Basement Construction in Ho Chi Minh
Pitfalls and Collected Stories

HCMC Typical Ground Conditions

- Soft soils to significant depth
- Soft clays, loose sands
- Typically 10 defined strata with sand density and clay stiffness increasing at depth
- Bedrock at -130 to -200m

Table 1. Basic Properties (average) of HCMC Soft Clay in the City Central Lowlands

Natural water content, wn	80%
Liquid limit, LL	89%
Plastic limit, PL	36%
Plasticity index, PI	53
Unit weight, γ	15 kN/m^3
Specific gravity, G_s	2.68
Clay content	63%

Footnote: where the water content is greater than the liquid limit these soils are virtually one stage from being fluid

Reference: Journal of Civil Engineering Paper by Nguyen Kiet Hung and N. Phienwej, August 2014.

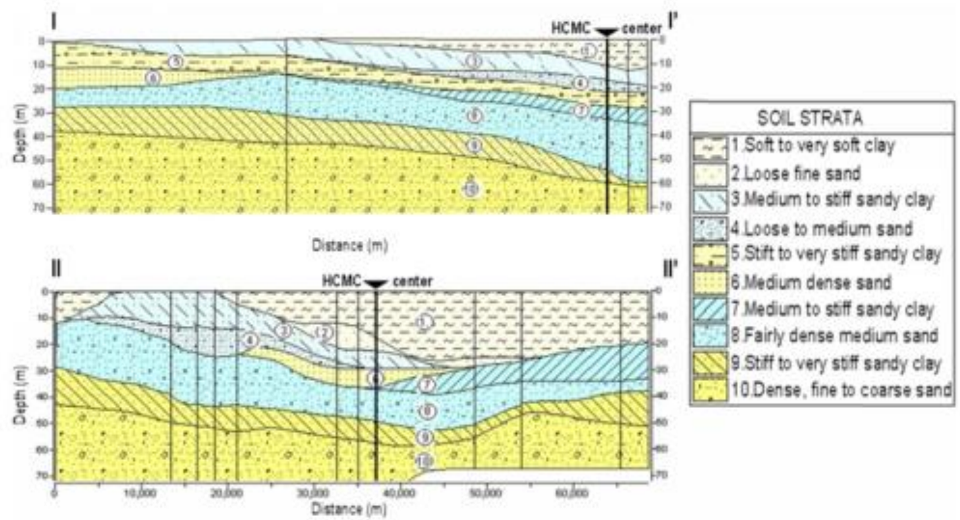


Fig. 2. Typical Geotechnical Sections of the City Center Lowlands (recompiled from Pham, 2008)

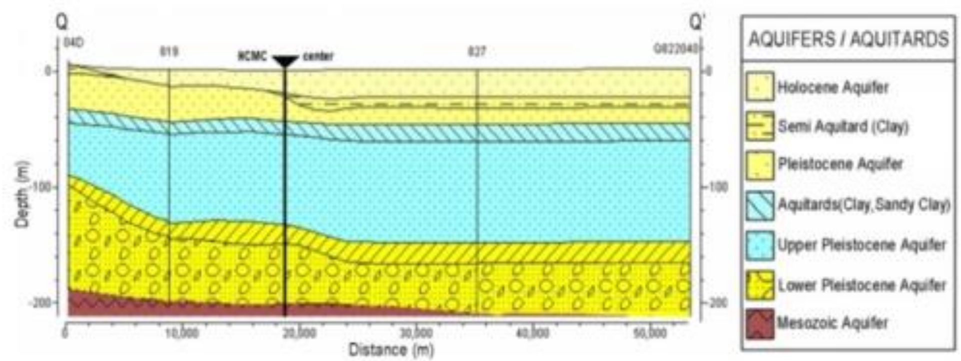
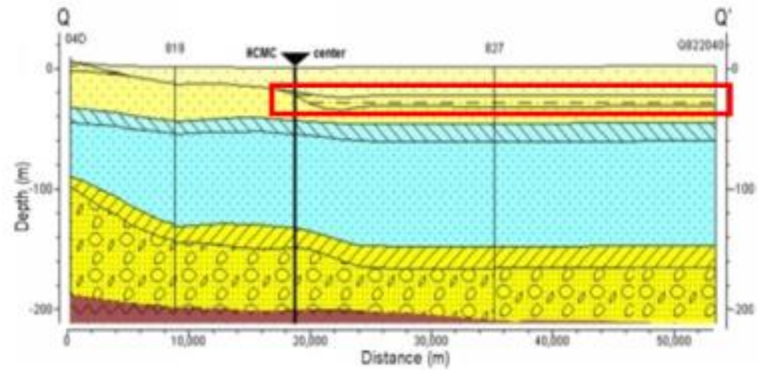
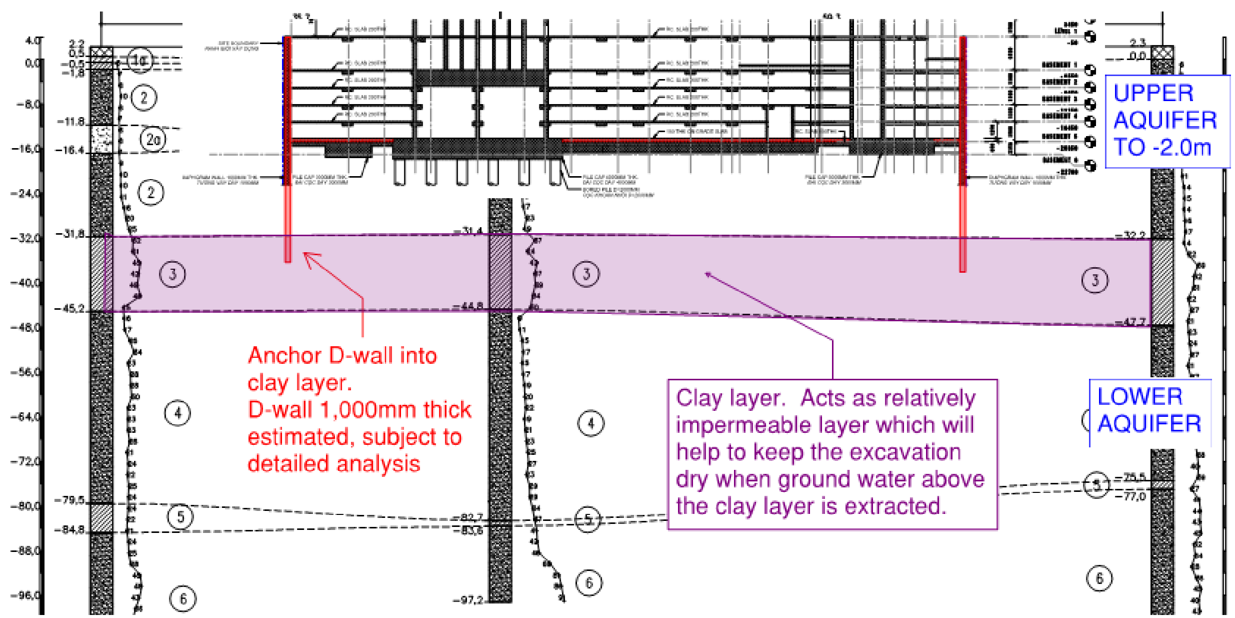


