2-4 Doughty Mews, WC1N

Structural Report on Proposed Building Alterations & Extension

For the Egypt Exploration Society

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INTRODUCTION

Context

Bailiss & Company Ltd have been appointed by the client Egypt Exploration Society to work with the design team to provide full civil and structural design services for the refurbishment and roof terrace extension of the property at 2-4 Doughty Mews, WC1N.

The purpose of this Structural Report is to describe the structural and civil engineering concept design of the proposed development to support the preliminary cost estimates for the project.

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This report should not be relied upon exclusively for decision making purposes and should be read in conjunction with other documents and drawings by the design team.

Report Objectives

This report summarises the advice and investigations to date. It is intended to describe the civil and structural strategy for the proposed scheme, as it stands at the conclusion of RIBA Stage 2. The report and its findings are not exhaustive and are limited to the visual and investigative inspections carried out to date.

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DESIGN BRIEF AND STRUCTURAL FRAMING STRATEGIES

Design Brief

The project proposal is to extensively refurbish and re-fit the building. Part of the refurbishment is to house a collection of ancient papyri and cartonnage, as well as other archival materials, in a stable environmental condition, protected from leaks and with additional security. The storage of the materials is proposed to be in rolling stack shelving. These storage and research areas will require approximately 100m2 floor area, and therefore the ground and first floors will need to be utilised. To create additional space, a vertical extension to create a new second floor level with roof terrace is proposed.

Of structural significance, the refurbishment will require:

- Installation of new foundations, including underpinning of existing walls.
- Re-arrangement and removal of several internal walls. Infilling some of the front elevation windows at ground floor level.
- Installing new structure to support upper floors and provide stability to the building
- Installing new floors (concrete and timber) at all levels to support proposed loads.
- Creating new roof extension with roof terrace.
- Installing new platform lift located adjacent to the existing stairs.
- The proposed structural arrangement is presented in APPENDIX 2

Structural Framing Strategies

Possible framing strategies for the building include:

i) In situ concrete frame with flat slabs
ii) In situ concrete frame with post-tensioned flat slabs
iii) In situ concrete frame with waffle slab
iv) In situ concrete frame using hybrid precast/in situ RC slab (Omnia or bubble deck)
v) Precast concrete frame with precast concrete 'hollowcore' planks with a structural topping.
vi) Steel frame supporting in situ concrete slabs cast onto metal deck as permanent formwork
vii) Steel frame supporting precast concrete 'hollowcore' planks with a structural topping within depth of steel beam (Slimflor)
viii) Steel frame supporting in situ concrete slabs cast onto metal deck as permanent formwork with a structural topping within depth of steel beam (Slimdek)
ix) Steel frame supporting cross laminated timber floor slabs
x) Glulam frame supporting cross laminated timber floor slabs
xi) Glulam frame supporting CLT floor slab on glulam ribs

At ground and first floor levels, there are high levels of imposed loads expected from the papyri-cartonnage stores. Hollowcore, Slimdek or CLT floor systems would be need short spans and/or a large structural depth which is not compatible with access requirements. Therefore, using an in situ concrete frame with concrete floors for the ground/first floor levels (i – iv) would be most appropriate. For the second floor extension and roof terrace the loads are lighter, and the structural grid is not particularly in line with the floor below, therefore a steel frame and timber floor solution can be utilised as an economical and flexible solution.

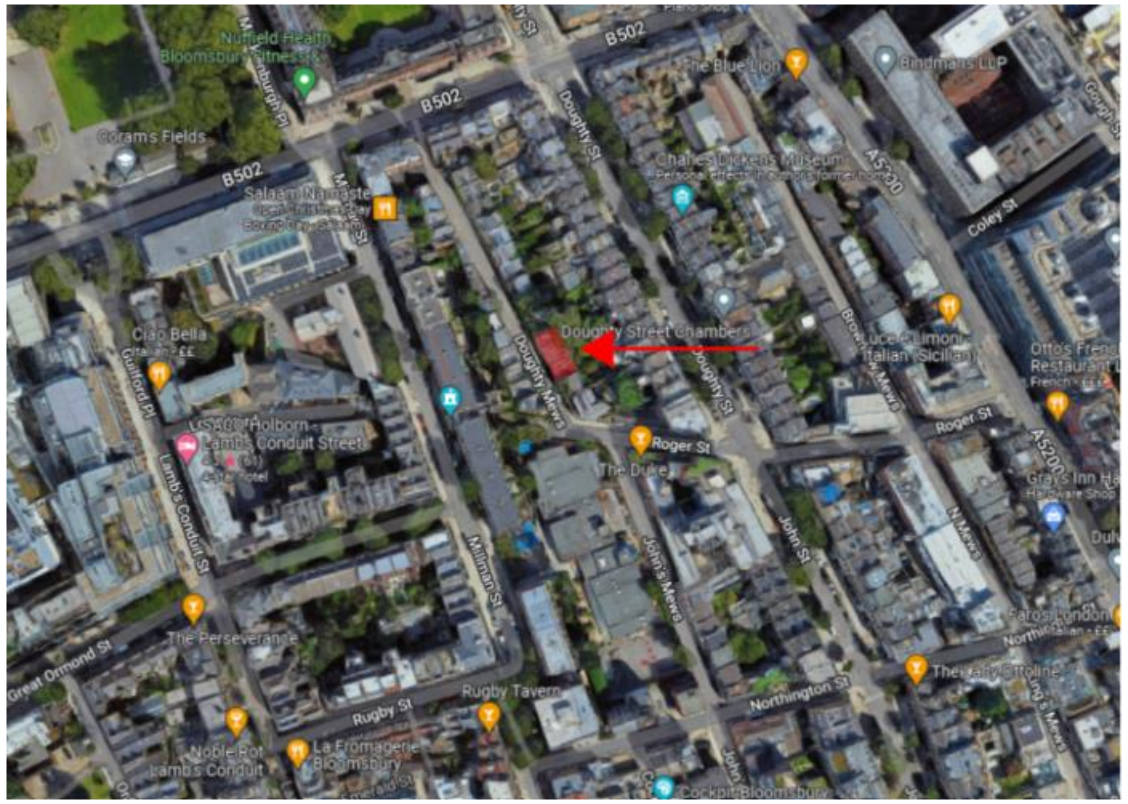
Section 5 of this report (Superstructure Proposals) develops these options into a Stage 2 scheme.

