Who are you designing your tunnel for?

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ABSTRACT: This conference will cover many aspects of tunnel use and design. Experts from a broad range of disciplines will share with us their experiences and no doubt, at times their frustrations encountered in getting the job done. Most will focus only on their particular field. Some however will be responsible for the eventual overall outcome which is the ongoing life of the tunnel and its intended use. We each have our barrow to push, and in the case of emergency services it's the safety of the tunnel user and emergency service workers called in when things go wrong. In this paper I will attempt to explain where we are coming from and why. To this end the paper is not a technical one but intended more as a guide on the needs and processes. At the end of this conference I hope it will be clearer to all of us who we are designing tunnels for.

1 INTRODUCTION

It has taken a number of years and projects to come to the point where the New South Wales Fire Brigades (NSWFB) can feel comfortable in where they fit into the design of tunnels in this state.

And when I talk about tunnels I mean all kinds of tunnels - road, rail, and service tunnels such as telephone and power. The NSWFB have over twenty records on file covering all of these. The majority are road and rail and there has or will be a proliferation of these, as space above ground becomes more critical.

Our role is now firmly locked in with protocols in place to ensure input into fire and life safety from conception to commissioning and beyond.

Probably the most important change has been the working relationship between all the major players. This is critical to a successful outcome. But informal relationships have proven to not always work and must be backed up by formal protocols.

Fire services in Australia are fortunate to have had in place, for a considerable time, sections that deal with building construction and major infrastructure developments. This requires a good knowledge of the Building Code of Australia (BCA) and fire and life safety systems. Fire Officers sit on Australian Standards committees dealing with these systems and, at a more senior level, on state and federal committees which influence the content of the BCA.

The Australasian Fire Authorities Council (AFAC) through their Community Safety Strategy Group meet at least twice yearly to share experiences and help provide consistency across Australia and New Zealand in fire service approach to fire and life safety.

Granted this is not always achieved but through development of such things as the AFAC Guidelines for Road Tunnels things are moving ahead well.

2 DESIGNING FOR DISASTER

When you ask, "Who are you designing the tunnel for?" the answer is not as obvious as it may seem to the uninitiated. A road tunnel is there to improve the traffic flow and get the motorist from A to B quicker, with fewer traffic lights and with less stress (in theory at least). It makes politicians more popular and reduces traffic in built up areas. The tunnel operator sees it as a business, which hopefully will return a profit, all of which is reasonable.

But consider when something goes horribly wrong. On a busy morning in peak hour vehicles collide in a tunnel and a fire ensures. There is no traffic flow any more, stress is high on the agenda, and politicians are already asking questions within their area of responsibility as to whether or not we did everything we could have. The tunnel operators see their asset under threat, with a potential loss of revenue of mammoth proportions.

But more importantly what about the commuters? They are faced with a situation that is fast becoming a trap for those who do not react in time, do the unthinkable, or can't help themselves.

Now the tunnel design must incorporate aspects that can control this situation. It now must be designed to save both the occupants and the asset.

Experience overseas has shown us that these situation can be real. They have in some cases exposed the shortcomings in design for protection of both the people and the tunnel.

3 FIRE AND LIFE SAFETY SYSTEMS

What are the basic elements of fire and life safety systems?

- Escape for occupants and access for emergency workers
- Fire suppression systems
- Fire detection systems
- Smoke hazard management
- Emergency lighting
- Exit signs
- Emergency phones
- Emergency service radio system
- Flame traps for flammable liquid spills and fire water
- CCTV
- Traffic flow monitoring
- Fire hydrants and boosters
- Fire extinguishers and hose reels

For rail tunnels other considerations will be:

- Elevated walkways
- Track surface
- Train evacuation method (side v front and rear)

Service tunnels require special consideration as they are occupied infrequently but asset protection may well be a high priority.

3.1 Escape for Occupants and Access for Emergency Services

Basic tunnel design is critical to this issue. Duel tunnels reduce the likelihood of head on accidents in road tunnels and eliminate them in rail tunnels. This lessens the likely severity of the accident and ensuing fire. Duel tunnels also allow relatively easy construction of cross passages to allow both the escape of occupants and access by emergency services via the unaffected carriageway

An alternative is intervention shafts, which have not been well accepted by developers due to the cost involved. They are the only real alternative when single bore duel carriageways or twin rail track are used. NFPA 130 sets out the requirements for these shafts.

Escape is assisted by the installation of smoke management system, emergency lighting, and exit signs.

3.2 Fire Suppression Systems

This is one of the most controversial issues, along with smoke management systems that the NSWFB have encountered. There are critics on the use of drencher or sprinkler systems in road tunnels. The arguments include:

- Smoke layers lose their buoyancy on operation of the system
- Steam is produced placing occupants at risk
- Flammable liquids are spread
- Because the fires are generally internal drenchers are ineffectual.

