

Great Northern Warehouse

Listed Building Structural Report

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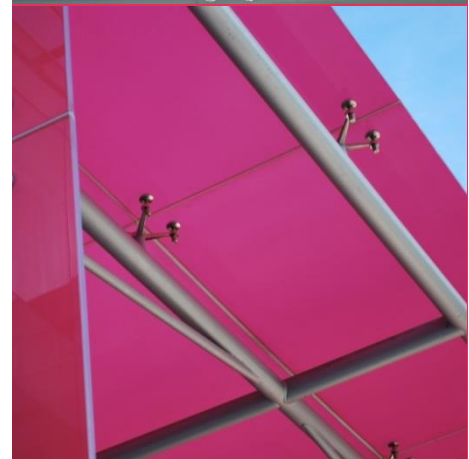
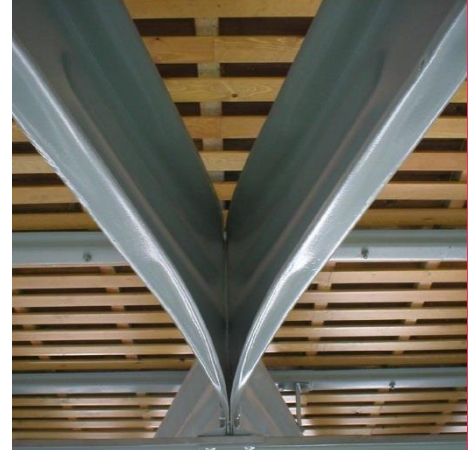
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Author	Signature	Date
Declan Brown MEng (Hons) Senior Engineer		31/08/22

Authorised	Signature	Date

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Appendix A Structural GAs and Details

1.0 Executive Summary

Curtins Consulting have been commissioned by GNW Development Ltd to provide structural engineering services in connection with the development of the Great Northern Warehouse project.

The proposals include the re-use and sensitive adaptation of the Great Northern Warehouse and Deansgate Terraces.

Existing modern interventions that currently detract from the listed buildings and their setting will be removed to enable the delivery of:

- Office spaces, together with associated amenity space and cycle parking through:
 - Conversion of car parking levels in the Great Northern into office units
 - Modification of existing roof structure to provide terrace and plant space
 - An atrium circulation area
 - Conversion of upper levels of Deansgate Terrace to office units.
- Extension of mezzanine floorplate to accommodate amenity space.
- Introduction of retail and leisure uses as part of a publically accessible viaduct feature, utilising the listed viaduct connected to the Great Northern Warehouse
- Creation of a new at-grade pedestrian connection (Dean Street) between Great Northern Warehouse and Deansgate Terrace, which will be activated by retail frontages in a new three-storey extension to the terraces as well as retail kiosks to the Great Northern Warehouse.

This document provides an overview of the work required to facilitate the development and identifies the proposed mitigation measures to ensure the fabric, load bearing capacity and the stability of the remaining structure is maintained both permanently and during the course of the works.

Given the Grade II* and Grade II listed status of the Great Northern Warehouse (including Viaduct), the Former Entrance to Deansgate Goods Station and Deansgate terraces respectively the structural interventions have been designed and detailed so they have as little impact on the existing structure as possible.

From the out-set a set of 'structural principles' were issued to the team and the works have been carefully designed to minimise the amount of the historic structure that will need to be removed and to

maintain equilibrium and stability. Any new columns are also located within the optimum position to avoid over loading. Refer to section 5.0 for the methodology for the structural intervention works.

For the Warehouse building the calculations indicate that the existing foundations will have sufficient reserve capacity to carry the additional loads from new terraces at roof level.

Section 5.0 outlines in more detail all the structural interventions required with respect to attaining listed building consent for the proposed works. These will be formally incorporated into a full scope of investigations in due course.

2.0 Introduction

Curtins Consulting have been commissioned by GNW Development Ltd to provide structural engineering services in connection with the development of Great Northern Warehouse.

This document provides an overview of the work required to facilitate the development in relation to the listed Buildings and identifies the proposed mitigation measures to ensure the fabric, load bearing capacity and the stability of the remaining structure is maintained both permanently and during the course of the works.

Section 3.0 identifies the site and describes the context of the proposed development.

A brief description of the project and the proposed development is provided in section 4.0.

Typical structural interventions required by the scheme and the proposed methodology are detailed in section 6.0 of this document.

3.0 Site Description

The Site is located within Manchester City Centre adjacent to Deansgate. It is bound by Watson Street to the east, Peter Street (A34) to the north, Deansgate to the west and the Leisure Box and Great Bridgewater Street to the south. Site grid reference SJ835978.



Figure 3.0: Aerial Photograph (© Google)

The existing site comprises three listed buildings;

- The Grade II* Great Northern Warehouse building (the former Great Northern Railway Company's Goods Warehouse) which also includes the viaduct structure to the south
- The Grade II 223-233 Deansgate Former Entrance To Deansgate Goods Station
- The Grade II 235-291 Deansgate Terrace

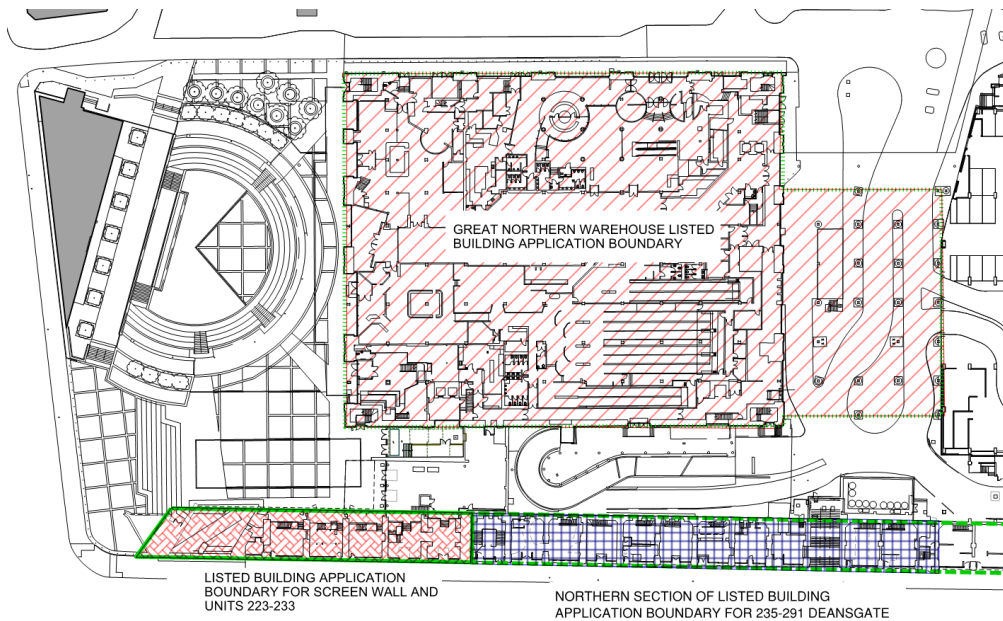


Figure 3.1 Location of Listed Buildings

The Grade II* Great Northern Warehouse building is a five-storey structure currently accommodating a number of established retail, restaurant and leisure uses, including a bowling alley and casino at ground floor and level 01. Public car parking is provided at levels 02, 03 and 04, these levels are accessed via a modern ramp which has been constructed to the western elevation of the historic structure.

