BURO HAPPOLD

SIM - Sitewide Capital Works

Stage 3 Structural Report – NW & SEG Planning Submission

SIM-BHE-XX-XX-RP-S-0100

0054704

5 September 2023

Revision P02

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Revision	Description	Issued by	Date	Checked
P01	Stage 3 Planning Submission	Darren Conboy	08.08.23	
P02	Stage 3 Planning Submission	Darren Conboy	05.09.23	

https://burohappold.sharepoint.com/sites/054704/02_Documents/04_Reports/10 Planning Docs at Stage 3-4/SIM-BHE-XX-XX-RP-S-0100 - NW & SEG planning report.docx

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1 Introduction

1.1 Overview

Note – this document is an abridged version of the structural Stage 3 report which has been prepared to support planning and listed building consent application for the project. Only information directly related to the planning submission is included.

Buro Happold (BH) have been appointed to provide structural engineering services for a suite of projects at the Science + Industry Museum (SIM) site in Manchester. These projects are to be delivered collectively as the Sitewide Capital Works 2025 project.

This report summarises all information related to the proposed structural projects. This includes descriptions of the existing structures based on archive information and investigation work, as well as structural details and assessments for the proposed works.

The projects are noted as follows, and reference should be made to Figure 1-1 for the relevant locations:

i. New Warehouse
ii. SEG
iii. Station Viaduct
iv. Gantry Restoration
v. Upper Yard & Entrance

This report has been prepared pursuant to the planning and listed building application for the New Warehouse and SEG.

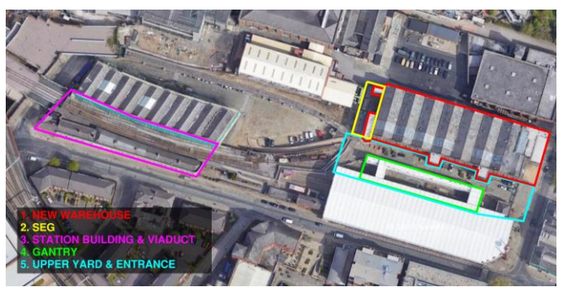


Figure 1-1 Site location plan

1.2 Executive Summary

Reference should be made to the BH Stage 3 drawings package for proposed works. Please note that some survey information is still outstanding, and design coordination is still ongoing. As such, contingencies should be made against costs for these works to account for possible future design development.

1.2.1 New Warehouse

Structural Condition

- The roof structure of the New Warehouse (NW) is generally in fair condition, despite significant water ingress. This is likely due to the beneficial effect of heating and ventilation in the spaces below.
- However, several areas of decay have been identified which will require remedial action.
- The external fabric of the NW is generally in fair condition, with only minor defects identified.

Structural Discussion

- The proposed works require the existing roof structure to be assessed as they lead to changes in loading. These are primarily from increased insulation weight, changes to rooflights and inclusion of stepped lead valleys.
- Analysis has shown that existing trusses are adequate for the changes in loading.
- Scaffolding and temporary weather protection is likely to have an impact on the existing building, which will require assessment in further design stages.

Recommended Works

- Timber repair
  - Resin timber repair of 6 no. locations where decay has been identified to structural timbers.
  - Replacement of 10 no. locations where decay has been identified to valley / sarking boarding.
- Re-roofing – existing roof fabric to be replaced broadly like-for-like to architect's details.
- Additional timber to support new lead valley detail
- New steelwork structure to west entrance at ground floor.
- External fabric repairs:
  - Re-pointing of areas of localised loss of mortar. Mortar to match existing..
  - Repair of minor cracking of masonry to 9 no. locations.
  - Cleaning of masonry where evidence of staining / efflorescence due to moisture.
  - Blasting and re-painting of embedded metalwork where corrosion is visible.

1.2.2 SEG

Structural Condition

- Structural elements – jack arches, iron beams, walls, lintels – appear to be in generally fair condition, despite localised water ingress. Some exceptions are noted below.
- In a small number of locations, water ingress has led to corrosion or possible structure issues, but these are judged to not present a current issue.
  - Lintel to eastern wall is corroded, but it is judged that adequate section remains and waterproofing works should safeguard.
  - Beam ends local to western wall appear to be more corroded that in other areas, but previous survey works suggest that the level of corrosion is mild.
  - Localised repointing and cleaning of masonry required across SEG entrance area.

Recommended Works

- Localised repairs to masonry – repointing and cleaning. Refer to SEG sketch for extents.
- Removal of redundant steel pipe penetrating through the jack arch and in filling the gap with brickwork and mortar.

