Burnley Tunnel Fire - The Arup View

The fire which followed a tragic road accident in the Burnley Tunnel in Melbourne on 23 March 2007 has attracted a good deal of media, community and industry attention. For fire safety professionals, particular interest has focussed on the apparent success of the water deluge system in preventing fire spread and major tunnel damage.

This paper highlights the major design features of the tunnel, its fire protection measures and the sequence of events which led to the fire and its subsequent control.

The details in this paper are gleaned only from media reports and publicly available information. They are therefore speculative, and will only be confirmed once official investigations and the coronial enquiry are completed.

Tunnel details

The Burnley Tunnel forms part of the CityLink toll road system and is one of the pair of tunnels which carries traffic under the Yarra River and part of the city in Melbourne, Australia. The CityLink tunnels were opened in 2001.

The two tunnels, namely the Burnley Tunnel and the Domain Tunnel are both three lanes, but have different alignments, lengths, and depths below grade. They run in parallel only for part of their length as illustrated in Figure 1 below. Each tunnel has no breakdown lane or stopping bays.

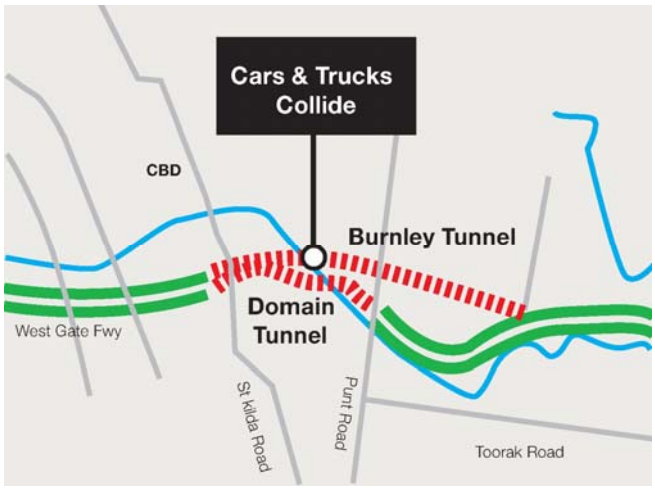

FIGURE 1. Tunnel Location

The Burnley Tunnel which takes traffic from west to east around the city has a length of approximately 3.4km, and at its deepest point is some 65m in below grade, as illustrated in Figure 2. The grades in the Burnley Tunnel are significant, with a 6.2 degree downhill slope starting at the entry and 5.2 degrees on the upgrade toward the exit portal.

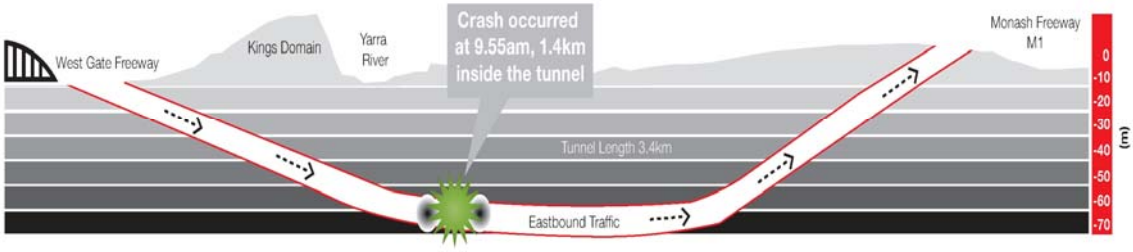

FIGURE 2. Longitudinal Tunnel Section

The tunnel cross section clear of equipment at roof level is approximately 4.9m high, with three lanes each 3.5m wide. This is illustrated in Figure 3.

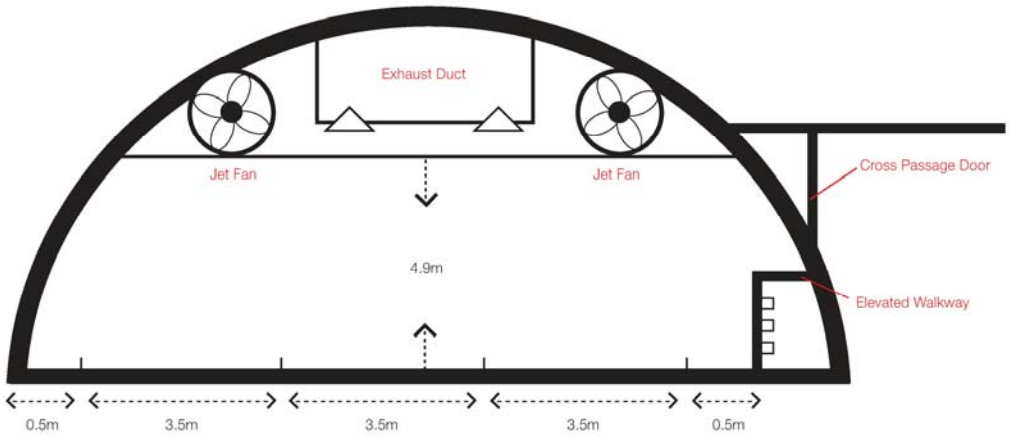

FIGURE 3. Tunnel Cross Section (not to scale)

