 03/02/23
ARCHITECTS LLP			

SMG - 1830 Warehouse - Glazing

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1.0 INTRODUCTION

- 1.1 Conisbee were appointed by David Brown on behalf of the Science Museum Group to undertake a structural appraisal of all glazed door openings at the south elevation of the 1830 Warehouse at the Science & Industry Museum.
- 1.2 Defects were previously found to be present to openings at Bays 1 and 2, requiring temporary support to be provided to the glazing. The purpose of the inspection and reporting is to determine the structural condition of the existing glazing and identify where repair, replacement and/or improved support is needed to maintain the integrity and safety of the glazing.
- 1.3 Our inspections were visual only at this stage and no opening-up, testing or other intrusive works have been undertaken.

2.0 BUILDING TYPE, CONSTRUCTION & CONTEXT

- 2.1 The 1830 Warehouse was constructed as a storage facility for goods transported by rail on the adjoining line, which passes over a brickwork viaduct directly abutting the south elevation. The viaduct track level is slightly below first floor level in the Warehouse.
- 2.2 The building has a solid brickwork external envelope and is separated internally into 5 individual 'Bays' by brickwork cross walls. The internal structure of the Bays is predominantly of timber frame construction with cast iron columns also present at basement level. The Bays are numbered 1 – 5 from west to east on plan.
- 2.3 At the south elevation, at least large one cargo door opening is present to each bay (refer to elevation drawings in the architectural and heritage consultant's reports). These openings were utilised in the past to allow small goods wagons to enter the warehouse building for unloading. The internal floor level is around 1 metre above the current track level and it appears that such wagons would have entered the building via a localised lower level of floor structure for ease of unloading.– this arrangement is still visible in Bay 4. In the remaining bays, the lower floor structure has been removed and supplementary timber structure added to infill these areas to match the main floor level.
- 2.4 Although the overall structural opening sizes remain historically consistent, a range of infill configurations exist with a mixture of timber doors and glazing, with and without brickwork spandrel panels to bring the base of the doors/glazing up to the internal floor level.

3.0 BAY 1

- 3.1 The cargo door at this Bay is fully glazed. No brickwork infill is present at the base and the internal floor structure appears to have been trimmed back to permit some daylighting into the mezzanine level of the Warehouse. A narrow strip of glass has also been installed internally at floor level and appears to have been intended to be able to support foot traffic, if not permanent loading. The glazing is inserted into a channel cut into the stonework at the sides and head of the opening. It is assumed that this was formed specifically when the glazing was installed as it would not seem have any useful function for timber doors.
- 3.2 The glazing was supported at the base on a timber 'sill' with brickwork under. The top surface of the sill and the base of the glazing are at or very close to the external ground level (Photograph 1). An external rendered apron is provided directly adjacent to the building with a concrete drainage channel beyond.



Photograph 1: General view of the lower part of the glazing externally showing sill/base flush with the external ground level.

- 3.3 Various attempts have been made at waterproofing this junction using bituminous sheet materials and liquid membranes (Acrypol or similar). These efforts have ultimately been unsuccessful, and the sill has almost completely decayed (Photographs 2 and 3)



Photograph 2: General internal view showing the floor joists cut back and re-supported on a new sub-frame. The decayed sill is visible beyond.



Photograph 3: Detail view showing severe timber decay to the sill.

- 3.4 The timber decay has caused the glazing panels to lose support and drop out of the perimeter channel. The floor level horizontal glazing panel is also not unsupported and at risk of collapse if accidentally weighted.
- 3.5 Some temporary measures have been installed to make the glazing safe, but a permanent solution is urgently required.
- 3.6 The structural requirement is to provide adequate support at the base and utilise materials that not vulnerable to water damage. In this instance, brickwork bedded on lime mortar would be an option and provide the required safety and longevity and an alternative is to create an insulated metal sill as part of the structural glazing system, assuming that improvements are made to water management generally.
- 3.7 There are various long-standing water ingress and management issues in the viaduct area which have been subject to past and ongoing investigation by others. The decay to the sill is probably mainly due to rainwater running down the glazing to the base of the window however, we cannot exclude the possibility that other defects or water flows on viaduct may be contributing to the issue. Whilst it would be beneficial overall to address these matters, the exclusion of timber supports should help to mitigate any residual risks.
- 3.8 Due to inconsistency of the infill arrangements and historical evolution, it is not clear whether the base of the structural opening was originally completely flush with the track level or whether any kind of upstand was present. Although lime mortar brickwork is robust, it remains somewhat vulnerable to mortar washout in the long-term if consistently wet. There would be structural benefit in considering formation of a brickwork upstand of up to 150mm height as part of improvements to the waterproofing arrangements. This will however need to be considered in the context of the entire elevation and any visual impacts.

4.0 BAY 2

- 4.1 The cargo door at this Bay is fully glazed. The lower level floor has been removed and infilled internally with the revised timber floor structure extending to and bearing onto the external brickwork. This brickwork appears to have been retrofitted to support the timber structure.
- 4.2 The timber framing arrangements vary slightly due to the presence of a crane internally but most of the floor joists extend through the wall and project to provide support for a (now defunct) sliding door externally (Photographs 4, 5 and 6).



Photograph 4: General external view of the base of the glazing showing floor joists projecting through the wall.



Photograph 5: General internal view of the glazed opening.



Photograph 6: Internal view showing the timber framing arrangement and joists passing through the wall.

- 4.3 The glazing has also dropped at this bay and it is assumed that this is due to decay of a timber sill, although confirmation through intrusive investigation will be needed.
- 4.4 Extensive decay has also occurred to the timber joists passing through the wall (Photograph 7) as well as to the timber plate externally below the joists (see Photograph 5).



Photograph 7: Typical example of decay to floor joist projection

- 4.5 This decay has occurred due to rainwater running of the glass surface and draining onto the timber elements under. Most of these joists appear to have been replaced during major works circa 1992/3 so have not proved durable due to existing poor water management.
- 4.6 The glazing remains somewhat better supported in this location as its potential for further movement in the short-term is limited by the brickwork below the presumed sill. We do note that decay of the timber wall plate below the joists could result in settlement of the brick courses above and further movement to the glazing.
- 4.7 The structural works at this location will involve extraction and like for like replacement of the decayed timber elements. Some localised rebuilding of brickwork will also be needed, and bricks would be reused wherever possible. This work will need to undertaken in tandem with improvements to waterproofing details and flashings to prevent the problem from recurring in future.

5.0 BAY 3

- 5.1 The glazing arrangement at Bay 3 is very similar to that previously described at Bay 1 (Photographs 8 & 9). The waterproofing detail externally is similar in design but is in much better condition and appears to retain some fall away from the building at the base of the glazing to direct water towards the drainage channel.



Photograph 8: General external view of glazed opening at Bay 3.

- 5.2 Some water ingress has nonetheless occurred at the base of the glass, as evidenced by staining to the timber bearer internally (Photograph 9). Direct access for 'hands-on' inspection was not possible due to the high level location in the foyer area internally. It is assumed that the supporting timber was in better condition at the time of inspection than the equivalent at Bay 1 as there was no obvious sign of glass slippage due to loss of support. This nonetheless remains a poorly designed structural detail and will have ongoing vulnerability to water ingress and decay of the timber support.



Photograph 9: General internal view of glazing support and floor framing arrangements at Bay 3 showing water staining to the timber support at the base of the glazing.

- 5.3 A similar scope of structural repair work to that at Bay 1 could be considered here and either implemented preventatively in the short-term or undertaken in future if and when decay of the supporting timber advances. Due to potential safety issues arising from loss of support to the glazing, there would be a case for preventative action, particularly as no historic fabric would be adversely affected by such works.
- 5.4 The embedded ironwork from the historic door hinges remains in place but has corroded and cracked the architrave stonework (Photograph 10). This is not of structural significance yet but does need to be addressed. Previous project experience at Bay 5 suggests that, although extraction and cleaning would be the best solution, removal without further damage is impractical and in-situ treatment is preferable.



Photograph 10: Corroded historic hinge ironwork at Bay 3

6.0 BAY 4

- 6.1 Bay 4 is generally considered to have retained the most 'original' arrangements within the building both structurally and architecturally. The lower level floor structure at track level is still present internally (Photograph 10) and a timber door remains present to cover the structural opening in the external wall (Photograph 11).



Photograph 10: General internal view at Bay 4 showing locally lowered floor structure to allow goods wagons to enter.



Photograph 11: General external view showing timber door and sill.

- 6.2 A timber sill of circa 150mm height is provided at the base of the opening, presumably for weather protection, but it is not known whether this replicates the original detail as the historic track level at the time of construction cannot be conclusively confirmed. This sill is in any event non-structural as the doors bear onto pins externally which are presumed to be set into mass concrete pads. The upper hinges are fixed to ironwork set into the stone architrave blocks.
- 6.3 There is no waterproofing visible at the sill and water does seem to track underneath on occasion as evidenced by staining and salt deposition on the stonework internally (Photograph 12). There was no visible evidence of decay to the timber sill however some intrusive investigations would be recommended to confirm whether the underside has deteriorated where damp.
- 6.4 No structurally significant defects were observed around this opening.



Photograph 12: Water staining internally at the Bay 4 door opening.

- 6.5 Although we cannot conclusively confirm that the current door arrangement at Bay 4 is faithful to the original scheme, it seems highly probable that some kind of upstand was present at the opening to act as a weather and debris barrier. This may have a bearing on any future decision to provide a similarly sized upstand when re-glazing at Bay 1 and potentially at Bay 3 in the future as, in addition to providing durability and safety benefits, an upstand may be considered to be more in keeping with historical detailing.

7.0 BAY 5

- 7.1 Bay 5 was subject to extensive internal remodelling in the early 1980s. All internal timber floor structure was removed and replaced with pre-cast and in-situ reinforced concrete slabs and steel beams.
- 7.2 Two cargo doors were originally present at Bay 5. The left-hand (west) door opening has been partially infilled externally with a brick spandrel panel up to the internal floor level (Photograph 13). The remaining space is occupied by a pair of timber doors mounted at the inside of the opening (as opposed to the historical position of the doors on the outer face)



Photograph 13: Bay 5 – left-hand (west) door opening.

- 7.3 No structural defects were observed around this opening although we note that the original embedded hinge components are also corroding and cracking the stonework. Whilst the doors could be modified for architectural or aesthetic reasons, there is very limited potential for removal of the brickwork spandrel panel (possibly to create an effect similar to that at Bays 1 and 3) due to replacement of the timber floor structure internally.
- 7.4 The right-hand (east) door opening has been infilled with glazing, although in this instance the external timber doors have also been retained (Photograph 14).



Photograph 14: Bay 5 – left-hand (west) door opening.

- 7.5 The floor structure directly adjacent to the right-hand door opening is a landing area forming part of a cast in-situ reinforced concrete staircase. The glazing infill bears onto this concrete structure with no timber visible at the base (Photograph 15). An approximate 150mm upstand height is also present here.
- 7.6 No structural defects or water ingress were observed in this location. The doors have been replaced as part of recent external works. The water proofing detailing beyond the concrete slab is noted be in poor condition (as is the case generally along the elevation).



Photograph 15: Bay 5 – detail view of glazing base area

1830 Warehouse

Museum of Science & Industry, Manchester

Internal Structural Inspection Report

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Version 1.1

05 December 2022

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1.0 BRIEF

- 1.1 Conisbee were appointed by our client, the Science Museum Group to undertake a detailed visual inspection of the internal structure of the 1830 Warehouse in order to record the condition of the building fabric and structure, provide recommendations for maximum floor loadings, and to propose appropriate remedial solutions to address any notable defects or deterioration.
- 1.2 Simon Wilkinson and Ben Angus of Conisbee visited site on 19th July 2022 and carried out the visual inspection of the structure.
- 1.3 No fixtures or fittings were removed, or intrusive/destructive testing undertaken, however comprehensive photographs were taken for record purposes. A selection of photographs is included in this report – others are available on request.
- 1.4 Whilst our investigation work has been taken far enough to satisfy the requirements of the brief, it has, of necessity, not been exhaustive. The findings cannot therefore be warranted to apply to areas of the building not inspected or investigated.
- 1.5 The building fabric has been assessed as observed at the time of inspection and the condition may be subject to change between the time of recording and commencement of works on site.
- 1.6 This report is intended for the use of our client, the Science Museum Group, and no liability can be accepted for use by any third party.
- 1.7 In summary, the requirements of our involvement are three-fold –
 - Establish that these structures are, and will remain, suitable to support the floor, roof, and walls in its current arrangement.
 - Appraise the condition and material of the structure to understand what maintenance or remedial works are likely to be required in the short and long term.
 - Based on findings, give recommendations for maximum floor loadings (by level and by bay) in kilograms per square metre.
- 1.8 This report builds on the previous preliminary structural appraisal by Conisbee carried out in 2018 (180426 / S Brookes report), & Hutton & Rostron's November 2018 timber condition survey report of the roof structure (210.58). This report should also be read in conjunction with Conisbee's defects and loading plans in Appendix B & C.

2.0 PROPERTY TYPE, CONSTRUCTION & CONTEXT

- 2.1 The 1830 Warehouse is Grade I listed for its special architectural and historic interest. The identity of the architectural designer remains speculative with both George Stephenson and Thomas Haigh being suggested as candidates however it is known to have been constructed by contractor David Bellhouse Jr in 1830. It is thought to be the world's first railway warehouse building and also forms a contiguous part of the world's first railway station, located on the opposite side of the viaduct to the south.
- 2.2 The building is slightly curved on plan, presumably to follow the line of the railway viaduct to south to which it abuts. For the purposes of this report, the elevations are assumed to be orthogonal about the compass axis. The building has 4 main storeys (inc. basement) but with an intermediate 'mezzanine' floor between Ground and 1st at Bays 1 and 2, only. Working top down, the floors are identified as follows –
- Roof
 - 2nd Floor
 - 1st Floor
 - Mezzanine Floor
 - Ground Floor
 - Basement
- 2.3 At roof level, the building presents as 10 individual gable-ended bays each with dual-pitched roofs with ridgelines running approximately north-south. The building description presented in this report follows the internal structural layout which is formed of five double bays each separated by load-bearing brickwork walls. The bays are numbered from 1 to 5 running west to east for ease of reference.
- 2.4 The structure generally comprises load bearing red brick walls laid in lime mortar in Flemish bond which form the outer envelope with brickwork internal cross walls running north south and separating each bay. The internal structure within each bay (including the roofs) comprises traditional cut timber framing. Queen post trusses span between bay cross walls and beams and columns providing support at the central valley of each bay. The trusses support 2 no. purlins to each pitch supported on cleats and embedded in the gable wall masonry.

2.5 Dimensions of timber floor structure elements as follows (depth x width) –

Basement, Ground & Mezzanine members:

- Timber columns 240mm x 250mm (3.6m centres north / south, and 4m east / west)
- Timber beams 360mm wide x 360mm
- Floor joists 250mm x 145mm (typically 530mm centres)

First & Second floor members:

- Timber columns 240mm x 250mm
- Timber beams 350mm wide x 330mm
- Floor joists 250mm x 145mm (typically 530mm centres)

2.6 Dimensions of timber roof elements as follows (depth x width) –

Queen-post trusses:

- Principal rafters 210mm x 120mm
- Tie beam 350mm x 180mm
- Straining beam 220mm x 130mm
- Queen posts 190mm x 120mm
- Struts 80mm x 80mm

Principal members:

- Upper purlin 240 x 150mm
- Lower purlin 240 x 150mm

2.7 The vertical loads from the roof trusses are transferred to the cross walls, gutter beams, and regularly spaced timber columns down to 'yard level,' then into cast iron columns at basement level and ultimately the building's foundations. Similarly, floor loading in each bay transfers from the floor joists into north south floor beams and into the timber columns and cast-iron columns at basement level.

2.8 Externally the bays on the north-east elevation generally follow a pattern of having either one or two full height loading-bay openings in the brickwork with either single or paired window openings at first and second floor level. Hoisting equipment to lift goods into the warehouse at each level was installed at the top of each slot opening and although no longer operational, remnant elements are present in most bays.

- 2.9 Hutton & Rostron undertook a localised inspection of internal structural timbers at the south elevation of Bay 4 in November 2015. This report addresses distortion and cracking in replacement timber lintels, beams, and joists (installed in 1992) and also notes that cracking has occurred in surrounding masonry following drying shrinkage of unseasoned timber. Recommended remedial actions include moderating heating levels within the building to reduce excessive drying, and thereby permit slow partial rehydration and expansion of the affected timber.
- 2.10 Hutton+Rostron conducted a further damp and timber decay survey at the roof frame (only) on 6-7 November 2018. The findings of this survey have been taken into consideration in this report, but reference should still be made to their report, in conjunction with Conisbee's.
- 2.11 Extensive repair works are understood to have been undertaken in around 1992 as part of a project to convert the building into a gallery space. The full extent of these works cannot be fully confirmed through reference to archive materials but internally appears through visual inspection to have included extensive timber repair and replacement, including to the bearing ends of tie beams, principal rafters, and purlins together with replacement of roof finishes and leadwork externally. Internal frame repairs include fabricated stainless-steel flitches with through-bolted connections and scarf joints.

3.0 INSPECTIONS & REPORTING

- 3.1 Our inspection methodology involved a visual inspection of the internal building structure, gaining hands-on access wherever possible and using a ladder where appropriate, to record and photograph each individual defective or deteriorated item or area. This provided a comprehensive record of the condition of the internal frame. Photos from the visual inspection are found in Appendix A. For general location of the photos, refer to the annotated floor plans in Appendix B.
- 3.2 No safe access was possible to the highest parts of the roof structure for inspection of structure or finishes, however there was no obvious further deterioration or change over and above matters reported by Hutton & Rostron in these areas.

4.0 OBSERVATIONS

Annotated floor plans relating to the below observations are provided in Appendix B. Note that the measured survey drawings are reflected ceiling plans, and as such the observations noted on the plans refer to the structure above, as visible from that level (i.e. notes on first floor plan relates to the floor structure of the second floor as viewed from below). Conversely, the structure elements described in this report are referred to in their direct location (i.e., first floor structure described is the floor structure of the first floor).