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2 New Warehouse

2.1 Introduction

The New Warehouse (NW) stands at the northeast corner of the SIM site and operates as the main entrance for the museum. At present it houses exhibition, office and event spaces over several floors. It is understood to have been built in 1880 as a goods warehouse as part of the expanding railway station and goods depot at the current SIM site, with several phases of alterations carried out since the original construction. Most notably external circulation cores and an entrance area appear to have been added in the recent past, and internal structures have been altered to add or partially infill an atrium.

Reference should be made to architectural information for a detailed building description.



Figure 2-1 Site Location - New Warehouse



Figure 2-2 New Warehouse – viewed from SW



Figure 2-3 New Warehouse – viewed from NW



Figure 2-4 New Warehouse

2.1.1 Overview of Works

The works to the New Warehouse can be considered in 2 sections:

i. Roof replacement & alterations
ii. External fabric repairs
iii. West entrance canopy and porch

Roof Replacement & Alterations

Based on previous survey work, it is judged that the existing roof covering has reached the end of its useable life and requires replacement. This is supported by widespread evidence of water ingress through the roof and failing fabric and rainwater goods – valleys, hoppers, downpipes etc. As part of the works the existing roof fabric is therefore to be replaced.

External Fabric Repairs

Previous inspections of the external fabric of the building have highlighted defects which may require addressing. The structural scope for this project includes carrying out a detailed assessment of the external walls / fabric of the building, advising on any required remedial works, and then undertaking the repair works.

West entrance canopy and porch

A new canopy and porch is proposed to be constructed at the western existing entrance of the new warehouse. A simple steel structure is proposed to support the free standing canopy.

2.2 Existing Structures

BH carried out several visual inspections of the NW roof area over Stages 2 and 3 which have been used in combination with the timber and damp survey to inform this section of the report.

2.2.1 Description

Building Description

The New Warehouse is a large rectangular plan building, with three stories and a basement level. The ground storey appears to be significantly taller than the first and second storeys. The roof is multi-pitched, with seven bays orientated perpendicular to the length of the building.

Roof Structure

The internal roof structure consists of eight bays of pitched solid timber roof trusses with intermediate valleys. Trusses span east-to-west between internal cast iron columns or external masonry walls. 4 types of trusses are present within the roof system (locations specified in SIM-BHE-NW-XX-DR-S-1111) as per Figure 2-5 to Figure 2-8.

Trusses are predominantly made up from solid timber sections, except for truss vertical members which are typically formed from (presumably) early steel rods. Truss members are connected by metal shoes and hanging stirrups, presumed to be cast iron and early steel respectively. Truss types 1 to 3 are based on the same queen post form, although types 2 and 3 include additional bracing and props. The type 4 trusses are a small king post truss although these are only found in the easternmost bay. In some areas the roof structure includes additional elements including cross beams, additional braces and lifting equipment. These are all understood to be part of the building's heritage as an operational goods warehouse.

Additional modern steel bracing is visible across the roof structure, including a longitudinal brace at the apex of the trusses which then ties into the northern and southern masonry walls, and braces along the length of the head of the western external wall. This is presumed to have been added to restrain trusses and the head of the wall and provide a robust diaphragm at roof level. Figure 2-16 to Figure 2-18.

Timber purlins span between the trusses, which in turn support timber sarking boards and the roofing build-up. In areas the roof structure includes additional elements, presumed to be related to the previous industrial usage of the building, including bracing and lifting beams.

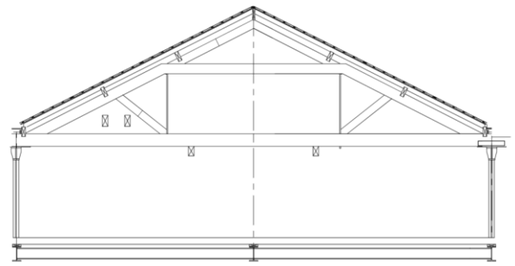


Figure 2-5 Type 1 Truss

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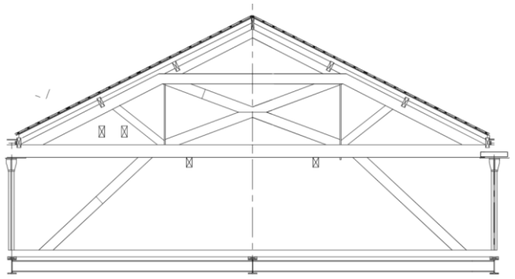


