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

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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
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 infrastructures 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)
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

M7 Eastbound On Ramp open to traffic at all times

Proposed Maintenance Bay for ITS Gantry
CASE STUDY 1: M7 RAMP RETAINING WALL

- Hybrid- Pile Supported L-shaped Wall

~12 m
CASE STUDY 1: M7 RAMP RETAINING WALL

• Geotechnical Subsurface Conditions

Existing Fill (Stiff to Hard)

Alluvium (Stiff to very stiff)
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
CASE STUDY 2: BURNETT ST RAMP RETAINING WALL

• Site Locality and Constraints

One lane open to traffic at all times

Existing Retaining Wall to be maintained
CASE STUDY 2: BURNETT ST RAMP RETAINING WALL

• Site Constraints (cont’d)

- Existing Power Line to be relocated to underground
- Auburn St services residents and a school nearby. Access to be maintained at all times

Existing Retaining Wall
CASE STUDY 2: BURNETT ST RAMP RETAINING WALL

- Pile Supported RC Stem Wall

Proposed 5 m High Noise wall

Existing Wall
CASE STUDY 2: BURNETT ST RAMP RETAINING WALL

• Geotechnical Subsurface Conditions
## CASE STUDY 2: BURNETT ST RAMP RETAINING WALL

### Final Design Features

<table>
<thead>
<tr>
<th>Description</th>
<th>CH 0 to CH 30</th>
<th>CH 30 to CH 160</th>
<th>CH 160 to end</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retaining Wall RW1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum retained height</td>
<td>3.9</td>
<td>5.6 m</td>
<td>3.4</td>
</tr>
<tr>
<td>Min wall stem thickness</td>
<td>900 mm</td>
<td>900 mm</td>
<td>900 mm</td>
</tr>
<tr>
<td>Foundation cast-in situ bored pile</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pile Length</td>
<td>Min 6 m</td>
<td>Min 11 m</td>
<td>Min 8 m</td>
</tr>
<tr>
<td>Pile Diameter</td>
<td>750 mm</td>
<td>900 mm</td>
<td>750 mm</td>
</tr>
<tr>
<td>Pile Centre to Centre Spacing</td>
<td>2250 mm</td>
<td>1800 mm</td>
<td>2250 mm</td>
</tr>
<tr>
<td>Rock socket requirement</td>
<td>Min 4.0 m into Class IV</td>
<td>Min 2.0 m into Class III Shale/Sandstone</td>
<td>Min 2.0 m into Class III Shale/Sandstone</td>
</tr>
</tbody>
</table>
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
CASE STUDY 3: COLEMAN ST RAMP RETAINING WALL

- Site Locality and Constraints

One lane open to traffic at all times
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
CASE STUDY 3: COLEMAN ST RAMP RETAINING WALL

- Soil Nail System + Shotcrete

Precast Panel to Meet Urban Design Requirement

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

<table>
<thead>
<tr>
<th>CHAINAGE (m)</th>
<th>MAX CUT DEPTH / MAX WALL HEIGHT (m)</th>
<th>ROW No.</th>
<th>NAIL SPACING (m)</th>
<th>DISTANCE OF ROW TO WALL TOP LEVEL (m)</th>
<th>ANGLE OF INCLINATION TO HORIZONTAL 'α' (DEGREES)</th>
<th>NAIL LENGTH 'L' (m)</th>
<th>MINIMUM WORKING STRENGTH (kN)</th>
<th>BAR DIAMETER (mm)</th>
<th>GROUT HOLE DIAMETER (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FROM</td>
<td>TO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>60</td>
<td>6.79</td>
<td>1</td>
<td>2.0</td>
<td>15</td>
<td>0.5</td>
<td>15</td>
<td>6.0</td>
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<td>60</td>
<td>260</td>
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<td>15</td>
<td>15</td>
<td>0.5</td>
<td>15</td>
<td>7.0</td>
<td>50</td>
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<tr>
<td>260</td>
<td>ENO</td>
<td>4.69</td>
<td>1</td>
<td>15</td>
<td>15</td>
<td>0.5</td>
<td>15</td>
<td>4.0</td>
<td>50</td>
</tr>
</tbody>
</table>
CASE STUDY 3: COLEMAN ST RAMP RETAINING WALL

- Soil Nail Testing

<table>
<thead>
<tr>
<th>ITEMS</th>
<th>REQUIREMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUITABILITY TEST (ON SACRIFICIAL NAILS)</td>
<td></td>
</tr>
<tr>
<td>NUMBER OF TESTS</td>
<td>1% OF THE PERMANENT NAILS BUT NOT LESS THAN 2</td>
</tr>
<tr>
<td>TEST LOAD</td>
<td>TO PULL-OUT FAILURE OR TO 200% OF THE DESIGN WORKING LOAD</td>
</tr>
<tr>
<td>ACCEPTANCE TEST</td>
<td></td>
</tr>
<tr>
<td>NUMBER OF TESTS</td>
<td>3% OF THE PERMANENT NAILS</td>
</tr>
<tr>
<td>TEST LOAD</td>
<td>TO 150% OF THE DESIGN WORKING LOAD</td>
</tr>
</tbody>
</table>
CASE STUDY 3: COLEMAN ST RAMP RETAINING WALL

- Constructability