Waterman Moylan
Engineering Consultants

Knockrabo Phase 2

Planning Stage – Structural Report

October 2021

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Knockrabo Phase 2

Planning Stage – Structural Report

Client Name: Knockrabo Investments DAC

Document Reference: 20-086r.006

Project Number: 20-086

Quality Assurance – Approval Status

This document has been prepared and checked in accordance with
Waterman Group's IMS (BS EN ISO 9001: 2015 and BS EN ISO 14001: 2015)

Issue	Date	Prepared by	Checked by	Approved by
01	05.02.21	R. Nelson	R. Nelson	R. Osborne
02	15.10.21	R. Nelson	R. Nelson	R. Nelson
03	28.10.21	R. Nelson	R. Nelson	Richard Nelson 2021.10.28 14:49:10 +01'00'

Comments

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Appendices

1. Introduction

1.1 Scope

Waterman Moylan has been appointed by Kidac to provide Structural Consultancy Services for the proposed residential development at Knockrabo Phase 2, Mount Anville Road, Dublin 14 and to develop the scheme to Planning Stage.

The following provides a summary of the advice and encapsulates the information gathered thus far.

The main structural issues covered are as follows:-

- Develop an understanding of site constraints.
- Form of the new structure.
- Advise structural dimensions.
- Review of construction methodology in relation to the site constraints
- Optimise building envelope within site constraints.
- Liaised with the other consultants engaged on the project regarding the structural works.

2. Site Constraints

The site of circa 1.78 hectares forms part of a broader site of circa 5.39 hectares on which the construction of Phase 1 has already taken place. Phase 1 to the East of the site comprises a mix of two-storey houses and apartment scheme and was completed in crica 2019.

The subject site occupies the Western side of the broader Knockrabo development and was included as part of the existing grant of planning [D17A/1124]. It is proposed to construct 227 no. residential apartments within four separate blocks (Blocks E, F, G & H) along will associated external communal space and car parking. The site is currently a greenfield site with areas used as allotments, well-established trees and extensive vegetation. The site has a sloping topography that falls from South to North and ranges in level between +76.5mAOD and +58.5mAOD.

The site is relatively constrained with:

- Knockrabo Phase 1
- Protected Structures (Cedar Mount & Gate Lodge)
- Dublin Eastern By-Pass (DEBP)
- Adjacent Residential Properties
- Traffic Management
- Ground Conditions

2.1 Knockrabo Phase 1

Site access and infrastructure services to the site were installed as part of Phase 1. Coordination will be required between the as-built record information and the proposed development.

2.2 Protected Structures

Cedar Mount House and the Gate Lodge lie to the South of the site. These protected buildings will need to be adequately safeguarded from the works to the proposed development.

2.3 Dublin Eastern By-Pass (DEBP)

The proposed Dublin Eastern By-Pass (DEBP) route runs adjacent to the Northern boundary. Following the publication of the DEBP Corridor Protection Study (2011) an access route will be required along the Eastern boundary during construction of the DEBP. Noise attenuation measures and requirements to be considered within the development are outlined in the DEBP Corridor Protection Study (2011).

A noise and vibration assessment with regard to the DEBP has been undertaken and is included as part of this planning application.

2.4 Adjacent Residential Properties

The site is adjacent to several residential properties along Mount Anville Road. Dilapidation surveys will need to be undertaken to these properties ahead of the works commencing, in addition to monitoring of noise and vibration during the works.

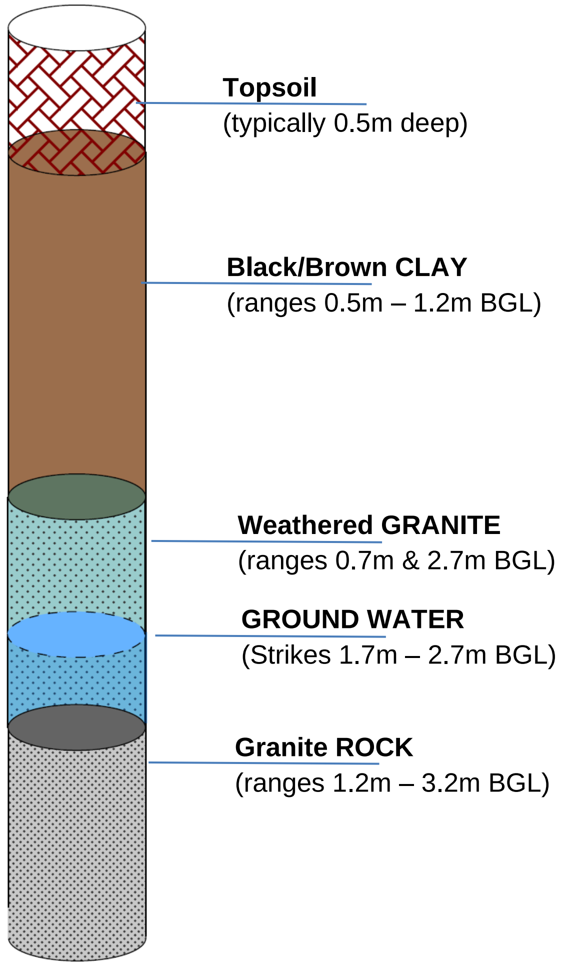
2.5 Traffic Management

Construction timings and methods, protection and potential temporary detours for both pedestrians and vehicles shall be studied prior to the commencement of construction activities. The Contractor shall agree and submit proposals to Dun Laoghaire Rathdown County Council for approval.

2.6 Ground Conditions

Geotechnical investigations were carried out on the site by Ground Investigations Ireland in 2019 as part of Knockrabo Phase 1.

The borehole records from the site investigation indicate that shallow granite rock extends across the site and is typically encountered at 2.3m below ground level. The anticipated subsurface geology is likely to be as follows:



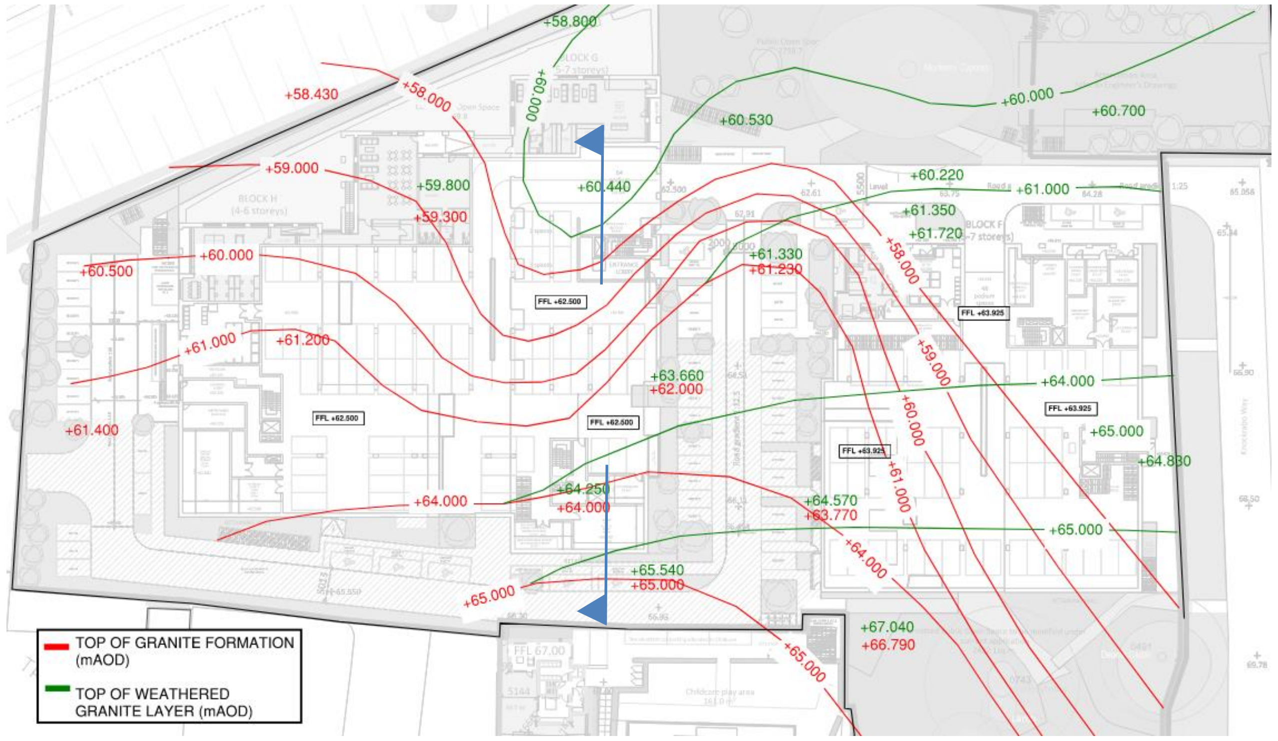
2.7 Ground Water Table

Groundwater strikes were noted and ranged between 1.7m and 2.7m (bgl). With regards to the basement waterproofing and consideration in accordance with BS8102:2009 – code of practice for the protection of below ground structures against water from the ground, the water table can be classified as category "high" in accordance with clause 5.1.3.

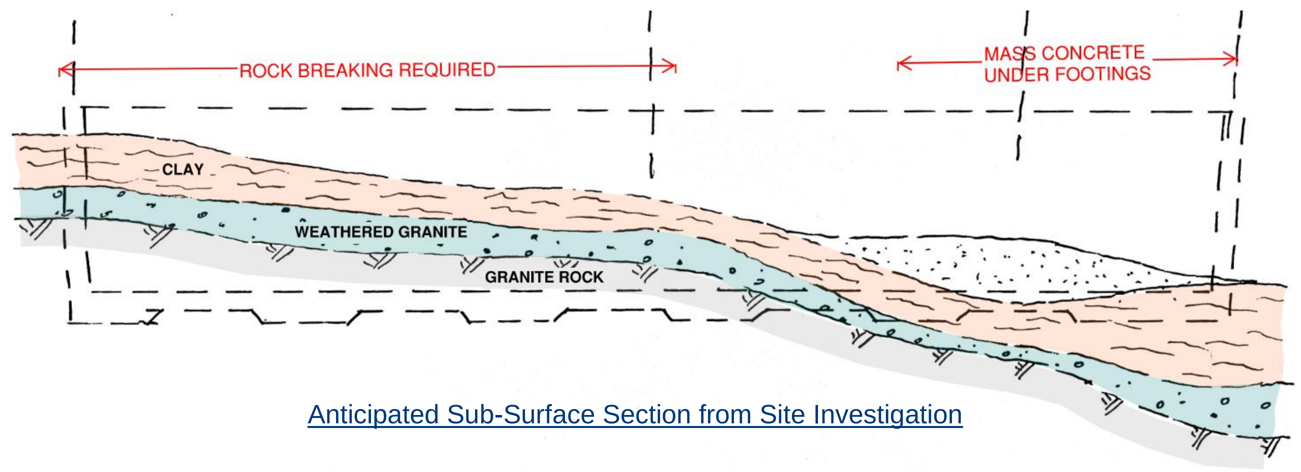
2.8 Granite Formation

The extent of the shallow granite is shown below. For the majority of the site the proposed building foundations will be kept shallow and will bear directly onto the Weathered Granite formation, that can be excavated using conventional methods for up to 1200mm below the top of this stratum.

To the South of Blocks F, G & H allowance should be made for rock breaking techniques where the Granite Rock formation is shown higher than the proposed Ground Floor levels. To the North of Blocks F, G & H mass concrete lean-mix will be required under footings to achieve a consistent bearing where the Weathered Granite extends to lower levels.



Interpreted Granite Levels from Site Investigation (mAOD)



Anticipated Sub-Surface Section from Site Investigation

3. Structural Concept

The structural scheme has been arrived upon following the review of a number of design iterations and assessment of floor spans and structural zones.

The scheme presented here aims to:

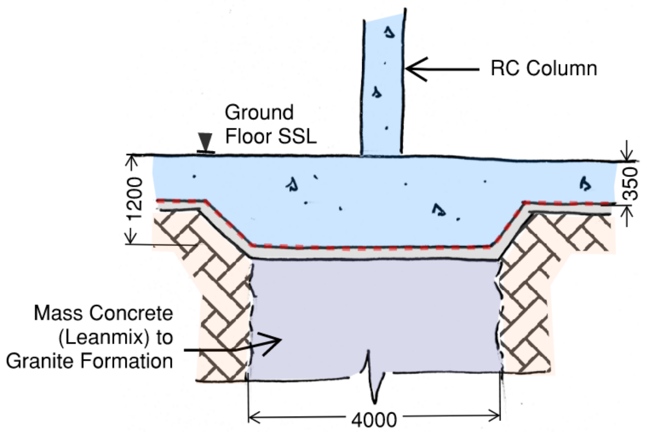
- Provide a flush soffit (as much as possible), achieving optimal floor sandwich whilst maximising clear floor-to-floor heights.
- Provide a clear path for service routes (as much as possible)
- Minimise the number column transfers between the ground floor and basement layouts;
- Avoid ground floor transfer structures through the use of cross-walls acting as deep beams;
- Be capable of fast construction minimising on-site programme time;

3.1 Substructure

3.1.1 Foundations

From the anticipated soil conditions, it is expected that the structure will be supported on shallow foundations. This will comprise 1200mm thick reinforced concrete strip and pads on mass concrete (leanmix) extending to granite rock or weathered rock formation. To the North of Blocks F, G & H mass concrete lean-mix will be required under footings to achieve a consistent bearing.

The ground floor slabs are 350mm thick reinforced concrete and suspended between the strip and pad footings. The slabs are formed on 50mm T3 Blinding with minimum 225mm T2 hardcore to SR:21 requirements.



Typical Foundation Detail

3.1.2 Retaining Wall Structure

The Southern perimeter of Blocks F, G & H form a cutting into the sloping site topology. This will require a 300mm thick reinforced concrete retaining wall to uphold the site levels.

The ground floor retaining wall to Blocks F, G & H is approximately 22m from the foundations to Cedar House. This is considered far enough away to allow for an open-cut battered excavation without the need for temporary retention works during construction.

3.1.3 Below Ground Waterproofing

Requirement and details for waterproofing to the below ground elements are shown by the Architect.

