# 2.6 KEY STRUCTURAL PRINCIPLES

- Design Criteria report by Structural Engineers

# HOLLOWAY HEAD BIRMINGHAM

# STRUCTURAL ENGINEERING DESIGN CRITERIA REPORT

## CWA-17-181

| | |
|---|---|
| **Revision:** | **P01** |
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| **Signed:** | |
| **Dated:** | **04/11/2022** |

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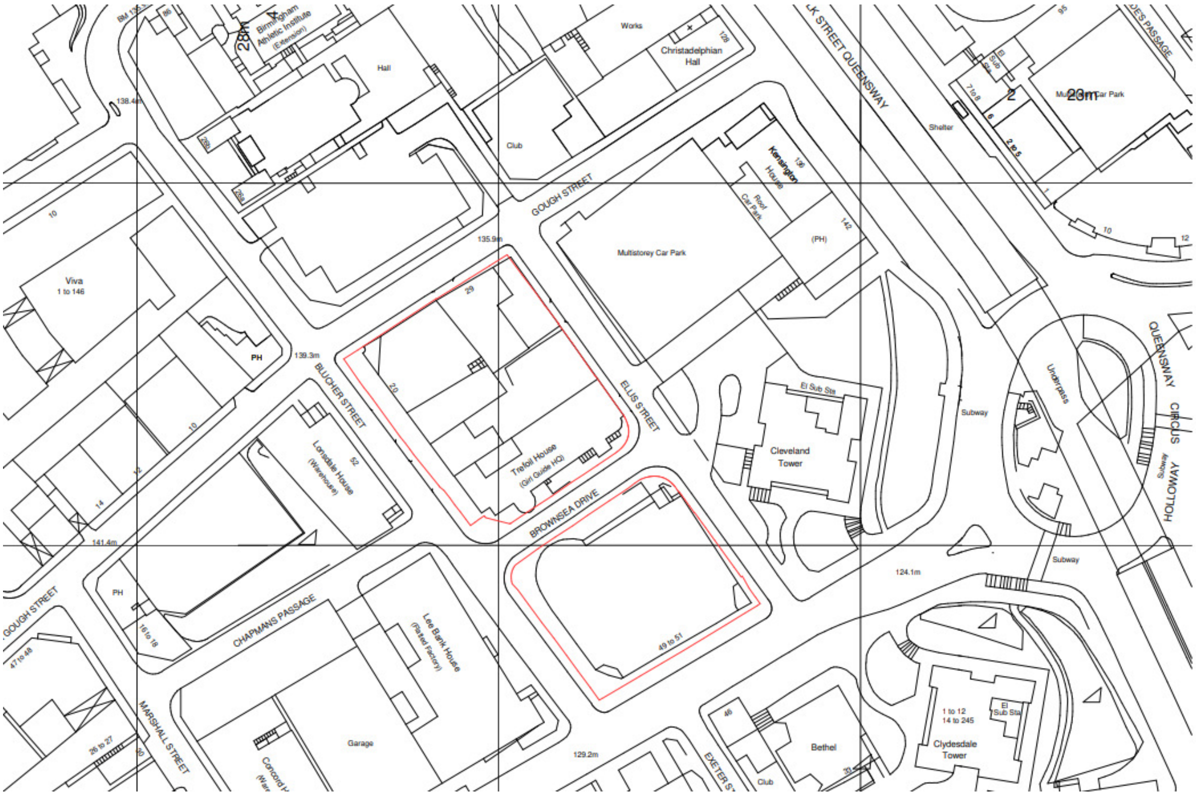
# 1.0 INTRODUCTION

## 1.1 PROJECT DESCRIPTION

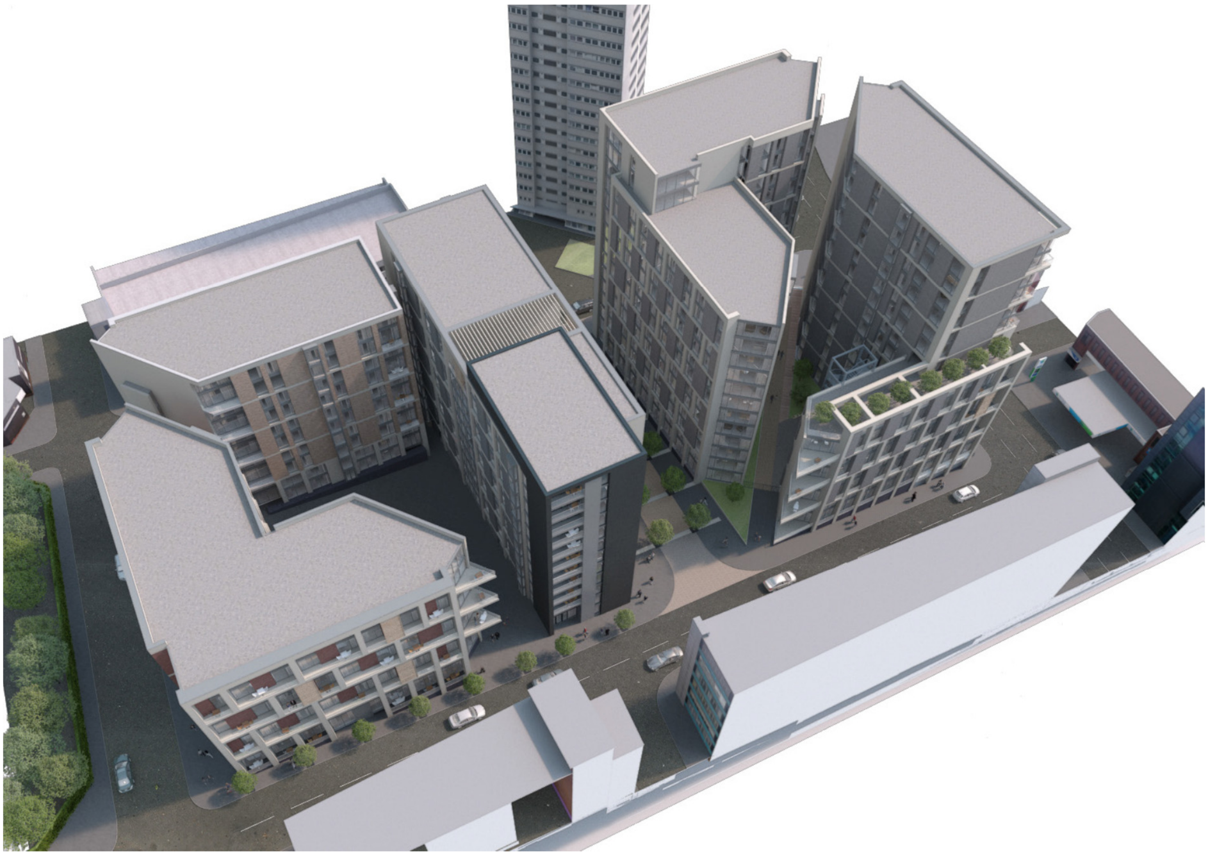
A site in Birmingham is proposed to be developed into residential accommodation comprising four blocks varying in height from 8 to 16 stories. The development includes car parking facilities, commercial/retail space and a new HQ for the girl guides. See Figure 1 below showing the proposed site plan.

