Design of the Retaining Wall Structures on the M4 Smart Motorway Project, Sydney

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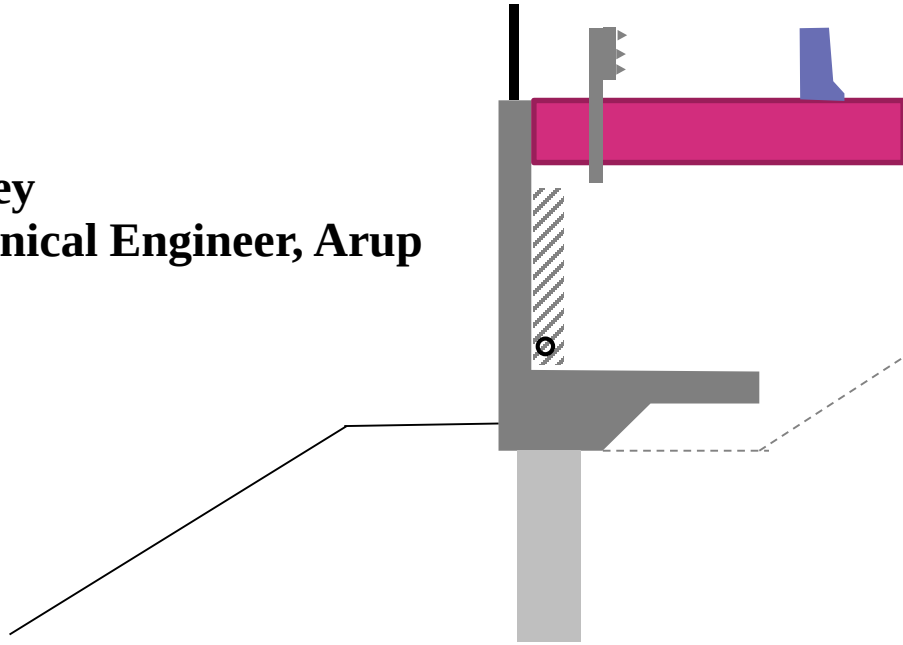

8th Australian Small Bridges Conference
27-28 November 2017

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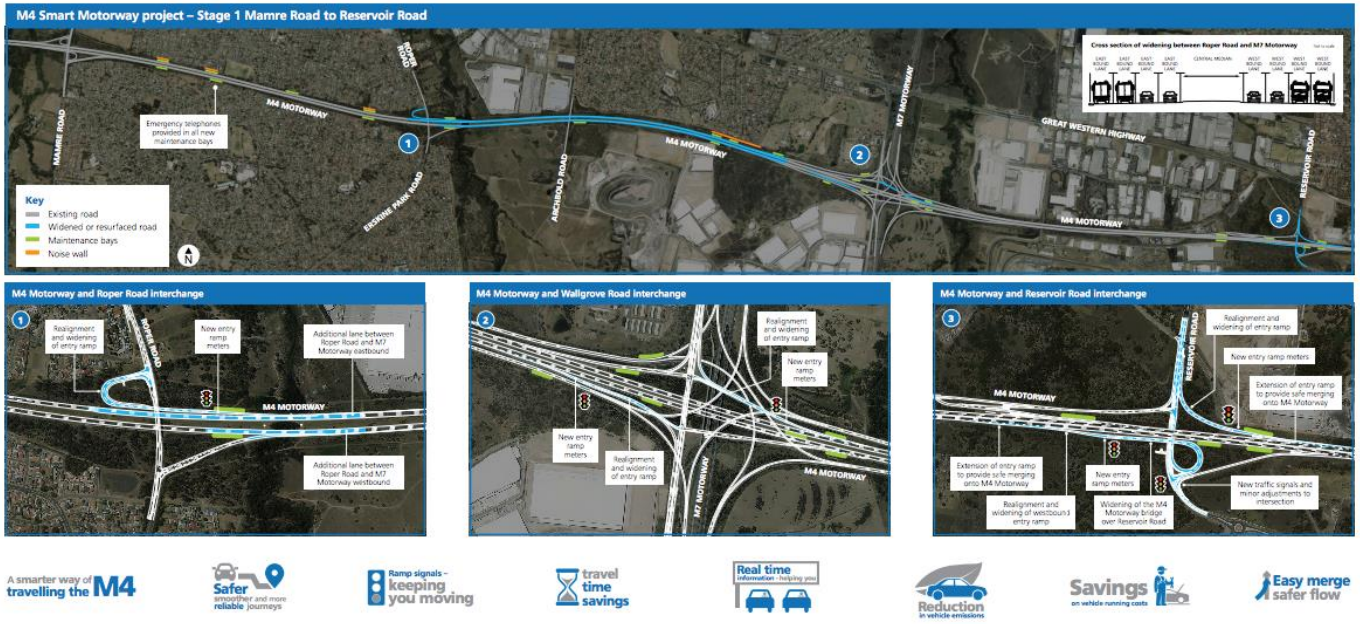
PRESENTATION OUTLINE

- ❖Project Background
- ❖Design Constraints and Criteria
- ❖Case Study 1: M7 Ramp Retaining Wall
- ❖Case Study 2: Burnett Street Ramp Retaining Wall
- ❖Case Study 3: Coleman Street Ramp Retaining Wall
- ❖Conclusions

PROJECT BACKGROUND



A smarter way of travelling the M4

Safer smoother and more reliable journeys

Ramp signals - keeping you moving

travel time savings

Real time information - helping you

Reduction in vehicle emissions

Savings on vehicle running costs

Easy merge safer flow

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DESIGN CONSTRAINTS AND CRITERIA

- 17 retaining walls are required to facilitate the ramps widening and to implement maintenance facilities for the ITS infrastructures

- The main constraints include
  - Existing Infrastructures including utilities
  - Physical space constraints to build and maintain the structures
  - Requirements to maintain existing traffic flows on the motorway and ramps
  - Urban design requirements
  - Community feedback
- The wall type and detail were selected to specifically best meet the above constraints for the retaining wall sites
- Many retaining walls are required to support other infastrutures including noise walls, safety barriers, lighting poles, …etc.

DESIGN CONSTRAINTS AND CRITERIA

- The M4SM Description of Services
- Roads and Maritime publications, in particular the Bridge Technical Directions (BTDs) and Geotechnical Technical Directions (GTDs)
- AS 5100 (excluding part 5)
- AS/RMS Standard AS5100.5 Interim
- AS4678 (only on aspects not covered by AS5100.3)

File: SF2013/080714

Transport Roads & Maritime Services

ROADS AND MARITIME SERVICES BRIDGE TECHNICAL DIRECTION MANUAL

Australian STANDARD

Bridge design

Professional services contract
Description of Services

Detailed Design, Investigation, Construction Documentation and Construction Support Services.

