

SIM - Sitewide Capital Works

Stage 3 Structural Report – Viaduct Repair Planning Submission

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1 Introduction

1.1 Overview

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

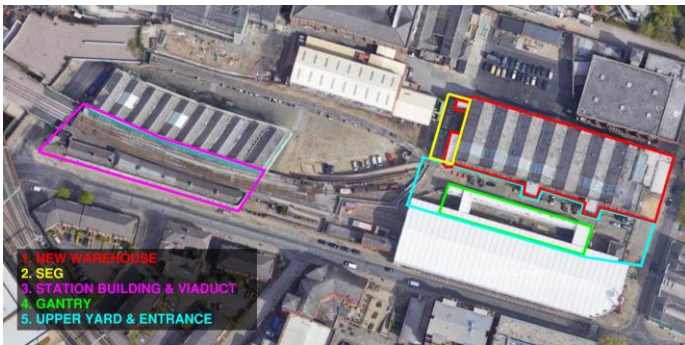


Figure 1-1 Site location plan

1.2 Executive Summary

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

Structural Condition

- The masonry arches which make up the Station Viaduct appear to be in good structural condition, with no signs of structural distress.

- The condition of structures outside of the arches is unknown as these were not accessible for inspection. In particular it is possible that existing timber and steelwork within the Station Building may have been damaged by moisture ingress. This will be verified at later stages.
- Within the Station Building basement there are several areas of degradation of masonry and heavy efflorescence due to (apparent) rising damp and/or condensation. It is suggested that this will require remediation.

Moisture Ingress

- It is clear that there is widespread ingress of moisture through the masonry arches and into adjacent spaces.
- The exact routes for this ingress are not clear, but is suggested that the existing concrete capping slabs and drainage channels may not be adequately waterproofed to prevent surface water passing through, and that water may be being routed through the arch structures.

Structural Discussion

- The adjacent Storage arch is defective and measures will need to be taken during construction to limit loading on the arch, although these shouldn't significantly impact the proposed works.

Proposed Works

- Minor re-pointing to be carried out to all arches where not previously carried out. This primarily applies to arches 1A, 2B, 3A.
- Several elements of work are required at track level to improve drainage and waterproofing:
 - Reinstating expansion and construction joint mastic. All joints to be cleaned out to full depth and new waterproof structural mastic to be injected.
 - Localised repairs to surface of existing concrete to accept waterproofing.
 - Exposing and waterproofing the existing capping slab, channels and external areas of the Station Building.

- Demolition of some concrete elements around the existing drainage channels, plus construction of new concrete kerbs.
- Formation of penetrations through existing cast iron columns to Station Building to accommodate RWP outlets. This works required to allow this are currently TBC at Stage 4.

2 Station Viaduct

2.1 Introduction

The Station Viaduct area consists of 10 no. connected masonry arches which are confined on both sides along their fully length by the adjacent buildings – The 1830s Warehouse to the north, and the Station Building to the south. The viaduct was constructed in the 1830s as part of the original railway line at the SIM site.

The arches are c. two stories tall with the floor level of the arches generally corresponding with the basement (LG) levels in the Warehouse and Station buildings. The arches support a historic external railway build-up at track level which corresponds to the first floor of both adjacent buildings.

Archive photos and localised opening-up works show that a concrete capping slab was installed at track level, below the rail build-up, at some point in the 1980s. It is assumed that this slab was installed to try to control water ingress through the arches, although it isn't clear whether this slab was waterproofed. It is understood that the movement joints between the concrete have now failed and may be one of the causes of water ingress.

The extent of the area covered by these works is shown below and extends from the western end of the Station / 1830s Warehouse buildings to the interface with the concrete bridge to the east of the buildings. This section of viaduct is abutted on both ends and sides by other structures which are currently out of the scope of this report.