4.1 TIMBER FRAME

- 4.1.1 Deflection of the bottom chord of the primary longitudinal roof trusses was noted in multiple locations, suggestive of under-sizing and/or overloading. The deflection is most pronounced at Bay 2, where there has been historic overloading of the trusses during goods movement into and out the warehouse. Significantly sized lifting beams are secured to the side of these tie beams and running north-south between trusses. In 2 No. locations, the tie beam (bottom chord) has actually snapped (see photos 21 & 22).
- 4.1.2 Square Hollow Section (SHS) steel columns (4No) have been installed in recent times to prop the failed trusses as well as the adjacent truss to the North, which receives the other end of the old lifting beam. Tracking the location of these SHS props through the floor, it was noted that the columns are sat on the boards between joists, and away from primary North-South beams.
- 4.1.3 The tie beam of a primary truss to the south of the two locations noted above has also failed (see photos 23 & 24). The failure in the southern truss is close to the position of a knot which is a natural weak point, as well as being close to the king post tension rod, from which the tie beam is effectively hung.
- 4.1.4 The floor levels vary within each bay, with distortions in the plane of the floor easily visible to the naked eye (see photos 17 & 18), as well as noted from the spot levels on the measured survey. This local change in floor joist level is dictated by the level of their bearings at cross beams and ultimately, the level of the column supports. The magnitude of this variation shows a higher depression in the upper levels, notably in two locations the south side of Bay 2 & 3.

- 4.1.5 The timber floor framing at in the old platform locations at ground and 1st floor, typically uses a single bolt side fixed plate / corbel onto which the 1st floor primary beam dead-bears (see photos 11 & 12). In various locations shown on the observation plans, shrinkage and frame racking has reduced the bearing of timber beam, with very little contact remaining in some locations.
- 4.1.6 Throughout the building there are locations where initial design, shrinkage and frame racking has resulted in floor joists with minimal bearing (see photos 3, 4 and 9). This is exacerbated at column locations, where the full depth bearing of the columns from above further reduces the bearing of the floor joists.
- 4.1.7 Various timber joists and isolated timber beams are noted to show cracking (both longitudinal and shear), at ground, mezzanine and first floor level (see photo 13). The majority of locations the beams do not appear to be at risk of progressive failure, however the capacity of the beam remains limited by the reduced cross section.
- 4.1.8 Reference should also be made to Hutton & Rostron's timber condition report on the roof frame, although most structural defects in that report were repaired in recent Urgent Remedial Works package.

4.2 BRICKWORK ENVELOPE

- 4.2.1 Various 'fine' to 'moderate' vertical and diagonal cracks were noted at the cross walls of the building, particularly beneath lintel bearings at door penetrations. Some of these cracks have been filled with a cementitious grout mix.
- 4.2.2 At the north elevation, the brickwork piers between the loading bays were previously observed to be bulging outwards, and to have relatively poor lateral restraint. The bulging is likely attributable to a combination of axial shrinkage of the internal frame, combined with irreversible expansion of the brickwork following firing. The joist direction at the north elevation is generally parallel to the wall and supporting beam embedment's are therefore intermittent. Some steel restraint tie straps had been installed but some had later been cut to install perimeter trench heating circa 1992. New stainless steel restraint ties were installed across Bays 1 – 4 at first and second floor levels during the recent works to address the issue.

4.2.3 The floor joists at each level largely run longitudinally, parallel, and clear of the north and south long elevations, bearing onto cross walls between each bay and perpendicular primary beams (ridge and valley). These north-south spanning primary beams bear into pockets in the wall and along with the cross walls, provide intermittent restraint to the long elevations. Shrinkage of the timber appears to have reduced the bearing length of these embedded beams, but not observed to a concerning degree.

4.2.4 Vertical and diagonal cracking was noted at various locations up the inside face of the piers (see photo 7 & 8) either side of the tall doors at the North elevation, which possibly suggests high localised stresses. Historic crack filling was evident suggesting that the issue may be ongoing.

4.3 MOISTURE INGRESS

4.3.1 Minimal historic staining at top floor level was noted, localised to the top and sides of the valley beams, suggestive of historic valley gutter blockage, rather than liner failure.

4.3.2 There appears to be a small risk of moisture ingress at roof level in Bay 4 where the lime mortar torching beneath the roof tiles is not well keyed into the timber battens. This has been noted by the Science Museum Group as a concern due to the falling mortar elements.

4.3.3 There appears to have been a history of water penetration via the gable ends and many of the purlin bearings have been repaired as a result of timber decay. Salt crystallisation on the internal surface of the gable brickwork is indicative of a history of wetting and evaporation. These repeated cycles of dissolution/crystallisation have caused stresses within the brickwork, causing some minor spalling of brick faces in these areas. The gable ends have recently been repointed in lime mortar externally which should reduce moisture penetration and provide accelerated drying as compared to the previous cementitious pointing.

- 4.3.4 The majority of the timber throughout the structure appears to be dry and without substantial historic or current decay – the majority of these issues were addressed in the early 1990s and then subsequently in the most recent works. There are a small number of locations at ground, mezzanine and first floor level where some deterioration is apparent that has not been previously addressed. These areas are currently dry but the extent of any loss of structural integrity can't be visually confirmed. Photo 10 shows a typical location in Bay 1 as viewed at ground floor.

4.4 METALWORK

- 4.4.1 Minor surface corrosion was apparent on the horizontal bearing face of the basement level cast iron column heads. No significant section loss was evident, and no remedial works are required, although the shoe is without weep holes and moisture could get trapped.
- 4.4.2 At basement level, there was moderate surface corrosion noted in Bay 1 where diagonal iron beams are embedded in the corners to support the primary timber floor beams (see photo 1). This has resulted in some minor spalling of brick faces in these areas. No significant section loss was evident.
- 4.4.3 A heavily corroded downpipe penetrates through the inside face of the South wall at basement level. There is no evidence of salt deposits or tide marks around the opening which may suggest the penetration does not pass through the full thickness of the wall, but the pipe itself is exhibiting moderate to high levels of corrosion and further investigation is warranted to determine its functionality.

4.5 FOUNDATIONS

- 4.5.1 Inspection at basement level showed variation in the cast iron column's foundations, with some on monolithic stone bases, some on cast concrete pads. The perimeter brick wall at basement level supports the north south floor beams and structure above, and also works as a retaining wall. The foundations to the wall are not visible onsite but assumed to be corbelled brick footings.

5.0 DISCUSSION

5.1 Following Conisbee and Hutton & Rostron's on-site inspection work, the assessment of the structure has adhered to the following process:

- Review historical and chronological context.
- Understand the performance of the structural system (construction, load transfer, stability).
- Review the condition of structural members and investigate the causes of any defects discovered.
- We have structurally modelled elements to aid our understanding of the structural behaviour of the frame and have undertaken a design check to assess its capacity and give recommendations for maximum floor loadings (by level and by bay) in kilograms.

5.2 Hutton & Rostron's 2018 timber species assessment provided the basis for our structural assessment of the frame –

- Roof framing - Softwood Scots pine (*Pinus sylvestris*)
- Posts/Columns - Hardwood Oak (*Quercus spp*) OR Hardwood Sweet Chestnut (*Castanea sativa*)

5.3 The broad approach of the loading assessment and repair recommendation work is to attempt to prevent future deterioration based on a minimum intervention approach in line with sound conservation principles. The aim is to retain as much of the existing fabric as possible and to incorporate good conservation maintenance, by repairing currently defective elements using compatible techniques and materials that will not compromise the long-term health of the building structure and decorative features.

5.4 Generally, the timber frame is sound and not unduly concerning from a structural perspective. The speed with which this building was erected is evident in the form of rudimentary jointing with initial limited bearing, which is exacerbated in some locations (primarily beneath columns) by unchecked drying shrinkage of the horizontal members.

- 5.5 The primary concern resulting from the axial shrinking, initial construction and supplementary repairs issues focuses on the limited bearing area of many of the timber beams and joists. Whilst in most cases the limited bearing does not appear to result from progressive movement, a repair in multiple locations to enhance the bearing would be recommended to enhance the load capacity and robustness of the structure.
- 5.6 It is evident that historic local overloading of the truss bottom chords in second floor Bay 2 is the cause of the additional, more pronounced deflection and tie beam failure. Semi-permanent propping in the form of SHS posts have been installed (likely in 1992) and serve to transfer the roof load to the floorboards and joists of the 2nd floor, and away from primary structure. The failure of the tie beam in this Bay 2 truss means that the post at this location will be receiving the majority of the roof load, and it is our opinion that the floorboards and joists under are not suitable to receive such loading in the long term. Whilst no failure is evident in the boarding, minor stress fractures were seen in the joist directly below the prop that is beneath the failed truss A repair should be implemented to re-establish the structural integrity of this tie beam thereby re-instating the original load path down the primary timber posts.
- 5.7 The truss bottom chord immediately to the south of the propped trusses has also failed with vertical cracking observed. The failure in the tie beam is close to the king post tension rod, which is the location of the greatest vertical load in the truss. As such a repair should be implemented to enhance the shear capacity of the tie beam and enhance the robustness of the truss.
- 5.8 Our on-site observations showed that the floor plates at each floor level and within each bay were at variable levels. Axial shrinkage of the timber columns will undoubtedly have affected the length of each column and consequently the bearing level of each primary beam, on-site review showed the magnitude of depression to be most pronounced at first and second floor level on the south side of Bays 2 & 3. New columns are observed directly beneath these depressions at ground floor level, and it is assumed that the additional axial shrinkage of the new columns along with the inevitable settlement during install has resulted in these locations having greater magnitude of depression.

- 5.9 Localised areas of brickwork and stonework joints at the inside face have been re-pointed using a modern conventional sand and cement mortar. The age of this work could not be confirmed however it is unlikely to post-date the known previous internal repair works undertaken in 1992 due to increased awareness of appropriate mortar choice and planning controls.
- 5.10 Various brick piers at basement level displayed vertical cracking adjacent to timber beam bearing, which possibly suggests high localised stresses. Historic crack filling is evident in some locations. Whilst the brick piers do not appear to be at risk of failing, providing re pointing and reinforcement across the cracks will tie the piers into the perimeter walls re-establishing the robustness of the structure.
- 5.11 At basement level, there was moderate corrosion noted in Bay 1 where diagonal iron beams are embedded in the corners to support the primary timber floor beams. This corrosion is to be expected as the masonry at this level retains the damp earth beyond. This has resulted in some minor spalling of brick faces in these areas. It appears that no significant section loss was evident, however this should be cleaned down to expose the degree of corrosion.
- 5.12 The majority of the timber throughout the structure appears to be dry and without substantial historic rot decay. However, for the small number of locations at ground, mezzanine and first floor level where deterioration due to moisture is apparent, it is recommended to have Hutton & Rostron inspect and report on the timber condition.

6.0 LOADING RECOMMENDATIONS

- 6.1 Annotated floor plans of the allowable imposed loading described below are provided in Appendix C.
- 6.2 Whilst this investigation has been taken far enough to inform the load recommendations, it has not been exhaustive and as such occurrences of localised hidden defects to the structure may be present, altering the localised structural performance. It is recommended that local checks should be made prior to positioning any high concentrated loads to ensure they do not overload areas with defects.

- 6.3 The vertical loads from the roof are transferred to the roof trusses and in turn are passed through the cross walls and through regularly spaced timber posts down to 'yard level' and into cast iron columns at basement level. The existing floor structure consists of timber joists which span onto primary timber beams and into the columns down to yard level. The lateral stability of the structure is maintained by horizontal loads being transferred through the plate action of the floor structure and into the brick walls in the longitudinal and transverse direction. Additionally, the timber structure provides a degree of sway frame stability due to its double height columns and bracing elements.
- 6.4 The analysis of the individual members determined that the capacity of a typical grid of timber joist, beams, and columns (sizes taken from the smallest observed on site) was limited by the primary timber beams (see photo 9) which ranged from 330mm x 340mm to 360mm x 380mm. The maximum allowable imposed load capacity assessed for the general floor grid is 2.5kN/m².
- 6.5 The above typical grid loading has been reduced in areas where defects are noted to have an impact on load capacity and robustness of the structure (i.e., notched ends of floor joists with minimal bearing). These areas have been assessed to have an allowable imposed load capacity of 1.5kN/m². If repairs are undertaken, the allowable imposed loads may be increased.
- 6.6 The stair wells, circulation spaces, and steel structure in bay 5 at ground, first and second floor level was constructed in the late 20th Century. These areas have been assessed as having an allowable imposed load capacity of 4.0kN/m². This is based on the observed structural layout, condition, and the assumed code requirements during the time of design / construction. The Eurocode (C35) and former British Standard requirements for load capacity of imposed loading stairs, landings in public, museum or institutional buildings is 4.0kN/m².
- 6.7 The basement level floor structure is observed to be typically a ground bearing brick floor. These are understood to be founded on the well consolidated made ground and the underlying dense gravelly sand. The basement is assessed to have an allowable imposed load capacity of 10kN/m².

7.0 RECOMMENDATIONS AND REPAIRS

- 7.1 The majority of the more minor defects affecting the durability of the structure can be addressed with relatively minor, yet carefully considered repairs. These should be approached by a specialist conservation repair contractor.
- 7.2 The overall structural stability of the internal timber frame is adequate, with the early 1990's repairs addressing the majority of major works. There are outstanding significant issues relating to the acceptability of the historic propping of such trusses in Bay 2; deterioration of adjacent truss; the limited bearing of a proportion of the floor joists onto floor beams; and the deflection of the primary transverse trusses.
- 7.3 Our outline remedial recommendations are as follows:
- 7.3.1 Minimal bearing –
- Ground floor (observed from basement). A primary beam splice is positioned at the edge of a cast iron column head plate. The connection should be reinforced to reduce eccentric loading of the cast iron column.
 - Ground floor structure (observed from basement) - Bay 1, 3 and 4. Floor joists have reduced bearing length on the floor beams in multiple locations. Continue to monitor the locations and avoid overloading the floor structure.
 - First floor structure (observed from ground) – Bay 2. Floor joists have reduced bearing length on the floor beams in various locations. Continue to monitor the locations and avoid overloading the floor structure.
 - Roof truss. A reduced bearing length of an upper beam at a primary roof truss in Bay 2. Install formal monitoring devices.
 - Where additional load capacity is required beyond that recommended, support brackets should be installed in locations of minimal bearing to enhance the robustness of the floor structure.
- 7.3.2 Heavily split mezzanine floor joists -
- Severe shrinkage of floor joists visible from ground floor level in Bay 2 has led to significant splitting. The joists should be replaced in the long term, like for like in both materials and dimensions.

7.3.3 Failed trusses, Bay 2 –

- Discuss with the Science Museum Group regarding their options for removing the propping.
- To facilitate removing the propping, the bottom chord of the truss should be strengthened across the length of the failed chord using new steel plate details. A repair detail would likely involve plates bolted either side of the bottom chord to span from primary valley beam to wall. Failure and significant bowing of existing bottom chords makes member recovery difficult. Careful consideration of temporary works would be required for all remediation options.
- The failure of the bottom chord of the southern truss in Bay 2 should be addressed using localised plate repairs.

7.3.4 Cracked basement and ground floor brick piers, Bay 1 & 2 –

- Whilst the brick piers do not appear to be progressively failing, diagonal and vertical cracking reduces the robustness of the structure and bearing capacity.
- Install monitoring devices across the cracks,
- Where additional capacity is needed in the floor structure, providing horizontal bed joint reinforcement and re-pointing should be carried out in the brick piers.

7.3.5 Moisture ingress -

- Maintenance of the valley gutters and hoppers serving the rainwater goods should be continued to ensure no gutter overtopping.
- Cleaning of the corroded elements at basement is recommended to assess to extent of section loss and confirm if measures are required to limit progressive corrosion.

8.0 APPENDIX A – PHOTOGRAPHS



Photograph 01: Looking at the southwest corner. corrosion in corner support to ground floor timber floor beam



Photograph 02 – Vertical cracking through a primary beam support pier at the South wall at basement level.



Photograph 03, 04: limited bearing of timber floor joist.

Note base of timber column above floor beam. This limited bearing has been addressed in various areas of the building, however, there remains floor joists which are at increased risk of end bearing / dynamic failure



Photographs 05 - Stepped cracking, mortar loss and historic re-pointing at the face and return of the piers.



Photograph 06 - Floor beam 'but' connection off centre overcast iron column. s. floor beam eccentrically loading cast iron plate.



Photograph 07 – A full height photo of a ground floor pier at the inside of the Northern elevation, showing the extent of vertical cracking evident through bricks.



Photograph 08 – A photo of a ground floor pier at the inside of the Southern elevation, providing limited lateral restraint to the head of the wall.



Photograph 09 – View of limited bearing of floor joist on floor beam, and brick cracking beyond.



Photograph 10 – View from ground floor level of degraded timber post and beam, H&R to review level of rot.



Photograph 11, 12 – View from ground floor (11) mezzanine (12) of east west beams with limited bearing on vertical plate. Vertical plate bolted to column using single M20 bolt. Shrinkage and frame racking has pulled the timber off this bearing and it now very little contact remains.



Photograph 13 – View from mezzanine floor level of cracking in floor joist.



Photograph 14 – Service penetrations in precast concrete planks observed from first floor. locally filled using resin / mastic, however minimal corrosion assumed based on staining.



Photograph 15 – View from first floor level of degraded timber post and beam, H&R to review condition of timber.



Photograph 16 – View from first floor level of diagonal cracking in floor beam.



Photograph 17, 18 – View from first (16) and second (17) floor level of general depression in floor level



**Photograph 19 – Steel props at second floor beneath roof truss ties.
Note props load onto second floor beams below (i.e., they are not over
columns)**



**Photograph 20 – A general view of the top floor of the building, showing
typical arrangement of regularly spaced timber columns, block corbel
heads and primary valley beams onto which the timber Queen post
trusses sit.**



Photograph 21 – Square Hollow Section columns (4No), serve to prop failed trusses at the East side of Bay 2.



Photograph 22 – The column head plates are pressed firmly to the underside of the trusses using a threaded plate separation system.



Photograph 23 – Roof truss to the south of propped trusses in Bay 2, with cracking of main tie.



Photograph 24 – Close up of roof truss cracking, to the south of propped trusses in Bay 2, with cracking of main tie.



Photograph 25 & 26 – Roof truss in Bay 1 showing high level splitting in principal rafter.

