Stockland

601 Pacific Highway, St Leonards

Structural Engineering Planning Proposal Report

ARP-REP-ST-0001

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Job number 279347-00

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1 Introduction

Arup has prepared this Structural Engineering report on behalf of Stockland Development Pty Ltd to support a Planning Proposal to amend the statutory planning controls that apply to 601 Pacific Highway, St Leonards (Lot 71 in Deposited Plan 749690) (**the site**) under North Sydney Local Environmental Plan 2013 (**LEP**).

The intended outcome of this Planning Proposal is to amend the LEP planning controls as follows:

- Establish a site-specific building height control, with maximum building height of RL259 metres; &
- Establish a site-specific floor space ratio (**FSR**) control, with a maximum FSR of 20:1.

The Planning Proposal does not amend the site’s existing E2 Commercial Centre zoning. Future development aligned with the Planning Proposal is consistent with the permissible land uses and objectives of Zone E2.

The new planning controls seek to unlock the potential of a strategically-located landholding within the St Leonards centre and facilitate a new commercial building in a precinct earmarked for density uplift.

This Planning Proposal will deliver strategic planning merits commensurate with State and Local government policy and align with the *St Leonards and Crows Nest 2036 Plan* adopted by NSW Department of Planning, Industry and Environment (**DPIE**) (August 2020). Future development of the site will generate substantial public benefit and make a significant contribution to the evolving character of St Leonards town centre.

2 Site

2.1 Location

The site to which this Planning Proposal relates is 601 Pacific Highway, St Leonards, within the North Sydney Local Government Area (**LGA**). The site is located approximately 4.5 km north of the Sydney CBD and within close proximity to the commercial centres of St Leonards, Chatswood, and Macquarie Park.

The site has a primary (south-facing) frontage to the Pacific Highway and secondary frontages to Mitchell Street (to the east) and Atchison Street (to the north) (refer below site location plan).

Figure 1: Site location

The site comprises a single allotment (Lot 71 in DP 749690) with a total area of 2,840 sqm (approximate).

2.2 Site Context

The site occupies a prominent location on the corner of the Pacific Highway and Mitchell Street, with a secondary frontage to Atchison Street. The site is located in the heart of St Leonards within convenient walking distance of the facilities and services available within the St Leonards rail precinct.

The area is well advanced in its transition from an older style commercial precinct to a thriving mixed-use area incorporating commercial and residential land uses, in tall tower building forms. This transition is facilitated by ongoing construction activity, recent development approvals, and further planning proposals.

The immediate surroundings include a range of building forms which are predominantly medium and high rise commercial and multi-storey mixed-use residential buildings.

2.3 Topography

The topographic contours obtained from SIXMaps NSW Land and Property Information are shown in Figure 2. These contours indicate that the site is moderately sloping from northeast towards the southwest. The relative elevation of the site varies from approximately 92m AHD at the north eastern corner to 87m AHD along the south western boundary.

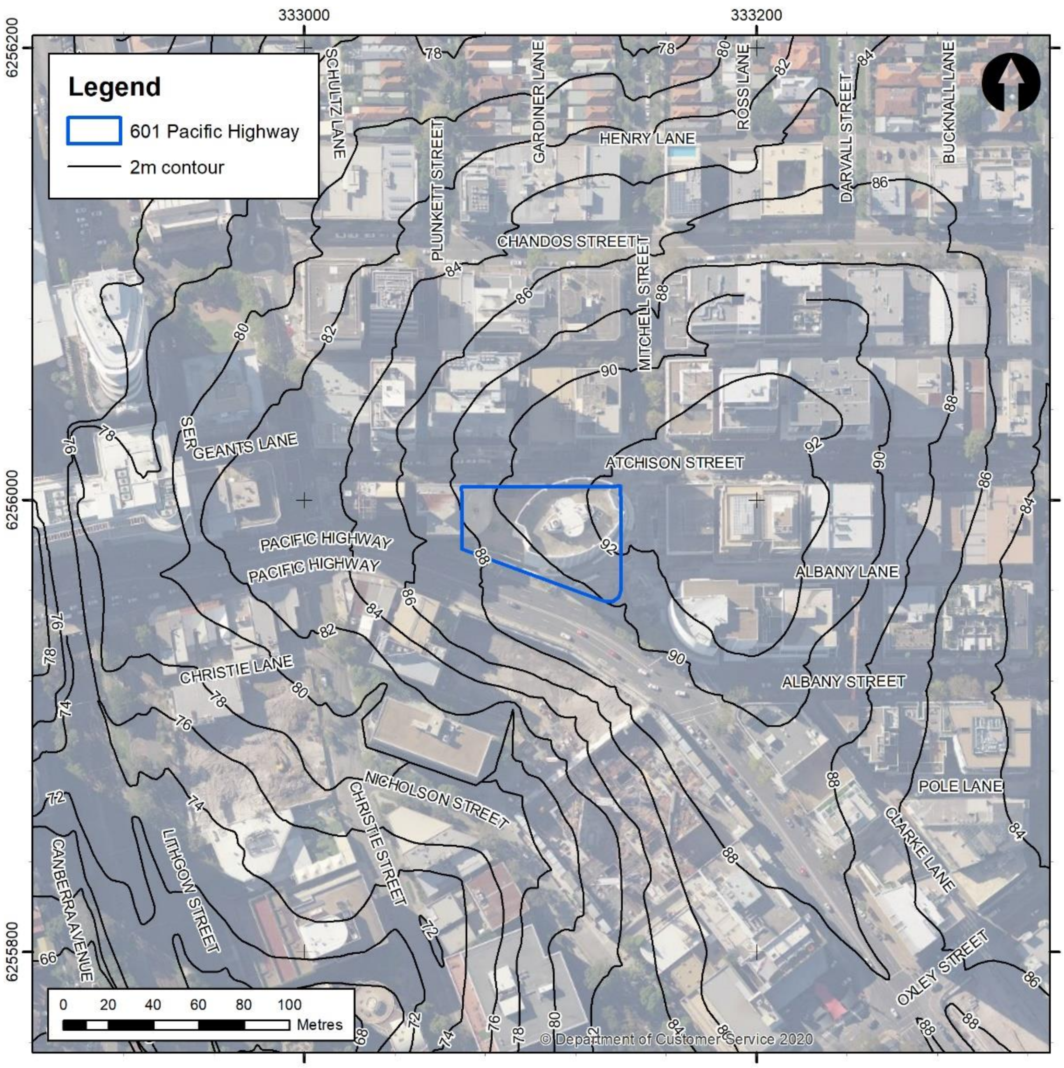


Figure 2: Site Topography (Source: SIXMaps)

2.4 Existing Building

A review of the site historical development has been undertaken by reviewing historical imagery. From this, it was concluded that the site was occupied by small residential structures up until 1951 with a multi-storey building being developed between 1951 and 1961.

The existing 14-storey commercial building was completed in 1988 and has four basement levels that extend down to approximately 80.0mAHD. This building is concrete framed with a centre core. The existing basement is expected to be entirely founded in the shale bedrock, with a drained retention system comprising soldier piles and shotcrete infill.

2.5 Ground Conditions

Reference is made to the Geotechnical Desk Study prepared by Arup reference 279347-ARP-GT-RPT-002 for detailed information regarding the expected ground conditions.

A summary of the anticipated subsurface ground profile of the site is provided in Table 1.

Table 1: Anticipated ground profile

Unit	Description	Approximate Thickness (m)
Fill / topsoil	Fill – material type and condition unknown	0.0 – 0.5
Residual soils	Silty clay, medium plasticity	1.5 – 3.0
Rock	Ashfield Shale and Mittagong Formation	2.7 – 15
	Hawkesbury Sandstone	Underlying Ashfield Shale

2.6 Sydney Metro

2.6.1 Site Interaction & Geometrical Relationship

With reference to Figure 3 below, the recently constructed Sydney Metro City and South West (C&SW) tunnels are located within the site footprint in an east west direction. The tunnel crown level varies between 61mAHD (eastern site boundary) and 57mAHD (western site boundary) while the invert level varies between 54 and 50mAHD. The tunnel crown varies between 20 and 30m below the existing basement detailed excavation levels.

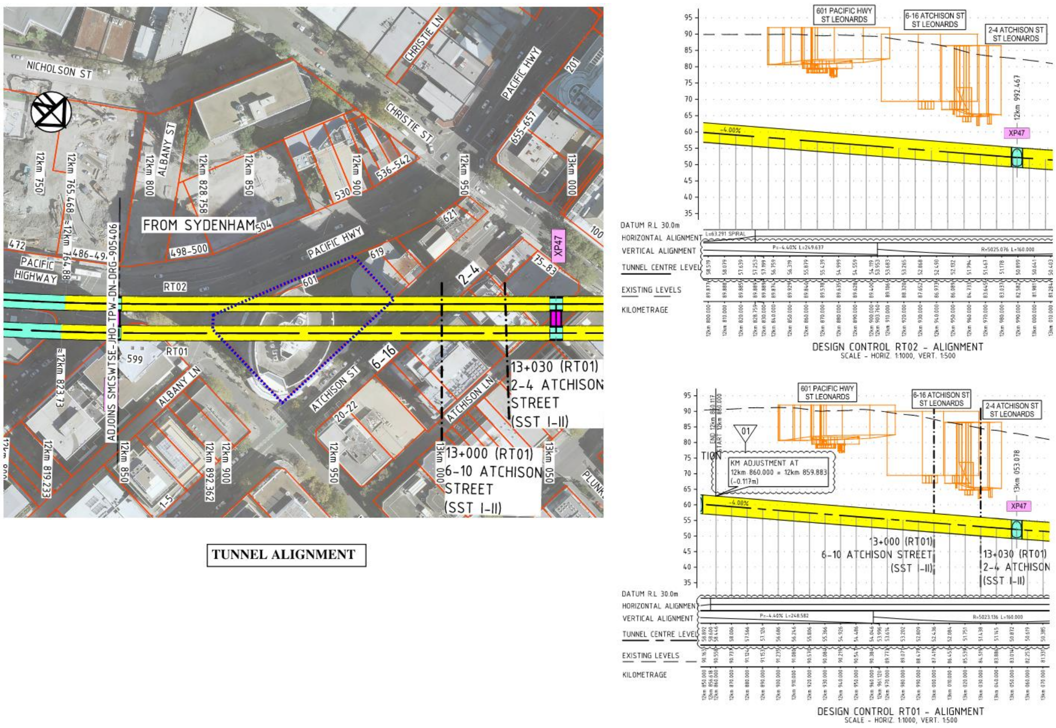


Figure 3: Site location plan and sections including metro tunnel overlay

2.6.2 Tunnel Construction

Tunnelling on new 15.5-kilometre twin railway tunnels between Chatswood and Sydenham was commenced in early 2018 and completed in early 2020.

The tunnels were constructed by tunnel boring machines (TBMs) with a cutting face diameter of 7.04 m. The tunnels below the site comprise 50MPa steel fibre reinforced concrete (SFRC) segmental liners. The tunnel lining was constructed by automated assembly by the TBM train and formed within Hawkesbury Sandstone. The liner has six precast concrete panels in each ring connected with bolts in the circumferential direction and dowels in the longitudinal direction. The assembled ring has an external diameter of 6.69 m, an inner diameter of 6.17m, a thickness of 260mm and a clear opening (inner diameter less tolerances) of 6.0 m as highlighted in Figure 4.

Each panel has a gasket installed around its perimeter. These gaskets are anchored within the concrete during panel construction. The precise gasket efficacy is not known; however, it is considered the tunnel is designed as watertight for full hydrostatic pressure.

The annulus between the liner and surrounding sandstone rock was back-grouted with a 2 MPa strength grout pumped into the annulus at a pressure of 1 atmosphere (~100kPa).

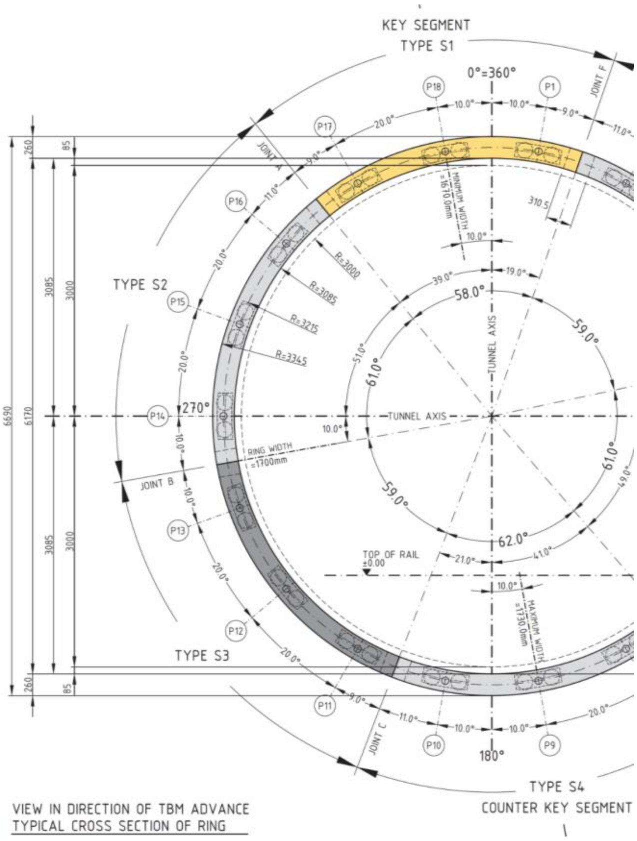


Figure 4: C&SW tunnel dimensions and ring assembly

2.6.3 Sydney Metro Protection Requirements

2.6.3.1 Reserves & Substratum

The Sydney Metro rail protection reserves are categorised as either the ‘first reserve’ or ‘second reserve’ by the ‘Sydney Metro Underground Corridor Protection - Technical Guidelines’ (Document no. NWRLSRT-PBA-SRT-TU-REP-000008) and are established to protect the tunnel and rail infrastructure during the construction and operation of adjacent developments.

The relevant extents of the first reserve below the development site are governed by the extent of the Sydney Metro substratum. Figure 5 below shows the extents of the protection reserves relative to key development layout elevations.

- Minimum of nine (9) metres above the tunnel crown - up to approximately 69.15m AHD above the crown ;
- Five (5) metres distance either side of the tunnel; &
- Approximately 7.5m below the invert of the tunnel.

The first reserve represents the area which should not be encroached upon by any future construction or development.

The relevant extents of the second reserve below the site extend: from the tunnel crown up to the ground surface, from the tunnel sidewalls out by 25 m, from the tunnel invert down by 25m. The second reserve represents the area where developments have the potential to impact on the performance of the tunnel support and its operation.

