



LOWER CAMPFIELDS BUILDING
LIVERPOOL ROAD, MANCHESTER
STRUCTURAL APPRAISAL OF EXISTING ROOF
SECOND ISSUE

JANUARY 2023

PROJECT REF: TM/22/1334

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DOCUMENT VERIFICATION

Project title		Lower Campfields Manchester		Job number TM/22/1334	
Document title		Structural Appraisal of Existing Roof		File reference TM/22/1334	
Document ref		TCM-LCM-ZZ-ZZ-RP-S-0001			
Revision	Date	Filename	1334/WIP/Reports/TCM LCM ZZ ZZ RP S 0001		
First Issue	12/22	Description	First Issue		
			Prepared by	Checked by	Approved by
		Name	R J Harmston	S McBride	
		Signature			
Second Issue	04/23	Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name	R J Harmston	S McBride	
		Signature			
Third Issue		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			

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STRUCTURAL APPRAISAL REPORT

1 EXECUTIVE SUMMARY

Tier Consult were engaged by OBI Property to undertake a structural appraisal of the existing roof structure in advance of the proposed recovering works.

A measured survey of the existing roof structure was undertaken together with check calculations using assumed loadings associated with the proposed roof coverings. The proposed loadings allowed for insulation and fibre cement tiles.

Check calculations indicated that the existing structure was able to safely support the proposed loadings.

The load capacities calculated demonstrated that the roof structure was working at its safe limit under the actions of the current man-made fibre cement tiles. The calculated capacities therefore indicated that heavier roof coverings, than currently extant, would require significant structural intervention to reduce the loading on the existing roof support members.



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2 INTRODUCTION

2.1 SCOPE OF REPORT

Tier Consult were engaged by OBI Property Ltd to investigate the roof structure of the lower Campfields Market Building, Castlefields, Manchester.

The focus of the investigations was to appraise the roof structure for its ability to support the loads from a proposed new roof covering. It is understood that the existing roof coverings are to be removed and are to be replaced with a build-up comprising fibre cement tiles and insulation. It has not been assumed that the glazed elements are to be replaced.

This report assesses the structural capacity of the roof structure and its individual members, no geotechnical investigations or appraisals were undertaken however these are not deemed to be a limitation with respect to the loadings considered.

Tier Consult were provided a copy of a Structural Condition Report undertaken by Tomasons dated March 2022. This report presents a comprehensive review of the condition of the structure and recommendations for ongoing repair. For the purposes of the Tier Consult study, it has been assumed that the recommendations of the Thomason report will be implemented and no allowance for any existing defects has been made in the considerations of this report.

Access was arranged with and facilitated by the staff in the adjacent Museum of Science and Industry.



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3 LOCATION

3.1 SITE LOCATION

The site is located to the north of the eastern end of Liverpool Road, Manchester. The longitudinal axis of the building is orientated in the north-west / south east direction.

The building is surrounded on all sides by low rise buildings, 2-4 storeys, affording nominal sheltering from the wind