M4 Smart Motorway

Contract Number: 14 2186 0499 -0033

Issue 1.0 (15 April 2016)

Easing Sydney Congestion Program Office
Roads and Maritime Services

Australian / RMS Standard®

Bridge design

Part 5: Concrete

This edition of AS 5100.5 has been prepared as an RMS interim concrete bridge design code to incorporate some of the necessary changes in AS 3600-2009 into AS 5100.5-2004, together with the contents of RMS Bridge Technical Directions BTD 2007/10 and BTD 2007/11 and the cement composition requirements of RMS B80.

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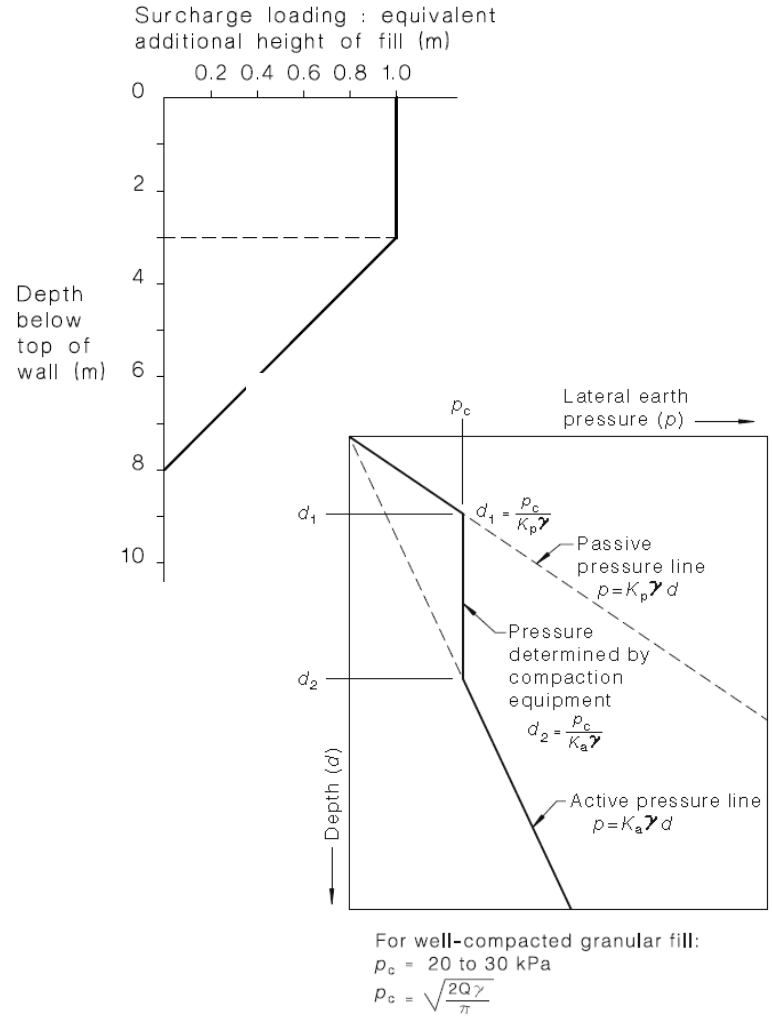
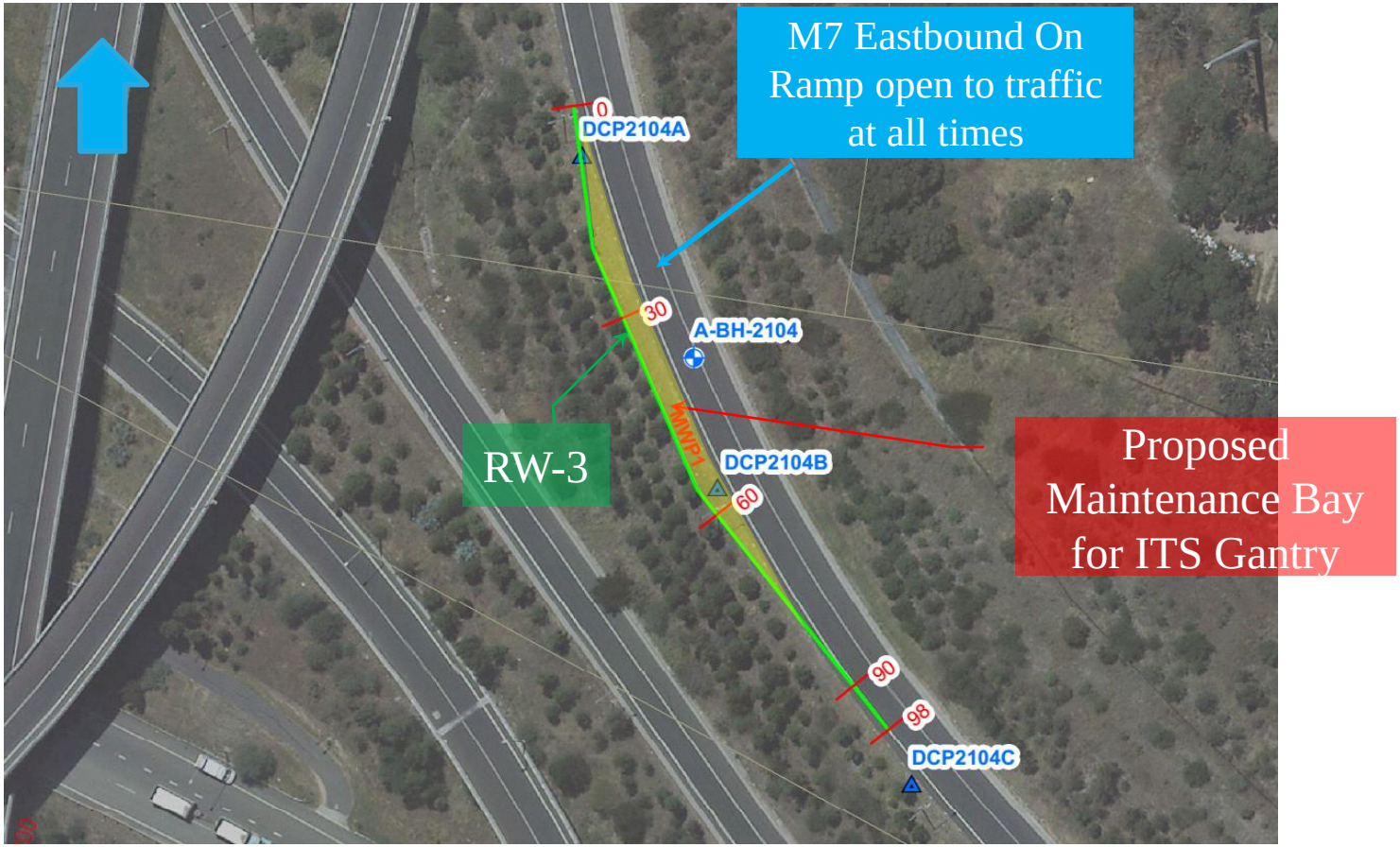
DESIGN CONSTRAINTS AND CRITERIA