9.0 APPENDIX B – DEFECTS PLANS

NOTE:
TIMBER STRUCTURE SHOWN IS AT HIGH
LEVEL □ REFLECTED CEILING PLAN □

CORRODED AND PARTIALLY
DELAMINATING DIAGONAL IRON
BEAM SUPPORTING TIMBER
WALL PLATE

MASONRY CRACKING AROUND
EMBEDDED BEAM. PREVIOUSLY
REPAIRED IN CEMENT MORTAR

LIMITED BEARING OF NOTCHED
FLOOR JOIST ONTO TIMBER
BEAM

LOCALISED VERTICAL
CRACKING IN MASONRY,
BENEATH FLOOR JOIST
PADSTONE

CORRODED AND PARTIALLY
DELAMINATING DIAGONAL IRON
BEAM SUPPORTING TIMBER
WALL PLATE

MASONRY CRACKING AROUND
EMBEDDED BEAM

TYPICALLY 350 W x 330 D
TIMBER BEAMS SUPPORTING
145 W x 250 D FLOOR JOISTS

LIMITED BEARING OF
NOTCHED FLOOR JOISTS
ONTO TIMBER BEAM

MASONRY CRACKING
AROUND CORRODED
EMBEDDED BEAM

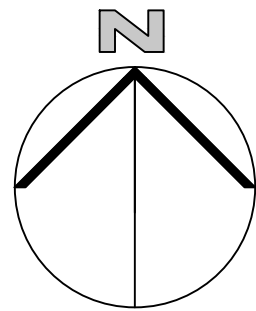
TIMBER FLOOR BEAM 'BUTT'
CONNECTION OFF CENTRE OVER
CAST IRON COLUMN. FLOOR
BEAM ECCENTRICALLY LOADING
CAST IRON PLATE/COLUMN

GROUND BEARING BRICK FLOOR. REFER
TO 2019 SRL SITE INVESTIGATIONS
REPORT FOR GROUND AND COLUMN
FOUNDATION DESCRIPTION

NO VISIBLE DEFECTS IN GROUND
FLOOR STEEL BEAM & CONCRETE
DECK FLOOR STRUCTURE

LIMITED BEARING OF NOTCHED
FLOOR JOISTS ONTO TIMBER
BEAM

FLOOR BEAM 'BUTT' CONNECTION
OFF CENTRE OVER CAST IRON
COLUMN. S. FLOOR BEAM
ECCENTRICALLY LOADING CAST
IRON PLATE



GENERAL NOTES

- THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECTS, ENGINEERS AND SPECIALIST DRAWINGS AND SPECIFICATIONS
- DO NOT SCALE FROM THIS DRAWING IN EITHER PAPER OR DIGITAL FORM. USE WRITTEN DIMENSIONS ONLY.

STRUCTURAL CONSERVATION NOTES

- DRAWINGS ARE TO BE READ IN CONJUNCTION WITH CONISBEE'S STRUCTURAL ASSESSMENT REPORT.
- A SPECIALIST TIMBER DECAY SURVEY IS RECOMMENDED IN CERTAIN LOCATIONS TO FULLY QUANTIFY THE EXTENT OF REPAIR AND REPLACEMENT TO HISTORIC TIMBER STRUCTURE.
- DEFECTS AND OBSERVATIONS SHOWN ARE THOSE VISUALLY CONFIRMABLE ONSITE. FURTHER DEFECTS AND / OR WORK REQUIREMENTS MAY BECOME APPARENT FOLLOWING REMOVAL OF FINISHES AND OTHER INTRUSIVE INVESTIGATIONS.
- THE DESIGN INTENT IS TO RETAIN AND REPAIR AS MUCH EXISTING HISTORIC STRUCTURE AND FABRIC AS POSSIBLE. IT IS ANTICIPATED THAT TRADITIONAL CARPENTRY TECHNIQUES WILL BE USED FOR TIMBER REPAIRS SUPPLEMENTED BY STEEL PLATE OR BRACKET STRENGTHENING WHERE APPROPRIATE.
- WHERE REPLACEMENT IS REQUIRED, THIS WILL BE UNDERTAKEN ON A LIKE FOR LIKE BASIS AND INCORPORATE DISCRETE STRENGTHENING WHERE NEEDED.

DRAWING KEY

DEFECT PHOTO REFERENCE:

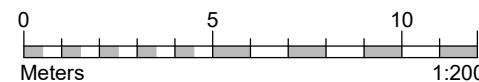
AREA OF LIMITED FLOOR
JOIST BEARING:

LOCATION OF ECCENTRIC LOADED
CAST IRON COLUMN:

LOCATION OF SUSPECTED TIMBER
DETERIORATION FOR H&R REVIEW:

ISOLATED TIMBER FAILURE NOTED:

P10



NOT FOR CONSTRUCTION

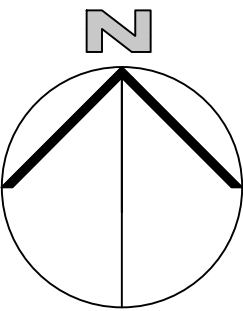
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Rev	Date	Description	Drawn	Check

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Drawing Status INFORMATION

Project	Date	SEP 2022
SIM - 1830 WAREHOUSE INTERNAL STRUCTURE	Scale	1:200@A1
	Drawn	SW
Title	Engineer	SW
BASEMENT PLAN OBSERVATIONS & STRUCTURAL DEFECTS	Project No	220626
Drawing No 220626-CON-XX-00-DR-S-1099	Revision	P1

NOTE:
TIMBER STRUCTURE SHOWN IS AT HIGH
LEVEL (REFLECTED CEILING PLAN)



GENERAL NOTES

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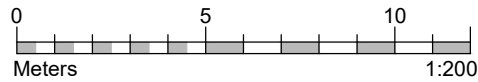
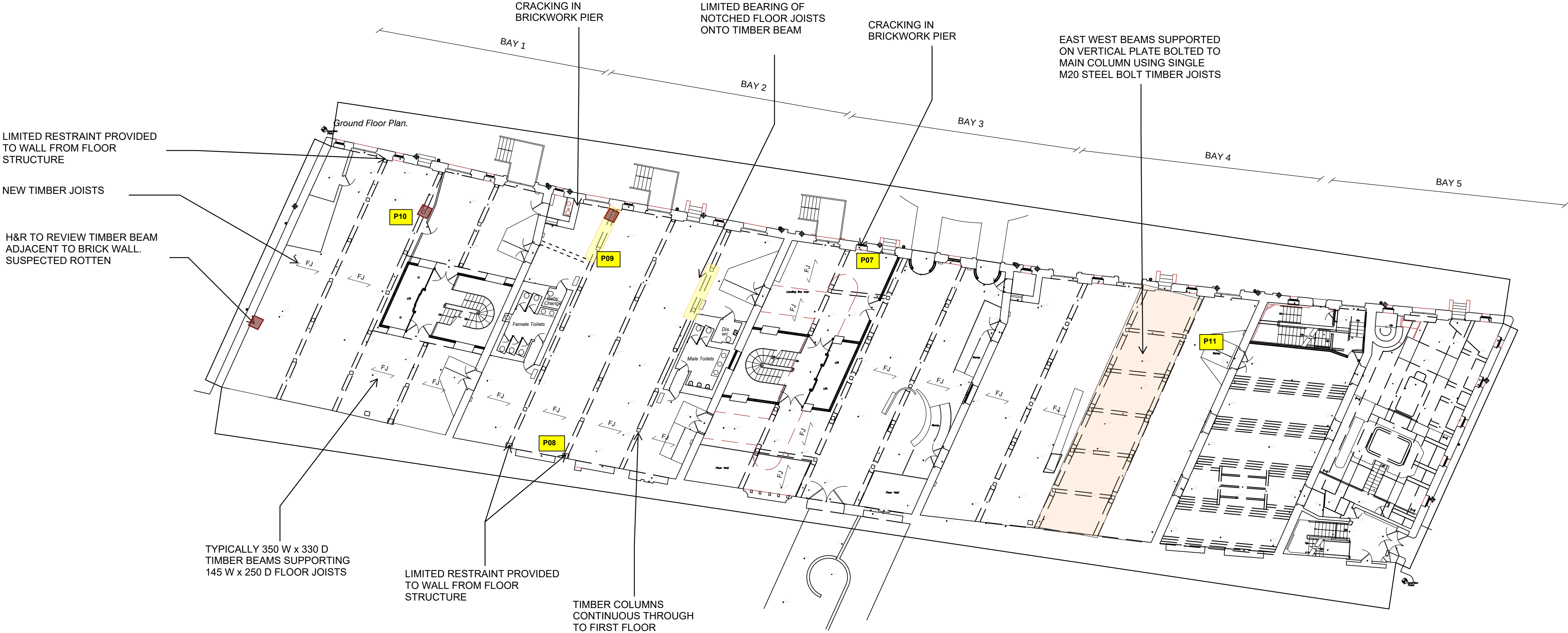
AREA OF LIMITED FLOOR
JOIST BEARING:

LOCATION OF ECCENTRIC LOADED
CAST IRON COLUMN:

LOCATION OF SUSPECTED TIMBER
DETERIORATION FOR H&R REVIEW:

ISOLATED TIMBER FAILURE NOTED:

P10



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P1 29.09.22 FOR INFORMATION BA SW

Rev Date Description Drawn Check

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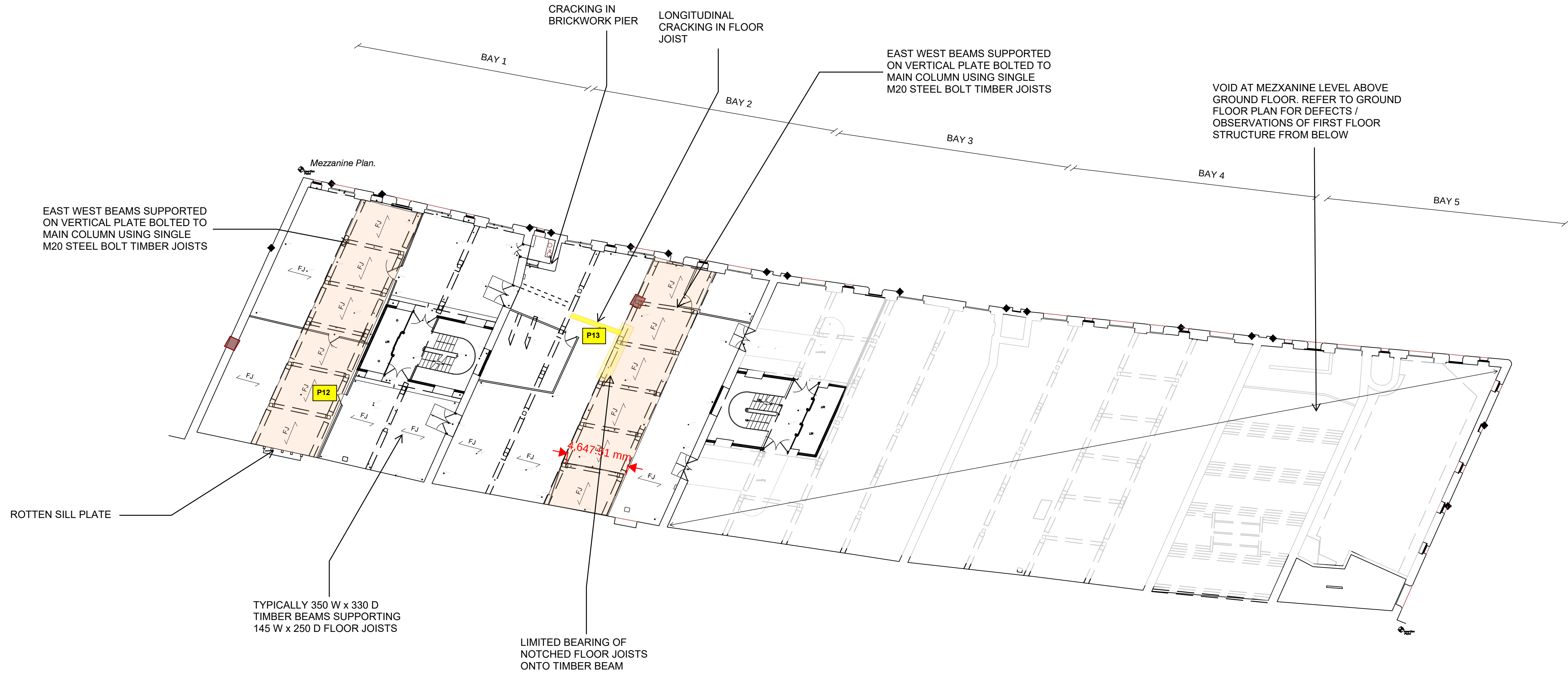
Drawing Status
INFORMATION

Project Date SEP 2022
SIM - 1830 WAREHOUSE Scale 1:200@A1
INTERNAL STRUCTURE Drawn SW

Title Engineer SW
GROUND FLOOR PLAN OBSERVATIONS
& STRUCTURAL DEFECTS oject No
20626

Drawing No
220626-CON-XX-00-DR-S-1100 Revision
P1

NOTE:
TIMBER STRUCTURE SHOWN IS AT HIGH
LEVEL (REFLECTED CEILING PLAN)



GENERAL NOTES

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STRUCTURAL CONSERVATION NOTES

- DRAWINGS ARE TO BE READ IN CONJUNCTION WITH CONISBEE'S STRUCTURAL ASSESSMENT REPORT.
- A SPECIALIST TIMBER DECAY SURVEY IS RECOMMENDED IN CERTAIN LOCATIONS TO FULLY QUANTIFY THE EXTENT OF REPAIR AND REPLACEMENT TO HISTORIC TIMBER STRUCTURE.
- DEFECTS AND OBSERVATIONS SHOWN ARE THOSE VISUALLY CONFIRMABLE ONSITE. FURTHER DEFECTS AND / OR WORK REQUIREMENTS MAY BECOME APPARENT FOLLOWING REMOVAL OF FINISHES AND OTHER INTRUSIVE INVESTIGATIONS.
- THE DESIGN INTENT IS TO RETAIN AND REPAIR AS MUCH EXISTING HISTORIC STRUCTURE AND FABRIC AS POSSIBLE. IT IS ANTICIPATED THAT TRADITIONAL CARPENTRY TECHNIQUES WILL BE USED FOR TIMBER REPAIRS SUPPLEMENTED BY STEEL PLATE OR BRACKET STRENGTHENING WHERE APPROPRIATE.
- WHERE REPLACEMENT IS REQUIRED, THIS WILL BE UNDERTAKEN ON A LIKE FOR LIKE BASIS AND INCORPORATE DISCRETE STRENGTHENING WHERE NEEDED.

DRAWING KEY

DEFECT PHOTO REFERENCE:

AREA OF LIMITED FLOOR
JOIST BEARING:

LOCATION OF ECCENTRIC LOADED
CAST IRON COLUMN:

LOCATION OF SUSPECTED TIMBER
DETERIORATION FOR H&R REVIEW:

ISOLATED TIMBER FAILURE NOTED:

P10

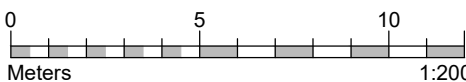
P12

P13

P14

P15

P16



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P1	29.09.22	FOR INFORMATION	BA	SW
Rev	Date	Description	Drawn	Check

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Drawing Status INFORMATION

Project	Date	SEP 2022
SIM - 1830 WAREHOUSE INTERNAL STRUCTURE	Scale	1:200@A1
	Drawn	SW
	Engineer	SW
Title	Project No	220626
MEZZANINE PLAN OBSERVATIONS & STRUCTURAL DEFECTS	Revision	P1
Drawing No		220626-CON-XX-00-DR-S-1101

NOTE:
TIMBER STRUCTURE SHOWN IS AT HIGH
LEVEL (REFLECTED CEILING PLAN)

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DRAWING KEY

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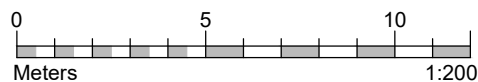
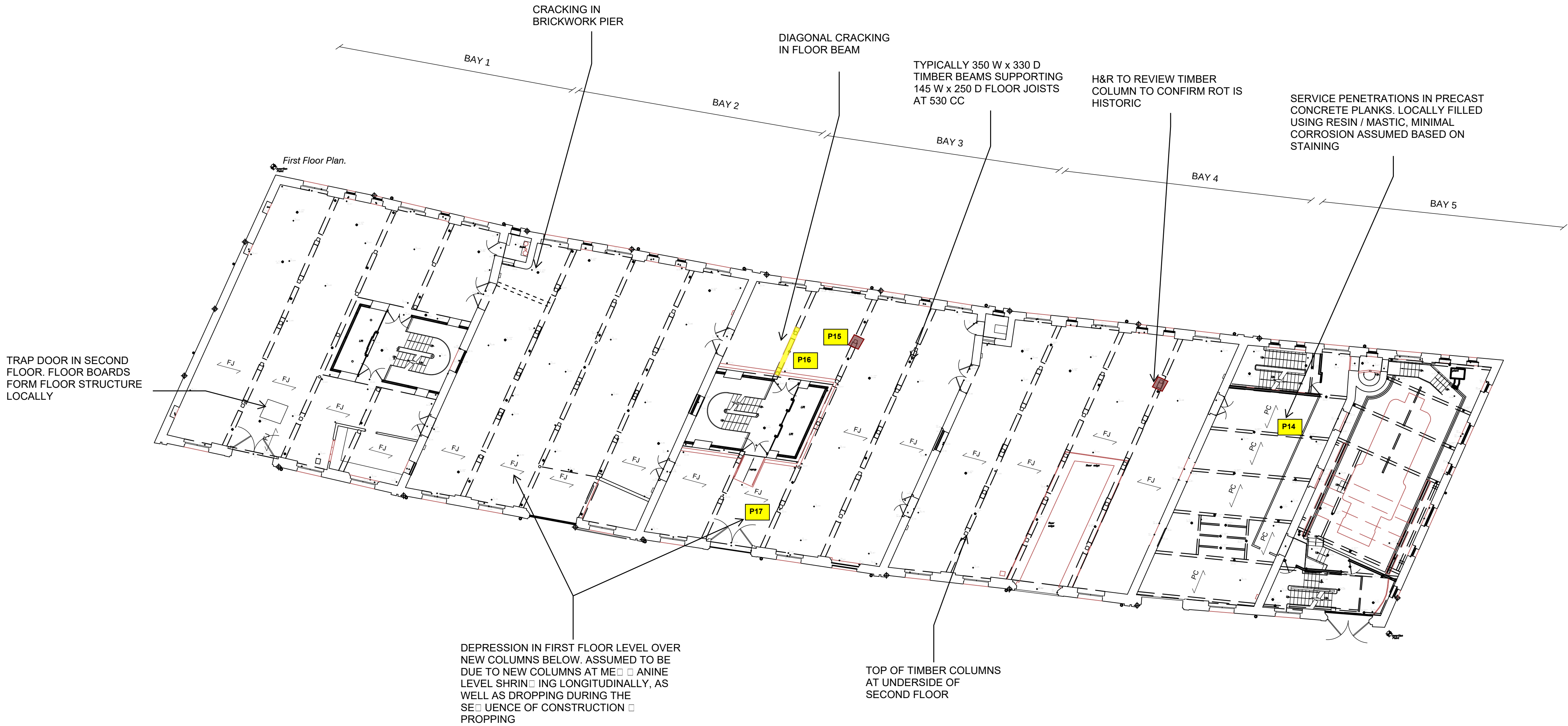
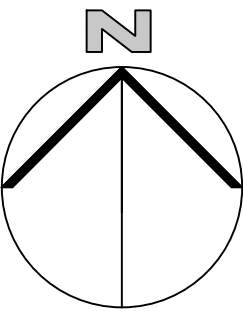
AREA OF LIMITED FLOOR
JOIST BEARING:

