

SIM - Sitewide Capital Works

Stage 3 Structural Report – Gantry Planning Submission

SIM-BHE-XX-XX-RP-S-0102

0054704

14 September 2023

Revision P03

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	
P03	Stage 3 Planning submission	Darren Conboy	14.09.23	

[https://burohappold.sharepoint.com/sites/054704/04_Outgoing/230914 Updated SIM Stage 3 Planning Gantry Report/SIM-BHE-XX-XX-RP-S-0102 - Gantry planning report.docx](https://burohappold.sharepoint.com/sites/054704/04_Outgoing/230914%20Updated%20SIM%20Stage%203%20Planning%20Gantry%20Report/SIM-BHE-XX-XX-RP-S-0102%20-%20Gantry%20planning%20report.docx)

Report Disclaimer

This Report was prepared by Buro Happold Limited ("BH") for the sole benefit, use and information of SMG for Stage 2 report. BH assumes no liability or responsibility for any reliance placed on this Report by any third party for any actions taken by any third party in reliance of the information contained herein. BH's responsibility regarding the contents of the Report shall be limited to the purpose for which the Report was produced and shall be subject to the express contract terms with SMG. The Report shall not be construed as investment or financial advice. The findings of this Report are based on the available information as set out in this Report.

author

Darren Conboy

date

14 September 2023

approved

signature

date

..

Contents

SIM - Sitewide Capital Works	1
1 Introduction	4
1.1 Overview	4
1.2 Executive Summary	4
2 Gantry	5
2.1 Introduction	5
2.2 Existing Structures	5
2.3 Structural Discussion	6
2.4 Recommended Works	7

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

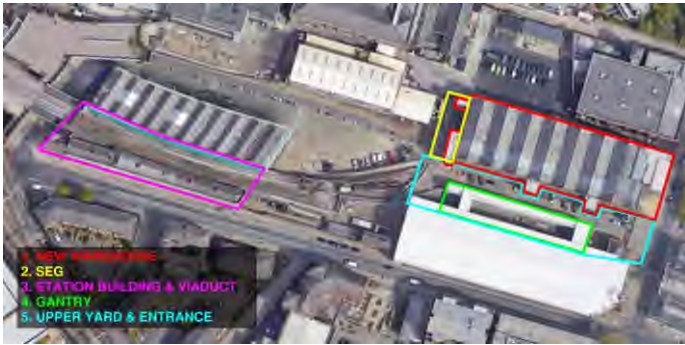


Figure 1-1 Site location plan

- The Gantry superstructure is widely corroded due to failing paint coatings. The severity of corrosion varies. In some places the level of corrosion is judged to have led to a significant reduction in structural capacity. In other areas corrosion may be less significant, but unless addressed will lead to future problems.
- BH carried out a MEWP-assisted survey during Stage 3, the results of which are covered in this report.
- Several queries are still outstanding regarding the structural behaviour of the Gantry and the most appropriate methodology for any repair works. These will be resolved as the project progresses.

Recommended Works

- Possible dismantling parts of the gantry and move to an off-site facility for cleaning / repair.
- Blast clean whole Gantry structure (paint and corrosion removal) either in-situ or off-site.
- Detailed visual inspection following cleaning to properly ascertain current level of corrosion.
- Carry out repair works to areas of significant corrosion.
- Recoat and paint steelwork, suitable for external exposure.
- Install lead capping cantilevering from the Power Hall and covering South beams.

1.2 Executive Summary

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

1.2.1 Gantry

Condition & Structural Assessment

2 Gantry

2.1 Introduction

The Gantry is located at the eastern end of the Science and Industry Museum plot, directly adjacent to the north of the Power Hall. It was built in the 1880s to facilitate unloading the goods from train wagons.

The Gantry superstructure is approximately 15m wide x 72m long. It consists of two rows of nine columns with longitudinal beams running between the column heads in the east to west direction. These beams support two paired crane beams which previously were able to track along the length of the Gantry. Secondary structures are also present which house lifting gear, and form balustrading and access gantries.

Archive photographs show timber cabins being present as part of the crane beam lifting gear, but these are understood to have been removed in the 1980s and not reinstated.



Figure 2-1 - Site Location - Gantry (Google Maps, 2023)



Figure 2-2 Gantry overview

2.1.1 Overview of Works

The Client intends to preserve the Gantry as a static historic exhibition. Lifting and moving features or cabins and access gantries do not need to be restored.