The single storey viaduct to the south of the main warehouse supports the modern Atrium Connection Building, which acts as a connecting structure to provide pedestrian access between the Great Northern Warehouse and the Leisure Box, as well as a bridge that connects into a pedestrian route to Deansgate-Castlefield Metrolink Station.

The Grade II Former Entrance To Deansgate Goods Station is located to the west of the site fronting Deansgate, the arches are enclosed by a recent extension over and to the rear of the historic structure. The extension provides retail at ground floor and offices over.

The Grade II Listed Deansgate Terraces are located along the western boundary of the Site, fronting Deansgate ranging from 2 to 4 storey's in height. At lower levels, there are retail unit frontages, some of which have been merged into larger self-contained units, accommodating a mix of uses including cafes, shops and restaurants. The upper levels of Deansgate Terrace provide some office space and storage for the units at lower level, as well as the Great Northern Management Suite.

4.0 Existing Structure

4.1 Great Northern Warehouse and Viaduct

Construction of the Great Northern Warehouse began in 1885 and the building work was completed in 1889. The building was granted grade 2* listed status in 1974 and converted into the current leisure complex in 1999.

The Warehouse was constructed by the Great Northern Railway Company to provide goods storage and interchange facilities.

The main warehouse comprises a five-storey building approximately 81.4m (267ft) long and 66.1m (217ft) wide. The two lower levels of the building were previously used as rail and road depots. The upper three levels were used to store goods such as malt, grain, paper, cloth, rags, cotton and case goods.

The high-level depot linked directly with the Great Northern rail line with the low-level depot being linked to the high-level rail line via two number inclines to the east and west of the viaduct.

Both levels were also linked to the road network, with an approach ramp constructed to the north and west of the warehouse to provide road access to the high-level depot.

The following is the description of the building structural form as detailed in 'The Engineer' dated September 1898.

'It is entirely of fireproof construction, practically a series of storeys built of mild steel stanchions with connecting girders, cast iron junction boxes being employed to join them, and cross girders, with jack arches turned between them, forming the floors. The walls are constructed in a most substantial manner, the lower portion consisting of blue brickwork in cement and the upper portion of hard local red bricks relieved by blue band bricks. The brickwork of the station is wholly in cement.

The steel stanchions rest on large granite bases, which are bedded upon blue-brick and concrete foundations going down to solid rock, as is also the case with the walls.

Each Stanchion is calculated to sustain a weight of 650 tons, when the warehouse and the stations are fully loaded.'

The upper floors comprise of 9" inch brick jack arches spanning between mild steel riveted plated girders and mild steel stanchions. The brick arches have been found to be capped with concrete.

The roof structure comprises a series of traditional Queen post timber trusses supported by the external masonry piers and internal columns which historically were located at the end of each truss. The trusses support timber purlins, supporting timber rafters, supporting timber battens, supporting tiles.

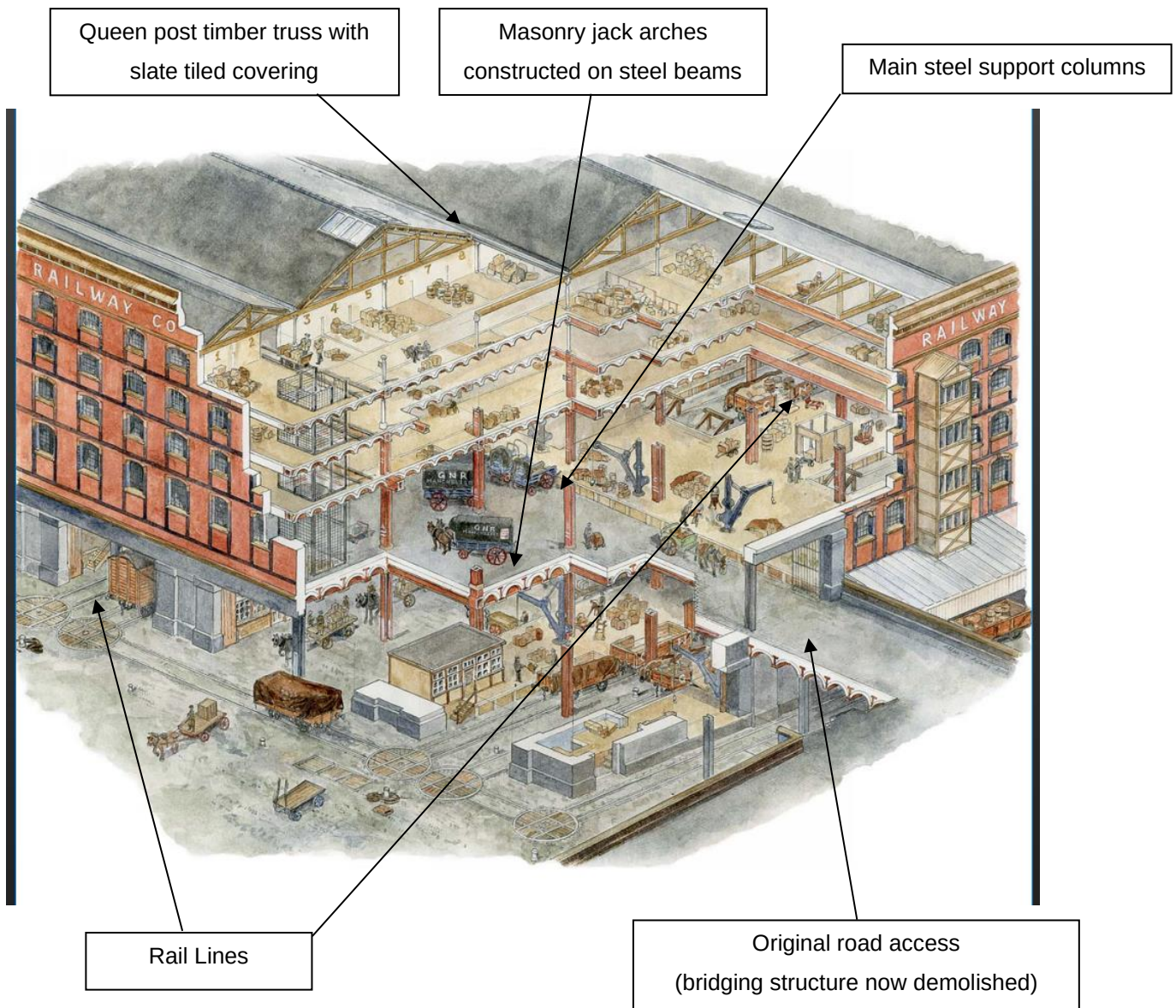


Figure 4.0: Historical section through Great Northern Warehouse indicating original construction

New modern mezzanine floors have been introduced at ground floor and first floor level.

The building was refurbished in 1999 as part of the Morrison Merlin works. The building currently houses leisure units including a casino and a bowling alley at ground and first floor with the top three storeys utilised as a car park.

To provide access into the upper car parking levels two one-way ramps (entry and exit) were constructed to the west of the warehouse. These required a series of new openings to be formed between the existing piers.

To allow for vehicular movements at third floor level a significant number of the stanchions supporting the timber trusses needed to be removed within the proposed car parking aisles. Steel beams were installed to transfer the roof loads to the adjacent columns.

The columns above third floor are significantly smaller than the columns on the lower levels, we believe that concrete surrounds were added to the columns above third floor to provide protection against vehicular collision, but also to provide support to the new transfer beams.