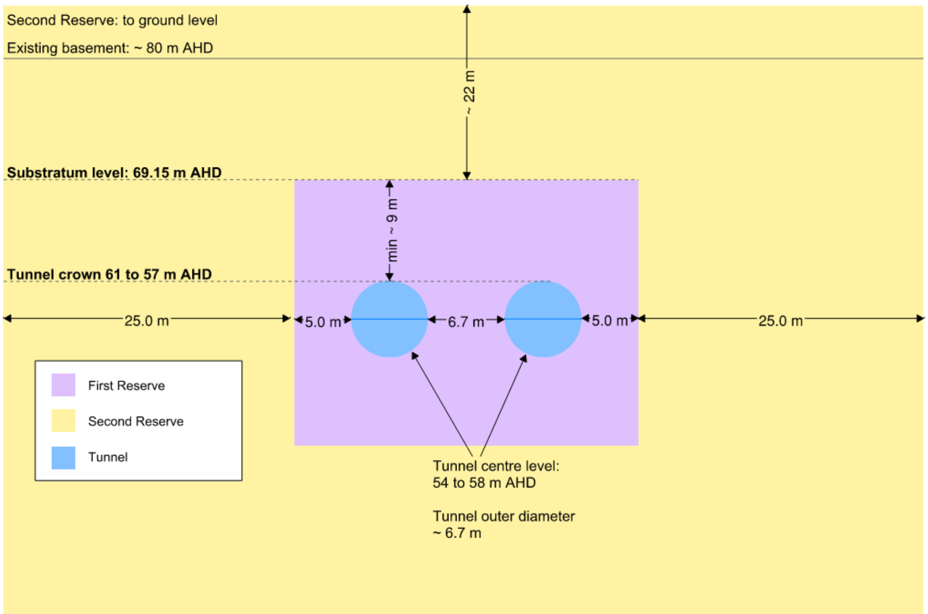


Figure 5: Diagram showing SM protection reserves

2.6.3.2 Ground/Tunnel Movement Limitation

The Sydney Metro Underground Corridor Protection - Technical Guidelines Document no. NWRLSRT-PBA-SRT-TU-REP-000008 provides limits on absolute and differential movement at the tunnel lining of 10mm and 1:2000 respectively.

On the basis of the properties of the Hawkesbury Sandstone and the TBM excavation and construction of the C&SW tunnel, it is reasonable to assume the majority of ground movement due to rock stress relief (that results from the tunnelling operation) would have occurred prior to completion of the tunnel lining. However, a significant proportion of the loading on the tunnel lining is expected to manifest as axial compressive stress within the tunnel lining ring (developing a beneficial hoop stress); which enables the section to resist higher bending moments, similar to the effect of post-tensioning. Complete coupling between C&SW tunnel lining and the surrounding rock is assumed as a result of the back-grouting undertaken as part of the finishing works. As such any ground movements induced by the adjacent development is assumed to be directly applied to the C&SW tunnel lining.

Reference is made to Section 8 of the Geotechnical Desk Study for further discussion regarding specific geotechnical considerations and risks.

2.7 Third party authority approvals and requirements

Third-party approvals will be required. Relating to the structural design this will include the following:

- Sydney Metro;
- Sydney Water;
- Transport for NSW (TfNSW); &
- Utility providers relating to services within the footpaths

2.8 Reliability, Availability and Maintainability (RAM)

A reliability, availability and maintainability (RAM) strategy will be required developed in accordance with the stipulated Assurance requirements. The objective is to predict the RAM results of the site to provide confidence that the requirements specified in the Deed have been met.

2.9 Safety in Design and Assurance

A Safety Assurance Plan will be developed to define the processes and activities that support the overall project safety assurance management, safety assurance activities and safety assurance deliverables. Compliance with the safety assurance management will produce demonstrable safety deliverables supported by valid evidence that assure assets are designed, and can be constructed, commissioned, operated, and maintained to an acceptable level of safety. This acceptable level minimises risk So Far as Is Reasonably Practicable (SFAIRP).

During this process, the design shall be subject to a systematic examination of potential hazards, failures, operational and maintenance issues via a Safety in Design Workshop.

3 Preliminary Structural Design

The preliminary structural system is summarised as follows to demonstrate the viability of the Planning Proposal. System selection and geometry may change as the project progresses, but in all cases respond to the required structural performance criteria herein. Reference is made to the structural sketches attached in Appendix A.

3.1 Excavation & Retention

The basement excavation is to be extended through the shale to the sandstone bedrock within the existing footprint. All pile embedment, excavation, temporary, and any permanent anchors or rock bolts are outside of the 1st Reserve and above the substratum.

The existing permanent soldier pile and shotcrete infill retention system will be re-used as a minimum as temporary support during demolition and excavation. Inspection and material testing and examination will be undertaken to confirm performance and design life. These walls are currently propped by the existing basement and ground level slabs, and new temporary anchors and walers will need to be installed prior to demolition below ground level.

New soldier piles will be installed within the existing for both temporary and permanent retention below the level of the existing excavation. These piles will be temporarily anchored during excavation and propped by the new structure in the permanent condition.

Depending on the design life or maintenance requirements of the existing retention system, a new reinforced concrete wall may be required along the inside of the existing system, above the line of the new inner shoring piles.

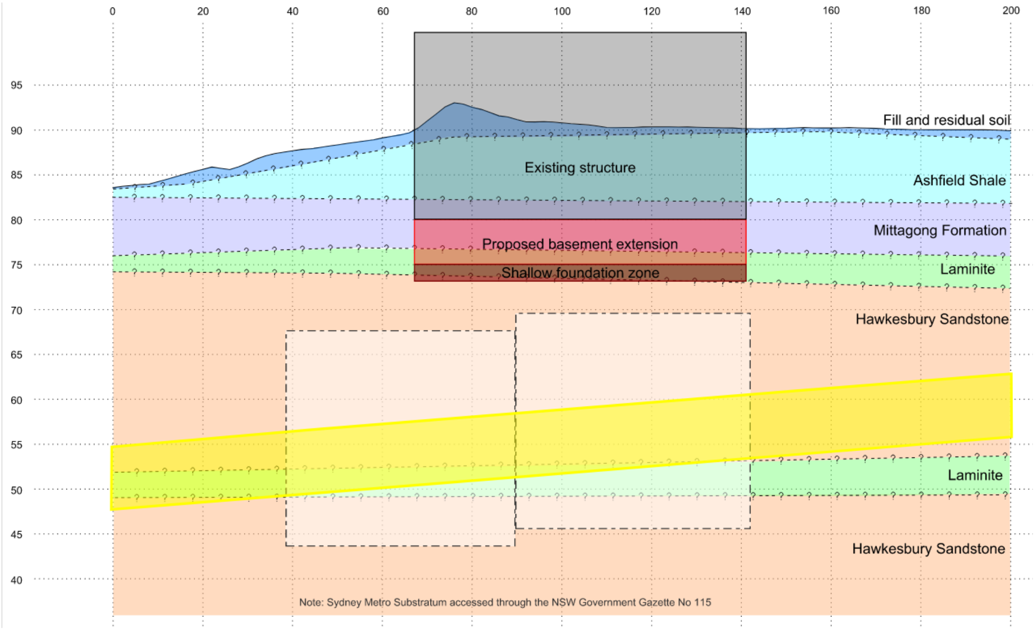


Figure 6: Relationship of proposed basement excavation to Sydney Metro tunnel reserves and founding strata

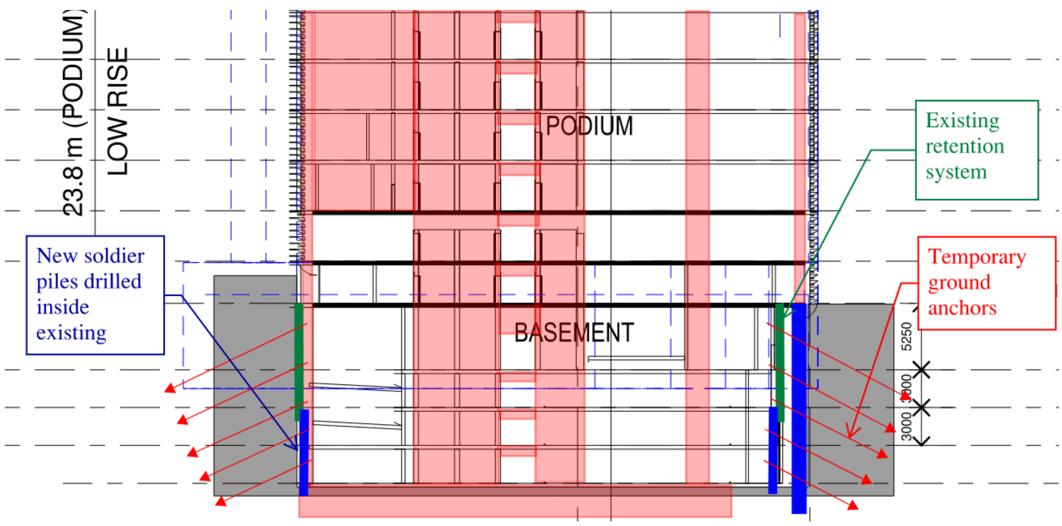


Figure 7: Basement section indicating the relationship between existing retained and new retention system to extend basement depth.

3.2 Foundation System

It is proposed to found the building predominantly on raft and pad footings on minimum Class III sandstone at the base of the proposed excavation. Bored piles terminating above the substratum will be required for lightly loaded podium columns located outside of the existing basement retention extent. Figure 8 shows a preliminary foundation arrangement selected for this purpose. A reduced core raft footprint may be feasible following detailed numerical modelling.

The predicted net increase in loading across the site is approximately 300kPa considering both replacement of the existing building and unloading from additional basement excavation. Based on preliminary empirical analysis, this foundation system and founding level allows us to spread the loads sufficiently across the site above the level of the Sydney Metro first reserve to limit the movements to well within the Sydney Metro criteria of 10mm or 1:2000 differential movement. Initial estimates are <2mm.

It is recognised that numerical modelling will be required to be undertaken at a future stage in compliance with the requirements of NWRLSRT-PBA-SRT-TU-REP-000008, however given the results of our empirical study we do not believe that this is necessary for the Planning Proposal.

Reference is made to Section 8 of the Geotechnical Desk Study for further discussion regarding specific geotechnical considerations and risks.

Figure 8: Preliminary foundation arrangement for indicative concept.

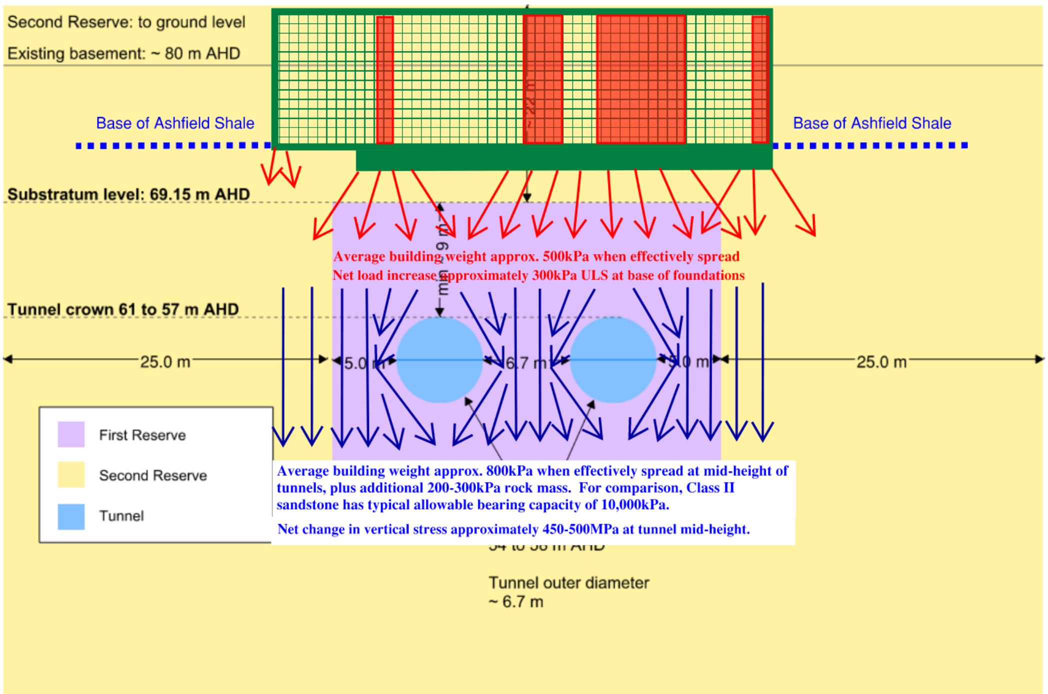


Figure 9: Anticipated vertical stress change at tunnel level

3.3 Vertical Structure

For the indicative concept, conventional high strength reinforced concrete columns are proposed, with all tower columns extending continuously from foundation to roof level. Composite columns may be used through the basement and podium levels to jump start construction or minimise column size for planning purposes. Additional basement and podium columns are provided both at the perimeter floor extensions, and to reduce spans through the centre of the site in the basement, loading dock, and lobby higher loading and articulated areas.

Columns will be transitioned to accommodate the steeping profile at the top of the building. A hanging column from L25 is provided to support the cutaway slabs at the SE corner at Levels 23 and 24.

The lift and services core is proposed to be of reinforced concrete jump-form construction including the podium lifts. Transition is required in the core at the top of the podium, with the eastern and western stair and riser zones added and the core configured to span the basement ramping.

3.4 Stability System

Stability is provided primarily by the reinforced concrete core, with outriggers at the Level 24 plantroom level coupled to the southern tower columns to enhance the relatively narrow north-south core width and resist wind loads using the full structural width to minimise foundation impact and alleviate net tension. Preliminary lateral analysis in ETABS has been undertaken to assist proportioning core wall thickness and confirm expected performance.

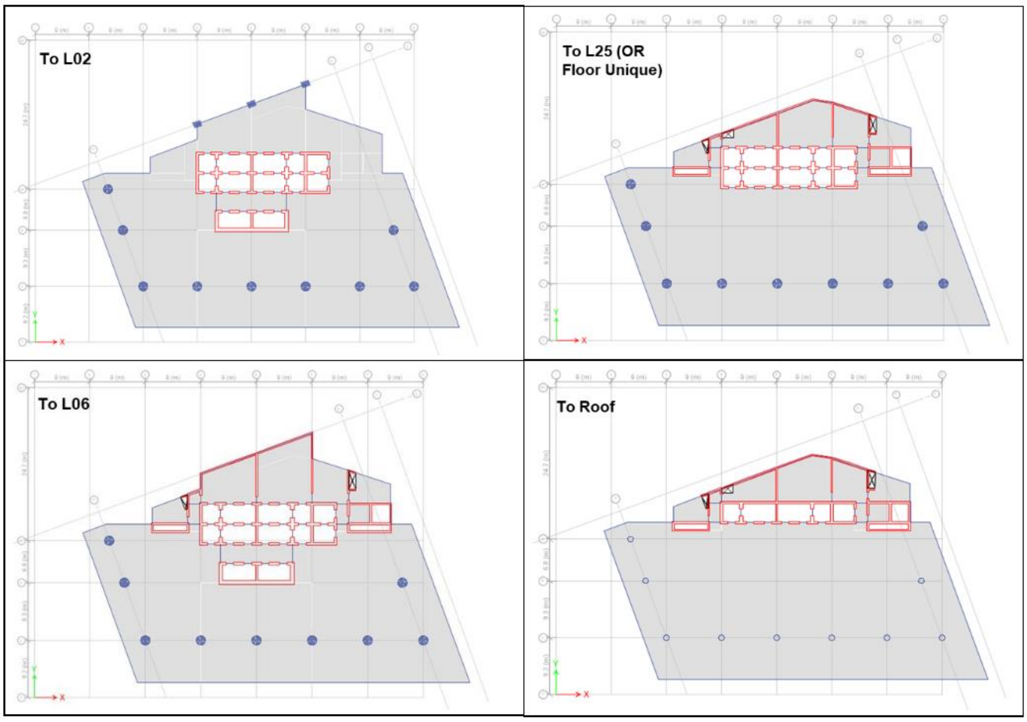


Figure 10: Core plans from the ETABS model showing structural core zoning over the tower

3.5 Floor Systems

3.5.1 Basement

Banded reinforced concrete slabs are proposed for the basement levels designed for the appropriate varying loading conditions. These diaphragms will also provide permanent restraint to the perimeter retention system.