**Figure 1 – Proposed Site Plan (Source: Corstophine + Wright Architects)**




The site is split into two separate areas, consisting of two blocks each. Blocks A and B are located at the North end of the site and Blocks C and D are located to the South. See Figure 2 below showing a visualisation of the scheme

**Figure 2 - 3D Visualisation looking East (Source: Corstophine + Wright Architects)**



CWA have been appointed by Winvic Construction Ltd to provide Civil and Structural consultancy services for the proposed redevelopment.

## 1.2 PURPOSE OF THIS REPORT

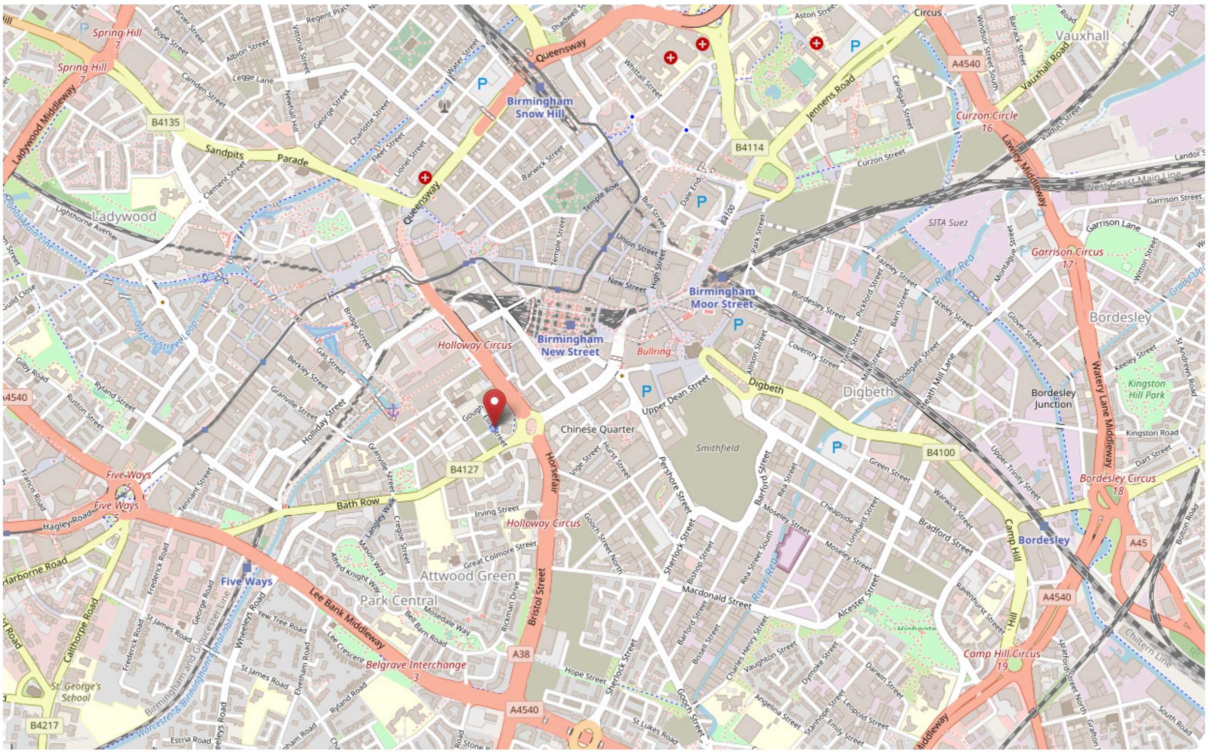
This report is intended to identify the basis of design that will be adopted for the structural design of the new buildings and the key design criteria that will be used. The engineering designs presented herein have been developed in liaison with the Architect and MEP consultant.

# 2.0 BACKGROUND INFORMATION

## 2.1 EXISTING SITE

The site is located in Birmingham adjacent to Holloway Head approximately 500m southwest of the city centre. The site is bordered by Ellis Street to the East, Gough Street to the North, Blucher Street to the West, Holloway Head to the South and Brownsea drive divides the site into two. The Ordnance Survey grid reference for the site is SP067863.

**Figure 3 – Site Location (Source: openstreetmap.org)**



## 2.2 EXISTING BUILDINGS

The North site contains two existing buildings, Trefoil House to the south which is currently occupied by the Girl Guides and a brickwork shed to the North which appears to be unoccupied. It is understood a third building once stood in an area of hardstanding currently being used a car park. All buildings are proposed to be demolished to make way for residential blocks A and B. The South site has been cleared although it is understood it was previously occupied by a building that was demolished in circa 2015. Refer to Figures 4-6 below showing the existing buildings on the site.

**Figure 4 – Existing Buildings (Source: Google Maps)**

**Figure 5 - Trefoil House on North Site (Source: Google Maps)**

**Figure 6 - Demolished Building on South Site (Source: Google Maps)**

## 2.3 SITE HISTORY

The earliest records dating back to 1890 show the site was occupied mainly by residential buildings and an infant school. In 1951, records show that some of the residential buildings had been replaced by larger buildings. A ruin was present at the centre of the site with other ruined buildings surrounding the site (probable WWII damage). Records between 1960-1979 show extensive redevelopment had taken place on the site and surrounding area. All buildings on the site had been demolished with new structures in their place. Brownsea Drive had been constructed dividing the site into two. The North site contained six medium sized buildings and the South site contained one large building. At present day the large building to the south has been demolished (as described above) and several of the medium sized buildings on the North site have also been demolished.

## 2.4 TOPOGRAPHY

The site has a significant cross fall, falling approximately 13m from Northwest to Southeast. The highest point of the Northern site is 139m AOD falling to 130m AOD (9m cross fall). The highest point of the Southern site is 133m AOD falling to 126m AOD (6m cross fall).

