STRUCTURAL SUMMARY

Hayes Town Centre – Phase 1

Higgins Partnerships

September 2022

HTC-ISS-XX-XX-RP-S-7200

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IESIS STRUCTURES

REPORT ISSUE

Revision	Date	Notes
C01	27/09/2022	First Issue

PREPARED BY

Daniel Miller September 2022

REVIEWED BY

Alan Werrett September 2022

DISCLAIMER

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iesisSTRUCTURES

1 SUBSTRUCTURE

1.1 FOUNDATIONS

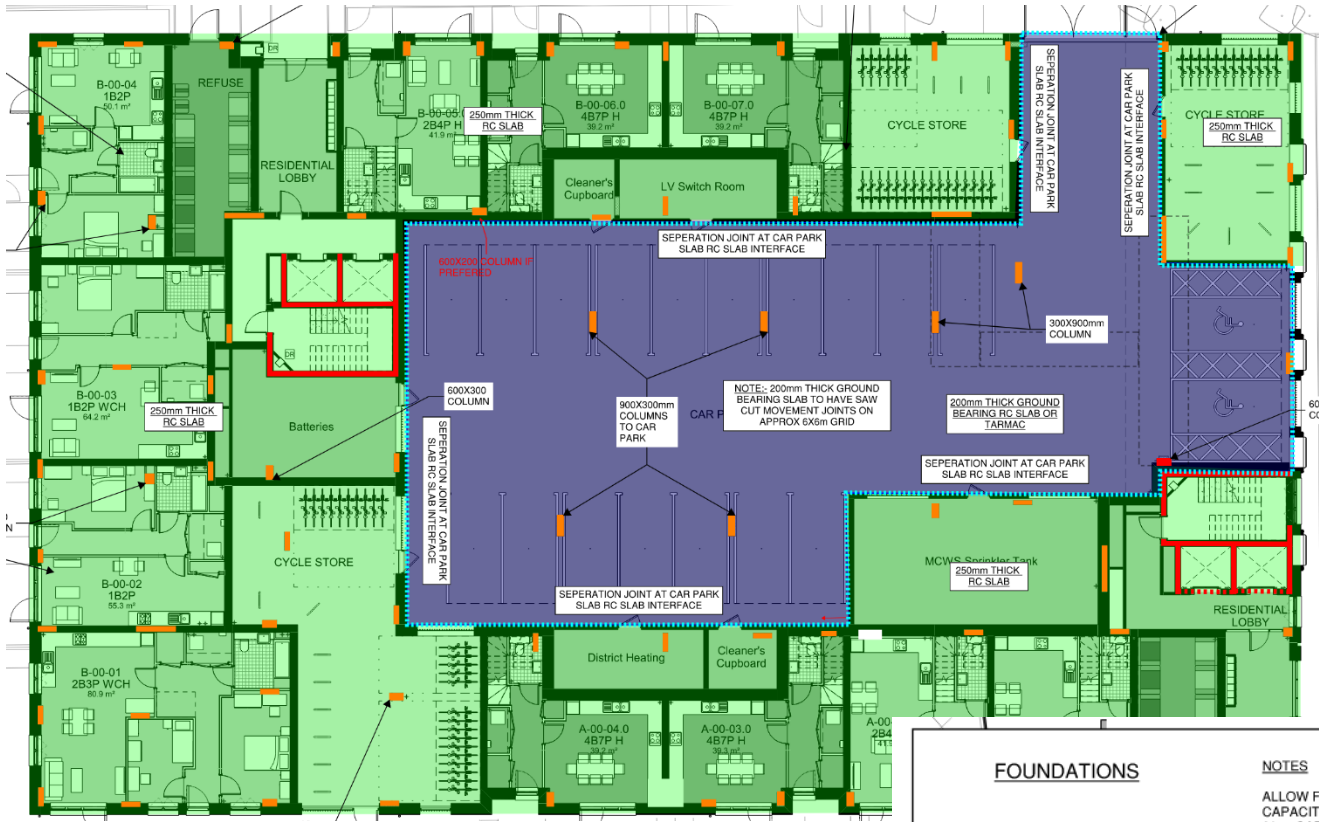
Due the size of the building it is likely that piled foundations will be the only suitable foundation solution and thus this is what is proposed.

There are a number of options for the piles including driven, precast or bored and each has it benefits and drawbacks. With the proximity of adjacent buildings and the specific ground conditions on this site it is proposed that bored CFA piles are used throughout.