Figure 2-6 Type 2 Truss

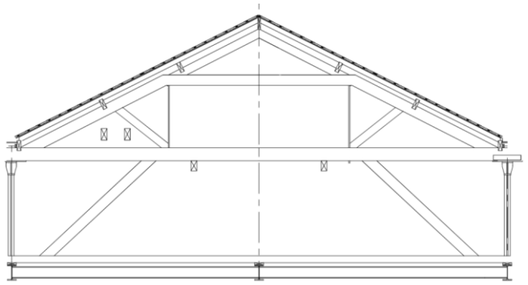


Figure 2-7 Type 3 Truss

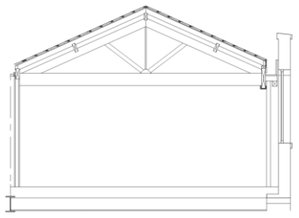


Figure 2-8 Type 4 Truss (Situated in two locations on the East side)

The remaining roof structure includes timber purlins which span between the trusses, notched into the main truss members. These support a system of rafters and sarking boards. The current roof fabric is understood to be of traditional slate construction, with a strip of glazed rooflights located towards the southern edge and a series of discrete rooflights across the remainder of the roof. Refer to architectural report for full details of roof build-up.

From the Hutton & Rostron timber and damp survey is it approximated that the timber trusses material consist of originally Scot's pine with an equivalent structural grade of C16. The repair timber is understood to be Douglas Fir and Norway Spruce (summarised in Table 1) . For the purpose of the roof truss assessment it is assumed that all of the members are C16 strength softwood.

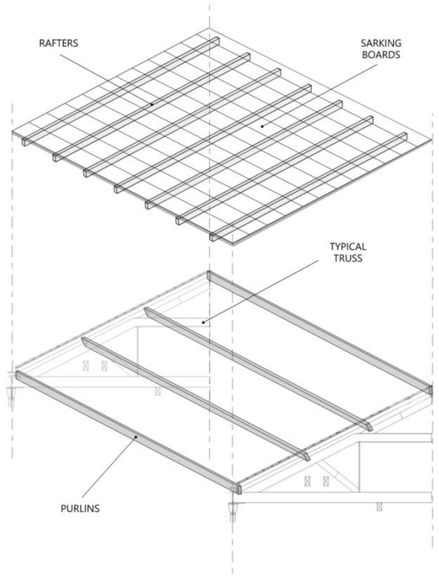


Figure 2-9 Typical Truss System

Material	Original / Repair	Bulk Density γ (kN/m³)	Modulus of Elasticity E (kN/mm²)	Tensile Strength (fy ult) (N/mm²)	Compressive Strength f_{cu} ult (N/mm²)	Shear Strength fy ult (N/mm²)
Scot's Pine	Original	5.3	8 - 10	41.8	21 - 42	5.2 – 9.7
Douglas Fir	Repair	4.8 – 5.6	11 -13	45 - 73	49 - 74	7.4 – 8.8
Norway Spruce (Spruce)	Repair	4.3	7 - 9	36 - 62	19 - 39	4.3 - 8