## 2.5 SITE CONSTRAINTS

Both sites are surrounded by Birmingham City Council owned footpath and highways which contain a large amount of buried services. Within the site boundaries, there are no significant constraints. The south site has already been cleared including all buried services. The North site is still operational and as such there are a number of buried services serving the buildings and car park. The site will be cleared including capping and removal of all services, and demolition of the existing buildings and their foundations. As such, the main constraints for the site can be summarised as;

- The site boundary and buried services in the adjacent BCC footpath and highway.
- The sloping nature of the site and maintaining existing levels

## 2.6 GEOTECHNICAL INFORMATION

A phase II ground investigation was carried out by Applied Geology in 2018. The investigations included rotary cored and continuous sampling boreholes along with machine excavated trial pits. A summary of the geotechnical information is given below however for further details refer to the Ground Investigation Report (report ref AG2759-17-AD40).

### 2.06.1 Anticipated Geology

A summary of the anticipated geology based on the ground investigation is presented in Table 1 below.

**Table 1 – Summary of Anticipated Geology**

| Stratum | Depth (m) BGL | Description |
|---|---|---|
| Made Ground | 0 - 5.5 | Generally comprised sand and gravel mixtures containing demolition rubble (concrete, asphalt, brick, glass, plastic, timber and metal) and occasional industrial by products (ash and clinker) together with quartzite gravel. All trial pits terminated on obstructions (brick/concrete floors) |
| Helsby Sandstone Formation | 4.0 – 19+ | Generally comprised extremely weak to very weak reddish brown slightly micaceous sandstone interbedded with extremely weak sandy mudstone. At depth the strata generally comprised more homogenous and massive fine to medium micaceous sandstone that was generally more competent. |

### 2.06.2 Groundwater

No groundwater was recorded during excavation of the trial pits or during formation of the boreholes. Subsequent groundwater monitoring results showed groundwater was present in the boreholes at a depth between 11 – 13m below ground level. Water levels varied with the ground level 122m AOD in the northwest and 114m in the southeast.

### 2.06.3 Ground gas

Six phases of ground gas monitoring were carried out. The site was considered to be characterised as situation 1 (CS1 to CIRIA C665) and as such no ground gas protection measures are considered necessary.

### 2.06.4 Risk of Contamination

The made ground contained some ash and clinker fragments. However, there was no obvious visual or olfactory evidence of any petroleum hydrocarbons or other significant contamination observed in the exploratory holes. The risk assessment indicated that the made ground in some parts of the site may pose a risk to human health receptors due to some outlying results. Since the majority of the site will be excavated by several meters to construct the proposed buildings basement and foundations, the risk to human health was considered negligible. There was also considered to be a low risk to controlled waters.

### 2.06.5 Foundation Design

Due to the height of the structure and the applied column loads, traditional foundations were not recommended. It was noted that small column loads could be supported on pad foundations bearing upon the sandstone with an allowable bearing capacity of 250kN/m$^2$.

Piled foundations taken down into the rock were recommended to support column loads. A contiguous piled wall was also recommended for the basement construction, although noting that specialist advice should be sought to determine the most appropriate solution.

### 2.06.6 Ground Floor Slabs

Based on the proposal for a basement it is anticipated that the made ground would be removed and that ground bearing basement floors can be constructed bearing on the Helsby Sandstone formation. Any exposed soft spots encountered following the excavation for the basement should be removed and replaced with suitable granular fill and proof rolled.

### 2.06.7 Buried Concrete

The Design Sulphate (DS) Class and the Aggressive Chemical Environment for Concrete (ACEC) was assessed for each strata and is summarised below.

**Table 2 – Buried Concrete Classification**

| Stratum | Soluble Sulphate (mg/l) | pH | Design Sulphate Class | ACEC | Design Chemical Class |
|---|---|---|---|---|---|
| Made Ground | 1900 | 7.9 | DS-3 | AC-2s | DC-2 |
| Helsby Sandstone Formation | 30 | 6.6 | DS-1 | AC-1 | DC-1 |

## 2.7 BURIED SERVICES

A utilities survey was undertaken at the site and was carried out by Midland Survey Ltd in November 2017 with updates in August 2020. The footpath and highway surrounding the site are heavily congested with existing services including electric, gas, water, comms and a combined sewer. Within the site boundary, the North site is still operational and as such there are a number of buried services serving the buildings and car park. It is understood the site will be cleared including capping and removal of all services. The south site is understood to have already been cleared. Refer to topographical and utilities survey drawing 30360 for details.

# 3.0 STRUCTURAL DESIGN PHILOSOPHY

## 3.1 SUPERSTRUCTURE

In evaluating suitable structural solutions CWA considered potential solutions against several design criteria including;

- Satisfying geometrical constraints including grid setting out and structural zones.
- Servicing strategy and integration (resulting floor to floor height).
- Flexibility for change in use or servicing strategy.
- Aesthetics, where exposed or featured.
- Speed of construction.
- Cost of materials.
- Sustainability including embodied carbon, thermal mass and BREEAM targets.

It should be noted that at this stage, only blocks C&D have been designed. Blocks A&B will be designed and constructed at a later date due to the phasing of the project. This basis of design report shall be updated once the scheme for blocks A&B has been sufficiently developed.

The structure is proposed to be of insitu reinforced concrete construction using blade columns and walls supporting insitu reinforced concrete flat slabs. A 3.6m x 3.6m grid was agreed with the Architect at the concept stage. This lends itself to a structural grid of 7.2m x 7.2m to suit ground floor parking and typical apartment layouts. However, due to the irregular shape of the building and the proposed internal layouts, a regular grid has not been maintained. Where possible, columns have been positioned to be outside of the internal space of the apartments, to be concealed within corridor and party walls. Spans have typically been limited to 7.2m where possible.