3.5.2 Podium & Typical Floors

Banded post-tensioned floor slabs are proposed, with band beams of up to 650 thick required to facilitate clear spans of up to 18m and cantilevers up to 6m. Bands will be tapered and stepped at the cantilever to minimise structural mass and to facilitate higher ceilings. Slabs will be nominally 160 thick at the interior zones and thickened to the east and west for the longer span areas and as required for the cantilevers.

4 Design Standards and Sources of Reference

4.1 General

The design and documentation of the building and associated works shall comply with current editions of:

- Relevant Australian Standards;
- the Building Code of Australia;
- Sydney Metro/TfNSW standards and requirements where applicable;
- Asset Standards Authority (ASA) Network Rail Standards where applicable;
- Standards and accreditation of the Office of the National Rail Safety Regulator (ONRSR) where applicable; &
- RMS standards and requirements where applicable.

Client and design brief requirements shall be considered in addition where appropriate.

Requirements stipulated under any Delivery Deed executed between the Client and TfNSW, Sydney Metro, Sydney Trains, RMS, Sydney Water or other related government entity shall be adhered to.

Standard Specifications or Codes of the British Standards Institute (BS) or the American Society for Testing and Materials (ASTM) are referenced only when a relevant SAA publication does not exist. Current editions shall apply, as above specified.

4.2 BCA Structural Provisions

Importance Level of Building:

- 3 - Structures designed to contain a large number of people

Design Events for Safety	Annual Probability of Exceedence
Wind	1:1000
Earthquake	1:1000

4.3 Codes and Standards

The following codes and standards will form the basis for the structural design:

Table 2: Relevant Australian Standards

Code	Title
AS/NZS 1170.0	Structural design actions – General Principles
AS/NZS 1170.1	Structural design actions – Permanent, imposed, and other actions
AS/NZS 1170.2	Structural design actions - Wind actions

AS 1170.4	Structural design actions – Earthquake actions in Australia
AS 1720.1	Timber Structures Code - Design Methods
AS 2121	Cold Formed Steel Structures Code
AS/NZS 2312	Guide to the protection of structural steel against atmospheric corrosion
AS 2327	Composite structures
AS 3600	Concrete Structures Code
AS 3700	Masonry Code
AS 3735	Concrete Structures for Retaining Liquids
AS 4100	Steel Structures Code
AS4678	Retaining Structures Code
AS 5100	Bridge design
BS 5950-8	Structural use of steelwork in building – Code of practice for fire resistant design
BS 8102:1990	Code of practice for protection of structures against water from the ground
BCA	Building Code of Australia

Table 3: Relevant ASA standards

T HR CI 12051 ST	Development near rail tunnels 15 Nov '18
T HR CI 12080 ST	External Developments 10 Nov '18
T MU CI 12140 GU	Geotechnical Instrumentation and Monitoring
SMS-06-GD-0268	Working around Electrical Equipment
ESC 510	Boundary Fences
T MU AM 04001 PL	TfNSW Configuration Management Plan
T MU MD 00009 F1	AEO Engineering Services Matrix
T MU MD 00014 GU	Multi-Discipline Rail Infrastructure Design Management
T MU MD 20001 ST	System Safety Standard for New or Altered Assets
T MU MD 00006 TI	Technical Information for CAD and Engineering Drawings
T MU MD 00006 ST	Engineering Drawings and CAD Requirements

4.4 Design References

Table 4: Relevant design references

Number	**Title**	**Author**
CCIP-016	Guide on the Vibrations of Floors	The Cement & Concrete Association

CIRIA C660:	Early-age thermal crack control in concrete	CIRIA
CIRIA r139	Water-resisting basements	CIRIA

4.5 Computer Software

The following programs will be used in the design and analysis of the structure:

Table 5: Computer software

Program	Function
ETABS	Building analysis & design
STRAND7	Finite element analysis program
Oasys GSA	General structural analysis
Oasys Compos	Compos (composite beam design)
RAPT	Reinforced and prestressed concrete design
RAM	Concrete and composite floor design
Limsteel	Structural steel design
Limcon/Statica	Steel connection design

4.6 Specifications

Specifications will be prepared for:

- Piling;
- Concrete;
- Structural steelwork;
- Composite construction; &
- Structural masonry.

5 Loads

5.1 General

All design loads shall be selected and applied in accordance with the relevant Australian Standard, specifically AS/NZS1170.1 to 1170.4, and the BCA.

5.2 Dead Loads

Dead loads should be calculated on the basis of the following densities:

- Reinforced concrete: 24.5 kN/m³
- Steel: 78.5 kN/m³

5.3 Superimposed Dead Loads and Live Loads

The structure will be designed for the following uniformly distributed imposed loads. Superimposed dead loads include floor finishes, ceiling, services, and partitions. Concentrated loads will be in accordance with AS/NZS1170.1.

Live load reduction will be in accordance with AS/NZS1170.1.

Ground level and potentially other basement and podium slabs may require provision for construction loading of up to 20kPa.

Table 6: Imposed loads schedule

Area	**Superimposed Dead Load**	**Live Load**
Offices	1.0 kPa moveable partitions 0.45 kPa raised floor 0.5 kPa ceiling and services	3.0 kPa
Compactus Zones	0.45 kPa raised floor 0.5 kPa ceiling and services	7.5 kPa storage areas over 5% office floor area in accordance with PCA Premium Grade
Foyer (including stairs and landings)	2.0 kPa finishes 0.5 kPa ceiling & services	5.0 kPa
Retail tenancies	2.0kPa finishes 1.0kPa partitions 0.5kPa ceiling and services	5.0kPa
Terraces (including stairs and trafficable roofs)	2.5 kPa finishes 0.5 kPa ceiling & services	4.0 kPa
Public Plaza and pedestrian laneways	3kPa finishes 0.5 kPa ceiling and services	5kPa generally 15kPa where emergency vehicle access.
Egress stairs and landings	0.5kPa	4.0 kPa

Kitchens	2.0kPa	5.0kPa
Carparking	0.25 kPa	2.5 kPa
Loading dock and driveways	0.5 kPa	12 kPa minimum to be confirmed based on vehicle type. Concentrated wheel loads assessed on vehicle or AS5100.
Plant Areas	3.0 kPa partitions and plinths 0.5 kPa ceiling and services	As calculated for relevant use. 5.0 kPa minimum
Tank rooms	3.0 kPa plinths	Tank volume as calculated. Minimum 20 kPa
Substation and main switchroom	As calculated trenches and plinths in accordance with approved substation design	7.5 kPa
Non-trafficable concrete roofs	2.5 kPa finishes 0.25 kPa ceiling & services	2.0 kPa BMU loads as provided by the supplier.
Lightweight roofs	As calculated	Generally 0.25 kPa Street awnings 1.0 kPa

5.4 Wind Loads

Wind loading will be in accordance with AS 1170.2 SAA Wind Loading Code.

For global stability design and assessment of accelerations, wind tunnel testing by high-frequency integrated pressure (HFPI) or high frequency force-balance (HFFB) techniques will be conducted by the wind consultant with the mass, stiffness, and dynamic properties of the structure provided by Arup.

Façade pressure tests will also be undertaken, and these results will be used for the structural design of individual components and may also be numerically integrated and calibrated as a check on the results of the HFFB.

The following design parameters have been assessed for the building in accordance with AS 1170.2:

Table 7: AS/NZS1170.2 design criteria

Parameter	Value
Region	A2
Basic wind speeds: Ultimate, V_{1000} Serviceability, V_{20}	 46 m/s 37 m/s
Terrain category, TC	As calculated by direction
Structure height, Z	Varies by direction
Variation of wind speed with height, $M_{(z,cat)}$	As calculated
Structural importance multiplier, M_i	1.0
Topographic multiplier, M_t	As calculated

Shielding multiplier, M_s	As calculated
Minimum internal pressure coefficient, $C_{p,i}$	+0.2/-0.3 generally
Area reduction factor, K_a #	As calculated, 0.8 minimum
Combined action reduction factor, K_c #	As calculated, 0.8 minimum
Local pressure coefficients	As calculated

Note: # denotes minimum K_a x K_c = 0.8.

5.5 Seismic

Earthquake loading applied to the structural elements and detailing of the seismic stability system will be in accordance with:

- AS 1170.4 – 2007: Earthquake actions in Australia for building structures:

Specific AS 1170.4 seismic data is summarised as:

Table 8: AS/NZS1170.4 design criteria

Parameter	**Value**
Importance level	3
Hazard factor, Z	0.08
Site sub-soil class	Be-Rock
Importance level, I	3
Annual probability of exceedance	1/1000
Probability factor, k_p	1.0
Design earthquake category	II
Structural system	Table 6.5(A) AS 1170.4

The structure shall be analysed by dynamic modal analysis in accordance with AS 1170.4.

5.6 Structural Robustness & Disproportionate Damage

The structure will be designed to comply with the requirements of AS/NZS1170.0 Section 6. This includes requirements for minimum levels of lateral resistance (notional horizontal load), connections, and tying.

5.7 Earth Pressure Loading

Earth retaining structures shall be designed in accordance with the recommendations in the Geotechnical Investigation report.

Retention at boundaries will be designed for surcharge in accordance with AS 5100.2-2004, with a minimum magnitude of 10kPa.

5.8 Water Pressure Loading

Groundwater is expected to be situated in a perched water table in the alluvium above the sandstone bedrock, and below the lowest basement level in the bedrock. Water ingress will be limited to flow at the top of the sandstone bedrock and through seams and joints following periods of rainfall.

Basement retaining walls will be required to control groundwater above the level of the sandstone bedrock, and below this level drained with a subsoil drainage system located at the lowest basement level to catch any seepage through and over the sandstone bedrock. Permanent electric pumps will be provided within a sump arrangement connected to the stormwater discharge system.

5.9 Accidental Horizontal Loads

All loading in accordance with AS/NZS1170.1.

Table 9: balustrade loading schedule

Location	UDL	Concentrated load
Terrace balustrades	1.5 kN/m	0.6kN
Stairs, landings, walkways in gallery and foyer areas	1.5 kN/m	0.6kN
Offices	0.75 kN/m	0.6kN
Egress stairs, landings, walkways	0.75 kN/m	0.6kN
Maintenance walkways & stairs	0.35 kN/m	0.6kN
Car park parapets, walls, barriers		In accordance with AS/NZS 1170.1. 30 kN generally 40 kN loading dock 240 kN at base of ramps > 20m long
Delivery area columns		40 kN

5.10 Imposed Movements

The effect of imposed movements on the structure will be considered in the calculations. These include the following types of movement:

Table 10: Imposed movements schedule

Parameter	Value
Settlement	1% of footing width at allowable bearing pressure
Temperature (exterior elements)	Mean temp 20°C. Maximum range for exterior steelwork +5°C to +65°C (not painted black)

Shrinkage	As calculated for vertical structure or floor slabs
Creep	As calculated for vertical structure and post-tensioned floor slabs
Elastic shortening	As calculated for vertical structure and post-tensioned floor slabs

5.11 Blast

It is not intended to design the structure for any specific blast requirements.

6 Serviceability

6.1 Design Life

The structure will typically be designed for a 40 to 60-year design life in accordance with the BCA and SAA material standards.

Reference should be made to the relevant material standard regarding maintenance construction and maintenance assumptions that form the basis of the design code.

6.2 Serviceability Limit States

In accordance with AS/NZS1170.0 to Part 4 and the relevant material standard.

6.3 Deflection Limits

The following deflection limits are proposed for the building structure. Further reference may be made to Table C1 of AS/NZS1170.0.

Table 11: Deflection limits schedule

Element	**Deflection (total load UNO)**	
Beams and Slabs:	Spans	Cantilevers
Generally	L/250 (up to 40mm max. at centre of panels)	L/125 (up to 40mm max at centre of panels)
Live load only	L/360	L/180
Supporting articulated masonry	L/500 (incremental)	L/250 (incremental)
Supporting unjointed masonry	L/1000 (incremental)	L/500 (incremental)
Supporting curtain wall and glazed assemblies	L/500 or 18mm max	L/250 or 18mm max
Transfer structures (cumulative at location of element transferred)	L/1000 or 12mm max	L/500 or 12mm max
Roof beams under wind load (other than glazed roofs)	L/200	L/100
Wind columns	L/240	L/120
Wind sway SLS		H/500
Storey drift under wind SLS		h/400
Storey drift under seismic ULS		1.5%h
Differential settlement	L/1000	L/500

6.4 Floor Vibrations

Vibration of superstructure floors is controlled by checking the natural frequency and response. Verification calculations will be conducted to the Cement and Concrete industry publication CCIP-016 `A Design Guide for Footfall Induced

Vibration of Structures', and The Steel Concrete Institute publication SCI P354 'Design of Floors for Vibration: A new approach'.

Table 12: Floor dynamics design criteria

Space	Target Response Factor	Walking frequency	Damping
Offices	R = 6 generally R = 8 in low sensitivity areas	1.8-2.0 steps/sec 2.5 steps/sec	3.5% representing open plan normal office fit-out.
Foyer	R = 8-10	2.5 Hz	2.5% representing open-plan sparsely furnished floor.
Internal bridges	R = 16	2.5Hz	1%

6.5 Tall Building Acceleration

The dynamic response of tall buildings due to wind loading may be significant in terms of both member design and user comfort. Depending on the building and structural properties, the dynamic sway motion may be perceptible to the users of the building, and therefore the building must have sufficient stiffness and damping to maintain accelerations to levels acceptable to the occupants. Building motions can occur both in the direction of the wind (along-wind), orthogonal to the wind (crosswind), and in torsion.

Accelerations will be estimated based on the structural modelling and wind tunnel regime as discussed in Section 5.4.

The predicted maximum acceleration at the top of the building under a wind with annual, 5 year, and 10-year return periods is compared against internationally accepted criteria defining population acceptance of accelerations as defined in ISO10137, ISO6897, and NBCC respectively.

Table 13: Selected serviceability design criteria

Criteria	Proposed Limit	Notes
Building accelerations # (critical at highest occupied floor)		
Annual peak, ISO 10137	13.8mg at f=0.15Hz 12.2mg at f=0.20Hz 10.4mg at f=0.30Hz	Frequency dependant
10-year peak, NBCC	25-30mg	
5-year standard deviation, ISO 6897 (Irwin)	5.7mg at f=0.15Hz 5.1mg at f=0.20Hz 4.4mg at f=0.3Hz	Frequency dependant

Critical to the calculation is the structural damping ratio. The damping ratio is a natural property of the structural form, materials and finishes. And will be selected once the structural system and materiality are further developed.

For a concrete based superstructure and stability system the following criteria are appropriate:

- Serviceability wind damping: = 1-1.5%
- Ultimate wind damping; = 3%

Supplementary damping will be provided if required.

6.6 Concrete

6.6.1 Durability

The requirements of AS 3600 will be applied to all reinforced concrete.

Structural requirements for certain elements may increase concrete strengths above the minimum required for durability.