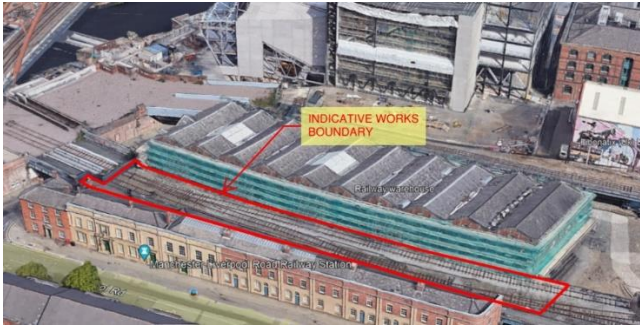


Figure 2-1 Extent of Station Viaduct



Figure 2-2 Plan view of LG level showing extent of Station Viaduct

2.1.1 Overview of Works

There is clear evidence that the areas underneath the Station Viaduct arches suffers from water ingress from the track level above. This water ingress affects the arches themselves but also appears to be leading to ingress into the adjacent Station Building, where there is significant water damage to finishes. At present the routes by which water is moving through the structures are unclear.

The multi-disciplinary scope for the scheme is subject to development as it progresses, but is anticipated to include:

- Review of existing concrete capping slab and degree of watertightness,
- Review of existing drainage system – both historic and from 1980s works,
- Review of water damage and impact on existing buildings,
- Proposals for making good damage to existing buildings,
- Proposals for remedial works to minimise future water ingress.

From a structural point of view, the scope is narrower and is anticipated to include:

- Review of condition of existing structures to determine impact of water ingress,
- Proposals for remedial works to address historic impact of ingress,
- Proposals for remedials to minimise future ingress,

2.2 Existing Structures

2.2.1 Description

The existing viaduct arches are constructed from solid masonry, with a crown thickness of 2 bricks on end. The infill between the crown of the arches and track level is unknown, but is assumed to be clinker or loose rubble. The arches are constructed with a noticeable skew along their length, meaning that the exact dimensions change between the arches. This is discussed further in the BHA reports discussed in section **Error! Reference source not found..**

At track level, the original build-up has been capped with a new concrete slab and drainage channels to the north and south, which were constructed in the 1980s. This slab includes extensive expansive and construction joints, the failure of which may be a cause of water ingress. The details for slab and channels appear to be well-documented, and a selection of details are included below.