Figure 4.1: Column removal & installation of transfer beams



Figure 4.2: Column head detail supporting roof truss

The historical information we have for the foundations show the steel stanchions supported on concrete foundations which have been extended to bear onto sandstone which is approximately 5.5m below ground level.

This single story viaduct structure provided the link between the high-level rail line and Level 01 of the warehouse.

The viaduct structure comprises of 9" inch brick jack arches spanning between mild steel riveted plated girders and mild steel stanchions.

Where the foundations are located over the now drained canal to the south of the site, deep ground beams using steel girders encased in concrete have been used to bridge over the canal. The adjacent foundations comprise of deep pad foundations bearing onto the underlying sandstone bedrock. See figure 4 for details.

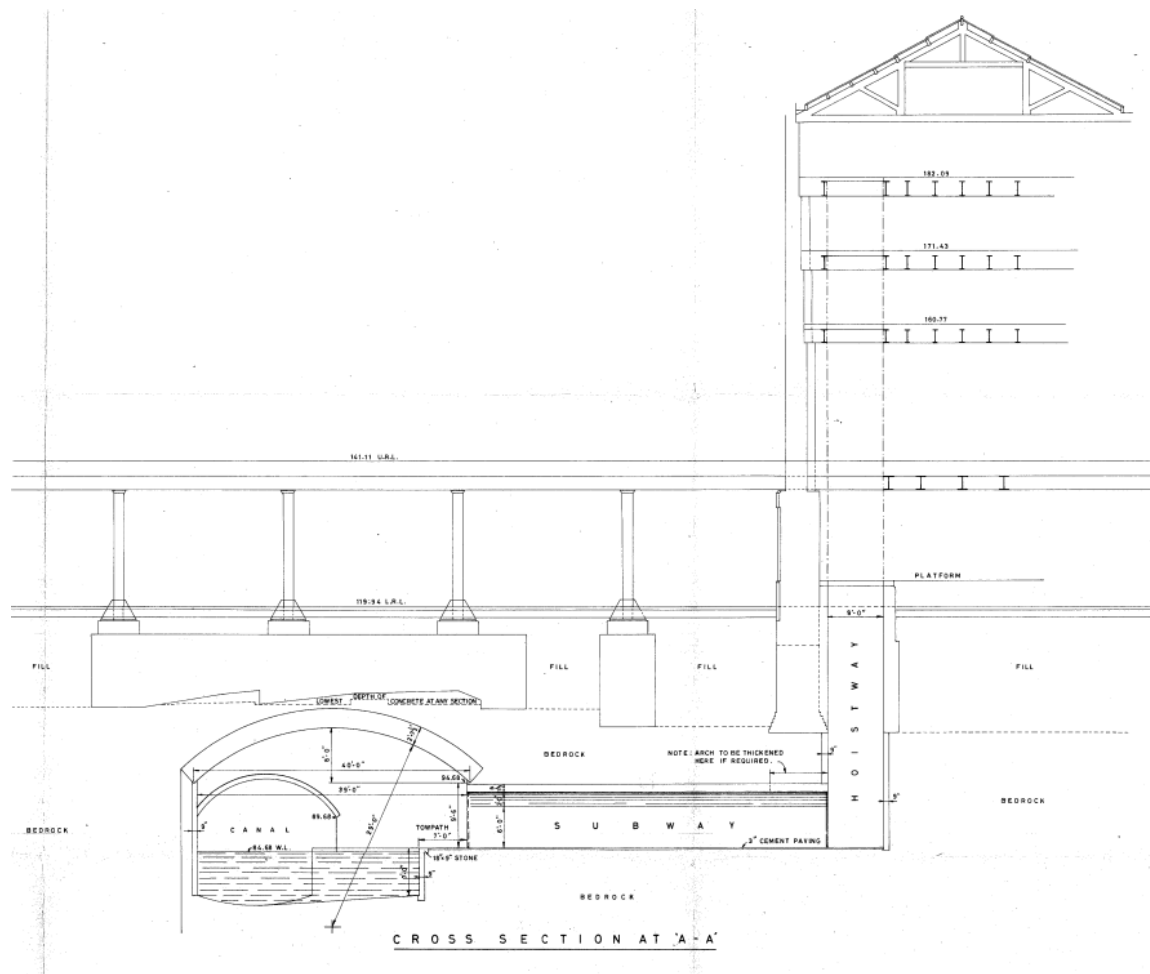


Figure 4.3: Section through viaduct (from historical drawings)

4.3 223-233 Deansgate Former Entrance To Deansgate Goods Station

The historical structure was constructed as part of the original depot circa 1900 and is Grade II listed.

The structure comprises the remaining section of a masonry arch viaduct which provided a vehicle access route from Water Street into the level 01 of the warehouse.

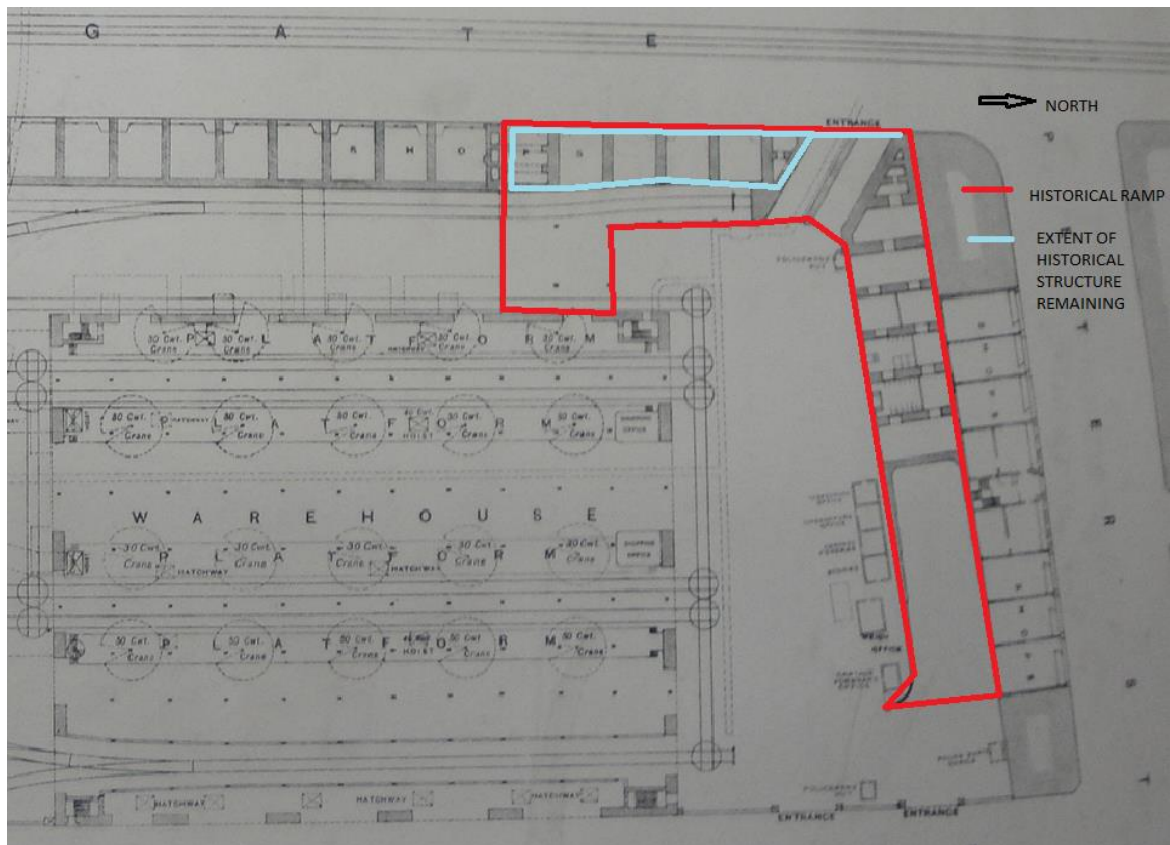


Figure 4.4: Extent of historic approach ramp

A modern steel framed 'wrap' was constructed in 1999 to the rear and over the arches, this extended the structure towards the warehouse by approximately 1.5m and included a new single storey steel framed extension constructed on top of the existing arches.