6.6.2 Crack Control

The degree of crack control to be provided in concrete elements will be in accordance with AS 3600.

6.7 Steelwork Corrosion Protection

The corrosion protection for the structural steelwork will be dependent on the location of the steel elements within the building. Systems will be selected in accordance with AS/NZS 2312 as a minimum specification.

Internal steelwork which is in marginally damp areas where occasional condensation may occur, such as around the building perimeter and in the vehicle and plantroom areas, will require a higher level of protection than inside the air-conditioned office space which is permanently dry. For both these internal environments it is assumed that there is no access for maintenance, and either a hot dip galvanised (HDG) or multi-build paint system will be specified.

A high standard corrosion protection system is required for all exposed steelwork and will require maintenance during the life of the building. A design life of 25 years and warranty period of 10-15 years from the coating supplier and applicator may be expected.

Care must be taken during handling, transport, and erection to minimise damage to the coating system that will require making good on site and compromise long-term performance. This may include wrapping of elements.

The paint system for corrosion protection must be compatible with any required Fire Protection.

6.8 Fire Resistance Levels for Structural Elements

Fire resistance levels for structural elements shall be determined in accordance with the Building Code of Australia, Ausgrid, and any subsequent approved relaxations based on approved fire engineered approaches.

Concrete covers are to be in accordance with AS 3600. The fire rating of blockwork walls is to be shown on the architect’s schedule.

Structural steel elements shall be provided with passive protection or designed based on limiting temperatures. A fire engineered approach including detailed may be adopted to both reduce the extent of passive protection from the deemed-to-satisfy requirements.

6.9 Protection of Basements from Groundwater

The design of the basement walls and floors are to be such as to provide acceptable environmental conditions for the Client.

There are no relevant Australian standards. BS 8012:1990 will be used as a design guide, which describes four grades of environment to be achieved, and three appropriate types of construction.

7 Materials

The following structural materials are used in the works. Typical design properties of these materials are listed. These values are to be adjusted and enhanced as appropriate during the detailed design of the structure, and specialist materials may be investigated and specified as appropriate.

7.1 Concrete

In accordance with AS3600.

Table 14: Concrete properties

Parameter	Value
Grades, f'c	32 to 100 MPa
Short-term E	As calculated
Coefficient of thermal expansion	10×10^{-6} per °C
Basic shrinkage strain	As calculated and specified
Basic creep factor	As calculated
Poisson's ratio	0.2
Density Mass concrete Reinforced concrete	 24 kN/m^3 25 kN/m^3

7.2 Reinforcement

In accordance with AS/NZS4671 and AS/NZS4672.1.

Table 15: Reinforcement properties

Parameter	Value/Designation
Plain 'R" bars	R250N
Deformed 'N' bars	D500N
Welded wire fabric	D500L & D500N
Young's modulus	205 x 10^3 MPa
Post-tensioning strand (superstrand)	∅12.7mm fpb = 1870 MPa ∅15.2mm fpb = 1790 MPa (min)

7.3 Structural steel

In accordance with AS4100.

Parameter	Value
Steelwork density	7850 kg/m^3
Yield stress	fsy = 250 to 400 MPa
Young's modulus	205 x 10^3 MPa

Poisson's ratio	0.3
Coefficient of thermal expansion	11 x 10 $^{-6}$ per °C

7.4 Timber

Timber shall be selected and designed in accordance with AS1720.1 and 2.

7.5 Foundation Materials

The foundations will be designed based on advice from the geotechnical engineer. The following foundation design parameters are appropriate for foundations on sandstone:

Rock Quality	SLS (kPa)		ULS (kPa)		Young's modulus (E) (MPa)	
	Bearing	**Adhesion#**	**Bearing**	**Adhesion#**	**Static**	**Dynamic**
Class IV sandstone	1,000	100	3,000	150	100	300
Class III sandstone	4,000	400	20,000	800	1,000	3,000
Class II sandstone	8,000	800	80,000	2,000	2,000	6,000
Class I sandstone	12,000	1200	120,000	3,000	3,000	9,000

Notes:

- Sandstone quality in accordance with Pells et al.
- Shaft adhesion is in compression. Apply a 0.7 factor for tension
- # denotes surface roughness as specified by the geotechnical engineer. 50% of this value to be used in tension.
- Appropriate geotechnical factors shall be applied at ULS in accordance with AS2159.
- SLS bearing values are based on settlement of 1% of footing width
- Spoon testing or proof coring requirements vary with rock quality. Nominally 33% of footings for Class III/IV, 50% for Class II, and 100% for Class I.

7.6 Retention

The retention system will be designed based on advice from the geotechnical engineer. Where appropriate, the geotechnical engineer shall undertake staged soil structure analysis of the retention system and provide actions for the design of the structural elements by the structural engineer. Geotechnical stability will remain the responsibility of the geotechnical engineer.

The following information is provided for drained material. Consideration of hydrostatic pressure shall be based on both the ground water levels and drainage provision above the water table. Consideration shall be given to burst water mains.

Unit	Bulk unit weight (kN/m^3)	Effective Cohesion (kPa)	Effective friction angle	Active earth pressure coefficient (Ka)	At rest earth pressure coefficient (Ko)	Passive earth pressure coefficient (Kp)
Fill	18	0	30	0.33	0.5	3
Class IV/V sandstone & shale	23	30	35	0.27	0.43	3.7

Note:

- Class III and better sandstone may be cut vertically. Adequate measures shall be provided locally for adverse jointing.

7.7 Greenstar & Sustainable Design

7.7.1 General

Reference is made to the to the requirements of the sustainability consultant for:

- Concrete mix requirements – specifically Portland cement and natural aggregate replacement with industrial waste products;
- Steel reinforcement – recycled content and prefabrication; &
- Structural steel – recycled content and design for disassembly.

Concrete mix design shall comply with both the structural performance criteria as specified by the structural design, and the constituent requirements for compliance with the selected Greenstar rating.

7.7.2 Materials

The Green Star points relating to building materials are being targeted as part of the structural design scope:

- **Life Cycle Impacts:** Performance Pathway - Life Cycle Assessment and impact reporting
- **Responsible Building Materials:** To reward projects that include materials that are responsibly sourced or have a sustainable supply chain.

The structure has been designed to facilitate achievement of these points by incorporation of the following:

- At least 30% replacement by mass of Portland Cement in all concrete with supplementary material;

- At least 40% of coarse aggregate in the concrete is crushed slag aggregate or at least 25% of fine aggregate (sand) inputs in the concrete are manufactured sand, or another alternative material, (provided that the use of such materials does not increase the use of Portland cement by over five kilograms per cubic metre of concrete);
- 95% of the building's steel (by mass) is to be sourced from a Responsible Steel Maker;
- For concrete framed buildings, at least 60% (by mass) of all reinforcing bar and mesh is produced using energy-reducing processed in its manufacture (measured by average mass by steel maker annually).
- At least 100% (by cost) of all timber used in the building and construction works is either certified by a forest certification scheme or is from a reused source; &
- 90% (by cost) of all permanent formwork has an EPD or meets Best Practice Guidelines for PVC.

8 Conclusion

This structural engineering report assesses the structural feasibility of the indicative concept design scheme prepared by Architectus to inform the Planning Proposal. The studies undertaken and outcomes described in this report demonstrate that the site is capable of accommodating future development aligned with the proposed planning control changes, including compliance with the appropriate Sydney Metro corridor protection guidelines, the National Construction Code, and relevant Australian Standards.

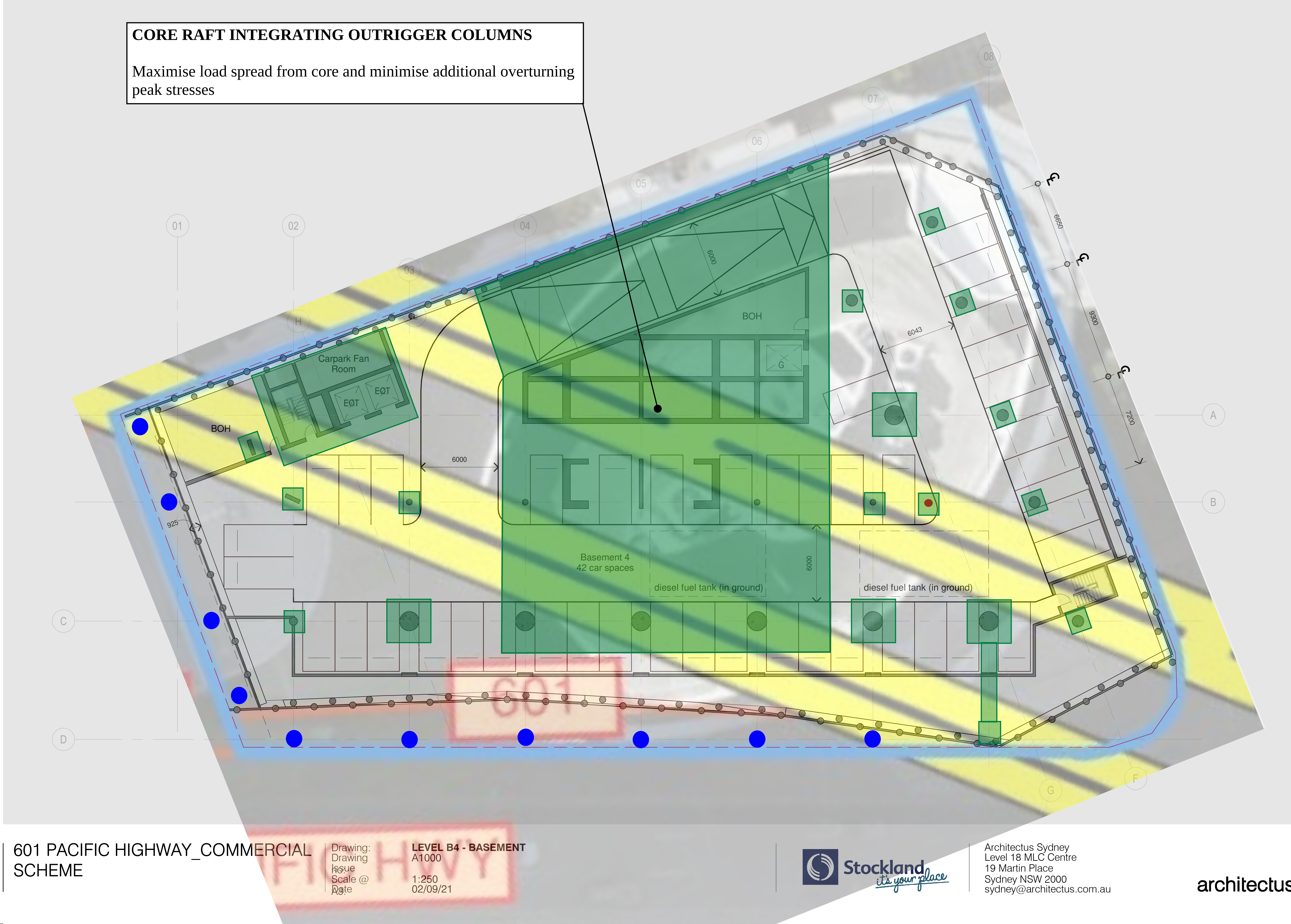
A comprehensive assessment of the structural impacts associated with a detailed development proposal will be required as part of a future development application for the site.