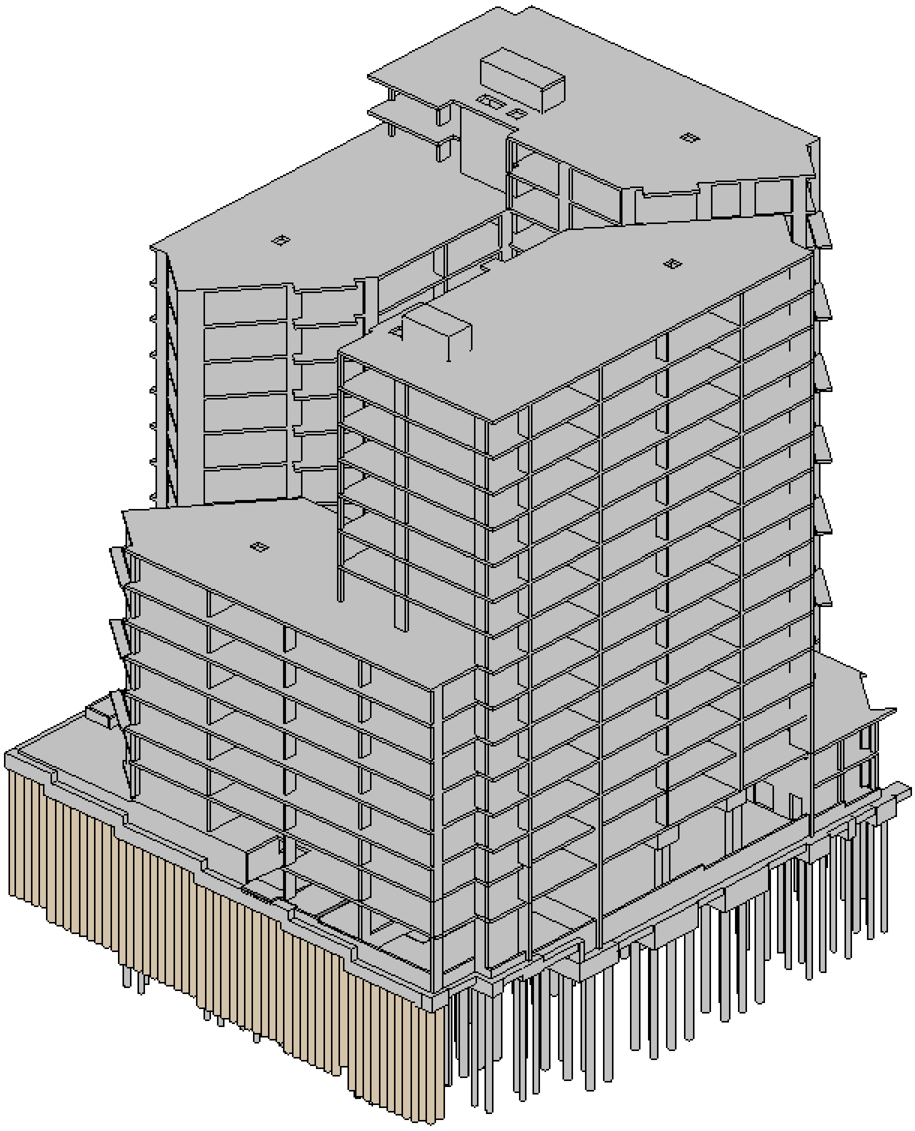
Columns sizes are typically rectangular in plan, either 250x1000mm or 300x1200mm.

Reinforced concrete walls are typically 250mm thick and all floor and roof slabs are 250mm thick.

Cladding consists of Stofix reconstituted stone panels supported by a carrier system attached to an inner leaf of SFS framing, both elements of which will be designed by a specialist sub-contractor.

See Figure 7 below showing the structural model for blocks C&D.

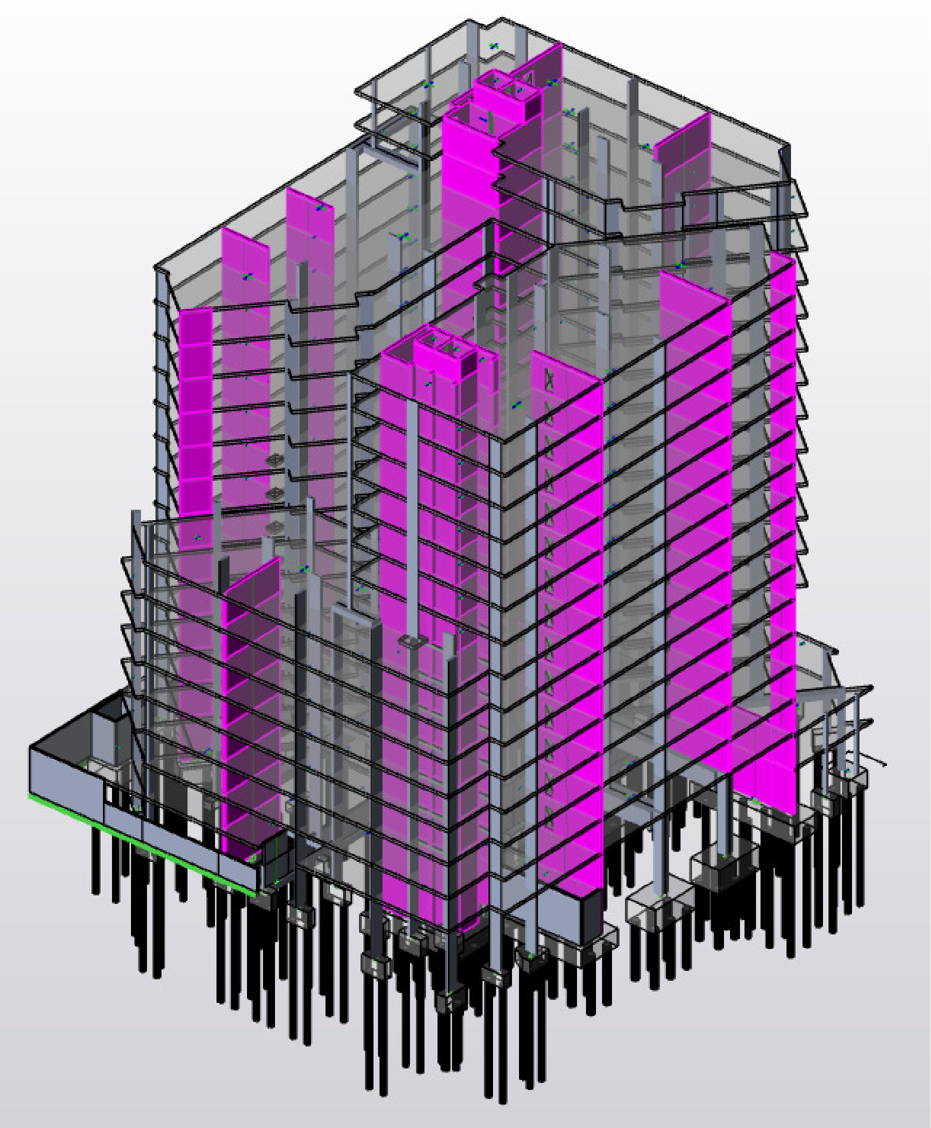
**Figure 7 – Blocks C&D Structural Revit Model (Source: CWA)**



### 3.01.1 Lateral Stability

Lateral stability shall be provided to the building by utilising reinforced concrete shear walls located within the lift and stair cores and elsewhere within the structure as required. Lateral forces applied to the structure, such as wind, shall be distributed to the walls by diaphragm action of the floor and roof slabs. Due to the height of the structure, blade columns have been utilised to provide frame action with the floor slabs in their stronger axis to further limit horizontal deflections. The use of moment transfer between columns and slabs is required to limit SLS deflections only. Shear walls shall be designed assuming there is no contribution from the column and slab interaction. Columns and slabs shall be designed for both ULS and SLS design forces from the moment transfer. See Figure 8 below showing the shear walls highlighted in the structural analysis model.