Table 1 Timber Truss Material Assumptions

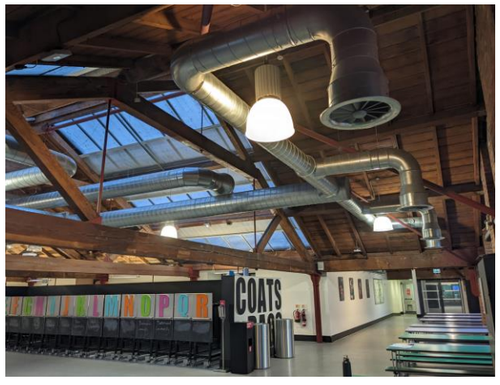


Figure 2-10 General roof structure details

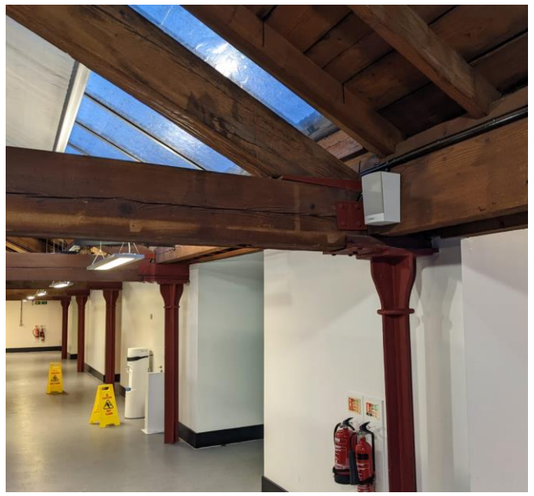


Figure 2-11 Typical bearing detail for truss onto columns



Figure 2-12 Roof structure w/ evidence of water ingress



Figure 2-13 Roof structure w/ evidence of water ingress

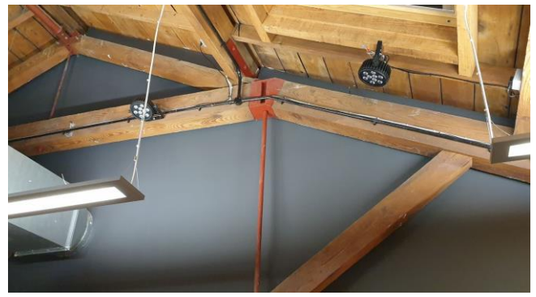


Figure 2-14 Typical truss details

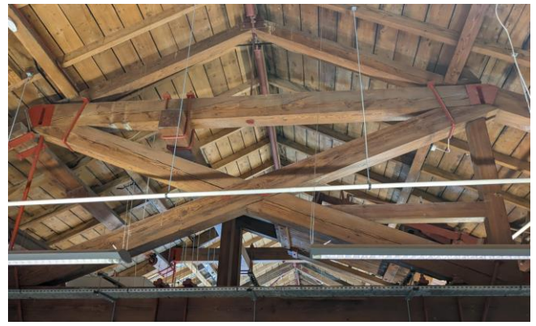


Figure 2-15 Additional secondary roof structures



Figure 2-16 Modern steel bracing to head of western wall

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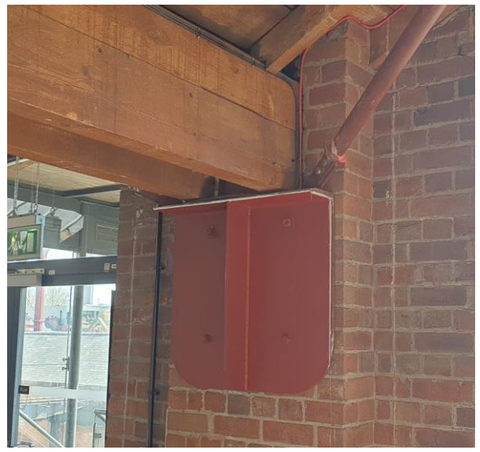


Figure 2-17 Modern bracing connection to south wall



Figure 2-18 Typical detail for modern brace to truss apex

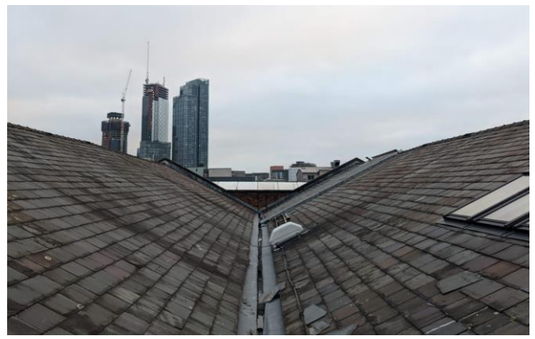


Figure 2-19 View of topside of roof

External Fabric

The external walls of the NW are constructed from load-bearing clay masonry, presumed to be solid and of significant thickness. The masonry is decorative, with both blue and red masonry units, and natural stone lintels, jambs, cills, padstones and detailing around windows. In addition to windows the external fabric includes several large openings with iron lintels and warehouse doors.



Figure 2-20 Typical details for external fabric

Internal Floor Structures

As the scope of this project primarily covers the external fabric and roof, the internal non-roof structures of the NW have not been assessed in detail.

The lower floors of the NW (ground and first floor) are typically of masonry jack arch construction – with shallow masonry arches spanning between embedded beams, presumably constructed from wrought or cast iron. These secondary beams are supported from deeper primary beams which project below the masonry and are in turn supported on internal cast iron columns, or onto the external masonry walls. Upper floors appear to be of similar construction, but with timber floors spanning between the secondary beams.

