104A FINCHLEY ROAD

Structural Feasibility Report

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PARMAR BROOK

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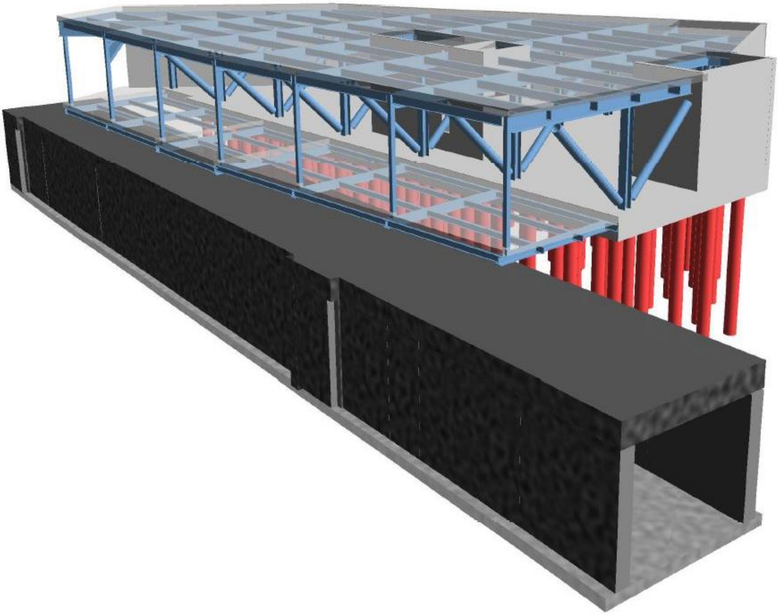

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CONTENTS

1.0 INTRODUCTION

Parmarbrook have been appointed by Trevellyan Developments Ltd to undertake a Structural Feasibility Assessment in relation to the proposed development at 104a Finchley Road, NW3.

The purpose of this document is to assess the feasibility of using an open steel grillage structure as an alternative to a structural concrete scheme developed by a previous structural engineer. This scheme was developed with the intent of minimising the structures embodied carbon and maximising the building's flexibility in occupation. This report describes the proposed structural scheme, records the key input data, and describes the principles used in the analysis and design of the structure. It is to be used within Parmarbrook for reference and it will also be issued externally to the professional team to confirm the key input data and structural constraints.

1.1 EXECUTIVE SUMMARY

This report describes the proposed development at 104a Finchley Road. It marks the beginning of design development for the proposed structural works and all information is under development, to be revised to suit final design, programme and both structural and architectural requirements.

The site is heavily constrained by a London Underground tunnel and Thames Water sewer running across the front of the site, a retaining wall to the sides, and likely party wall constraints down the line. As such a cantilever transfer structure was required to the front of the building to avoid surcharging the third-party assets and support the upper floors. A previous iteration of the structure, under another design team, included a cantilevering RC wall system. Upon development of the buildings usage, this was found to restrict the ground floor to too great an extent and so a more open steel system was proposed.

This report describes the suitability of a steel system, including the constraints that it imposes and benefits of steel as an efficient structural solution.

1.2 DEVELOPMENT DESCRIPTION

The existing site currently operates as a petrol service station and is operated by BP. It is proposed to construct a new six storey block on the site which will comprise residential accommodation above commercial retail and educational (school) uses.

To facilitate construction, the existing buildings and below ground structures on the site are to be demolished. The new structure will comprise a ground floor cantilever/transfer structure which supports the upper 5 storeys; these are likely to be constructed in lightweight cold formed steel sections or timber frames.

It is proposed that the new structure will occupy the entire site with access at Ground floor level from Finchley Road, and additional access at First Floor level from College Crescent at the rear of the building.

