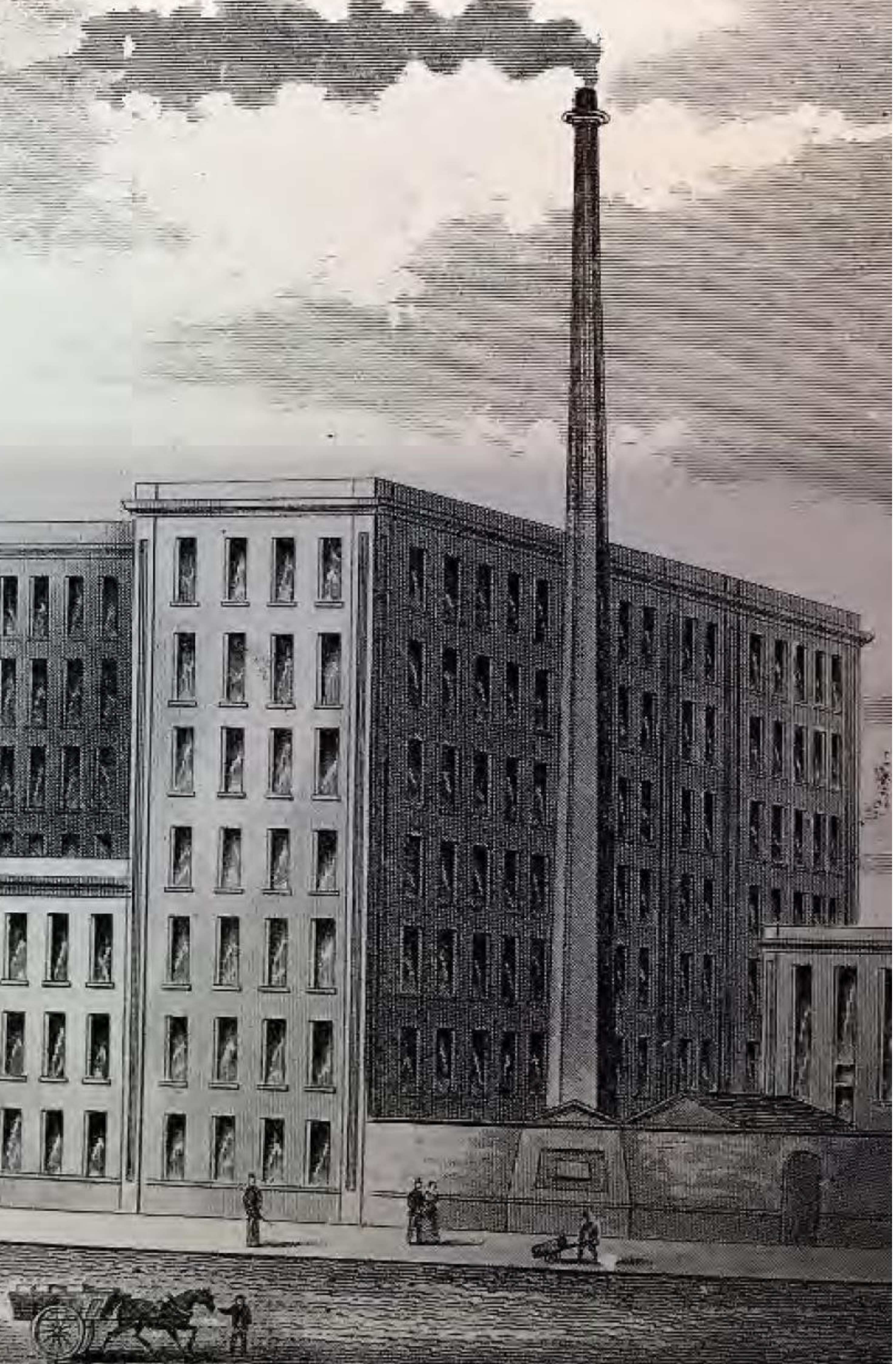

Civic Engineers

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Brunswick Place

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Contents

Structural Appraisal

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1. Executive Summary

Civic Engineers have been appointed by Maryland Securities to carry out a Structural Appraisal Report as part of the redevelopment of Brunswick Mill to residential apartments.

The site, Brunswick Mill, is situated on Bradford Road, Manchester, M40 7EZ. The proposed development works involve the conversion of Brunswick Mill to form a residential scheme of apartments and ground floor commercial units

The aim of this report is to study and discuss the structural intervention required, if any, to demonstrate the feasibility of change of use.