Basements run under the full length of the terraces. It is assumed that the load bearing walls are bearing onto the underlying sandstone strata and as the level of the bedrock is thought to be 3 to 4m bgl the construction of the basement would have been practical.

4.4 235-291 Deansgate Terrace

The building comprises a three/four storey load bearing masonry structure. At level 02 the floors comprise steel beams spanning between the party walls with jack arch infills. Floors at other levels appear to be an alternative construction but the form of construction will need to be confirmed by an intrusive survey.

Retail units use the space at ground and basement and there are offices at level 02 and where applicable level 03. Historically the upper floors were used as a part of the warehouse facilities.

Basements run under the full length of the terraces. It is assumed that the load bearing walls are bearing onto the underlying sandstone strata and as the level of the bedrock is thought to be 3 to 4m bgl the construction of the basement would have been practical.

5.0 Proposed Development

The proposals comprise the following:

5.1 Great Northern Warehouse

- Removal of modern interventions such as the car park ramps and the atrium building over the viaduct
- Conversion and extension of existing space at Level 0 Mezzanine to incorporate changing facilities and bicycle storage
- Conversion of existing space at Level 01 to co-working / events space (including Mezzanine)
- Conversion of existing car parking at Levels 2, 3 and 4 to office use leading to the introduction of an atrium and amenity space and creation of new terrace areas for plant equipment and amenity usage at roof level (Level 5)
- Creation of a new office entrance incorporating external lift cores
- Addition of a new link bridge structure between the warehouse and northern terraces
- Introduction of retail units at ground level
- Introduction of cycle storage to mezzanine level beneath the viaduct
- New retail uses and public realm along Deansgate Mews adjacent to Great Northern Warehouse
- Elevational alterations associated with these changes

5.2 223-233 Deansgate Former Entrance To Deansgate Goods Station

- Removal of modern interventions
- Creation of a three-storey extension to Deansgate Terrace, comprising new retail, food and beverage uses with office space above
- Elevational alterations associated with these changes

5.3 235-291 Deansgate Terrace

- Removal of modern interventions
- Conversion of existing office floorspace at upper levels of the northern end of Deansgate Terrace to residential use
- Creation of a three-storey extension to Deansgate Terrace, comprising new retail, food and beverage uses with office space above
- Elevational alterations associated with these changes

6.0 Proposed Structural Interventions and Methodology

6.1 Great North Warehouse

6.1.1 General Structural Principles

Curtins worked with the team to minimise the structural intervention works required to the existing Grade II* listed building.

A set of structural principles were established with the team at an early stage to ensure that the fabric, load bearing capacity and the stability of the remaining structure is maintained both permanently and during the construction of the works.

The main principles were:

1. Due to the sectional nature of the internal steel frame (storey height stanchions which are connected to each other and the primary floor beams by a cast iron junction) it was advised that the primary beams which brace the columns should be maintained if at all possible. This ensures the stanchion restraint at each floor is unaffected and therefore the load bearing capacity of the existing stanchions is not compromised. See figure 6.1.



Figure 6.1: Connection junction at floor

2. Where possible the openings within the floor plates should be constructed within the jack arched to avoid the removal of the existing girders.
3. Horizontal holes through webs of the girders can be provided but would be ideally limited to a diameter of 200mm, larger opening could be formed but stiffeners would be required.

4. In all cases the clear distance of the edge of the opening must be at least 175mm from the top and the bottom of the beam to avoid the riveted angle sections connecting the web to flange plate. The horizontal location would need to be co-ordinated also to avoid the vertical web stiffeners. See figure 6.2.



Figure 6.2: Web stiffeners / angle connection

5. Openings within the webs should not be formed within 1200mm of the end of the beams.
6. Individual vertical holes up to 300 diameter are acceptable within the jack arches. Although openings greater than 150 mm may require a steel sleeve.
7. Where large openings are required, due to the nature of jack arches generating a lateral thrust at springing level, tie rods would be required were long openings are created in the floor plate.

Refer to Curtins drawings 064582-CUR-Z2-XX-DR-S-27100, 27101, 27102 for details.

6.1.2 Proposed Works

The scheme was subsequently developed around the above principles.

The proposed scheme requires the following structural interventions:

- New foundations and structure for external lift core for the office entrance
- New openings requiring the removal of existing riveted plated girders and jack arches
- New openings through jack brick arches
- New openings through the webs of the existing mild steel riveted plated girders
- Propping, modification and strengthening works in relation to existing roof trusses
- Infilling of existing openings
- Construction of new balconies within existing openings
- Construction of new mezzanine below the viaduct structure and level 01

Refer to drawings in Appendix A for location of the proposed intervention works.

New foundations and structure for external lift cores for the office entrance

The proposed works require the removal of the existing external hardstanding adjacent to the warehouse and to facilitate new lift pits.

The ground conditions below the ground floor slab are thought to comprise approximately 5.5m of made ground over sandstone bedrock. The existing building foundations are thought, based on historical information, to bear onto the underlying sandstone.

The new structure will require piled foundations to transfer loads down the competent sandstone. Where required the piles will be sleeved to ensure the existing foundations are not subject to horizontal surcharge loads from the new foundation loads. The piles would be constructed using a bored solution to minimise noise and vibration.

The above ground structure will act independently to the warehouse and have its own bracing system to transfer lateral forces to the foundations and ensure stability. The structural framing of the lobby level floorplates will require fixing back to the warehouse fabric. The connection will be via anchor fixings to the masonry fabric.

New openings requiring the removal of existing riveted plated girders and jack arches

Large openings are required to provide a light well within the central section of floor plates at levels 03 and 04. In accordance with the initial structural principles, girders which provide the horizontal restraint to the stanchion are to be maintained with only the girders internal to the bay removed.

To maintain equilibrium where the jack arches span onto the edge of the new opening, tie rods are to be installed at 2.5m centres between two parallel arches. These tie rods will be bolted through the two adjacent bays to provide restraint to the horizontal thrust generated by the arch once the adjacent arch is removed. These will be installed prior to the removal of the jack arches.