The current protective coatings to the Gantry have failed in many locations, leading to widespread corrosion of the existing structures. Based on inspections it is clear that the Gantry needs restoration works to stop the progressive deterioration and corrosion of the superstructure.

2.2 Existing Structures

BH carried out a MEWP-assisted visual inspection of the Gantry superstructure on 25/05/23, with the results informing the description and condition report below. Reference should be made to sketch SIM-BHE-GA-XX-S-0002 for full details from the survey.

2.2.1 Description

- Gantry columns are c. 7m tall and measure c. 610 x 315mm with intermediate web stiffeners and penetrations through the web (Figure 2-43). Columns appear to be single-piece cast elements.
- Gantry beams vary in depth due to the plated construction, but measure c. 410mm wide x 700mm deep. The Gantry beams are compound sections – formed from separate plates held together with angle sections and rivets (Figure 2-44). Where beams meet at the column heads, they appear to be bolted to each other via end plates as well as being bolted into column heads.
- Crane beams are constructed as per the Gantry beams, but appear to be hollow with two separate webs. It is assumed that internal vertical stiffeners are present due to vertical lines of rivets being visible on the beam faces. Crane beams are c. 320mm wide with a fish belly profile meaning that the depth increases towards the midspan (Figure 2-45).
- At their base columns are bolted into a cast iron plinth which is assumed to be hollow and either internally stiffened or infilled. The plinths are in turn bolted to stone pads onto masonry pier foundations. These are assumed to sit onto the underlying rock but this has not been confirmed.
- Based on metal testing carried out by RSK, columns are understood to be formed from cast iron, whilst the

longitudinal and transverse crane beams are early carbon steel. The fact that beams are steel rather than iron is relevant as it should improve weldability and therefore facilitate repair work. The RSK report identified that the steel is likely to have good weldability based on metallurgic testing.

- Lateral stability of the Gantry is assumed to work as follows:
 - Braced bays in the East-West direction.
 - For the southern column row this is formed by two bays of tension-only cross bracing.
 - For the northern column row the system includes a single bay of compression cross bracing, which appears to be modern. Archive photos suggest that the original bracing matched the southern row.
 - In the north-south direction it is assumed that the columns cantilevering from their fixed bases resists lateral load.
 - Along the southern row of columns the masonry façade of the Power Hall has been chased vertically to accommodate the Gantry columns. This is assumed to be an original detail due to difficulty accessing and suggests a lack of proper coordination between the two structures at the time of construction. The gap between the rear face of the Gantry columns and the Power Hall façade decreases from bottom to top and in some locations it appears that they are touching.
 - Verticality of the south columns and Power Hall facade were assessed by Greenhatch in a survey which suggests that both structures are leaning to the North, with the masonry façade leaning further and so leaning onto the Gantry, See section 2.3 for further discussion.
 - South plinths are not located symmetrically against the columns above due to the adjacent Power Hall. At the base, the columns are up to 70mm apart from the brickwork with the upper part of the column being in contact with the wall or chased into the brickwork.
 - North side columns have broader top endplates. Based on the historic photographs it is very likely that those supported catwalks providing access to crane beam cabins. Secondary steelwork present at the North-West end of the Gantry was serving a similar function,
 - Original Lifting capacity of the crane beams appears to be 10tons, based on a plaque noted at the visit.
- #### 2.2.2 Condition
- A high-build paint finish, thought to be micaceous iron oxide containing, has been applied to visual surfaces, but this has now failed in several locations. Inaccessible areas such as the rear face of the southern columns and beams do not appear to have been coated.
 - Importantly – the existing paint finish likely obscures additional corrosion and prevents a full understanding of current levels of corrosion. Determining the full extent of corrosion will require blast cleaning and then additional assessment, currently intended to be carried out by the specialist metalwork contractor as part of the works.
- #### Foundations, plinths, and columns
- Plinths are in good visual condition,
 - Columns appear to be in generally good condition, with no sign of significant corrosion. However it is possible to crevice corrosion is occurring at the interface between the cast iron and steel elements. There is some evidence of minor surface corrosion.
 - Column paint finish is generally in better condition than for the beams, but has failed in several locations,
 - Column head impact damage to 1 no. column head.
 - Thanks to refurbishment works carried out at the Power Hall some of the Gantry foundations were exposed, allowing for a visual inspection. The pad stones are in good condition, not cracks or deterioration was observed. The blockwork below the pads is un-mortared, however It is assumed that this is the original condition rather than being a sign of mortar wash out.
- #### Longitudinal Gantry Beams
- Gantry beams show widespread evidence of corrosion, ranging from minor surface corrosion to localised severe corrosion and loss of structural capacity. Figure 2-35 to Figure 2-40.
 - There are 3 main areas of corrosion to the Gantry beams:
 - Southern face of south beams. Severe corrosion of the top and bottom flanges has reduced the section