Fig. 3. Hydrogeological Section Q-Q' (after DEHGSV, 2006)

Aquifers

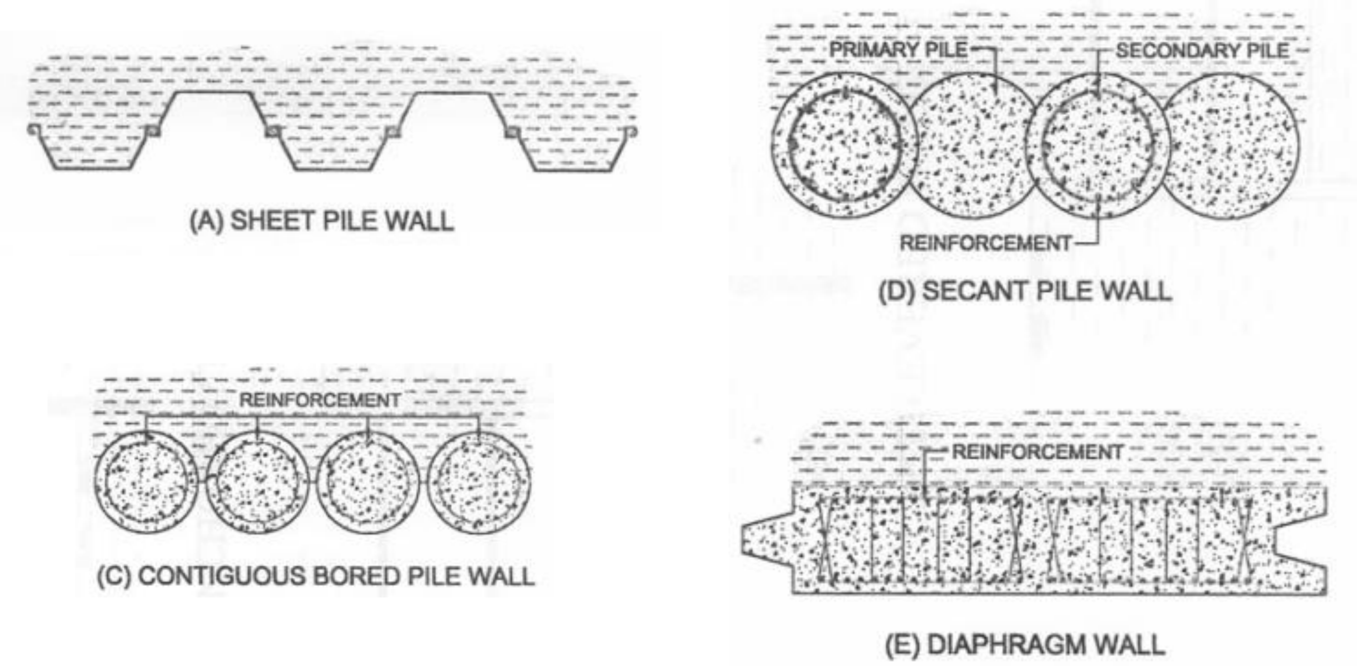
- 5 no. Aquifers in HCMC area
- 2 no. upper aquifers (Holecene and Pleistocene) may directly affect deep excavations
- Clay aquitard between these two aquifers



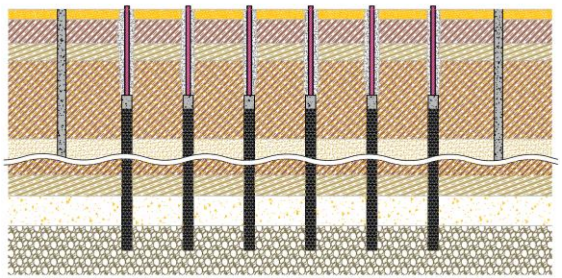


Site Retention Wall Types

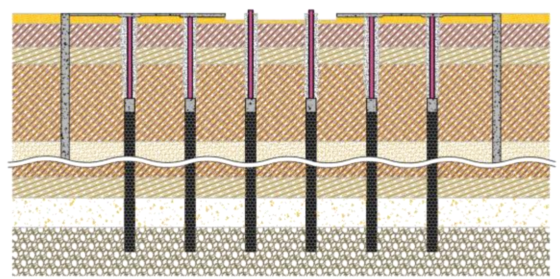
- 4 main types in HCMC
- Dependent on the soils and excavation depth
- 2 basements or more: D-wall likely



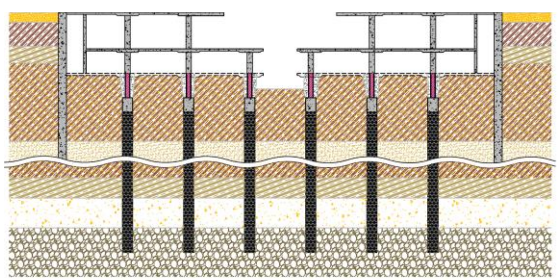
Substructure – Semi Top-Down Construction



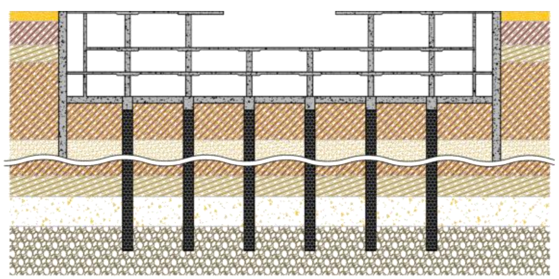
Stage 1 : Diaphragm Wall and Piles are installed into the ground. King posts are provided at each column/pile location.