1.3 TEAM

The current pre-planning team comprises the following:

Role	Company
Client	Trevallyan Developments Ltd
Architect	TP Bennett
Structural & Civil Engineers	Parmarbrook
Services Engineer	WME
Planning Consultant	TP Bennett

1.4 SCOPE AND LIMITATIONS

At present, Parmarbrook have a provided a scope of service to provide the following items:

1. Undertake structural modelling of the ground floor frame to help establish floor layouts.
2. Undertake sufficient analysis to ascertain approximate deflections and member stresses
3. Utilise standard rolled-steel section sizes
4. Provide 3D modelling and drawings of the proposed lower and upper ground floor system
5. Provide 3D Revit model to enable material quantities and carbon quantities to be measured.
6. Provide a report with commentary on the works undertaken, and further works required to develop the scheme

This report has taken a single arrangement through for development which has involved coordination with the architect to develop a coordinated if not fully optimum design. Nor has this section of work involved liaison with London Underground or Thames Water to confirm the proposed arrangement, although note has been taken of previous communications with LUL Details are given within the report to detail the further proposed works.

2.0 EXISTING SITE

2.1 SITE DESCRIPTION

The site is currently occupied by a petrol service station, which is operated by BP. The site consists of a large, covered forecourt with three islands of petrol pumps and below ground storage tanks. A two- storey structure exists on the eastern edge of the site which includes the retail offering for the service station. The existing structures to be demolished are identified in more detail within the Pre-Demolition Report dated June 2022 by Sustainable Construction Services.

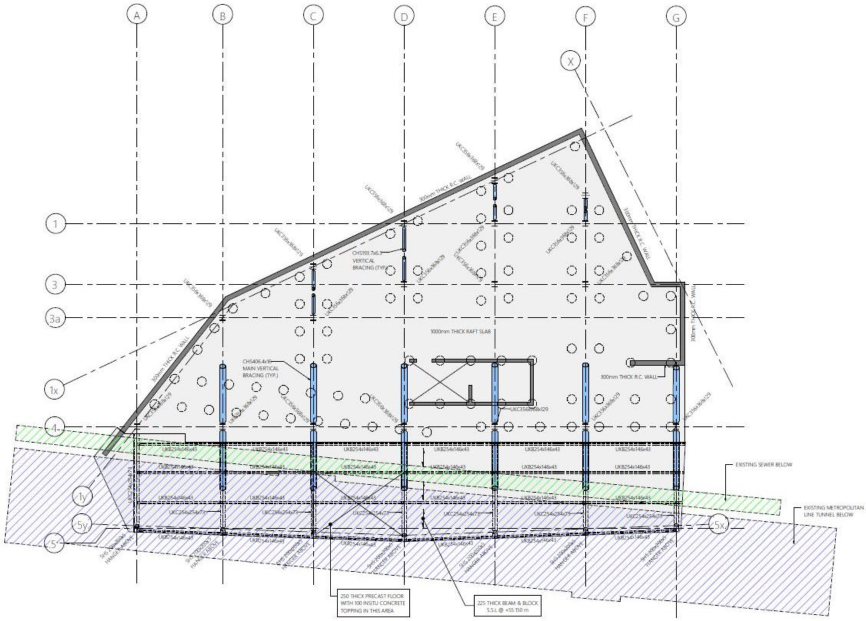
The grid reference is 526471E 184554N.

2.2 SITE CONTRAINTS

A full topographical survey has been completed as well as a Phase 1 Environmental Assessment dated June 2022 by Subadra Consulting Ltd. This confirmed the underlying soils to be firm to stiff to very stiff London Clay with localised areas of perched water. However further soil and site investigation are still required to determine accurate design and construction parameters and identify any potential below ground issues. Buried services have been identified beneath the site but no significant contamination issues were apparent. The report concluded that the site was suitable for redevelopment.

The site has relatively level access across the Finchley Road boundary but is heavily sloping up College Crescent. From the junction at College Crescent and Finchley Road to the most Northern corner, the ground level rises by over 5m. To facilitate this change in levels, there is a retaining wall that runs from the junction around most of the perimeter of the site. It is assumed to be reinforced concrete with a toe that protrudes into the site, however this has not been confirmed. It is assumed that the toe will be broken out for the new foundations, however there will be limits in how close we can pile to the boundary due to logistical restrictions in the size of the piling rig head; this is currently estimated at 1.2m from site boundary to pile centre but may reduce.

On the southern edge of the site, bordering Finchley Road, the Southbound Metropolitan line runs below ground in addition to a Thames Water sewer line. The excerpt below is from the structural drawings; the green hatch indicates the zone of the Thames Water sewer, and the blue hatch indicates the underground train line.