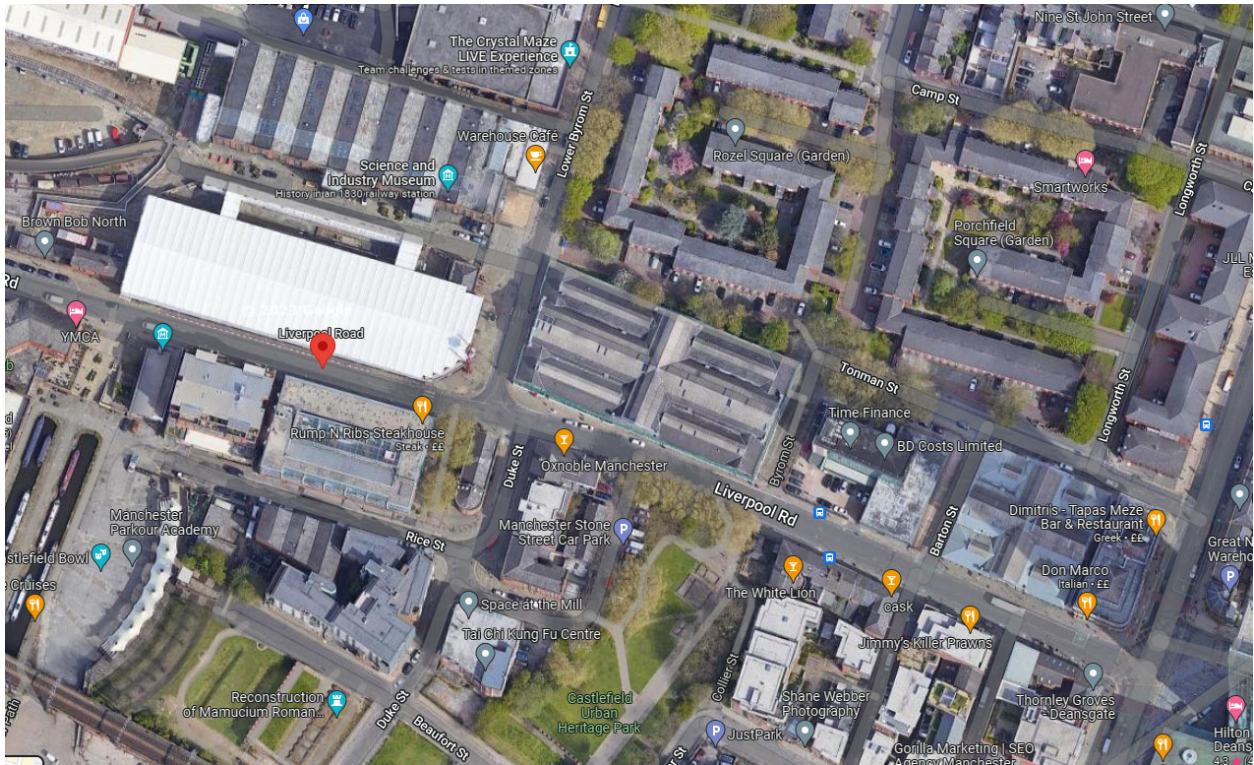


Figure 1 – Site Location



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4 EXISTING BUILDING

4.1 EXISTING STRUCTURE

The existing building comprises a single storey building with a central glazed arch lantern roof forming a cruciform profile in plan complemented with duo pitch roofs along the long elevations. The duo pitch roofs also benefit from raised glazed lantern features along the ridge.



Figure 2 - Aerial View of Roof

The structure also comprises a mezzanine level platform floor to the full perimeter of the building.

The arched central span measured 16m between supporting columns with the external duo pitch roof spanning 11m to the external columns. The central arches and the perimeter duo pitch trusses were located at 8.3m and 4.15m intervals respectively, the latter receiving support for the intermediate trusses from longitudinal lattice girders.

A detailed roof structure layout is included in Appendix A

For notation of member types indicated in Appendix A refer to Figure 3

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KEY TO MEMBER NOTATION	
Member Notation	Member Type
1	Iron Lattice Arch (tied)
2	Iron Lattice Truss (internal)
3	Iron Lattice Truss (external)
4	Iron Duo pitch Truss (internal)
5	Iron Duo pitch Truss (Hips)
6	Hip Truss
7	Iron Lattice Purlin
8	Timber Purlin
9	Timber Rafters
Shaded Areas	Tiled Roof

Figure 3 Roof Structure Key Plan

4.2 EXISTING ROOF COVERING

A tiled roof covering is provided to all pitched roof areas and to the lower section of the glazed central arched lantern roof. The remaining roof areas comprise glazing supported by glazing bars bearing on to the structure. The tiled areas are underdrawn with solid timber boarding assumed 25mm thick arranged in a chevron formation. It is assumed that the existing tiles are supported on tiling battens directly affixed to the boarding. It is these areas which are considered for the new roof covering.



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Figure 4 - Tiled Duo Pitch Roof to Perimeter