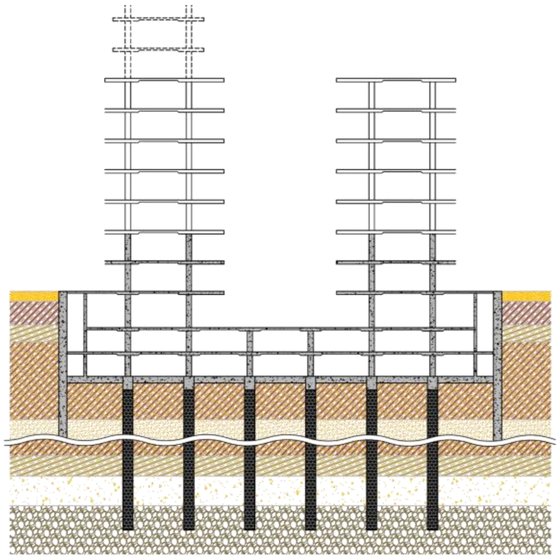
Stage 2 : Ground floor slab is constructed first, leaving opening for excavation



Stage 3 : Excavation is carried out simultaneously with basement construction

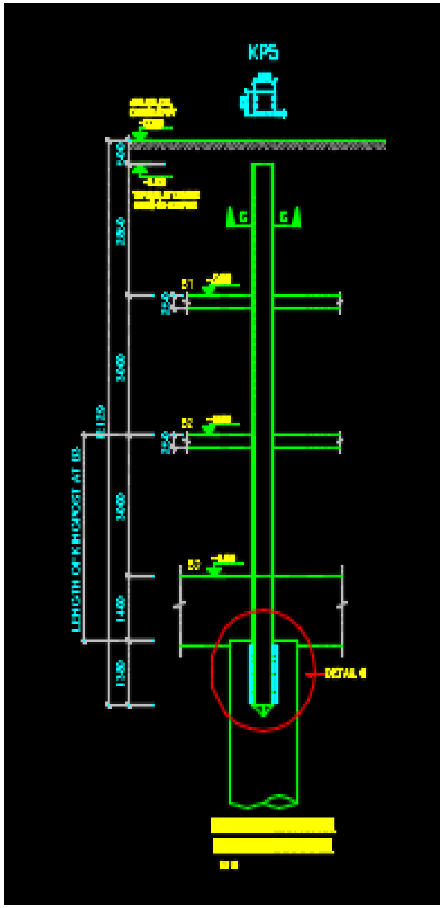


Stage 4 : Basement floors completed and pile cap completed prior to commencement of superstructure

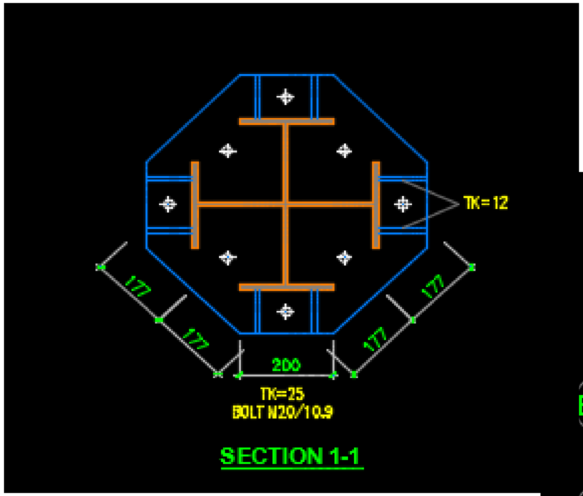


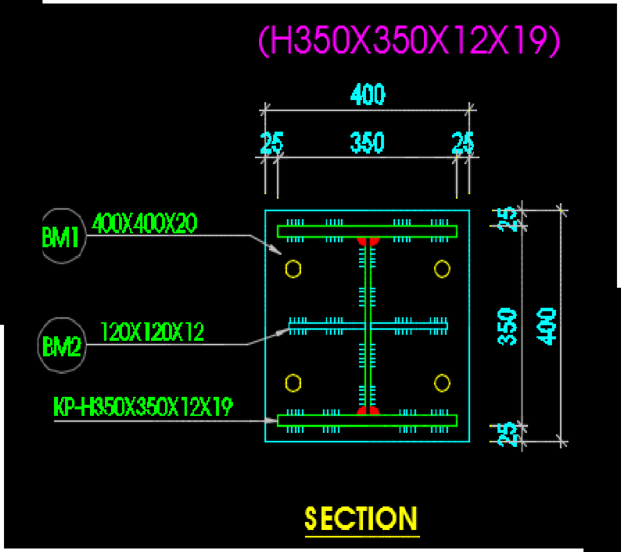
Stage 5 : Superstructure is constructed on completion of the basement