To prevent damage or disturbance to the third-party assets, there are important design considerations which are discussed further below. The Thames Water sewer requires a minimum 1.5m distance between the outside face of the sewer to the outside face of the pile. On this basis the piles will also be outside the 3.0m Tunnel Protection Zone required by LUL.

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3.0 STRUCTURAL PROPOSALS

3.1 DESIGN PRINCIPLE

The principle of the structural design is to provide a steel structure which can cantilever over the third-party assets to the front of the site, whilst supporting the load of the five storeys above. In addition, the structure is required to be open to maximise the flexibility of usage of the ground floor space.

In addition to the above ground constraints imposed by the assets to the front of the site, there are also below ground impacts. Some early consideration has been given to what this would mean for the substructure, however this is largely outside the scope of this report.

3.2 SUBSTRUCTURE AND FOUNDATIONS

Whilst the substructure and foundations were outside of the scope of this report, some initial thought has been made with regards possible layouts and pile numbers. It is important to note that this is purely indicative at this stage and requires further development, as well as additional information in the form of site and soil investigations.

Much of the vertical load is transferred to the columns which are immediately adjacent to Finchley Road, which is also where foundations are most restricted. In order to transfer this load back into piles which are set back from the slab edge across the entire perimeter of the building, it is proposed to provide a one-metre-thick reinforced concrete piled raft. Based on previous experience and limited analysis we believe this is a reasonable assessment of the likely foundation raft slab.

We have indicatively shown an average of 6No piles per column adjacent to Finchley Road, 4No for internal columns and 2No for all other columns. Additional piles may be required for the stair and lift core as these details develop. A full detailed piled raft ground model analysis will be required at the next stage based on site soils information. This will be critical to ensure that anticipated ground movements do not compromise existing infrastructure.

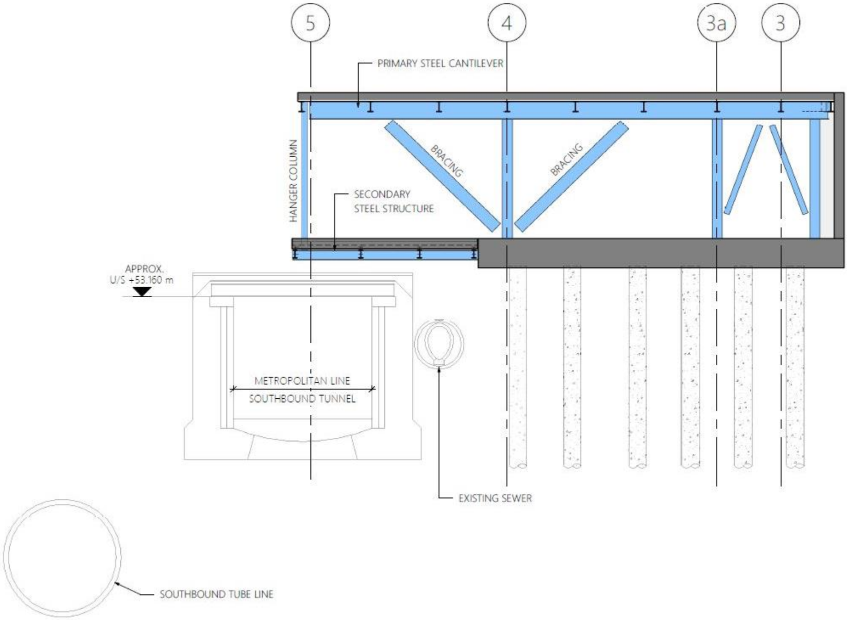
To the rear of the site, the toe of the existing retaining wall will need to be cut back in order to install the new foundation system. To facilitate this, temporary propping will be required to support the existing retaining wall and a new RC wall is to be constructed as part of these works, which will be tied into the primary structure. This new RC wall will act as the retaining element in the permanent case.

3.3 STEEL TRANSFER/CANTILEVER STRUCTURE

To maintain an open ground floor, the proposed steel structure comprises a series of deep primary steel members which span across the columns and cantilever at the end. Steel bracing has been used to limit the depth of these members and optimise the structural efficiency.