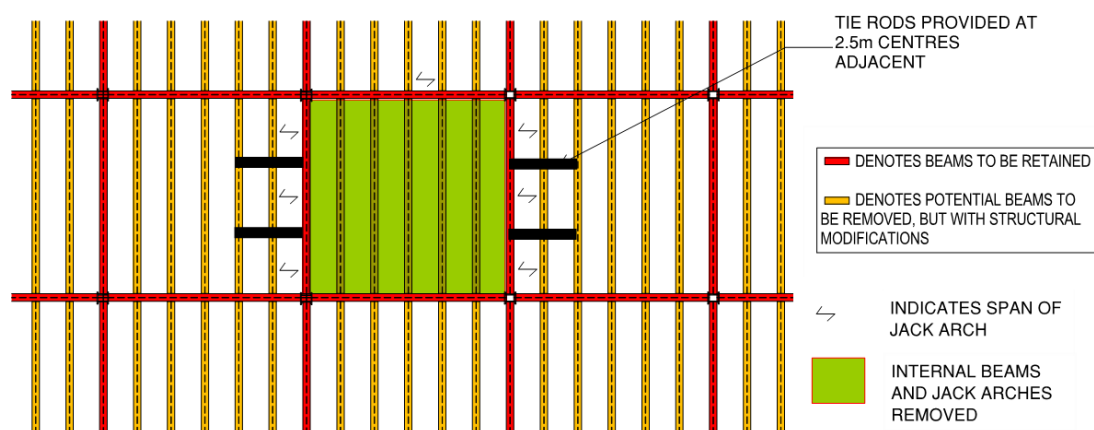


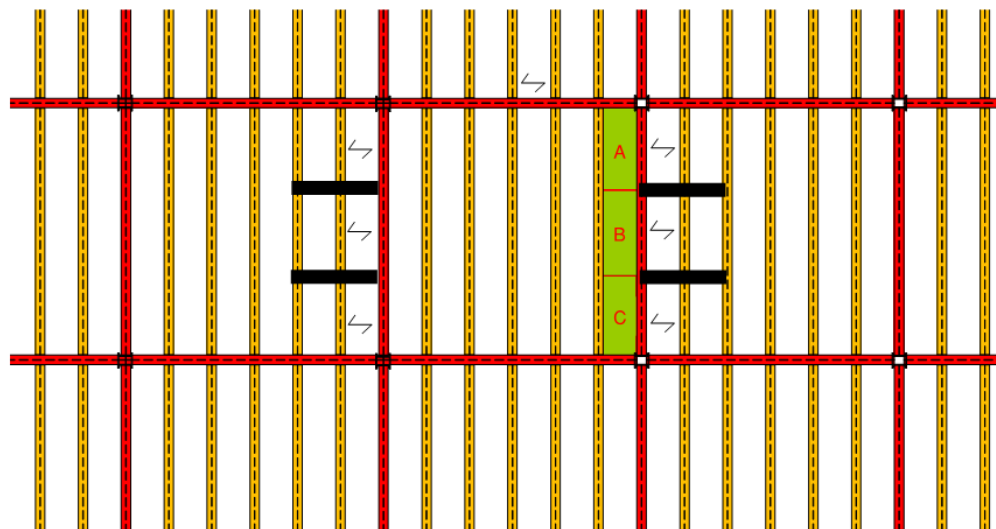
Figure 6.3: Internal bay floor removal

This solution has already been adopted within the existing warehouse at level 01 where an opening has been created for the installation of the escalators at the entrance. Refer to Figure 6.4 for photograph.



Figure 6.4: Existing tie rods installed at Level 01

To maintain stability of the jack arches during the demolition works, the arches will be removed in a sequential manner, with temporary propping installed as required until all the jack arches are removed within the bay. Refer to Figure 6.5 for a suggested sequence.



DEMOLITION METHODOLOGY

1. TIE RODS INSTALLED AT 2.5m CENTRES ACROSS TWO ADJACENT SPANS TO EDGE OF PROPOSED OPENING
2. SECTION 'A' OF ARCH REMOVED AND TEMPORARY PROPPING INSTALLED
2. SECTION 'B' OF ARCH REMOVED AND TEMPORARY PROPPING INSTALLED
2. SECTION 'C' OF ARCH REMOVED
3. FOLLOW SAME METHODOLOGY FOR ADJACENT ARCHES
4. ONCE ALL ARCHES REMOVED, TEMPORARY BRACING AND INTERNAL GIRDERS REMOVED

Figure 6.5: Suggested Demolition Sequence

New openings through jack arches

Penetrations through the existing jack arches are feasible provided that the construction methodology considers the “balanced” nature of masonry arch design.

The basic principles set out at the beginning of the project were that openings $\leq 300\text{mm}$ can be created using a core drill technique with larger openings detailed as to remove the full width of the jack arch.

For the core-drilled openings $> 150\text{mm} \leq 300\text{mm}$ the integrity of the masonry arch is maintained throughout the process by the insertion of a steel sleeve whilst the drill is being extracted, thus maintaining the restraint to the face of the cut masonry at all times. For smaller openings $\leq 150\text{mm}$ the additional steel sleeve will not be required.

For the larger openings, where the full width of the arch is to be removed, openings $\leq 1250\text{mm}$ will not require any additional restraint. For larger openings tie rods as detailed in section 6.1.2 or a steel ‘picture frame’ may be required to ensure the horizontal thrusts generated by the arch are balanced.

The general principles for the creation of the openings within the existing jack arches are illustrated on Curtins drawing 064582-CUR-Z2-XX-DR-S-27102

New openings through the webs of the existing mild steel riveted plated girders

The scheme has been developed by the team to minimise the requirement for new openings with the jack arch / girder web.

Based on the depth of the girder the maximum permitted size of the opening has been restricted to 200mm. Restrictions were also provided in relation to the plan location. The areas noted in ‘red’ are the exclusion zones for the web openings.

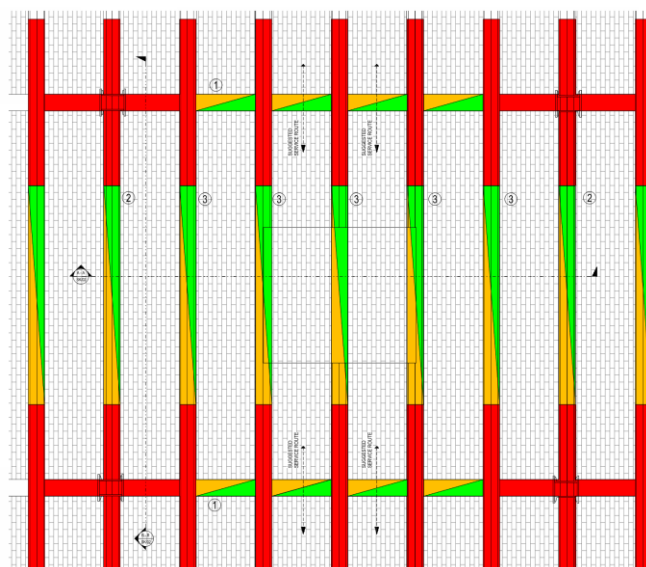


Figure 6.6: Exclusion zones for new openings

In all cases the clear distance of the edge of the opening must be at least 175mm from the top and the bottom of the beam to avoid the riveted angle sections connecting the web to flange plate. The horizontal location would also need to be co-ordinated also to avoid the vertical web stiffeners.

The general principles for the creation of the openings within the girder web plate are illustrated on Curtins drawing 064582-CUR-Z2-XX-DR-S-27101

Removal, modification and strengthening works in relation to existing roof trusses

Part of the proposals at roof level is to provide terrace spaces for plant equipment and amenity usage.

This requires the following works to be undertaken :

1. Removal of existing timber trusses in the locations of the truss
2. Installation of new steelwork framing to support the proposed terrace floor construction
3. Reinstatement of columns to support the terrace steelwork. These columns were removed as part of the 1999 refurbishment works to form car access lanes to the car parking.
4. Addition of new columns between level 3-4 supported on the existing columns which currently terminate at level 3

The preliminary load calculations indicate that in relation to comparative loadings the existing stanchions will be supporting a higher loading between level 03 and 04. This is based on a conservative warehouse imposed loading of 5kN/m². Further detailed design will be undertaken to assess the capacity of the existing columns to determine if strengthening works are required.