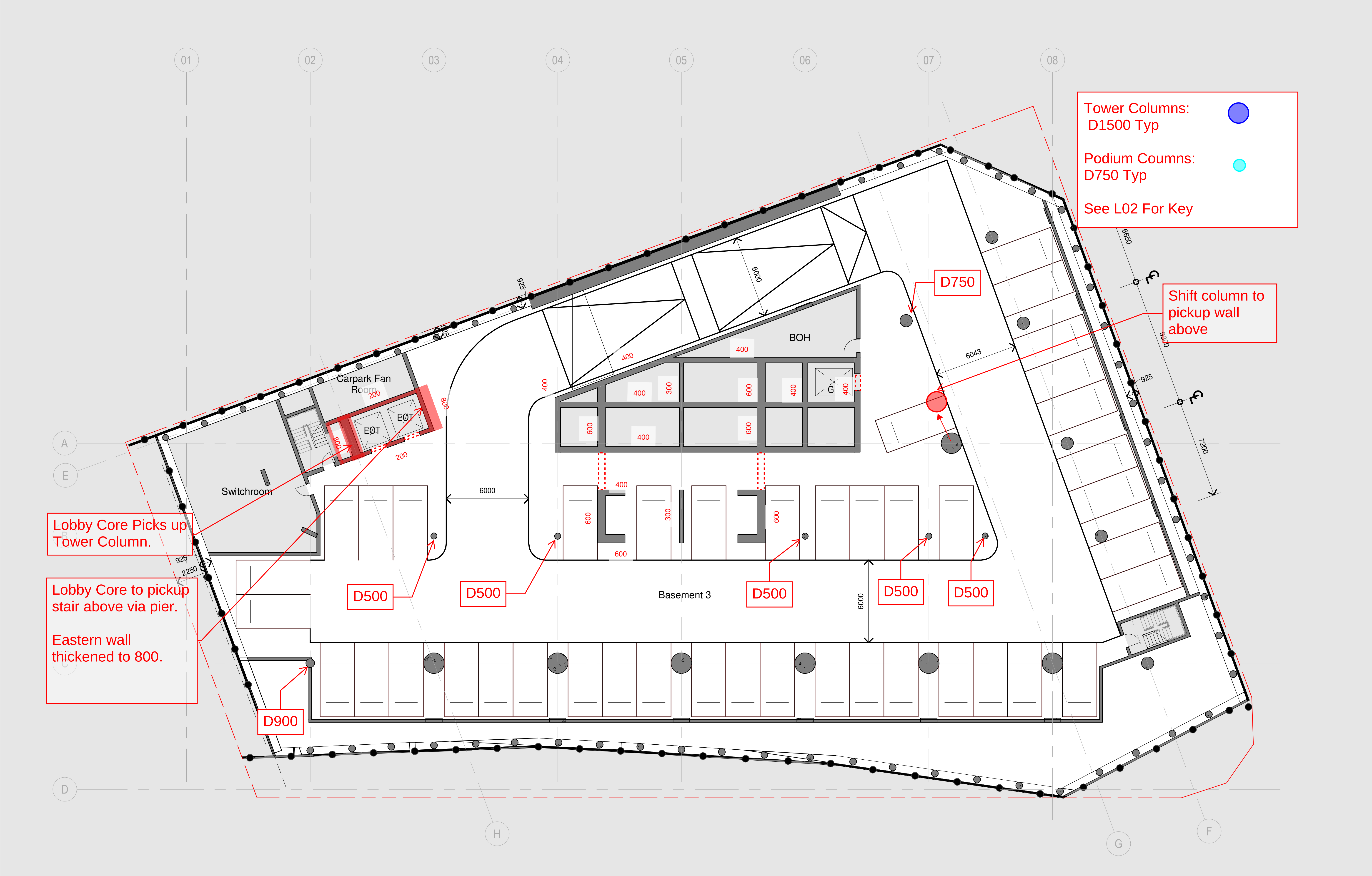
Appendix A

Preliminary Structural Sketches

CORE RAFT INTEGRATING OUTRIGGER COLUMNS

Maximise load spread from core and minimise additional overturning peak stresses





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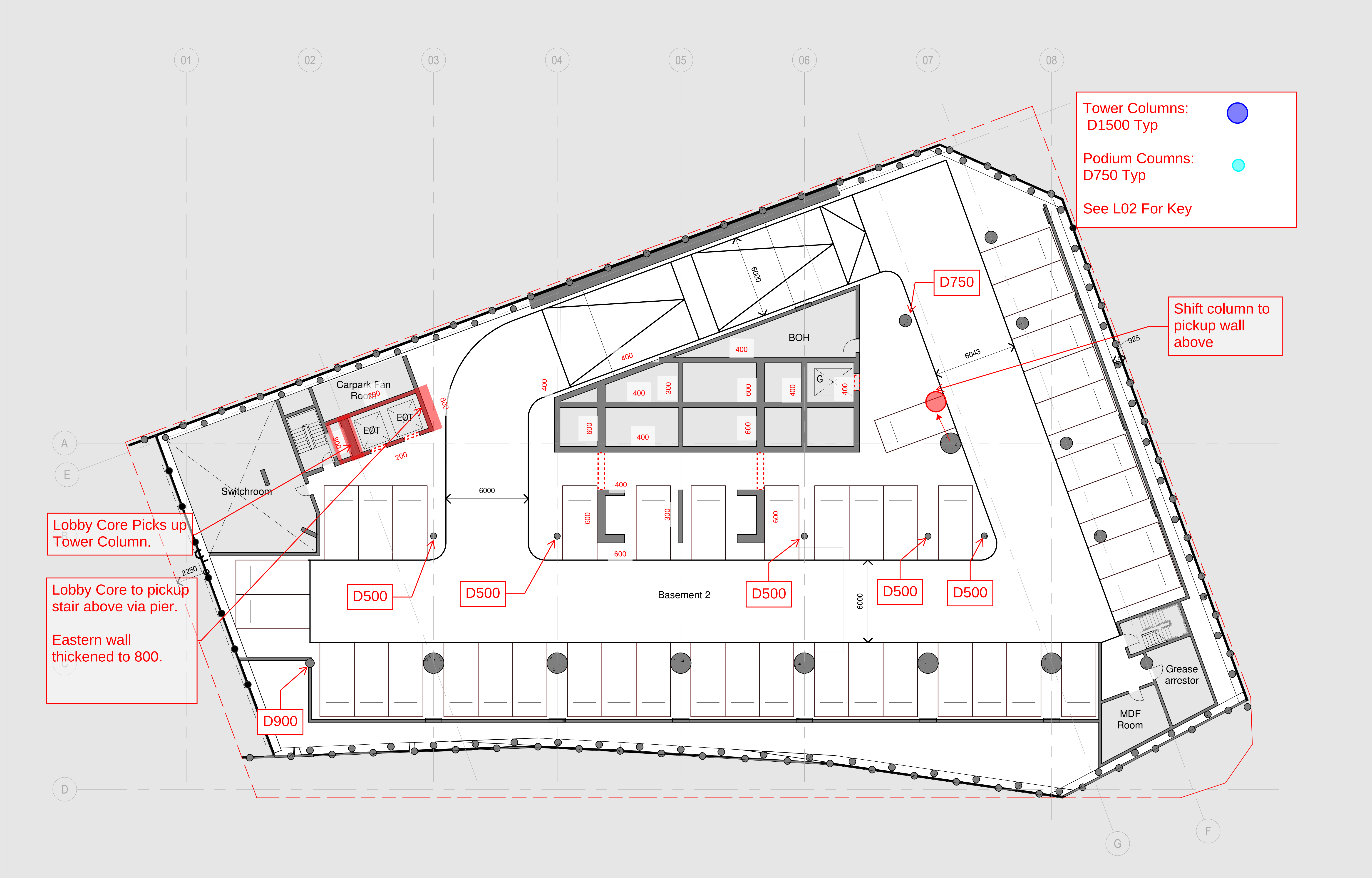

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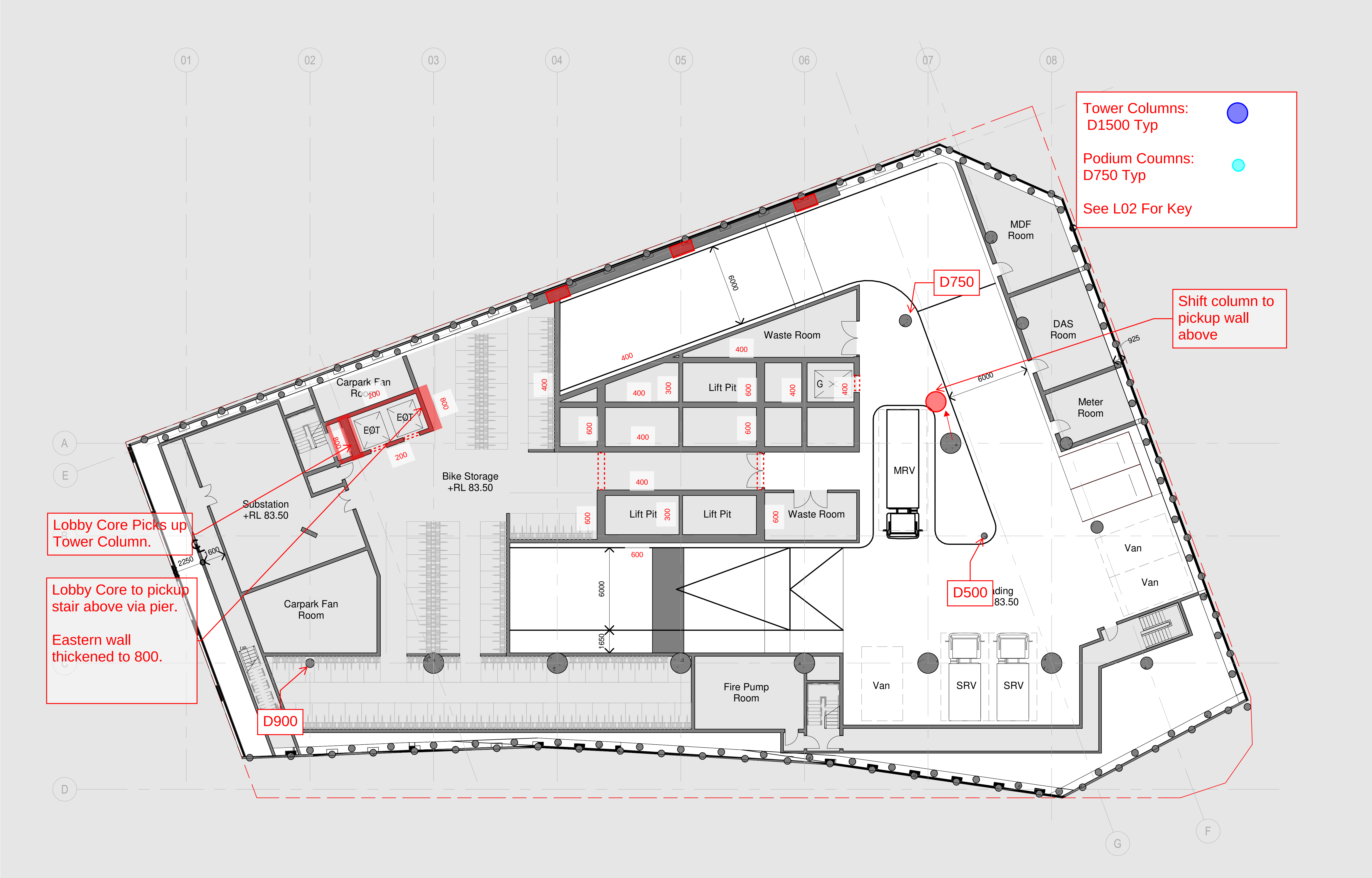

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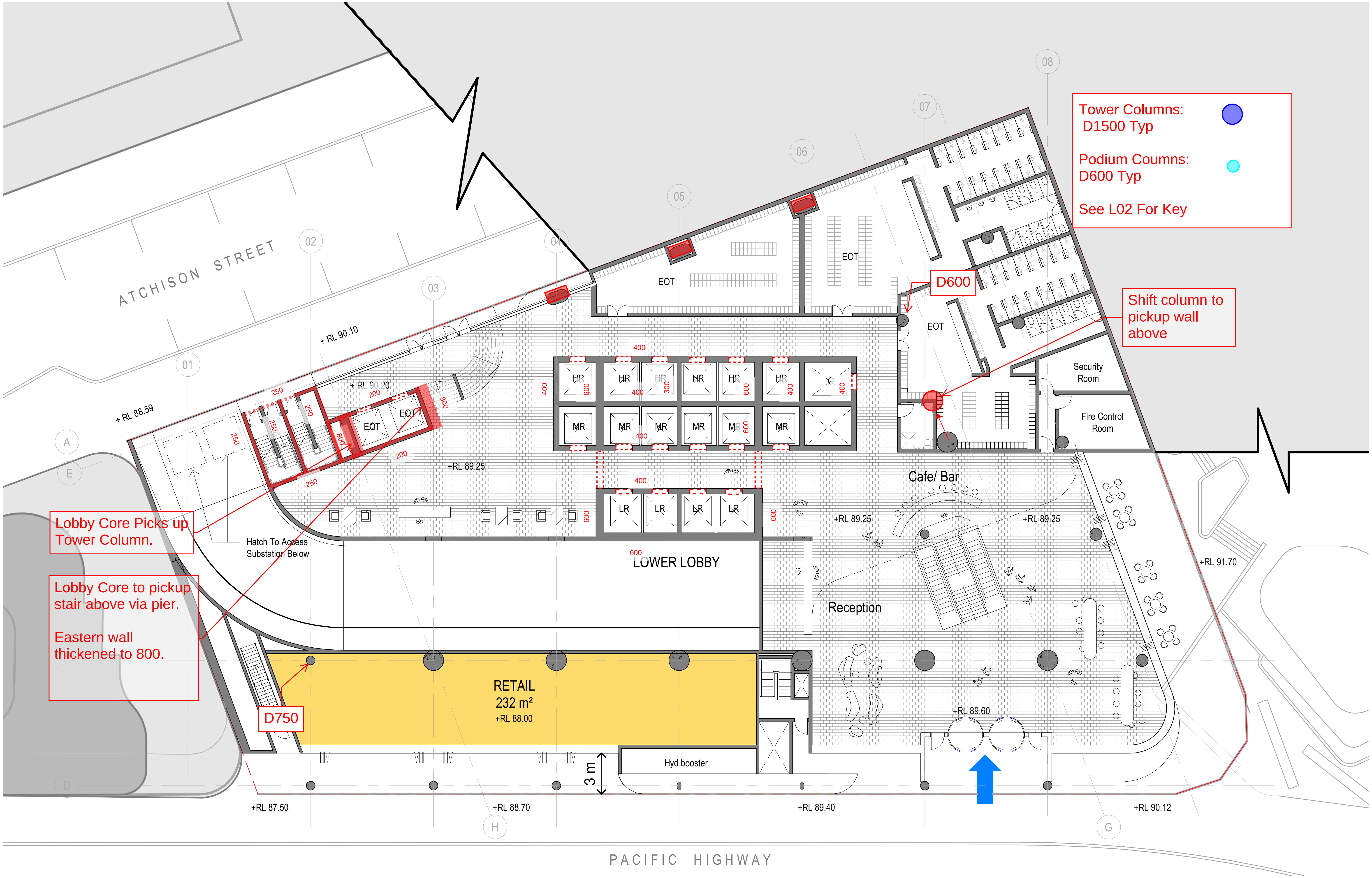

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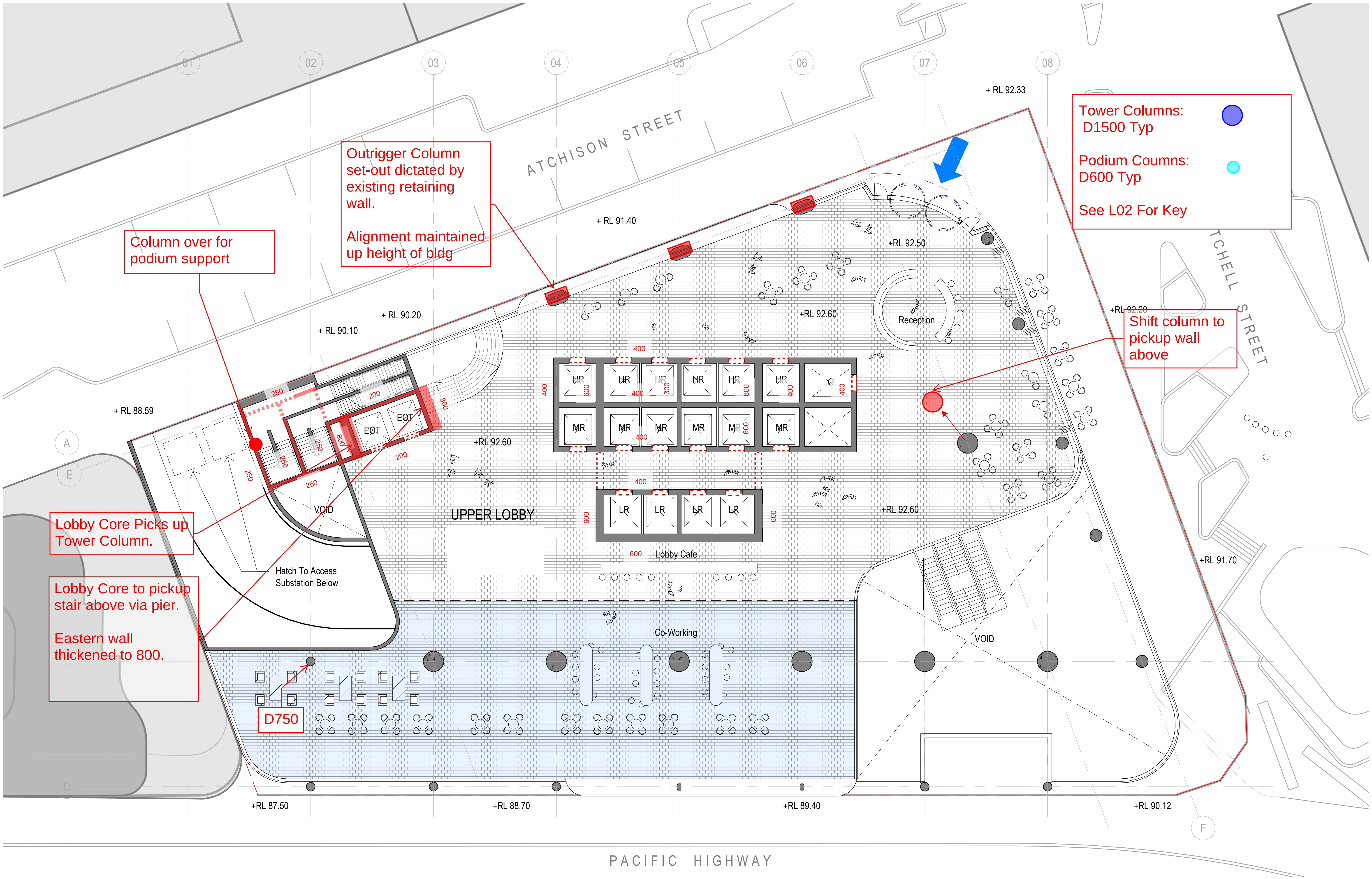