LOCATION OF ECCENTRIC LOADED
CAST IRON COLUMN:

LOCATION OF SUSPECTED TIMBER
DETERIORATION FOR H&R REVIEW:

ISOLATED TIMBER FAILURE NOTED:

P10



NOT FOR CONSTRUCTION

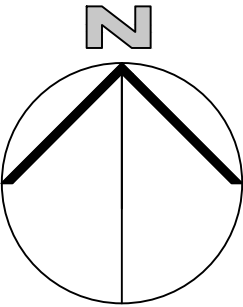
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Rev	Date	Description	Drawn	Check

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Drawing Status
INFORMATION

Project	Date	SEP 2022
SIM - 1830 WAREHOUSE INTERNAL STRUCTURE	Scale	1:200@A1
	Drawn	SW
Title	Engineer	SW
FIRST FLOOR PLAN OBSERVATIONS & STRUCTURAL DEFECTS	Project No	220626
Drawing No	Revision	P1
220626-CON-XX-00-DR-S-1102		

NOTE:
TIMBER STRUCTURE SHOWN IS AT HIGH
LEVEL (REFLECTED CEILING PLAN)



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DRAWING KEY

DEFECT PHOTO REFERENCE:

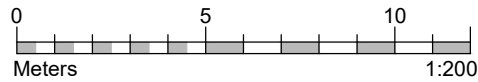
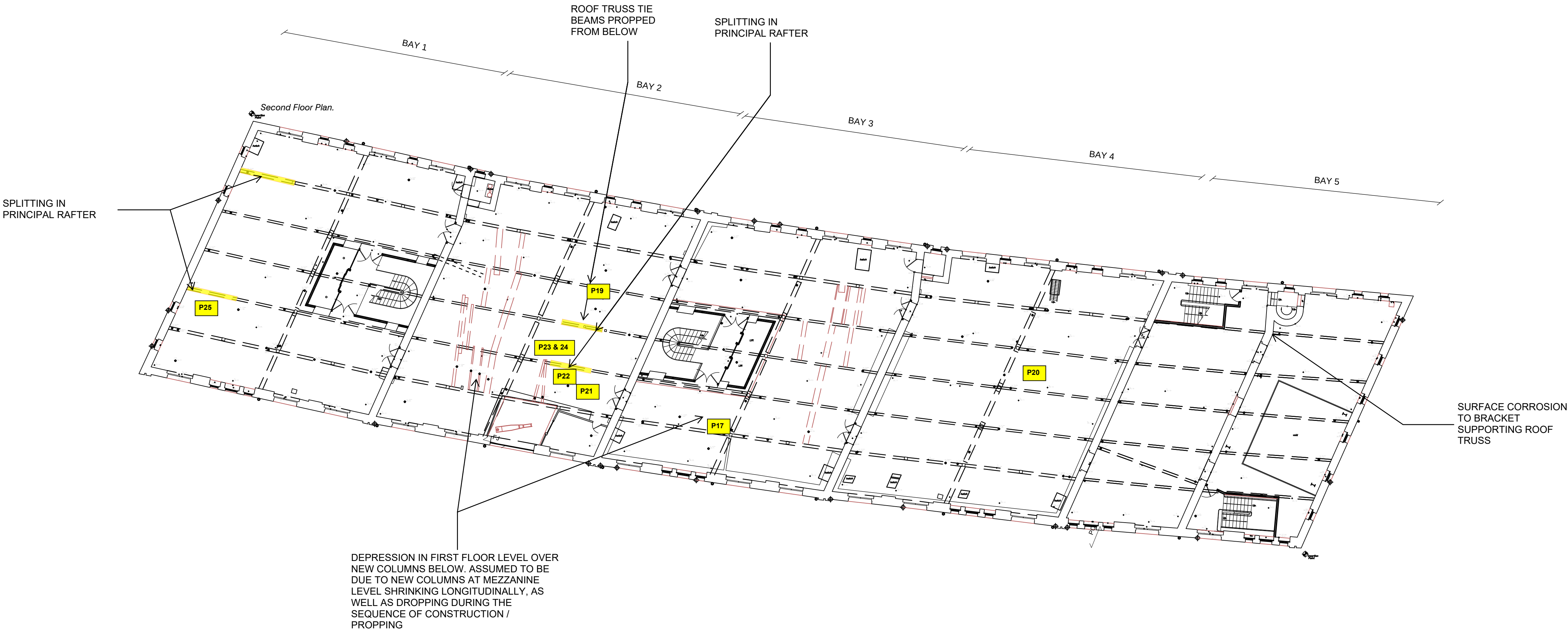
AREA OF LIMITED FLOOR
JOIST BEARING:

LOCATION OF ECCENTRIC LOADED
CAST IRON COLUMN:

LOCATION OF SUSPECTED TIMBER
DETERIORATION FOR H&R REVIEW:

ISOLATED TIMBER FAILURE NOTED:

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Rev Date Description Drawn Check

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Drawing Status
INFORMATION

Project Date SEP 2022
SIM - 1830 WAREHOUSE Scale 1:200@A1
INTERNAL STRUCTURE Drawn SW

Title Engineer SW
SECOND FLOOR PLAN OBSERVATIONS
& STRUCTURAL DEFECTS Project No
220626

Drawing No Revision
220626-CON-XX-00-DR-S-1103 P1

10.0 APPENDIX C – MAXIMUM LOADING PLANS

GENERAL NOTES

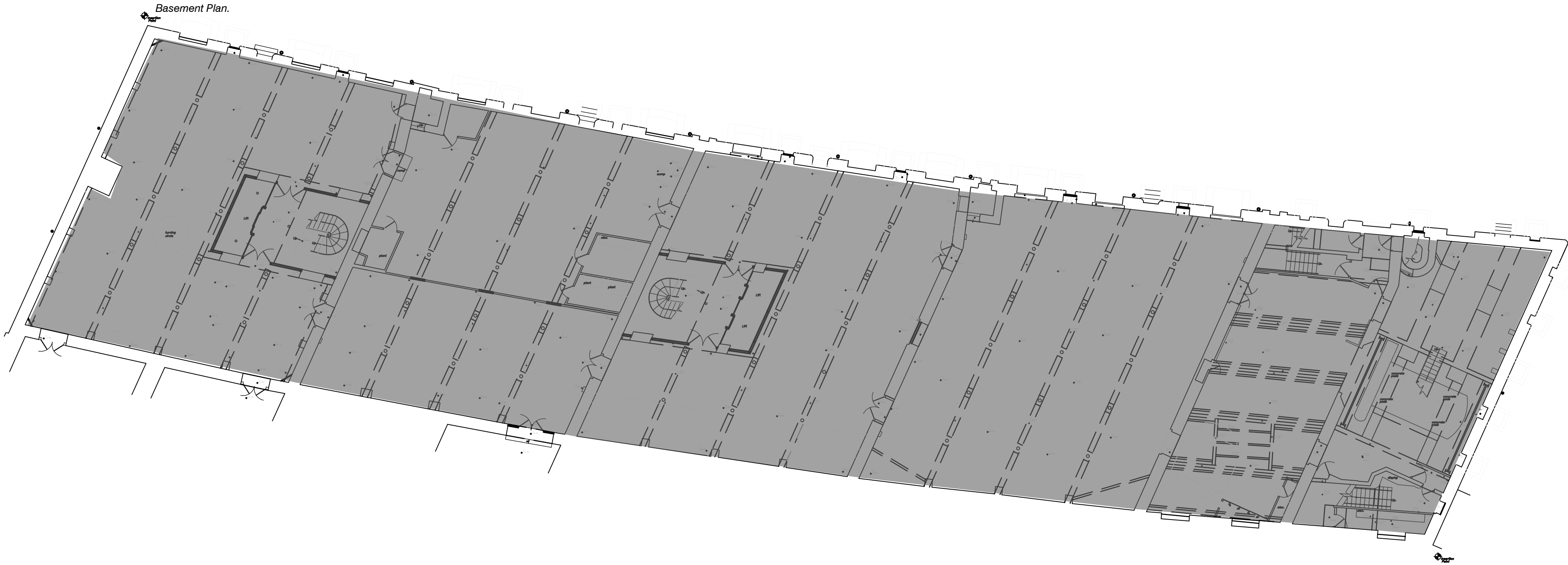
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LOADING NOTES

- SHOULD IT BE PROPOSED THAT THE LOADING BELOW IS EXCEEDED THEN CONISBEE SHOULD BE CONTACTED TO PROVIDE ADDITIONAL ADVICE. FURTHER CAPACITY MAYBE POSSIBLE BUT SHOULD BE INVESTIGATED ON A CASE BY CASE BASIS, FOR EXAMPLE CRANE LOADINGS.
- THIS AREAS ASSESSMENT LOADING DRAWING IS BASED UPON THE FINDINGS OUTLINED IN CONISBEE REPORT 220626/B ANGUS.
- THE STRUCTURE HAS ONLY PARTIALLY BEEN INSPECTED IN PART TO INFORM THESE RECOMMENDATIONS, BUT OF NECESSITY HAS NOT BEEN FULLY INSPECTED. AS SUCH NO LIABILITY CAN BE TAKEN FOR UNKNOWN LOCALISED DEFECTS, VOIDS OR DEVIATIONS TO THE STRUCTURE, AS WELL AS UNKNOWN BELOW GROUND SERVICES OR ANY OTHER UNKNOWN FEATURES NOT INSPECTED BY CONISBEE.
- LOCAL CHECKS SHOULD BE MADE PRIOR TO POSITIONING HIGH CONCENTRATED LOADS TO ENSURE THEY DO NOT LOAD AREAS NOTED WITH DEFECTS

ALLOWABLE IMPOSED LOADING SCHEDULE

1000 Kg/m2	
400 Kg/m2	
250 Kg/m2	
150 Kg/m2	



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Drawing Status INFORMATION	
Project	Date SEP 2022
SIM - 1830 WAREHOUSE INTERNAL STRUCTURE	Scale 1:200@A1
	Drawn SW
Title	Engineer SW
BASEMENT PLAN RECOMMENDED FLOOR LOADING	Project No 220626
Drawing No 220626-CON-XX-00-DR-S-10991	Revision P1

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Structural Repair Summary

1830 Warehouse – Essential Repairs (LBC Application No.1) Science & Industry Museum, Manchester

Ref: 220627/S Wilkinson

09 Feb 2023

Status: For Information

Version 1

External Works

A programme of external works was completed in 2022 which addressed significant structural defects generally and brickwork durability issues (replacement of spalled bricks, repointing) to the gable ends above cornice level on both elevations.

The works proposed for 2023 aim to address matters previously excluded from scope, including: patch repointing below cornice level, isolated brick replacements, isolated stone indent repairs, works to support glazing replacement and address subsidence to external stone steps at the base of the North elevation.

These are generally very localised 'like for like' repairs using reclaimed or matching brick and stone and appropriately matched lime mortars. The subsided steps require works at foundation level, however the historic fabric will not be altered.

Internal Works

Internally, repairs to restore structural capacity of isolated timber members are proposed. This work is required to address historic decay or splitting and historic design/modification issues that have locally reduced the capacity of some individual timbers and areas of the floor structure. The proposed works will involve traditional carpentered splice repairs to decayed members and provision of limited supplementary bolting and brackets elsewhere.

At basement level, limited works are proposed to tie existing brickwork piers supporting floor beams to the main walls and clean and treat corroded iron beams.

Essential Works & Repairs, 1830 Warehouse

Science & Industry Museum

APPENDIX 3 - Methodology



Prepared by:
Studio Downie Architects LLP
February 2023

APPENDIX:

- **Appendix 3 Methodology**
 - **3.1: Methodology for Brickwork Repairs**
 - **3.2: Methodology for Stonework & Associated Metalwork Repairs**
 - **3.3: Methodology for Timberwork Repairs**
 - **3.4: Methodology for Decorations**
 - **3.5: Methodology as General Summary**

APPENDIX 3.1/

- **Methodology for Brickwork Repairs**

3.1: Methodology for Brickwork Repairs

Brickwork Repair Specification;

- There are very few if any bricks requiring replacement with the aim to retain the existing bricks. Those to be considered are a limited number of damaged or missing bricks and if replacement is required salvaged bricks held in storage on site by the client will be batch checked and carefully aligned with adjacent brickwork.
- Salvaged bricks to be cleaned and free from matter such as mortar, organic growth, plaster and paint etc.
- Supply new matching replacement brick (to approval) if needed.

Methodology for Preparing Area to Receive Masonry;

- Carefully remove all damaged and defective material to extents as agreed with design team and client to a suitable solid surface. Mark clearly, but not indelibly, on face of masonry units or parts of units to be cut out and replaced.
- Process will be managed carefully to ensure remaining adjacent masonry is not disturbed, marked or damaged during this process.
- Removal of redundant metal fixings. Any holes in bricks will be sympathetically repaired and colour matched to the surrounding surface
- Removal of all loose material and any projections into repair location.
- All joint surfaces to be left in a suitable condition to receive the replacement masonry units. Area will be protected from inclement weather if area is not to be worked on immediately after with regards to replacement masonry units.

Methodology for Installing Replacement Masonry Units;

- All exposed faces of material will be managed and kept to the agreed surfaces.
- Of the faces, features and angles all elements will be set out and aligned carefully to ensure interfaces and junctions with existing masonry is maintained.
- Joint widths are to be maintained and replicated on newly installed units and where they interface with existing material.
- All joint surfaces will be dampened to assist with control of suction as deemed necessary.
- All units to be laid will be laid and sighted on a full bed of mortar with all joints filled.
- Installation process will ensure that any exposed faces will be kept clear of mortar and grout during the installation.

Methodology for brickwork rebuild under Bay 2 Wagon Arch:

- Dismantle and remove infill glazing. Lift floorboards over decayed timber joists, de-nail and set-aside
- Carefully remove bricks between timber joists and remove joists. Continue to dismantle brickwork over decayed bonding timber.
- Remove bonding timber and clean away dust and debris prior to re-building.
- All bricks removed to be assessed and any salvageable units cleaned (if laid in lime mortar) and set aside for re-use.
- Rebuild brickwork to level of underside of joists and allow mortar to cure. Supply new similar bricks to replace broken or shattered units (or where cementitious mortar cannot be removed).
- Reinstall new timber joists and continue reconstruction of brickwork to match original levels.
- Bedding mortar to be NHL 3.5 and sharp sand in 1:2.5 ratio.
- Pointing mortar to be NHL 2: Nosterfield sand: Leighton Buzzard sand: Black grit in appropriate proportions to achieve required colour match.

Quality Control;

- The specification and drawings will be adhered to fully. Any potential deviation or requirement to deviate will be fully discussed with design team taking on all comments regarding suitable solutions.
- Prior to the works being carried out in the particular location it will be photographed extensively to form part of the repair/remedial report and form part of the final records of the works.
- All stages of the methodology will be followed and adhered to.
- Particular care will be taken during the removal back to solid masonry. Extents of removal will be clearly agreed with design team and limits set to ensure adjacent solid masonry is left in place untouched and undamaged.
- Mortar pointing to the affected area will be closely monitored for colour match as per the approved control sample.
- During the repointing care will be taken to not mark the surrounding faces of existing masonry and ensure there is no overspill of mortar on to the exposed faces.
- Upon completion of the repair work the area will then be photographed to form the final part of the repair/remedial report of the works.
- All evidence of the sample repair will be submitted to the design team electronically and also offered for physical inspection on site.

Mortar Re-Pointing Specification;

- The works only address specific areas. The proposed minimal intervention approach is to remove cement where loose, friable or easily removed by hand avoiding damage where cement is well adhered.
- Mix ratio for repointing is: 25% St Astier NHL 2 (Lime), 10% Nosterfeild washed river sand, 20% Ash/Black Grit, 45% Leighton buzzard sand.
- Sand will be sourced with design team's comments and in line with mortar analysis of the historic mortar from RSK.
- Sand will be well graded sharp sand.
- Mortar joint profile to match existing externally.

Methodology for Preparation for Repointing;

- Before starting work, use measurements and photographs as appropriate to record bonding patterns, joint widths, special features.
- Working from the top of the required section downwards, existing mortar will be removed carefully using hand tools only.
- The approach may require alternative methods. The aim is to use the method which avoids damage to the existing brick and to preserve the arris. The 'best practice' method for hand removal is to use a TCT tipped sharp chisel (of appropriate width to the joint). In some cases cutting may be better than hammered chisel. An alternative method is to carry out sample removal of mortar using an Arbor Saw with a narrow gauge Heritage Blade. This is a low dust reciprocal saw. A discrete test panel prepared for review. If the teeth start to pull a brick, work will halt work immediately. Brick quality may vary over the building and hand tools will be used only in some areas.
- Care will be taken when removing existing mortar to not damage the adjacent masonry or widening the existing joints.
- The affected area will be raked out to a minimum depth of twice the joint width.
- Design team instruction will be sought if any loose or friable mortar is found that goes beyond the specified rake out depth.
- The same process will be applied if any cavities are found during the rake out of existing mortar.

Methodology for Repointing;

- Ensure all joints are suitably prepared.
- Mix mortar to required strength with correct quantities to provide finished product with correct level of colour match as agreed with design and project team.
- The mortar will be pressed well into the joints using hand pointing tools, to ensure that all joints are fully filled.
- The finish will be matched to surrounding joints.
- Care will be taken to keep the face of masonry clear of mortar and all joints will be finished neatly.
- After the initial set has taken place the mortar will be brushed to remove laitance and excess fines to give a coarse texture.