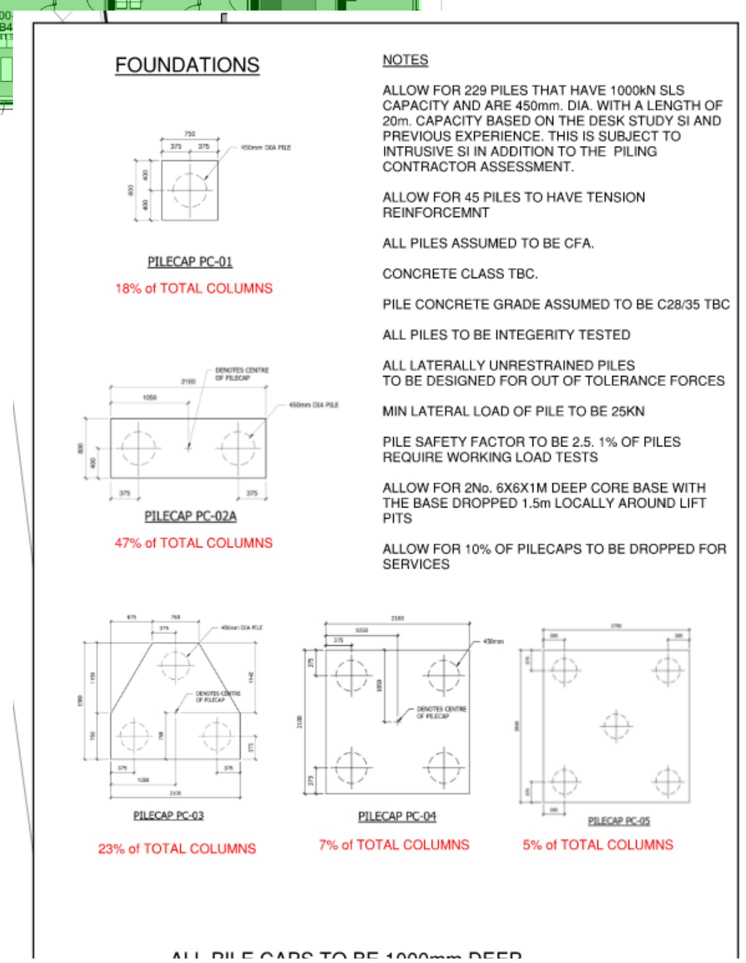
The CFA pile option has the advantage of being relatively quiet and vibration free in a built up area and will not require casing through loose soils and running water.

Piles are initially assumed as being 450mm diameter, although this will need to be confirmed following receipt of the final design by the piling contractor, and will be tied together with reinforced concrete pile caps that are to be minimum of 1000mm deep.

A preliminary review of the desk study site investigation combined with knowledge of ground conditions on sites within close proximity would suggest a safe working load capacity of 1000kN with working load pile testing. The foundations shown on the scheme sketches are based on this assumed capacity.



Extract of ground floor structural layout



Typical foundation details and notes

1.2 GROUND FLOOR CONSTRUCTION

1.2.1 COMMUNAL AND RESIDENTIAL

The structure supporting the proposed ground floor construction is in-situ concrete slab spanning between pile caps. The slab will act to tie the pile caps together, omitting the need for ground beams, and will support the external masonry loads. The slab is currently proposed as 250mm thick.

1.2.2 CAR PARK

The proposed car park floor is be constructed of in-situ concrete which is ground bearing. The slab is currently proposed as 200mm thick and is to have saw cut movement joints on a 6x6m grid.

2 SUPERSTRUCTURE

2.1 Frame Construction

The building varies in height and shape, ranging from 2 to 8 storey in height with a central courtyard podium at first floor level. There are a number of possible construction methods that could be used but the height and usage of the building suggest a concrete framed solution would be the most suitable.

The residential layouts largely dictate the column spacing which in turn sets the required slab depth. Based on the current layouts we have proposed a reinforced concrete flat slab scheme comprised of both 225mm and 250mm thick slabs on circa 6x6m and 7x7m column grids respectively.

Vertical loads are supported on reinforced concrete columns concealed within walls where possible. Columns will be rotated and may change shape between floors as required by the architectural proposals.

Internal walls and the internal leaf of perimeter walls will generally be of lightweight construction. The external facades will be a combination of masonry and cladding elements supported on the slab edges.

Minor transfers in column alignment are required where layouts do not stack or the elevations step in, these have been dealt with through walking or offset columns.