To avoid surcharging the tunnels at the front of the site, the cantilever primary beam supports a hanger column which in turns supports a secondary steel structure. Importantly, this structure exerts no vertical load onto the ground, and everything is transferred back into the primary cantilever beam. At present, a precast concrete slab structure has been indicated over the tunnels if maintenance access is required in the future.

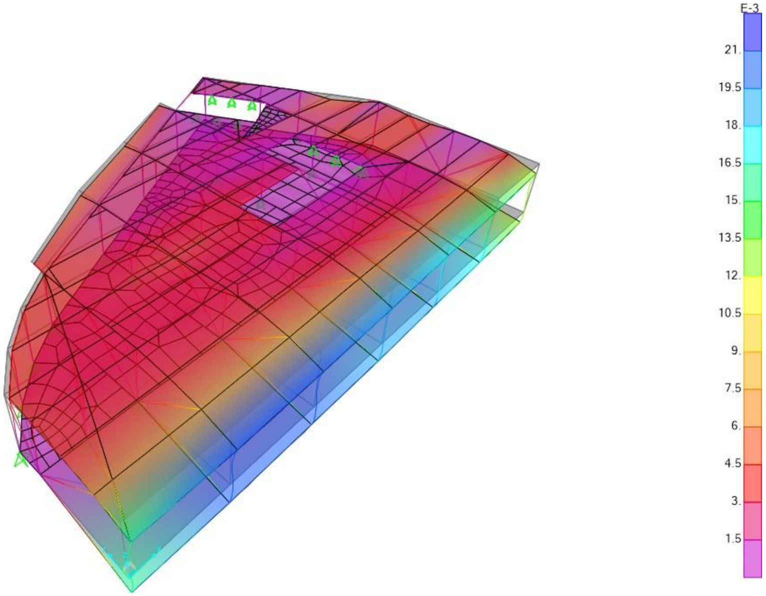
The image below represents a typical bay:



Whilst this proposal creates a large open space, the use of a small number of columns versus the extensive reinforced concrete walls of the previous scheme means that there are large concentrated vertical loads which may make for a more complicated foundation system, in terms of design. Localised punching shear loads will be greater with steel columns that for the concrete wall option.

Sitting on the steel structure is a reinforced concrete composite slab which will work to support the weight of the cold formed steel superstructure above.

The deflection of the cantilever element is critical for the design and longevity of the structure above. Our initial analysis model indicates deflections of up to 20mm which are within the range that we would expect – output below.



3.4 SUPERSTRUCTURE

It is critical that the upper floors of the building are constructed in an exceptionally lightweight structural system to minimise the load on the ground floor superstructure and substructure and enable savings in material use and embodied carbon. Keeping loads to a minimum is absolutely key to efficient design, which will result in an overall less carbon intensive solution.

Two solutions have been considered in tandem for the purpose of this planning submission, a MetFrame light-weight steel framed structure and a full timber framed solution. Both options save carbon compared to more traditional concrete-framed, steel-framed, or load-bearing masonry structures and both enable a greater quantity of insulation within the external wall build-up. Whilst timber is considered by many to sequester carbon for the life of the building, it is also renders the building more difficult to insure, hence the consideration of both lower-carbon alternatives at this stage and their incorporation within the wider designs.

The loads generated by the super structures will be transferred back to the ground via the upper ground floor structure described in 3.3 above. The details of the MetFrame and timber frame structures are outside the scope of this document, however their use is key to the overall building solution as they are extremely light weight which will reduce the amount of supporting structure required both above and below ground compared to the traditional options. Furthermore, by greatly reducing internal wall and floor loads a slightly heavier brick façade becomes feasible.

As part of the current proposals a new sub station is required. The location of this at the front of the building has been carefully considered and structure incorporated to suit operational considerations. In a similar fashion the roof top plant area has been positioned to reduce the impact on the structure as far as possible.

3.5 LATERAL STABILITY

The lateral stability of the building is expected to be achieved through reinforced concrete stair and lift cores, as well as the rear retaining wall, which form stiff elements.

The exact details of this are beyond the scope of this study, which has been focussed on the vertical loading.