Quality Control;

- The specification and drawings will be adhered to fully. Any potential deviation or requirement to deviate will be fully discussed with design team taking on all comments regarding suitable solutions.
- Prior to the works being carried out in the particular location it will be photographed extensively to form part of the repair/remedial report and form part of the final records of the works.
- Sample types:
 - Sands for bedding and pointing mortars .
 - Mortars for bedding and pointing: provide mortar samples for each type for approval of visual compatibility. Samples are to be created as soon as possible to allow time for drying and curing.
 - Raking out and removal of defective cementitious pointing. Provide approx 0.5m x 0.5 sample area.
 - Repointing – for each different type of mix/ pointing profile/ finish prepare sample areas of approximately one square metre for approval.
- All stages of the methodology will be followed and adhered to.
- Particular care will be taken during the raking out of the existing joints. Extents of removal will be clearly agreed with design team and limits set to ensure adequate bed is left and suitable to receive the new mortar pointing.
- Mortar pointing to the affected area will be closely monitored for colour match as discussed and set-out in terms of material composition to ensure best match is provided in line with planning officer and design team expectations.
- During the repointing care will be taken to not mark the surrounding faces of existing masonry and ensure there is no overspill of mortar on to the exposed faces.
- Upon completion of the repair work the area will then be photographed to form the final part of the repair/remedial report of the works.
- All evidence of the sample repair will be submitted to the design team electronically and also offered for physical inspection on site.

Specification for CemTie;

- Helifix CemTie – 10mm diameter Grade 316 Stainless Steel. HeliBond is grout to be used as part of installation.

Methodology for CemTie Works;

- Holes are to be calculated and drilled out carefully and accurately in locations as shown on the Structural Engineers drawings. This will vary dependant on repair location.
- The holes will be drilled to suit the type and length of tie required for the remedial repair through brick centres to structurally connect the outer skin of brickwork to the inner leaves. Each hole will be cleaned from debris and drilling dust.
- Care will be taken not to damage or disturb the adjacent in-situ masonry as part of these works.
- Once the hole is drilled and ready to receive the tie, the tie will be placed into the pinning nozzle and inserted into the hole. As the grout is injected by hand operated pump through the grout gun the CemTie is carried into the hole with the grout, back pressure then pushes the nozzle out of the hole to leave a fully grouted tie.
- Care will be taken to ensure there is no overflow of the grout onto the face of the masonry.
- The fully fixed CemTie will be sat recessed from the face of the masonry unit to ensure a suitable repair can be carried out.
- A suitable colour matched repair will be installed by filling the hole with a lime/brick dust mortar repair and ensuring it is finished flush and neatly with surrounding masonry.

Specification for Helibar;

- Helifix HeliBar – 6mm diameter Grade 316 Stainless Steel. HeliBond is grout to be used as part of installation.

Methodology for Helibar Works;

- Remove existing mortar using approved methodology. This will be done whilst taking care not to damage or disturb the adjacent masonry. Care is also to be taken to not widen the mortar joint.
- Recess is to be formed to the depth as recommended by the reinforcement manufacturer.
- The recess is to be cleaned out to ensure there is no debris or dust following rake out. The recess is to be fully damped down with clean water.
- A bead of HeliBond will be injected along the back of the recess. The HeliBar will be pushed into the recess and into the grout to ensure a good bond and coverage is achieved. The grout will be recessed 25mm from face.
- The recess will then receive a mortar finish in line with Structural Engineers specification. The repointing will be colour matched.

Quality Control;

- The specification and drawings will be adhered to fully. Any potential deviation or requirement to deviate will be fully discussed with design team taking on all comments regarding suitable solutions.
- Prior to the works being carried out in the particular location it will be photographed extensively to form part of the repair/remedial report and form part of the final records of the works.
- All stages of the methodology will be followed and adhered to.
- Particular care will be taken during the drilling of the holes and will be carried out fully in accordance with the Structural Engineers drawings. Care will be taken so as not to cause damage to the masonry unit being fixed through by using sharp drill bits that are required for the task at hand.
- When infilling the repair site, care will be taken to ensure none of the repair material encroaches onto the masonry exposed face and that a neat unobtrusive finish is provided.
- Particular care will be taken during the raking out of the existing joints. Extents of removal will be clearly agreed with design team and limits set to ensure adequate bed is left and suitable to receive the HeliBar repair system.
- Mortar pointing to the affected area will be closely monitored for colour match as discussed and set-out in terms of material composition to ensure best match is provided in line with planning officer and design team expectations.
- During the repointing care will be taken to not mark the surrounding faces of existing masonry and ensure there is no overspill of mortar on to the exposed faces.
- Upon completion of the repair work the area will then be photographed to form the final part of the repair/remedial report of the works.
- All evidence of the sample repair will be submitted to the design team electronically and also offered for physical inspection on site.

Example of previous Works using CemTies and Helifix/Helibar



Helifix chase cut



Helifix chase cut



Helifix chase cut to corner



Helibar inserted



Repointing completion



Brickdust repair to Cemtie

APPENDIX 3.2/

- **Methodology for Stonework & Associated Metalwork Repairs**

3.2: Methodology for Stonework & Associated Metalwork Repairs

Stonework Repair Specification;

- New sandstone/gritstone insert to match existing material.
- Bedded into mortar with a mix of 1:2 NHL2 Hydraulic lime:fine sand
- 8mm diameter Grade 316 Stainless Steel Dowel Bars. Resin anchored into repaired cornice at 200mm centres with a minimum of 150mm embedment using Hilti HIT-RE 500 V3 resin.
- Dowels to be set back 20mm from face of stone repair.
- Infill hole with colour matched hydraulic lime : stone dust mortar.
- Match adjacent mortar. Press into joints to fully fill and neatly finish. After initial mortar set has taken place remove laitance and excess fines by brushing, to give a coarse texture. Do not compact mortar.

Methodology for Cutting Pockets;

- Areas of stone insert repairs to be cut out carefully and accurately in line with design and agreement with design team as to extents.
- Undercut sides of pocket to facilitate space for the bonding material.
- Control and adjust depth to enable the gritstone insert to stand proud of the existing stonework allowing for finishing the detail in-situ.
- Ensure the area is thoroughly cleaned out and suitable to receive gritstone repair material.

Methodology for Installing Sandstone/Gritstone Insert;

- Cut the gritstone material to the relevant rectangular shape, which is suitable to replace the defective area already removed. This will allow to provide the material a firm seating.
- Install the replacement material and bed onto the mortar.
- Locally hold insert in place, through existing holes already drilled within the stone repair the dowel holes can be drilled and cleaned out sufficiently ready to receive the resin anchored dowel bars.
- Allowing the resin to set in line with manufacturer's recommendations the repair holes can be filled with a colour matched mortar. This is to be locally pressed well into the dowel hole and is ensured to be fully filled. There will be no encroachment to the exposed face of the gritstone repair and the finish will be flush with the face.

Methodology for repair to stonework steps;

- Carefully lift cobbles around subsided steps to create a margin of ~500mm. Number cobbles and set aside for refitting in the same locations.
- Carefully dismantle stone steps. Number each unit, protect and store away from work area.
- Excavate existing sub-base material around steps to depth of ~750mm. Assess spoil and if suitable sand/gravel material, reintroduce in 150mm layers and compact each layer. If existing material is poor, provide new sand and/or Type 1 recycled aggregate material to provide a sound bearing area for the new foundation.
- Install new reinforced concrete pad foundation of ~250mm thickness – adjust formation level to ensure that no concrete is visible at step margins on completion.
- Reconstruct stone step units to match previous configuration. Stone units to be bedded on NHL 3.5: sharp sand: stone dust mortar. Proportions to be adjusted to achieve good colour match. No repair or replacement of stone units is proposed.

Quality Control;

- The specification and drawings will be adhered to fully. Any potential deviation or requirement to deviate will be fully discussed with design team taking on all comments regarding suitable solutions.
- Prior to the works being carried out in the particular location it will be photographed extensively to form part of the repair/remedial report and form part of the final records of the works.
- All stages of the methodology will be followed and adhered to.
- Particular care will be taken during the cutting and forming of the pocket to receive the repair. The area will be clearly marked and agreed with the design team to prevent overcutting of pocket.
- The filling of the repair hole will be done with caution to ensure that there is no encroachment to the surrounding stone.
- Upon completion of the repair work the area will then be photographed to form the final part of the repair/remedial report of the works.
- All evidence of the sample repair will be submitted to the design team electronically and also offered for physical inspection on site.

Window Security Bars Specification;

- A condition survey recommendation by the structural engineer noted expansive corrosion of embedded structural ironwork including window bars and pintel fixings has caused serious cracking in a number of locations which will need to be addressed to avoid risks of falling debris and other related damage.
- There are specific locations along the south elevation above the arched windows which require remedial work while with access the main contractor will also inspect all other security bars into stone sills.

Methodology for repairs to Window Security Bars (& Pintels);

- The security bars are socketed into the sill and will be retained in place as removal may damage the sill.
- The bars will be rubbed down and anti-corrosive treatment will be applied before repainted to match the existing colour.
- The interface with the sill will be examined to ascertain the extent of repair.
- Tapping out will remove any loose material.
- The crack can then be fully exposed and cleaned out and prepared for resin grout injection set back from finished surface.
- Final mortar application blended with dust to match adjacent surface.

Quality Control;

- The specification and drawings will be adhered to fully. Any potential deviation or requirement to deviate will be fully discussed with design team taking on all comments regarding suitable solutions.
- Prior to the works being carried out in the particular location it will be photographed extensively to form part of the repair/remedial report and form part of the final records of the works.
- All stages of the methodology will be followed and adhered to.
- Particular care will be taken during the filling of the repair hole to ensure that there is no encroachment to the surrounding stone.
- Upon completion of the repair work the area will then be photographed to form the final part of the repair/remedial report of the works.
- All evidence of the sample repair will be submitted to the design team electronically and also offered for physical inspection on site.

APPENDIX 3.3/

- **Methodology for Timberwork Repairs**

3.3: Methodology for Timberwork Repairs

Timberwork Repair Specification;

- This element relates a range of structural and architectural repair and treatment.
- Structural Softwood – Species to be generally Pinus Sylvestris/Pseudotsuga menziesii. The timber will be graded to C24.
- Structural Hardwood – Species to be generally European Oak. The timber will be graded to THB/TH1 – equivalent of D30 graded structural timber.
- The Contract Administrator or Structural Engineer will be notified if there is the need to deviate due to the requirement to match an existing species.
- The surface finish of the timber will be regularised.
- There are no preservative treatments required.
- Planned moisture content of timber at point of installation to be 20%.
- Timber to be sourced from well-managed plantations or forests in accordance with
 - o Local laws in forest management in country of production.
 - o International agreements such as Convention on International Trade in Endangered Species of wild fauna and flora (CITES)
- Evidence will be provided to support compliance with sourcing of material with regards to provenance of timber supplied or evidence that the supplier of the material has adopted and implemented a formal environmental purchasing policy for timber and other wood based products.
- Friable material will be removed. Where localised repairs are required the decayed wood will be carefully cut-out and replaced with hardwood scarfed in. Where decayed throughout, the existing profile will be recorded, the existing decayed element removed and replaced with hardwood to match the existing profile.
- Generally, the surfaces to be redecorated will be prepared, degreased and rubbed down to give a light key. The character of retained timber with cracks and holes will be retained and not filled. Surfaces to be repainted with an initial preparatory coating then topcoats to match existing using high quality coatings from Akzo Nobel / Keim to match existing colour.

Methodology for splice repairs;

- All operatives will be suitably skilled and experienced in carrying out the works.
- Retention where the majority of the section of wood is in good condition with localised repairs.
- Remove and replace those elements of wood where major rotting and crumbling of the material has occurred. Cut out full cross section of member where wood is defective or decayed,
- The area of works will be carefully assessed for temporary propping requirements before any works commence. The temporary propping solution will be suitable for the task at hand and will be assessed at each stage of the repair to prevent damage to the structure.
- All dimensions will be taken on site for the affected units etc. to ensure accuracy prior to fabrication.
- Once material is on site it will be stored in a dry, under cover location. When siting the timber for storage it will be elevated from the ground with good ventilation. Supports will be level and regularly spaced on a dry and solid base.
- The timber unit will not be over handled during delivery, storage and movement to repair area. This is to prevent distortion or disfigurement to the units.
- Any fixtures or fittings that need temporary removal for installation of replacement unit will be carefully marked up and set aside. Once new unit is in place they will be refixed and reinstated in line with traditional methods.
- Once area for timber replacement is propped and stripped the defective member will be carefully removed and set aside.
- Once there is a clear opening any other necessary works will be carried out to the area to prepare for the installation of the newly provided unit.
- The unit will be lifted and fixed into place in line with the relevant structural timber detail. All surrounding interfaces will be finished in line with the Structural Engineer detail. This will be the dry packing to the bearing ends of the beams. Where timber is in contact with masonry, a DPC of bitumen will be installed.
- Upon completion the newly installed timber unit will be carved or branded with the date of repair. The location of this is to be agreed with the design team.

Methodology for Installing New Support Brackets

- Contractor to provide safe access equipment for joint inspection of presumed short joist bearings with structural engineer. Where joists are confirmed to abut columns forming a bearing of ~30mm length and not to be notched, supplementary support will be required. All such locations for inspection are indicated on the structural repair plan drawings.
- Where support is required, install new bespoke steel support bracket beneath joist. New brackets are designed to be as unobtrusive as possible and to generally replicate the design of other historic bracketry in the building and paint finished to match.
- Brackets are to be fixed into the underside of the affected joists using two coach screws and into the vertical face of the adjoining beam using four coach screws.

Methodology for Timber Repairs Cargo Door Sill

- Assess each timber sill to confirm whether one or both ends are built into the brickwork (this varies)
- Carefully cut away mortar around sill ends (don't unnecessarily disturb brickwork).
- Cut the existing timber sill at a 45 degree angle in the centre span and ease out each half away from brickwork.
- Prior to installation of new sill, infill and repair any voids at the opening reveals using new matching bricks cut to size and bedded in lime mortar.
- Clean brickwork surfaces under sill and apply new lime bedding mortar to the required level.
- Install new timber sill leaving 15-20mm gap at each end. Ram-in lime:sharp sand dry pack mortar to fully fill the gap and help hold the new sill in position.
- Decorate the new sills (ref. Appendix 3.4 methodology).

Methodology for repairs to split timbers

- For application where structural timbers have split but are not to be replaced.
- Inject crack with thixotropic epoxy resin adhesive. Recess adhesive to minimise visibility at timber surface. Protect external timber surfaces from contact with adhesive. Clean immediately if required.
- Pre-drill pilot holes for coach screws and form counter-sunk recess at timber surface for screw head. Recess to be of sufficient depth to accept timber plug.
- Where possible, clamp or prop timber to close joint surfaces prior to bonding and fixing.
- Install new coach screws followed by matching timber plug. Timber plug to be installed flush with surface and with grains on both elements aligned.

Methodology for repairs to secondary columns in former trackbeds.

- Pre-drill clearance holes for bolts and form counter-sunk recess at timber surfaces on both sides for bolt heads. Recess to be of sufficient depth to accept timber plug.
- Install new bolts and tighten followed by matching timber plug. Timber plug to be installed flush with surface and with grains on both elements aligned.

Quality Control;

- The specification and drawings will be adhered to fully. Any potential deviation or requirement to deviate will be fully discussed with design team taking on all comments regarding suitable solutions.
- Particular care and attention will be paid to timber source and eventual timber selection for each individual timber replacement/repair. The timber will be responsibly sourced in line with the specification.
- Prior to the works being carried out in the particular location it will be photographed extensively to form part of the repair/remedial report and form part of the final records of the works
- All stages of the methodology will be followed and adhered to. Care will be paid at each stage from the propping of the opening through to the removal of the timber unit. Particular care will be paid to the remaining masonry and surrounding interfaces that are to remain untouched, undamaged and in-situ whilst the repair is being carried out.
- Upon completion of the repair work the area will then be photographed to form the final part of the repair/remedial report of the works.
- All evidence of the sample repair will be submitted to the design team electronically and also offered for physical inspection on site.

APPENDIX 3.4/

- **Methodology for Decorations**

3.4: Methodology for Decorations

Specification for Decoration of Cargo Door Sills;

- Dulux Trade Aquatech Preservative Basecoat.
- Dulux Trade Ultimate Opaque – Colour. Ref. 17272, 82YY85038 satin finish.

Methodology for Decoration of Cargo Door Sills;

- Clean down surface / degrease prior to creating suitable key to receive decorative finish.
- Create suitable key through rubbing down of existing surface and remove any irregularities that may be present.
- A sample will be reviewed at the appropriate stage in the process when a key has been established.
- Temperature and humidity will be taken into account prior to application of any decorative finish.
- All surfaces will be clean and dry prior to application of any coatings.
- The bare surfaces will be primed with two coats of Dulux Trade Aquatech Preservative Basecoat and where possible same day as surface preparation has been carried out.
- Bring forward any primed and/or filled areas to match the existing system with 1 coat of Dulux Trade Ultimate Opaque.
- Once at final coat stage apply 2 coats of Dulux Trade Ultimate Opaque and ensure the finish is smooth and even.
- All elements for decoration that have moving parts will ensure to be eased prior to decoration.

Specification for Decoration of Window Security Bars;

- Following on from repairs as per Appendix 3.2, Dulux Trade – Colour. Ref. 17272, 82YY85038 satin finish.

Methodology for Decoration of Window Security Bars;

- Carefully clean down surface / degrease prior to creating suitable key to receive decorative finish.
- Carefully create suitable key through lightly rubbing down of existing surface and remove any irregularities that may be present.
- A sample will be reviewed at the appropriate stage in the process when a key has been established.
- All surfaces will be clean and dry prior to application of any coatings.
- The bare surfaces will be primed with two coats and at final coat stage apply 2 coats of Dulux Trade Ultimate Opaque and ensure the finish is smooth and even.

Specification for Decoration of Rainwater Downpipes;

- Following paint analysis, the Museum will take a curatorial decision on the livery colour to be applied.

Methodology for Decoration of Rainwater Downpipes;

- The methodology will be followed as for the Window Security Bars.