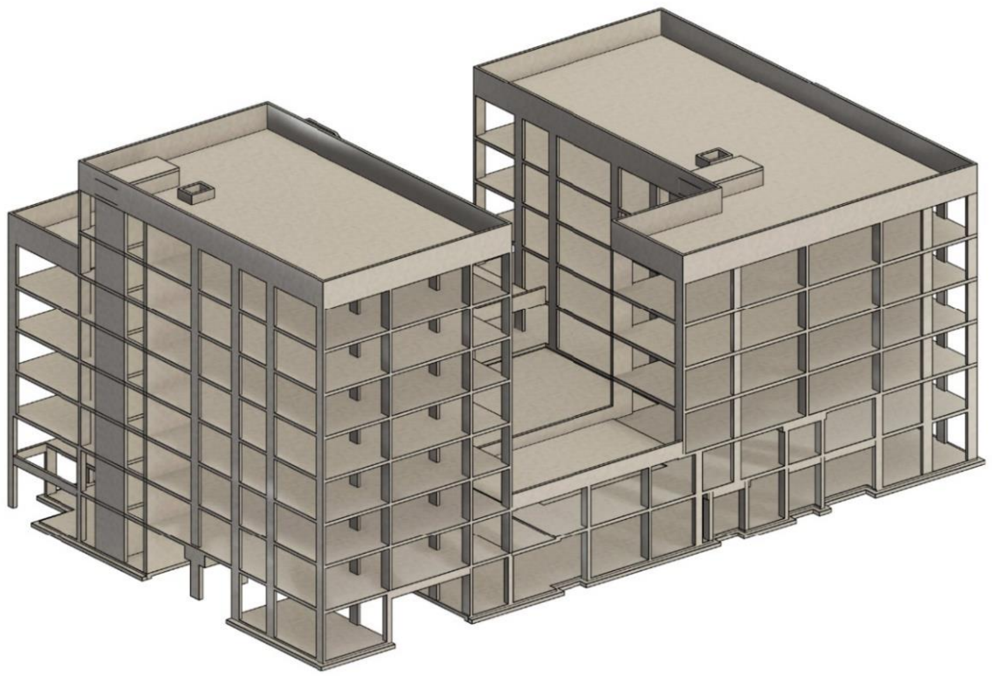
Where a major adjustment to the column grid is required reinforced concrete transfer beams have been provided. Transfer beams are located at first floor level where the residential units are situated above the car park and to the perimeter of the building where balcony doors are situated below masonry piers at first and second floor level.

Stair and lifts core walls are to be formed from in-situ concrete which is 200mm thick.

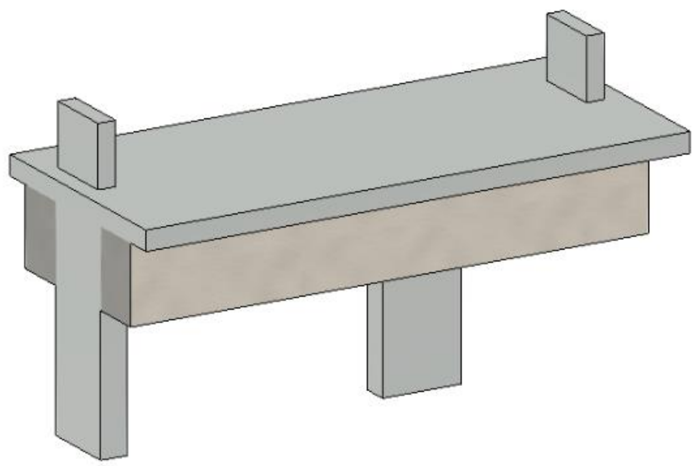
The main advantages of RC frame and flat slabs for this project are the flexibility available with column spacing and locations allowing the creation of relatively large clear open spaces at the lower levels. The possible use of precast elements to speed the erection has also been considered and it is felt that systems such as twinwall and precast columns could be employed successfully.

The option of steel frame, with composite deck or precast units, was reviewed but the residential usage and non-uniform layouts made the steel layout very complicated and would have required significant build up to achieve the acoustic requirements.

The table later in this report details some of the options that were considered for the scheme and lists the advantage and disadvantages of each that led to the current proposals.



View of 3D Model



Transfer Beam at 1st floor level

2.2 STAIRS

It is currently proposed that stairs will be in-situ concrete with a soffit former such as the Stairmaster system