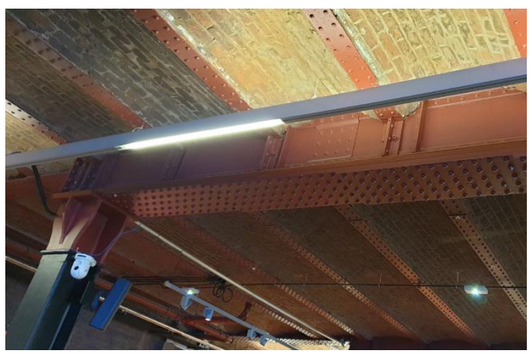


Figure 2-21 NW – typical lower floor construction

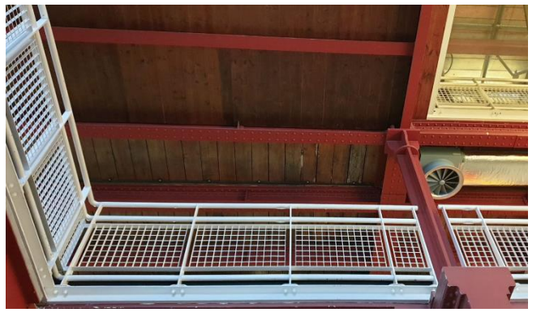


Figure 2-22 NW – typical upper floor construction

Alterations around the entrance atrium are visible where new steelwork has been inserted (presumably to trim the new atrium void) and extents of the masonry jack arches replaced with vaulted concrete. See Figure 2-23. It isn't clear whether these works were to reduce the size of an existing void, or to add a new atrium.



Figure 2-23 Alterations to NW floorplate

Foundations & Ground Conditions

Foundations for the NW are not fully understood, but archive information indicates that they are similar to those shown in Figure 3-3. This consists of granite padstones and blue brick masonry and large mass concrete pile foundations (depth unconfirmed). It is assumed that these piles bear directly onto the underlying rock.

2.2.2 Condition

This section is based primarily on the detailed H + R timber and damp survey, supported by findings from BH inspections.

Roof

- The roof structure (trusses, purlins, valley timberwork, sarking boards) is generally in fair condition. Intrusive testing showed that most timber elements appear to be dry and structurally sound.
- There is clear evidence of widespread and prolonged water ingress, particularly at valleys, roof lights and gables. However, as timber is generally sound it is likely that heating and ventilation of the occupied floor below the roof structure has prevented widespread decay of timber elements.
- Structurally significant decay caused by wet rot has been identified in several areas, most notably at bearings ends of purlins, valley timberwork, tie beams and sarking boards. The timber and damp survey indicated 7 locations where structural timbers have decayed, and 9 locations boards where gutter/sarking boards have decayed.
- There is evidence of previous repair work to the timber structures, which will require review as part of the current works.

External Building Fabric

BH undertook a visual survey of the New Warehouse external fabric on 30.11.22. The results of this survey are summarised below and on sketch SIM-BHE-NW-XX-SK-S-0001 which is included as Appendix A in this report. It should be noted that this inspection was carried out from external ground level only and so is limited to aspects viewable from this position.

- The external fabric of the building appears to be in generally fair condition. Whilst the masonry façade shows signs of weathering and age-related defects, these are not considered to pose significant structural issues at present.
- Several types of minor defect are present across different areas of the façade, as follows:
  - Localised loss of mortar.
  - Weathering of sandstone elements, leading to delamination.
  - Minor cracking of masonry.
  - Damage to brickwork due to previous interventions, primarily at RWP locations.
  - Staining / efflorescence due to moisture.
  - Corrosion to embedded metal elements – lintels, historic features etc.

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2.3 Structural Discussion

Roof Structure – Repair

Based on the findings of the H+R T&D survey a number of timber repair works will be required to correct damage and decay of existing timberwork. The current proposed works for these repairs are shown in the Stage 3 drawings, with detailed design to be carried out at Stage 4.

Several aspects are likely to require consideration:

- Methodology for carrying out repairs, likely informed by subcontractor input.
- Any temporary propping which may be required to support elements whilst work is ongoing.
- Determination of severity of decay and priority for repair, especially for secondary timber elements or where elements are wet but not necessarily decayed.
- Investigation of previous repairs.
- Future maintenance plan for roof structures.

Roof Structural – Re-Roofing & Alterations

The proposed works for the NW include several aspects which require structural assessment of the roof. These include:

- Increased loading from changes to roof build-up, primarily the inclusion of thicker and more dense insulation and a slightly layout of slate.
- Introduction of stepped lead-lined valley gutter detail.
- Removal of rooflights and replacement with heavier slate build-up.

As part of the Stage 3 works, BH have carried out detailed analysis of the roof trusses to verify the impacts of these changes to loading. The findings of this are as follows:

- Trusses were analysed for load cases of current and proposed.
- Under current loadings, most truss members are lightly to moderately utilised – typically sitting in a range of 30 – 70%.
- Under proposed loading - truss members typically experience an increase in utilisation of c. 10% and are therefore still less than 100% utilised. This means that most truss members are adequate for the increased loading.
- At present, one truss member is shown to fail, with a utilisation of 140% under the proposed loading. However this member also fails under current loading, which from inspection of the roof structure does not appear to be supported by reality. This suggests that there are mitigating circumstances for this member which will be investigated further at Stage 4. For this stage, we are comfortable that the roof trusses are adequate for the increased loading.
- Analysing historic structures against modern design codes is often challenging due to differing approaches to design over time. We would aim to analyse these structures pragmatically, taking particular account of the fact that they have proven to be adequate for existing loading, regardless of theoretical analysis.