- Design loadings:
  - Dead Loads due to Structures and attachments self-weight
  - Earth Pressure
  - Live load surcharge: 20kPa where the walls support pavement or 10kPa elsewhere
  - Construction surcharge: 10 kPa
  - Locked in compaction pressure: 10kPa
  - Impact loading from the safety barriers
  - Earthquake loads
  - Wind Loads



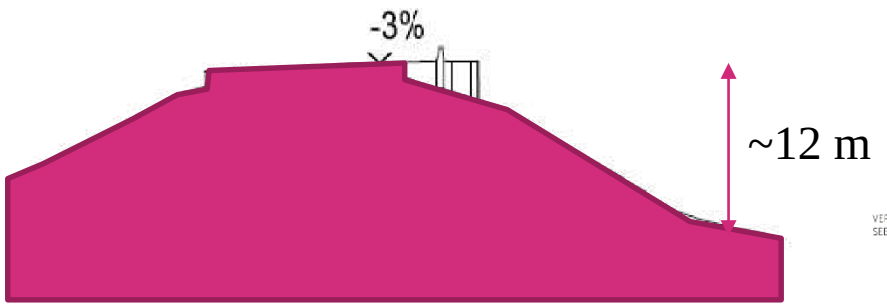
CASE STUDY 1: M7 RAMP RETAINING WALL

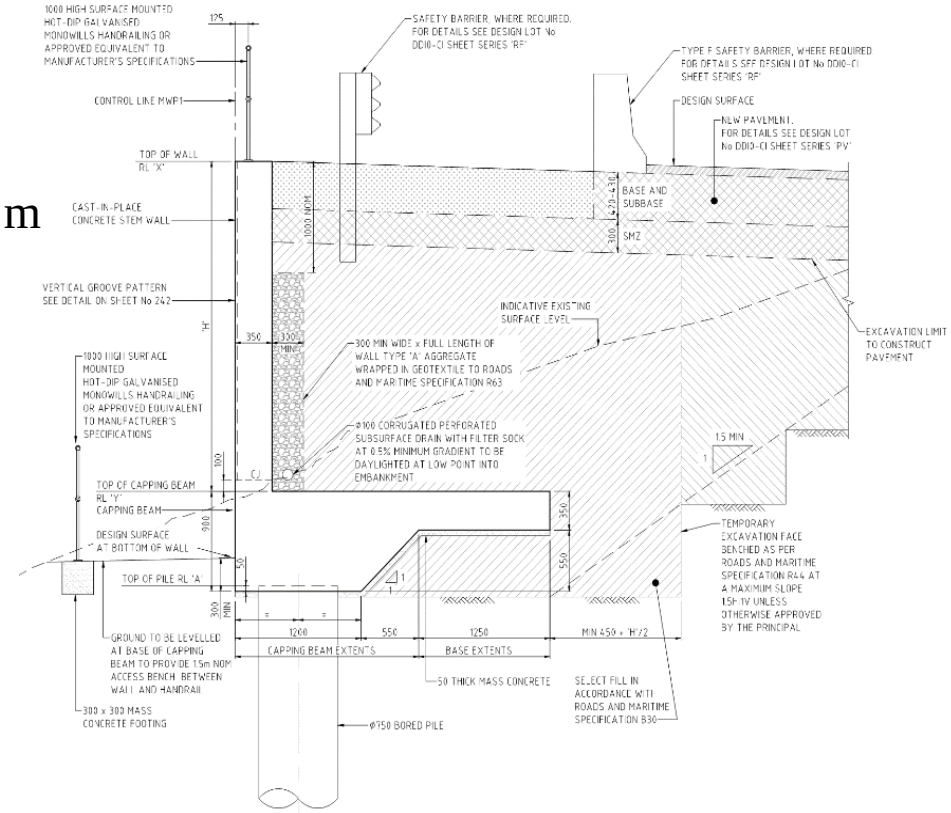
- **Site Locality and Constraints**



CASE STUDY 1: M7 RAMP RETAINING WALL

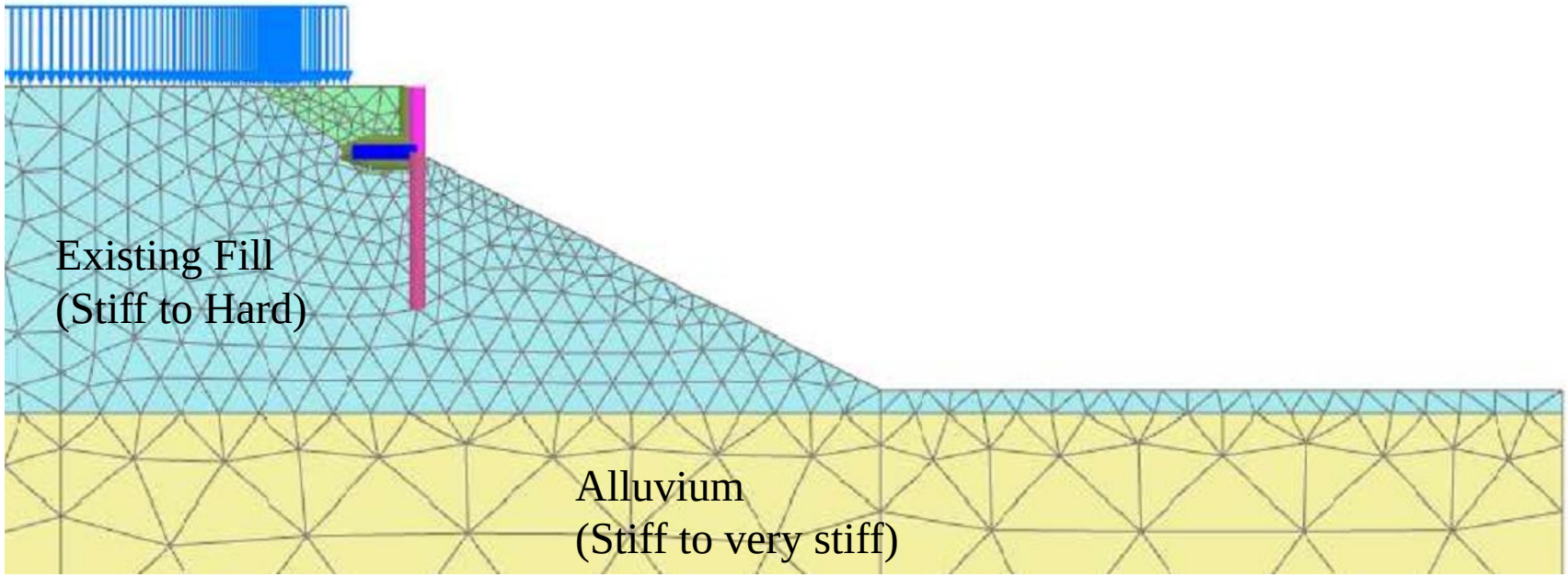
- **Hybrid- Pile Supported L-shaped Wall**