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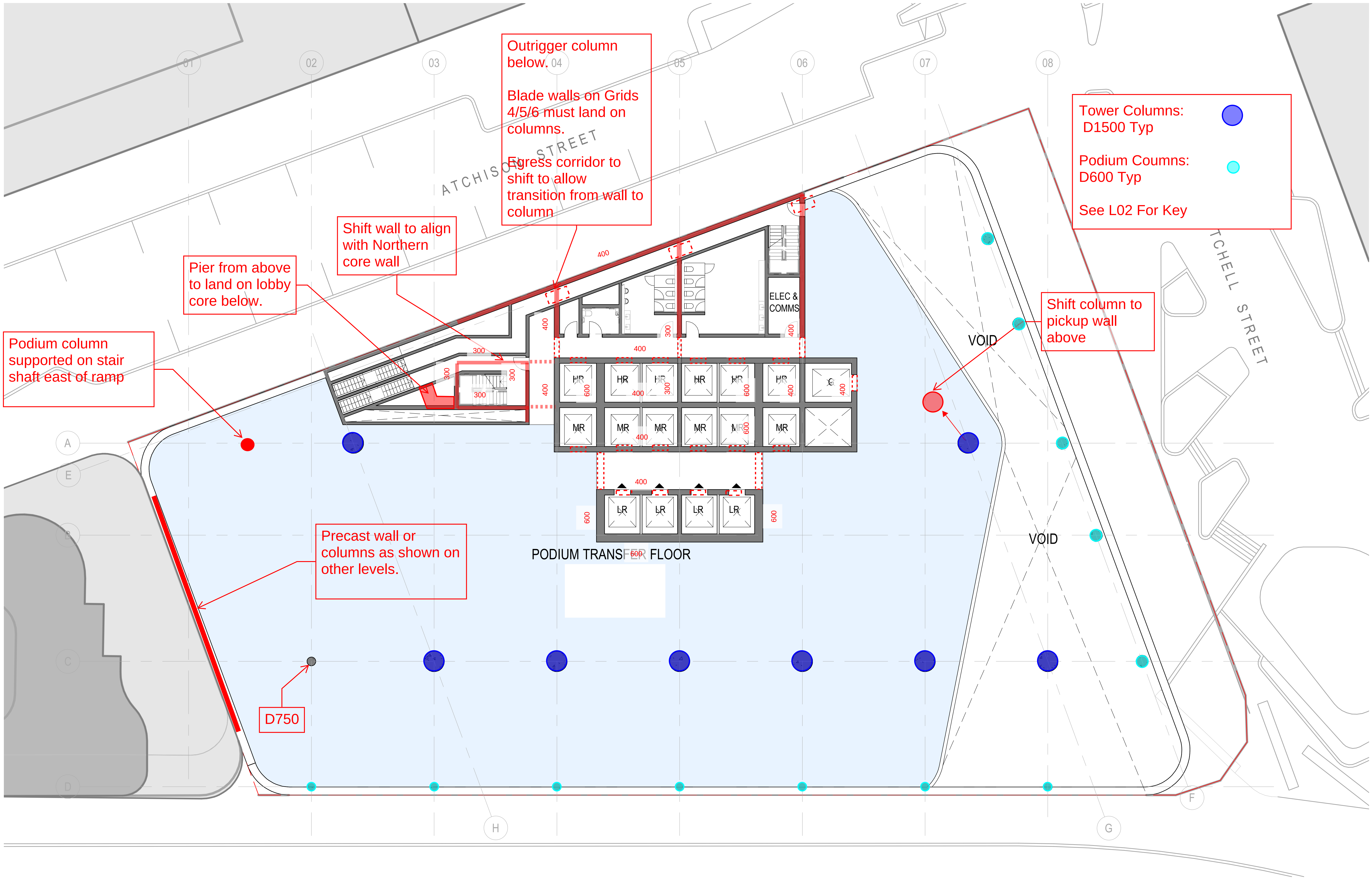

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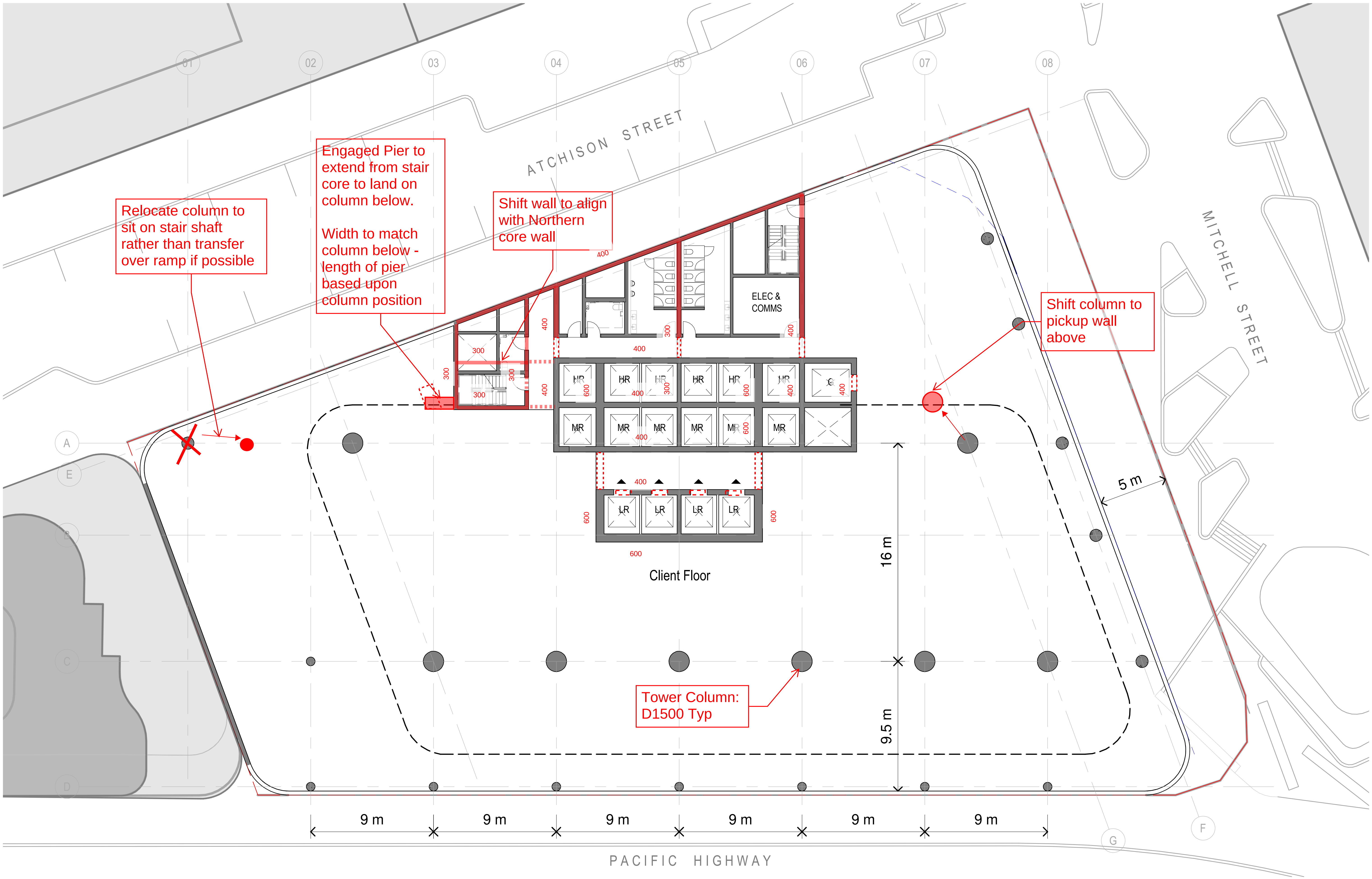

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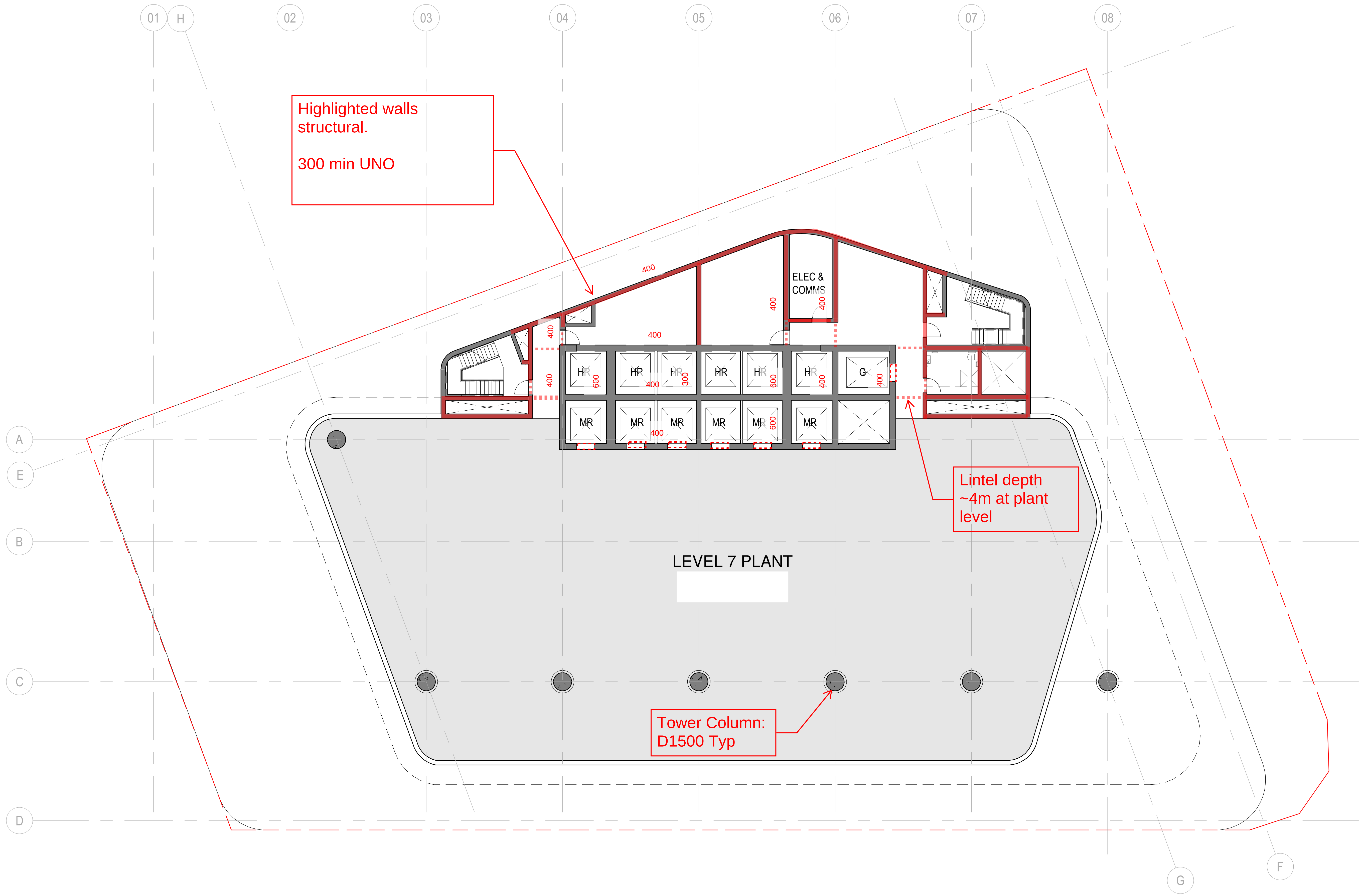

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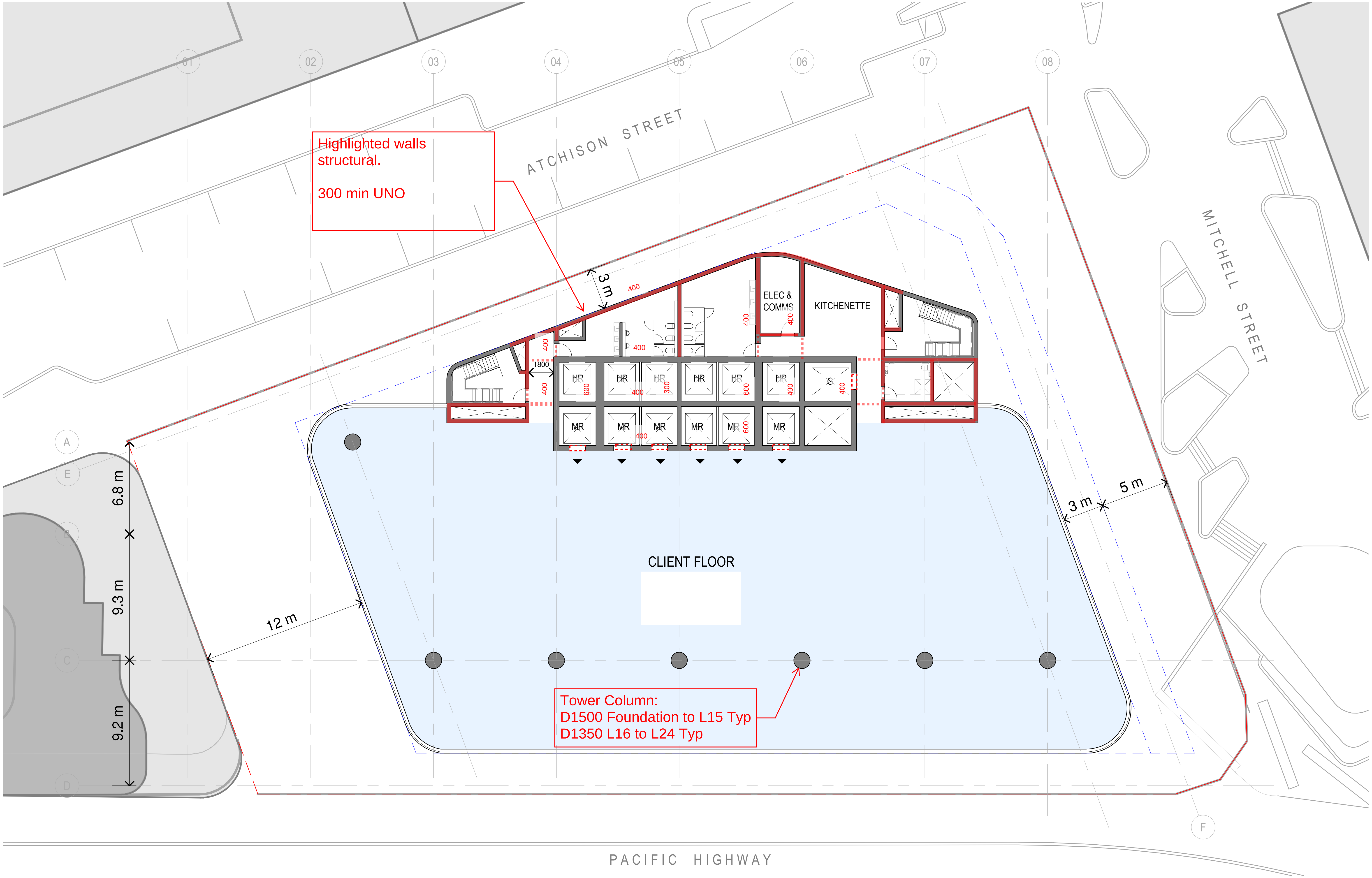