SITE AND GROUND CONDITIONS

Location

The building at 2-4 Doughty Mews is located Bloomsbury, in the London Borough of Camden. The site postcode is WC1N 2PG. Doughty Mews is a no through road which is bordered by the B502 (Guilford Street) to the north, Doughty Street to the east and Millman Street to the west. The end of gardens belonging to properties along Doughty Street borders with the rear elevation of 2-4 Doughty Mews. The River Thames is approximately 1.5km to the south of the site.

The site is located in the Bloomsbury Conservation area Sub Area 10 (Great James Street / Bedford Row).



Geotechnical Ground Conditions

To date, geotechnical investigations have been confined to trial pit and borehole investigations carried out by Herts & Essex Site Investigations on 27th May 2021. This is detailed in a report by William J Marshall & Partners (ref OE/A.6037) dated 10th Jan 2022. These investigations were specific to 2No mature plane trees within the boundary of No8 Doughty Street rear garden that are causing damage to the rear wall of No4 Doughty Mews. Therefore, these investigations do not represent a complete geotechnical investigation in relation to the proposed works for 2-4 Doughty Mews.

N.B. The geotechnical investigations indicate that one of the plane trees is causing the rear wall of No4 Doughty Mews to bow out by approximately 75mm. Therefore, should permission be sought to remove the tree, suitable temporary works and rebuilding of the wall/foundations will be necessary. Additionally, the extent of tree roots mean that it is likely that the existing brick corbel foundations have been affected, and therefore underpinning of the walls will likely be necessary.

Hand augured borehole depths extended to 4.0m bgl, with no ground water encountered.

HERTS & ESSEX SITE INVESTIGATIONS

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Appendix No.: 2
Sheet No.: 2
Job No.: 16709
Date: June 2021

REAR OF NO.4 DOUGHTY MEWS, LONDON, WC1N 2PG — Borehole No.: One

Description of Strata	Depth B.G.L. (m)	Reduced Level	Legend	Strata Thickness (m)	Water Level (m)	Samples Number	Samples Type	Samples Depth (m)	S.P.T. N - Value or Vane Strength	Casing Depth (m)
Loose dark brown slightly sandy TOPSOIL with rare sub-angular gravel - MADE GROUND	0.30			0.30						
Loose dark brown sandy FILL with much fine - medium brick and chalk fragments - MADE GROUND	0.70			0.40						
Firm dark orange brown mottled dark brown slightly sandy CLAY with some sub-rounded to sub-angular gravel and brick fragments - MADE GROUND	0.90			0.20						
Medium dense dark orange brown mottled brown / grey slightly silt CLAY with some sub-rounded to sub-angular gravel, brick and ash fragments - MADE GROUND	1.20			0.30		1 1	D N	1.00 1.00	29	
Medium dense dark brown / black very clayey SAND with some sub-rounded to sub-angular gravel and brick fragments - MADE GROUND Becoming a very sandy CLAY with depth						2 2	D N	1.50 1.50	27	
					DRY	3 3	D N	2.00 2.00	26	

Borehole one, recovered topsoil to a depth of 0.30m bgl, where a loose dark brown sandy FILL with much fine – medium brick and chalk fragments was then seen to 0.70m bgl. Below this a firm dark orange brown mottled dark brown slightly sandy CLAY with some sub-rounded to sub-angular gravel and brick fragments – MADE GROUND. Between 0.90m bgl and 1.20m bgl, a medium dense dark orange brown mottled brown / grey slightly silty CLAY with some sub-rounded to sub-angular gravel brick and ash fragments – MADE GROUND was present. Beyond this and found to the close of the borehole at 4.00m bgl, a medium dense dark brown / black very clayey SAND with some sub-rounded to sub-angular gravel and brick fragments – MADE GROUND, this became very sandy CLAY with depth.