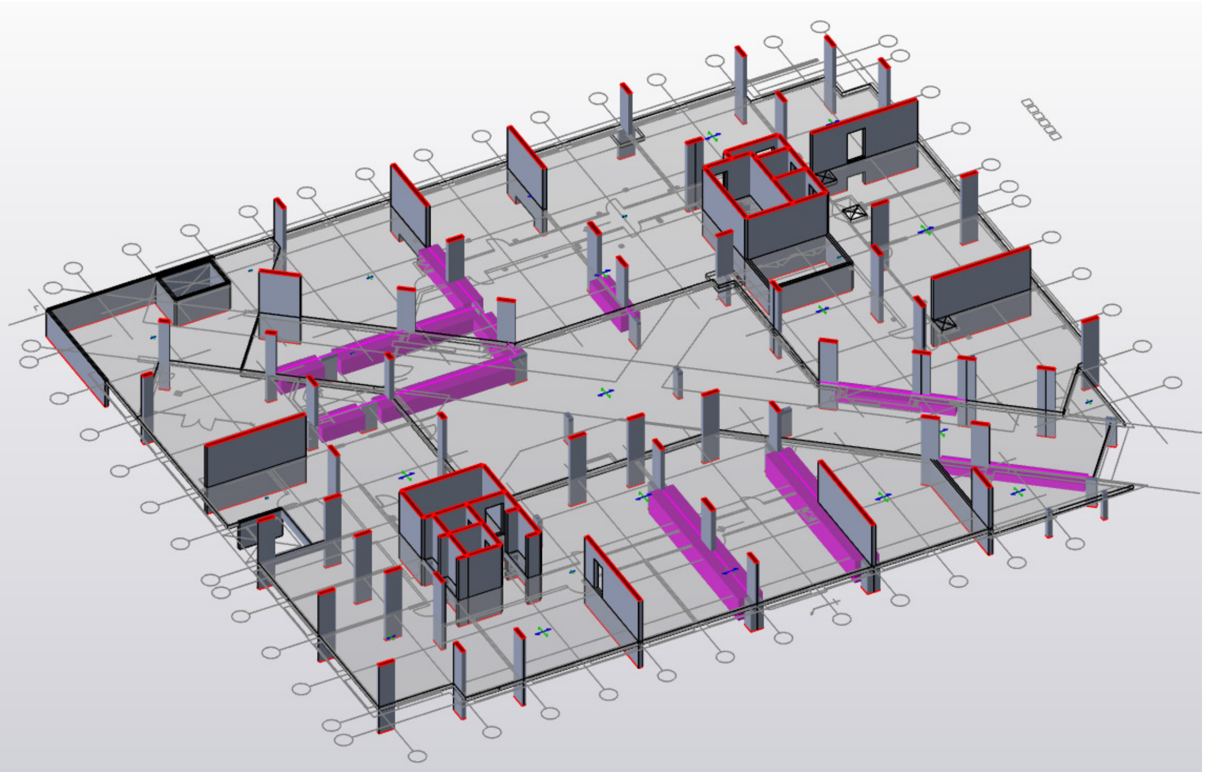
**Figure 8 – Location of Shear Walls in Structural Analysis Model**



### 3.01.2 Transfer Structures

The use of transfer structures has been limited where possible by coordinating layouts between floors. However, due to the change in use from residential accommodation to car parking below upper ground level, some transfer structures are required. The main hall to the girl guides space in block D is also required to be column free which requires additional transfer structures to support columns and walls above. At transfer locations, the column layouts have been developed to align columns in at least one direction to facilitate the use of reinforced insitu-concrete downstand beams. See Figure 7 below showing transfer beams at upper ground level.