The creation of the central atrium to the warehouse requires modifications to the existing structure at roof level. To achieve the required ventilation rates the finished level of the roof glazing is to be raised above the level of the current truss profile. This will be achieved by the introduction of a new steel frame supported on the existing trusses. Further detailed design will be undertaken to assess the capacity of the existing trusses to determine if strengthening works are required to support the point loads from the new structure.

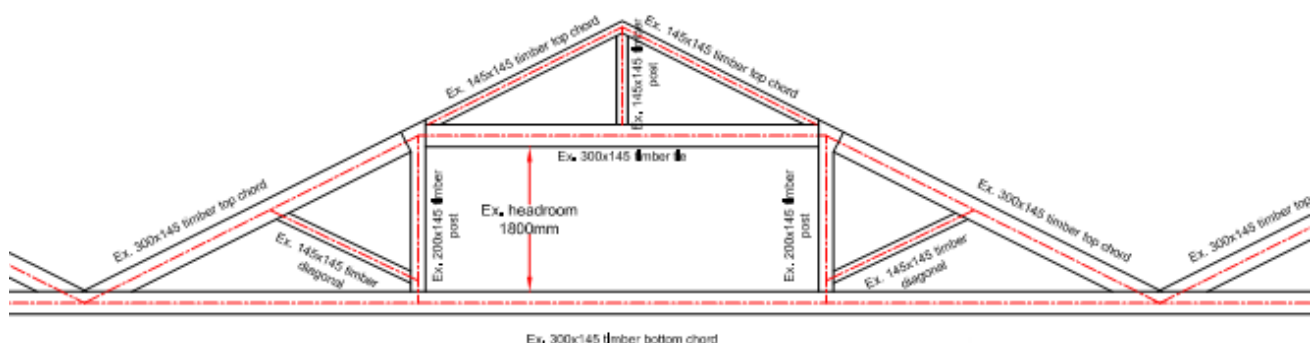


Figure 6.7: Existing Truss

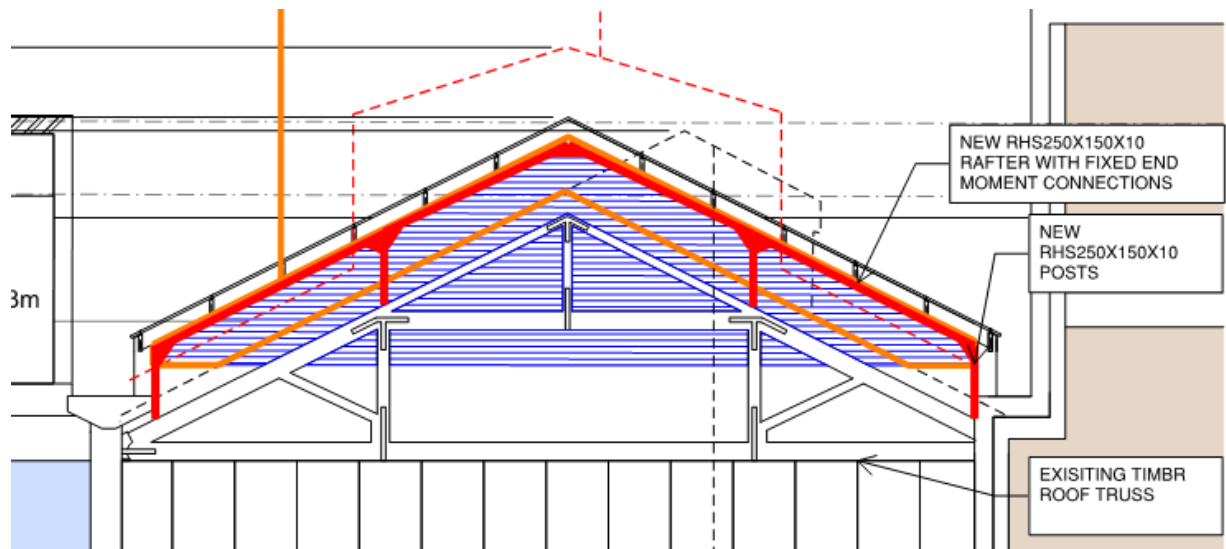


Figure 6.8: Indicative structure for forming new roof profile

Infilling of existing openings

The larger openings at level 01 are to be infilled using precast concrete flooring units based on the form of the existing jack arches supported by new steel beams supported by existing beams. The proposed flooring will be of a similar weight of the existing floor and therefore will be within the load bearing capacity of the existing structure.

Construction of new balconies within existing hoistway openings

New balconies are to be provided in the existing hoistway openings to replicate the former hoist way enclosures.

The balconies are to comprise a cantilevered steel frame. The back-span beam will be tied back to a steel beam spanning across the internal width of the opening which in turn will be bolted to the existing masonry. The front span will be bearing onto the cill of the existing opening.

Construction of new mezzanine below the viaduct structure

The development includes the construction of a new mezzanine floor below the existing viaduct structure to provide storage space.

The proposals are to utilise the existing stanchions to support the new steel framed mezzanine floor. Due to restricted access, the floor plates are to comprise a reinforced concrete in-situ slab on a profiled metal deck. Preliminary calculations have demonstrated that the existing stanchions and the foundations can support the proposed works without the requirement for strengthening.

6.2 223-233 Deansgate Former Entrance To Deansgate Goods Station

6.2.1 Proposed Works

- New structure off the existing piers to the old approach ramp
- New extension to existing terrace

New structure off the existing piers to the old approach ramp

The proposals comprise the construction of a new steel frame over and to the rear of the masonry arches which historically formed the ramp providing vehicle access into level 01 of the warehouse.

The proposals are to utilise the existing structure to support the loads generated from the extension.

The new structure over the arches will comprise a two-storey steel frame with the column locations aligning with the masonry piers below.

Calculations indicate that the existing masonry piers have sufficient reserve capacity to carry the additional loads from the proposed structure. This will be validated during the proposed intrusive works.