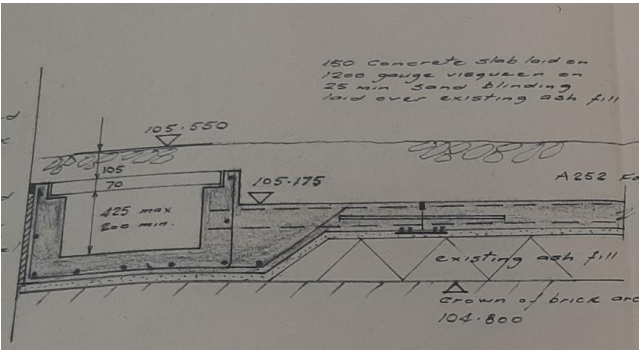


Figure 2-3 Section through 80's slab and drainage channel

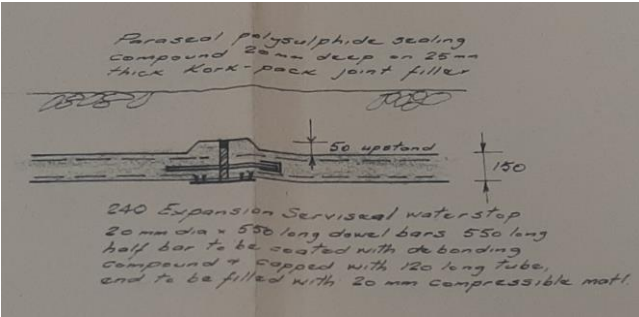


Figure 2-4 Section through expansion joint

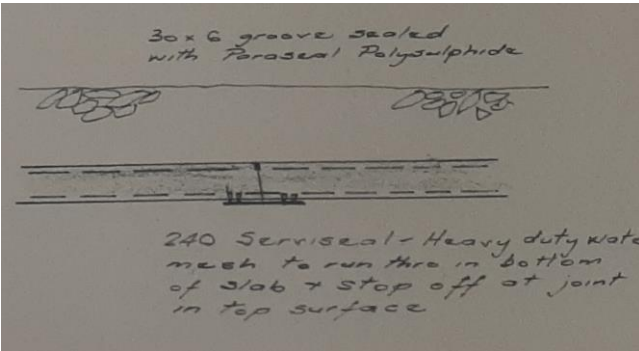


Figure 2-5 Section through construction joint

The structure of the adjacent Station Building appears to have been mostly re-built during the 1980s, meaning that it is of modern construction. Whilst original cast iron columns have been retained above track level to the north of the building, the remainder of the structure appears to be structural steel, with precast concrete floor planks.

2.2.2 Condition

A visual inspection was undertaken by BH structures on 08.09.22 to assess the condition of the masonry arches and adjacent spaces and review impact of water ingress. This inspection was summarised in BH document *SIM-BHE-AR-XX-RP-S-XX-0001 - Technical Report* and reference should be made to this document for full details.

In summary:

- The Station Viaduct masonry arches were found to be in good structural condition throughout, with no signs of cracking, significant movement, or other sign of distress. This is in keeping with previous survey work in the spaces – most notably the BHA inspection report from 2017.
- It is apparent that the crown of arch 4A at the southern face has dropped by a small amount. As there is no evidence of cracking or progressive movement it is likely that this movement occurred in the past, likely due to mortar loss as this area appears to have suffered from significant historic water ingress. This is not judged to pose a structural concern at present. See Figure 2-6.
- Clearly the arches have suffered ongoing moisture ingress which in some locations is relatively serious, but this appears to have led to minimal structural issues. Masonry is generally sound and re-pointing has already been carried out in the worst-affected arches. Some localised re-pointing may be required though.
- The basement of the Station Building building has suffered more significantly due to moisture ingress or

condensation, with fairly severe degradation of masonry noted in several areas. However, this appears to be due to penetrating low level damp rather than from water ingress through the arches, and as such is unlikely to be remedied by the works proposed as part of this scheme at present. This should be addressed in further design stages. See Figure 2-13 and Figure 2-14.