Following the recent tragic tunnel fires overseas the NSWFB is even more comfortable with our decision to go with the drenches. Other AFAC members support this position.

The manual operation of the drenches is necessary to overcome the heat transfer caused by air movement in the tunnel. This could cause heat detection and operation of drencher zones ahead of the fire and hence cause the system to overrun its design capacity. The use of CCTV by tunnel operators is necessary to determine the two zones to be operated.

Training of tunnel operators is critical to correct and appropriate use of the drencher system. It will be necessary in many cases to make that decision before the Brigades attend the scene. It is also critical that Fire Service personnel work with tunnel operators to extract the best from their combined skills and knowledge.

Many of the arguments against suppression systems have focussed on the application of water on fires of the magnitude of 50 MW or more. We argue that proper use of the system will prevent fire growth, and in the case of sheltered fires the spread of fire as was the case in overseas events.

3.3 Smoke Hazard Management

The preferred method of smoke management in NSW road and rail tunnels has in the main been longitudinal ventilation using jet fans. Fire services ask that, like in buildings, people in tunnels be given as clean an atmosphere as possible to assist them to escape. The ventilation can provide a sufficiently clear atmosphere, which may allow the fire service personnel to reduce the use of their breathing apparatus in circumstances the senior Officer determines suitable.

Although a number fire services have engineers on staff, it is not the fire service that is charged with designing tunnel ventilation systems. They will however be involved in fire engineering design briefs and meetings that determine the suitability of the proposed system. At commissioning stage the fire service will generally witness a hot smoke test and assess its effectiveness from a practical viewpoint.

Ventilation needs to be appropriate to the design fire. In the case of rail tunnels the maximum fire size is 20 MW, a figure agreed upon following technical advice. For road tunnels that do not permit dangerous goods the design size is around 50 MW and this will at least double where dangerous goods is allowed. At this time dangerous goods are not permitted in any of New South Wales major tunnels.

Smoke tests can never hope to replicate a real fire, but they do provide an indication of smoke movement patterns. This is valuable to not only the fire service but also the system designers who may need to make some adjustments to achieve maximum performance.

Emergency Lighting and Exit Signs

Emergency lighting, although a critical element in emergency escape, is a relatively simple concept. A power source independent of the main supply and a lux sufficient to illuminate the way out is simple and effective. I am not so sure exit signs are as simple, and they certainly require more than the sense of sight to be effective.

Experience has taught me that they are not as well understood as might be thought. Having investigated complaints on the lack of exits in major shopping centres, only to find the required number existed but were not recognisable by the person making the complaint, I have over time formed the opinion they may not always serve their purpose.

In the case of a shopping centre people generally go out the way they come in, the main entrances or entry from car parks. Its logical to think tunnel occupants may attempt to do the same thing unless encouraged to do otherwise. Are standard exit signs sufficient to do this or is more needed? Overseas there is efforts being made to investigate further how to entice people to use emergency exits in tunnels. Some NSW tunnels incorporate strobe lights to back up the exit signage.

3.4 Flame Traps

All major road tunnels since, and including NSW first major tunnel under Sydney Harbour, incorporate flame traps to prevent running flammable liquid fires, a major source of concern regarding uncontrolled fire spread. The application of firewater and its effect on flammable liquids is also controlled through the installation of flame traps.

3.5 Communications

It is critical if a satisfactory outcome to a tunnel emergency is to occur that good communications is achieved. From the tunnel controller's contact with commuters via interruption to commercial radio broadcasts, or the train controller's contact with the train driver, through to the ability of emergency services to talk within and between agencies through access to the Government Radio Network (GRN), good communications are essential.

CCTV and traffic flow monitoring also provides operators with a constant form of communication with what is occurring within the tunnel.

3.6 Fire Hydrants and Boosters

Basic tools of trade for firefighters, hydrants spaced at suitable distances and accessible through the relative safety of cross passages are critical to final suppression of fires in vehicles. It is the belief of the NSWFB however that if some form of inbuilt controls are not inherent in the tunnel, we will be forced to do what our overseas colleagues have done. That is wait until the fire has died sufficiently to enter and mop up.

3.7 Fire Extinguisher and Hose Reels.

In many cases the occupant of a vehicle will be capable of extinguishing small fires without the necessity to operate the major fire safety systems. Fire extinguishers or hose reels provide sufficient first aid fire fighting capability for these tasks. Of course not everyone is competent or willing to use such equipment but it should be there for those who are.

Cabinets can be alarmed which achieves two purposes:

- It alerts the tunnel operator to persons attempting to remove the equipment illegally.
- It alerts the tunnel operator to the fact that a fire has occurred and attempts are being made to extinguish the fire as well as the location. CCTV can then monitor the situation.