**Figure 9 - Location of Transfer Beams in Structural Analysis Model at Upper Ground Level**



## 3.2 SUBSTRUCTURE

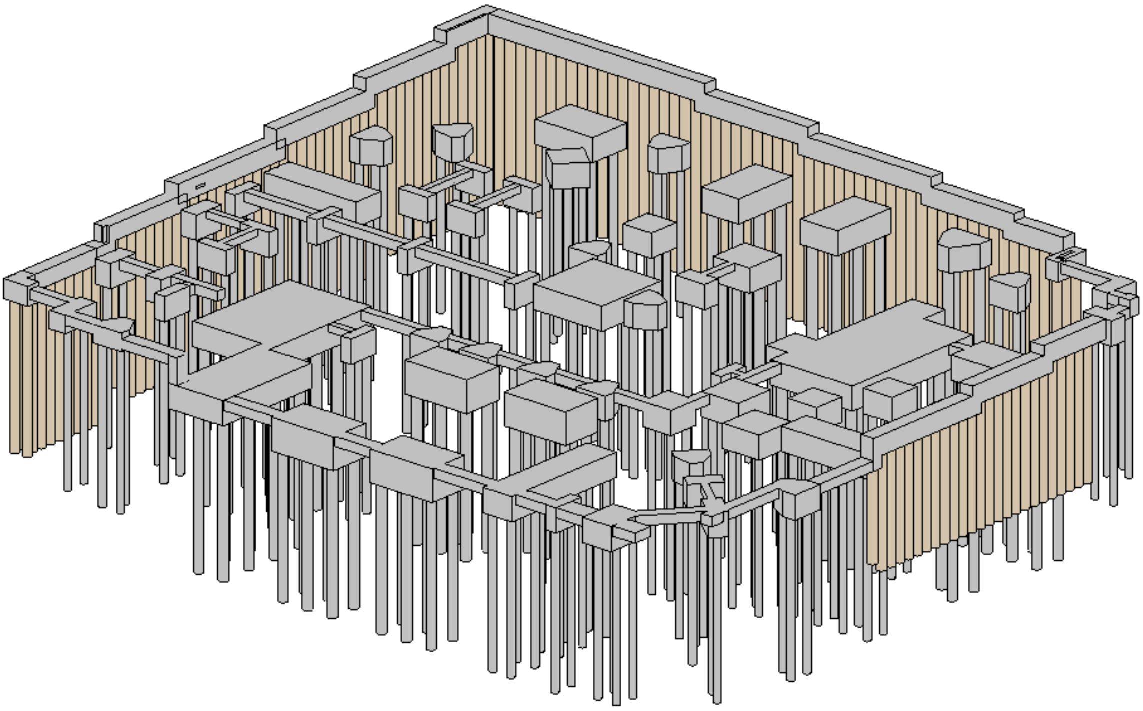
### 3.02.1 Foundation Strategy

Continuous Flight Auger (CFA) bearing piles taken into the Helsby Sandstone Formation are proposed throughout. A combination of 450mm and 600mm diameter piles are used with 450mm piles typically used at column locations and 600mm piles typically used at shear wall locations. The proposed pile lengths vary from 7m – 14m dependent on location and loading. Reinforced concrete pile caps are used to transfer loads from columns and walls to the piles. Pile caps are typically 1500mm deep.

### 3.02.2 Basement Strategy

A contiguous piled wall is proposed to form the basement around the perimeter of the site on 3 elevations. The piles are proposed to be 600mm in diameter and vary in length from 6m – 12m. The wall shall be designed to support the adjacent footpath and highway with a maximum retained height in its permanent condition of 4m. The wall will also be used to provide support to the footpath and highway in the temporary condition, during construction of the lower ground foundations and floor slabs. A reinforced concrete capping beam is proposed to tie the tops of the piles and provide support for the external walls. See Figure 10 below showing a 3D view of the proposed substructure.

**Figure 10 - 3D View of Substructure**



In order to waterproof the basement, a concrete lining wall is proposed to the inside face of the piles. The degree of waterproofing to the basement varies dependent on the environmental grading of the internal space in accordance with BS 8102:2009. The waterproofing strategy shall be developed by the Architect and the waterproofing consultant/specialist. It is understood that a combination of waterproof concrete (type B) and waterproof membrane (type A) are proposed.

### 3.02.3 Ground Floor Slabs

Ground bearing slabs have been proposed for all lower level floors. No ground gas protection measures are necessary and the water table is sufficiently low enough that no significant hydrostatic pressures shall be imposed upon the floor slabs.

### 3.02.4 Drainage

Both foul and storm water drainage relies upon a gravity system to remove flows from the building. Storm water is attenuated with a storage tank located in the mezzanine car park.

## 3.3 ANTICIPATED CONSTRUCTION SEQUENCE

The construction sequence shall be developed and agreed by the designer and the contractor during stage 5. A brief summary of the anticipated construction sequence is shown below based upon the design information to date.

1. Construct piling platforms and install contiguous piled retaining walls. Where required, install bearing piles from high level. Excavate down to pile cut off level to crop contig piles to required level, install waterproofing measures and construct reinforced concrete capping beam.

2. Excavate down to reduced levels in the basement. Install piling platforms for lower levels and install remainder of bearing piles. Excavate down to pile cut off level to crop piles to required level and install any waterproofing measures.

3. Construct reinforced concrete pile caps, ground beams and retaining walls. Install any waterproofing measures and backfill any excavations with agreement from the permanent and/or temporary works designer.

4. Install foul and surface water drainage manholes, pipes and attenuation tanks.

5. Construct reinforced concrete lift shaft and stair cores for block C and block D using slipform construction from foundation level up to roof level.

6. Construct all columns and walls from foundation level up to mezzanine level.

7. Construct lower ground level ground floor slabs.

8. Construct suspended flat slab at mezzanine level over lower ground level in Block C. Formwork to be propped from lower ground level (subject to temporary works design).

9. Construct all columns and walls from mezzanine level up to upper ground level.

10. Construct mezzanine level ground floor slabs.

11. Construct reinforced concrete downstand transfer beams at upper ground level. All transfer beams shall be suitably propped until the concrete has reached its full 28-day strength as a minimum, or as required for the construction of the upper floor slabs.

12. Construct suspended upper ground level slab in its entirety before proceeding to levels above. Formwork to be propped from mezzanine/lower ground level (subject to temporary works design) and back propped to lower ground level in block C.

13. Construct the remainder of the superstructure working sequentially level by level. It is anticipated that the slabs will need to be back propped by at least 3 levels (subject to temporary works design).

# 4.0 STRUCTURAL DESIGN CRITERIA

## 4.1 DESIGN STANDARDS

The new structures shall be designed in accordance with relevant British Standards and UK Building Regulations. This includes but are not limited to;

- BS 648: 1964 - Schedule of weights of building materials
- BS 5950: Part 1: 2000 - Structural Use of Steelwork In Building. Code of practice for design in simple and continuous construction: hot rolled sections.
- BS 6399: Part 1: 1996 - Code of practice for dead and imposed loads
- BS 6399: Part 2: 1997 - Code of practice for wind loads
- BS 6399: Part 3: 1988 - Code of practice for imposed roof loads
- BS 8002: 2015 - Code of Practice for Earth Retaining Structures
- BS 8004: 2015 - Code of Practice for Foundations
- BS 8110: Part 1:1997 - Structural Use of Concrete.
- BS 8500 Parts 1 and 2: 2019 - Concrete – Complementary British Standard to BS EN 206-1
- UK Building Regulations

## 4.2 DESIGN LIFE

The design life for the new structures shall be 50 years.

## 4.3 ROBUSTNESS

In some areas, the proposed new residential building exceeds 15 storeys in height for a class 2b structure, leading to a designation of Consequence Class 3 for Disproportionate Collapse in accordance with Table 11 of Approved Document A of the Building Regulations.

