Ensuring Safety in Railway Tunnels

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With land getting scarcer in developed cities, infrastructures are sometimes forced to go underground so as to minimise the impact on the city landscape as well as social economics. Malaysia is not spared this. Major cities such as Kuala Lumpur have become very congested above ground. So, like Singapore and Hong Kong, we are also constructing a new Mass Rapid Transit system right under Kuala Lumpur. All around the country, there are numerous railway tunnels, constructed and being constructed.

Fires in railway tunnels are major hazards, both for people trapped inside and for fire fighters. The lack of escape paths and difficulties that fire fighters face in accessing a tunnel, especially those underground, result in the need for stringent safety measures. Tunnel fires not only result in loss of life and severe property damage but also leave the public with a fear of using such systems.

When it comes to fire & life safety for railway tunnels, we must consider multiple elements such as structural design, architectural design, passive fire protection, active fire protection, ventilation system, evacuation strategy, smoke control system, detection system, monitoring system and fire personnel access.

A tunnel environment is usually a significant fire and life safety challenge. This is due to the different characteristics between a building and a railway tunnel. The life and safety of tunnel users depend heavily on the fire detection and prevention system in the tunnel. In the event of emergency, an evacuation strategy and operational control are critical in ensuring their safety. See Table 1 for a list of major railway tunnel incidents around the world for the past 50 years.

Channel Tunnel fire damage – ART (picture from subways.net)

REGULATIONS

Malaysia has yet to have its own standard with regards to railway tunnels although the designs for such tunnels in the country are based on international standards such as NFPA and Singapore Standard & British Standard, to name a few. Table 2 shows a comparison between NFPA 130 and Singapore Standard.

Table 1: List of Major Railway Tunnel Incidents

YEAR	NAME	LOCATION	INCIDENT	FATALITIES/INJURIES
2015	L'Enfant Plaza Metro station	Washington, USA	Electrical arcing, smoke in tunnel	1 dead/80+ injured
2008	Channel Rail Tunnel	France/UK	Truck fire on Eurotunnel rail (24 hours duration, 1200°C)	None reported
2003	Daegu Subway Tunnel	South Korea	Arson. Introduction of gasoline in wagon	192 dead/148 injured
1996	Channel Rail Tunnel	France/UK	Truck fire on Eurotunnel rail (10 hours duration, 1100°C)	None reported
1995	Baku Subway Tunnel	Azerbaijan	Short circuit in a wagon followed by fire	289 dead/270 injured
1987	Kings Cross London Subway	UK	Accidental ignition on escalator (matches)	31 dead
1972	Hokoriku Fukui	Japan	Passenger train, restaurant car fire	30 dead/714 injured

Table 2: Comparison of NFPA 130 & Singapore Standard for Railway Tunnel

			NFPA 130	SINGAPORE STANDARD
TUNNEL	PASSIVE	Motorised Trolley (Battery Operated)	1. Not mentioned	1. Required for Station Platform Level, Mid Tunnel Exit Staircase > 380m from a station & Trainway Portal
		Tunnel Cross Passage (CP) & Intervention Shaft (IVS)	1. Required for Tunnel 2. Spacing of 244m throughout the tunnel 3. Distance to exit staircase of station & portal < 244m 4. Clear width: 1.120m	1. Required for Tunnel 2. Additional CP required for turn-out/cross-over 3. Spacing of 250m 4. Distance to exit staircase or station public area < 500m 5. Distance between turn-out/cross-over and the nearest CP shall not be less than 125m and shall not be more than 250m 6. Clear width: 1m
		Exit Staircase	1. Required for Tunnel (in lieu of CP) 2. Spacing of 762m 3. Clear width: 1.120m	1. Required for Tunnel (in lieu of CP) 2. Additional 1m wide access staircase at portal shall be provided 3. Spacing: 760m 4. Clear width: 1m
		Escape Walkway	1. Required for Tunnel 2. Clear width: 610-760-610mm	1. Required for Tunnel 2. Clear width: 800mm
	ACTIVE	Hosereel	1. Not required	1. Required for Tunnel 2. Tank capacity: 18m^3
		Standpipe	1. Required for Tunnel 2. Required during construction 3. Tank capacity: 114m^3 4. Combined with Sprinkler 5. Access road to breeching inlet < 30.5m 6. Type: Wet riser for building > 23m, Dry riser for building < 23m	1. Required for Tunnel 2. No tank required 3. Access road to breeching inlet < 18m 4. Type: Dry riser

SAFETY DESIGN OBJECTIVES

The principle of the design is to eliminate any risk present in an underground environment. However, we know this is not always possible, so the next best solution is to mitigate the risk. Primarily, the objectives are to ensure the safety of passengers, occupants, employees and emergency services personnel.