Table 2 Grades of waterproofing protection

Grade	Example of use of structure A)	Performance level
1	Car parking; plant rooms (excluding electrical equipment); workshops	Some seepage and damp areas tolerable, dependent on the intended use B) Local drainage might be necessary to deal with seepage
2	Plant rooms and workshops requiring a drier environment (than Grade 1); storage areas	No water penetration acceptable Damp areas tolerable; ventilation might be required
3	Ventilated residential and commercial areas, including offices, restaurants etc.; leisure centres	No water penetration acceptable Ventilation, dehumidification or air conditioning necessary, appropriate to the intended use

A) The previous edition of this standard referred to Grade 4 environments. However, this grade has not been retained as its only difference from Grade 3 is the performance level related to ventilation, dehumidification or air conditioning (see BS 5454 for recommendations for the storage and exhibition of archival documents). The structural form for Grade 4 could be the same or similar to Grade 3.

B) Seepage and damp areas for some forms of construction can be quantified by reference to industry standards, such as the ICE's *Specification for piling and embedded retaining walls* [1].

Grades of Waterproofing Protection (extract from BS8102:2009)

In habitable areas, core lobbies, electrical rooms and lift-pits, the basement waterproofing performance will need to be BS 8102:2009 Grade 3. Current proposals to achieve this required environment will be developed over the next stage. At this stage and for any preliminary cost plans we would suggest that a "white tank" system by Rascor or Dryteck is considered.

3.2 Super-Structure

A material options study for the super-structure was undertaken and can be summarised as follows.

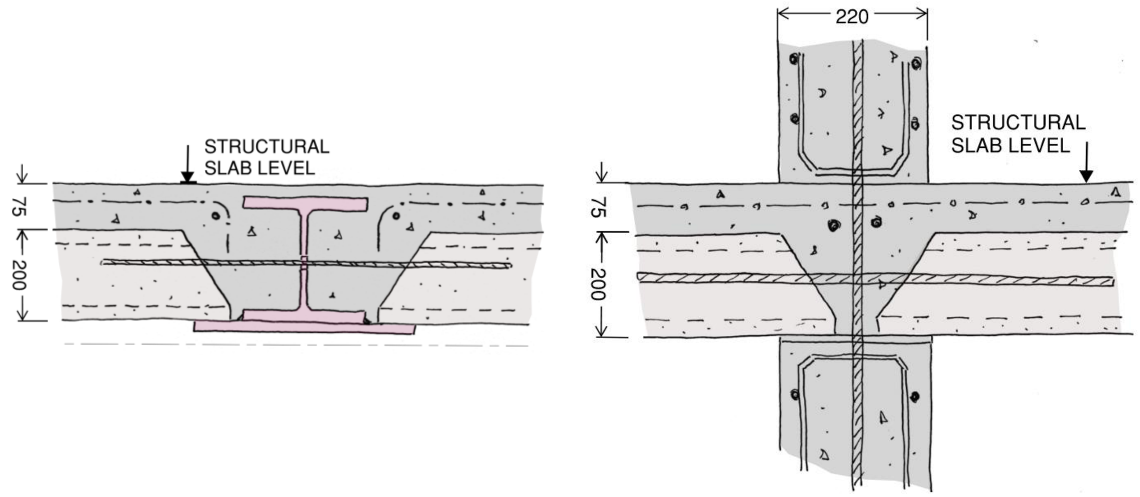
	Structural Slab Depth	Framing Layout	Speed-of-Construction	Fire Resistance	Acoustic Performance	Vibration Performance
Hybrid Precast Hollowcore & Crosswalls	275mm	Good	Good	Good	Good-Average	Good
In-situ Concrete Frame	325mm	Good	Poor	Good	Good	Good
Post-tensioned Concrete Frame	250mm	Good	Poor	Good	Good	Good
Steel Frame & Precast Concrete	275mm	Good	Good	Average[1]	Good-Average	Average
Masonry Walls & Precast Concrete	275mm	Poor	Poor	Good	Good-Average	Good
Timber CLT Slabs & Crosswalls	n/a[3]	n/a[3]	Good	Poor[2]	Average-Poor	Average

1. Additional measures required (intumescent paint/fire boarding/etc))
2. Additional measures required (fire boarding/etc) & early engagement with the local Fire Officer
3. Spans are too great for CLT

It is proposed to use a hybrid precast concrete hollow-core floor slabs with reinforced concrete cross-walls for the superstructure. The structural solution provides economy of design and speed of construction, whilst achieving the Architectural aspirations for minimum transfer structures at Ground Floor.

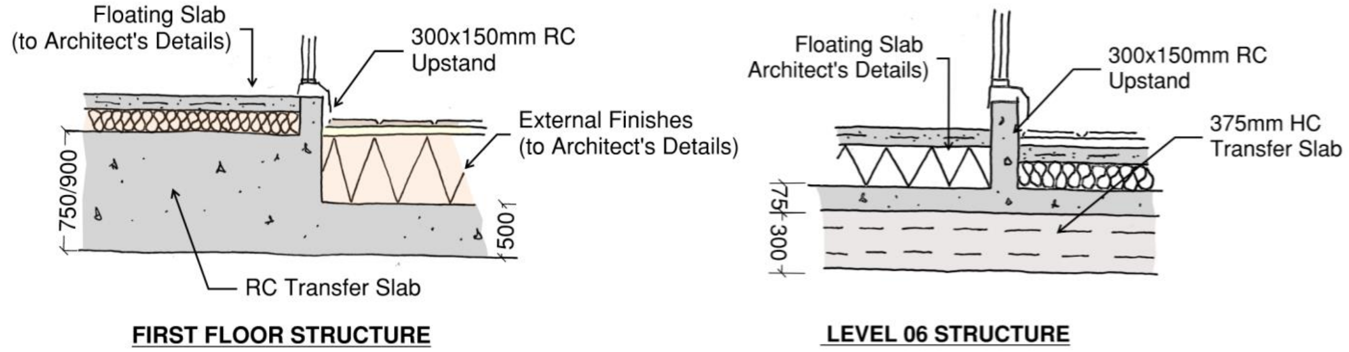
A hybrid precast concrete and in-situ cross-wall construction has a number of benefits over a conventional concrete frame approach:

- High strength to weight ratio
- Greater opportunity for off-site prefabrication
- Higher quality of finish due to off-site construction
- Less requirement for temporary works and back-propping slabs
- Less formwork and shuttering on site
- Faster construction time on site (early stage first-fix MEP)
- Longer achievable floor spans for shallow floor zone



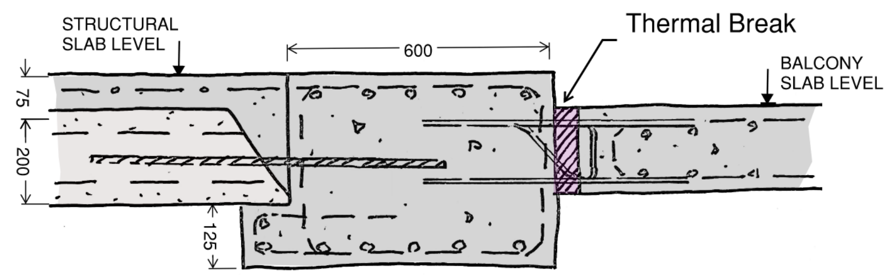
Typical Floor Structural Build-up

Transfers exist at 1st and 6th Floors where the columns layouts are not conductive to the floors below. At 1st Floor the transfer slabs comprise 750mm or 900mm thick reinforced concrete flat slabs with level soffits. At 6th Floor the transfer slabs comprise 300mm hollowcore slabs with a 75mm structural screed.