**Figure 11 - Building Consequence Classes**

| Consequence Classes | Building type and occupancy |
|---|---|
| 1 | Houses not exceeding 4 storeys |
| | Agricultural buildings |
| | Buildings into which people rarely go, provided no part of the building is closer to another building, or area where people do go, than a distance of 1.5 times the building height |
| 2a<br>Lower Risk Group | 5 storey single occupancy houses |
| | Hotels not exceeding 4 storeys |
| | Flats, apartments and other residential buildings not exceeding 4 storeys |
| | Offices not exceeding 4 storeys |
| | Industrial buildings not exceeding 3 storeys |
| | Retailing premises not exceeding 3 storeys of less than 2000m² floor area in each storey |
| | Single-storey educational buildings |
| | All buildings not exceeding 2 storeys to which members of the public are admitted and which contain floor areas not exceeding 2000m² at each storey |
| 2b<br>Upper Risk Group | Hotels, blocks of flats, apartments and other residential buildings greater than 4 storeys but not exceeding 15 storeys |
| | Educational buildings greater than 1 storey but not exceeding 15 storeys |
| | Retailing premises greater than 3 storeys but not exceeding 15 storeys |
| | Hospitals not exceeding 3 storeys |
| | Offices greater than 4 storeys but not exceeding 15 storeys |
| | All buildings to which members of the public are admitted which contain floor areas exceeding 2000m² but less than 5000m² at each storey |
| | Car parking not exceeding 6 storeys |
| 3 | All buildings defined above as Consequence Class 2a and 2b that exceed the limits on area and/or number of storeys |
| | Grandstands accommodating more than 5000 spectators |
| | Buildings containing hazardous substances and/or processes |

Notes:

To satisfy the requirements of disproportionate collapse in BS 8110, all load bearing elements in the concrete frame must be tied by providing horizontal and vertical ties to give an equivalent level of robustness in line with the requirements for a Class 2b building. To achieve this, the reinforcement will be well detailed to provide all the necessary internal and peripheral horizontal ties between columns and walls and also vertical ties through columns from the lowest to the highest level. As a minimum, this structure needs to be designed with all required ties to Class 2b which consist of:

- Peripheral Ties - At each floor and roof level a continuous tie running around the perimeter of the building to link all perimeter elements will be provided by the edge reinforcement in the top and bottom layer of the slabs that will pass through supporting columns and walls.
- Internal Ties - At each floor and roof level continuous ties in two directions at right angles to each other will be provided by top and bottom reinforcement in the slabs

and downstand beams which run into the peripheral ties with sufficient anchorage as required by good practice detailing.

- Horizontal Ties to Columns and Walls – External columns and walls require ties that are continuous with the internal ties and this will be provided by ensuring that all top and bottom reinforcement in the slab has the necessary laps and anchorages.
- Vertical Ties – All load bearing columns and walls require ties running from the lowest to the highest level and therefore all vertical reinforcement will run continuously from the starter bars extending from the raft foundation to the topmost floor or roof slab.
- Connection of Horizontal and Vertical Elements – The horizontal ties in the slabs should interact directly with the vertical elements and this will be achieved by a minimum of two bottom bars in each direction passing directly through the column or wall.

For Consequence Class 3 the requirements of the Building Regulations, clause 5.1e, state;

"*A systematic risk assessment of the building should be undertaken taking into account all the normal hazards that may reasonably be foreseen, together with any abnormal hazards. Critical situations for design should be selected that reflect the conditions that can reasonably be foreseen as possible during the life of the building. The structural form and concept and any protective measures should then be chosen and the detailed design of the structure and its elements undertaken in accordance with the recommendations given in the Standards given in paragraph 5.2.*"

To satisfy this, Appendix B contains a systematic review of the risks that the building could foreseeably be exposed during its lifetime and the measures that will mitigate each. In addition, all transfer structures and supporting columns shall be designed as key elements. An accidental load of 34kN/m$^2$ shall be applied to these elements.

## 4.4 LOAD REQUIREMENTS

### 4.04.1 Permanent Loads

Permanent loads shall be calculated for each individual element. The material weights used for calculation of permanent loads are outlined in the table below.

**Table 3 – Standard Weights of Materials**

| Material | Density (kN/m$^3$) |
|---|---|
| Steel | 78.5 |
| Reinforced concrete including normal percentage of reinforcing and pre-stressing steel | 25 |
| Blockwork | 16 |
| | |
| Brickwork | 22 |
| Glass | 25 |

### 4.04.2 Super-Imposed Permanent Loads

The structure shall be designed for the following superimposed loads

**Table 4 - Lower Ground Floor (Girl Guides)**

| Material | Load (kN/m$^2$) |
|---|---|
| Finishes | 1.00 |
| Screed | 2.40 |
| **Total** | **3.40** |

**Table 5 – Mezzanine (Apartment)**

| Material | Load (kN/m$^2$) |
|---|---|
| Finishes | 0.20 |
| Services | 0.10 |
| Suspended ceiling | 0.25 |
| **Total** | **0.55** |

**Table 6 - Mezzanine (WC & Showers)**

| Material | Load (kN/m$^2$) |
|---|---|
| Finishes | 1.00 |
| Services | 0.10 |
| Suspended ceiling | 0.25 |
| **Total** | **1.35** |

**Table 7 – Upper Ground (Courtyard)**

| Material | Load (kN/m$^2$) |
|---|---|
| Block paving (100mm) | 2.40 |
| Pedestals | 0.50 |
| Waterproofing | 0.50 |
| Services | 0.10 |
| **Total** | **3.50** |

**Table 8 - Upper Ground (Amenity)**

| Material | Load (kN/m$^2$) |
|---|---|
| Finishes | 1.00 |
| Services | 0.10 |
| Suspended ceiling | 0.25 |
| **Total** | **1.35** |

**Table 9 - Upper Ground (Apartments)**

| Material | Load (kN/m$^2$) |
|---|---|
| Finishes | 0.20 |
| Services | 0.10 |
| Suspended ceiling | 0.25 |
| **Total** | **0.55** |

**Table 10 – 1st to 13th (Apartments)**

| Material | Load (kN/m$^2$) |
|---|---|
| Finishes | 0.20 |
| Services | 0.10 |

| | |
|---|---|
| Suspended ceiling | 0.25 |
| **Total** | **0.55** |

**Table 11 – Brown Roof**

| Material | Load (kN/m²) |
|---|---|
| Brown roof 100mm thick | 1.80 |
| Roof filter fleece | 0.01 |
| Roof drainage and 40mm Storage Board | 0.05 |
| 100mm deep attenuation cell | 1.00 |
| Waterproofing and insulation | 0.15 |
| Green roof cap sheet | 0.10 |
| 2no underlayers | 0.10 |
| Services | 0.10 |
| Suspended ceiling | 0.25 |
| **Total** | **3.56** |

**Table 12 – Roof Terrace**

| Material | Load (kN/m²) |
|---|---|
| Paving or gravel | 2.20 |
| Waterproofing | 0.50 |
| Insulation | 0.10 |
| Services | 0.10 |
| Suspended ceiling | 0.25 |
| **Total** | **3.21** |

**Table 13 – Windows/Glazing**

| Material | Load (kN/m²) |
|---|---|
| Glazing | 1.00 |

**Table 14 – Brickwork Cladding**

| Material | Load (kN/m²) |
|---|---|
| Brick slips (25mm) | 0.55 |
| Backing board (20mm CP) | 0.15 |
| SFS | 0.20 |
| Insulation | 0.05 |
| Plaster + skim | 0.40 |
| **Total** | **1.35** |

**Table 15 – Rainscreen Cladding**

| Material | Load (kN/m²) |
|---|---|
| Rainscreen | 0.20 |
| SFS | 0.20 |
| Insulation | 0.05 |
| Plaster + skim | 0.40 |
| **Total** | **0.85** |

### 4.04.3 Imposed Loads

The following imposed loads shall be allowed for in accordance with BS 6399-1 and BS 6399-3.