The structural form of Brunswick Mill is typical and as expected for the construction era of the building. Floor slabs are formed as masonry jack arches spanning between presumed cast iron beams.

Presumed cast iron beams span between external masonry piers and internal presumed cast iron columns. In the seven storeys south, eastern wing (fronting the Ashton Canal) there are two internal rows of cast iron columns whereas in the remaining three wings there is a single row of internal columns. Thrust tie bars are evident within the depth of the jack-arch floor between cast irons beams to counteract thrust forces induced by arch action of the floors.

External masonry walls and piers are most likely to be solid owing to the era of construction though this should be confirmed via intrusive investigations during detailed design

A visual intrusive assessment was conducted at Brunswick Mill on Wednesday the 17th February 2021 by Civic Engineers. The data was then used to understand stresses in the beams and columns to conclude the capacity of structural beams and columns to confirm the feasibility for change of use.

Structural beams were first analysed under only the self-weight loads derived from the opening up works described above without historic strengthening works. In accordance with recommended Codes of Practice beams cannot be proven to be cast iron under the self-weight of structure alone. If beams are cast iron, then it is likely that the recommended factors are safety are not appropriate in this instance.

If beams are not cast iron, then wrought iron is the most probable alternative. The proposed conversion can be proven on this basis.

The first-floor rehearsal studios, which could be reasoned to impose similar loads to that of a residential space i.e., a regular grid of partitions with similar floor loading, would demonstrate the capacity of floor plates to support the proposed loading.

Structural columns are believed to be cast iron and appear to have sufficient strength for additional loads due to mill conversion.

Further investigations will be required at detailed design stage to confirm all assumptions made above. This will involve;

- Local opening up of masonry jack arches around beams to confirm true section size. Temporary works will be required to maintain stability of arch
- Further testing of columns, undertaken at all floors to confirm the change in section size, section gauge with building level.
- Metallurgical testing to confirm sections are wrought iron and confirm strength of sections compared to assumptions based on historic published data
- Opening up of masonry piers to confirm piers are of solid construction and to confirm padstone sizes
- Material testing to confirm masonry strength

2. Introduction

Civic Engineers have been appointed by Maryland Securities to carry out a Structural Appraisal Report as park of the redevelopment of Brunswick Mill to residential apartments.

The site, Brunswick Mill, is situated on Bradford Road, Manchester, M40 7EZ. The proposed development works involve the conversion of Brunswick Mill to form a residential scheme of apartments and ground floor commercial units

The aim of this report is to study and discuss the structural intervention required, if any, to demonstrate the feasibility of change of use.

Civic Engineers scope of works for this study involves the following.

1. Carry out a site visit to record the existing principle structural element sizes. This would require local opening up works in the form of small pilot holes through floors to confirm floor thicknesses. Further pilot holes will be required to the existing cast iron columns to understand thickness of columns.
2. Structural capacity check on existing floor slabs, cast iron frame and masonry piers for both the current condition and the proposed residential conversion condition to demonstrate the technical viability of the proposals
3. Production of short feasibility report including the following;
    a. Investigation findings
    b. Summary of technical feasibility

This report should be read in conjunction with Civic Engineers Structural Appraisal Report 846-01 17/02/21.

3. Brunswick Mill – Structural Form

The structural form of Brunswick Mill is typical and as expected for the construction era of the building.

Floor slabs are formed as masonry jack arches spanning between presumed cast iron beams. It would be expected that masonry jack arches are topped with a layer of concrete though this has not yet been confirmed.

Figure 1: Masonry Jack Arch Floor Slabs on Cast Iron Frame

Presumed cast iron beams span between external masonry piers and internal cast iron columns. In the seven storeys south, eastern wing (fronting the Ashton Canal) there are two internal rows of cast iron columns whereas in the remaining three wings there is a single row of internal columns. Thrust tie bars are evident within the depth of the jack-arch floor between cast irons beams to counteract thrust forces induced by arch action of the floors.

Within the south facing short wing, in the outer bays (fronting Bradford Road) of jack arches are reversed perpendicular to avoid thrust forces in masonry walls and piers. In the corner bays floors are cast in a squinch type arrangement. Refer to Figure 3.

Floors are topped in what is believed to be terracotta setts. Owing to the type of floor construction it is likely that these are cast on a concrete topper which is cast directly onto the masonry jack arches below.