Borehole two, found TOPSOIL to a depth of 0.37m bgl, with a loose dark brown sandy FILL with much fine – medium brick and chalk fragments to 0.85m bgl. Below this a medium dense dark brown clayey SAND with some brick and gravel fragments – MADE GROUND was seen. Between 2.00m bgl and 2.70m bgl, a medium dense dark brown mottled orange brown very clayey SAND with some brick, gravel and ash fragments – MADE GROUND was recovered. From this depth and seen to the close of the borehole at 4.00m bgl, a medium dense dark brown / black very clayey SAND with some sub-rounded to sub-angular gravel and brick fragments – MADE GROUND was found.

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REAR OF NO.4 DOUGHTY MEWS, LONDON, WC1N 2PG — Borehole No.: Two

Description of Strata	Depth B.G.L. (m)	Reduced Level	Legend	Strata Thickness (m)	Water Level (m)	Samples Number	Samples Type	Samples Depth (m)	S.P.T. N - Value or Vane Strength	Casing Depth (m)
Loose dark brown slightly sandy TOPSOIL with rare sub-angular gravel - MADE GROUND	0.37			0.37						
Loose dark brown sandy FILL with much fine - medium brick and chalk fragments - MADE GROUND	0.85			0.48						
Medium dense dark brown clayey SAND with some brick and gravel fragments - MADE GROUND						1 1	D N	1.00 1.00	12	
	2.00			1.15		2 2	D N	1.50 1.50	17	
Medium dense dark brown mottled orange brown very clayey SAND with some brick, gravel and ash fragments - MADE GROUND					DRY	3 3	D N	2.00 2.00	27	
	2.70			0.70		4 4	D N	2.50 2.50	27	
Medium dense dark brown / black very clayey SAND with some sub-rounded to sub-angular gravel and brick fragments - MADE GROUND						5 5	D N	3.00 3.00	29	
						6 6	D N	3.50 3.50	27	
	4.00					7 7	D N	4.00 4.00	30+	
Borehole closed at 4.00m b.g.l. No Roots										

Remarks:

Scale 1:20

Key: U - Undisturbed Sample; W - Water Sample; B - Bulk Sample; D - Disturbed Sample; Water Strike; Standing Water; V - Shear Vane Test (kN/m²); N - SPT 'N' Value

The borehole information above shows that there is a large made ground quantities to a depth of about 4.0m bgl. However, British Geological Survey maps and local borehole records indicate that the ground conditions in the local area of the site have made ground to a depth of about 1m, underlain by Hackney Gravel, and then underlain by London Clay at a height of approximately 3.5m bgl. It is not clear why this inconsistency exists.

The geotechnical investigations testing showed that the made ground has Modified Plasticity Index is below 10%, i.e., a low risk of volume change potential. This is expected due to the large presence of granular materials in the made ground layers. However, again, there is some variability in this measure across the site, with Borehole 1 showing a Modified Plasticity Index of 20% in a more clayey part of the made ground at 1.0m bgl.

Further geotechnical investigations will be necessary before detailed design stage. These future investigations will need to cover more of the site (particularly due to the variability of strata as discussed above), assess bearing capacity of the soils, and further assess the impact of the 2No plane trees on the existing foundations.

Existing Building and Condition

Nos. 2-4 Doughty Mews are three terraced mews properties. They are located in the Bloomsbury conservation area in the London Borough of Camden.

