

# ACAA TECHNICAL CONFERENCE PAPER

5 MAY, 2006

## CROSS CITY TUNNEL, SYDNEY NSW

John Battaglia<sup>1</sup>, Susette Dixon<sup>2</sup>, Adam Hudson<sup>3</sup>

### ABSTRACT

The Cross City Tunnel was a complex and technically challenging major infrastructure project and required the highest levels of co-ordination and management throughout the duration of the contract. This major design and construct project accommodated multiple tunnels and large civil, structural, mechanical, electrical, tolling and fire services elements. Dual 2.1km twin lane tunnels run east to west, with connections to the Eastern Distributor, Western Distributor and Sydney Harbour crossings. The Cross City Tunnel dramatically reduces journey times across the city, and is designed to remove up to 90,000 cars per day from Central Business District (CBD) streets. It improves access and schedules for buses, reduces noise levels, improves air pollution, heightens pedestrian safety and enhances connections to major arterial roads along the east-west and north-south routes. An overall and significant factor is improvement to the general amenity and public spaces in the city. The Roads and Traffic Authority of NSW entered into an agreement with CrossCity Motorway to finance, design construct and operate the Cross City Tunnel in late 2002. In turn, CrossCity Motorway contracted the design and construction of the \$680 million project to the Baulderstone Hornibrook Bilfinger Berger Cross City Tunnel Joint Venture. Baulderstone Hornibrook maintains the Cross City Tunnel.

### KEY WORDS

Cross City Tunnel, Bauldertstone Hornibrook, Bilfinger Berger, design and construct, engineering innovation, construction excellence, driven tunnelling, cut-and-cover works, portal, bus crossover, viaduct, ventilation system, fire protection system, electronic toll collection system

---

<sup>1</sup> Mechanical and Electrical Zone Manager, Baulderstone Hornibrook Pty Ltd, Level 10 40 Miller Street North Sydney NSW 2060, Phone 02 99357100, [jbattaglia@bh.com.au](mailto:jbattaglia@bh.com.au)

<sup>2</sup> Environmental and Completion Manager, Baulderstone Hornibrook Pty Ltd, Level 10 40 Miller Street North Sydney NSW 2060, Phone 02 99357100, [sdixon@bh.com.au](mailto:sdixon@bh.com.au)

<sup>3</sup> Project Director, Baulderstone Hornibrook Pty Ltd, Level 10 40 Miller Street North Sydney NSW 2060, Phone 02 99357100, [ahudson@bh.com.au](mailto:ahudson@bh.com.au)

## **INTRODUCTION**

### **Project Description**

The Project comprises eastbound and westbound two-lane 2.1 km long road tunnels, with four single lane interconnecting ramps and eight portals. A separate 2.1 km long ventilation tunnel runs beneath the mainline tunnels to deliver vitiated air back to a single ventilation stack in Darling Harbour. Within the mainline tunnels there are seven reinforced concrete bridging slabs of which four are for tunnel crossovers for the future Metro Rail tunnels. Mechanical and electrical fitout included four underground electrical substations, a water treatment plant, a tunnel ventilation system with three underground ventilation stations, fire and life safety requirements, including 18 cross passages between eastbound and westbound tunnels for emergency egress.

Surface works included five cut and cover tunnels, three approach ramp troughs, widening by one traffic lane of an existing concrete viaduct and a two-tier expressway, connection of two flyovers to create a bus crossover lane, construction of a 40m wide landbridge, two footbridges over roads, construction of the Tunnel Control Centre and construction of a 62m high ventilation stack.

The project was put out to competitive tender as a build, own, operate and transfer project by the Roads and Traffic Authority of NSW (RTA). The tender was won by CrossCity Motorway (CCM), a consortium that included Bilfinger Berger Concessions, Deutsche Bank, and CKI from Hong Kong. The concession period is 33 years.