CASE STUDY 1: M7 RAMP RETAINING WALL

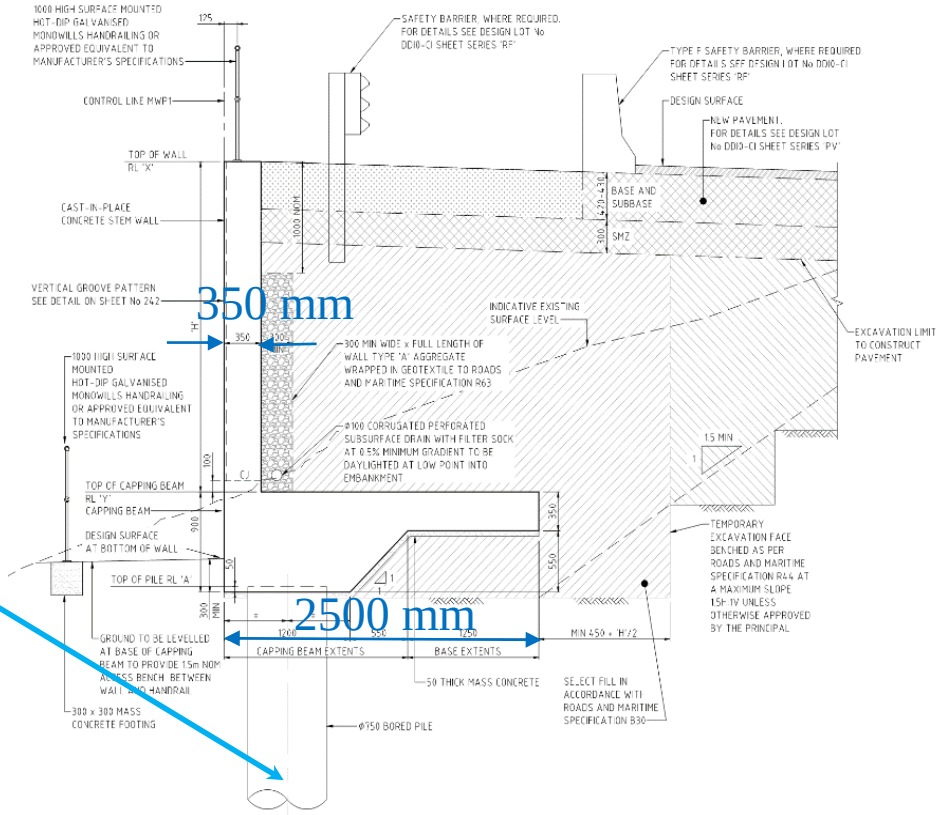
- **Geotechnical Subsurface Conditions**



CASE STUDY 1: M7 RAMP RETAINING WALL

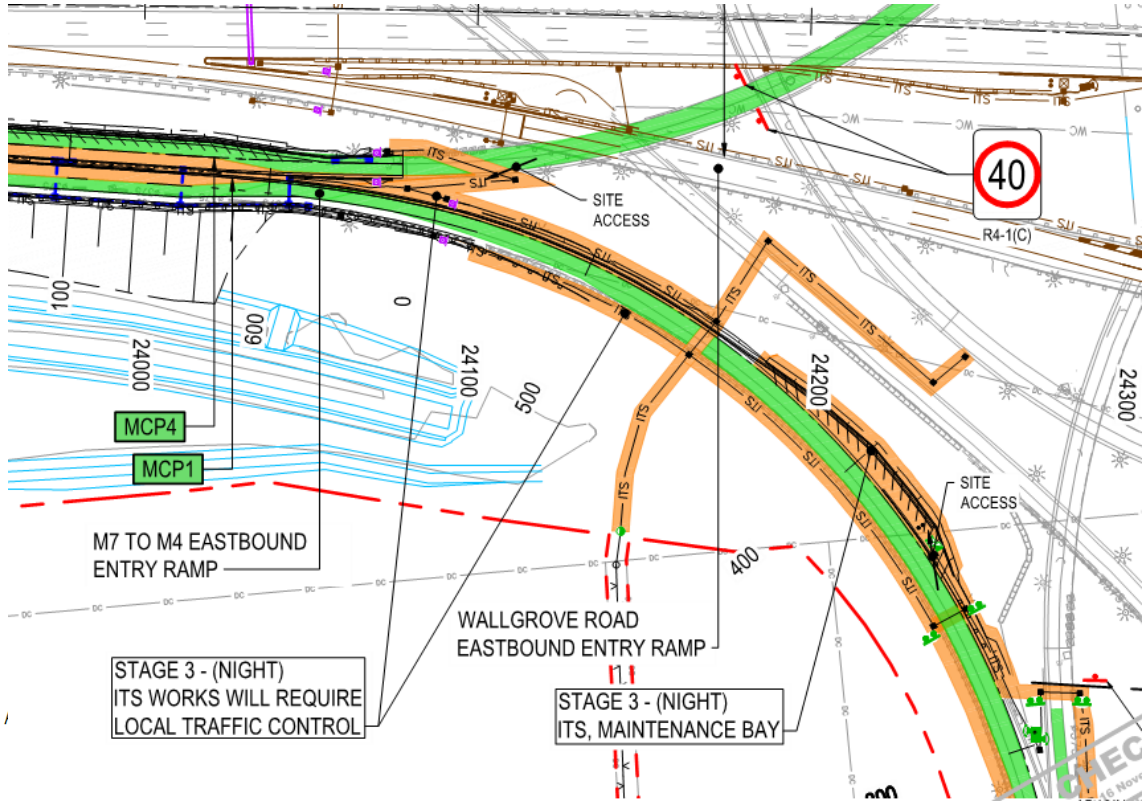
- **Final Design Features**

750 mm dia. Piles @ 1800 mm c/c spacing



CASE STUDY 1: M7 RAMP RETAINING WALL

- **Constructability**
  - One Stage with temporary traffic barriers to allow for one lane to remain open at all times



CONSTRUCTION STAGING

AREA OF WORKS IN STAGE

LIVE TRAFFIC ADJACENT TO

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CASE STUDY 2: BURNETT ST RAMP RETAINING WALL