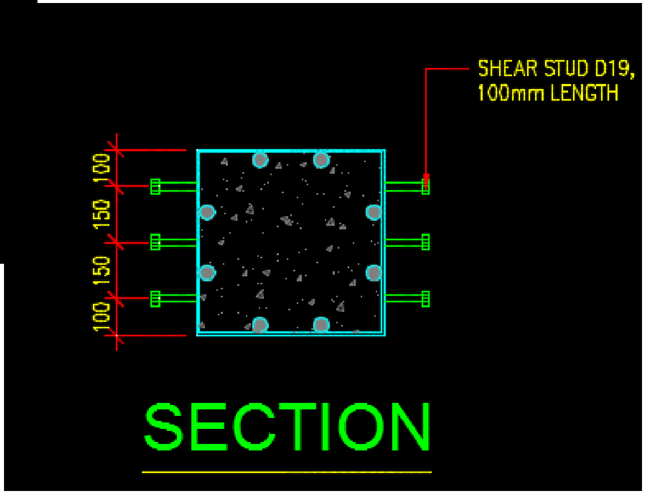
Kingpost Options



Kingpost Options

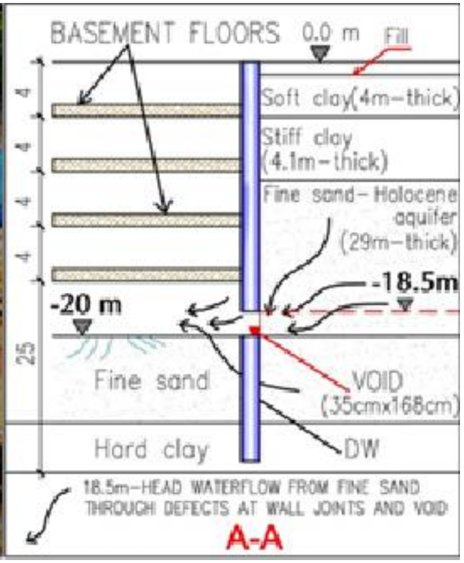






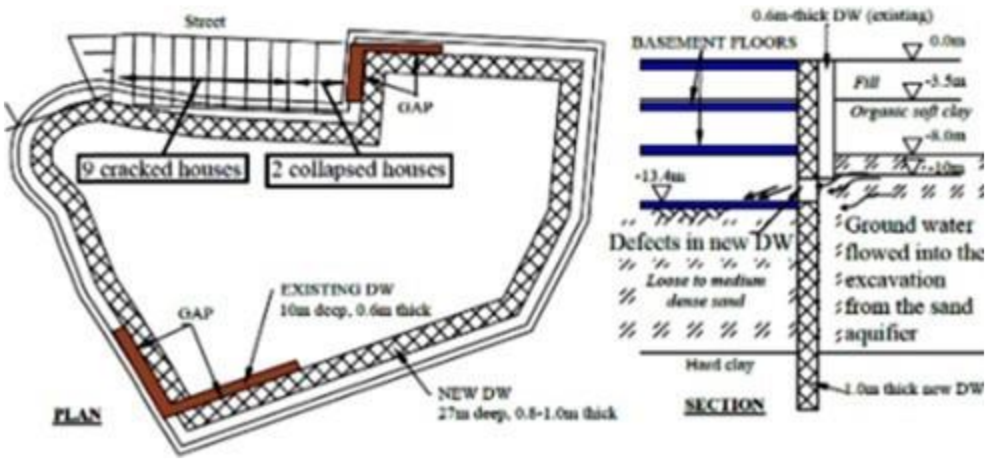
Case 1: City Centre - May 2007

- 5-level basement; 21 storey building
- 20m deep excavation
- 1m thick, 45m deep D-wall
- Large void in D-wall: 350mm x 1700mm at -21m
- Severe water ingress could not be controlled (water head 18.5m)
- Within 30min (!), excessive subsidence occurred, severe damage to 2 storey building
- Remedial measure – jet-grouted piles



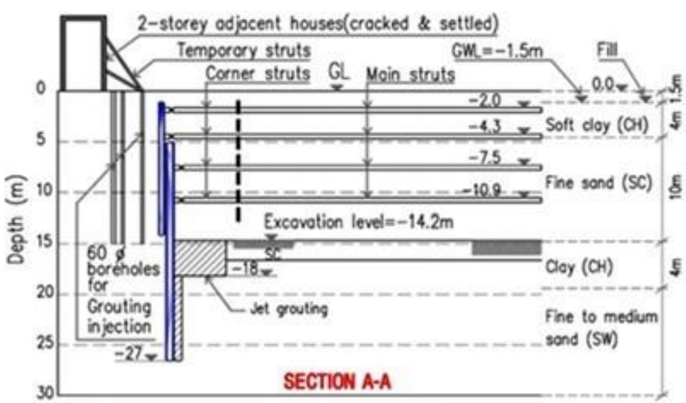
Case 2: City Centre – January 2011

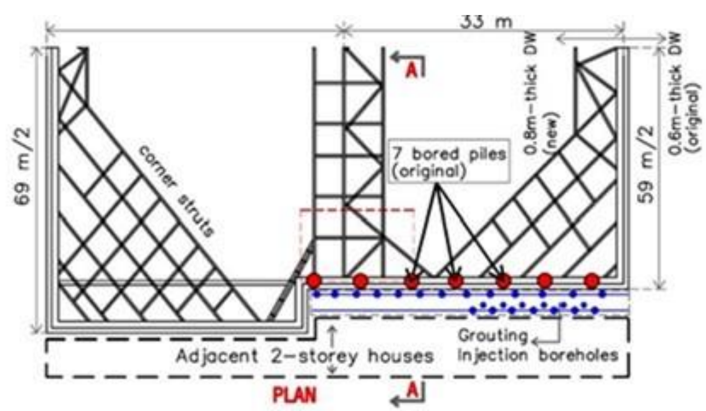
- 5-level basement; 40-storey building
- 19.8m deep excavation
- 0.8-1.0m thick, 27m deep D-wall
- Existing 600mm, 10m deep d-wall in two corners
- Existing d-wall integrated into new d-wall
- During excavation at -11m, structural failure at interface of new/old d-wall
- Severe water ingress
- 2 adjacent 2-storey buildings collapsed; 9 townhouses severely damaged.
- Remedial measures – jet-grouted piles



Case 3: City Centre – April 2009

- 3-level basement; 37-storey building
- 14.0m deep excavation; 0.8m thick, 35m deep D-wall
- Existing 600mm, 12m deep d-wall in two completed (for earlier 1-level basement)
- During excavation of 3rd basement at -11m, structural failure of d-wall at interface of new/old d-wall
- Poor interface between new and original D-wall panels – large ingress of groundwater and sandy soil
- Subsidence caused damage to adjacent building.
- After almost 1 year delay, jet grouting, and needle grouting sealed the leaks





Case 4: District 7

- 2 basement levels with - 9m-11.5m deep excavation
- Contiguous pile wall has been installed with the lateral support from temporary steel strutting
- Bottom-up construction
- Failure of the steel strutting system
- Collapse of the contig wall and damage to adjacent buildings

Case 4 (continued…)

Case 5: District 8 – June 2015

- 2 basement levels with -9m deep excavation
- bottom-up construction
- Steel sheet-piles with lateral support from steel strutting system
- Excessive adjacent ground settlement (200-400mm)
- Failure of sheet piled wall due to failure of strutting system

Case 5 (continued…)