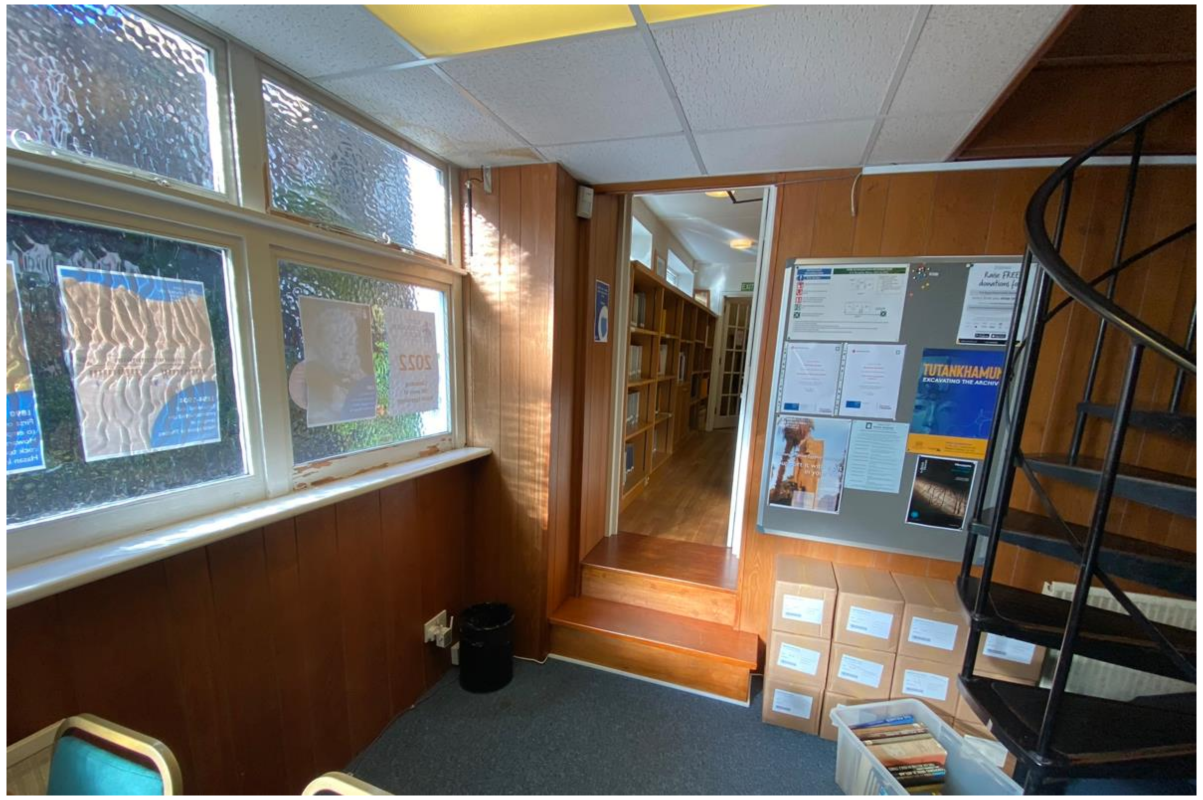
The front building façade is yellow stock masonry. To the rear a masonry façade faces onto the rear gardens of properties along Doughty Street.

The following records the visual site survey to date.

Floor	Notes
-	Front elevation Nos 2-4 Doughty Mews Generally good condition. Beams span across large Ground floor openings that have been partially infilled. 
G	No2 Doughty Mews. Steel encased in concrete beams supporting floor above. The floor above slopes toward the front of the property – believed to be of concrete construction. Ground floor is of concrete construction. 

G	No3 Doughty Mews. Ground floor of concrete construction. The ceiling grid covers a similar 1st floor construction to No. 2 – a grillage of beams (believed top be steel encased in concrete) with a concrete floor between.

G	No3 Doughty Mews. Above suspended ceiling at ground floor level; beams supporting floor above.

G	No3 Doughty Mews – view to No. 4 Doughty Mews with step up and timber floor (believed raised over concrete floor). Stair up to right of picture. 

	No. 4 Doughty Mews – Detail of cracking on back wall caused by tree impact. 
1	No3 Doughty Mews - This opening at first floor level above indicating presence of existing concrete floors and a previous investigation. 

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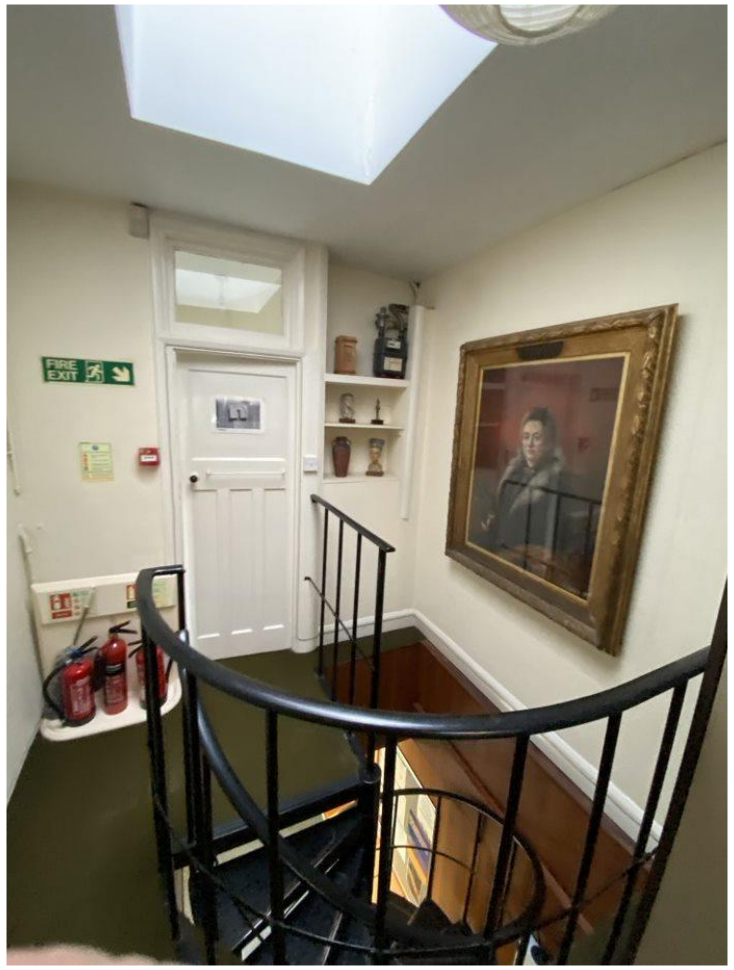
1	No3 Doughty Mews. First floor level office. Downstand indicating existing steel or timber beam supporting roof. The concrete floor of this office is very uneven. 