- **Site Locality and Constraints**

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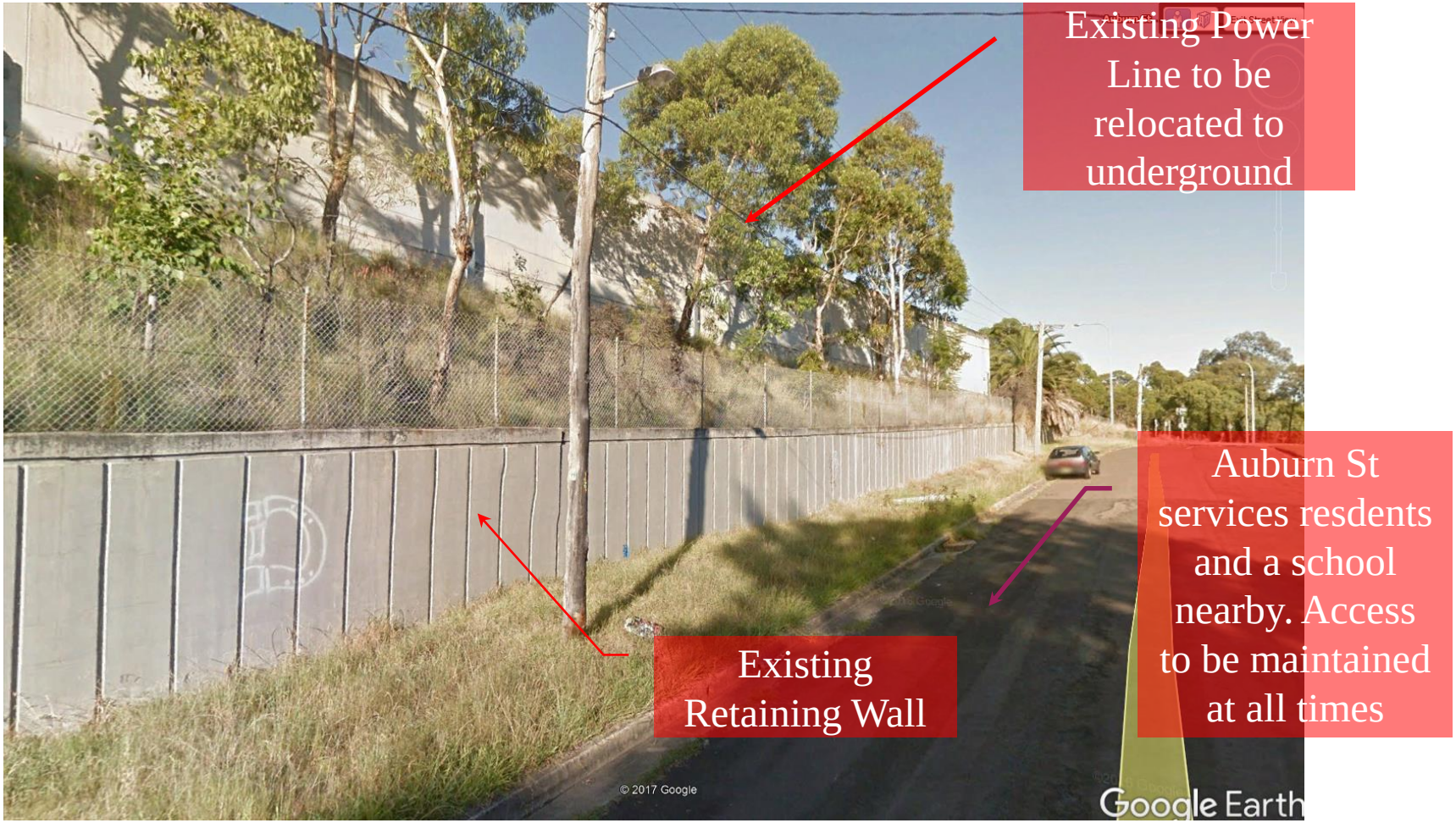
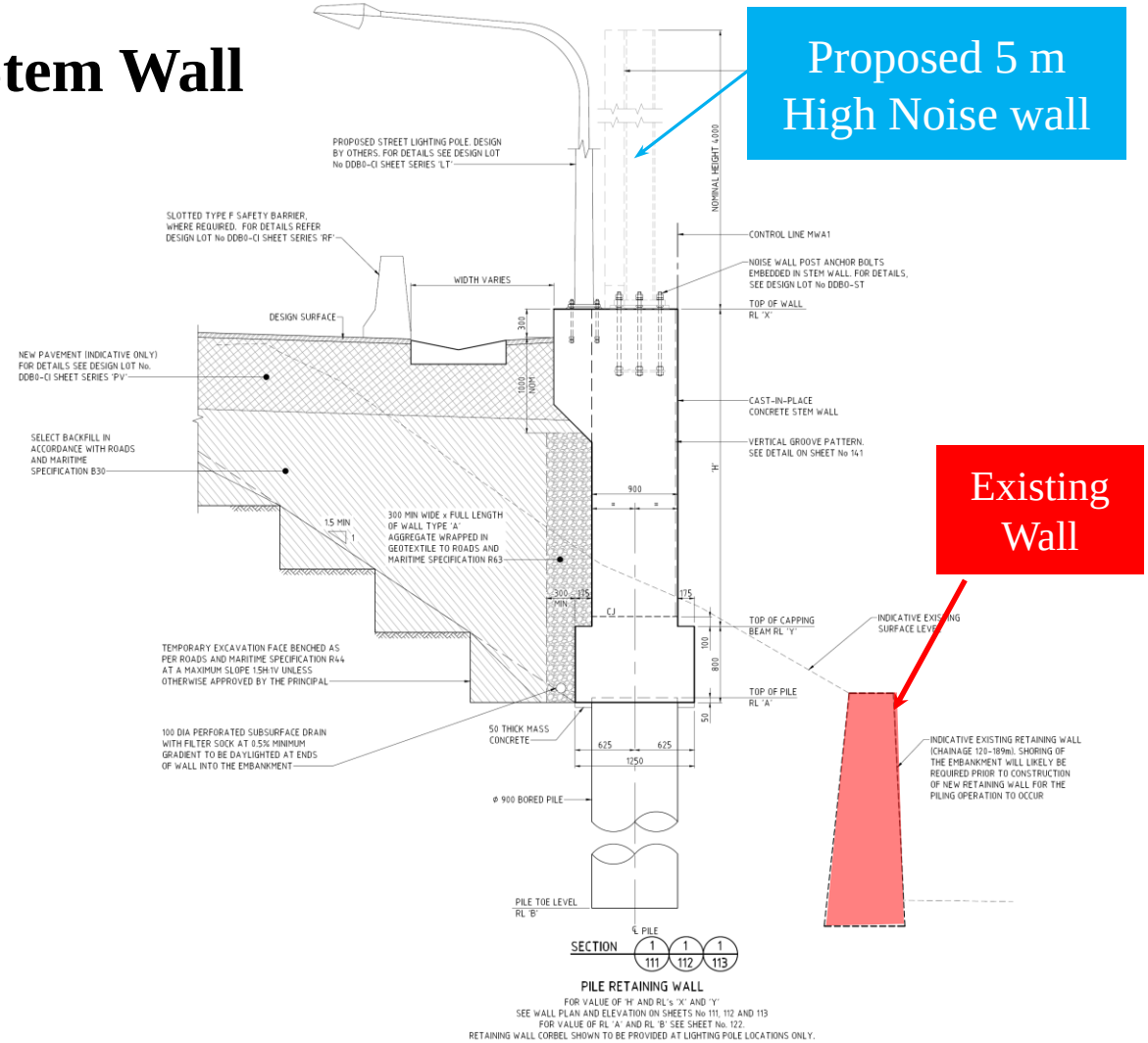
CASE STUDY 2: BURNETT ST RAMP RETAINING WALL