First Floor & 6th Floor Transfer Slabs

The balconies will be connected to the floor slabs at every level via thermal breaks. The balconies will comprise of either steel frame or in-situ concrete. The balconies may be prefabricated off site and lifted into position.



Typical Balcony Support Detail

4. Sustainability

The two main types of carbon impact associated with buildings and infrastructure comprises embodied carbon, which is associated with the locked-up carbon in construction materials, and operational carbon which results from the running of the building's heat, energy and services.

It should be noted that reference to net zero carbon and scoring criteria outlined in BREEAM and LEED typically refer to the building's operational carbon only.

4.1 Embodied Carbon

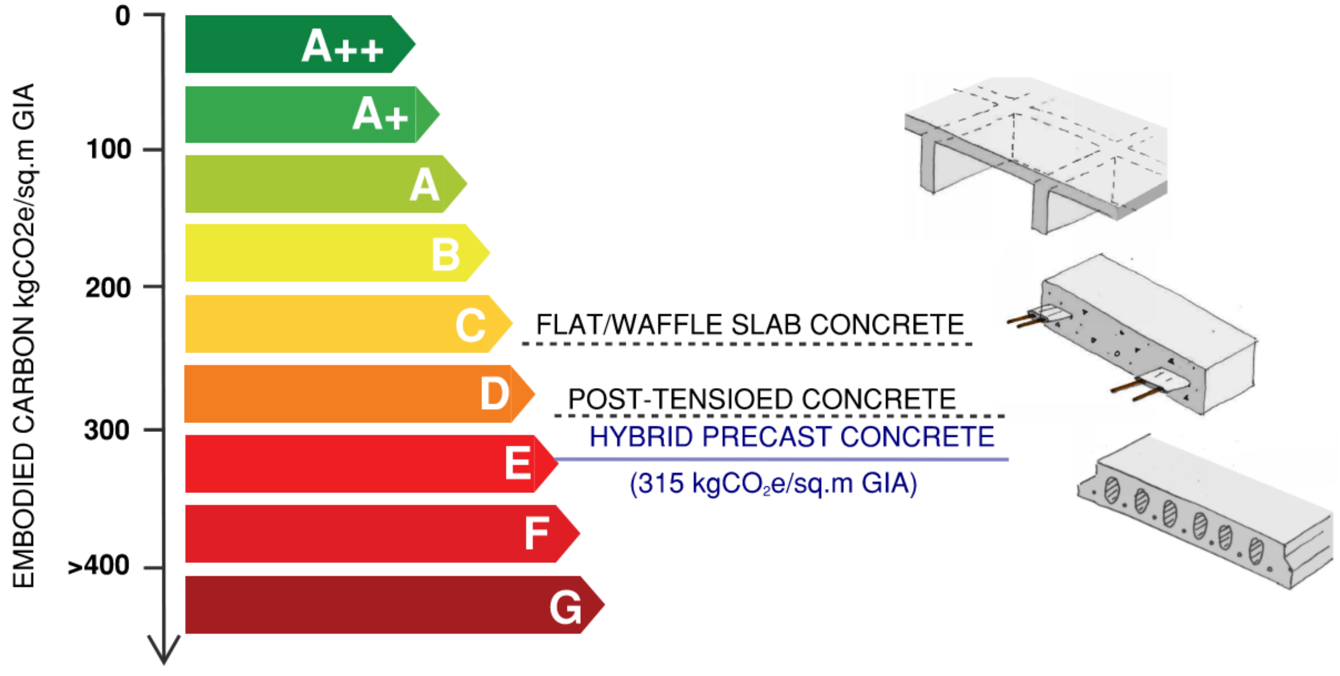
Waterman-Moylan are committed to minimising the embodied carbon in buildings and raising awareness of the impact design decisions have on the environment. Our design process has adopted the following measures in order to reduce embodied carbon in construction:

- Minimising materials used in construction (efficient sizing of all structural members).
- Avoid transfer structures where possible and if used maximise their efficiencies within the structure.
- Develop opportunities for off-site prefabrication/construction to minimise material wastage.
- Consider low carbon material substitutes (GGBS, PFA, etc) replacing carbon intensive materials.
- Seek to repurpose and refurbish existing buildings and/or re-use existing structural elements (existing foundations, etc).
- Consider the performance of the structure in conjunction with other disciplines (thermal mass, waterproofing performance, etc).
- Considering buildability, installation requirements and follow-on trades to avoid complex details that slows construction and escalates costs.

4.2 Preliminary Embodied Carbon Assessment

Over the Planning Stage, we undertook an initial carbon assessment of the proposed building structure in order to assess the structural scheme against alternative materials. We have developed a simple carbon assessment tool that calculates the carbon of the principle structural materials (steel, concrete, timber, etc) through stages A1-A5 of the BS EN 15978.

MATERIAL	EC (kg/CO_2e/m^2)	% Used
Precast Hollowcore	55	17.5
Screed (C30/37)	24	7.6
In-situ Concrete (C32/40)	120	38.1
Reinforcement	106	33.6
Steelwork	10	3.2
TOTAL	**315**	**100**



Embodied Carbon SCORE Rating Scheme (IStructE 2020)

The proposed structural scheme has a higher embodied carbon in comparison to alternative materials. This is primarily due to the carbon intensive production of precast concrete elements and the reluctance by precast manufacturers to use cement replacements (GGBS, PFA, etc).

In-leu of the above, the following measures may be incorporated into the design over the next Stage to reduce the embodied carbon of the proposed structural scheme:

1. Further rationalise the transfer structures at Ground Floor and at 6th Floor.
2. Incorporate cement replacement GGBS (up to 50% by volume) within the structural screeds, mass concrete, foundations and ground floor slabs.
3. Consider an exposed structure where possible in-leu of architectural finishes.
4. Consider designing the structural elements for a longer design life of 75 years.
5. Optimise the thermal mass of the building's concrete elements for a reduced M&E operational demand.

5. Fire Protection of the Structure

It is currently understood that a 90-minute fire protection will be required generally for the structure, with 120 minutes required for certain core and escape routes, subject to the Fire Consultants Report. 240 minutes is required in electrical ESB substation rooms.

Fire protection to all concrete elements will be achieved as follows, as per IS EN 1992-2:

Core walls and Columns	-	RC concrete cover and minimum element dimensions
Horizontal members and hollowcore slabs	-	RC concrete cover and minimum element dimensions.
120 minute areas	-	RC concrete cover and minimum element dimensions.
240 minute areas	-	RC concrete cover and minimum element dimensions.

6. Proposed Loadings

6.1 Design Loadings and Service Movements

6.1.1 Vertical Loads

These comprise superimposed live loads [due to occupancy, plant, storage, etc.], superimposed dead loads [due to M&E services, etc.] and self-weight of structure plus cladding. Superimposed live loads and dead loads are listed below and the design takes into account structure and cladding self-weight.