1	No3 Doughty Mews. Existing spiral stair to first floor with roof light over. 

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2 (roof)	No2 Doughty Mews. Roof level No2 & No 3 Doughty Mews with the pitched roof of no. 4 furthest away. The roof is believed to be of timber construction, pitched front and back with a flat central section. 
2 (roof)	Roof level (Nos 2&4Doughty Mews). 

	No4 Doughty Mews. Internal view of existing trussed timber roof. 

2 (roof)	2No plane trees in rear garden of No8 Doughty Street next to No4 Doughty Mews rear wall. 

2 (roof)	2No plane trees in rear garden of No8 Doughty Street next to No4 Doughty Mews rear wall. 

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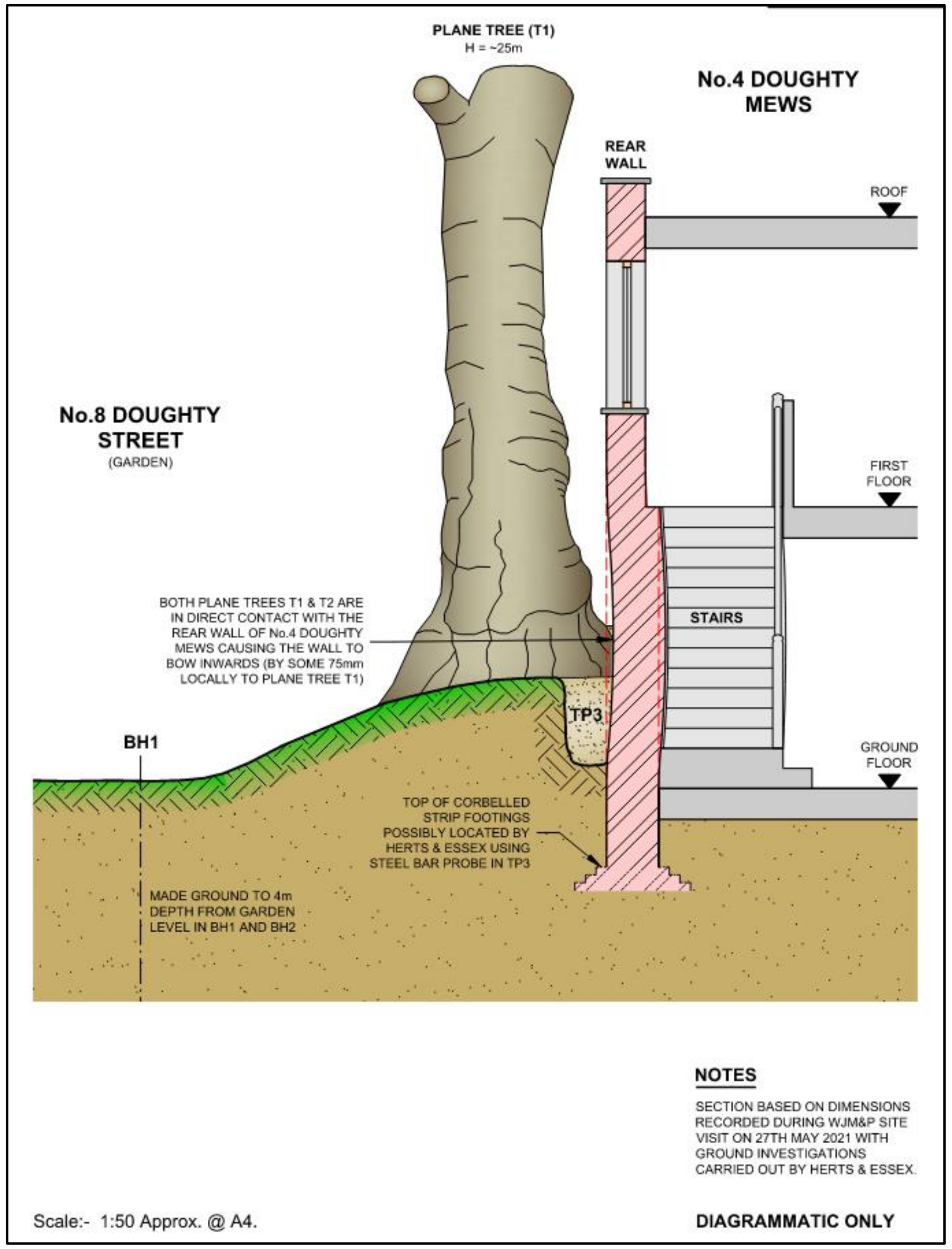
Trees adjacent to rear wall of No 4 Doughty Mews

There are 2No plane trees adjacent to the rear wall of No4 Doughty Mews.

One of these trees has caused the rear wall to bow by approximately 75mm. The figure below (obtained from the William J Marshall & Partners report) shows a section through the rear wall.