width by up to 50mm. This is more prevalent at the western end of the Gantry, but is present across the whole length. Figure 2-31 to Figure 2-33.

- Lower part of beam web, at stiffener/column head locations – south and north. These areas appear to have trapped water leading to moderate/severe corrosion in most instances along the length of the beams. This typically affects the angle which connects the web to the bottom flange, but also includes corrosion of the web and flange themselves.
- Top face of the beams – south and north. Moderate/severe corrosion is present across the Gantry in these locations, particularly affecting the rail section which allows movement of the crane beams.
- Much of the corrosion is likely due to failure of protective coatings and construction details which are prone to the collection of water in crevices and on flat surfaces,
- Corrosion has likely been ongoing for some time as there is evidence of previous repairs in several locations. There typically include bolted plates to replace lost sections of metalwork.

Crane beams

- As with the Gantry beams, the crane beams show widespread corrosion, ranging from minor to localised severe cases. Figure 2-22 to Figure 2-27
- 3 main types of corrosion are present on the crane beams:
 - Moderate/severe corrosion to the lower section of the beams along their full length. Similar to the Gantry beams this typically affects the angle which connects the web to the bottom flange, but also includes corrosion of the web and flange themselves.
 - Minor/moderate corrosion to the beam webs – particularly affecting the outside faces of beams 2 and 3.
 - Moderate severe corrosion to the top face of beams, with details as per the Gantry beams.
- Crane beams are understood to be hollow and the lack of drain holes means that they are likely to trap water, leading to internal corrosion. This is likely exacerbated by internal stiffeners which will trap water at various

locations along the length of the beam. It is suggested that the conservation works address this by adding drainage points, and the works should include allowance for these areas to be inspected via borescope of similar.

- Many of the crane beams show evidence of previous repairs. There typically include welded plates to replace lost sections of metalwork. It is worth noting that most of these repairs would not be considered to be appropriate for conservation work due to their appearance.
- The crane beams include several secondary structures including balustrades and lifting gear. Figure 2-29 & Figure 2-30.
 - Balustrades are typically in poor condition due to deformation and corrosion and can no longer considered to be functional. However, it is assumed that they no longer need to fulfil this function. Assuming they are retained as part of the exhibit they will require remedial measures to address corrosion.
 - The lifting gear appears to be sound, but with widespread minor corrosion. As the gear supports cabled hooks etc, it is suggested that this apparatus is inspected by a craneage specialist subcontractor who can advise on how best to preserve and make safe the gear.

Bracing

- Bracing to the southern columns shows signs of historic surface pitting but appears to be generally free from current corrosion. Braces are distorted along their length suggesting that they are no longer functional in resisting lateral loads, without first allowing significant movement. Figure 2-18.
- Bracing to the northern columns appears to be in good condition, with little sign of corrosion.

2.3 Structural Discussion

Loading Considerations

The conversion of the Gantry into a static historic exhibition reduces or removes most types of loadings originally acting on the superstructure. This is relevant as it allows more flexibility in options for repairs as the Gantry does not necessarily need to be repaired to restore full capacity. Load changes include:

- Reduces vertical dead and live load due to removal of access catwalks, cabins and potentially all secondary steelwork elements and installations which served the original functions e.g.: balustrades, cables, mechanical equipment, engines or platforms substructure,
- Removes crane beam lifting loads,
- Removes dynamic loads both vertical and horizontal due to crane beams operation,
- Reduces snow and wind loading acting due to removal of catwalks, platforms and cabins.

Interface with Power Hall

As addressed previously it appears that lack of coordination when constructing the Gantry (1880s) and Power Hall (1850s) means that the two structures are in extremely close proximity. Subsequent (presumed) movement in the Power Hall has meant that it now leans onto the Gantry in some locations.