Figure 5 Duo Pitch / Arched Roof Interface



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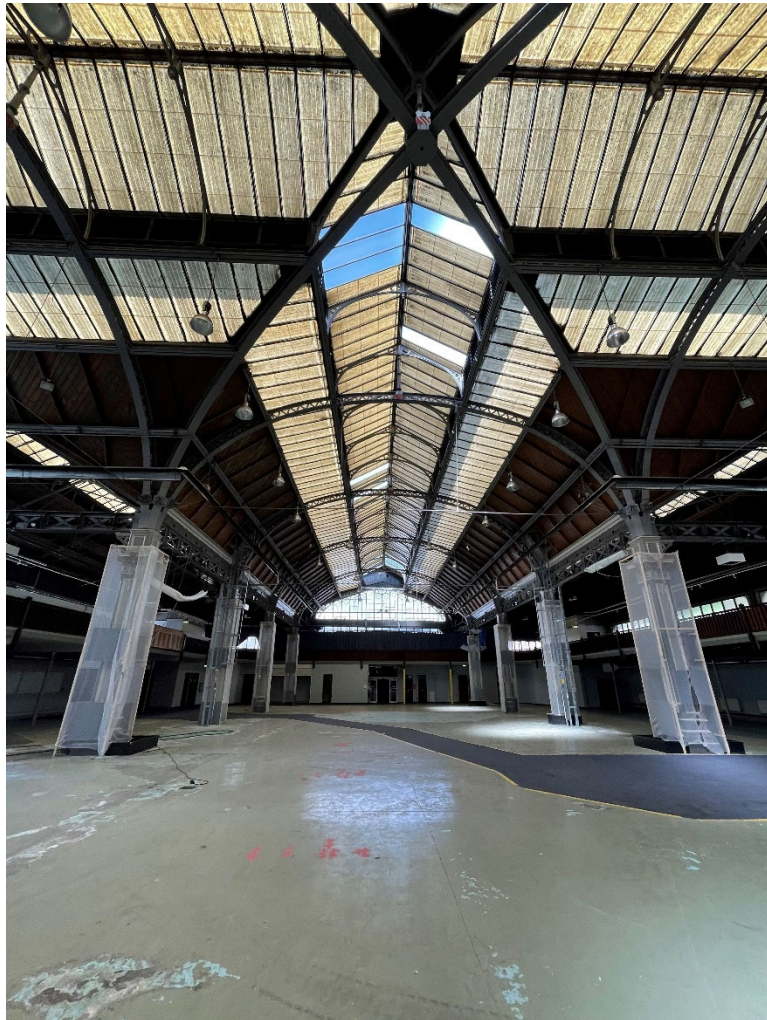


Figure 6 Glazed Cruciform Roof



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5 EXISTING CONDITION SURVEY

5.1 CONDITION SURVEY REPORT

Tier Consult have been supplied with a copy of a Structural Condition Report prepared by Thomasons (Structural Engineers) dated March 2022. The salient points therein being

- Evidence of previous strengthening works, tying of the arch trusses across springing points
- Introduction of ridge beam to the duo pitch trusses, assumed to prevent out of plane instability of the ridge node
- Evidence of previous structural movement, addressed by the works above
- Local corrosion due to water ingress
- Corrosion of external envelope members due to bi-metallic action
- Instability of a number of decorative motifs

It is assumed that the recommendations of the report will be implemented and therefore for the purposes of this report no allowance for these defects will be made.

It should be noted that no significant evidence of structural distress was noted in the report, this accords with the Tier observations.



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6 PROPOSED RE-COVERING WORKS

6.1 ROOF COVERING

It is understood that the existing roof covering has exceeded its reasonable design life and it is proposed that the existing coverings be replaced.

Whilst removing and relacing the roof covering the opportunity will be taken to introduce insulation which is assumed not be present in the current in the current situation.

It is assumed that the insulation will be introduced between the solid board under-drawing and the tiled finish. This will require the existing tiling battens to be removed and the new tiles being supported on a raised system above the insulation such a rails or battens on a 'helping hand' bracket system.

Any bracket system should allow for sufficient fixings to resist wind uplift loads applied to the inclined surfaces.

6.2 PROPOSED LOADING

it is suggested that the previous structural movement discussed in the Thomasons condition survey was caused by the use of 'heavy' tiling or slates as the roof covering to the sloping areas, this was rectified by replacement with lighter fibre cent tiles.

It is therefore proposed that the replacement roof covering be of a similar lightweight construction. The following Eternit 'Rivendale' fibre cement tiles have been assumed as typical of this type of material, salient product details are indicated below in Figure 7

The installed weight of these tiles at maximum lap is 22.8 kg/m² which is approximately a half to a third the weight expected from a slate or concrete tile solution.

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Technical data

Size of slate	600mm x 300mm
Minimum pitch**: Moderate exposure	22.5° (100mm lap) 20° (110mm lap)
Minimum pitch**: Severe exposure	25° (100mm lap) 22.5° (110mm lap)
Maximum pitch	90°
Typical laps	100, 110mm
Slate hooks	Hook fixed 100 -150mm
Maximum gauge	245 - 250mm
Slate thickness	4mm
Covering capacity (net)	13.4 slates/m ² at 100mm lap 13.6 slates/m ² at 110mm lap 14.8 slates/m ² at 150mm lap
Weight of slating (approx)	20.4 kg/m ² (0.20 kN/m ²) at 100mm lap 20.9 kg/m ² (0.20 kN/m ²) at 110mm lap 22.8 kg/m ² (0.20kN/m ²) at 150mm lap
Battens required (net)	4.00 lin.m/m ² at 100mm lap 4.08 lin.m/m ² at 110mm lap 4.45 lin.m/m ² at 150mm lap
Batten size recommended (fixed to BS 5534)	50 x 25mm for rafters/supports not exceeding 600mm centres