- **Site Constraints (cont'd)**



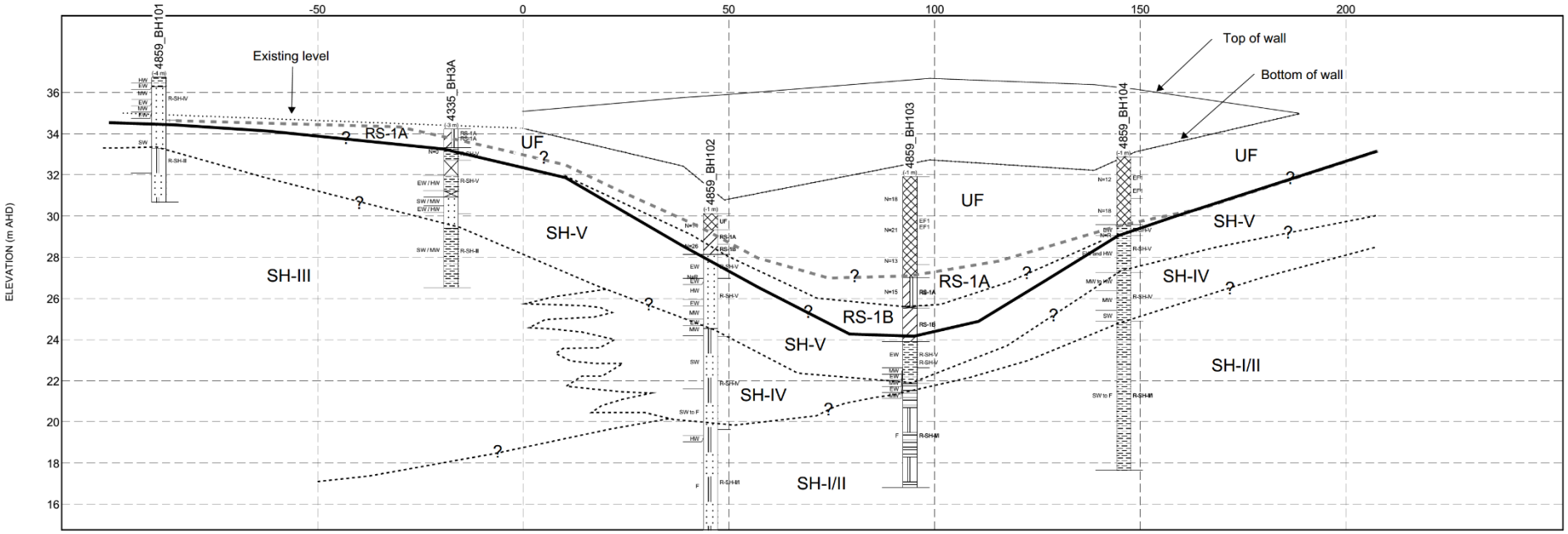
CASE STUDY 2: BURNETT ST RAMP RETAINING WALL

- **Pile Supported RC Stem Wall**



CASE STUDY 2: BURNETT ST RAMP RETAINING WALL

- **Geotechnical Subsurface Conditions**



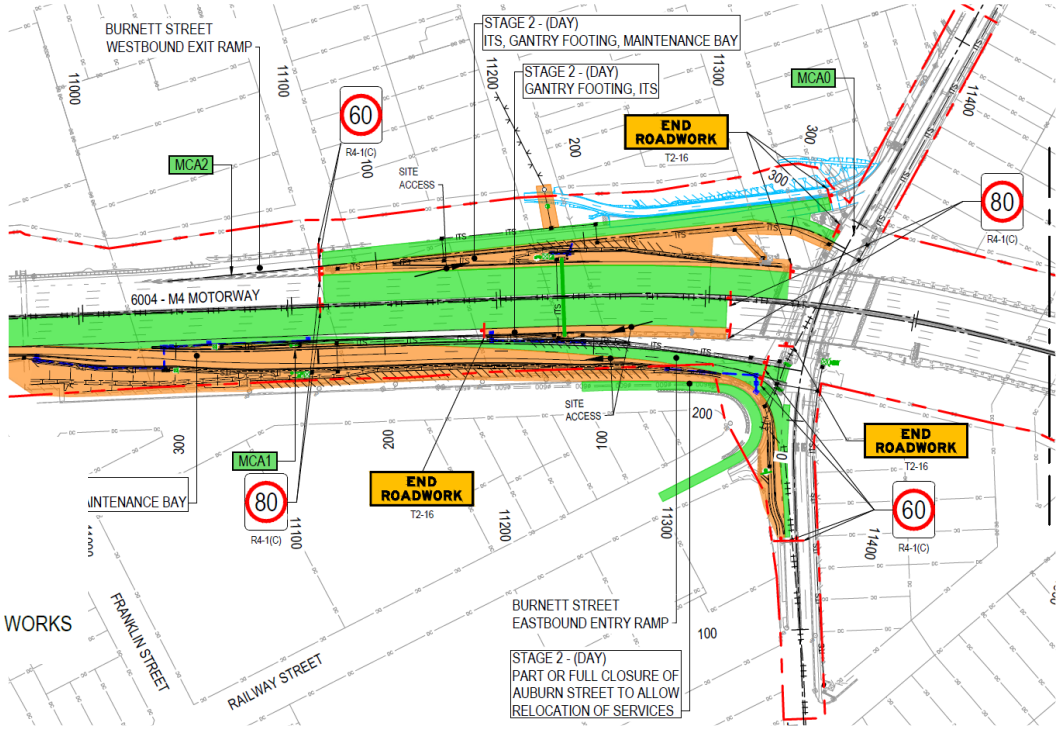
CASE STUDY 2: BURNETT ST RAMP RETAINING WALL

- **Final Design Features**

Description	CH 0 to CH 30	CH 30 to CH 160	CH 160 to end
Retaining Wall RW1			
Maximum retained height	3.9	5.6 m	3.4
Min wall stem thickness	900 mm	900 mm	900 mm
Foundation cast-in situ bored pile			
Pile Length	Min 6 m	Min 11 m	Min 8 m
Pile Diameter	750 mm	900 mm	750 mm
Pile Centre to Centre Spacing	2250 mm	1800 mm	2250 mm
Rock socket requirement	Min 4.0 m into Class IV	Min 2.0 m into Class III Shale/Sandstone	Min 2.0 m into Class III Shale/Sandstone