The primary structural concern with this interface is that lateral load from the Power Hall may be placed onto the Gantry, and the Power Hall may become reliant to some extent on the Gantry for lateral capacity. Whilst this is a valid concern, there are mitigating factors:

- The works currently ongoing to the Power Hall are understood to have addressed lateral spread of the roof and therefore any further outwards movement of the walls. This needs to be verified by future verticality surveys, but is positive.
- The extent of lateral load attracted to the Gantry from the Power Hall is based on its stiffness relative to the stiffness of the Power Hall itself. This will be investigated further at Stage 4 once survey results are returned, but for the current stage it is judged that the Gantry is likely to be significantly less stiff than the Power Hall and so only has limited ability to act as a prop and therefore attract load.

The following options are considered:

- Option A – Assuming that movement is not progressive, the interface between Gantry and Power Hall wall remain as current, with some amount of contact between them. The reasoning would be that this causes no detrimental structural effect in either.
- Option B – chase the brickwork further to separate two structures. This would require an assessment of whether movements are progressive and/or whether

disconnecting the two elements may lead to negative effects in either.

Previous Alterations

It is apparent that changes have been made to the Gantry over time. These include alterations to the bracing to the north row of columns, the addition of secondary structures and the removal/addition of transverse beams. It is proposed that the Gantry to be preserved in its current state, rather than for previous iterations to be re-instated.

Repair & Conservation Strategy

The repair and conservation strategy needs to address the following aspects:

- In several locations the extent of corrosion will require structural repairs to be carried out. Our aim is to be pragmatic with where this is required, based on the now reduced Gantry loading. However, some areas will still require full repair and replacement of section.
- It is suggested that the whole structure be re-painted with an appropriate system to achieve a minimum of 25 years design life. This is likely to require blast-cleaning of the whole structure followed by a systematic approach to re-painting. A robust paint system should provide significant protection against further corrosion.
- There is clear evidence that corrosion has affected specific areas due to lack of proper access for maintenance and detailing which leads to water accumulation. Details which will prevent water accumulation and facilitate maintenance in future should be considered, although a properly-applied paint system may reduce the importance of this.
- Determination of appropriate methodology to allow for cleaning and protection of the structure, especially for spaces between compound elements.
- Rainwater protection and bird access/ nesting protections to be considered for the South beam.
- Whilst removing elements of the Gantry to carry out repairs may be beneficial in some ways, there are significant limitations to doing so. The interface with the Power Hall is likely to cause difficulties, and any limitations might apply to columns at the North ends due to anchor fixing unknowns. It might be a feasible and efficient solution to dismantle the crane beams and beam and repair those off site,

- Crane beams have been subject to previous repair works which are not deemed to be of conservation standard. Whether or not these are replaced with more appropriate repairs should be considered.

Specialist Input

As the repair works are likely to be specialist items, BH led discussions with the possible specialist subcontractors to get input and help develop proposals. A summary of the input is as below:

- Repair and blast cleaning are feasible both in-situ and with elements removed. Removing is likely to make the works easier to carry out, but will clearly have significant knock-ons in terms of transportation, and safe disassembly and reassembly.
- If the gantry is to be blasted in-place, significant temporary shielding will be required to control lead-containing dust.
- If elements are to be removed, chemical stripping of paint/corrosion is possible. However, still would be subject to size of removed elements and may not be suitable depending on size / material composition.
- All contractors approached would intent to carry out their own detailed survey once blast cleaning was complete, and would then develop location-specific repair details.
- Blast cleaning and re-painting may need to be procured separately to the repair works, dependent on appointed subcontractor.
- Repair details would likely include welding of plates to make-up corroded sections of metalwork. An alternative option would include bolting new metalwork in place mirroring the current construction, i.e. bolted angles to replace the current riveted ones.

2.4 Recommended Works

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

Works in summary:

- Possible dismantling parts of the gantry and move to an off-site facility for cleaning / repair.
- Blast clean whole Gantry structure (paint and corrosion removal) either in-situ or off-site.

- Detailed visual inspection following cleaning to properly ascertain current level of corrosion.
- Carry out repair works to areas of significant corrosion.
- Recoat and paint steelwork, suitable for external exposure.
- Install lead capping cantilevering from the Power Hall and covering South beams.