It is understood that permission is being sought to remove these trees. Issues and points to consider are:

- It is possible that one or both trees are providing structural support to the existing walls. Therefore, temporary works will be required to prop and support the walls during tree removal.
- The exact nature, depth and condition of the existing foundations are unknown. Further trial pits will be required to ascertain this information.
- Due to the possibility of existing damage to the foundations, the requirement in the proposed scheme for a lower ground floor level, and the risk of further soil subsidence during tree removal underpinning of the walls will be necessary.
- The existing walls will require strengthening, supporting and/or rebuilding where necessary in order to safely support transfer of loads to foundation level.
- More extensive geotechnical investigations are required to confirm more precisely volume change potential of the soils in the site.

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SUBSTRUCTURE PROPOSALS

Foundation Options

Based on the geotechnical investigations so far, it is expected that the allowable bearing capacity of soils would be in the region of 100-150kPa. Shallow pad and strip foundations is a viable foundation solution (based on information received to date) in order to support the proposed concrete and steel frames above. In areas of higher concentrated or point loads (i.e. at columns), piling may be required.

The existing masonry walls will require underpinning in order to reduce the height of the ground floor levels. These underpins will have to be designed as retaining in order to resist lateral earth pressures and surcharge loading.

Piled foundations may be required for heavier loading conditions (as discussed above). Ideally mini piles would be used to minimise disruptions and costs, or if necessary continuous flight auger piles (CFA). The approach would need to be confirmed by further information from geotechnical investigations. Note that the piles will need to rely on skin friction and end bearing in the London Clay strata.

Ground Slabs

Based on the low volume change potential of the soil, a ground bearing concrete slabs is possible. This has the advantage of reducing loads at the existing and strip foundations as well as being less costly. The existing ground will need to be excavated to a lower level and properly prepared (compacting, sand blinding, hardcore inserted etc).

In the event of geotechnical recommendations confirming areas of higher volume change potential it may be necessary to use suspended concrete slab with anti-heave protection measures.

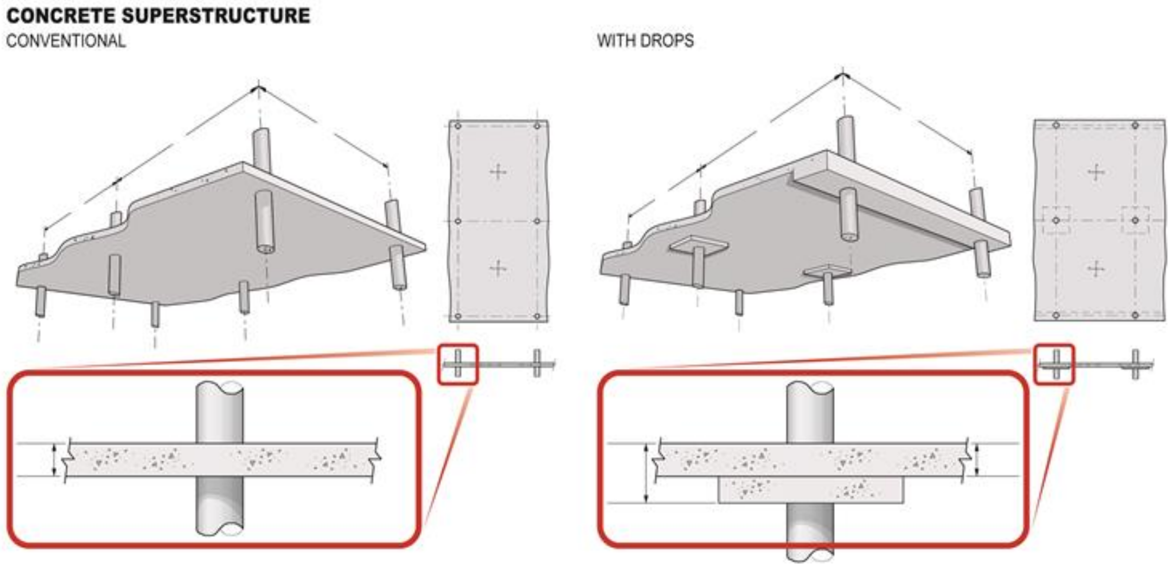
SUPERSTRUCTURE PROPOSALS

In Section 2 Structural Framing Options, a range of likely framing options were discussed. The conclusion was to use a concrete framed structure at ground and first floor levels with flat slab or ribbed/waffle type slabs. This was determined by the needs of the storage of papyri-cartonnage stores, i.e. the floors need :

- High load capacity and stiffness due to the weight and requirements of storage roller stacks.
- Suitability for security measures and fire protection.
- To have limited structural depth.

In-situ reinforced concrete frame with flat slabs

In this option, the frame comprises an in situ reinforced concrete (RC) frame with in situ RC columns and a two-way spanning in situ RC flat slab, with a flat soffit. The flat slab is cast onto temporary formwork and reinforced with steel reinforcement bars and/or mesh. Enhanced shear capacity over column heads is either achieved with a shear link system locally, or, for a thinner slab, localised increased thickness drop heads.