6.1.2 Horizontal Loads

These comprise either wind loading on the building façade or "notional loads" as defined in British Standards. Notional loads occur due to lack of fit of the structure, etc. The combination of these two are used in the design in accordance with IS EN 1990.

6.1.3 Service Movements

Horizontal and vertical movements due to superimposed live loads and wind loads are limited to the following:

Horizontal building sway [wind load] = $\frac{height}{500}$

Vertical slab/beam deflections [superimposed live load]:

i] Floor beams = $\frac{span}{360}$

ii] Slab/Beam supporting cladding = $\frac{span}{500}$ or 10 mm whichever is less.

6.1.4 Loading Table

A <u>Typical Bedroom Floor</u>

200 Precast Slab	3.00 kN/m^2
75mm Screed	1.80 kN/m^2
Floor Finishes	0.35 kN/m^2
Ceiling & Services	<u>0.25 kN/m^2</u>
	5.40 kN/m^2
Imposed load (Class A1)	3.0 kN/m^2

[Including 1.5kN/m^2 partitions with finishes]

B <u>Typical Ground Floor Commercial</u>

350 normal weight slab	8.75 kN/m^2
Raised floor	0.35 kN/m^2
90mm Screed (2000kg/m^3)	1.80 kN/m^2
Floor insulation	0.05 kN/m^2
Ceiling &services	<u>0.45 kN/m^2</u>
	11.40 kN/m^2
imposed load	5 kN/m^2

D <u>Roof Areas</u>

200 Precast Slab	3.00 kN/m^2
75mm Screed	1.80 kN/m^2
Sedum	3.00 kN/m^2
Waterproofing	0.30 kN/m^2
Insulation	<u>0.20 kN/m^2</u>
	8.30 kN/m^2
imposed load (MEP)	7.5 kN/m^2
Imposed load (PVs)	3.0 kN/m^2
Access/Maintenance	0.6 kN/m^2

E <u>Corridor / Lobby Areas</u>

200 Precast Slab	3.00 kN/m^2
75mm Screed	1.80 kN/m^2
Floor Finishes	0.35 kN/m^2
Ceiling & Services	<u>0.45 kN/m^2</u>
	5.60 kN/m^2
Imposed load	5.0 kN/m^2

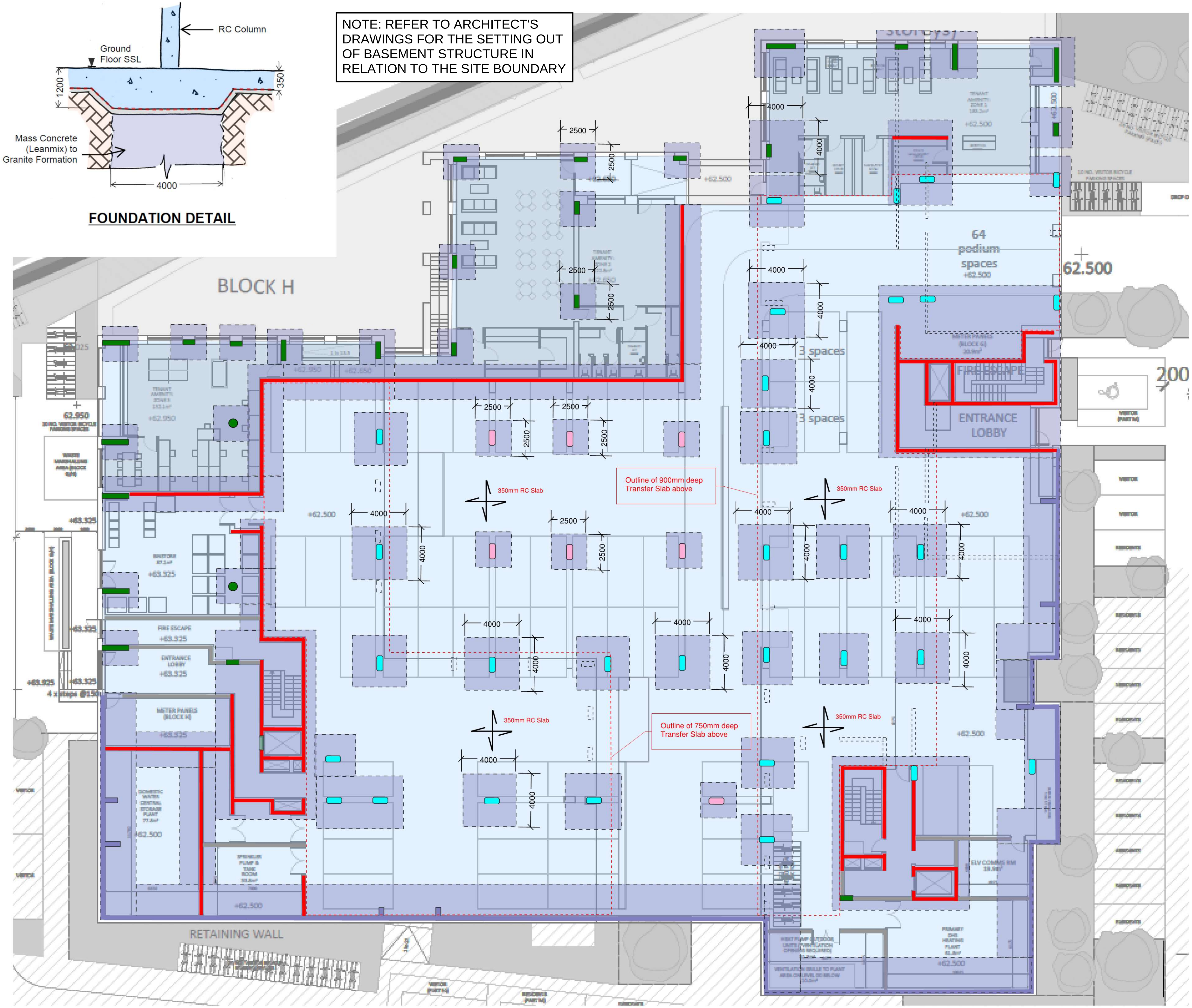
F <u>Disproportionate Collapse</u>

The structure is in excess of five storeys and therefore will be checked for disproportionate collapse in accordance with IS EN 1991-1-7:2006 Annex A and Building Regulations.

Accidental loading at 34 kN/m^2 will be applied to "key elements", i.e. columns and beams carrying columns, and criteria in regard to perimeter ties and tying forces.