CASE STUDY 2: BURNETT ST RAMP RETAINING WALL

- **Constructability**
  - Two Stages: with temporary traffic barriers to allow for one lane to remain open at all times
  - Strengthening of Existing Retaining Wall



CONSTRUCTION STAGING

AREA OF WORKS IN STAGE

LIVE TRAFFIC ADJACENT TO AREA OF WORKS

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CASE STUDY 3: COLEMAN ST RAMP RETAINING WALL

- **Site Locality and Constraints**

CASE STUDY 3: COLEMAN ST RAMP RETAINING WALL

- **Site Constraints (cont'd)**

Great Western Hwy

Urban Design- Visual Impact of proposed 9 m high near vertical cut into the existing slope

Operation of Existing Ramp Not Disrupted

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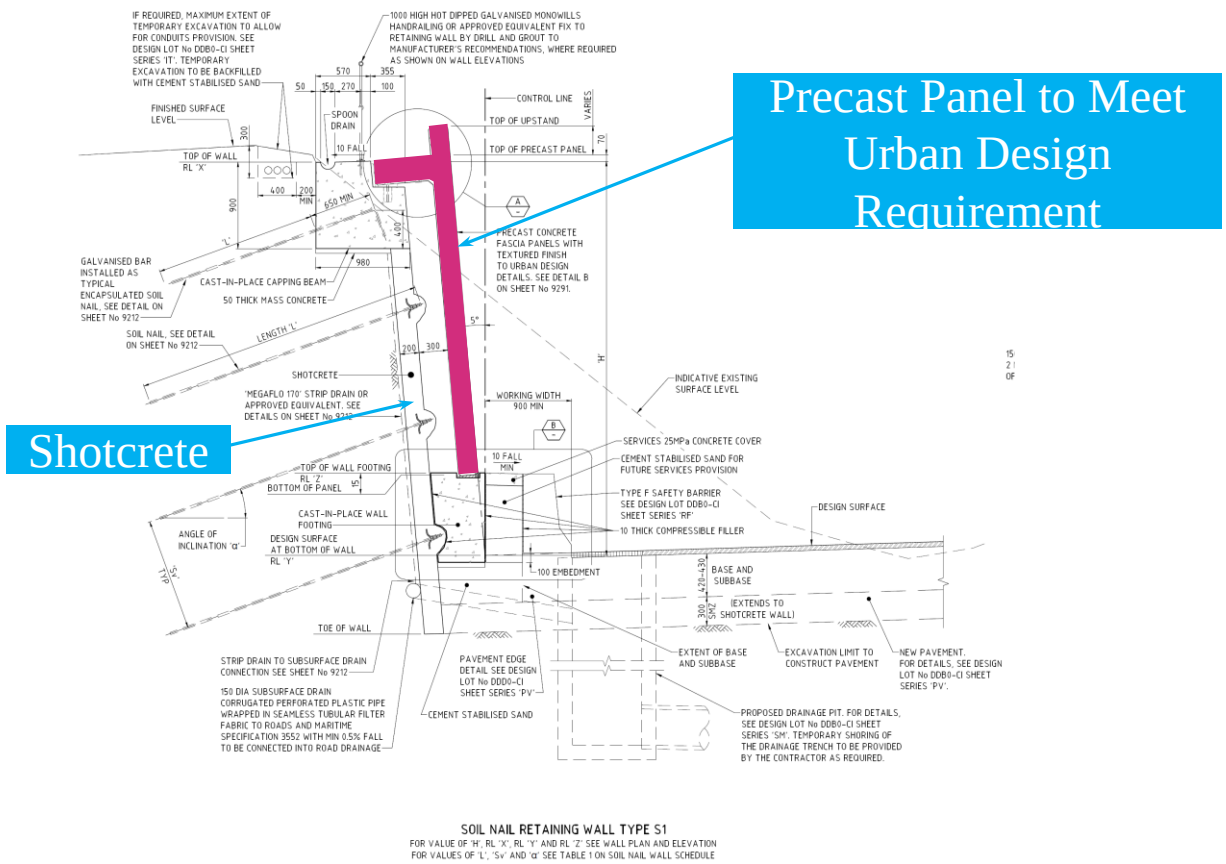
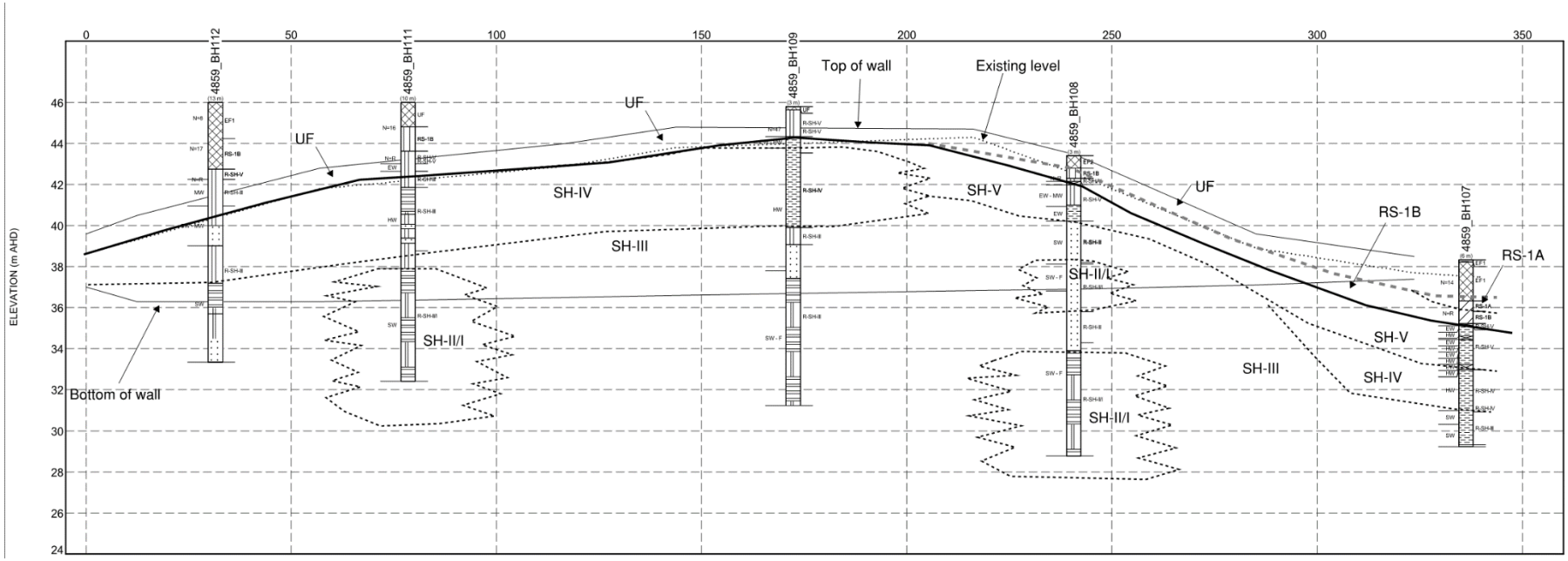
CASE STUDY 3: COLEMAN ST RAMP RETAINING WALL