The benefits for this solution include:

- It allows excellent horizontal services distribution below the slab with no downstand beams, maximising the potential for installation of prefabricated services.
- Reinforced concrete has inherent fire protection
- Reinforced concrete has inherent good acoustic properties
- Provides a monolithic structure
- The structure is complete as-struck
- Exposed soffit provides high thermal mass.
- This method of construction is extremely flexible to form any geometry.

The disadvantages for this solution include:

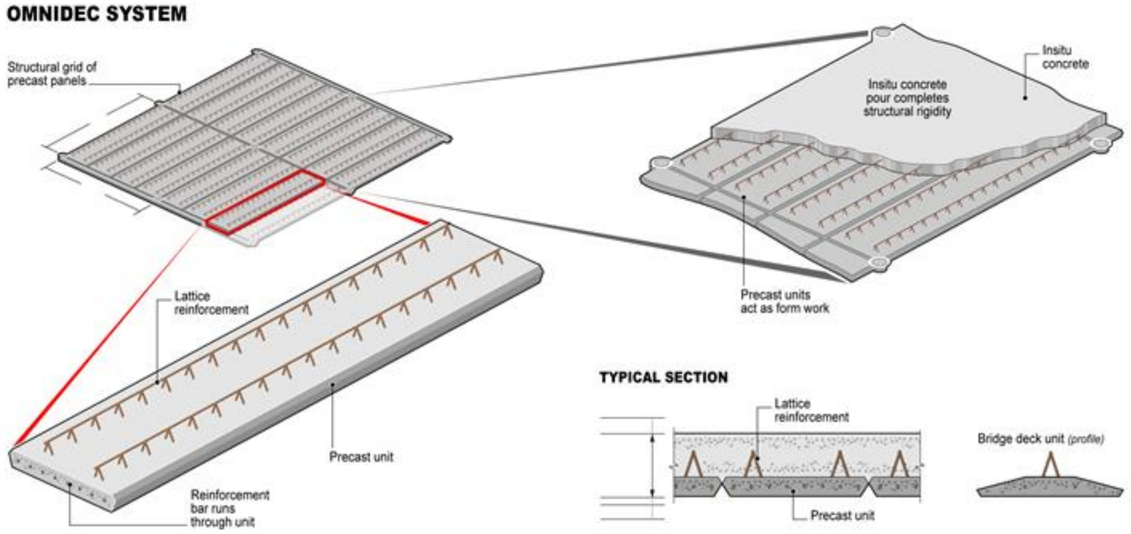
- Typically, an in-situ concrete frame construction is slower to erect than steel frame or precast concrete frame solution.
- Multiple small loads of concrete and steel will be required to build the superstructure.
- Formwork will be required for the columns, walls and slabs and will have to be moved up the building as it progresses.

In situ concrete frame with post-tensioned flat slabs

This option is likely to offer too much of a restriction on frame subcontractors since post tensioning is still relatively ‘niche’ in the UK. For the size of scheme this option is not considered viable/

In-situ reinforced concrete frame using hybrid precast/in situ RC slab (Omnia or voided deck)

This option starts to take advantage of prefabrication of elements by means of pre-casting concrete elements. Voided slabs such as Bubbledeck, Cobiax or Airdeck all work on similar principle and are similar to a straight precast "biscuit" slab such as Omnia deck. To the basic slab, a void former is fixed. This removes material from the centre of the slab and therefore provides a lighter precast slab solution. The overall slab thickness may be slightly thicker than a standard Omnia deck or flat slab solution, however up to 30% of the weight of the slabs can be saved, with knock on savings to the foundations and columns. In the case of Omnia deck, the hybrid slab comprises a thin precast concrete plank with a lattice girder mesh. This is installed onto the in-situ RC frame and then topped with a structural screed which acts compositely with the precast plank via the lattice girder and with the in-situ RC beams to effectively form T-beams.



The benefits for this solution include:

- Reinforced concrete has inherent fire protection
- Reinforced concrete has inherent good acoustics
- Provides a monolithic structure
- The precast deck eliminates the need for formwork to form the slabs and provides a temporary working platform, however propping is required for large spans.
- Exposed soffit provides high thermal mass.
- Void formers can be used to reduce weight of building, materials used and foundations.
- Precast columns, beams and slab elements can considerably increase construction speed while providing a high-quality finish.

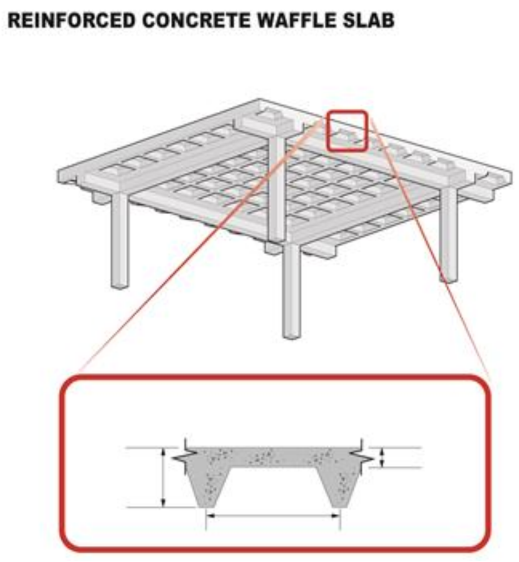
The disadvantages for this solution include:

- Large elements will need to be delivered to site and lifted in to place. The site must have good accessibility and cranage options.
- Propping is still required for slabs.
- If propping of slabs is to be avoided downstand beams will be required that will block service routes.
- Some elements may be thicker than their cast in-situ equivalent.

