Overview

- Construction Engineering
- Scoping requirements
- Existing conditions summary
- Assessment approach
- Key considerations of design
- Key assessment findings
- Key submission issues

By key areas West Gate, Tunnel, Port CityLink, city connections
West Gate Freeway

- Surface works
- Road widening
- Bridges
Tunnel (Overview)

- Portals
- Bored Tunnels x2
- Cross Passages (120 m spacing)
- Spoil Transport routes
- Laydown areas
Portal Structures
- Entry / exit to tunnel
- Large excavations (approx. 25m deep) with engineered ground support

Source – Herrenknecht (Katzenberg 2007) 11.2m diameter
Tunnel Metrics

- Outer Diameter = 15.6 m
- Typical depth to top of tunnel = 20-30 m
- Minimum (at portals) = 5-8 m
- Combined length = 6.8 km
  - (2.8 km east bound tunnel)
  - (4.0 km west bound tunnel)
- Dug using Tunnel Boring Machine (TBM)
- Built below the water table
Earth Pressure Balance (EPB) Tunnel Boring Machine (TBM)

Concrete tunnel lining built immediately behind TBM
Conveyor system removes mined spoil to surface
Hydraulic jacks push TBM forward
TBM cutter head

Approx. 20-30 m
**Tunnelling Modes (EPB TBM)**

- **Closed Mode**
  - Adopted in soil and mixed ground (controls groundwater inflow)
  - ![Green Check](✓)

- **Semi Closed Mode**
  - Adopted in hard rock (Tvn) (controls groundwater inflow)
  - ![Green Check](✓)

- **Open Mode**
  - Not used (free draining)
  - ![Red X](✗)
Principles of Earth Pressure Balance (EPB) tunnelling

- A plug of modified soil formed behind the cutter head
- Bentonite mud injected around TBM & segments grouted in
- Controls soil in-rush / over excavation and groundwater leakage
Segmental Tunnel Lining

- Approx. 500 mm thick steel reinforced segments
- Built in 10 pieces to form a ‘ring’
- Rings built progressively within the rear of the TBM
- Cemented in place behind TBM (Simultaneous tail skin grouting)

Cross passages

- Emergency exits between tunnels & EOU’s for single tunnel case
- Probe & grout first
- Excavated with small plant
- Jacked concrete box or sprayed concrete support
- Plastic membrane or gasket seals for waterproofing

Note – EOU stands for Emergency Out & Under.
Spoil Management

- Tunnel spoil conveyed to Northern portal
- Detained in bunded concrete bays within covered sheds
- Moved off site via truck
Main construction laydown areas

- Spoil transport route via Footscray Road to CityLink
- Southern portals - spoil transport route via West Gate Freeway
- Final disposal of spoil in accordance with legislation & EPRs

Source – Technical report A (Transport)
Port, CityLink and City Connections

- River Crossings (Bridges)
- Elevated Viaducts
- Ramps
Port, CityLink and City Connections

- Thick weak soil
- Deep piled supports required
Existing Conditions – Site Investigations

EES supported by extensive investigations and existing data

- Geology distribution
- Hydrogeology
- Geomechanical properties

Investigation Locations

Groundwater Wells
Regional Surface Geology – Project Scale

- Complex layer cake of hard basalt rock and sediments
- ‘Melbourne Formation’ bedrock tilted and buried deeply below younger geology
- Capped at surface by younger (Newer) basalts
- Trough of ‘Yarra Delta’ sediments east of river

Massive basalt flows ~2-4 million years old
Overlies older stratum

Trough of weak deltaic sediments to east of river <2 million year old

Source – Technical report D (Ground Movement)
Existing conditions - human effects

- Diversion & filling of waterways
- Backfilled quarries
- Contamination
- Major infrastructure (e.g. North Yarra Main Sewer)

Source – Technical report D (Ground Movement)
Assessment – Ground Movement

The Ground Movement study objectives include:

- Understand the risk of ground movement and potential impacts
- To identify risk and mitigation measures to minimise adverse effects on land and river bank geomorphic stability from project activities
- To develop performance requirements that drive acceptable outcomes

**Note:** Aspects associated with river erosion are addressed separately in Technical report E (Surface Water)
Ground movement risks include:

Damage to linear infrastructure
- pipelines
- rail lines
- roads
- bridges, etc.