2.3 STABILITY

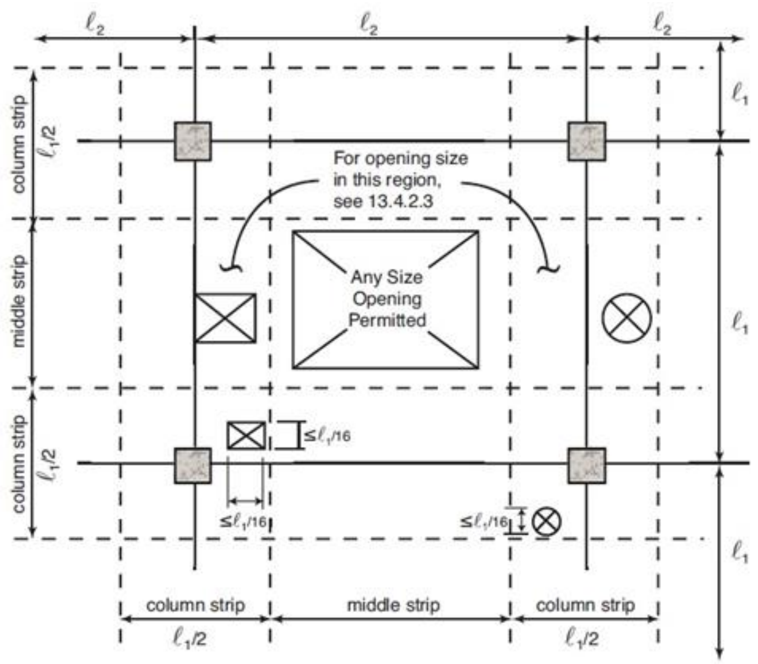
Lateral stability of the frame under wind and horizontal forces is provided through diaphragm action of the floor slabs transferring lateral loads from the cladding to the core walls and shear walls. These walls then transfer the loads to the foundation system. Wind loads have been assessed for the site and building and have been included within the preliminary design model.

2.4 SLAB OPENINGS

While RC flat slab construction allows a lot of flexibility in layout and openings there are some constraints that should be followed regarding the positioning of openings in the slab.

The diagram below shows the notional design strips for a standard bay and highlights some of limitations on opening sizes and locations. These limitations are to avoid excessive stresses and reinforcement at column head locations due to shear.

For post drilled openings the limitations are greater since the slab cannot be additionally reinforced to deal with the hole.



Punching shear diagram

2.5 FIRE PROTECTION

The RC elements will have an inherent fire period and this will in some cases dictate the size of elements. With the height of the building over 18m to highest accessible floor level and the usage of the building a fire period of 90 minutes is required for the structure (to Building Regulations part B). This has dictated certain element sizes to ensure this can be achieved, including a minimum column dimension of 200mm and a minimum slab depth of 200mm.

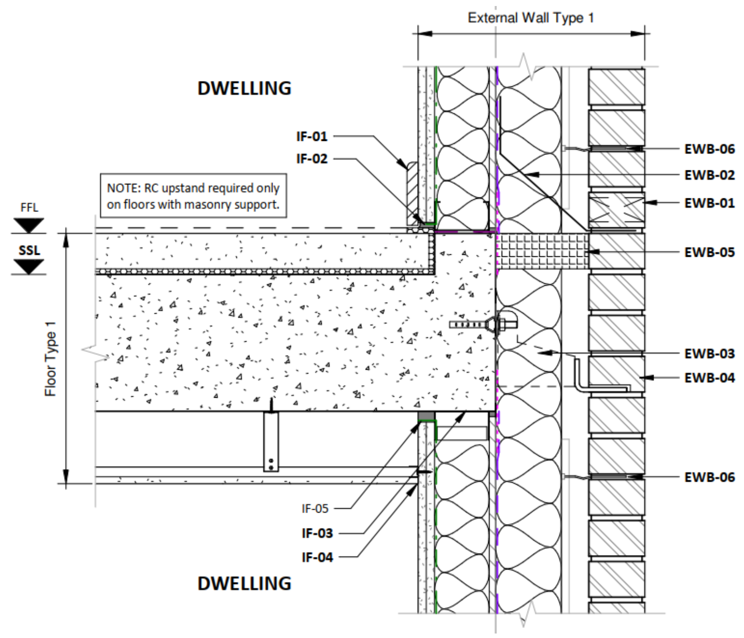
2.6 CLADDING

The cladding system for the building is in the form of masonry with a series of setbacks and steps across the extent of the façade.

Typically it is assumed that the inner leaf will be light gauge steel (LGS) studwork which will act as the main structural element to resist the wind loadings imposed on the building and transfer them back to the main structure. The external brickwork would then skin be supported at the ground level on the RC toe and then supported again at intermediate levels on a masonry support system utilizing a cast in channel in the slab edge.

Masonry over openings will be supported using standard single leaf lintels such as the Catnic ANG or CCS lintels. The inner leaf frame will not require lintels but areas of plant or storage with blockwork walls will have an internal single leaf lintel (either Catnic as above or precast concrete).

It should be noted that all cladding packages must be designed and detailed to accommodate the anticipated movements and tolerances as will be defined in this report.



Typical masonry support system

2.7 PRECAST OPTIONS

Consideration could be given to the use of precast concrete for columns to increase the speed of erection of the vertical elements. If these are to be considered it is more cost effective to limit the number of different column sizes so that there are economies of scale in the production costs.