APPENDIX

A. Waterman-Moylan Structure's Drawings



FOUNDATION DETAIL

NOTE: REFER TO ARCHITECT'S DRAWINGS FOR THE SETTING OUT OF BASEMENT STRUCTURE IN RELATION TO THE SITE BOUNDARY

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LEGEND

- Denotes 350mm thick RC Ground Floor Slab Allow C32/40 with 170kg/m3 reinforcement (Note - Integrated waterproof concrete additive "Drytech" to be considered in allowances)
- Denotes outline of transfer slab over (Level 01)
- Denotes 300mm thick RC Retailing Wall Allow C32/40 with 170kg/m3 reinforcement (Note - Integrated waterproof concrete additive "Drytech" to be considered in allowances)
- Denotes 220mm thick RC Wall Allow C32/40 with 200kg/m3 reinforcement (Note - wall achieves 2HR Fire Resistance)
- Denotes 220x880mm or 220x2000mm RC Blade Column. Allow C50/60 with 220kg/m3 reinforcement
- Denotes 350x650mm RC Column Allow C50/60 with 220kg/m3 reinforcement and 25mm Chamfered Corners
- Denotes 350x650mm RC Column Allow C32/40 with 150kg/m3 reinforcement and 25mm Chamfered Corners
- Denotes 100mm thick (7.5N) Blockwork Wall Allow Ancon WP2 Windposts @5m c/c
- Denotes 1200mm thick RC Strip/Pad Footing Allow C32/40 with 200kg/m3 reinforcement (Note - Mass concrete "leanmix" to Rock)

ADDITIONAL NOTES
- All stairs to be pre-cast concrete construction
- Reinforcement densities noted include allowance for laps. Densities to be applied over the gross internal area including opes.
- Extent of foundations shown subject to site investigation

DRAWING STATUS
ISSUED FOR PLANNING

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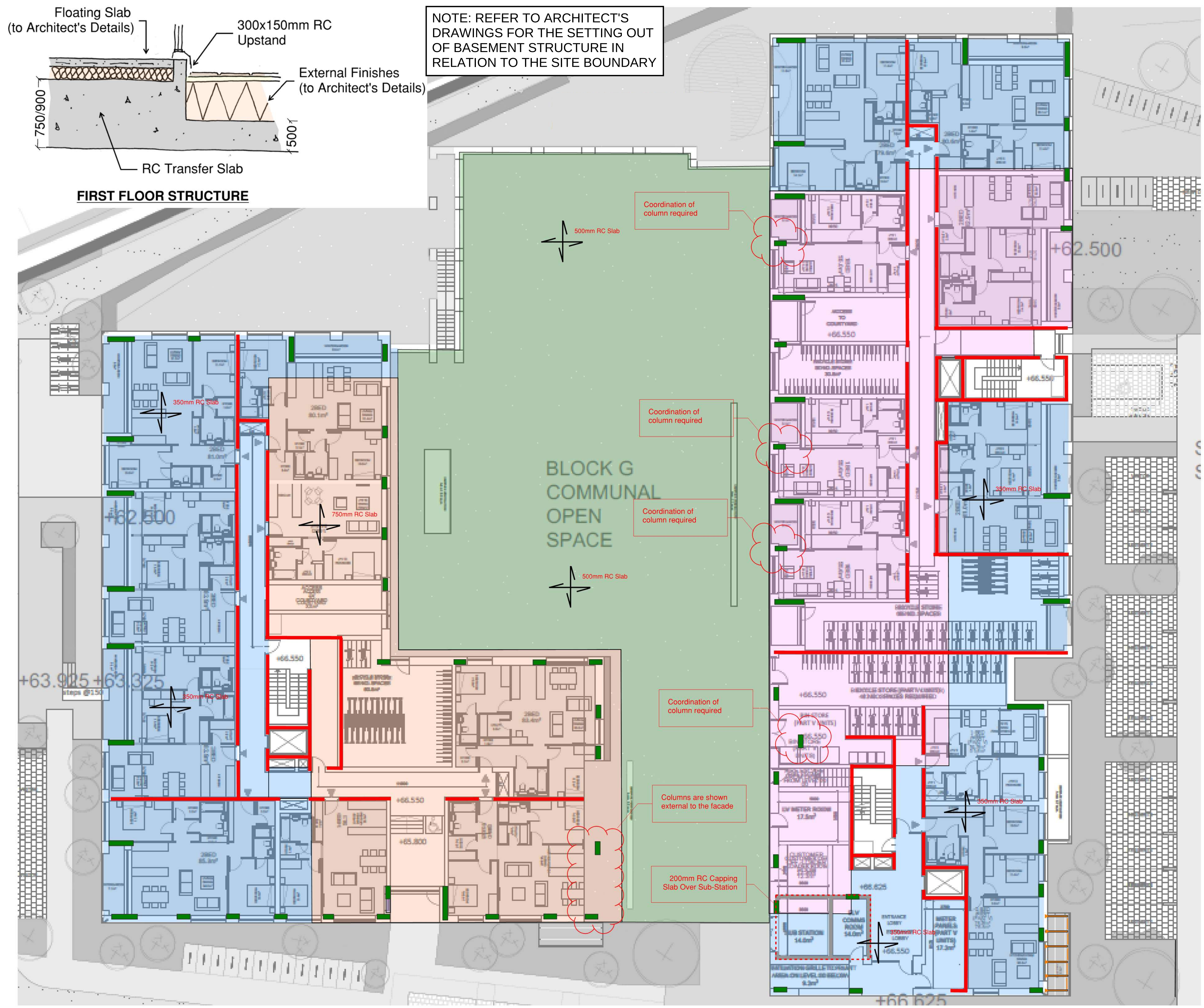
CLIENT
KIDAC

PROJECT
Knockrabo Phase 2

TITLE
BLOCK G & H LEVEL 0 GA

DRAWN	DESIGNED	CHECKED
RN	RN	RO
PROJECT	DATE	SCALE
20-086	26.01.2021	NTS

DRAWING REFERENCE
20-086-WMS-ZZ-ZZ-SK-S-0001



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- Denotes 350mm thick RC Level 1 Slab Allow C32/40 with 170kg/m3 reinforcement
- Denotes 750mm thick RC Transfer Slab Allow C32/40 with 200kg/m3 reinforcement
- Denotes 900mm thick RC Transfer Slab Allow C32/40 with 200kg/m3 reinforcement
- Denotes 500mm thick RC Podium Slab Allow C32/40 with 180kg/m3 reinforcement
- Denotes 220mm thick RC Wall Allow C32/40 with 200kg/m3 reinforcement (Note - wall achieves 2HR Fire Resistance)
- Denotes 220x880mm or 220x2000mm RC Blade Column. Allow C50/60 with 220kg/m3 reinforcement
- Denotes Thermal Break (Schock Isokorb T)
- Denotes 203UC46 Cantilever Balcony. Allow thermal break (Schock Isokorb T-SK) and all external steelwork to be hot-dip galvanized minimum 85μm
- Denotes 215mm thick (7.5N) Blockwork Wall (Note - wall achieves 4HR Fire Resistance)

ADDITIONAL NOTES
- All stairs to be pre-cast concrete construction
- Reinforcement densities noted include allowance for laps. Densities to be applied over the gross internal area including opes.
- Allow 150x300mm deep RC Up-stand to Ground Level Building Envelope (refer to typical details)

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CLIENT
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Knockrabo Phase 2