Quality Control;

- The specification and drawings will be adhered to fully. Any potential deviation or requirement to deviate will be fully discussed with design team taking on all comments regarding suitable solutions.
- Prior to the works being carried out in the particular location it will be photographed extensively to form part of the repair/remedial report and form part of the final records of the works.
- All stages of the methodology will be followed and adhered to.
- The areas will be checked to ensure they are free from brush strokes, runs and other defects. It will be ensured that the final finish is uniform in colour and all cutting in will be done neatly to reflect the sympathetic final aesthetic of the surface.
- Upon completion of the repair work the area will then be photographed to form the final part of the repair/remedial report of the works.
- All evidence of the repair will be submitted to the design team electronically and also offered for physical inspection on site.

APPENDIX 3.5/

- **Methodology as General Summary**

3.5: Methodology as General Summary

General specifications/ methodologies which will be followed for the works

- 1 The following advice is intended to be a brief over-view highlighting key considerations and requirements. It is not intended to be complete guidance and may be superseded/augmented by advice given on the particular building in question. Regard could usefully be had to relevant Historic England guidance in their 'Practical Conservation' series and NBS specifications/methodologies although the latter need to be modified to ensure a conservation-led approach.
 - 2 **Implementing work:** All works should be undertaken carefully by trained and experienced contractors. Works affecting the original/historic built fabric should only be undertaken carefully using hand-held, non-mechanical tools unless with prior written agreement of Planning Service.
 - 3 **Mortar:** Any use of mortar should be to an agreed detailed specification/methodology including the use of mortar that matches the original on the building in terms of composition (by chemical analysis), colour, texture and appearance of finished application. The submitted information should also, for example, include:
 - (a) The depth of mortar to be removed for any re-pointing and should confirm that mortar would not be used inappropriately such as to provide a fill where masonry is missing.
 - (b) Regard to environmental conditions.
 - (c) The need to carefully use only hand-held, non-mechanical tools for the works to avoid damage to the adjacent masonry/built fabric.
 - 4 **External building cleaning:** It is critical that building cleaning takes place prior to determining the appropriate match of existing and new materials (such as mortar, bricks and stone) needing to be introduced as a part of the works. Cleaning should aim to achieve a gentle 'lift' in the appearance of the building rather than an 'as new'. It is likely this is the intention of the proposed light wash. Cleaning should be to an agreed detailed specification/methodology which should include the use of small trial areas in discreet locations and should not include the use of abrasives or chemicals. Great care is required to ensure an appropriate clean that does not further exacerbate the deterioration of existing stonework and brickwork.
 - 5 **Leadwork:**
 - (a) As with other works, intervention should be kept to the minimum that can be justified in heritage terms and a detailed methodology/ specification should include the criteria used to determine the appropriate approach in a range of circumstances.
 - (b) Any inappropriate past repairs (including the use of non-lead products) need to be reversed.
 - (c) New leadwork should be undertaken on a like-for-like basis to take them back to their original detail/condition/appearance. They should be to Lead Sheet Association standards unless this conflicts with achieving a like-for-like outcome and where an approach should be agreed with the Planning Service.
 - (d) Existing leadwork should be re-used as far as possible. For example, where lead has become detached but is otherwise in acceptable condition it should be re-affixed.
 - (e) Where largescale replacement of existing lead is proposed it should be re-smelted and re-used in the proposed works to avoid the loss of the material from the building
 - 6 **Stonework repairs:** Stonework repairs should be to a detailed specification/ methodology agreed with the Planning Service. This would need to include the criteria to be employed when determining the type of repair to be used. For example:
 - (a) There may be small blemishes and weathering (not causing water pooling or other maintenance issues) that contribute to a patina of age of the building and that should be left.
 - (b) Descaling may be appropriate but this may lead to the need for re-dressing stone or other repair and this needs to be understood.
 - (c) An individual stone may have modest cracks or other small scale damage (such as drill holes left by removed fixings) that can be successfully repaired with an appropriate lime-based mortar/filler type system to give an 'invisible' repair. Such an approach of 'plastic' repair can also be used to restore minor damage to particular architectural features such as limited damage to capital heads.
 - (d) For larger areas of damage to individual stones the piecing-in of an element of matching new stone would become more appropriate than a plastic repair.
 - (e) Where the damage to an individual stone is significant a completely new element of matching stone may be required.
 - (f) The choice of repair technique would also need to consider the nature of the particular element - for example, a highly elaborate carved doorway feature may need a different approach than a more standard window cill feature.
 - (g) Any missing elements of stone would need to be appropriately replaced in matching stone.
- Any such detailed methodology/specification should confirm that consolidating fluids or similar surface treatments would not be used. Any proposed use of such a treatment would only usually be accepted if its use would fully comply with the detailed advice from Historic England on this matter. It would be difficult to see the use of consolidating fluids being appropriate or justifiable in this instance and any proposed use should be avoided.
- 7 **Modern sealants:** These are considered unacceptable where traditional building methods such as mortar and lead flashing provide an acceptable, alternative approach. The use of modern sealants would only be considered in other particular instances where a traditional method would be demonstrably inappropriate and these exceptional instances would need to be clearly explained, justified and avoid harm to heritage significance.
 - 8 **External redecoration:** This should be restricted to those features that are currently painted. This should be undertaken on an evidence basis with a paintwork analysis of the existing paint undertaken by someone with appropriate expertise to establish the painting history of the building. Where such evidence is found to be unclear or to no longer exist (for example due to previous removal of paint during past refurbishment) the proposed redecoration should be on a researched basis of buildings of a similar age and type.

It is noted that the paint colour 'brilliant white' and 'gloss' finishes were not available until after the Second World War so would be inappropriate for use on this building. The redecoration should be undertaken to a detailed specification/ methodology which should include the supporting evidence and/or research as appropriate.
 - 9 **Vegetation removal:** This should be undertaken to an agreed specification/methodology. The use of any chemicals would need to be undertaken with care to ensure they would not adversely affect the existing built fabric such as, for example, by causing staining. It should be confirmed that the vegetation has not become so invasive as to require any built elements to be taken down to enable removal although it is accepted that some repointing may be necessary. If this is not the case, any taking down would need to be limited and kept to the absolute minimum with the individual elements of removed built fabric being returned to their original position/orientation using traditional building methods.
 - 10 **Scaffolding:** Details should be provided of the proposed scaffolding to facilitate the proposed works. The design and type of scaffolding used should demonstrably avoid damaging intervention on the listed building such as caused by the use of wall ties. Consideration should firstly, therefore, be to use structural scaffolding or a range of other options for non-structural scaffolding to avoid wall-ties. The possibility to use a combination of these options and elements of structural scaffolding should be considered ideally to avoid wall ties or, at least to keep them to an absolute minimum. The use of wall ties should be an absolute last resort and would only be accepted where other options are demonstrably impractical and subject to an appropriate detailed specification/methodology that should, for example, confirm:
 - (a) Wall ties would be into mortar joints within areas of brickwork but only where the joints are sufficiently wide to avoid damage to the arrises of the adjacent bricks. Where the mortar joints are of insufficient width to avoid such damage then consideration should be given to the careful removal of a facing brick to enable a wall tie to be installed in the masonry behind. As the scaffolding is removed the tie would be removed, the drill hole appropriately repaired and the facing brick returned to its original position with appropriate use of mortar to achieve an 'invisible' repair. Where this approach is shown not to be feasible, ties should be located in the centre of individual facing bricks. The brick dust created by the drilling should be saved. As the scaffolding is removed the ties should be removed and the damage made good to give an 'invisible' repair using the collected brick dust to assist to achieve the matching colour and texture. The specification/methodology should include details of brickwork repair.
 - (b) Wall ties would only affect individual bricks and would not, for example, be located on any stonework or decorative brickwork/ brickwork features.
 - (c) Appropriate measures would be taken to avoid the building being abutted/damaged by scaffolding poles.

Essential Repairs including Replacement Wagon Arch Glazing

1830 Warehouse

Science & Industry Museum

APPENDIX 4 - Visual Assessment & Analysis of Wagon Arch Glazing



Prepared by:
Studio Downie Architects LLP
February 2023

APPENDIX 4:

Visual Assessment & Analysis of Wagon Arch Glazing

- 4.1: Methodology**
- 4.2: Visual Assessment**
- 4.3: Analysis of Bay 1**
- 4.4: Analysis of Bay 2**
- 4.5: Analysis of Bay 3**
- 4.6: Considerations**
- 4.7: An Illustrative Comparison of Glazing Solutions**
- 4.8: Design Development**
- 4.9: Considerations of a like for like frameless system**
- 4.10: Considerations of a framed system**
- 4.11: Options**
- 4.12: Proposal**

4.1 Methodology

- The design team have undertaken a review of the client requirements which has included a review of the client records, client surveys, a visual record of what's there now, an assessment of historical significance focused on the specific alterations, and an assessment of the condition of the fabric (including identifying repairs to the fabric).
- There is an urgent need to repair the two structurally defective glazed bays to Bay 1 and to Bay 2 as a priority (to Bay 3 as preventative measure, and we have considered the wider elevational approach to inform the design and detailing of the proposals.

• Understanding the group of windows to the southern facade only

- The 1830 Warehouse has two principle long elevations, the elevation to the north originally handled goods from the warehouse on to carts for road distribution via the Lower Yard, whereas the south elevation handled the unloading from train wagons on the viaduct (originally the whole wagon!) into the warehouse while the central Bay 3 originally featured a continuous train line passing through the building and over the Lower Yard. The east and west elevations do not have this active history of transition through openings, primarily because the structure of the five bays were assigned to specific commodities resulting in cargo transfer on a north-south axis. The south elevation abuts the viaduct (a key part of its historic function) and appears shorter in height than the north elevation which opens to the lower yard.
- The wagon arches on the viaduct side are a visual reminder of this industrious activity connecting the warehouse to the railway. Since the museum's phase of ownership, the museum has glazed four of these wagon arches. Though there are adjacent cargo doors and triple windows, the wagon doors themselves are a unique group of historical elements relating specifically to the viaduct. Curatorial decisions in the 1990s when the warehouse was restored led to a light weight touch as far as glazing, with limited slender frames and large sheets of glass to preserve as much of the sense of an open arch as possible. A similar approach was made to other window openings higher in the façade which were not historically glazed, but were infilled in this period. The cargo doors were never glazed, only the wagon arches and selected higher level windows in bays 1-3 and 5. Bay 4 was deliberately left with unglazed openings as a way of using the building as an exhibit and illustrating the 'original' format of the building.
- With the 1830 Station open to the public, the museum route takes visitors along the old platform alongside the viaduct with a view across to the south elevation. The platform side setting for visitors (in historic times, 'would-be' passengers) retains the relationship of the south elevation of the warehouse to the railway and to the 1830 Station.

• Assessment of the Wagon Arches

- The glazing installed in the 1980's and 1990's is a result of the recent phase of use as a museum. Defects have rendered two of the four glazed openings inadequate with a risk of further movement and further potential damage to the fabric and potential harm to users. The detail to Bay 3 is similar to Bay 1 and ultimately this detail will fail in time as Bay 1.
- The two wagon arches with timber doors are different and will be retained.
- The timber door to Bay 4 is a recreation of the original alignment of the early doors before function and use changed and the doors to the wagon arches were set back within the arch with short platforms projecting out towards the track through the archways, as a result of changes in floor level to reflect changing operational needs in line with technological developments. The door to Bay 4 serves as reminder of the origins of the wagon arches.
- The timber door to Bay 5 is reduced in height as part of the substantial remodelling of Bay 5 in the 1980's to accommodate the museum's curatorial needs of the time which included a change to the original structural system of timber floors to concrete floors, and the detail inside at the lower level has been filled in with the result that the external detail is now a brick faced wall below the raised sill which itself sits in line with the internal floor level. The door to Bay 5 would require substantial rebuilding of Bay 5 to change it back to an original detail and would serve only to reveal the substantial internal changes of the 1980's alterations to Bay 5.
- The eastern most wagon arch to Bay 5 has replica doors reinstated to hang externally, similar to Bay 4, however the infill to Bay 5 is a large glazed sliding door. This unique detail was part of the specific design of this bay which was substantially remodelled with new internal concrete floors to accommodate the very large object display internally. The concrete floor is level with the trackside with an internal arrangement of fire stairs and lobbies.

We have set out below a series of considerations which have emerged from the design team studies and feedback from the Conservation Officer. These considerations respond to the client brief and the ongoing and future use of the 1830 Warehouse.

Considerations for type of glazing:

- 1 No glazing. Reinstatement of timber doors (reduces weather protection and reduces internal environmental control). Not viable.
- 2 Replace as is (like for like) with planar glazed system. Not recommended due to defects/condition, does not adequately manage rainwater away from weak interfaces which will lead to future decay in historic fabric. Not viable.
- 3 Build masonry upstand to Bay 1. This has no historical precedent.
- 4 Build brickwork spandrel panel to Bay 1. This reflects previous historical interventions. It reduces legibility of the original wagon openings.
- 5 Replace glazing with alternate approach (there are sub-options):
 - a. Single glazing system of toughened and laminated glazing installed as part of an aluminium framed glazing system to provide weather protection and reduction in air leakage. Limited thermal improvement. Glazing requires UV reduction interlayer.
 - b. Double glazing system of toughened and laminated glazing installed as part of an aluminium framed glazing system to provide weather protection and reduction in air leakage. Glazing requires UV reduction interlayer. Improved thermal environment but limited by the fact that many openings are not glazed.
- 6 Secondary glazing. This could be a future approach to some or all openings but will add a new layer of intervention throughout the building. Not recommended.

Following consideration of the above, the preferred approach is to replace glazing as 5a above with single glazed system as part of an aluminium framed system. This approach would be applied to wagon arches with existing structural glazing, Bay 1, Bay 2, Bay 3.

The museum does not propose to install glazing to wagon arches with wood doors in Bay 4 and Bay 5 nor to replace the sliding glass door to Bay 5.

• Developing the preferred approach

- The approach is to replace the structural glazing as a family of details which respect the legibility of the history of the building, and its multiple phases but don't replicate or directly mimic existing details and creates a consistent contemporary vocabulary to these wagon arches to render these interventions clearly legible and honest interventions, building on earlier intervention strategy and also to have all structurally glazed openings as clear and light weight as possible.
- The proposals for replacement glazing requires the repair of structural defects and associated fabric repairs.
- The proposed structural glazing system is an aluminium frame with new sill and integrated upstand details. The interface design will manage rainwater away from interfaces.
- The following pages provide an overview of the appraisal of the existing before setting out the design approach.

4.2 Visual Assessment

- The Bays are numbered 1 – 5 from west to east on plan. Defects were previously found to be present to the former wagon openings at Bays 1 and 2, requiring temporary support and shatter proof film to be applied to the glazing. Further investigation has been undertaken and preliminary liaison with MCC Planning Authority and Conservation Officer to understand the scope for replacement. With the risk of further movement in the glazed infills to Bay 1 and Bay 2 it is important to replace the glazing as soon as possible.

Bay 1



Wagon Arch D1S1.02
Externally:

- Single layer of structural glazing with glass fins
- Timber Cargo door behind arched opening of stonework
- Glazing extends to the level of trackbed.



Wagon Arch D1S1.02 Cargo door closed.
Internally:

- Raised floor plinth
- Museum Collection Display
- Open gallery

Bay 2



Wagon Arch D1S2.03
Externally:

- Glass window_double height.
- Straight wood lintel to head,
- Stone reveal in part, brick reveal.
- Decayed cut short joist ends
- Brickwork below sill



D1S2.03 Glass window
Internally:

- Crane
- Museum Collection

Bay 3



Wagon Arch D1S3.02
Externally:

- Single layer of structural glazing, glass fins
- Glazing extends to the level of trackbed.
- Timber Cargo door behind
- Arched opening of stonework
-



Wagon Arch D1S3.02
Internally:

- Open gallery
- Museum Collection

4.3 Analysis of Bay 1



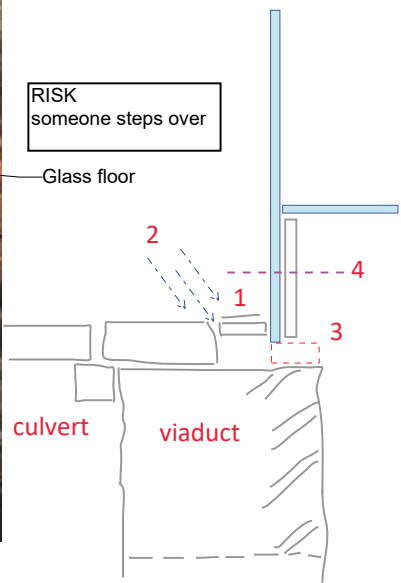
Temporary restraints.
and shatter proof film
internally.

Horizontal glazing not supported



Rubble fill below concrete apron.
Waterproof detail not working
properly leading to water ingress
and decayed sill inside.

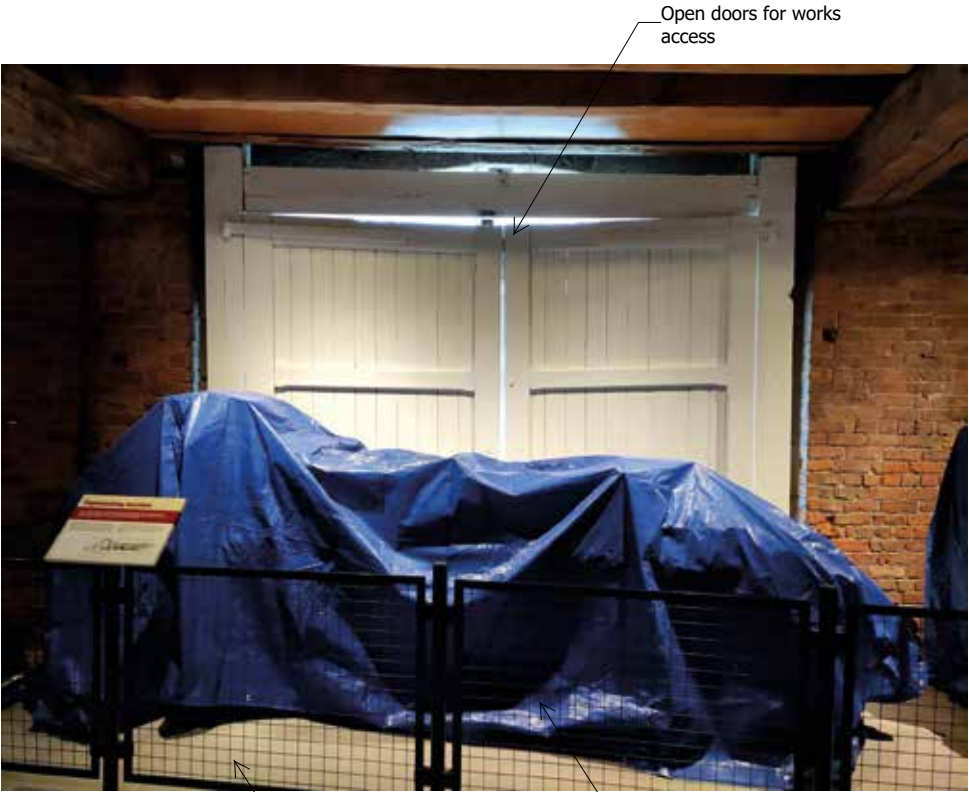
80-90mm ACRYPOL



Avoid fixings close to edge.
Pref. short resin anchors /
No expansion bolt



collapsed



Open doors for works
access

Collection Object relocated by client
enabling works

Plinth removed by client enabling works

4.4 Analysis of Bay 2



REPAIRS
some pointing at same time on site during the works before reinstate glazing

Hoist on Turntable
(protect)

Glass cut round

Glass interface with stone

TRAP DOORS!