**Table 16 – Imposed Load Requirements**

| Use | BS Category | Distributed Load (kN/m$^2$) | Partition Allowance (kN/m$^2$) | Point Load (kN) |
|---|---|---|---|---|
| Apartments | A | 1.5 | 1.0 | 1.4 |
| Offices for general use | B | 2.5 | 1.0 | 2.7 |
| Corridors, hallways, stairs, landings | C3 | 3.0 | - | 4.5 |
| Girl Guide Main Hall | C4 | 5.0 | - | 3.6 |
| Girl Guide Shop | D | 4.0 | 1.0 | 3.6 |
| Girl Guide Activity Rooms | C1 | 3.0 | 1.0 | 2.7 |
| Girl Guide WC | A | 2.0 | 1.0 | 1.8 |
| Car park | F | 2.5 | - | 9.0 |
| Communal working | B | 2.5 | 1.0 | 2.7 |
| External Courtyard | C3 | 3.0 | - | 4.5 |
| External Courtyard subject to vehicle access | G | 10.0 | - | 35.0 |
| Refuse store | E | 5.0 | - | 4.5 |
| Sprinkler tank room | E | 20.0* | - | 10.0* |
| Plant rooms | E | 7.5 | - | 4.5 |
| General Storage | E | 5.0 | - | 4.5 |
| Roof with access | - | 1.5 | - | 1.8 |
| Communal roof terrace | - | 3.0 | - | 4.5 |

*Sprinkler tank loadings TBC by MEP Engineer

### 4.04.4 Wind Loads

Wind loads shall be calculated in accordance with BS 6399-2.

**Table 17 - Site wind loading parameters**

| Parameter | Value | Units |
|---|---|---|
| Site Altitude | 140.0 | m |
| Basic wind speed | 22.0 | m/s |
| Seasonal factor | 1.0 | - |
| Probability factor | 1.0 | - |

### 4.04.5 Snow Loads

Snow loads shall be calculated in accordance with BS 6399-3.

**Table 18 - Site snow loading parameters**

| Parameter | Value | Units |
|---|---|---|
| Site Altitude | 140.0 | m |
| Basic snow load | 0.55 | kN/m$^2$ |
| Site snow load | 0.61 | kN/m$^2$ |

### 4.04.6 Accidental Loads

Columns and walls located within the car park shall be designed to resist impact loads from vehicle collision in accordance with BS 6399-1.

**Table 19 – Accidental loading parameters**

| Parameter | Value | Units | Comments |
|---|---|---|---|
| Vehicle collision | 150 | kN | Applied 375mm above FFL |
| Key elements | 34 | $kN/m^2$ | Limited to maximum area of 6m square |

### 4.04.7 Retaining Wall Surcharge Loads

The contiguous pile wall around the perimeter of the site has been designed with a surcharge load of $10kN/m^2$. Retaining walls within the building have been designed for a $10kN/m^2$ surcharge at slab formation level, reducing to the imposed loads given in Table 16 at slab level.

### 4.04.8 Load Combinations

The following load combinations shall be considered in the design in accordance with BS 8110. A breakdown of all combinations considered shall be provided in the relevant calculations.

**Table 20 – Load combinations to BS 8110**

| Load Combination | Load Type | | | | | |
|---|---|---|---|---|---|---|
| | Dead | | Imposed | | Wind | Accidental |
| | Adverse | Beneficial | Adverse | Beneficial | | |
| Dead and Imposed | 1.4 | 1.0 | 1.6 | 0 | - | - |
| Dead and wind | 1.4 | 1.0 | - | - | 1.4 | - |
| Dead and imposed and wind | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | - |
| Dead and imposed and accidental loads | 1.0 | 1.0 | 0.35 | 0 | - | 1.05 |

## 4.5 DEFLECTION LIMITS

Deflection limits for the structure are given below.

**Table 21 - Deflection Criteria**

| Element/Load Case | Serviceability Deflection Limit |
|---|---|
| Beams/Slabs – Vertical Deflection – Imposed Load Internal Spans | Span/360 or 20mm |
| Beams/Slabs – Vertical Deflection – Imposed Load Slab Edges | Span/500 or 20mm |
| Beams/Slabs – Vertical Deflection – Total Load | Span/250 |
| Cantilever Beams/Slabs – Vertical Deflection – Total Load | Span/180 |
| Column – Horizontal Deflection – Total Load | Height/300 |
| Horizontal Storey Drift | Height/500 |
| Transfer Beams – Vertical Deflection – Total Load | Span/500 |
| Transfer Beams – Vertical Deflection – Imposed Load | Span/1000 |

## 4.6 DEMOLITION

The main frame of the building is cast in-situ reinforced concrete, consisting of columns, walls and floor and roof slabs. The structure should be demolished 'top down', where no columns or walls are removed on the lower storeys until the superstructure above has been removed.

Depending upon the exact sequence of demolition, to be decided upon by a competent and qualified demolition engineer, it may be necessary to introduce temporary propping during the process.

## 4.7 RESIDUAL HAZARDS

Any proposed modification to the concrete frame should be discussed with a suitably qualified and experienced structural engineer to determine the potential effect on the structural integrity of the building.

Similarly, the introduction of any additional plant items or the change of usage within the building which would alter the imposed floor and roof loadings should also be referred to a suitably qualified and experienced structural engineer for checking.

Excavations near the building foundations and retaining walls are also to be discussed with a suitably qualified and experienced structural engineer.

Any proposed changes to the external finished levels are to be discussed with a suitably qualified and experienced civil engineer to determine the effect on drainage.

Manholes should not be entered for maintenance purposes by untrained personnel without the correct safety equipment to hand.

## 4.8 DELETERIOUS MATERIALS

No deleterious materials have been specified in the design of this project.