Buranda Busway Tunnel
Boggo Road Busway Tunnel
Boggo Road Tunnel – 14m excavated width
Boggo Road Tunnel – Plan and Long Section
Boggo Road Tunnel –
Section Under Buildings – 5m ground cover
GEOMETRY OF BUILDING 'A' SOUTHERN WALL - DISPLACED SHAPE AT MAXIMUM 10mm AT TUNNEL CENTRE

Brick Stress: xx (MPa)
- 4.5464 [Bk:6,Nd:91]
- 3.2202
- 1.2308
- 0.7586
- 2.7480
- 4.3737
- 5.0689 [Bk:1431,Nd:1339]

Undisplaced Shape
Displaced Shape
CELL BLOCK C - FRONT ELEVATION

Note:
- Blue colour: Brick
- Magenta colour: Brick
- Red colour: Concrete

REAR WALL (Brick)
INTERNAL WALL-1 (Brick)
INTERNAL WALL-2 (Brick)
SIDE WALL-1 (Brick)
SIDE WALL-2 (Brick)
FRONT WALL (Brick)

# Footing (Concrete)

**CELL BLOCK C - OUTER SIDE OF FRONT WALL - STRESS**

- Average stresses are measured at centroid of element.
- Tensile stresses are exceeded at zones 3 and zone 4. Hence, bricks will crack at these locations.

**ALLOWABLE TENSILE STRESS FOR BRICK = 0.2 MPa**

**ALLOWABLE TENSILE STRESS FOR CONCRETE = 2.66 MPa**
Settlement Under Buildings C and D
North Strathfield Rail Underpass
Shallow Cover Driven Tunnel

1. Introduction
2. Project Overview
3. Train Operations – Freight/Passenger
4. Clients Cut and Cover Proposal
5. Tunnelling Options
6. Selected Driven Tunnel Option
7. Shallow Cover Tunnel Case Studies
8. Settlement and Monitoring
9. Shotcrete as Permanent Lining
10. Conclusions/Questions
Acknowledgements - Reference Design

Acknowledgements - Detailed Design
The North Strathfield Rail Underpass is Stage 1 of 19 stages of the NFC Project.
Project Overview

NSRU – Scheme Plan

Use existing roads (e.g. Railway Street and George Lane) as access routes into and out of the railway corridor. Use the existing intersections at Parramatta Road and George Street/George Lane as access points. Maintain public access to properties in George Lane.

Bidirectional entry to southern half of down side of the track via “George Lane” worksites.

Entry to up side of the track adjacent to the dive structure. Half of Queen Street to be closed off to allow access between the Queen Street worksite and the railway corridor.

Bidirectional access to work site via Columbia Lane

Access to Goods loop (up side) at the Y loop (through working RailCorp buildings)

Access to Goods loop (down side) at the Y loop

Bidirectional access to Queen Street worksite via existing gate south of Waratah Street.

Access to up side of the track and exit from north of Pemroy Street

Bidirectional access to northern half of down side of the track via existing gate in Hamilton Street East.

Access to up side of the track via existing gate at Yaralla Street.

Exit only from up side via existing routes on Queen Street

Heritage listed substation fenced off from construction worksite

NOTES

Zone 1 - Goods Loop
Zone 2 - West Dive
Zone 3 - Cut & Loop
Zone 4 - East Dive
Zone 5 - North of Pemroy Street

Access to Homelsh Bay Drive

North Strathfield Station

Access to Homelsh Bay Drive

Queen Street worksite

Station forecourt

Pemroy Street bridge

Columbia Lane worksite

George Lane worksite

Potential temporary partial road possession

Potential worksite

Station forecourt

Columbia Lane worksite

George Lane worksite

To Parramatta Road

Access to Parramatta Road

Access to Homelsh Bay Drive

To Parramatta Road
Train Operations

Freight Trains

Up to 1.5 km long with diesel locomotives
20 plus trains per day
Dangerous goods transported including hydrocarbons
Special unique operation controlled by signalling system

Passenger Trains (secondary use, OHW)

Very limited number of special event trains e.g. major sporting events 1600 - 2000 passengers per train
Train Operations – Freight/Passenger
Train Operations – Freight/Passenger
NSRU – Plan and Extent of Tunnel Option
(Cut and Cover Tunnel Shown)
<table>
<thead>
<tr>
<th>No</th>
<th>Type</th>
<th>Down Relief</th>
<th>Down Main</th>
<th>Up Main</th>
<th>Works</th>
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<tr>
<td>1</td>
<td>72hrs</td>
<td></td>
<td></td>
<td></td>
<td>Enabling Works, prepare piling platforms, temporary works for supporting existing OHLE gantries, track works</td>
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<tr>
<td>2</td>
<td>48hrs</td>
<td></td>
<td></td>
<td></td>
<td>18 piles co-ordinated with dive structure</td>
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<tr>
<td>3</td>
<td>48hrs</td>
<td></td>
<td></td>
<td></td>
<td>28 piles</td>
</tr>
<tr>
<td>4</td>
<td>48hrs</td>
<td></td>
<td></td>
<td></td>
<td>14 piles + 55m pile cap</td>
</tr>
<tr>
<td>5</td>
<td>72hrs</td>
<td></td>
<td></td>
<td></td>
<td>28 piles + 35m pile cap</td>
</tr>
<tr>
<td>6</td>
<td>48hrs</td>
<td></td>
<td></td>
<td></td>
<td>13 piles + 55m pile cap</td>
</tr>
<tr>
<td>7</td>
<td>48hrs</td>
<td></td>
<td></td>
<td></td>
<td>37m pile cap + 30m plank laying</td>
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<tr>
<td>8</td>
<td>48hrs</td>
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<td></td>
<td></td>
<td>37m plank laying</td>
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<tr>
<td>9</td>
<td>72hrs</td>
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<td></td>
<td></td>
<td>35m pile cap + 75m plank laying, transfer OHLE on to new gantries</td>
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<tr>
<td>10</td>
<td>48hrs</td>
<td></td>
<td></td>
<td></td>
<td>Completion of the above</td>
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Cut and Cover Construction Stages
Tunnelling Options