Figure 2-6 Flattening of crown of arch 4A



Figure 2-7 Typical condition of viaduct arches

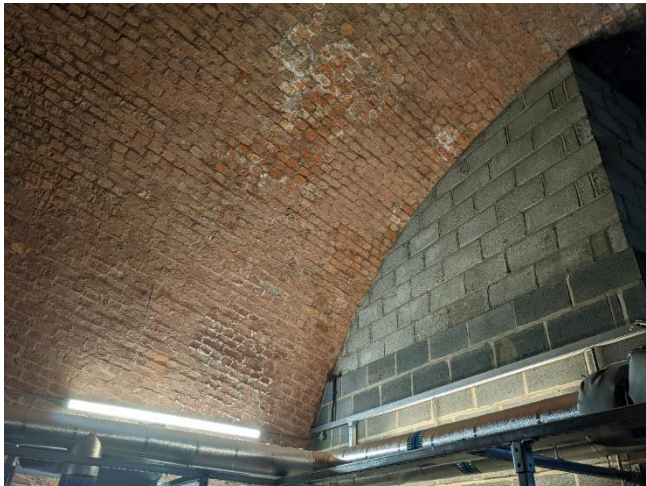


Figure 2-8 Typical condition of viaduct arches



Figure 2-9 Staining due to extensive water ingress – arch 3A



Figure 2-10 Efflorescence to face of masonry – arch 5B



Figure 2-11 Water damage to ceilings in Station Building



Figure 2-12 Staining due to water ingress – arch 5B



Figure 2-13 Station Bldg basement – masonry degradation due to moisture ingress

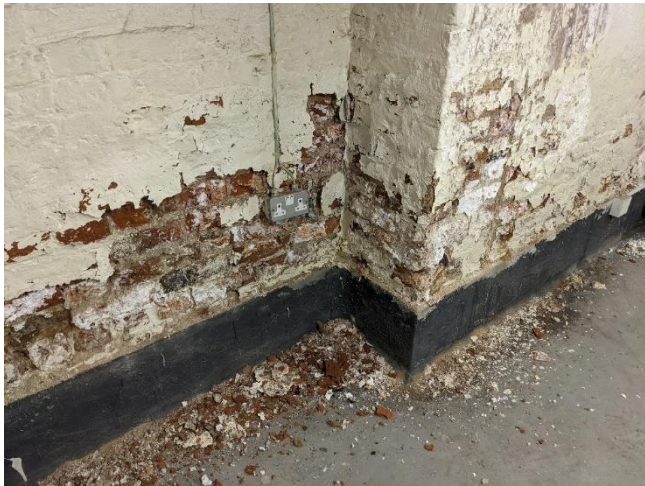


Figure 2-14 Station Bldg basement – masonry degradation due to moisture ingress

2.3 Structural Discussion

Storage Arch assessment

- During the review of existing information for the Station Viaduct, previous survey reports covering the Viaduct and adjacent areas were reviewed. In these reports, concerns had been raised about the arch directly to the east of the concrete bridge which marks the edge of the scope boundary for the Viaduct works – known as the Storage Arch. The abutment wall of this arch appears to have rotated/moved, leading to a drop in the crown of the arch, and the arch deforming to the west. The assessments included in the reports agreed that the arch was adequate for continued loading, but the full details of this are not necessarily clear. As such there remains a concern that temporary loading of the arch during construction will require additional assessment.
- BH were instructed to carry out this assessment as part of the Stage 2 works, and it is anticipated that this will continue through future design stages.
- BH Stage 2 assessment was based primarily on a review of existing surveys and assessments, although a visual inspection was carried out.
- The Storage Arch is in poor condition and will continue to degrade until repair works are carried out.
- Previous assessments are not conclusive in their findings regarding allowable future loading, and some of the input data used requires confirmation.

- It is likely that the arch can sustain construction traffic loading, but it is suggested that vehicle weights and speeds are limited to avoid overstressing the arch. In addition, it is likely that the northern area of the arch will need to be excluded from construction loading due to its particularly poor condition.
- Further assessment will be required in future design stages if works are to be carried out around the arch.

outlets. This works required to allow this are currently TBC at Stage 4.

2.4 Proposed Works

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

- Minor re-pointing to be carried out to all arches where not previously carried out. This primarily applies to arches 1A, 2B, 3A.
- Several elements of work are required at track level to improve drainage and waterproofing. Reference should be made to the architectural proposals for these works to avoid duplication, but structural aspects are addressed below:
 - Reinstating expansion and construction joint mastic. All joints to be cleaned out to full depth and new waterproof structural mastic to be injected. Expansion joints are assumed to be full slab depth (150mm) and construction joints 30mm deep. Extent is to be confirmed at later design stages but archive drawings indicate 3 no. expansion joints which run N-S across track area, and a series of construction joints (which also require shallow mastic) at c. 10x10m centres. Based on this a suggested allowance of 450m of mastic should be allowed for.
 - Localised repairs to surface of existing concrete to accept waterproofing. Extent is unclear but allowance is to be made for localised patch repairs with structural grout. Architectural report suggests 25% of gross area of slab / channels.
 - Exposing and waterproofing the existing capping slab, channels and external areas of the Station Building.
 - Demolition of some concrete elements around the existing drainage channels, plus construction of new concrete kerbs.
 - Formation of penetrations through existing cast iron columns to Station Building to accommodate RWP

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