TITLE
BLOCK G & H
LEVEL 1 GA

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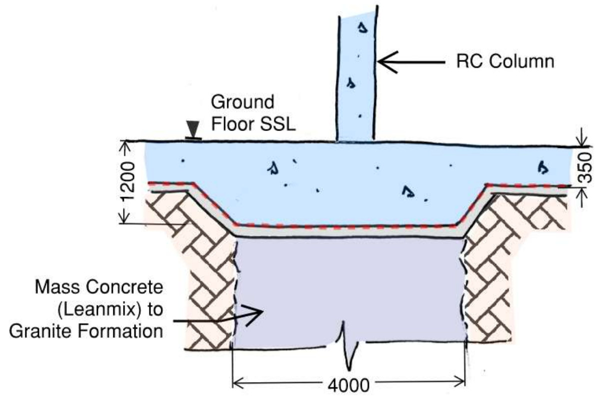

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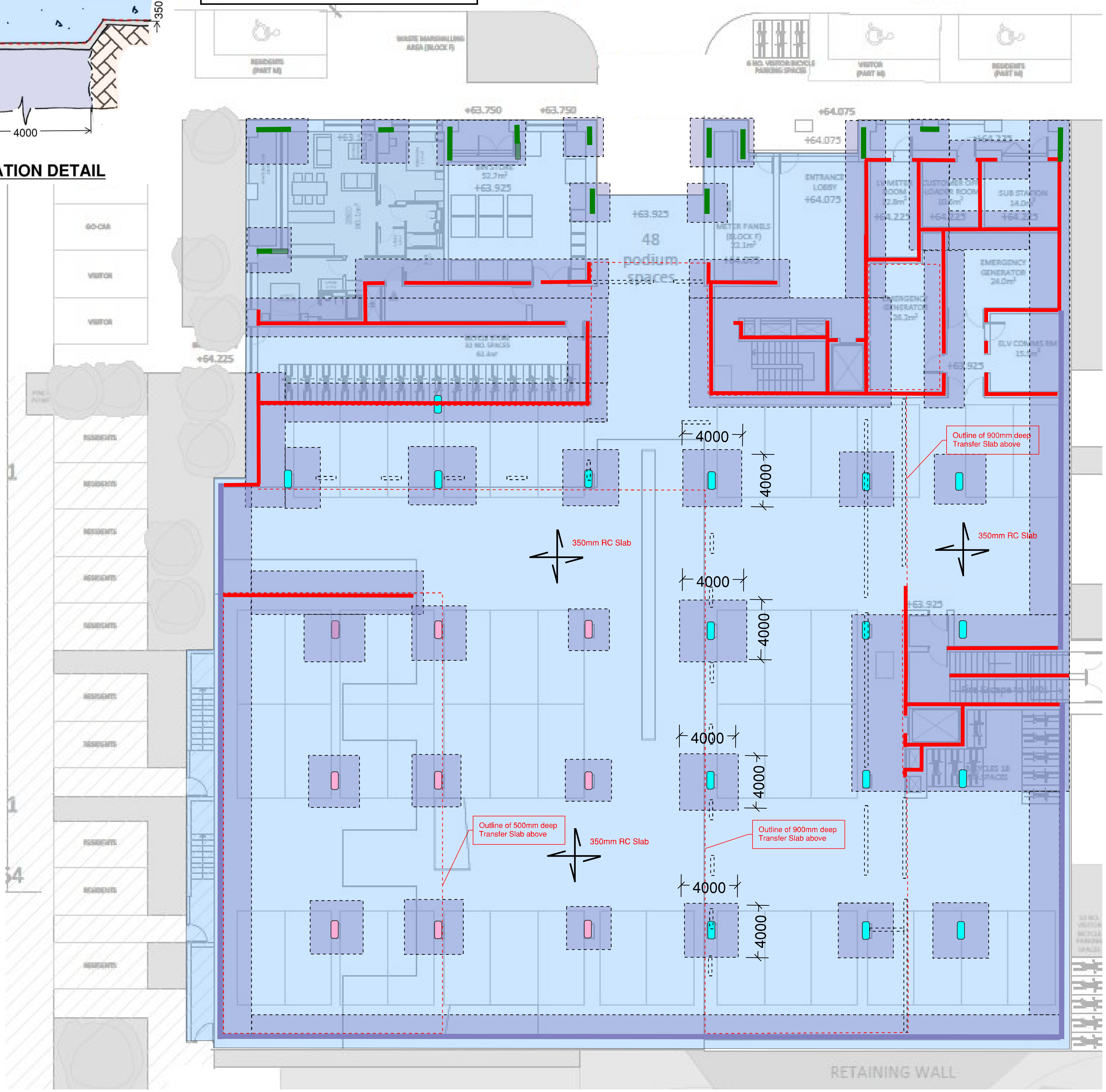

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KIDAC

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TITLE
BLOCK F
LEVEL 0 GA

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PROJECT	DATE	SCALE
20-086	26.01.2021	NTS

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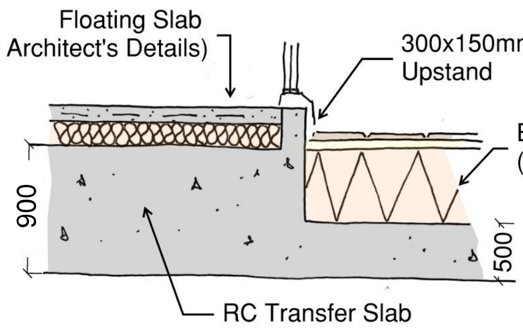

FIRST FLOOR STRUCTURE

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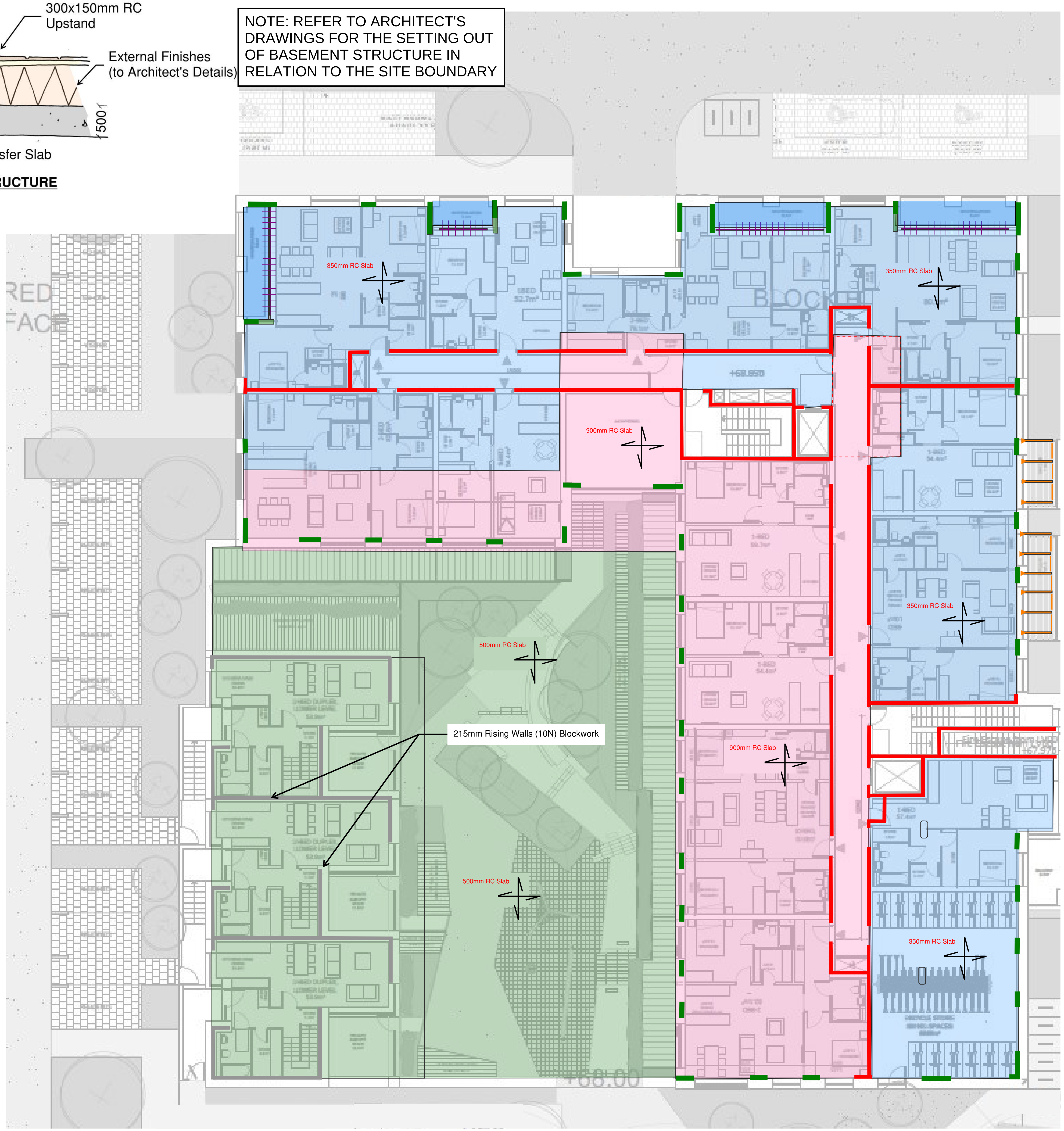