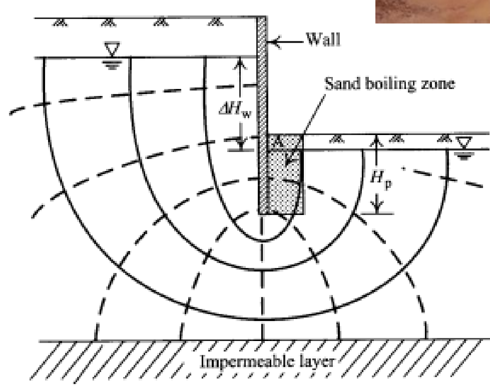
Observed settlement of the adjacent walkway is about 20 to 40 cm

Case 6: District 7 – December 2016

- 2 basement levels with - 9m-11.5m deep excavation
- Bottom-up construction
- Steel sheet-piles with lateral support from steel strutting system
- Failure of steel strutting system leading to collapse of the sheet piling

Case 7: District 7

- 2 basement levels with -9m-11.5m deep excavation
- Very thick sand layer situates below the ground level
- Bottom-up construction
- D-wall with lateral support from steel strutting system
- The sand boiling due to short D-wall.
- Inadequate water level management.

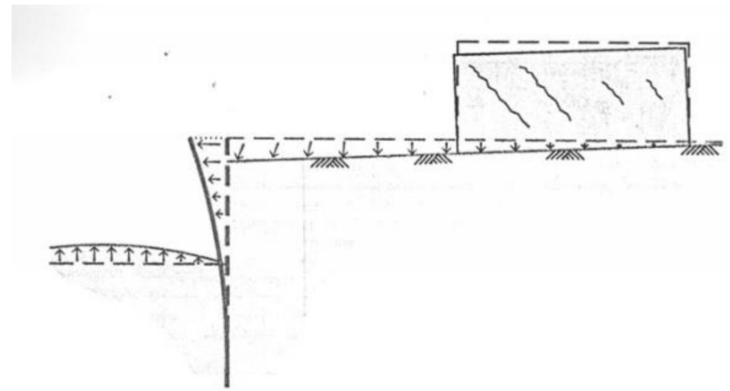


INDOCHINE ENGINEERING

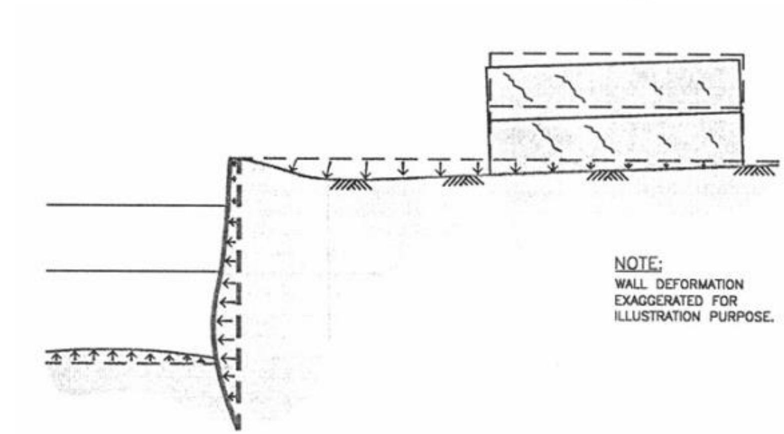
S&A SATCHELL & ASSOCIATES
STRUCTURAL DESIGN ENGINEERS

Current Vulnerabilities

- Lateral displacement > 50mm
- SI focus on foundation parameters
- Heave of the excavation base
- Reliability of the FEA (Plaxis)
- Lack of guidelines/regulations
- Lack of instrumentation
- Lack of dilapidation surveys



CANTILEVERED WALL



BRACED WALL

INDOCHINE ENGINEERING

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Prevention

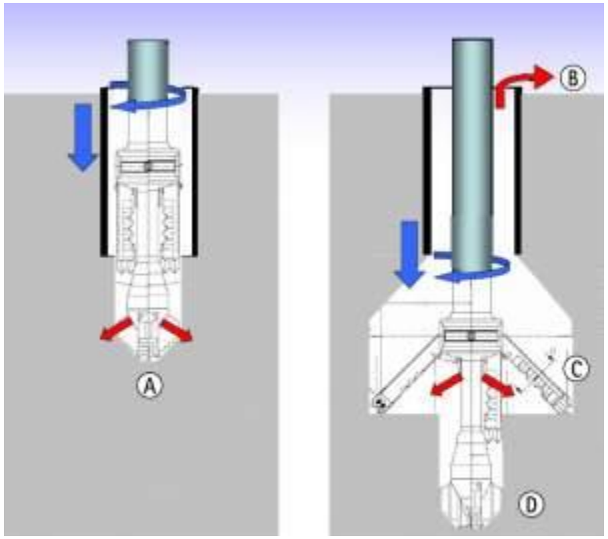
- Reduction of wall deflections during excavation
- Clear authority guidelines
- Selection of wall type and bracing method (D-wall with top-down construction in city centres)
- DW embedded into impermeable layer (or if not practical, lowering the ground water table)
- Use of ground improvement (eg. jet grouting) – Cost vs Risk….!
- Selection of appropriate soil parameters (especially soil stiffness of soft clay)