Consideration could be given to the use of precast concrete for various elements of an in-situ concrete frame solution.

Core walls could be formed using twinwall construction, this is a walling system that combines the speed of erection and quality of precast concrete with the structural integrity of in-situ concrete. Prefabricated panels comprising two slabs separated and connected by cast-in lattice girders are placed, temporarily propped, and then joined by reinforcing and concreting the cavity on site.

The panels have a high quality finish, and can incorporate openings and cast in services. Twinwall will have inherent fire resistance and acoustic performance similar to that of cast in-situ RC but allows for increased rates of erection. Twinwall can be more expensive than the equivalent in-situ option and also has limitations on flexibility of form for complicated structural arrangements.

2.8 CORE FORMATION

It may be preferable to form the lift and stair core ahead of the rest of the building to allow the tower crane to be sited and to speed construction. If this approach is adopted the core will need to be tied together to allow construction. This could be done through the use of upstand or downstand beams across the corridor but these will need to be carefully considered and detailed to avoid impacting on services distribution in these areas.

2.9 BALCONIES

There are several options that can be considered for the balcony construction within the development with the principal options noted below along with their pros and cons. The preferred option on this project is steel with cast in spigots and thermal break.

Option	Advantages	Disadvantages
RC with thermal break	• Balconies completed with frame • No follow on steel erection required • Thermal break is very effective • Accuracy of construction is good • Greater flexibility of form	• Heavy construction • Greater depth for longer spans than steel • Greater reinforcement than insulated option
RC insulated	• No expensive thermal breaks required • Cost • Simplified reinforcement detailing • Greater flexibility of form	• Thicker build up depth of balcony than RC with thermal break due to insulation
Steel with cast in spigots and thermal break.	• No post drilling of concrete fixings • Spigot fixing is within the slab depth – no top plate • Cheaper than post fixed spigots	• Lead in required on spigots could affect frame construction
Steel with post fixed spigots	• Accuracy – spigots can be positioned and fixed accurately • Procurement should not affect the frame construction	• Additional fixing operation before cladding can be erected • Damage to slab edge and reinforcement from drilling • Top plate need to be accommodated within finishes • More expensive than cast in spigots