The tunnel carries high traffic volumes with substantial numbers of freight vehicles along with cars and buses. Latest figures indicate usage of over 100,000 vehicles/day, of which 14,000 are trucks. The normal speed limit is 80km/hr, but in times of lane closure, minor accidents or maintenance periods, the speed limit is usually reduced to 60km/hr. During peak hours, traffic can be congested and travelling at less than the signed speed limits.

The tunnels, together with the associated toll road system, is managed by CityLink on behalf of the ultimate owner Transurban, who own and operate other toll road systems in Australia and the US.

Fire safety features

The Burnley and Domain Tunnels were considered to have the state-of-the-art fire protection when constructed. In part, this was due to studies conducted by the CityLink design team on the results of the Mont Blanc fire, and the design of the Harbour Tunnel in Sydney.

The key fire safety features include:-

- A water based deluge system, with 30m long zones, normally activated remotely from the control room
- A combination longitudinal and semi-transverse smoke control system, with a central duct at tunnel roof level with extract dampers at 80m intervals, plus sets of jet fans to control critical velocity. The duct extract is vented through an exhaust stack(s) at the end(s) of the tunnels.
- A linear heat detection system set at 68°C.
- Cross passages to the adjacent tunnel and exits to an emergency egress tunnel for part of the Burnley Tunnel. In addition, there are three safe havens and one lift to the surface.
- An elevated walkway about 750mm high and 750mm wide on the right hand side (inside) of the tunnel.
- "Fire boxes", consisting of hydrants, hose reels, and portable extinguishers about each 60m.
- A CCTV system, with cameras at 150m centres, with stopped vehicle alarm provisions.
- A radio 'break in' system with AM/FM rebroadcasting to transmit traffic control or emergency messages
- Overhead variable message signage at 120m intervals to indicate lane closure, and other emergency messages. Also speed limit signs
- Exit signs to cross passage/exit doors
- A public address/emergency warning system, and emergency telephones at 120m centres.
- DISPLAN communication points for emergency services direct communication to their control rooms.
- Emergency lighting systems
- An emergency incident management plan, which has been regularly well rehearsed by CityLink staff with the emergency services

The incident

The traffic accident which triggered the fire occurred at approximately 10am on Friday 23 March 2007, a little after the peak hour rush but at a time of relatively heavy traffic volumes. The accident occurred about 1.4km into the Burnley Tunnel at the end of a long downhill grade.

Media accounts suggest the following sequence of events:-

- A truck travelling through the tunnel suffered a tyre blow-out and pulled to a stop in the tunnel's left hand lane

- The truck stopped was immediately detected by a CCTV camera linked to the CityLink's control room
- An alarm sounded in the control room, and tunnel signs told motorists that the left-hand lane was closed, the speed limit was reduced (presumably to 60km/hr), and an incident response truck was dispatched
- Within 2 minutes of the alarm being raised, the traffic accident occurred when cars stopped behind the broken down truck tried to merge right and change lanes to get past the stopped truck
- A second semi-trailer truck (HGV), apparently travelling in the centre lane, struck these two cars, throwing one between the tunnel wall and the stationery truck, and crushing one into the back of the stationary truck. A third car, hit by this second truck, was thrown into the right hand lane, and struck by a third truck.
- It appears at least one of the cars burst into flames, and people reported a number of "explosions" and a "fire ball", with flames reaching the tunnel roof. It is unclear whether the "explosions" were the noise of the impacts, tyres bursting, or petrol or LPG actually exploding.
- The resultant fire led to the deluge system being activated (presumably manually from the control room) and the smoke exhaust system being activated. Cars ahead of the accident, and subsequent fire, drove out of the tunnel. However, some 200 cars and 400 people were stopped by the accident and fire, and were instructed to leave their cars and evacuate.
- Some people walked back through the incident tunnel to the tunnel entrance. The remainder evacuated using the cross passages and exit stairs linked to the Domain Tunnel which was closed soon after the accident. Media reports indicate there was "no sign of panic or alarm".
- The tunnel entrances became staging points or assembly areas for persons evacuated, where they were given identifying wrist bands, provided with food and water, and given instructions by police and CityLink emergency personnel.
- The deluge system appeared to control the fire, and the fire brigade attended with 30 fire trucks and 84 fire fighters, as well as 10 special police crash investigators.
- The fire was finally extinguished at approximately 11am, 1 hour after the accident occurred.
- Disabled people were assisted in evacuation by able bodied people apparently quite successfully
- The final toll was three dead (all drivers of the cars involved), plus two persons with minor injuries taken to hospital
- All cars remaining in the tunnel were removed by 1:30am on the following day.
- The non-incident Domain Tunnel was re-opened to traffic at 2:30pm on that day, Friday 23 March 2007.
- The Burnley Tunnel was re-opened to full traffic operations at 10am on the following Tuesday, 27 March 2007, four days after the incident, following system testing and checks of essential fire protection measures.