Figure 2-3 Archive



Figure 2-4 Archive 1980s



Figure 2-5 Archive 1980s



Figure 2-6 Archive 1980s



Figure 2-7 Archive 1980s



Figure 2-8 High level view 2018



Figure 2-9 Plinth / foundation detail



Figure 2-10 Plinth detail



Figure 2-11 Column base



Figure 2-12 Power Hall interface



Figure 2-13 Power Hall interface



Figure 2-14 General view from west



Figure 2-15 North bracing



Figure 2-16 Crane beams



Figure 2-17 South cross bracing



Figure 2-18 South cross bracing showing pitting & deformation



Figure 2-19 – Power Hall chimneys



Figure 2-20 – North bracing connection detail



Figure 2-21 – Crane beam support



Figure 2-22 Corrosion to top face crane beam



Figure 2-23 Corrosion top face crane beam



Figure 2-24 Corrosion to side face crane beam (western)



Figure 2-25 Corrosion to side face crane beam (eastern)



Figure 2-26 Corrosion to bottom of crane beam



Figure 2-27 Crane beam end corrosion



Figure 2-28 – Previous repair to crane beam



Figure 2-29 Crane beam balustrade – corrosion & deformation



Figure 2-30 Lifting gear to western crane beam



Figure 2-31 Severe corrosion & loss of section width – southern face of south Gantry beam, bottom flange



Figure 2-32 Severe corrosion & loss of section width – southern face of south Gantry beam, bottom flange



Figure 2-33 Severe corrosion & loss of section width – southern face of south Gantry beam, top flange



Figure 2-34 Corrosion and lack of protection to southern face of south Gantry beam



Figure 2-35 Typical corrosion to Gantry beam at column head



Figure 2-36 Typical corrosion to Gantry beam at stiffener



Figure 2-37 Severe corrosion to Gantry beam at stiffener



Figure 2-38 Typical corrosion to Gantry beam



Figure 2-39 Typical corrosion to top face Gantry beam



Figure 2-40 Moderate corrosion to top face Gantry beam



Figure 2-41 – Historic lifting capacity



Figure 2-42 North beams – north face

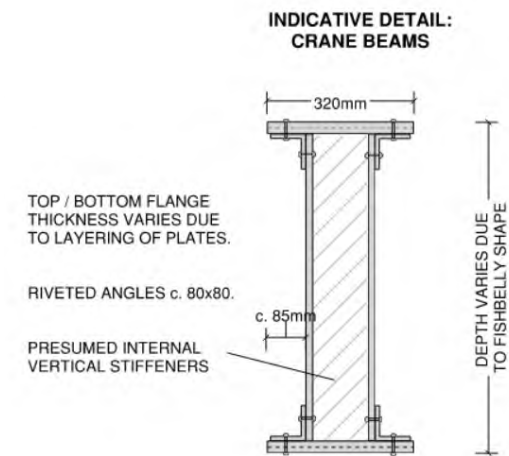


Figure 2-45 Crane beam details

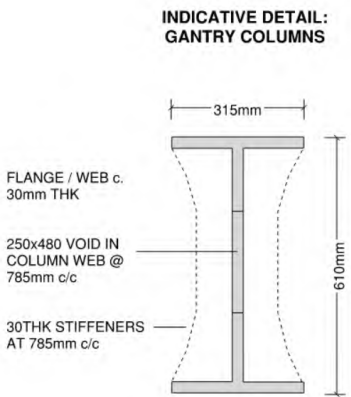


Figure 2-43 Gantry column details

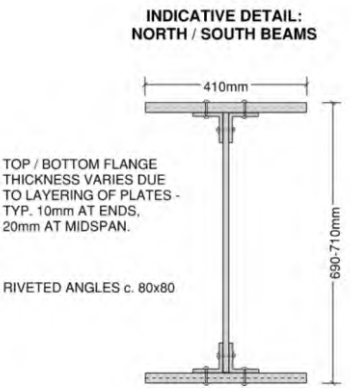


Figure 2-44 Gantry beam details

[Click here to enter text.](#)

Darren Conboy
Buro Happold Limited
3 Wellington Place
Leeds LS1 4AP
UK

T: +44 (0)113 204 2200
Email: darren.conboy@burohappold.com