Managing geotechnical risk during road construction

A case study: Toowoomba Second Range Crossing (TSRC) project

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Presentation outline

1. Overview of the Toowoomba Second Range Crossing project
2. Geotechnical risk
3. Issues during construction
4. Investigation and remediation
5. Lessons learned.
Toowoomba Second Range Crossing (TSRC) – overview
TSRC – overview (continued)
Fast facts

10 million m$^3$ of cut earthworks

42 cut excavations on the main alignment

30 m deep cutting at the top of the range

6 grade separated interchanges

500,000 tonnes of asphalt

24 bridges

40 road embankments

28 km four lane carriageways

15 km two lane carriageways

IPWEAQ Conference – Gatton | 7–8 March 2019
Public Private Partnership – contractual structure

- Design
- Construct
- Operate and maintain (25 years).

SPV = Project Co., operating as Nexus Infrastructure

SPV – Special Purpose Vehicle (Concessionaire or Principal Contractor)
Geotechnical risks
Risks identified by TMR/Project Co. Tender/Design

- Collapse during excavation – weak rock underlying high strength rock
- Groundwater – slope instability, pavement issues
- Embankments on loose soil deposits – instability, settlement
- Rock falls/rock mechanics failures
- Reactivation of dormant landslides
- Degradation of batters – due to slaking and dispersion.
Issues during construction
Eastern section – ch12500 to ch17500
Schematic long section along TSRC alignment
Corridor constraints – top of the range
Corridor constraints – 40m thick sidelong embankments
Investigation and remediation
Boreholes/test pits Embankment 24 – tender

4 boreholes
2 test pits
Boreholes/test pits Embankment 24 – design

- 9 boreholes
- 6 test pits
- 8 seismic lines
(in addition to 4 boreholes and 2 test pits from Tender)
Embankment 24 – original design

CONSTRUCTION SEQUENCE

1. Topsoil stripping and clear and grubbing operations to remove topsoil and soft/bare materials in accordance with WRT24.

2. Installation of cofferdams proposed at toe of embankment. Refer to instrumentation and monitoring drawings.

3. Removal of unstable foundation materials such as clay/bands clay material (Clause 8 WRT24). Embankment foundation shall be made dense (friction angle >32 degrees) or stiff (or better) with undrained shear strength:
   - Soils: 125 kPa at pH 7.5-10.0 – CH15750,
   - Soils: 130 kPa at pH 7.5-10.0 – CH15751,
   - Soils: 140 kPa at pH 7.5-10.0 – CH15752,
   - Soils: 150 kPa at pH 7.5-10.0 – CH15753.

   The prepared ground surface (after clearing and grubbing, stripping of topsoil, unstable materials and above instability material) in accordance with Chapter 9 WRT24 may be removed (in accordance with Clause 12 WRT24) to achieve the minimum undrained shear strength requirements. It’s to be confirmed in writing by an experienced geotechnical engineer/contracting geologist.

3. For foundation retaining structures and requirements refer to Earthworks General Notes drawings. For batching details refer to Drawing No. 099243. For further construction sequence Refer to Drawing No. 099245 and reference section.

4. Construct the temporary trench drain. Flattening of bottoms of the installation temporary support or sub-plantation support or other suitable measure shall be made as required to ensure that the trench drain will not weaken the surrounding soil. Refer Drawing No. 099246 for Type B Foundation Drainage.

5. Construction of the rockfill/soil drain at CH15750 – CH15990 and CH15991 – CH15993. Flattening of bottoms of the installation temporary support or sub-plantation support may be required during the excavation of the sheet key. Design of temporary excavations may be required to ensure protection of the sheet key trench will not weaken the surrounding soil. Refer Drawing No. 099237 and 099238 for rockfill drain key.

6. At gully areas CH15990 and CH10000 respectively, extend the rockfill/soil drain key at minimum grade 2E to ensure free drainage at the lowest point. Remove all potentially unstable materials downstream from the drainage outlet. Rock protection may be required at the drainage outlet to further disperse any fines. Never direct water onto unstable rock/ground material.

7. Drainage blanket is constructed throughout the embankment footprint. Refer to Drawing No. 099239 and 099240.

8. Foundation preparation and the temporary trench drain and the drainage blanket shall be constructed prior to the longitudinal drain at the toe of the embankment. A minimum 2m cover of low permeability material is required to minimize any surface water into the drainage blanket.

9. Minimum of eight months of entire embankment loading shall be required to meet consolidation requirement. If construction period of the embankment is one year, a minimum of two months of pre-loading is required.
Embankment 24 – May 2017
Embankment 24 movements – instrument monitoring
Embankment 24 – map of surface cracking
Embankment failure – shear plane under foundation
Embankment continued to move

Embankment unloaded to stop further sliding
Boreholes/test pits – post failure

Additional 36 boreholes plus instrumentation and 10 test pits
Cross section – post failure
Proposed redesign options considered

1. Remove and replace
2. Toe berm
3. Structural retaining system
4. Viaduct on piled foundations.
Remove and replace

Toe berm
Structural retaining system

- Large diameter bored cast in-situ reinforced concrete (RC) piles
- Installed across the toe of the embankment.
Reconstruction of Embankment 24 – option 1

New finished level
Embankment 24 construction – February 2019
Lessons learned
Lessons learned

• Inherent geotechnical risk in large earthworks projects
• Match scope of geotechnical investigation to level of risk
• Corridor selection/planning to lower geotechnical risks
• Earthworks may not always be the most economical design option.
In summary…

1. Overview of the TSRC project
2. Embankment 24 design – risks identified
3. Issues during construction
4. Further investigation and re-design
5. Lessons learned.
Drone Photo – Embankment 24 (27th Feb 2019)
Thank you
and stay connected

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