- **Soil Nail System+Shotcrete**



CASE STUDY 3: COLEMAN ST RAMP RETAINING WALL

- **Geotechnical Subsurface Conditions**



CASE STUDY 3: COLEMAN ST RAMP RETAINING WALL

- **Final Design Features**

TABLE 1 - SOIL NAIL WALL SCHEDULE

CHAINAGE (m)		MAX CUT DEPTH / MAX WALL HEIGHT (m)	ROW No.	NAIL SPACING (m)		DISTANCE OF ROW TO WALL TOP LEVEL (m)	ANGLE OF INCLINATION TO HORIZONTAL 'α' (DEGREES)	NAIL LENGTH 'L' (m)	MINIMUM WORKING STRENGTH (kN)	BAR DIAMETER (mm)	GROUT HOLE DIAMETER (mm)
FROM	TO			'Sv' MAX	'Sh' MAX						
0	60	6.79	1	2.0	1.5	0.5	15	6.0	50	N24	150
			2	2.0	1.5	2.5	15	6.0	50	RB25	150
			3*	2.0	1.5	4.5	15	6.0	50	RB25	150
60	260	8.77	1	1.5	1.5	0.5	15	7.0	50	N24	150
			2	1.5	1.5	2.0	15	7.0	50	RB25	150
			3	1.5	1.5	3.5	15	7.0	50	RB25	150
			4	1.5	1.5	5.0	15	7.0	50	RB25	150
			5*	1.5	1.5	6.5	15	7.0	50	RB25	150
260	END	4.69	1	1.5	1.5	0.5	15	4.0	50	N24	150
			2	1.5	1.5	2.0	15	4.0	50	RB25	150
			3	1.5	1.5	3.5	15	4.0	50	RB25	150

CASE STUDY 3: COLEMAN ST RAMP RETAINING WALL

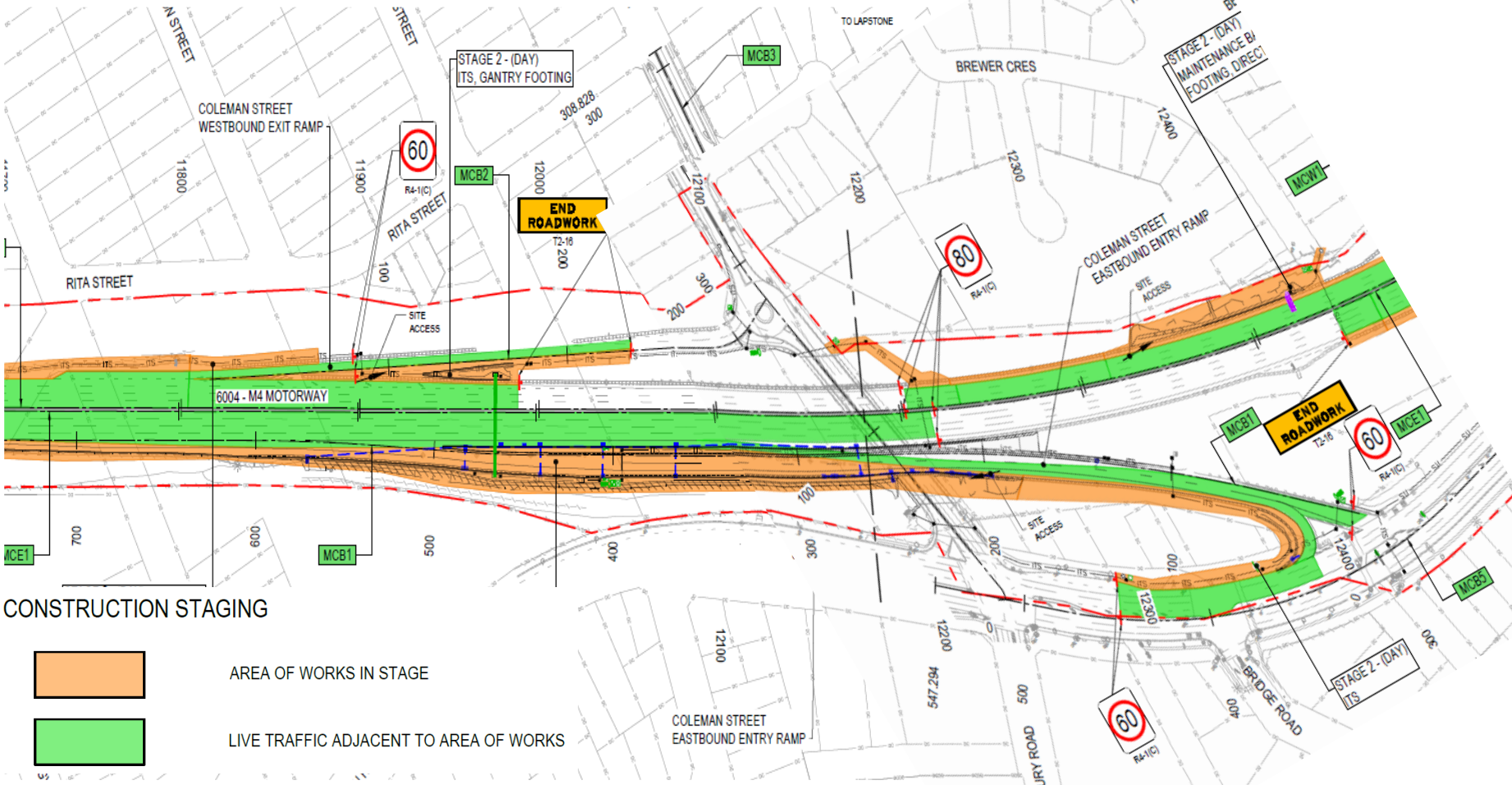
- **Soil Nail Testing**

TABLE 2 - SOIL NAIL TESTING REGIME

ITEMS	REQUIREMENTS
SUITABILITY TEST (ON SACRIFICIAL NAILS)	
NUMBER OF TESTS	1% OF THE PERMANENT NAILS BUT NOT LESS THAN 2
TEST LOAD	TO PULL-OUT FAILURE OR TO 200% OF THE DESIGN WORKING LOAD
ACCEPTANCE TEST	
NUMBER OF TESTS	3% OF THE PERMANENT NAILS
TEST LOAD	TO 150% OF THE DESIGN WORKING LOAD

CASE STUDY 3: COLEMAN ST RAMP RETAINING WALL

- **Constructability**



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