Damage to buildings
- residential buildings, commercial buildings
Assessment Methodology

- Characterise the existing ground conditions and identify triggers
- Develop predictive models of ground movement
- Assess the level of risk of ground movement
- Incorporate EPR’s measures to control and minimise risk
West Gate Freeway

- Works involve ‘at surface’ freeway widening and some bridge structure (common urban road works – example Tullamarine widening)

- Ground movement risks localised and confined to road corridor assets (examples: pavement cracking, slope retention, settlement of new structures)

- Considered manageable with existing EPRs (GMP1 to GMP6)
- Strong ‘Newer’ basalt rock (Tvn)
- Variable ‘Tertiary’ sediments (Tmn, Tpa, Tpb, Tew) – clays and sands
- Weathered ‘Older basalt’ (Tvo)

Source – Technical report D (Ground Movement)
Simplified Tunnel Geology

- Simplified geology overview - sediments ‘sandwiched’ between two ancient volcanic flows
Tunnel – key issues (potential triggers)

- Ground movement (settlement) impacting on existing buildings and other sensitive infrastructure along the tunnel alignment
- Ground movement due to soil relaxation or instability towards large open excavations
- Depressurisation of groundwater in areas underlain by compressible soils, which may trigger consolidation settlement
Tunnel – key issues (potential triggers)

- TUNNELLING SETTLEMENT
- GROUND RELAXATION
- SUBSIDENCE
Tunnel – Design considerations

- Piled retention and sprayed concrete to support portal excavations
- Injection grouting (reduced groundwater inflow)
- Recharge wells (mitigates groundwater lowering)
- EPB tunnel boring machine (controls ground stability and groundwater inflow)
- Undrained ‘tanked’ design
- Largest settlements predicted near northern portal (industrial zone), approximately 60-70mm

- Predicted movements reduce as tunnel deepens

- Thick (10-15 m) cap of strong basalt geology assists in protection of residential areas

- Negligible ground movement west of Williamstown road (in strong rock)

Source – Technical report D (Ground Movement)
Controlling uncertainty - Tunnelling under buried creek (former Stony Creek)

- Design allowance – 5 m rock cover
- Consultation with VicRoads (EPR GMP1 to 4)
- Detailed design ➔ Construction (ALARP) (EPR GMP1, GMP5, GMP6)

Source – Technical report D (Ground Movement)

ALARP = As Low As Reasonably Practical
Risk - combined sources (Construction case)

- Combined ground movement risk prediction for groundwater subsidence, tunnelling & portal excavation
- Groundwater drawdowns based on modelling (Technical Report E)
- Conservative - does not consider groundwater reinjection (favourable)

Source – Technical report D (Ground Movement)
Risk during operation

- Risk issues are limited to dewatering
- Tunnel and portals designed as undrained ‘tanked’ structures
- Predicted operational groundwater drawdown due to ‘leakage’ less than 1m*
- Negligible ground movement (subsidence) predicted

* Based on Technical report C (Groundwater
Tunnel EPR’s

- GMP1 – Geotechnical model & assessment (maintain & update)
- GMP2 – Drainage control (design and as reactive contingency)
- GMP3 – Condition surveys (before and after)
- GMP4 – Determine settlement limits of utilities with relevant service authority
  (example – VicRoads, Melbourne Water, Mobil Exxon, etc)
- GMP5 – Monitoring (linked with GMP1)
- GMP6 – Implement timely mitigation to limit impacts if detected (plan, monitor, act)
Port, CityLink and city connections

- Area underlain by thick deposits of weak compressible Coode Island Silt (CIS) soil
- Ground conditions poor
- Risk would be mitigated by standard engineering design solutions used such as:
  1. Deep piled support common to area and well understood
  2. Limiting fill loads (e.g. embankment weight that may compress CIS) or alternatively adopt ground improvement
Key submission issues