The works were constructed under a design and construct contract by the Baulderstone Hornibrook Bilfinger Berger Cross City Tunnel Joint Venture (BHBB JV), an association that combined one of Australia's leading civil contractors, Baulderstone Hornibrook, and Bilfinger Berger, one of Europe's leading civil and tunnelling contractors.

Baulderstone Hornibrook maintains the tunnel for CCM.

### **Key Challenges**

Designing and constructing the Cross City Tunnel beneath the heart of Australia's largest city presented an array of challenges and necessitated a thorough assessment of and responses to both stakeholder and community needs. The primary challenge was excavation of 8.5km of tunnel and removal of the resultant spoil, and construction of associated surface structures with minimal disruption to the existing (and already congested) traffic network, and to the city community. It was critical that each stage of construction was thoroughly planned, coordinated and managed in order to ensure daily life in Sydney could function as usual.

The CBD location and small footprint of the Cross City Tunnel worksites presented exceptional construction planning and traffic management challenges throughout the construction phase. In addition, thousands of utility investigations were conducted to successfully construct the tunnel through the existing intense sub-surface infrastructure.

The need to comply with emerging in-tunnel air quality goals that are the highest specified in Australia, and the restriction to only use one exhaust stack located at the

western end of the tunnels proved also to be an extreme challenge to the design team and construction team alike.

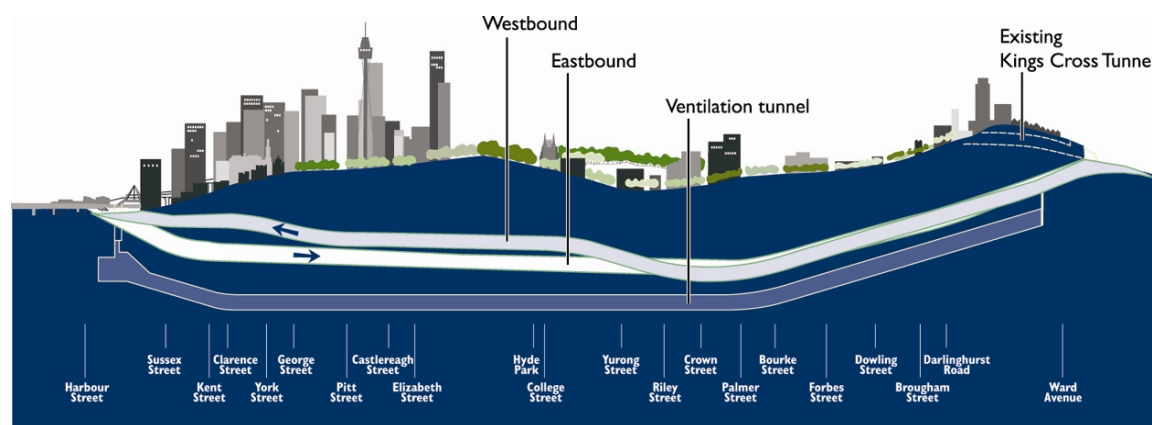
The innovative solutions produced by the design team and construction team to overcome these challenges are further described below.

## CIVIL WORKS ELEMENTS

### Tunnels

Tunnel alignment was constrained by the location of the portals, which had been fixed in the Environmental Impact Statement (EIS), and the required traffic movements specified by the RTA. Other restrictions included avoiding future metropolitan underground rail projects MetroWest and MetroPitt, Town Hall underground railway station and City Circle Lines, Telstra's ageing brick cable tunnel in Kent Street, the Eastern Distributor tunnel, the Kings Cross rail tunnel and the Kings Cross road tunnel. The final alignment chosen changed the geometry from the original concept by:

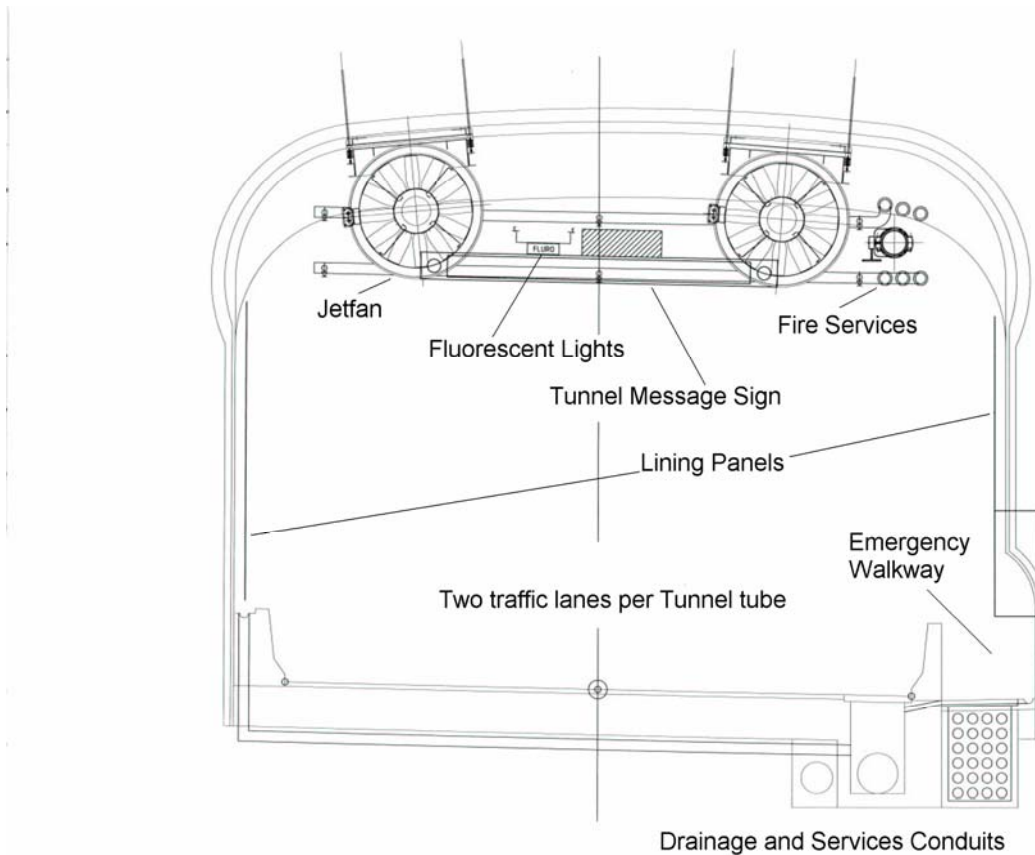
- extending mainline tunnels to the east such that portals would be located to the east of Kings Cross Road Tunnel and thus avoiding portals in William Street;
- passing underneath the Eastern Distributor instead of over it, thus improving tunnelling conditions and avoiding cut and cover works in William Street; and
- lowering the Riley Street off-ramp and avoiding soft ground conditions at the portal, the Yurong Street Paleochannel and cut and cover works in Riley Street.



Other portals remained as per the original concept with the westbound tunnel daylighting through a cut and cover section in Druiitt Street, and the eastbound tunnel commencing in a cut and cover construction at the end of Bathurst Street.



Tunnels were designed with a minimal lining in accordance with standard practice in Hawkesbury Sandstone. Support type design ranged from standard rockbolts and steel fibre reinforced shotcrete in the crown and sides to canopy tubes specified for the fault zones, sections under the Yurong Street Paleochannel and at portals. Invert consisted of a no-fines drainage layer overlain with a 7mm AC separation layer, a continuously reinforced concrete slab and an asphalt wearing course. A typical tunnel cross section is shown below.



Road drainage was provided which drained to the water treatment plant located beneath the road level at the low point of the tunnel system. The treated water is discharged to stormwater.