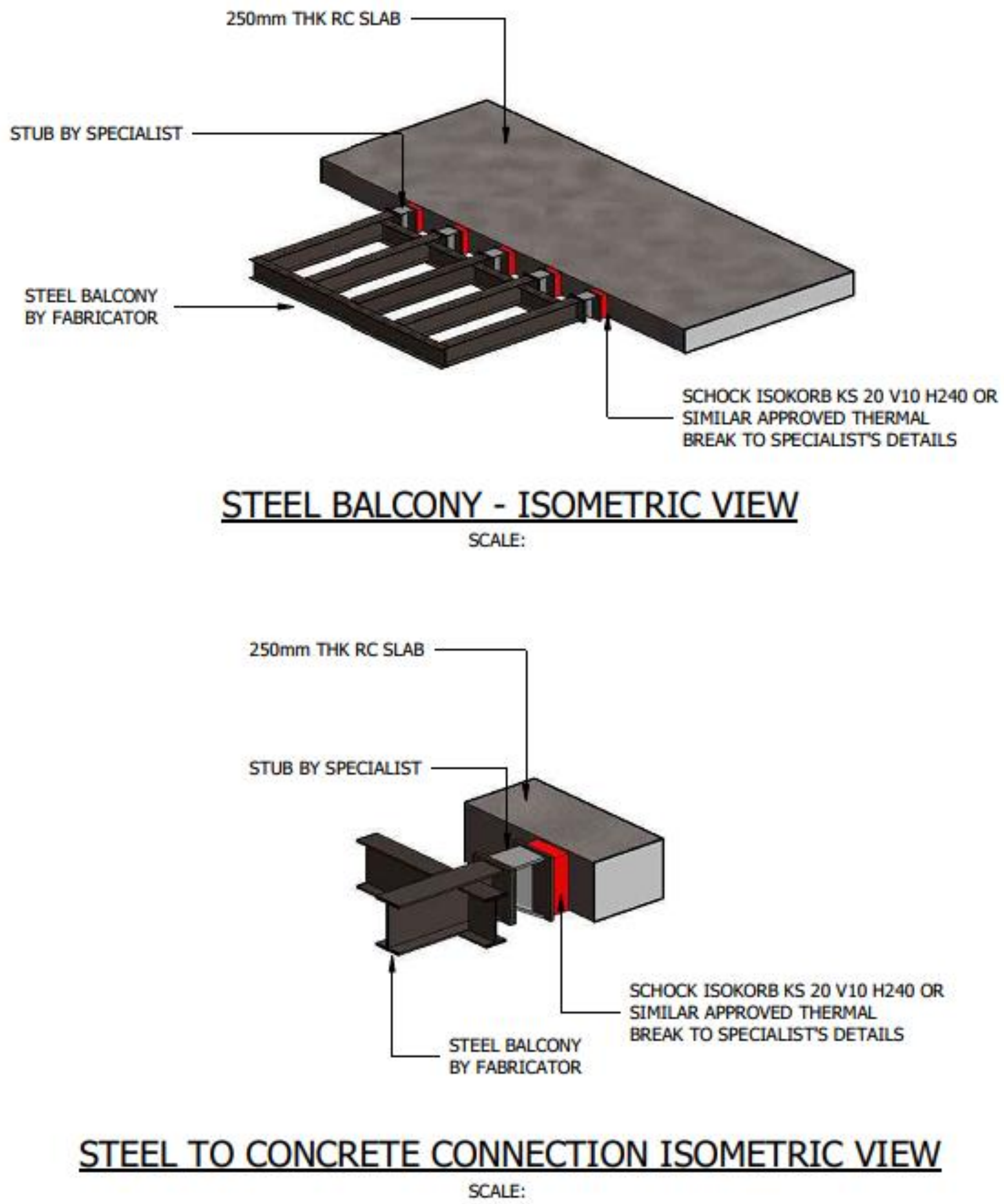
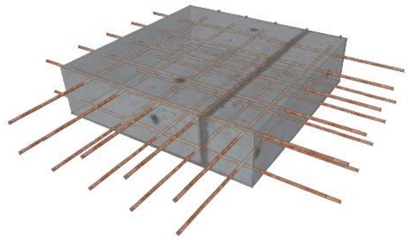
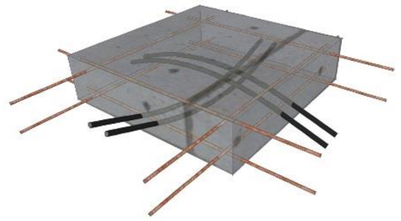
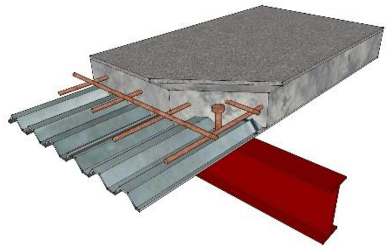
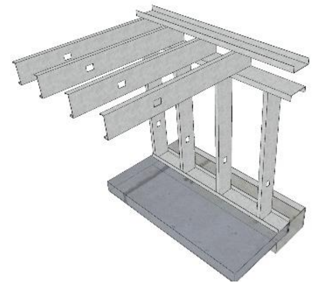


Figure 1 Typical Steel Balcony

2.10 SUMMARY OF CONSTRUCTION OPTIONS

	RC Flat Slabs	RC Post Tensioned Slabs	Steel Frame	LG Steel/Timber Frame
				
General	• Flat slabs and soffits provide clear services zones. • Flexible column and void locations. • Exposed soffit possible. • Precasting of elements possible. • Relatively simple shuttering. • Limited craneage required.	• Shallower lighter slab than RC (approximately 10-20%). • Flat slabs and soffits provide clear services zones. • Exposed soffits possible. • Flexible column and void locations. • Relatively simple shuttering. • Limited craneage required.	• Steel frame with either precast or in-situ composite floors. • Downstand beams interrupt service runs. • Relatively inflexible column positioning. • Heavy craneage required. • No temporary propping required.	• Frame by specialist. • Deeper floor plates than RC/PT options. • Wall locations fixed. • No temporary propping required. • Limited capacity for cantilevers.
Foundations	• Heavy construction. • Piled foundations typically required for more than 5-6 stories.	• Approximately 10-20% lighter than comparable RC.	• Lightweight construction, approximately 50% lighter than RC frame.	• Lightweight construction, approximately 60% lighter than RC frame.
Adaptability	• Able to accommodate late changes to the design. • Simple to post fix to structure after completion if required.	• Limited time period for accommodating changes. • Simple to post fix to structure except at tendon locations.	• Limited possibility to incorporate late changes. • Can be easily altered once complete. • Simple to post fix.	• Limited time period for accommodating changes to wall positions.
Acoustics	• Dense slab provides good acoustic properties.	• Dense slab provides good acoustic properties.	• Requires significant sound proofing for typical separating floors.	• Requires significant sound proofing for typical separating floors.
Fire	• Inherent fire protection to the frame.	• Inherent fire protection to the frame.	• Fire protection to beams and columns required.	• Fire protection required.
Programme	• Short lead time but longer on site than prefabricated options. • Use of precasting possible to reduce programme.	• Increased lead in time to RC frame. • Less rebar to fix and faster striking times than RC. • Use of precasting possible to reduce programme.	• Long lead in period. • Short erection period. • Longer site time required for fire protection and detailing.	• Long lead in period. • Short erection period. • Longer site time required for fire protection and detailing.
Environmental	• Recycled aggregates may be utilised. • Locally sourced concretes and aggregates may be specified. • High percentage of recycled steel used in rebar. • High thermal mass. • Concrete and rebar recyclable.	• Recycled aggregates may be utilised. • Locally sourced concretes and aggregates may be specified. • High percentage of recycled steel used in rebar. • High thermal mass. • Concrete and rebar recyclable.	• High percentage of recycled steel used in standard sections. • Limited thermal mass. • Major maintenance required every 15 to 20 years.	• High percentage of recycled steel used in standard sections. • Limited thermal mass.
Chosen scheme	✓	✗	✗	✗
Commentary	Preferred option due to flexibility and ease of construction.	A PT frame would allow for shallower slabs and less columns.	This option has been discounted on the basis of the required acoustic treatment and fire protection which would have significant cost and programme implications.	This option does not suit the various set backs and layout changes but could be assessed as an option for the top levels.