TEMP PROTECTION
Internal avoid dust Hoarding
1.5m internal working zone
External Scaffold
weathertight protection

Localised re-pointing with
lime mortar and brick repair
once glass removed



Glass interface with brickwork

Glass cut round stone

Glass interface with stone



New flashing detail
required to protect wood
sill

Hoist Turntable

Access Internally by gate

Glass simply supported
and clamped by timber
bead

Existing timber
beading screwed
down

New shoe detail required
with adequate drip

Lift two boards to
investigate during
the works

Primary Beam.
Dead bearing



Hoist Turntable
restrained and locked

viaduct archway



Shoe detail
(defect to rectify)

Proper shoe detail
over joists.
- Lead

Timber sill rotten
↑
Don't replicate detail

4.5 Analysis of Bay 3



View out of Bay 3, which is a point of arrival from the steps from the lower yard entrance



The glazing detail is very similar to the failed detail at Bay 1



As with Bay 1, Bay has a glass floor with structure bearing down on a timber batten



The viaduct level is visible from the landing at ground floor mezzanine



Looking up from the yard level arrival



Bay 2 foreground, and Bay 3 to the right. The Bay 3 detail to the viaduct is the same as Bay 1

4.6 Considerations

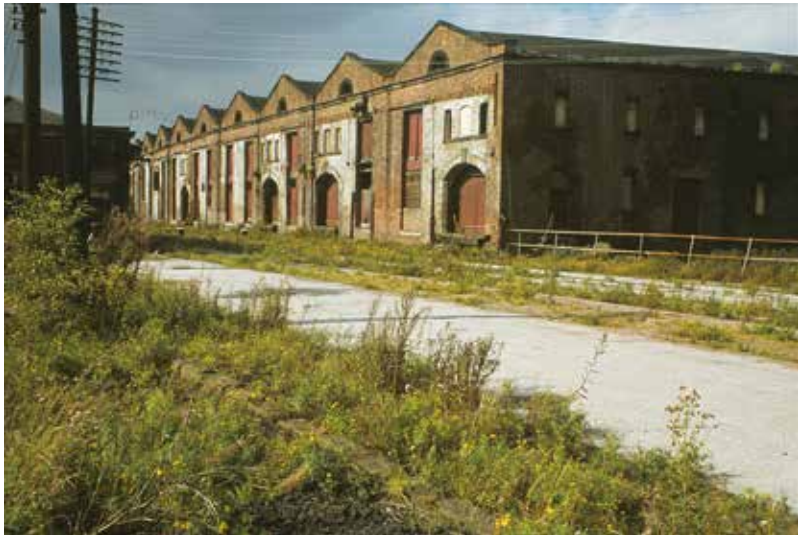
- The design approach is to create a new vocabulary for contemporary details to replace the previous phase of museum interventions and to create a family of details which can be applied to a group of the wagon arches.
- The approach to the new replacement to the structurally glazed infills considers analysis of the historical context of internal floor levels and trackbed level, visual consistency across a group of wagon arches, reviewing the defects and eventual failure of the existing detail, and preparation of new proposed detail to the wagon arches.
- None of the glazing is original.
- The aim is to create a strategic approach rather than piecemeal approach.
- The visual approach to the replacement glazed infill to the wagon arches of Bay 1, Bay 2 and Bay 3 will set a consistent approach. The approach considers the functionality of the space behind, understanding its current and future planned use to determine the level of specification (for example single or double glazed, thermal performance, UV exclusion). The structural glazing to the wagon arches in Bay 1-Bay 3 are part of the external enclosure (weathertight, maximising daylight, minimising ultraviolet light penetration to the collection, etc) and also provide a visual connection from inside the museum to the viaduct, the trackbed, and the 1830 Station.
- The design approach of the new glazing infill to the wagon arch needs to consider that existing openings to cargo doors, triple windows, lunettes are in many cases unglazed and therefore the envelope of the building is not fully weather protected and not able to provide a fully controlled internal environment but the structurally glazed wagon arches are located on the principal floor of internal gallery spaces for the display of museum objects.
- Following review of the defects which have led to the failure of the current glazed openings at Bay 1 and Bay 2, the replacement with like for like is not suitable. We have reviewed what is closest to like for like and consistent across the elevation and the proposal is a metal framed system set within the stone wagon arches with simple glazed panels. While achieving consistency, the approach considers the necessity to spend money on the right solution for long term.
- The pictures opposite illustrate the historical form of the elevation and the current arrangement of Bay 4 which the museum has used to replicate the original configuration.



Close-up view of the Bay 4 wagon arch (centre) and Bay 5 wagon arches to the right of the picture. Undated photograph pre-museum occupation. Source: unknown.



View towards Bay 1 at western end (left of picture) showing the Bay 3 wagon arch. Undated photograph pre-museum occupation. Source: unknown.



View of the Bay 4 wagon arch (centre) and Bay 5 wagon arches to the right of the picture. 1978. Source: unknown.



View of the Bay 4 wagon arch interior - part of the Museum's historic preservation of an original wagon arch configuration. 2021. Note the Bay 4 doors have been installed to the original position of the pintels whereas the Bay 5 wood doors are set inside the archway. Source: Studio Downie Architects LLP.

4.7 An illustrative comparison of glazing solutions



Infill of glazing to former railway goods buildings in King's Cross. The abutting frame extends forward of the brickwork. The glazing element is simple and the transom defined.

Infill of glazing to former railway building, set back from face elevation keeps the definition of the masonry arch form.



Simple glass elements.
(source: Reynaers).



Thin metal framing elements set within masonry.
(source: Reynaers).



Single large glazed infill in metal framed systems. (source: Schueco).



The metal framed system links to the springing point of the arch which reduces the visual height of the arched opening. (source: Schueco).

Precedent and research:

- In parallel to historical assessment as part of our design approach we have reviewed design precedents and typical high quality glazing systems from well established manufacturer's who have a good track record.



Metal framed glazing system with external capping piece. Note that a single glazed system can be installed within the framework. The Frame can be adapted for opening vents.



Metal framed glazing system with external silicone seal 'flush effect'.

4.8 Design Development

- The existing system is 12mm thick toughened glass with 6mm tolerance each side in a 24mm internal width channel cut into the stone reveal. The interface detail is flawed and has enabled the glazing to slip and provide a risk to the fabric, the collection and to staff and visitors.
- The existing dimensions are as follows:
 - Bay 1: The right hand height is approx. 3325mm high from viaduct to springing point. The apex of the arch is 635mm high above the springing point. The width between the stone reveals is approx. 3115mm. The existing 12mm toughened glazing panel system arrangement is two over two with a further two panels below the level of the internal floor. The upper horizontal joint well below the springing point.
 - Bay 2: The left hand height is approx. 2690mm to corbel, an arched corbel of approx. 255mm, a further approx. 2215mm high to underside of timber lintel. The width of the lower part is approx. 3435mm, the width of upper part is approx. 3485mm. The existing 12mm toughened glazing panel system arrangement is three over three with the outer panels of the lower section cut to the odd profile around the perimeter.
- **Specification of replacement glazing:**
 - Following technical consultation with glazing specialists, the glass thickness should be designed to site specific criteria (e.g. wind loads, barrier loads, etc.) to ensure the glass does not over stress or deflect. The recommendations from glazing specialists propose the use of either of 17.5mm (or 24.5mm) thick toughened laminated glazing with PVB interlayer. They do not recommend the use of an 11.5mm thick toughened laminated glazed panel for use in this application to the wagon arches due to the size and arched profile.
 - The Saflex Poly Vinyl Butyral (PVB) interlayer is 0.76mm thick and this thickness is included within the 17.5mm (or 25.5mm) thick toughened laminated glazing panel.
 - Manufacturers advise that the maximum dimension for toughening sheets of glazing is 4500mm x 2500mm. To achieve a toughened laminated glass panel, a jointline between two adjacent panels will be required.



Bay 1 is similar to Bay 3



Glazed infill using a glazed infill system with external capping.



Bay 2 wagon arch was adapted in 1870 as a result of technological change,

4.9 Considerations of a like for like frameless system:

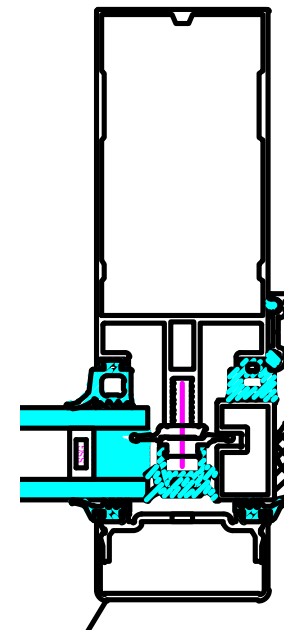
- The new glazing is required to be toughened laminated glass with a PVB layer. In a frameless system the PVB interlayer may absorb water at a maximum distance of 15 mm from the edge, which may change the tone of PVB.
- Replacement with a like for like frameless system to re-use the existing interface detail is not feasible without further change to the historical stonework which will cause potential harm to the stonework.
- The 17.5mm glass would not fit into the existing channel without adjustment and widening of the existing channel and would require further intervention into the stonework.
- The intervention would involve chasing a wider channel, a minimum 15-20 mm wider than existing. Even with due skill and care from an experienced craftsman, the chasing will cause vibration and resultant harm to the stonework. The process will also create extensive dust, posing a risk to operatives and occupants.
- The harm caused by installing the frameless system includes:
 - Material loss at the ariss,
 - Loosening of mortars and risk of movement in blocks,
 - Inducing cracking or widen existing fissures leading to further water ingress into the stone units and the risk of future loss of stone face.
- The future installation of double glazing is not feasible within the recessed channel detail.
- Inserting glass into the historic fabric poses a future maintenance issue should there be a need to repair the stone fabric surround.
- Maintenance issues include:
 - Any building settlement could result in the cracking of the glass.
 - The recessed frameless detail conceals degradation of seals from regular visual inspection. The result is that defects can go unnoticed until they develop into damage to, or loss of, the surrounding fabric or failure of the embedment to the glazing.
 - The recessed channel precludes the installation of double glazed units and so reduces future adaptation.
- Repairs needed include:
 - Mortar joints require repointing from time to time. Raking out may cause damage to adjacent seals to the glazing system.
 - Spalling of stonework due to inherent defects requires stone masonry indent repair. The vibration of this can dislodge or damage seals to the recessed frameless detail.
 - Inadvertent damage from repairs can cause water ingress and failure of the support for the glazing.
- Reason why working with defective installation is not feasible for long term sustainability:
 - The marginal tolerances of the frameless system have failed.
 - The position of wood sills has made them inaccessible to regular inspection and vulnerable to water ingress and water damage due to flawed detail and insufficient preventative maintenance due to the lack of adequate access to inspect and to carry out repairs.
 - The intolerance of the frameless glazing system has meant that any minor repairs have not been cost effective to undertake given the risk of movement or fracturing in the frameless glazing.
 - As a result of previous urgent repairs with the benefit of extensive temporary works access, the defects in the glazing system were identified and the installation of anti-shatter film and bracing to the joints was undertaken - but these are only temporary safety measures and a long term detailed solution is required.



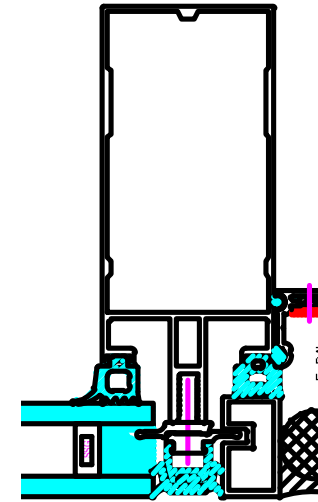
View of existing detail at Bay 3.

4.10 Considerations of a framed system:

- A review of an alternative Crittall type frame system was considered if it provided a thinner frame. The Crittall frame width is 27mm to 39mm + mastic width, based on the commercial MW40 range. The frame depth is 42mm. Due to the existing channel in the stone, an offset internal metal flange for bolted fixing will be required – the internal frame is 60mm deep. The Crittall frame system is designed for small panel sizes which results in a number of panes and more visible frame configuration of transoms and mullions across the glass infill to the arch.
 - The structural glazed framed system has both external cap and capless (butt jointed) detail options. The frame width is 48mm. The frame depth is 52mm. The internal frame is 90mm deep.
 - The system brought forward will be a high quality aluminium framed system with high performance toughened and laminated glass panels.
 - To keep the proposal as clean, simple and invisible as possible, the proposed large horizontal transom has been omitted. The associated perimeter frame is detailed with an aluminium weathering cap over the interface to the glass finish to maintain the simplicity and a similar minimalist feel of the existing system to the interface to the stone reveal.
 - The frames have a non invasive interface detail to the stonework while concealing the scar caused by the previous invasive channel detail. The system can be positioned to fix through the existing channel to avoid further damage to the historic fabric.
 - The frame system is detailed to provide tolerance to the existing fabric and is detailed to manage rainwater away from joint lines and interfaces.
 - The proposed frame detail provide interface details for future long term maintenance and ease of replacement.
 - The proposal considers the museum's future provision, i.e. the current brief is single glazing but double glazed units could be installed into a framed configuration while re-using the slot would preclude this opportunity for the museum.
 - The frame provides a family of details which is adaptable for future upgrade with a double glazed system into the framed system, to allow for future changes in use.
 - The proposed family of elements are thin vertical elements set back so that when viewed in context the frames would be secondary to the stone reveal of the wagon arches.
- **Summary:**
- The like for like installation is not feasible without further harm to the stonework. The frame system provides adaptability to future adaptation and ease of long term maintenance, and is a more sustainable approach with an aluminium frame to provide a better long term weatherproof detail and lower maintenance.



Detail of framed aluminium jamb with external capping piece.



Detail of framed aluminium jamb with flush gasket detail to external face.

4.11 Options

- This page illustrates the consideration of each option as developed following the meeting with MCC. These options consider feedback from the glazing specialists. The like for like installation is not feasible without further harm to the stonework. The frame system provides adaptability to future adaptation and ease of long term maintenance.
- The following pages illustrated the options at a larger scale for comparison.
- Considering MCC’s feedback, we recommend Option 1a which provides a solution which is as clean, simple and invisible as possible.

Option 1A

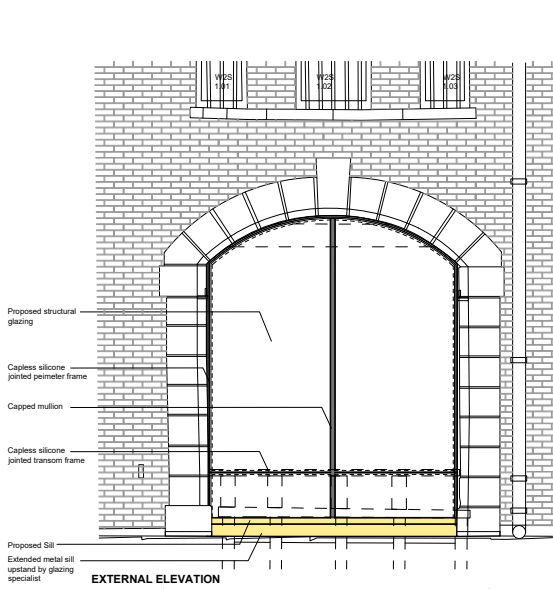
- Divided into two equal vertical panels.
- A capless perimeter frame reflects the existing minimal detail.
- Minimising interfaces.
- Maximising size of glass and reducing framed elements.
- A cap to the central vertical joint enhances vertical height.

Option 1B

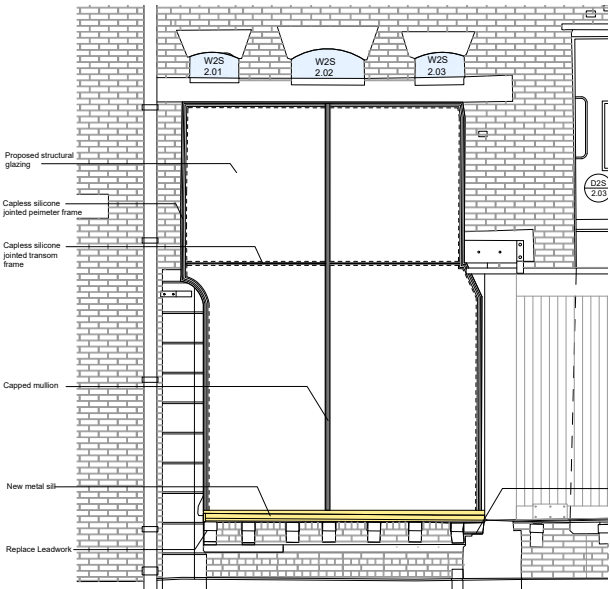
- Divided into two equal vertical panels.
- A capless perimeter frame reflects the existing minimal detail.
- Minimising interfaces.
- Maximising size of glass and reducing framed elements.
- A capless central frame. This adds more presence to the sill.