### **Geotechnical Considerations**

The majority of the driven tunnel components have been excavated through Triassic Age Hawkesbury Sandstone which is overlain by residual and alluvial soils and fill. Hawkesbury Sandstone is of medium strength, typically 35-40 MPa when fresh, but it can be massive, tough and abrasive with a quartz content of up to 80%. Well defined bedding planes and occasional layers of shale/siltstone occur in near horizontal planes with a maximum inclination of 30°. The thickness of the sandstone layers varies from a few centimetres up to some metres and is typically 1-2m. Associated with the Sydney basin are two major and two minor sub-vertical weakness planes in orthogonal direction to the tunnel alignment.

The Woolloomooloo Fault Zone was the largest area of disturbed rock through which the two mainline tunnels as well as the ventilation tunnel had to be driven. Fractured, soft rock together with increased water inflows required an adjusted construction sequence and heavier support in these areas.

The horizontal alignment of the Riley Street off-ramp connecting the eastbound tunnel to the Cahill Expressway follows the Yurong Street Paleochannel, which is an old river bed.

### **Surface Works**

Tunnel portals generally consisted of cut and cover works situated in existing city streets. These were designed using a maximum of precast elements and generally had to be designed to allow for construction in two or more stages. Wall support generally was achieved using bored piles.

Bridge widenings were required on the Western Distributor and Cahill Expressway for more efficient connections between the Cross City Tunnel and the existing network. These were achieved using steel headstock extensions post-tensioned to existing bridge headstocks, precast girders, precast concrete bridge deck soffit and insitu concrete deck stitched to the existing structure. There was also a bus crossover required which connected two independent flyover structures above Darling Harbour. In this case steel beams were used to join the two bridges, and a concrete infill deck section designed to provide the road surface.

Final works for the project included the upgrading of William Street, Park Street and Queens Cross by the addition of quality urban design furnishing and landscaping, and increasing footpath widths to facilitate the return of William Street to the community.

## **CIVIL CONSTRUCTION**

### **Tunnel Works**

Tunnelling was primarily undertaken from the Bourke Street site, situated at approximately the third point above the mainline tunnels, and where the Bourke Street

off-ramp and Palmer Street on-ramp come to the surface. On the site, a 42 metre deep shaft was sunk down to the level of the mainline tunnels, and the existing Eastern Distributor on-ramp was closed to traffic, lowered where it crossed over the Bourke and Palmer Street ramps to provide drive in access to the ramps. Thus tunnelling access was provided from this single point to the two mainline tunnels via the shaft, and the two ramps via the lowered Eastern Distributor ramp.

In addition, a spoil handling facility was set up at this site to load trucks either at the top of the shaft or in the underground chamber formed at the intersection of the Eastern Distributor ramp and the Bourke and Palmer Street ramps. Trucks would approach the site from the Palmer Street exit of the Eastern Distributor, and enter the site via Bourke Street. Trucks would be loaded at either the shaft or in the underground chamber, then proceed through an airlock, weighbridge and washing facility built in the existing Eastern Distributor on-ramp, and then exit the city via the Eastern Distributor. This way spoil trucks were only on city streets for approximately 100m. This facility was to handle, at peak, up to 5000 tonnes of spoil per day. Shaft works were enclosed in an acoustically lined shed, thus enabling 24 hour operations underground.

Tunnelling excavation was carried out using up to nine roadheaders at peak production. Guidance systems were used to control overbreak and improve efficiency by removing the need to mark up the face, or to set up lasers. Ventilation was managed by extracting from the face using in-tunnel fans and dustboxes.

Spoil was transported from the face to the Bourke Street site by off road dump trucks to either the base of the shaft or directly to the underground spoil loading chamber. The shaft was equipped with a high capacity spoil handling system that delivered the spoil to the surface, where it was temporarily stored in the shaft shed prior to loading onto trucks.