In situ concrete frame with in-situ ribbed or waffle slab

This option has similar has similar characteristics to a flat slab approach, but whilst more economic in terms of quantity of concrete it has higher associated formwork costs and rib depths may affect services in the ceiling void.

Ribbed slabs have drop beams in a single direction, whilst waffle slabs have a network of dropped beams in 2 perpendicular directions.

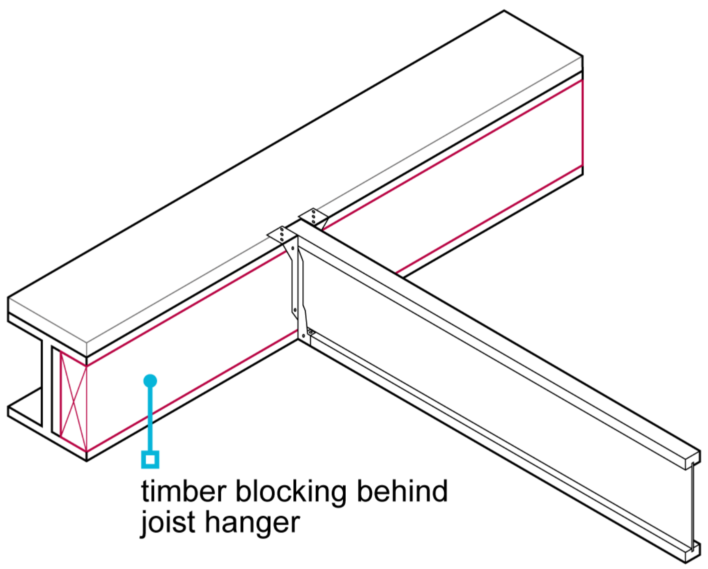


Second Floor – Timber / Steel Framing

The upper floors of the scheme as well as the roof are proposed to be constructed in a steel frame with timber joisted infill.

This form of construction is one of the most conventional and allows for a flexible, economic and quite sustainable construction.

The light weight of the construction will also limit load increases on the foundations as well and will be quite capable to be supported by the existing masonry walls.



Stability

The existing structure already exhibits adequate lateral stability. As is typical of traditional residential buildings, this is achieved by the floors acting as diaphragms which transfer lateral forces to solid masonry brick walls in orthogonal directions.

The proposed scheme retains the external walls; however, some internal walls are removed in order to open up the internal space. Therefore, bracing is required to maintain adequate lateral stability. At ground floor level a section of reinforced concrete shear wall is introduced and above first floor level, above this wall is replaced by a steel braced bay (using tension only diagonally orientated steel plates). At ground level between Nos 2 & 3, a steel box frame is used at an opening in the existing wall in order to maintain existing levels of stability.

CIVIL ENGINEERING WORKS

Existing Drainage

TBD - the Thames Water Asset Map for the area has not yet been acquired.

Proposed Foul Water Drainage

Access throughout for any new drainage system will be provided through the use of manholes or rodding eyes at branch connections and changes in direction to allow the system to be properly maintained and for blockages to be removed.

Assuming there are existing combined water outfalls on site to the public sewer network, these will be maintained. The connections points from the site are to be retained for the purposes of discharging foul and surface water and flows will be discharged via gravity where possible.

Relevant applications to Thames Water should be made as required, including pre-development enquiries and connection applications, in order to confirm that the sewer network in the vicinity has the required capacity to accept flows from the site.

Proposed Surface Water Drainage

As with foul water drainage, it is assumed that any new surface water drainage can connect into the existing system.

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CONSTRUCTION METHODOLOGY AND CDM

Key construction issues which have been identified at this early stage are outlined below. These will be developed and added to as the design progresses.

Access to site is off down a narrow mew road main road. This will restrict site access and size of deliveries, although this has not yet been fully quantified. This must also be considered in relation to access for piling rigs or cranes (if required).

It is also recommended that any proposed removal of existing trees is undertaken at the earliest opportunity. This will then give the underlying ground the maximum possible time to heave and reach a new equilibrium before the new foundations and ground slab are constructed.

The rear wall near the 2No plane trees will need to be strengthened prior to any works commencing. Should the trees be removed, the wall must be adequately supported and propped with temporary works.

Temporary works must be used to maintain stability of the building when floor and internal walls are removed.

Underpinning of the external walls will need to be done in a hit and miss sequence, in sections not exceeding 1.2m width. A full temporary works method statement must be developed to ensure underpinning and excavations operations are conducted safely. All temporary works and sequencing are to be agreed between the structural engineer and contractor prior to work commencing on site.