External Fabric

The primary structural findings for the NW external fabric relate to making good of identified defects. As all defects identified are judged to be minor, repair works are anticipated to be straight forward and unlikely to require significant assessment or difficulty when carrying out.

New Surround to West Entrance

As part of the proposals a new surround is to be constructed to the NW western entrance at ground level. This entrance currently suffers from rainwater ingress through the doorway due to lack of protection and the prevailing wind direction. This surround is anticipated to match the existing surround at the eastern entrance to the NW, broadly in line with the intent shown in Figure 2-24 below.



Figure 2-24 Architect's proposal for entrance surround

A simple steel structure is proposed to support this surround. It is currently assumed that a free-standing structural solution is preferable proposed, rather than one which is positively connected into the existing NW structure. Allowing connection to the NW structure will likely lead to a reduction in required section size. See Figure 2-25 for structural intent.

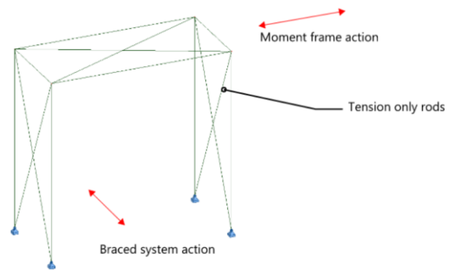


Figure 2-25 Proposed entrance surround – structural intent

Scaffolding

The proposal for scaffolding / weatherproofing during the roof replacement works includes a full-spanning weather tent which is ground-supported on the southern side of the NW, and partially cantilevering on the northern side where access to adjacent buildings needs to be maintained. BH have reviewed proposals and intend to continue working with the scaffolding subcontractor to inform proposals as they progress. The followings items are highlighted based on design at present:

- Scaffolding will place reasonably significant loads onto the external areas adjacent to the NW. These surcharge loads will ultimately need to be resisted by the NW basement walls. Based on the building usage and access/maintenance requirements, it is assumed that these walls have experienced similar surcharge loads in the past, but this needs to be investigated further at later design stages.
- The current scaffolding proposal includes widespread fixings into the building fabric. The loads associated with these fixings vary, but some are significant. Smaller loads will be resisted by anchors fixed into the masonry wall. The intent is that these will be placed into mortar beds to avoid damage to brickwork and any holes will be made good to architect spec. Scaffolding contractor will undertake pull tests to verify capacity of smaller fixings. More significant loads will be resisted by placing scaffold tubes through openings in existing glazing and using scaffolding to prop against the inside face of the external masonry walls. Damage to walls will be prevented by the use of timber packers.

2.4 Recommended Works

Reference should be made to the BH Stage 3 drawings package for proposed works.

Works in summary:

- Timber repair
  - Resin timber repair of 6 no. locations where decay has been identified to structural timbers. These locations include rafters, purlins, tie beams and valley beams. Details as per structural drawings.
  - Replacement of 10 no. locations where decay has been identified to valley / sarking boarding. Replacement to be like-for-like.
- Re-roofing – existing roof fabric to be replaced broadly like-for-like to architect's details.
- Additional timber to support new lead valley detail – as per structural drawings.
- New steelwork structure to west entrance at ground floor. See drawings.
- External fabric repairs:
  - Re-pointing of areas of localised loss of mortar. Mortar to match existing. For extents please refer to architect fabric repair drawings.
  - Repair of minor cracking of masonry to 9 no. locations. Allow for cleaning out of existing mortar joints (assume 5 no. courses, 1m long each), installation of crack-stitching rebar, re-pointing.
  - Cleaning of masonry where evidence of staining / efflorescence due to moisture. For extents please refer to architect fabric repair drawings.
  - Blasting and re-painting of embedded metalwork where corrosion is visible. Allowance for 50m of 600mm deep lintel is suggested at Stage 3.