## **Surface Works**

With tunnelling operations staged from the Bourke Street site, the majority of portal areas were left free to construct the cut and cover works required to bring the tunnels to the surface. These portal areas were bounded by high rise buildings with deep basements and were located in city streets, which meant traffic management became a critical activity on the project. A Temporary Traffic Control Centre (TTCC) was set up to manage the traffic issues and traffic switches necessary to construct the works. The TTCC was linked to the RTA's Traffic Management Centre and was able to pick up live feed from the relevant RTA CCTV cameras throughout the city. The TTCC was manned 24 hours a day.

Relocation of services was also a critical activity on the project. BHBB JV was required to coordinate all service relocations necessary to construct the works.

Portals were generally constructed using cut and cover techniques, and usually in a number of stages, to ensure traffic access was maintained. This required the installation of wall sections using bored piles, construction of headstocks on the top of the walls, excavation to allow precast decks to be installed, completion of the decks and reinstatement of the roads over the top, and then excavation of the ramp section from underneath the completed roof section.

Bridge widenings required on viaducts over Darling Harbour presented the construction team with some difficult challenges. The Western Distributor widening and the bus crossover were built using suspended work platforms, thus eliminating the need to

quarantine large areas of land to install scaffolding, and importantly, allowing works to proceed safely during the day over live traffic rather than at night under Road Occupancy Licences. Maximum use of precast and prefabricated elements ensured quick construction times. A further example of this was the 62 metre high ventilation stack which was constructed from steel segments, delivered to site complete with cladding, which were erected in a number of weeks, with 300mm clearance to the Western Distributor viaducts and with limited site access.

### **Programming Challenges**

A 34 month contract period was specified, included within the overall 33-year concession period; and any overrun would have required BHBB to compensate its client CCM for loss of revenue through the application of liquidated damages. Conversely, early completion offered benefits to all contracting parties.

Additional time constraints included the following:

- Programming of works in the Darling Harbour area had to accommodate the various activities and festivals held in this key tourist and entertainment precinct, which meant that many periods of time were unavailable for construction activity. In particular, key works had to be completed prior to the Rugby World Cup events held in Darling Harbour in 2004.
- EPA Licence conditions imposed stringent constraints on working hours, including restricting works to a limited number of nights per week and providing noise respites and restricting noisy works such as sawcutting and rockbreaking to midnight.
- Due to the traffic volumes on the roads where construction activities had to be undertaken, RTA Road Occupancy Licences (RoLs) were very restrictive in terms of access to sections of roads to carry out works. Often RoLs would not be granted until after 10pm, which together with the EPA Licence conditions, meant there were only short windows of time to carry out certain activities.
- In response to the needs of the local community, BHBB JV negotiated construction methods and working hours with affected business and residences to minimise disruption to them.

### **MECHANICAL AND ELECTRICAL ELEMENTS**

The Mechanical and Electrical Fitout included ventilation, hydraulics, electrical, lighting, signage, operations and management control systems incorporating traffic management and control systems and plant monitoring control systems, fire protection and detection, communications, and electronic toll collection systems. The ventilation, fire protection and toll collection systems are further described below.

The Cross City Tunnel is monitored and controlled from the Tunnel Control Centre, located on the existing cut and cover structure of the Eastern Distributor, and operates on a 24 hour basis.

#### **Ventilation System**

A modified longitudinal ventilation system was adopted. The plant comprises three major ventilation stations, a central exhaust vent station, a cross vent station, a by-pass vent station and 54 jet fans located in the ceiling of tunnels' carriageways. The air is introduced into the tunnels from all portals, as no portal emissions are allowed, and is generally circulated around the tunnels in the direction of flow of traffic. The vitiated air is finally discharged up a single 62 metre high stack.

The main challenge was brought about by stringent in-tunnel air quality goals associated with Carbon Monoxide (CO) levels within the tunnels. Previous road tunnel projects in NSW typically adopted the in-tunnel CO criteria of 87 ppm-15 min average time period. For the Cross City Tunnel, this criterion was 50ppm-30 min average time period. This air quality standard for CO exposure is the highest of any operating tunnel in Australia.