3.6 ROBUSTNESS AND DISPROPORTIONATE COLLAPSE

The building will fall under Class 2B as it is a mixed-use residential building greater than 4 storeys and will therefore require horizontal and vertical ties. The transfer structure will also need to act as a ‘key element’ under accidental load conditions. Development of these principles is beyond the scope of this report.

4.0 DESIGN STANDARDS AND REFERENCES

The following codes and references were used in the structural design:

Reference	Title
BS EN 1990:2002 + NA	Basis of Structural Design
BS EN 1991-1-1:2002 + NA	Eurocode 1: Actions on Structures. General actions. Densities, self-weight, imposed loads for buildings
BS EN 1991-1-4:2005 + NA	Eurocode 1: Actions on Structures. Wind actions
BS EN 1991-1-7:2006 + A1:2014	Eurocode 1: Actions on Structures. Accidental actions
BS EN 1992-1-1:2004	Eurocode 2: Design of Concrete Structures. General rules,
BS EN 1992-1-2:2004	Eurocode 2: Design of Concrete Structures. Structural Fire Design
BS EN 1993-1-1:2004 + NA	Eurocode 3: Design of steel structures. General rules and rules for buildings
BS EN 1997-1-1:2006 + NA	Eurocode 7: Geotechnical Design
BS 8500-1:2006 + A1:2012	Concrete – Complementary British Standard to BS EN 206

5.0 LOADING

This section describes the loading criteria used in the design of the various structural elements.

5.1 DESIGN PROCEDURE

Dead loads should generally be kept to a minimum and any unnecessary blockwork avoided due to both its weight and also because it's a brittle material with more onerous deflection criteria. It is assumed that the upper floors will be constructed entirely in lightweight cold formed steel.

A summary of the dead load allowances for typical floors are shown below:

GROUND FLOOR	LOADING (kN/m2)
Slab self-weight	Depth x 25
Floor finishes	1.00
Screed (75mm)	1.50
Insulation/Services	0.50
TOTAL	**3.00 + self-weight**

FIRST FLOOR	LOADING (kN/m2)
300 RC Transfer	7.50
Floor finishes	1.00
Screed (75mm)	1.50
Insulation/Services	0.50
TOTAL	**10.50**

TYPICAL FLOOR	LOADING (kN/m2)
150 Composite deck	3.00
Floor finishes	1.00
Screed (75mm)	1.50
Insulation/Services	0.50
TOTAL	**6.00**

5.2 FLOOR LOADING – LIVE LOADS

Live loads have been assessed in accordance with Tables NA.2 and NA.3 of the National Annex of BS EN 1991-1-1:2002. Live load reduction has not been used. A summary of the live load allowances for typical floors are shown below:

USAGE	LOADING (kN/m2)
Ground Floor Retail /School Reception	5.0
Residential Room	3.0 (including internal partitions)
Common Corridors	4.0
Balconies	2.0
Roof	1.5 (maintenance access)

5.3 CLADDING LOADS

Cladding loads have been broken down as follows:

TYPICAL PERIMETER CLADDING	LOAD (kN/m2)	LOAD (kN/m FOR 4m PANEL)
Brickwork (external leaf)	2.15	8.60
Metsec (internal leaf)	0.20	0.80
12.5m plasterboard	0.15	0.60
Insulation	0.05	0.20
TOTAL	**2.55**	**10.20**

6.0 PERFORMANCE CRITERIA

6.1 BUILDING LIFE

All elements of the structure will be designed for a life of 50 years.

6.2 DURABILITY

Concrete mixes and cover will be provided to protect the reinforcement against corrosion according to the exposure conditions defined in BS 8500 Pt1.

CONDITION	EXPOSURE
Internal slabs	XC1
Concrete balconies, roofs and external terraces	XC3
Foundations & structures in contact with ground	AC1s or DS-2
Foundation piles	AC1s or DS-2

6.3 FIRE RESISTANCE

Fire rating is to be confirmed by the fire engineer but the assumptions for various spaces are shown in the following table.

CONDITION	FIRE RATING (MINUTES)
General	90
Lift shaft	90
Stair cores	90
Service risers	90

Fire protection to steelwork is provided either by intumescent paint or fire cladding to Architect's details.