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3 SEG

3.1 Introduction

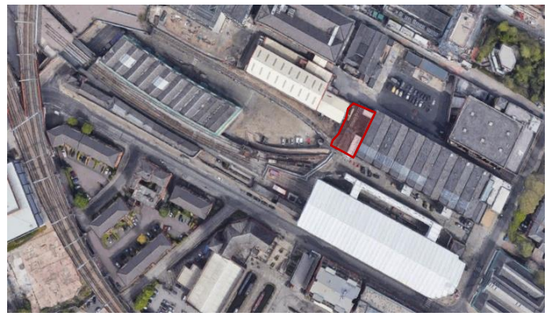


Figure 3-1: Site Location - SEG (Google Maps, 2023)

The Special Exhibition Gallery (SEG) is housed in the basement of the New Warehouse (NW), although the entrance area extends to underneath the external hard landscape area to the west of the NW.

The area of focus for the current works is the front of house / entrance area, which was developed as part of renovation works for the SEG in 2020. The works created a reception, toilet facilities, ticket desk and access to the main SEG area in the NW basement. The area can be accessed through the west entrance at the lower ground level underneath the Pineapple Line and through a southern stair core.

Note that this report only addresses the SEG entrance area where water ingress is an ongoing issue.

3.1.1 Overview of Works

Several locations within the SEG entrance area are prone to water ingress. The works are focused on the reduction of this water ingress, and the repair of any structural elements affected by the long-term water ingress into the SEG area.

Waterproofing and Drainage

An effective waterproofing and drainage strategy is to be developed to reduce the ingress of rainwater. Please refer to civil engineering and architectural reports for full details of the recommended works. This is anticipated to include the repair and possible alteration of an existing concrete capping slab, re-waterproofing, and repairs to the existing drainage system which appears to be defective.

Structural scope for this aspect of the works includes the following:

- Input to repair / alteration of concrete slab and any joints.

Repair of Damaged Elements

Where structural elements are found to have been negatively impacted by water ingress, remedial measures may be required, dependent on severity.

3.2 Existing Structures

3.2.1 Description

The SEG entrance area is housed within a below-ground space formed by a structural podium at the level of the Upper Yard. The structure of this podium level forms the ceiling of the SEG entrance.

Jack Arch Structure

The SEG ceiling structure is of historic masonry jack arch construction. Wrought iron beams at 2.1m centres span east-to-west across the entire entrance area with no intermediate columns or walls. Beams are rivetted and show an increase in flange thickness toward the midpoint of spans, through the addition of further plates.

Above the jack arch structures, at podium level, the SEG entrance area is capped with external hard landscaping of cobbled stone setts and asphalt with a concrete slab capping at least part of the extent. Details of the build-up between the arches and the cobbled landscaping is unconfirmed.

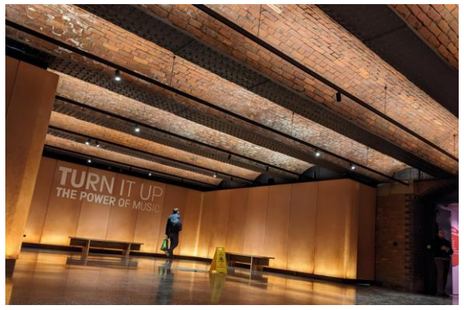




Figure 3-2 Typical details of jack arch structure

Vertical Structures

The jack arch beams span on to natural stone padstones or directly onto solid masonry walls located to the east and west of the entrance area. The eastern wall directly abuts the basement wall of the NW, but appears to be a separate structure. The western wall is positioned at the end of the Pineapple Line above. The foundations for these walls are shown on archive drawings (extract in Figure 3-3) and are understood to include granite padstones and blue brick masonry and large mass concrete pile foundations (depth unconfirmed). It is assumed that these piles bear directly onto the underlying rock.

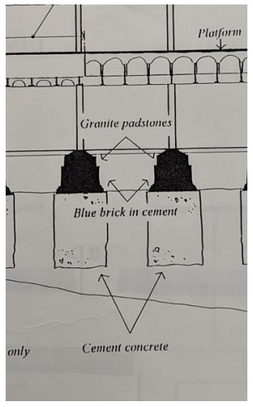


Figure 3-3 Assumed foundation detail to SEG, from archives

Wall Openings

Both east and west walls include large openings through the masonry. At opening positions the original structure includes plated iron lintels to support supports the ends of the spanning beams. These typically include vertical stiffeners.

Within one of the openings in the western wall of the SEG entrance there is evidence of recent interventions, understood to be part of the 2020 works. A pair of steel goal post frames have been inserted underneath the historic lintel, presumably to add support where corrosion has compromised the original structure.

3.2.2 Condition

BH carried out a visual inspection of the SEG entrance area in Dec 2022, which forms the basis of the condition report, along with additional existing information which was provided by the client. Findings from the BH inspection are included on sketch SIM-BHE-SEG-XX-SK-S-0001 which is included in appendix B.