In order to meet this standard whilst maintaining no portal emissions and a single stack, a by-pass vent tunnel and station was introduced. This by-pass vent system, in effect, allowed the shut down of the cross vent station by channelling the vitiated air via the by-pass vent tunnel to the central exhaust vent station. With the cross vent station shut down, more fresh air could be introduced into the opposite tunnel thereby providing extra capacity for diluting the CO gases emitted by the vehicles using the tunnel.

### **Fire Protection System**

Active fire protection was achieved with the use of the ventilation system in a fire mode operation and a fire sprinkler deluge system.

In fire mode, the ventilation system is configured to operate as a true longitudinal vent system. The air is introduced at the entry portal of the tunnel and flows in the direction of the traffic, out through the exit portal. The critical air velocity is maintained above 3 metres per second in order to avoid back layering of smoke onto vehicles which are trapped behind a tunnel fire.

The basic strategy behind the Cross City Tunnel fire suppression system includes:

- Air flow in the direction of traffic;
- Vehicles ahead of the fire drive out ahead of smoke;
- Occupants behind the fire remain in clear air;
- The deluge system contains the growth of a fire; and
- Allows remote fire fighting.

The fire protection system operates in a semi automatic mode with fail safe intervention. The Operator manually detects fire/smoke via the CCTV and manually confirms the fire location into the tunnel computer systems which immediately initiates the deluge system. The tunnel computer system automatically notifies the NSW Fire Brigade and initiates the appropriate ventilation smoke control mode and traffic management procedures. Should the Operator not manually detect a fire/smoke incident but the heat detector system triggers an alarm, the computer systems will commence the fire mode operation after a 90 second delay and initiate the deluge systems. Should there be a false alarm then the Operator can manually abort the activation of the computer systems in fire mode.

The use of deluge systems and critical velocity ventilation air flow is contrary to the recommendations made by the World Road Association, PIARC. PIARC recommends no deluge and low velocity ventilation as it relies on creating a smoke layer stratification to allow motorists to evacuate under the smoke layer. This dilemma created a challenge as the intent of safely evacuating motorists trapped ahead of the fire could be compromised. The combination of critical air velocity and the activation of the deluge systems destroy the stratified smoke layer which potentially placed a risk on those motorists trapped ahead of the fire.

This challenge was met by using innovations brought about by applying a comparative fire engineering study in accordance with fire guidelines, with reference to PIARC. The aim was to analyse how the fire suppression systems are utilised to meet the intent of PIARC whilst maintaining world's best practice.

The guidelines required the establishment of a peer group review panel in order to develop a basis of assessment. This assessment, amongst other issues, mainly concentrated on predicting the tenability condition faced by the evacuees in a smoke filled tunnel and determined whether they could safely reach the egress doors by foot. The tenability criteria looked at:

- temperature
- visibility
- toxicity.

Following the establishment of credible scenarios and by using smoke modelling tools, the overall comparisons concluded that the Cross City Tunnel's fire suppression systems was better than PIARC, that is:

- if all fires stay small by using the deluge at an early stage of a fire there is no exposure to conditions that surpass the tenability criterion;
- if all potential large fires grow to a maximum, the Cross City tunnel situation was found to be better than a PIARC designed system; and
- more fires can be expected to grow to a maximum in a PIARC designed system than in Cross City Tunnel due to the non-use of deluge.

### **Electronic Toll Collection System(ETC)**

The fully electronic tolling system was specified for urban design reasons to have its roadside gantry mounted radio (e-tag) and video tolling (e-toll) systems located within the tunnel, which is the first such in-tunnel installation in the world.

The ETC system was required to:

- classify vehicles to determine the toll charge;
- collect the toll charge;
- enforce the toll charge if the toll charge could not be collected; and
- collect tolls at vehicle speeds up to 100 km/hr.