Option 1 - Cut and cover tunnel

Option 2 - Hybrid cut and cover and driven tunnel

Option 2a - Interlocked horizontal steel tubes and driven tunnel

Option 3 - Shallow driven tunnel with alignment moved north

Final chosen - Option 3 Driven Tunnel
Project Constraints

Parramatta Rd U/B (Transom Top)

Ausgrid 132kV cables 1.4m cover

2.5% (1 in 40) Exit Grade

Pomeroy St O/B (Opt 3) widens this

2.8% (1 in 35) Entry Grade
Vertical Alignment - 2.5% grades
Indicative Geological Profile

Siltstone, Ashfield Shale Formation
Weathered Shale
Stiff Clay
Ballast and sub-base

Shallow driven tunnel
Driven Tunnel Canopy Tube Construction Method

1. Tunnel Cross Section

- Weathered Shale
- Fresh Shale

2. Tunnel Long Section at Tunnel Face

- 12m long 138mm dia. steel canopy tubes with 3m overlap (required until shotcrete arched formed at tunnel face)
- 350mm thick shotcrete close to tunnel face
- 12m long fibre glass face nails with 4m overlap
- Max. 1.2m

Direction of tunnel drive
Reference Design Tunnel Section
Detailed Design
Permanent Shotcrete Lining with Synthetic Fibres
Comparing NSRU Driven Tunnel with Buranda and Boggo

- **Buranda Case 1**
  - Railway Lines: 3m above
  - Buildings: 5m above
  - 14.5m to 19m (tapered from portal)

- **Boggo Case 2**
  - Railway Lines: 3m above
  - Buildings: 5m above
  - 14m wide

- **Pronounced Arch Profile NSRU Tunnel**
  - 9m wide
  - 19m to 14m (tapered from portal)
Road Header
Site drilling during two track possessions
Monitoring

Apart from conventional displacement monitoring investigating monitoring canopy tube deflections and stresses.
2D and 3D Finite Element Analysis
Permanent Shotcrete Lining

1. Safe Construction

2. Minimise settlement

3. Waterproof and Durable

4. High Fire Resistance (dangerous goods, hydrocarbon fire)
Shotcrete as permanent support “without” Lattice Girders
Shotcrete Test Panels sections prior to construction. Consideration was given to shotcrete and lattice girders as permanent support but because of shallowing effects caused by the use of the required accelerator in the shotcrete, a permanent concrete lining was installed. Using shotcrete alone at Boggo Road, where the tests were carried out was not an option at the time.
Ideal support reaction (canopy tubes and shotcrete at tunnel face)

Support reaction (other support types)

Load-deformation curve for tunnel
Ratio of Axial Stiffness

Relative to 150mm thickness of Shotcrete at 24 hrs
(per metre of tunnel length)
Arched Profile Permanent Shotcrete Lining with Synthetic Fibres
7 hours wait

6 MPa minimum strength before next excavation cycle
### 1.3m and 1.5m Excavation Cycle Scenarios

#### Table 1: 1.3m Excavation Cycle Scenarios

<table>
<thead>
<tr>
<th>Days</th>
<th>Rib Arch</th>
<th>Overlapping Array Canopy Tubes first 3m</th>
<th>Distance</th>
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#### Table 2: 1.5m Excavation Cycle Scenarios

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<th>Rib Arch</th>
<th>Overlapping Array Canopy Tubes first 3m</th>
<th>Distance</th>
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</thead>
<tbody>
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<td>8</td>
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</tr>
</tbody>
</table>

#### Note:
- Maximum compressive stress in shotcrete approx. 3MPa
- Face dowel installation 18 hours
- Canopy tube installation 48 hours
Record of actual excavation cycles, advance rates and shotcrete mix design.
Geology
Tunnel Plan – Geological Long Section
Tunnel Face at 20m
Tunnel Face at 40m
Permit To Tunnel (PTT)
Daily “Permit To Tunnel” meeting room
PPT Process has Initiated the following

1. 1m, 1.3m and 1.5m excavation advances
2. Increased number of dowels from 3 to 5 in crown apex
3. Installation of reinforcement in the canopy tubes
4. Adapted to changed ground conditions – dyke and fault zone
5. Permanent fibreglass dowels in walls
6. Reduced excavation advance back to 1m, increased back to 1.5m
7. Increased tunnel lining thickness from 250mm to 300mm
8. Increased at two locations the number of face nails
9. Weep holes in side walls and in tunnel face
10. Shotcreting the tunnel face
11. Added additional monitoring on surface and in tunnel
12. Decreased and increased the number of canopy tubes where required
13. Reviewed shotcrete mix and improved progressively
Canopy Tubes
Fibreglass Face Nails
(for face stability)
Monitoring Regime
Plan of Monitoring Surface

Remote Access robotic scanned survey data

24hrs/day via internet PC computer, iPad or iPhone
Ground Mark GM 024 one tunnel diameter back from face - 5mm

Tunnel Face at 101.7m
Predicted surface settlement 6mm
Actual range 5mm to 14mm

In tunnel crown settlement max. 1mm

In tunnel convergence max, 3.5mm (at dyke)

Excavation rate 5m/week
7 days 24hrs/day construction
Spray-on Waterproofing Membrane
Near Completed Tunnel with Track Slab
Questions

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Engineers Australia – South Coast - July 2015