Summary of issue

Concerns regarding tunnel northern portal position (options east of Maribyrnong River)

Response

- Functional objectives constrained or compromised (covered by others)
- Geotechnically unfavourable (thick deposits of weak compressible soils)
- Potential long term subsidence risks (i.e. drainage and consolidation of Coode Island Silt)
- Significant risk of ‘blow outs’ into base of river if tunneled (risk to river health)
- Greater presence of contaminated soil and acid sulphate soil east of river (spoil issues)
- Significant risk of encountering obstructions (e.g. old piles) due to soft ground
Key submission issues

Summary of issue

Concerns groundwater alteration (reduction) that may cause subsidence

Concerns dewatering may cause moisture loss and shrinkage of reactive founding soils.

Response

- Favourable geology (i.e. compressible soil deposits in tunnel area thin or absent)
- Analysis shows low risk of adverse subsidence impacts due to construction dewatering
- Groundwater located within the basalt rock, significantly below reactive soil zone
- EPR GMP 2 – minimise adverse changes to groundwater level
Key submission issues

Summary of issue
*Concern about how condition surveys will be undertaken*

Response
- GMP3 requires condition surveys to be undertaken in areas of possible ground movement risk:
  1. Building condition surveys of buildings are required before & after construction for comparison
  2. Any damage caused as a result of the project must be rectified or the asset owner compensated
  3. Mediation and independent assessment would be undertaken to assess claims
Key submission issues

Summary of issue

Concern about impacts of ground movement on property and assets

Response

- Impacts for West Gate Freeway and City, Port, city connection localized
- For the Tunnel area:
  - Low Risk (residential zone)
  - Two small moderate risk areas (industrial and freeway reserve)
- Protection measures embodied within EPRs GMP1 to GMP6 (included in design)
The IAC review has concluded that the relevant EES reports have been rigorous, comprehensive and diligent (14).

A number of detailed risks/ issues have been identified:
- Ground Movement (67, 68, 70, 78)
- Contaminated Soil and Spoil Management (93, 94, 96, 101)
- Groundwater (20, 34, 35, 38, 39, 40, 42)

These risks would be subject to detailed design and where necessary, measures would be included in the CEMP and OEMP (as indicated in 43, 46, 71, 79, 80).

Specific responses for some items are provided by each Technical Expert.
Response to IAC

Summary of issue

*Ground or groundwater related risks due to construction delays or TBM performance*

Examples:
- Mixed ground types (fluctuation in TBM face pressure & plug consistency)
- Areas of low cover (heave / frac-out)
- Uncontrolled water in-rush

**Known** construction risks considered in design and selection of tunneling methodology

**BUT** - some variance in local geological conditions always possible

Risks continually reassessed during construction – observational principle (EPR GMP1, 5 & 6)
Response to IAC

CEMP controls examples:

- **Technical (engineering controls)**
  1. Ground improvement, structural support, service isolation or diversion
  2. Real time monitoring and adjustment of TBM pressures (linked to GM instrumentation)
  3. Jaw crusher (breaks down boulders)
  4. Tail skin grouting (minimises annular closure)
  5. Compressed air, bentonite, polymer, foam (stabilize ground and water)

- **Procedural**
  1. Risk register (a live document)
  2. Permit to excavate (reviews risks on a daily basis)
  3. Planned interventions (reduces the risk of mechanical breakdown)

- **Contingency Planning**
Response to IAC

Summary of issue

*Depressurization of compressible soil (Coode) impacting on the West Gate Freeway*

- Considered in Tunnel section of study (7.4.1)
- Freeway embankment on stable soils – Coode replaced with engineered fill
- Ground movement prediction assumes drawdown with no reinjection (conservative)
- Grout curtain and reinjection as part of design around southern portals
Response to IAC

Summary of issue

Response 78: residual soil moisture depletion (clay shrinkage)

- Near surface drying/wetting (Hs zone approx. 1.8m)
- Unsaturated soil problem (suction $\Delta u$ change in clay)
- Water table is in rock (no suction change)

Source – AS 2870-2011

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Thank you
Trevor O’Shannessy