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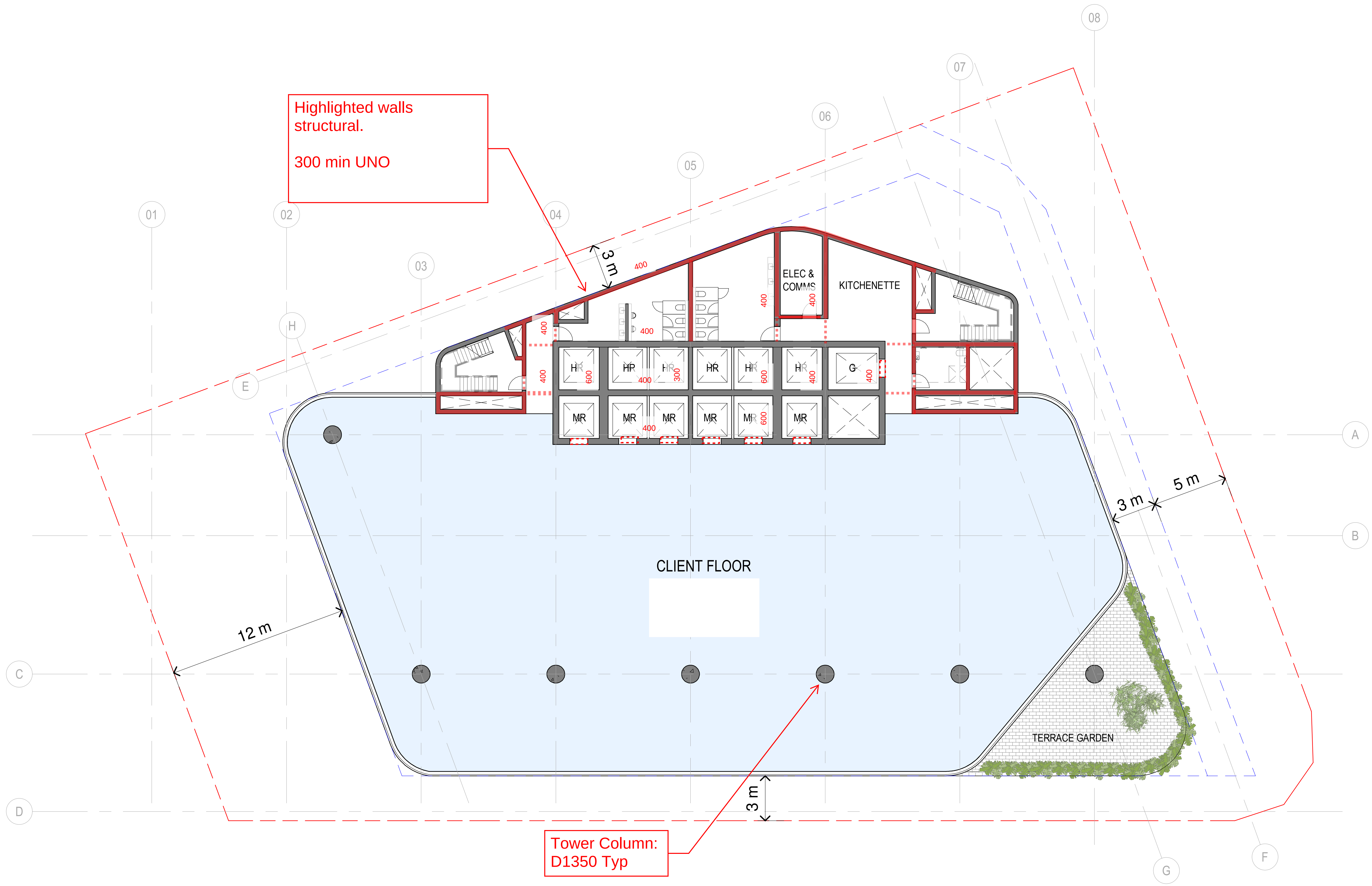

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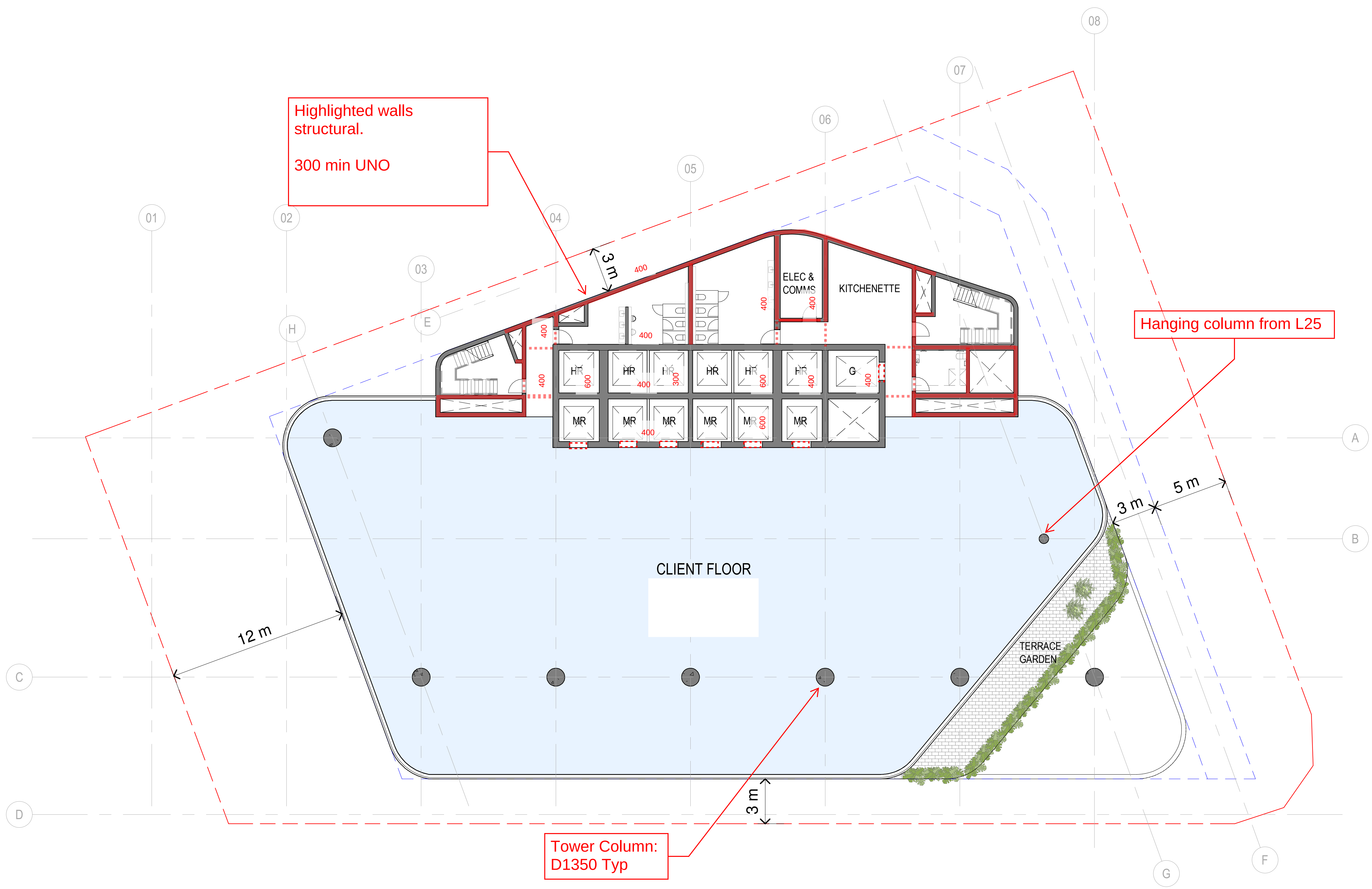

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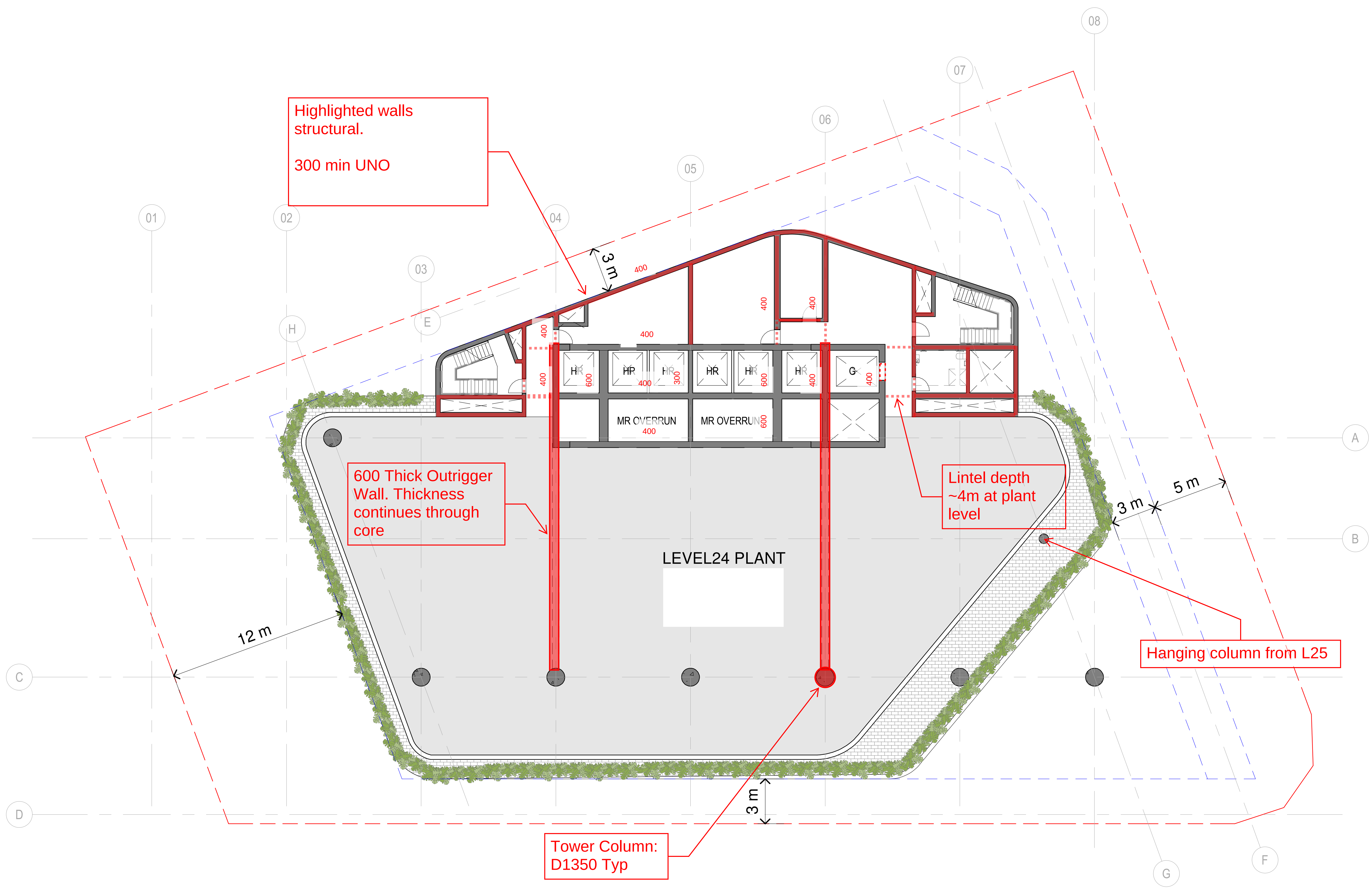

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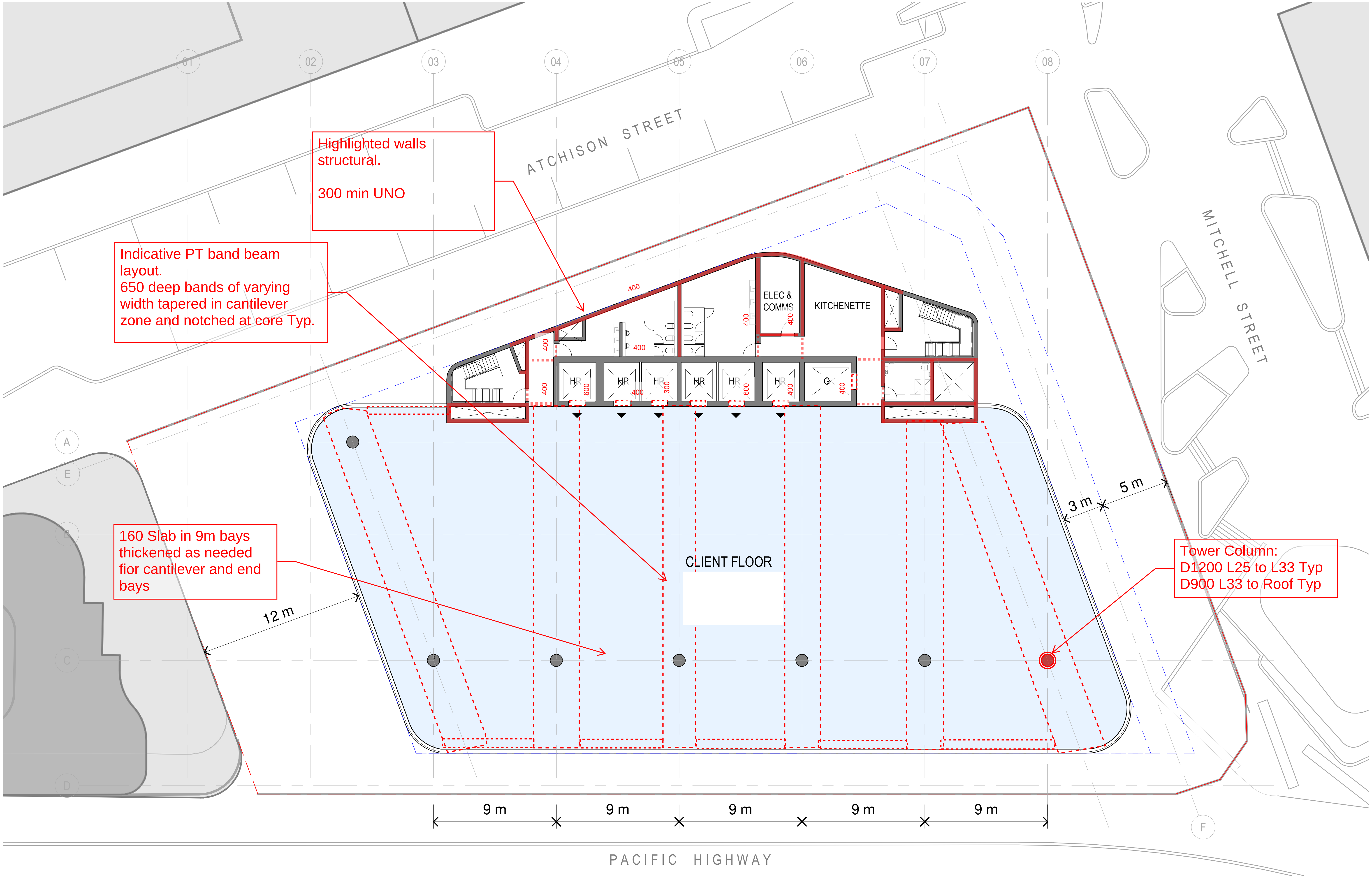