6.4 DEFLECTION

The deflection of the structure has been limited as below:

ELEMENT	CRITERIA
Total vertical deflection of concrete floors and beams under serviceability criteria	Lesser of span/250 or 40mm
Vertical post installation deflection of concrete floors and beams after installation of finishes	Lesser of span/500 or 20mm
Lateral sway under serviceability wind loads	Height/500

The deflection of the cantilever transfer structure is subject to more detailed analysis, as indicated within the report.

7.0 SUSTAINABILITY

7.1 SUSTAINABILITY

The project described above involves a relatively complex structural solution that has been coordinated carefully with the architecture and M&E requirements whilst complying with all regulatory requirements.

One of the most important aspects for designing sustainably is to optimise structural systems and reduce the embodied carbon in the structure. Optimising for embodied and operational carbon requires fundamental choices such as column positions, structural depths, and services integration strategies to be focused on reducing carbon.

New material types with lower embodied carbon credentials are become increasingly available from the supply chain and will be considered where possible for this project.

Embodied carbon has a direct relationship with self-weight. Lightweight structures such as full timber, timber hybrid, and light gauge composite construction types are prioritised to minimise the loads supported by structures such as transfer floors and foundations. Advanced dynamic analysis methods can be used to allow greater refinement of lightweight structures and whilst ensuring occupancy comfort is delivered.

We will be using finite element design models to analyse the lower and upper ground floor structures to provide a lean structural solution. Our software identifies embodied carbon values for each structural element, allowing fast and frequent optimisation of the design. Areas of significant embodied carbon are focused on and minimised.

We have adopted an efficient steel frae solution to support the upper ground floor transfer structure. However, the piles, raft slab and concrete walls will require reinforced concrete to be utilised. The concrete mixes adopted can be developed using different combinations of cement and aggregates to suit specific design criteria and by reducing cement content and increasing the amount of fly ash or ground granulated blast furnace slag will greatly reduce the amount of embedded carbon. See table below.

Concrete	Concrete type (slump class)	ECO_2 ($kgCO_2/m^3$)		
		CEM I concrete	30% fly ash concrete	50% GGBS concrete
Blinding, mass fill, strip footings, mass foundations	GEN1 (S2)	165	120	95
Reinforced foundations	RC25/30 (S")**	295	245	190
Ground floors	RC28/35 (S2)*	295	245	175
Structural: insitu	RC32/40 (S2)**	345	295	220
Higher strength concrete	RC40/50 (S2)**	405	330	255
*includes 30 kg/m^3 steel reinforcement **includes 100 kg/m^3 steel reinforcement				

8.0 SUMMARY AND FURTHER WORKS

This report outlines the design intent for a proposed structural steel solution for a 6-storey mixed-use residential and educational(school) structure. The building is located partially overactive London Underground and Thames Water assets and as such it is proposed to cantilever up to 6.5m over the existing structures so as to avoid any additional surcharge.

The proposed cantilever structure consists of regularly spaces steel frames, which are relatively lightweight and also allow for open and flexible use of the ground floor space. The steel bracing elements have been integrated as significant design features with the school and retail units. In addition, being a more lightweight and carbon friendly solution, it is inherently more sustainable.

Based upon the analysis completed, a steel option is considered to be structurally feasible and the optimal solution for occupational flexibility.

8.1 FURTHER WORKS

In order to progress these works further, there are a number of next steps and investigation works to undertake. The key points are summarised below:

- Further design coordination
- Additional on-site investigation works, to include:
  - Further soil and geotechnical investigation to determine site geology and allow progression of pile design and advanced movement assessment
  - Trial pits to determine the extent and nature of the existing retaining wall and its footing
  - Trial pits and measured survey to determine exact location of the Thames Water sewer and London Underground tunnel, with agreement from the relevant parties
- Coordination with LUL and other third parties in order to obtain technical approval for works and confirm assumptions regarding constraints
- Liaison with Thames Water regarding build over agreements
- Detailed ground movement assessment by specialist geotechnical engineers to assess impact on the tunnels.
- Development of an outline temporary works, construction strategy and method statements by a contractor familiar with such works.

It is worth noting that the project is currently at pre-planning and so a staged approach to these works is likely required in view of the projects current progress.

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