3 DESIGN CRITERIA

3.1 DESIGN CODES AND STANDARDS

In line with the current Building Regulations the structure will be designed in accordance with the Eurocodes. The principal codes are listed below.

Reference	Title
BS EN 1990	Eurocode 0: Basis of design
BS EN 1991	Eurocode 1: Actions on structures
BS EN 1992	Eurocode 2: Design of concrete structures
BS EN 1993	Eurocode 3: Design of steel structures
BS EN 1995	Eurocode 5: Design of timber structures
BS EN 1996	Eurocode 6: Design of masonry structures
BS EN 1997	Eurocode 7: Geotechnical design
NSCS	National Structural Concrete Specification 4th edition
NSSS	National Structural Steelwork Specification 6th edition

This list is a summary of the design codes and should be taken as including all the relevant sections and national annexes.

3.2 FIRE PERIOD

The top floor of the building is over 18m above ground which will dictate a 90 minute fire period in accordance with Part B2 of the Building Regulations. All elements of the primary structure will be designed to this.

3.3 DESIGN LIFE

The primary structure will be designed for a 60 year design life. Steelwork elements may require painting or maintenance during their life.

3.4 MATERIALS

The tables below list the typical materials on the project and any additional durability requirements.

Location	Mix	Additional
General	C32/40	XC-1 typically
Retaining walls	C32/40	Watertight concrete, DC class to suit ground conditions, XC-3
Roof slabs	C32/40	XC-3
Ground beams and foundations	C32/40	TBC
Columns	C50/60	XC-1 typically, XC-3 External columns

All reinforcement is to be high yield having characteristic strength of 500 N/mm2 conforming to BS4449. Precast elements to be designed and specified by specialist suppliers.

3.5 STEELWORK

Location	Grade	Consequence class	Execution class
General	S355	2b	EXC2

3.6 LOADING INFORMATION

The below tables detail the typical loadings to be applied to the frame and substructure. A detailed load assessment will be carried out as part of the design process.

Typical floors			
Permanent load (kN/m²)		**Variable loads (kN/m²)**	
Slab self-weight	Depth (m) x 25	Residential (A1)	1.5
Services and ceiling	0.3	Partitions	0.8
Screed and finishes	2.0		
Totals	**S.W. + 2.3**		**Varies**

Other Variable Loads			
Uniformly distributed loads (kN/m²)		**Concentrated loads (kN)**	
Communal areas	3.0	Communal areas	4.5
Balconies/terraces	2.5 (0.74 kN/m horizontal @1.1m above FFL)	Balconies/terraces	1.0/4.0
Plant rooms	7.5	Plant rooms	4.5
Roof with access	1.5	Storage	5.0
Podium Slab	5.0	Podium Slab	4.5

3.7 MOVEMENT AND DEFLECTIONS

3.7.1 VERTICAL DEFLECTION LIMITS

Area	Total deflection limit		Live load + creep	
	Deflection/span	Max mm	Deflection/span	Max mm
Relative deflection between any 2 columns			Span/500	
Superstructure floors	Span/250	40	Span/500	20
Perimeter beams & slabs	Span/250	30	Span/500	15

The above deflection limits are to include the effects of long term creep and shrinkage of reinforced concrete elements.