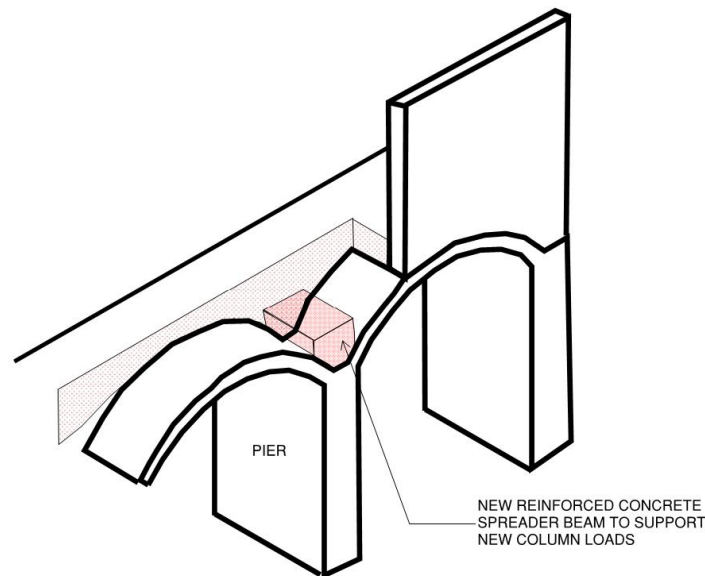


Figure 6.9 Steel columns supported off the concrete spreader beams

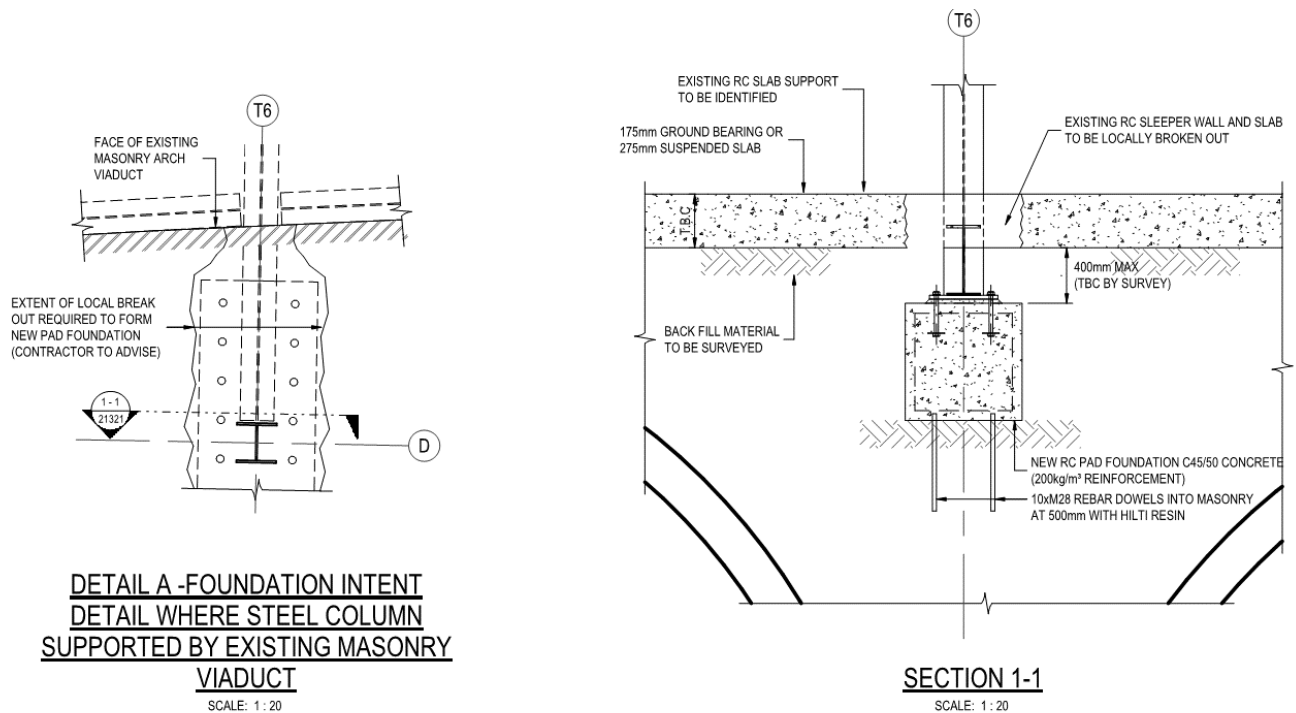


Figure 6.10 Steel columns supported off the concrete spreader beams intent detail

The new superstructure solution has been developed to minimise the applied loads. The additional load vertical loads generated by the new structure have been assessed to ensure that the increase in the bearing pressure at the base of the piers has not increased by more than 12 %.

To ensure the vertical load from the new columns are spread over the width of the pier it is proposed that a reinforced concrete spreader beam will be cast on top of the piers.

Due to the presence of the existing parapet which is approximately 6m high the lateral loads due to the wind loading will be equivalent to the existing.

The ground floor is currently a ground bearing concrete slab. The external columns to the extension are to be supported on a new piled foundation socketed into the sandstone.

The external columns to the rear extension will be supported by a bored / CFA piled solution to minimise noise and vibration.

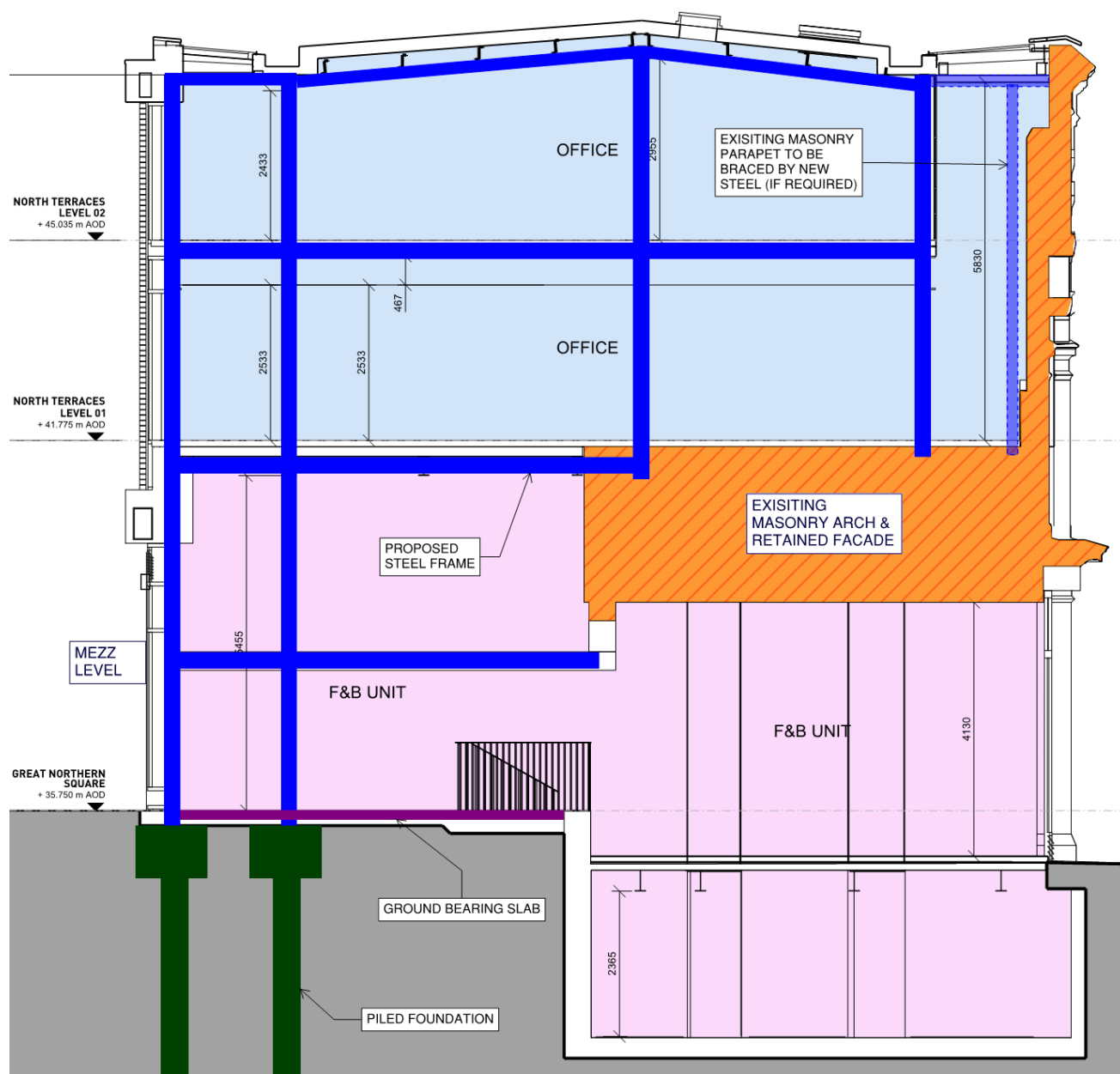


Figure 6.11: Structural proposals for the new extension

6.3 235-291 Deansgate Terrace

The development comprises the construction of a new steel frame to the rear of the existing terraces which historically were used as warehouse and shops.