External masonry walls and piers are most likely to be solid owing to the era of construction though this should be confirmed via intrusive investigations during detailed design

Figure 2: Thrust Tie Bars in Masonry Jack Arch

Figure 3: Squinch Corner Slab

Figure 4: External Solid Masonry Walls

There are two primary stair cores, these are located in the south western and north eastern (shorter) wings and are constructed around solid masonry walls. Stair treads and landings are formed using stone slabs which are supported on inner and outer solid masonry walls. The stair treads and landings on the lower floors have been capped with a screed or concrete layer, presumably as a remedial detail following excessive wear of the stone elements. The staircases terminate at the seventh storey with a decorative half domed masonry ceiling/roof slab.

Foundations were not exposed as part of these investigations however, it is likely that due to the type of construction evident in the storeys above and the era of construction these will be typical masonry corbel footings cast directly on to the subsoil.

In the seven storey south eastern wing the two external bays have been strengthened historically. According to "Brunswick Mill, Manchester Heritage Statement" by Stephen Levrant Heritage Architecture Ltd this was carried out during the 1920's to accommodate new cotton spinning machinery. Note that these strengthening works are limited to structural beams only and no strengthening was carried out to the masonry jack arches or cast-iron columns. These strengthening works were achieved using underslung tie bars (most likely mild steel) to the cast iron beams to create a truss-like action. Ties are restrained and positioned by what is believed to be, owing to the era, mild steel moulded clamps. Strengthening works were limited to levels three, four, six and seven only.

Stability of the building is achieved through a number of means. It is most likely that the three seven storey wings are stabilised by the two primary stair cores and the large external masonry walls. Masonry panels (inc piers) span vertically between floor plates which act as rigid structural diaphragms to distribute loads via in plane compression and tension to stair cores and external masonry walls. The masonry walls act as large, extremely heavy, cantilevering shear walls which resist load in compression only to transmit load to the underlying foundations. Foundations transmit load to the supporting subsoil via direct bearing.

In the four-storey wing fronting Bradford Road there are no stair cores therefore stability is achieved via the large external masonry walls. As above, masonry "panels" span vertically between floor plates which act as rigid structural diaphragms to distribute loads via in plane compression and tension to external masonry walls. These masonry walls act as large, extremely heavy, cantilevering shear walls which resist load in compression to transmit load to the underlying foundations. Foundations transmit load to the supporting subsoil in direct bearing.

As highlighted above no movement/expansion joints were evident across the building though there are no signs of major structural distress which would suggest movement induced cracking has occurred.

The chimney (now demolished) and later added dust chute (still standing) are both formed in solid load bearing masonry.

4. Approach to Study

A visual and intrusive assessment was conducted at Brunswick Mill on February 17th, 2021 by Civic Engineers. Investigations were limited to structural columns and masonry jack arch floors. Note that access was only available to floor six, in the wing fronting the Ashton Canal, to limit impact on existing tenants. Therefore, all assumptions made in this technical report will need to be verified as correct throughout during later stages of design.

The method of investigation works was as follows.

- Formation of 2No pilot hole through 2No structural columns on floor five to determine gauge (wall thickness) of circular hollow column
- Formation of pilot holes in 2No structural floor bays to understand structural and finishes depths of floor slabs. Floors slabs are known to be masonry jack arch type therefore pilot holes were formed in the following locations to deduce the overall profile
    - Pilot hole at beam line to determine cover to structural beam
    - Pilot hole adjacent to beam to determine arch depth at support
    - Pilot hole at centre of floor bay to determine arch depth at crown
- Note, no opening of the masonry jack arch soffit was available due to high level access limitations. This resulted in approximations to structural beam sizes which will need to be confirmed.

Appendix B shows an indicative arrangement of investigations.

The above measurements were interpolated to determine a realistic arch profile along with structural beam and columns sizes to calculate self-weight and superimposed dead loads.

The approximate structural build up based on investigation is presented in Appendix A.

The data was then compared with historic publications including the *"Historic Structural Steelwork Handbook"* and the applicable *"Dorman Long Handbook"* applicable for the time of construction of the mill.

The data was then be used to understand stresses in the beams and columns to conclude the respective capacities and confirm the feasibility for change of use.