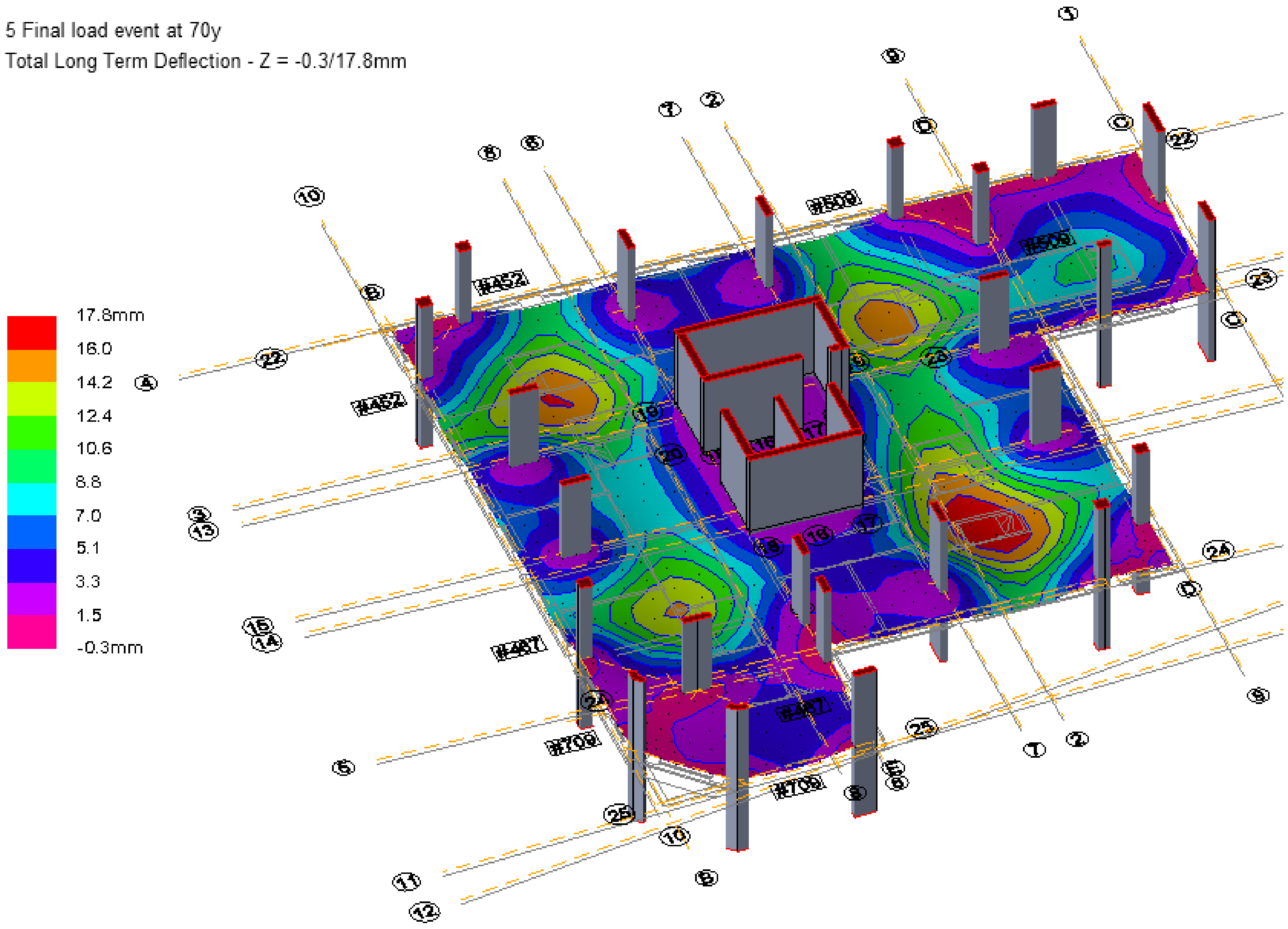
3.7.2 HORIZONTAL DEFLECTION LIMITS

The horizontal deflection from foundation will be limited to: height/500.

The deflection between any two adjacent floors will be limited to: height /600.

3.7.3 VIBRATION OF HORIZONTAL ELEMENTS

The vertical vibration of horizontal elements will be limited to 5HZ generally.



Example deflection plot

3.8 DISPROPORTIONATE COLLAPSE

The building has a consequence class of 2b from Table 11 of the Building Regulations - this is based on the height and usage of the building. Classification 2b requires effective horizontal and vertical ties for all floors, walls and columns. Effective ties will be provided by the reinforcement within the frame in accordance with the requirements of BS EN 1992. Additional checks for tie forces in columns will be carried out and key elements identified and checked.

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