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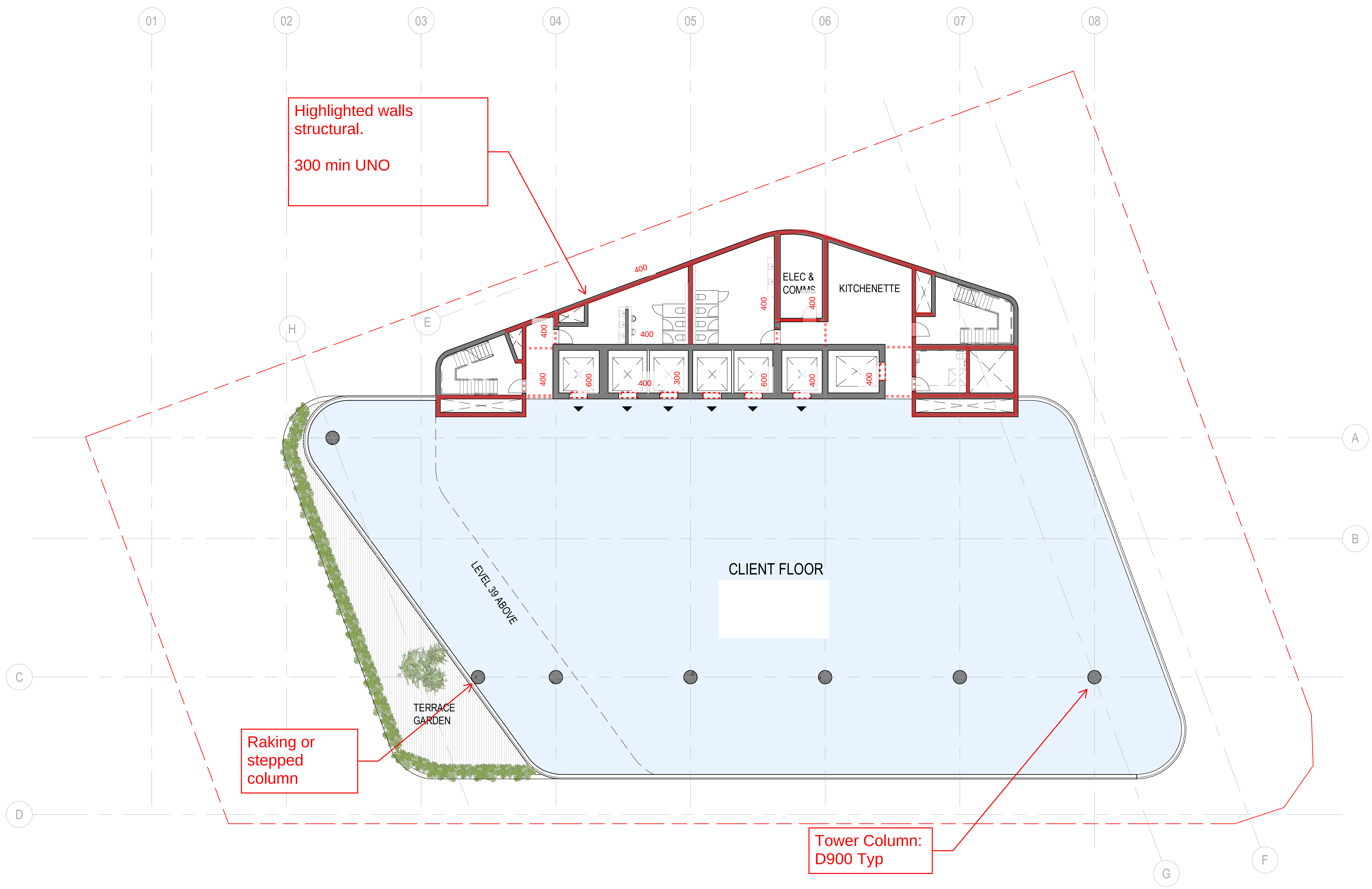

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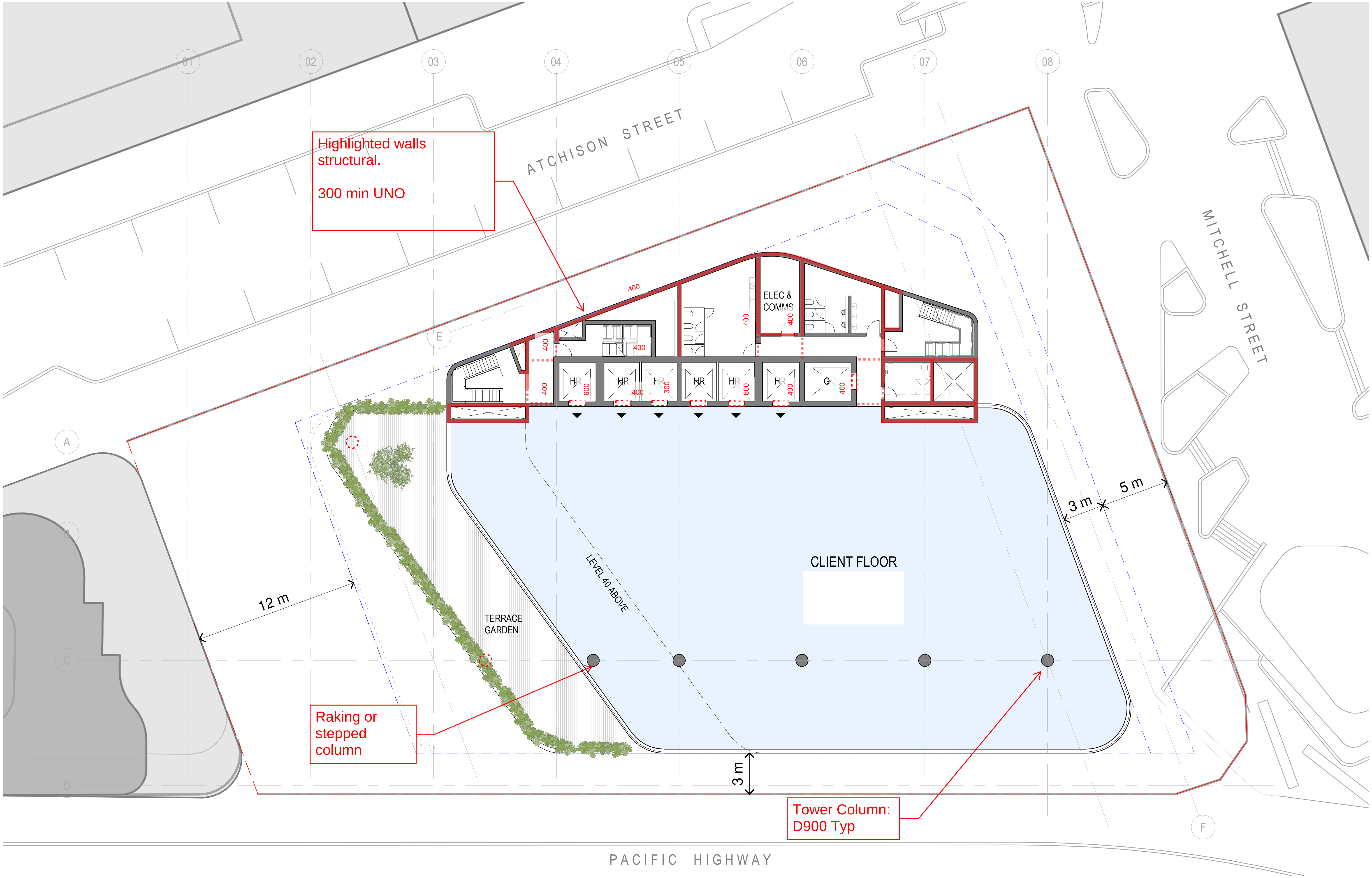

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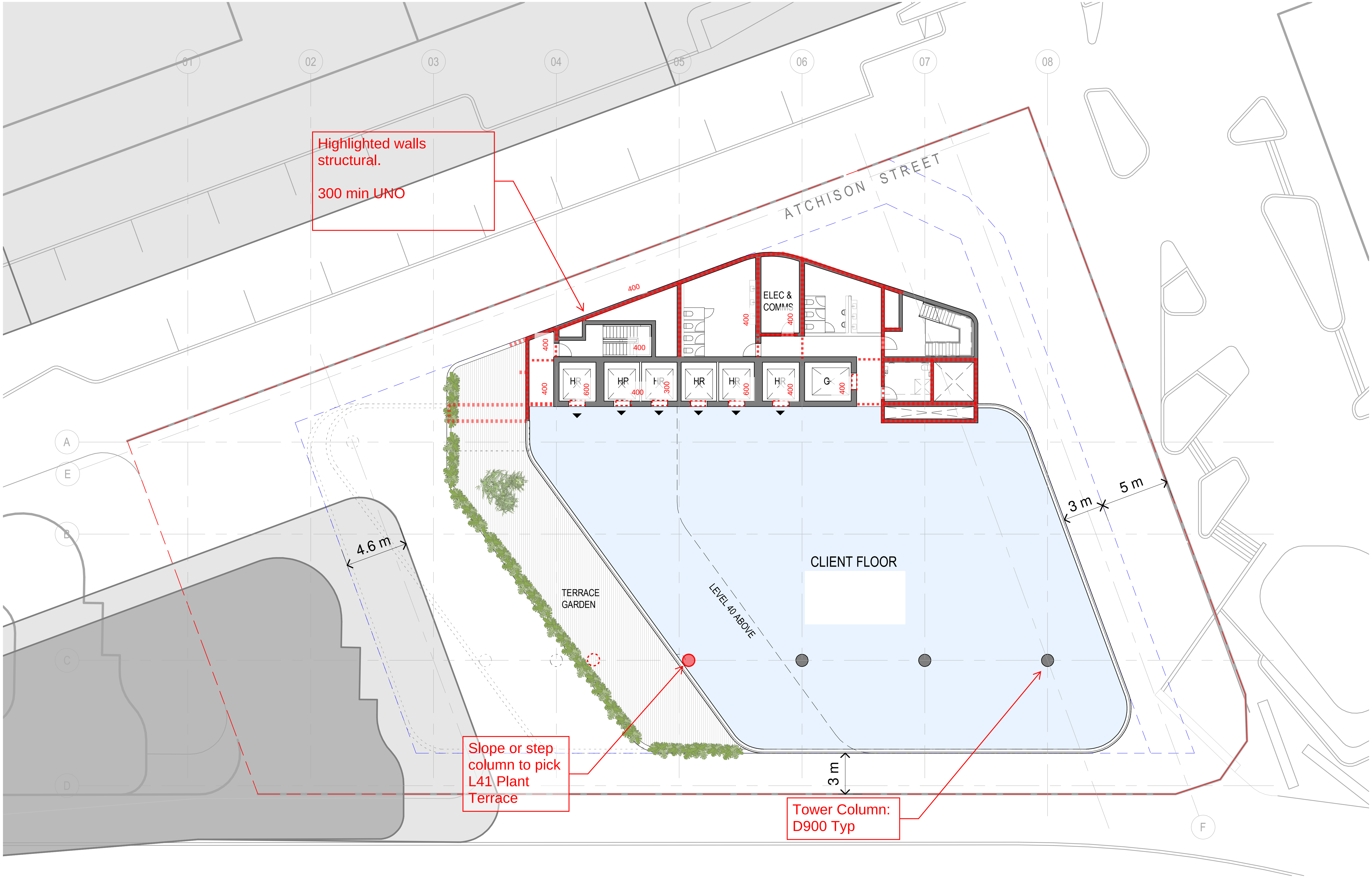

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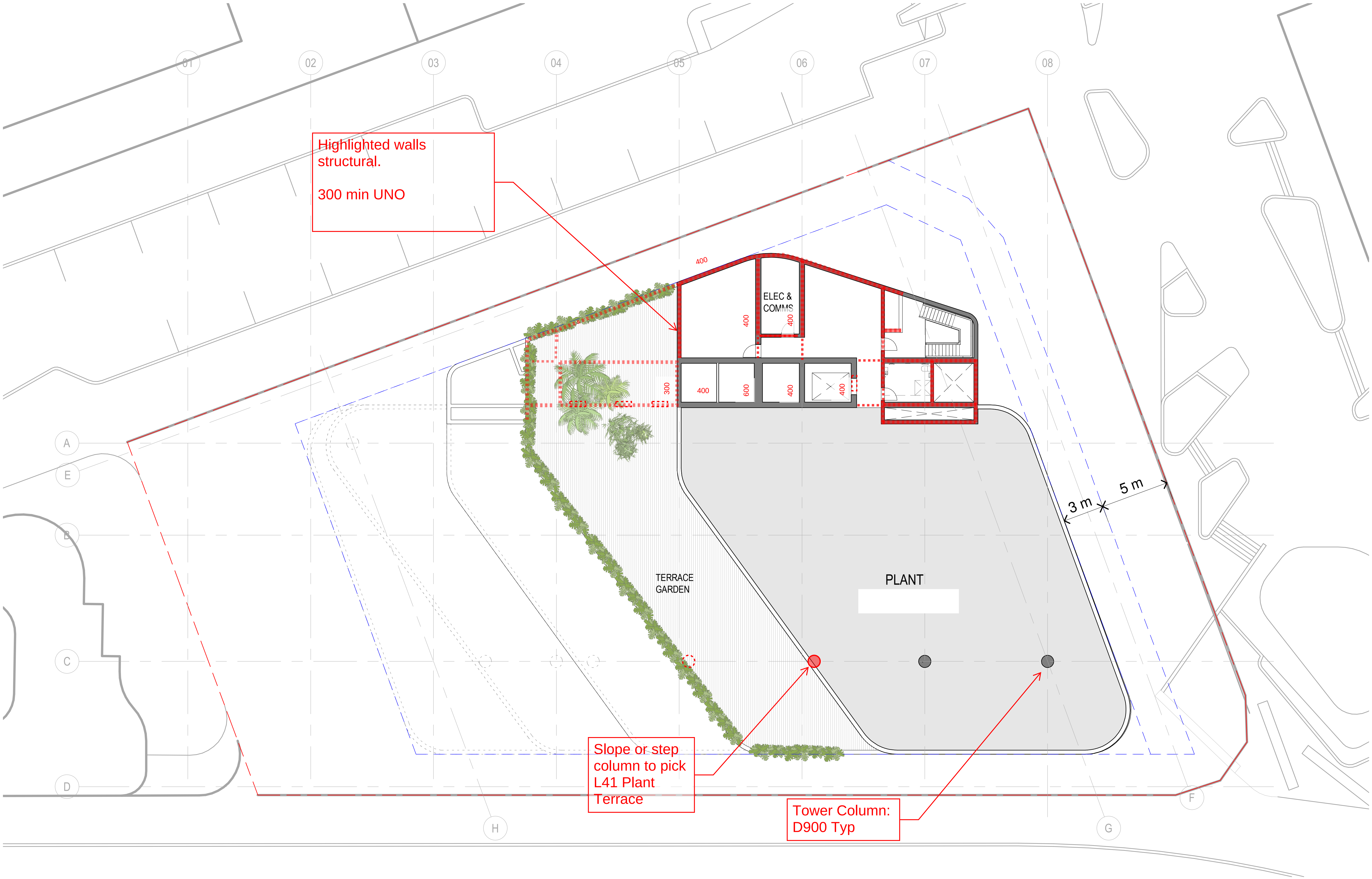

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