Option 2A

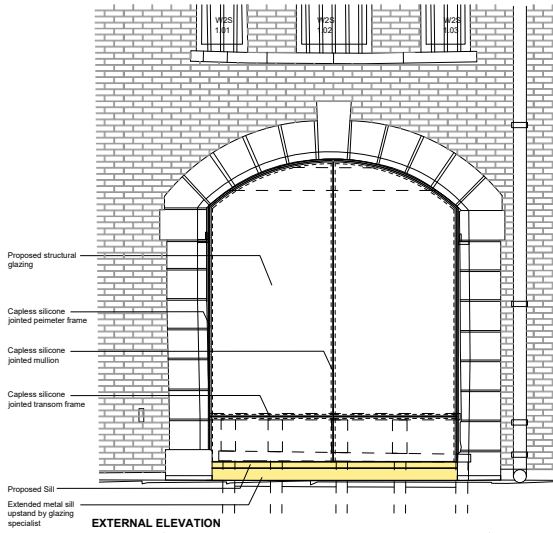
- Divided into two equal vertical panels.
- A capless perimeter frame reflects the existing minimal detail.
- Minimising interfaces.
- Maximising size of glass and reducing framed elements.
- A cap to the central vertical joint.
- A cap to the mullion joint adds scale and proportion.



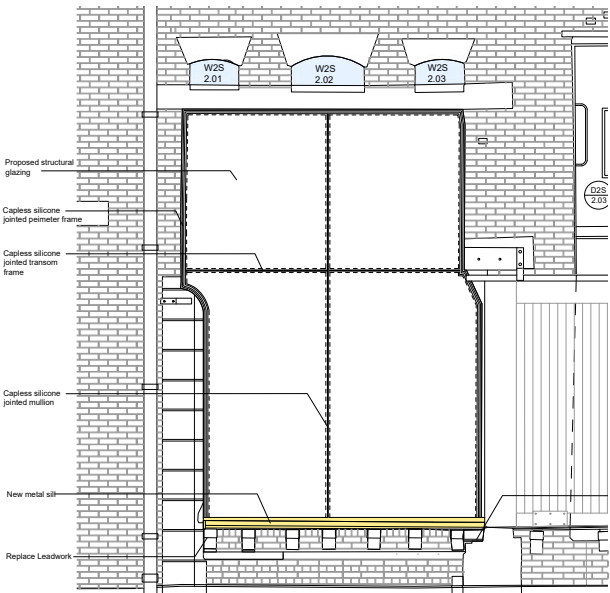
OPTION 1A to Bay 1 and Bay 3



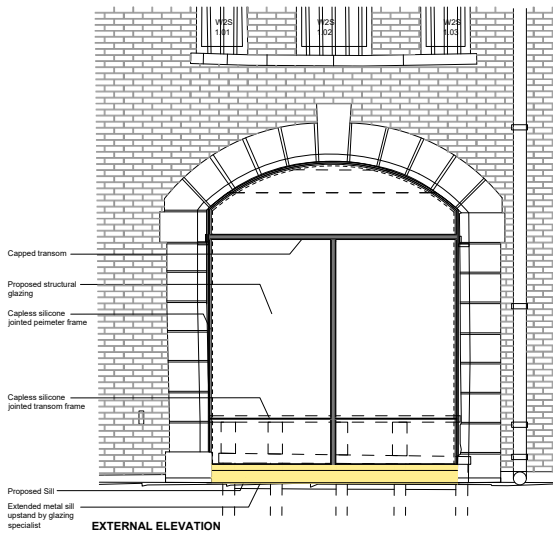
OPTION 1A to Bay 2



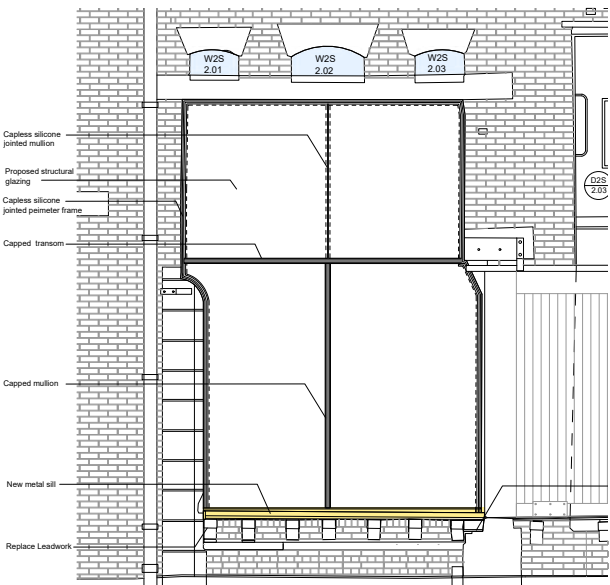
OPTION 1B to Bay 1 and Bay 3



OPTION 1B to Bay 2



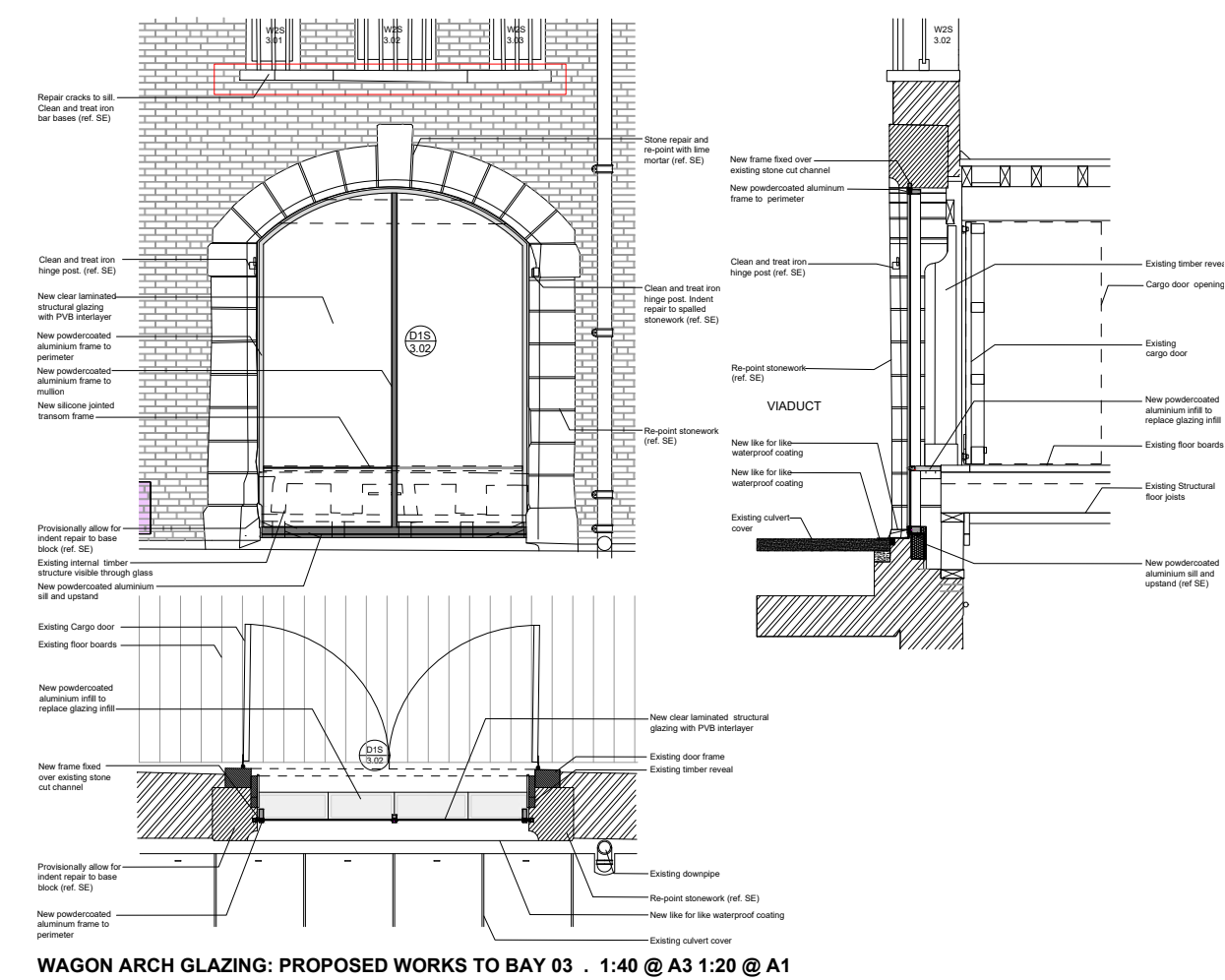
OPTION 2A to Bay 1 and Bay 3



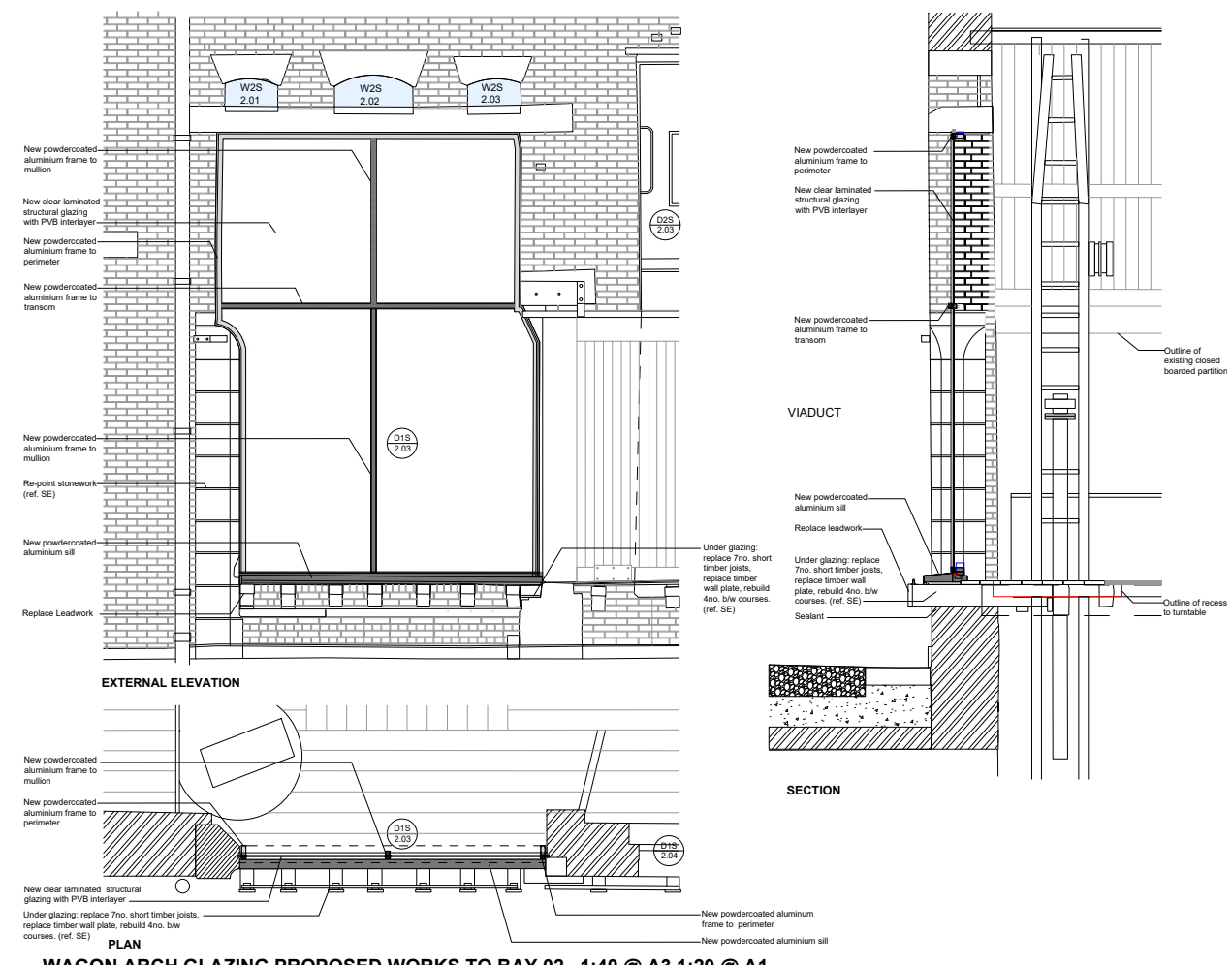
OPTION 2A to Bay 2

4.12 Proposal

- Considering MCC’s feedback, we recommend the propsoals developed from Option 1a. Reasons to support the revised proposal:
 - High quality aluminium framed system with toughened, laminated glass panels with PVB interlayer to protect the interior.
 - Maximises size of glass and reduces framed elements and associated air paths. Energy efficient solution.
 - Perimeter frame detailed with a capped detail to maintain simplicity. Cap to the central vertical joint enhances vertical height.
 - Frames have a non-invasive interface detail to stonework and conceal scar.
 - System can be positioned to fix through existing channel without damage to historic fabric.
 - Option to install double glazing in future.
 - Maximises size of glass and reduces framed elements.
 - Cap to the central vertical joint enhances vertical height.
 - High quality aluminium framed sill and upstand below provides better long term weatherproof detailing.
 - A solution which is as clean, simple and invisible as possible.



WAGON ARCH GLAZING: PROPOSED WORKS TO BAY 03 . 1:40 @ A3 1:20 @ A1



- **List of Drawings**

Studio Downie Architects Drawings - architectural and general arrangement

Location Plan

275/PD/001 Location Plan

Site Plan

275/PD/002 Site Plan

Existing General Arrangement Drawings

275/PD/010 Existing Building: Basement

275/PD/011 Existing Building: Ground Floor & Ground Mezzanine

275/PD/012 Existing Building: First Floor

275/PD/013 Existing Building: Second Floor & Second Floor Mezzanine

275/PD/020 Existing Building: External Elevation

275/PD/050 Existing Building: Internal Elevation GA

Wagon Arches Bay 1, Bay 2 & Bay 3

275/PD/101 Wagon Arch Glazing: Existing external & internal elevations

275/PD/110 Wagon Arch Glazing: Existing Bay 01

275/PD/111 Wagon Arch Glazing: Existing Bay 02

275/PD/112 Wagon Arch Glazing: Existing Bay 03

275/PD/201 Wagon Arch Glazing: Proposed external & internal elevations

275/PD/210 Wagon Arch Glazing: Proposed Works to Bay 01

275/PD/211 Wagon Arch Glazing: Proposed Works to Bay 02

275/PD/212 Wagon Arch Glazing: Proposed Works to Bay 03

Cargo Door Sills

275/PD/140 Cargo Door Sills: Existing detail

275/PD/340 Cargo Door Sills: Proposed Works

Repairs to interior and exterior

275/PD/710 Proposed Works to Existing Building: Basement

275/PD/711 Proposed Works to Existing Building: Ground Floor & Ground Mezzanine

275/PD/712 Proposed Works to Existing Building: First Floor

275/PD/713 Proposed Works to Existing Building: Second Floor & Second Floor Mezzanine

275/PD/720 Proposed Works to Existing Building: External Elevation

275/PD/750 Proposed Works to Existing Building: Internal Elevation GA

275/PD/811 Photo Reference: Essential Repairs to Ground Floor & GFL Mezzanine

275/PD/813 Photo Reference: Essential Repairs to Second Floor & 2FL Mezzanine

275/PD/820 Photo Reference: Essential Repairs GA External Elevation

275/PD/850 Photo Reference: Essential Repairs GA Internal Elevation

Conisbee Drawings - structural repairs

220627-CON-XX-00-DR-S-1099 BASEMENT PLAN STRUCTURAL REPAIRS

220627-CON-XX-GF-DR-S-1100 GROUND FLOOR PLAN STRUCTURAL REPAIRS

220627-CON-XX-M0-DR-S-1101 GF MEZZANINE PLAN STRUCTURAL REPAIRS

220627-CON-XX-01-DR-S-1102 FIRST FLOOR PLAN STRUCTURAL REPAIRS

220627-CON-XX-00-DR-S-3100 SOUTH ELEVATION BAYS 1 & 2 STRUCTURAL REPAIRS

220627-CON-XX-00-DR-S-3101 SOUTH ELEVATION BAYS 3 & 4 STRUCTURAL REPAIRS

220627-CON-XX-00-DR-S-3102 SOUTH ELEVATION BAY 5 STRUCTURAL REPAIRS

220627-CON-XX-00-DR-S-3103 EAST ELEVATION STRUCTURAL REPAIRS

220627-CON-XX-00-DR-S-3104 NORTH ELEVATION BAYS 5 & 4 STRUCTURAL REPAIRS

220627-CON-XX-00-DR-S-3105 NORTH ELEVATION BAY 3 & 2 STRUCTURAL REPAIRS

220627-CON-XX-00-DR-S-3106 NORTH ELEVATION BAY 1 STRUCTURAL REPAIRS

220627-CON-XX-00-DR-S-3107 WEST ELEVATION STRUCTURAL REPAIRS

Conisbee Drawings - structural repairs

220627-CON-XX-00-DR-S-1099 BASEMENT PLAN STRUCTURAL REPAIRS

220627-CON-XX-GF-DR-S-1100 GROUND FLOOR PLAN STRUCTURAL REPAIRS

220627-CON-XX-M0-DR-S-1101 GF MEZZANINE PLAN STRUCTURAL REPAIRS

220627-CON-XX-01-DR-S-1102 FIRST FLOOR PLAN STRUCTURAL REPAIRS

220627-CON-XX-00-DR-S-3100 SOUTH ELEVATION BAYS 1 & 2 STRUCTURAL REPAIRS

220627-CON-XX-00-DR-S-3101 SOUTH ELEVATION BAYS 3 & 4 STRUCTURAL REPAIRS

220627-CON-XX-00-DR-S-3102 SOUTH ELEVATION BAY 5 STRUCTURAL REPAIRS

220627-CON-XX-00-DR-S-3103 EAST ELEVATION STRUCTURAL REPAIRS

220627-CON-XX-00-DR-S-3104 NORTH ELEVATION BAYS 5 & 4 STRUCTURAL REPAIRS

220627-CON-XX-00-DR-S-3105 NORTH ELEVATION BAY 3 & 2 STRUCTURAL REPAIRS

220627-CON-XX-00-DR-S-3106 NORTH ELEVATION BAY 1 STRUCTURAL REPAIRS

220627-CON-XX-00-DR-S-3107 WEST ELEVATION STRUCTURAL REPAIRS

220627-CON-XX-ZZ-DR-S-4001 TYPICAL STRUCTURAL REPAIRS DETAILS SHEET 1

220627-CON-XX-ZZ-DR-S-4002 TYPICAL STRUCTURAL REPAIRS DETAILS SHEET 2

220627-CON-XX-ZZ-DR-S-4003 TYPICAL STRUCTURAL REPAIRS DETAILS SHEET 3

220627-CON-XX-ZZ-DR-S-4004 STONE REPAIR DETAILS