The Cross City Tunnel is the first cashless toll in NSW. The main concerns included:

- radio frequency signal reflection in a closed tunnel environment;
- reliability of incorrectly fitted e-tags; and
- collection of tolls for motorists without e-tags.

A multilane e-tag detection system was selected to enhance better reliability and an imaging system was used to record license plate numbers (LPN) for vehicles detected without e-tags by using optical character recognition technology. If the vehicles are detected with no e-tag and there is no match between the vehicles' LPN and the exception list, then a violation notice can be issued by the RTA.

A fully operational temporary mock-up of a typical tolling station was built external to the tunnels on a disused road and a select number of key ETC components were installed in a live tunnel motorway, the M5 East. These temporary installations were tested in order to establish the key characteristics which needed to be adopted into the installation process. The permanent ETC system was fully tested prior to opening the tunnel. Due to the importance of the ETC to the Client, an extensive validation and performance test was also preformed after the tunnel was opened.

The ETC proved to meet the reliability specified as follows:

- accurate detection of all vehicles;
- e-tag reads greater than 99.98%;
- LPN image capture greater than 90%;
- video enforcement greater than 98%; and
- equipment availability of greater than 99.995%.

## **OVERALL OUTCOMES ACHIEVED**

### **Time**

The project was delivered in August 2005 - two months ahead of the contract date. A number of major additions to the scope were absorbed within the original contract period.

### **Cost**

The original design and construct contract value was \$604 million. With variations to the initial contract scope, the price on completion was \$680 million. The Cross City Tunnel will be self-funding through electronic tolling.

### **Quality**

Hyder Consulting (Australia) Pty Ltd independently verified the quality objectives as a condition precedent to substantial completion. The Quality system was in compliance with AS/NZS ISO 9001 Quality Systems, the RTA specification for Quality DCM Q7 and additional contract specifications.

## **Innovation**

BHBB JV's innovative re-design of the original reference scheme produced the best value solution to meet the proponent's objectives.

Key design developments introduced by the BHBB JV team included:

- eastern entry and exit located 30m east of existing Kings Cross Tunnel as compared to the original EIS design location just west of the Kings Cross Tunnel, avoiding a cut and cover operation for the majority of William Street, and the consequent disruption to traffic and the community;
- improved tunnel alignments and design speed, widening of curves to improve sight lines and stopping distances;
- additional lane added on Western Distributor and Cahill Expressway for more efficient connections to the city road network;
- 40m landbridge extension at eastern end to reduce visual impact of portals;
- by-pass ventilation duct added to improve in-tunnel air quality and meet new CO exposure criteria introduced in the Supplementary EIS; and
- ventilation stack increased to 62m to improve exhaust air dispersion from the tunnel resulting in improved ambient air quality.

## **Completion**

As a pre-requisite to opening the tunnel safely to traffic a large number of pre-opening conditions specified in the Minister's Conditions of Approval and the contract had to be met. This involved the preparation of plans of management for the operational motorway, including an Environmental Management Plan, incorporating sub-plans, and other management plans relating to rail, security and crime management, fire and smoke management and emergency response. All of these plans were developed either in-house by the Project Team or jointly with specialist consultants. To ensure pre-conditions were adequately addressed the Joint Venture established a Completion Team twelve months prior to opening.

## **Safety**

Safety statistics for period January 2003 to end August 2005

- Medical Treatment Injuries: 283
- Lost Time Injury Frequency Rate: 5.60
- Personnel Inducted: 6069

Notwithstanding the high level of attention to safety a fatal accident occurred, as a result of a rock fall.

## **Significant Civil Engineering Achievements**

Removal of the majority of spoil from 8.5 km of tunnels with minimal use of the inner city road network, at rates of up to 5000 tonnes per day.

Widening of Western Distributor structure:

- additional lane created by adding new support to existing post tensioned headstocks.