The proposals are to utilise the existing load bearing masonry structure to support the loads generated from the extension at the interface between the old and new.

The extension comprises a two-storey steel frame with the column locations aligning with the existing party walls. A moment frame is to be provided to the external elevation with cross bracing added as required to restrain suction loads on the proposed extension.

Preliminary calculations indicate that the existing masonry walls have sufficient reserve capacity to carry the additional loads from the proposed structure. This will be validated during the proposed intrusive works.

The ground floor is currently a ground bearing concrete slab. The piles adjacent to the existing structure are to be sleeved to ensure the existing basement wall is not surcharged. The external columns to the extension are to be supported on a new piled foundation socketed into the sandstone.

The external columns to the rear extension will be supported by a bored / CFA piled solution to minimise noise and vibration.

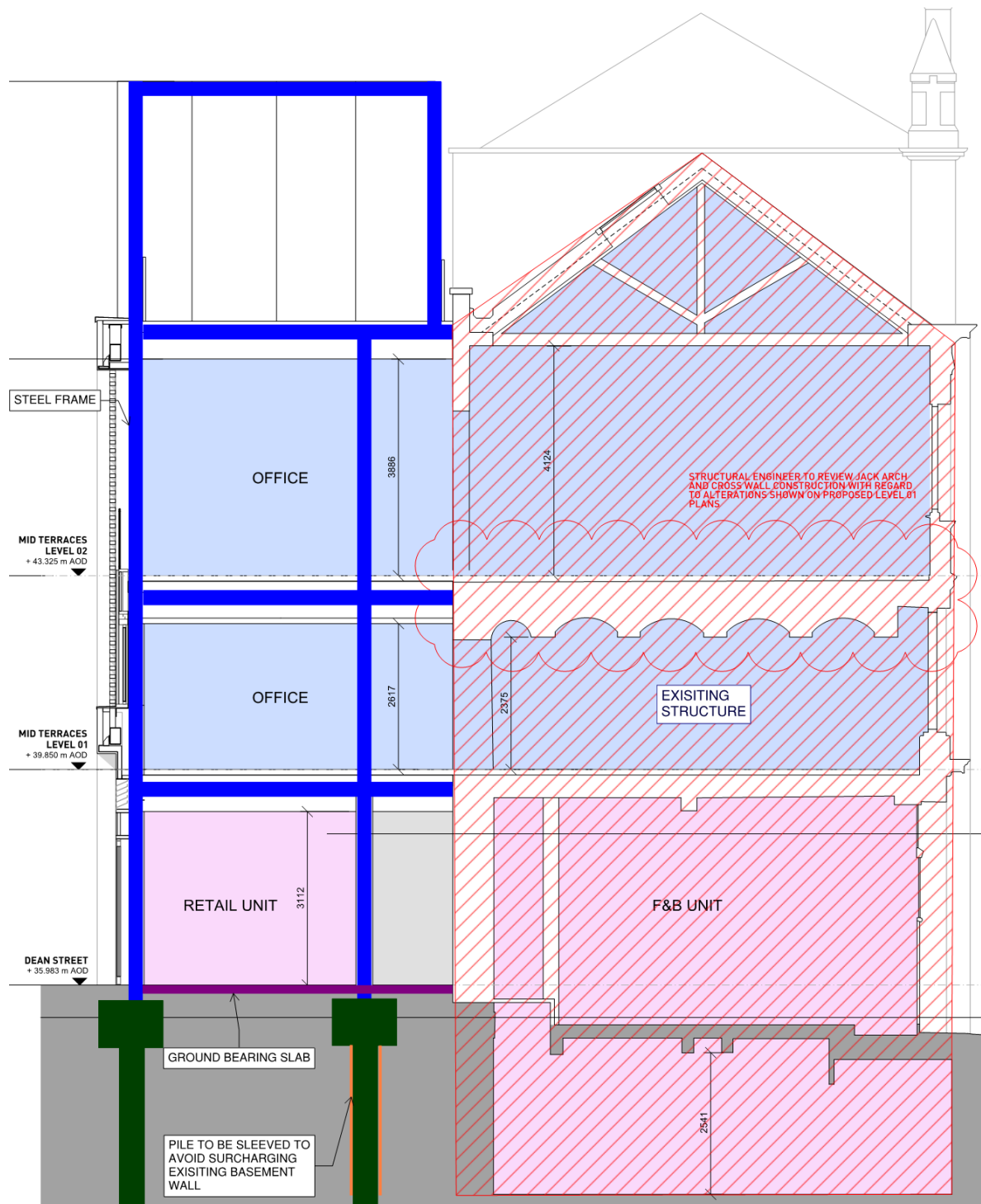


Figure 6.12: Structural proposals for the new extension

Appendix A Structural GAs and Details

Title	Drawing	No				
Site Constraints Plan	CUR	Z0	XX	DR	S	20700
Structural Principles Modification of Existing Floor Plate	CUR	Z2	XX	DR	S	27100
Service Route Assessment on Existing Structural Floor Beams	CUR	Z2	XX	DR	S	27101
Service Route Assessment on Existing Brick Arch Penetrations	CUR	Z2	XX	DR	S	27102
Warehouse Ground Floor Structural Intervention GA	CUR	Z2	GF	DR	S	20100
Warehouse Ground Floor Mezzanine Structural Intervention GA	CUR	Z2	M0	DR	S	20101
Warehouse 1st Floor Structural Intervention GA	CUR	Z2	01	DR	S	20102
Warehouse 1st Floor Mezzanine Structural Intervention GA	CUR	Z2	M1	DR	S	20103
Warehouse 2nd Floor Structural Intervention GA	CUR	Z2	02	DR	S	20104
Warehouse 3rd Floor Structural Intervention GA	CUR	Z2	03	DR	S	20105
Warehouse 4th Floor Structural Intervention GA	CUR	Z2	04	DR	S	20106
Warehouse Roof Structural Intervention GA	CUR	Z2	RF	DR	S	20107
Warehouse Sections Sheet	CUR	Z2	XX	DR	S	21300
Terrace A Basement Structural Intervention GA	CUR	Z3A	B1	DR	S	20080
Terrace A Foundation Structural Intervention GA	CUR	Z3A	FN	DR	S	20090
Terrace A Ground Floor Structural Intervention GA	CUR	Z3A	GF	DR	S	20100
Terrace A 1st Floor Structural Intervention GA	CUR	Z3A	01	DR	S	20101
Terrace A 2nd Floor Structural Intervention GA	CUR	Z3A	02	DR	S	20102
Terrace A 3rd Floor Structural Intervention GA	CUR	Z3A	03	DR	S	20103
Terrace A 4th Floor Structural Intervention GA	CUR	Z3A	04	DR	S	20104
Terrace A Roof Structural Intervention GA	CUR	Z3A	RF	DR	S	20105
Terrace A Site Constraints Section	CUR	Z3A	XX	DR	S	21700

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