Figure 7 - Eternit Rivendale Technical Details

6.3 STRUCTURAL LOADING

The following loading has been assumed in the analysis of the roof structure

Permanent Load

Timber Rafters	0.20 kN/m ²
Fibre Cement Slates	0.22 kN/m ²
Insulation Board	0.05 kN/m ²
Decking	0.12 kN/m ²
Services	0.10 kN/m ²

Variable Load

Roof	0.6 kN/m ²
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7 STRUCTURAL ANALYSIS

7.1 STRUCTURAL SURVEY

The roof structure was accessed by MEWP in August 2022. Wherever possible the roof member dimensions were recorded with tapes and vernier callipers.

7.2 STRUCTURAL ANALYSIS

Simple beam members, timber rafters and purlins, were analysed using statically determinate beam analysis methods

Truss members were analysed using 2d frame analysis software

The roof members were then checked using the appropriate material grades.

For the wrought iron trusses reference was made to the SCI Publication 'Historical Structural Steelwork Handbook'. This document gives recommendations for the design of wrought iron members as shown in Figure 8

6.3.2 Wrought Iron Beams

The figures quoted in 1879 for the ultimate strength values of wrought iron, which were generally accepted were:—

21 tons/sq inch (324.3 N/mm²) in tension

16 tons/sq inch (247.1 N/mm²) in compression

20 tons/sq inch (308.9 N/mm²) in shear

A factor of safety of 4 was considered as satisfactory which gives allowable stresses of:—

pbt or pt = 5.25 tons/sq inch (81.1 N/mm²)

pbc = 4.0 tons/sq inch (61.8 N/mm²)

pq = 5.0 tons/sq inch (77.2 N/mm²)

It has been reported that when the Forth Railway Bridge was being designed the use of steel instead of wrought iron was advocated "as the design stress could be increased from 5 tons/sq inch (77.2 N/mm²) to 6.5 tons/sq inch (100.4 N/mm²)". This suggests the use of 5 tons/sq inch in both tension and compression especially as it is stated that the ductile nature of the metal made observations on compressive strength difficult.

It is recommended therefore that when checking Wrought Iron beams a figure of 5 tons/sq inch (77.2 N/mm²) should be used for pbt and pbc provided of course that the compression flange is adequately restrained laterally.

Figure 8 - Extract of SCI Handbook of Historical Steelwork

This document gives working stresses against which the results of the analysis were compared.



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It should be noted however that, as stated in the figure above, a factor of safety of 4 is adopted on the 'failure load' of the material due to the variable nature of the manufacturing process and quality control

For the timber members the current grade of C24 timber has been assumed as appropriate for structural applications. This is considered to be conservative however due to the high quality of the existing timber and the likelihood of it being slow grown Baltic or Canadian softwood.

7.3 ANALYSIS RESULTS

The results of the analysis and member checks showed that the stresses generated within the members were acceptable and within the range of stresses suggested for the particular material.

One exception to the statement above occurred on the top rafter member of the duo-pitch trusses to each long elevation. The point loads imposed on the inclined members is causing elevated bending stresses however it should be appreciated that the analysis model is very conservative as it does not fully replicate the additional restraint or support afforded by the cast iron internal member.

Even considering the conservative nature of the analysis the factor of safety reduction in the rafter member material is minimal and therefore in our consideration is acceptable.



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8 CONCLUSION

The existing tiled roof areas have been considered for replacement with new fibre cement roof tiles and insulation.

The site survey and check calculations indicate that the roof structure is capable of supporting the loads from a market typical fibre cement tile and roof insulation board.

The check calculations indicate that there is no capacity to support loading in excess of that generated from fibre cement tiles, therefore thick natural slates or concrete interlocking tiles would not be suitable. The loading due to thick natural slate can be 3x the current fibre cement covering and as such should these be desired then significant structural intervention would be required at roof level. This works would likely entail the introduction of secondary roof frames between the existing trusses to relieve the timber purlins and iron trusses of the additional loads. These relieving members would then require supporting beams to direct the load back to existing column locations, assuming that new full height columns would be deemed unacceptable, due to the nature of the existing roof the integration of these members would be challenging both from a practicality and aesthetic consideration.

In order for the comments above to be valid the repairs suggested in the Thomasons Structural Condition Report should be implemented .



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APPENDIX A

Roof Structural Arrangement Plan