Fire performance

It appears that the deaths and injuries were due to the traffic accident and not the subsequent fire.

The water deluge system, which was zoned with open deluge heads and not a closed head sprinkler system, seems to have operated as intended and prevented fire spread from the immediate incident area. It appears to have been activated manually from the control room. There was some relatively minor damage to electrical systems in the immediate vicinity of the fire, but these were reasonably easily repairable.

The tunnel linings and exhaust duct appeared not to be damaged and were cleaned prior to the tunnel re-opening. The asphalt road surface suffered some minor damage but was repaired within three days.

According to media reports, the total asset damage and repair bill has been estimated at AUD$1.5 million and loss of toll revenue at AUD$3.0 million. Some temporary reduction in daily toll revenues might be expected in the weeks following the incident.

The CCTV also appears to have worked satisfactorily to provide an alarm to the control room to allow control room staff to make appropriate emergency management decisions.

The smoke extraction system appears to have worked satisfactorily, although it is unclear how much smoke was extracted downstream of the fire by the duct system, and how much smoke continued down the tunnel. However, given only some 100m of the tunnel needed to be cleaned, and there were reports of substantial smoke flowing out of the exhaust stack from the duct system, it indicates that heavy smoke was probably confined to this area near the fire. It also appears that the jet fans and exhaust duct operated to prevent “back layering” and smoke travelling uphill towards the tunnel entrance in the direction of evacuation.

The radio interrupt system and the signage telling drivers and passengers to stop their vehicles, begin evacuation and walk back towards the tunnel entrance, seems to have been heeded. Reports by evacuating people and the emergency services all seem to indicate that the pre-planning, fire drills and other training contributed significantly to the success of the entire emergency management system. This is in the following quote by Metropolitan Ambulance Operations Manager, Paul Holman, who said at the scene, “If there are any positives out of such a tragedy, it is that the emergency response worked like clockwork today. It was an horrific scene, but more importantly, it was safe…we could have had many more people injured or hurt.”

Further investigations

Following the incident, attention has centred on traffic management issues and avoidance of future accidents.

CityLink incident data has indicated that in 2006, there were 412 tunnel incidents attended to by the CityLink emergency response team. These included:-

- 11 banned prohibited users (errant vehicles)

- 17 accidents involving cars or trucks (5 causing minor or serious injuries)

The key issues to improve traffic safety and reduce the likelihood and severity of accidents which are being discussed in the media are:-

- Reduction in the speed limit for trucks to 60km/hr
- Trucks restricted to the left hand lane, and limited to use of the middle lane for overtaking
- All trucks banned from the right hand lane
- Provision of an emergency lane or breakdown bays in the tunnel (an expensive option)

There has also been a call by Professor Arnold Dix, an Australian member of the Permanent International Association of Road Congresses (PIARC) for more education to be given to drivers, especially when travelling on downhill sections of tunnels, and maintaining safe distances from vehicles in front of them.

It is clear that these issues will be canvassed further in the forthcoming official incident investigations. They are also likely to be discussed at the next meeting of the recently formed committee developing a new Australian Standard for fire safety in tunnels.

Conclusion

- The Burnley Tunnel traffic accident and subsequent fire was a major incident, resulting in three deaths and considerable damage.
- It appears that all the fire safety systems worked as intended
- The emergency management and evacuation and response appear to have ensured the safety of all those not directly involved in the initial accident.
- Major questions are being asked about tunnel design and traffic management in relation to future accident prevention
- Overall, in fire safety terms, the provision of the water based deluge and smoke control systems appear to have contributed most significantly to life safety and minimisation of asset damage and operational interruption.

The Authors

This paper was prepared by Peter Johnson and David Barber of Arup Fire in Melbourne. Further details of the incident can be obtained from Arup via the Arup website, www.arup.com, or via email to peter.johnson@arup.com.au and david.barber@arup.com.au. Considerable further detail is available through the media and other websites included in the reference list below.

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