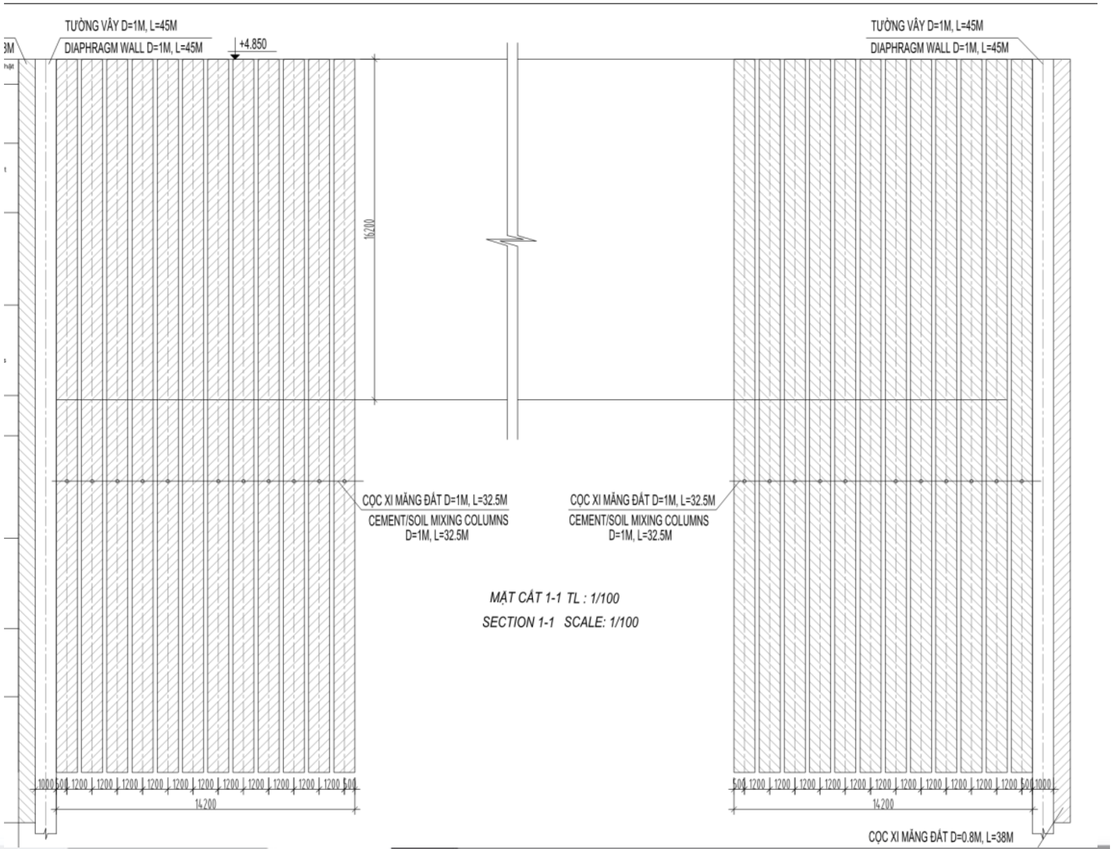
Table 4. Soil Parameters of HCMC Soft Clay Recommended for Soil Modeling using the HSM

Depth of soft clay stratum	E_{oed}^{ref}	$E_{ur,oed}^{ref}$	E_{50}^{ref}	E_{ur}^{ref}	$\frac{E_{ur,oed}^{ref}}{E_{oed}^{ref}}$	$\frac{E_{ur}^{ref}}{E_{ur,oed}^{ref}}$	$\frac{E_{ur}^{ref}}{E_{50}^{ref}}$	c'	ϕ'	m	R_f
	kPa	kPa	kPa	kPa	[−]	[−]	[−]	kPa	[°]	[−]	[−]
From 4 to 13 m	665	4680	2222	12200	7.0	2.6	5.5	9	20.6	0.94	0.87
	675		*1360*	*8000*			*5.9*	*9*	*20.6*	*0.90*	*0.90*
From 13 to 20 m	1375	9695	3200	12068	7.1	1.2	5.7	11	20.2	0.90	0.91
	965		*1800*	*9800*			*5.4*	*11*	*20.2*	*0.90*	*0.90*

CDM Ground Improvement

Option 1 – CDM Soil/Cement columns





Grouting Work for Soil Improvement

Option 2 – Jet Grouting

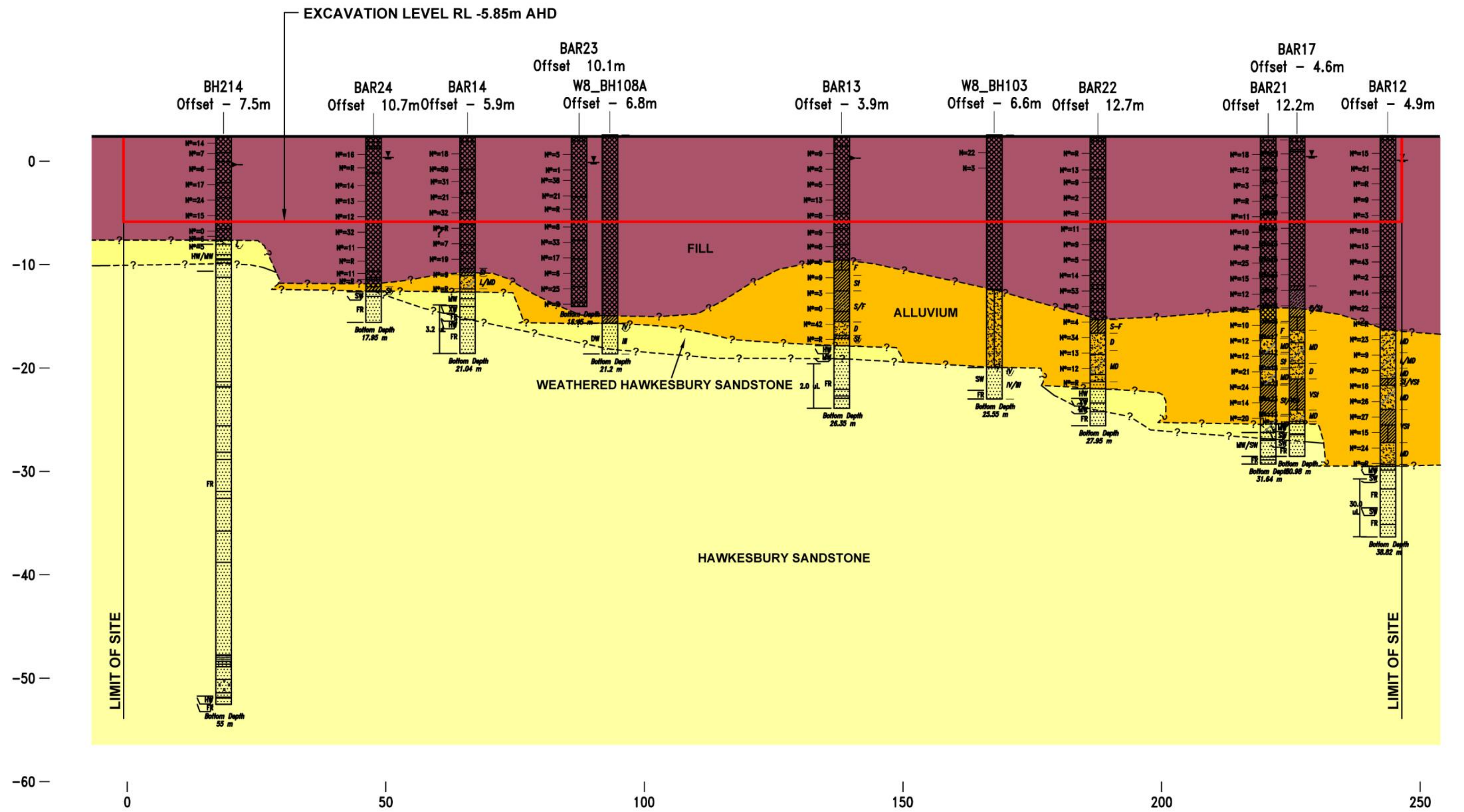
Injection of grouting mixture in soil at high pressure to form grouting piles