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LEGEND

- Denotes 350mm thick RC Level 1 Slab. Allow C32/40 with 170kg/m3 reinforcement
- Denotes 500mm thick RC Transfer Slab. Allow C32/40 with 180kg/m3 reinforcement
- Denotes 900mm thick RC Transfer Slab. Allow C32/40 with 200kg/m3 reinforcement
- Denotes 220mm thick RC Wall. Allow C32/40 with 200kg/m3 reinforcement (Note - wall achieves 2HR Fire Resistance)
- Denotes 220x880mm or 220x2000mm RC Blade Column. Allow C50/60 with 220kg/m3 reinforcement
- Denotes Thermal Break (Schock Isokorb T)
- Denotes 203UC46 Cantilever Balcony. Allow thermal break (Schock Isokorb T-SK) and all external steelwork to be hot-dip galvanized minimum 85μm
- Denotes 215mm thick (15N) Blockwork Wall

ADDITIONAL NOTES
- All stairs to be pre-cast concrete construction
- Reinforcement densities noted include allowance for laps. Densities to be applied over the gross internal area including opes.
- Allow 150x300mm deep RC Up-stand to Ground Level Building Envelope (refer to typical details)

DRAWING STATUS
ISSUED FOR PLANNING

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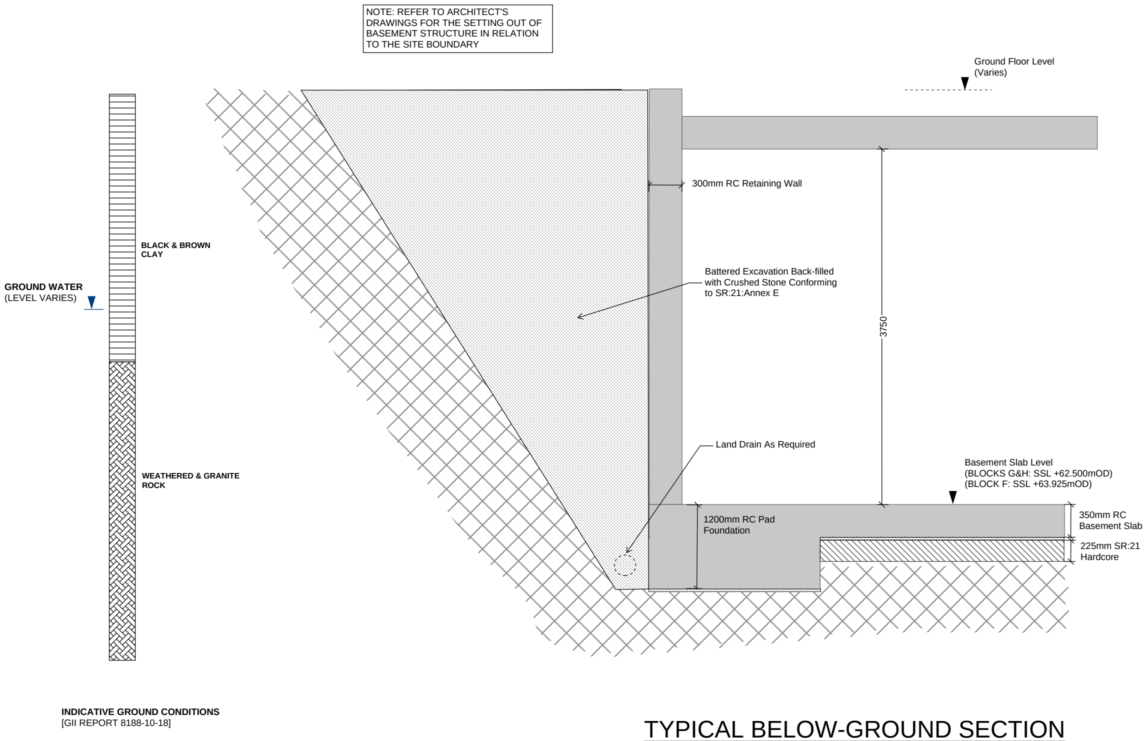
CLIENT
KIDAC

PROJECT
Knockrabo Phase 2

TITLE
BLOCK F
LEVEL 1 GA

DRAWN	DESIGNED	CHECKED
RN	RN	RO
PROJECT	DATE	SCALE
20-086	26.01.2021	NTS

DRAWING REFERENCE
20-086-WMS-ZZ-ZZ-SK-S-0009



TYPICAL BELOW-GROUND SECTION

SCALE 1:20 (@A0)

ADDITIONAL NOTES

1. TEMPORARY DEWATERING OF GROUND WATER DURING EXCAVATION WILL BE REQUIRED. A TEMPORARY DEWATERING REGIME SHALL BE PROVIDED BY THE CONTRACTOR AHEAD OF THE WORKS

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TITLE: TYPICAL GROUND FLOOR STRUCTURAL SECTION

DRAWING STATUS	INFORMATION				
DRAWN	RN	DESIGNED	RN	CHECKED	RO
PROJECT	20-086	DATE	15.10.2021	SCALE	1:20 (A0)

PROJECT: Knockrabo Phase 2

CLIENT: KIDAC

DRAWING REFERENCE: 20-086-WMS-ZZ-ZZ-SK-S-010

Waterman Moylan
Engineering Consultants

UK and Ireland Office Locations