Masonry Arches

The masonry arches which form the ceiling structure appear to be in generally good condition, with no signs of significant cracking, movement, or structural distress. There is however some localised evidence of mortar loss and efflorescence, and minor brick weathering.

Iron Beams

The iron beams appear to generally be in fair condition. There is widespread evidence of minor corrosion to the bottom flanges of beams, but this appears to be limited. Beams have been recently re-painted, presumably in 2020. As the majority of the beams are hidden inside the masonry arches it is not possible to comment fully on their condition, although there is no evidence of current structural distress.

Adjacent to the area of significant water ingress to the western wall (see below) the ends of beams appear to be corroded more than in other areas.

The beams were intrusively inspected in September 2020 with the results covered in the report noted in section 1.1. This report and associated metal testing confirmed the beams as wrought iron and found that whilst there was widespread corrosion this was judged to be minor. Structural capacity was checked and found to be adequate for proposed loads.

On the basis of this report and the fact that no additional signs of distress are noted, the existing roof structure is judged to be adequate. It is suggested however that periodic inspections take place moving forward, which will be discussed in more detail at later design stages.

Masonry Walls

Walls within the SEG entrance area appear to generally be in good condition, with no significant signs of cracking, movement or distress. There is widespread evidence of

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moisture ingress and efflorescence, but this is not judged to be structurally significant.

One section of wall to the northwest of the SEG entrance area is particularly badly affected by moisture ingress. Extensive algal growth and mineral deposits are visible. A concrete upstand has been built at the base of this wall and drainage provided, indicating the severity of the issue. The accumulation of deposits on the wall make inspection difficult, but it appears that the wall is in good structural condition, although will likely require repointing and cleaning. See Figure 3-4.



Figure 3-4 - Northwest wall water ingress condition

The rear face of this wall also shows evidence of significant moisture ingress. This face is accessed via the adjacent collections area which leads to a dead end corridor adjacent to the neighbouring building to the north of the SIM site. See Figure 3-4. In this location corrosion of the iron beam overhead is also visible, but it isn't clear how significant this is.



Figure 3-5 - Corrosion and water ingress at jack arch adjacent to neighbouring buildings

Embedded Steelwork – Western Wall

As per the previous section a lintel within a large opening in the western wall appears to be badly corroded, although this has been addressed by the insertion of new strengthening steelwork. This appears to be in good condition due to age and galvanised treatment. Shims are apparent between the original iron lintel and the new steel goal posts, however it was seen that some shims appear to be loose.



Figure 3-6 Western opening lintel - corrosion



Figure 3-7-Modern strengthening steelwork.

Embedded Steelwork – Eastern Wall

A further area of concern is visible at the eastern end of the SEG entrance area, at the entrance to the main SEG gallery. At the southern edge of this opening, there is evidence of ongoing water ingress and the historic iron lintel is clearly corroded. This has led to an apparent thinning of the bottom flange in this area, as well as corrosion to the web and stiffeners. The lintel appears to have been painted as part of the 2020 works, but there is evidence of bubbling of the coating, suggesting that corrosion may be ongoing.

It is understood that this was likely reviewed as part of the 2020 works and was apparently judged to be structurally acceptable.

Additional inspections carried out in May 2023 found that the thinning of the bottom flange only affects the tips of the flange, and that most of the width of the flange appears to have adequate thickness. In addition, there is no evidence of current structural distress. Ongoing corrosion would remain a concern, however as this area is to be waterproofed by the current works it is judged that this doesn't pose a current issue. As such, no works are proposed to this element.

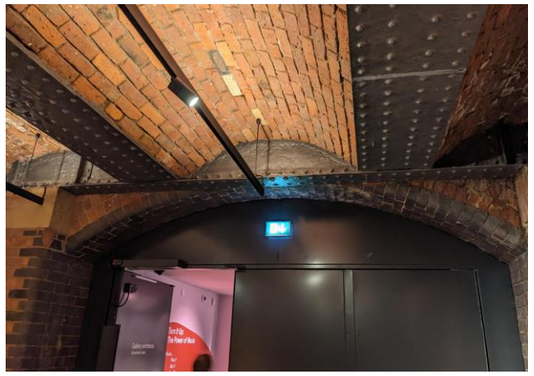




Figure 3-8- Eastern opening lintel corrosion

3.3 Structural Discussion

No additional items have been identified for discussion.

3.4 Recommended Works

Reference should be made to the BH Stage 3 drawings package for proposed works.

- Localised repairs to masonry – repointing and cleaning. Refer to SEG sketch for extents.
- Removal of redundant steel pipe penetrating through the jack arch and in filling the gap with brickwork and mortar.

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