BARANGAROO: BASEMENTS

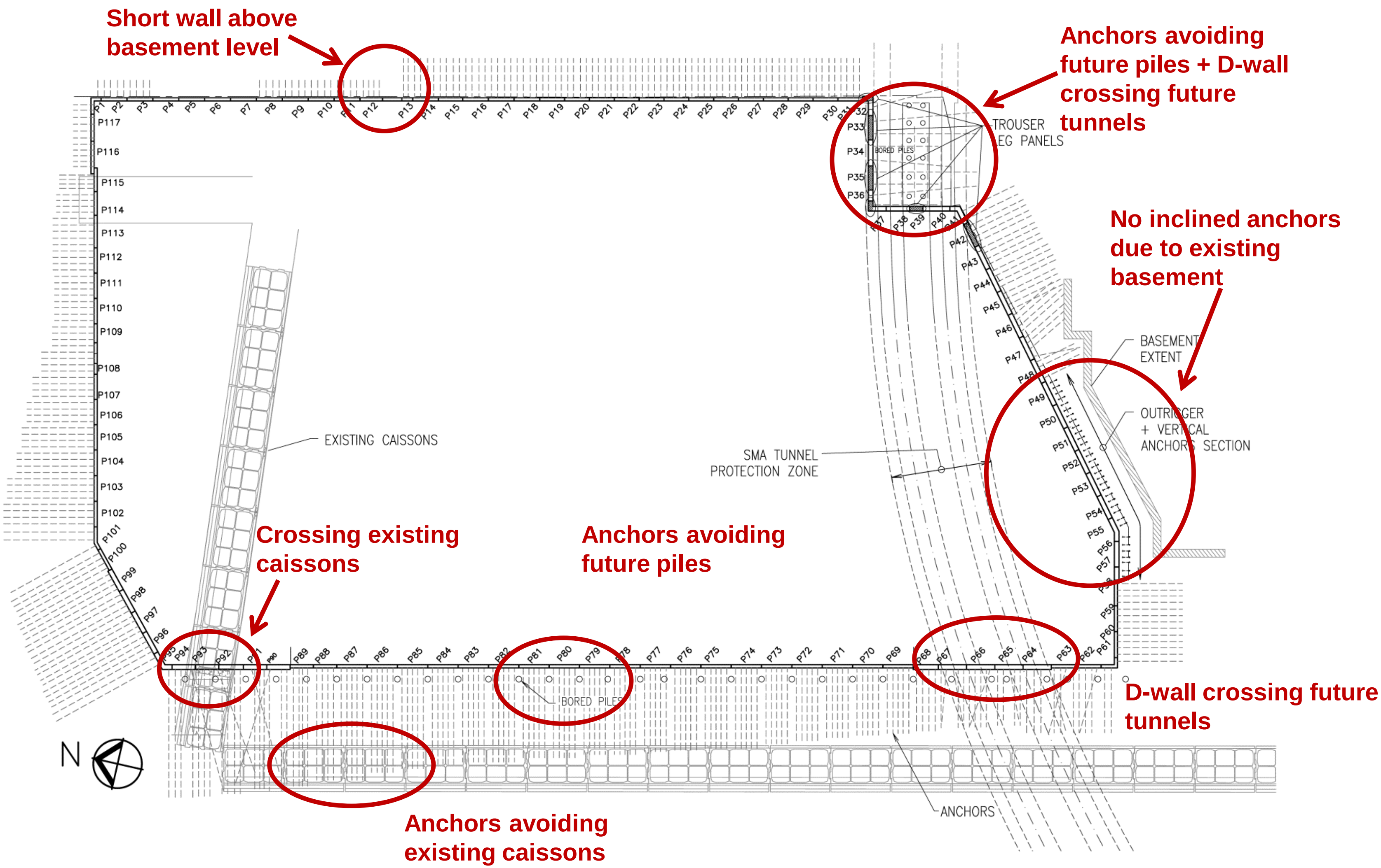
BARANGAROO SOUTH

- Developer: Lend Lease
- Project Location: Adjacent to Hickson Road, Sydney, NSW 2000
- Project Value: $6 billion
- Diaphragm wall D&C contractor: Mernard Bachy
- Diaphragm wall designers: MB/ Coffey/ Calibre Consulting
- Geotechnical Consultant: Coffey
- Piling Contractor: Bauer/AFS