5. Assumptions

The following are a list of assumptions made during the study;

- It was common practice, during the known period of construction, for masonry jack arch floors to be supported on inverted cast iron T sections. However, consulting data available and interpolating this with measurements on site, a T-section of similar size was not readily available. Therefore, if the structural beams at Brunswick Mill are T-shaped in nature this would have been a bespoke section which is reasonably assumed unlikely. This would have been a costly process. This is also supported by investigations; pilot holes were drilled off centre to beam lines and steel outstand flanges were encountered. Therefore, it is likely the section is a symmetrical beam type profile.
- The web of beams was unavailable for review without high level access and local removal of brickwork. Therefore, this was not explored on site and reasoned assumption is made
- The beam size assumed in calculations was therefore based on the measurements taken on site and not historical published data of section sizes at the time of construction. It is therefore assumed that the beam sections are bespoke or predate published tables
- Allowable stresses have been assumed based on data from "The Historic Steelwork Handbook".

6. Analysis Findings

6.1 Structural Beams

The first exercise was to understand the mill in its current condition. Therefore, the structural beams, based on the assumed bespoke section sizes, were analysed under only the permanent loads associated with the current structural arrangement derived from the opening up works described above without historic strengthening works

Comparing this with historical data for cast iron construction at the time the cast iron beams are calculated to have a utilisation factor of 300% (i.e., 3x overstressed under self-weight only).

Note that this calculation is based upon the recommendations of "The Historic Steelwork Handbook" with respect to factors of safety to account for the variability of cast iron as a structural material.

This would suggest the following.

- The recommendations prescribed within "The Historic Steelwork Handbook" are not applicable and a lower safety factor may be more appropriate.
- The assumption these sections are made from cast iron is incorrect and structural beams could be wrought iron.

Comparing the loads under self-weight only (as described above) with historical data for wrought iron construction at the time the beams are calculated to have a utilisation factor of 0.78 (i.e., 22% under stressed). This is in line with a level of utilisation of structure which would commonly be expected.

It is known that mills of this era were designed for very low live loads, circa 33kg/m2. Taking this additional live load into account along with the self-weight of structure and assuming no further finishes loads (reasonable for mills) this would result in a utilisation factor of 0.86 (i.e. 14% under stressed). This is in line with a level of utilisation of structure which would commonly be expected

This would support the assumption that beams are wrought iron and not cast iron.

The structural beams were then analysed under an assumed additional load as part of the mill conversion. The following additional loads were assumed based on previous Architects, Latham's, proposals as agreed with the Design Team.

Finishes (floor only) -	75kg/m2
Services and ceiling below -	15kg/m2
Live load for residential use -	150kg/m2 + 63kg/m2 allowance for partitions

The results of this analysis show the beams to have a utilisation factor of 0.90 (i.e., 10% under stressed).

The current use of the mill at first floor should also borne in mind. Observing the first-floor rehearsal studios, which could be reasoned to impose similar loads to that of a residential space i.e., a regular grid of partitions with similar floor loading, this would further support the proposals for conversion and suggest this will most likely be feasible on the existing floor plates.

It is recommended that structural beams are studied further during detailed design, which should include metallurgical testing, to determine whether beams are cast or wrought iron.

6.2 Masonry Piers

Masonry piers are 1200mm wide x 385mm deep and are evenly spaced to support structural beams. Structural beams are supported on masonry piers via concrete padstones as shown in the figure below.

Figure 5: Padstone supporting structural beam.

Existing stresses in the masonry piers due to the permanent loads associated with the current structural arrangement were calculated to be in the region of 1.1N/mm2. This is based on assumption of padstone width which would need to be confirmed during detailed design.

The existing stresses were compared with stresses due the above assumed loads (6.1.4) as part of the mill conversion. The results of this analysis show an approximate stress in brickwork of 1.58N/mm2 which equates to a percentage increase of 42%. Although this increase is large the magnitude of stress is still within limits which would be deemed acceptable for masonry. However, this would need to be verified through material testing of the masonry to understand the true strength of the material.

7. Conclusions and Further Works Required

The materiality of beams is yet to be confirmed without detailed intrusive metallurgical testing. However, the conversion of the mill is most likely be feasible based on the following approach.

1. In accordance with recommended Codes of Practice beams cannot be proven to be cast iron under the self-weight of structure alone. If beams are cast iron, then it is likely that the recommended factors are safety are not appropriate in this instance.
2. If beams are not cast iron, then wrought iron is the most probable alternative. The proposed conversion can be proven on this basis.
3. The first-floor rehearsal studios, which could be reasoned to impose similar loads to that of a residential space i.e., a regular grid of partitions with similar floor loading, would demonstrate the capacity of floor plates to support the proposed loading.

Intrusive metallurgical testing should be carried out in future design stages to confirm the materiality of beams and the above conclusions.

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