3.8 Egress in Rail Tunnels

Rail tunnels and track surface and its impact on egress has long been a concern of the NSWFB. The use of ballasted track and its potential for injury to both commuters and emergency services is considered very real. Having walked the surface on a number of occasions I have no doubt injuries would occur when you consider the need to carry stretchers or heavy rescue equipment.

There now appears to be a trend towards elevated walkways supplemented by an even track surface (concrete etc). I don't consider this an overkill as not only will some people opt to go down to the ground level to escape, but emergency services will almost certainly enter at track level.

Egress time from trains continues to be a concern. Front and rear egress is slow and awkward at about one person every six seconds. Considering that train capacity can be 1 600 persons then, at best, full evacuation will take around 2.5 hours if all goes well. Elevated platforms and side egress is faster, but wherever the train can continue on to the station it is obviously the best option.

4 SECURING THE FIRE SERVICE ROLE

The message I would like to relay to other fire services who believe they should play a part in tunnel design is to establish that role through formal protocols and procedures before the tunnel is past the idea stage

This has been learned the hard way in NSW due to a lack of a format setting out the rules under which we all play, in the early days of tunnel construction.

There are now firm procedures in place for both road and rail tunnels including:

- A heavy rail steering committee, which includes the NSWFB.
- A heavy rail protocol, which outlines the NSWFB position.
- A memorandum of understanding between the Roads and Traffic Authority (RTA) and the NSWFB.
- Inclusion of the NSWFB role in the approvals process for road tunnels in the RTA scope of works.

These formal procedures help prevent the gaps occurring in knowledge transfer as the project advances. These gaps can have a profound effect on the final tunnel design and may result in a lack of confidence of fire and other emergency services in their ability to respond and handle an incident in that tunnel

The political backlash potential can be significant and going back to fix any problems is virtually out of the question, mainly due to cost constraints.

Although the NSWFB has an extremely good relationship with all the major players involved in the design of tunnels in our state, and in the case of the RTA these go back many years, I recommend formalising these relationships in a way similar to that outlined above. At the same time the personal working relationships that have been formed are extremely important in building trust and understanding each other's position

Tunnels in NSW are designed following a risk assessment approach. Risk workshops have included all the necessary players including:

- Project managers
- proponents/owners
- 0perators
- NSWFB
- NSW Police Service
- NSW Ambulance Service
- NSW Rural Fire Service
- Fire engineers
- Ventilation experts

Risk assessment provides sound justification for the proposed mitigation measures. It is something that fire services have been applying to both their operational and prevention activities for some time.

5 CONCLUSION

Who are tunnels designed for? For everyone who has some interest or reason to be in or associated with the tunnel. Under what circumstances? All, including the time something goes very wrong and the paramount design features are those that can get people out, emergency personnel in and protect the valuable public asset.

The fire service has a critical role to play but like all those associated with tunnel design time should not stand still. Advances in technology and better understanding of human behaviour should be monitored and included in future designs.

The completion of the tunnel construction does not signal the end of emergency service involvement but the beginning of their response commitment under the various Acts that apply. Training exercises prepare them for the unfamiliar role of tunnel

emergency management. This will apply for the life of the tunnel.

Figure 1 Hydrant and Hose Reel Cabinet

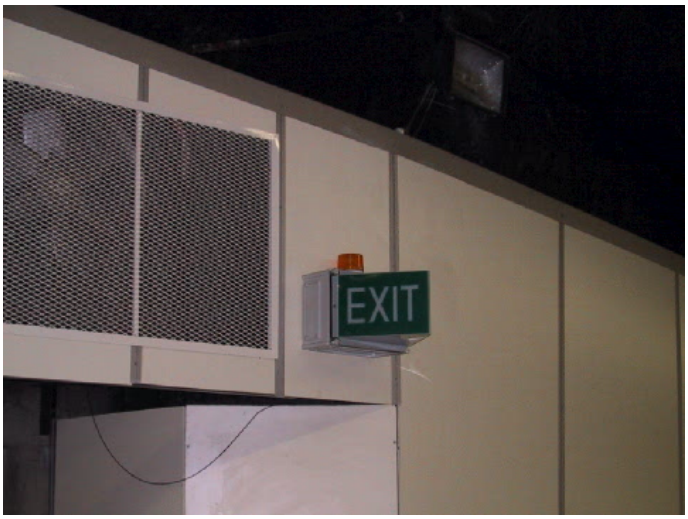

Figure 2 Exit Sign with Strobe Light

Figure 3 Fire Hydrant and Pressure Testing Equipment

Figure 4 Hot Smoke Test M5 Motorway

Figure 5 Drencher System Valves