GEOLOGY

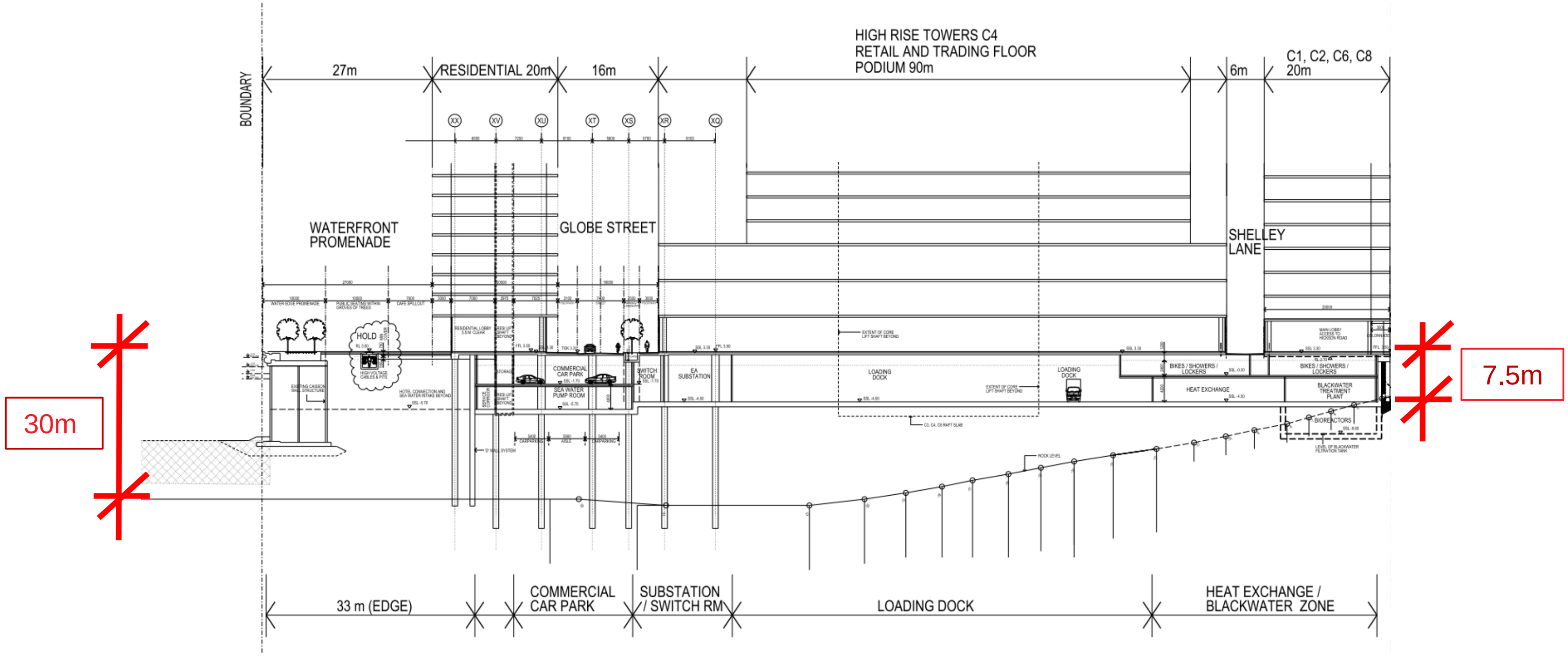

EXCAVATION LEVEL RL -5.85m AHD
BH214 Offset – 7.5m
BAR24 Offset 10.7m
BAR14 Offset – 5.9m
BAR23 Offset 10.1m
W8_BH108A Offset – 6.8m
BAR13 Offset – 3.9m
W8_BH103 Offset – 6.6m
BAR22 Offset 12.7m
BAR17 Offset – 4.6m
BAR21 Offset 12.2m
BAR12 Offset – 4.9m
FILL
ALLUVIUM
WEATHERED HAWKESBURY SANDSTONE
HAWKESBURY SANDSTONE
LIMIT OF SITE
LIMIT OF SITE
0
-10
-20
-30
-40
-50
-60
0
50
100
150
200
250

DIAPHRAGM WALL SOLUTIONS & CHALLENGES



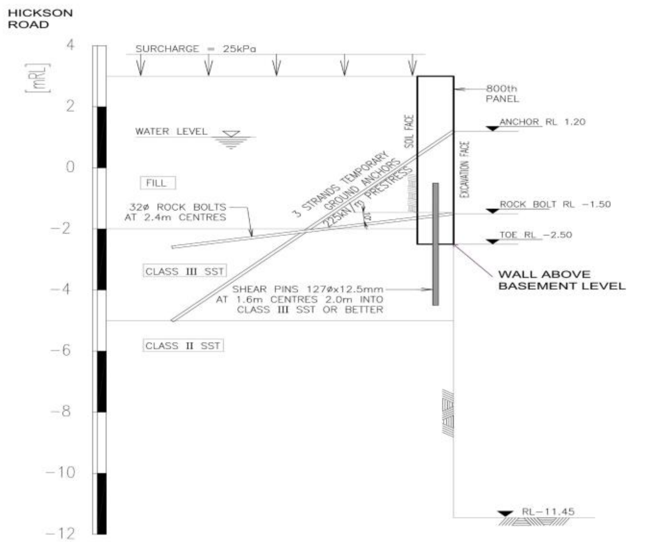
BASEMENT

- General depth of basement up to 9m - 12m
- Depth of wall from, 4.0m to + 30.0m
- Typical wall thickness 0.8m to 1.2m, Panel lengths from 3.4m to 7.8m
- Groundwater cut-off achieved economically with 0.3m embedment into rock
- Inclined External Rock Anchors, East, West and Northern Boundaries
- Vertical anchors adjacent to Macquarie Bank
- Open Excavation

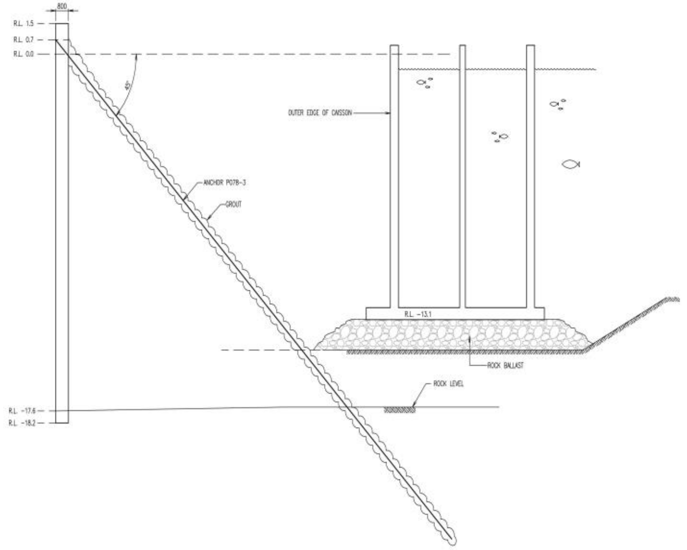


DIAPHRAGM WALL SOLUTIONS

Adjacent to Western Caisson



DIAPHRAGM WALL SOLUTION ADJACENT TO HICKSON ROAD EASTERN ELEVATION



DIAPHRAGM WALL SOLUTIONS ADJACENT TO WESTERN CAISSON

DIAPHRAGM WALL SOLUTIONS

Existing Basements