Removal of existing support and replacement with new structure on Western Distributor:

- existing pier reduced in width and stiffened to provide connection from the tunnel to Western Distributor;
- existing pier removed and new support structure constructed to bridge entry trough from Western Distributor.

Ventilation Stack:

- 62m tall slender steel structure prefabricated and erected over 25m deep shaft; and
- 300mm clearance to existing road viaducts.

## **Client Satisfaction and General Success of the Project**

The RTA informally acknowledged that on opening to traffic on 28 August 2005, the Cross City Tunnel was the most complete major road project ever handed over in NSW. In addition, the RTA Project team and Public Relations Unit expressed high satisfaction with the quality of design and construction of major milestones and major tunnel elements including:

- ventilation stack urban design and minimum impact construction methods;
- Tunnel Control Centre;
- environmental management; and
- Minister for Planning's Conditions of Approval compliance management.

## **General Satisfaction of Stakeholders**

Maximum cooperation was secured with major stakeholders throughout the design and construction including community groups, Sydney Foreshore Authority, Airport Motorway Ltd, Rail Infrastructure Corporation, Sydney Water, Royal Botanic Gardens, Domain Trust and Energy Australia. A high level of satisfaction was expressed by motorists due to successful construction stage traffic management and use of a separate traffic management control centre, fully integrated with the RTA Traffic Management Centre, which monitored traffic in and around the various construction sites and relevant city streets. During nine months of operation there has been no interruption to traffic or revenue collection. There was a high retention of staff throughout the project.

## TECHNICAL DATA/INFORMATION

- Twin 2.1 km road tunnels between Darling Harbour and Rushcutters Bay
- Deepest point 53m below Hyde Park
- Underground connections to Eastern Distributor and Cahill Expressway to complete the inner city road network, providing access to Sydney Harbour crossings and the airport
- EIS released July 2000
- Supplementary EIS July 2002
- Offer accepted 19 December 2002
- Conditions of Approval Applied 292
- Work commenced 6 January 2003
- First road header at work 19 May 2003
- Public opening 28 August 2005
- Motorway cost \$680 million
- Projected vehicles per day 90,000
- Traffic lights bypassed 18 eastbound, 16 westbound
- Average journey duration 2 minutes
- Speed limit 80kph
- Jobs (direct) 1600
- Jobs (indirect) 3600

## MATERIALS

### The Tunnel

- Rock volume excavated 1,350,000 tonnes
- Daily excavation rate 0.5 to 6 lineal metres
- Road headers used 9

### Civil Works

- Asphalt (road surface) 13,500 tonne
- Concrete (roof, walls, road pavement, kerbs, barriers) 122,000m<sup>3</sup>
- Rock bolts (roof support) 2.5m to 8m length 50,000+

- Shotcrete 20,000m<sup>3</sup>

**Fit-Out**

- CCTV cameras 133
- Tunnel fluorescent lights 4450
- Electric and communication cables 780km
- Electronic signs 609
- Static signs 300
- Emergency phones 108

**CONCLUSION**

The Cross City Tunnel includes a series of new road tunnels that extend under Sydney’s CBD from Ruscutters Bay in the east to Darling Harbour in the west. The tunnel system has two 2.1 km mainline tunnels, a separate 2.1 km long ventilation duct and a series of on and off ramps.

The Cross City Tunnel reduces journey times across the city from twenty minutes to two and is capable of removing an estimated 90,000 vehicles per day off surface roads and improves noise and air pollution in the city.

Completed two months ahead of schedule and featuring the world’s first fully electronic in-tunnel tolling system, the project displays an engineering awareness of community impact on a scale not seen before in Australia. It was built under, around and beside entire residential and commercial communities with minimum disruption to Sydneysiders and existing traffic.

By managing to reduce adverse impacts to the natural, cultural and urban environment the Cross City Tunnel represents a triumphant and vital public infrastructure project for a 21<sup>st</sup> century city.