The design should also minimise the impact of fire on the property, operation and environment and allow emergency personnel to conduct response activities. The fire engineer plays a huge role in ensuring that these objectives are met.

In Malaysia, for a tunnel design, a Fire Safety Design Philosophy (FSDP) has to be developed to address all fire safety concerns in the tunnel. Further to the design, the fire engineer has to model the underground environment to compare the Available Safe Egress Time (ASET) with the Required Safe Egress Time (RSET). The modelling is based on the scenario and criteria stated in the FSDP. This FSDP will be the base for designers to further develop their respective designs. The fire authority, (Bomba, in the case of Malaysia) also plays a big role as they will review the FSDP submitted by fire engineers so as to ensure fire-fighting and rescue operations have been taken into consideration in the design.

FIRE LIFE SAFETY SYSTEMS

1. **Smoke Management:** Typically, a Tunnel Ventilation System (TVS) will be in place in the tunnel. This consists of jet fans to regulate the flow of smoke and heat generated in the tunnel. In the event of a fire, the TVS will provide sufficient airflow to prevent smoke back-layering to ensure passengers can evacuate safely. The TVS will control the smoke to flow in the direction opposite to the occupants' escape route and be discharged outside the tunnel to maintain the tenability of the tunnel. This way, fire-fighters will be able to access the tunnel safely to fight the fire.

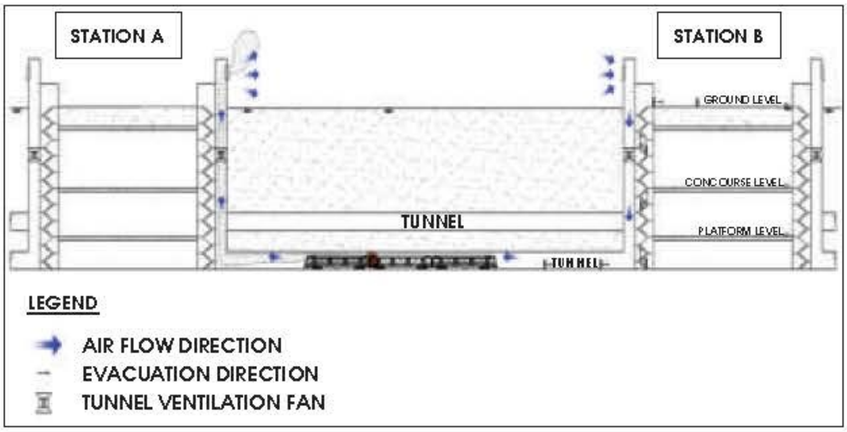

Diagram 1: Evacuation & smoke control

2. **Fire Fighting:** Landing valves are placed at appropriate intervals in accordance to codes, standards and local regulations. In tunnels, landing valves are usually placed at 60m intervals, with 2 numbers of 30m lengths hose provided. These valves can be of the wet or dry systems, depending on local regulations.

   In Malaysia, we use a wet riser while in Singapore, a dry riser is preferred. Nevertheless, in both countries, the intervals are 60m apart.
3. **Fire Detection:** There must be a system to detect a fire incident or event in the tunnel as well as accurately pin-point its location. Usually, a Linear Heat Detection (LHD) system is utilised in a railway tunnel as it is able to detect an anomaly such as a fire or any increase in temperature.
4. **Escape Staircase & Cross Passage:** In a railway tunnel, there are escape staircases and cross passages. These are used for the evacuation of

Daegu 2003 smoke (picture from railsystem.net)

Daegu 2003 train (picture from subways.net)

tunnel occupants in the event of a fire. Escape staircases are placed no more than 762m apart here while in Singapore the standard is slightly more stringent at 760m. In lieu of an escape staircase, cross passages can be utilised; however the maximum distance for a cross passage is only 244m. Cross passage designs consider the non-incident tunnel as a place of safety although it doesn't allow evacuation to the ground.

5. **Communication:** Railway tunnels are enclosed places and are usually equipped with communication systems such as:

a) Emergency telephone system.
b) Fire services telephone system at Escape Staircase/Cross Passage.
c) Mobile radio system.
d) Government Integrated Radio Network (GIRN).

CONCLUSION

A fire hazard in a railway tunnel presents significant fire & life safety issues to occupants and emergency response personnel, compared to normal building. In the event of fire, tenability for occupants and emergency services personnel relies heavily on the tunnel being equipped with an effective and reliable system which includes passive construction, active systems and proper response strategies.

It is of utmost importance to provide a safe and reliable railway tunnel, complete with the latest available technologies to ensure that public safety is not compromised. In this aspect, we can proudly say that railway tunnels in Malaysia are one of the best and most technologically advanced. ■

REFERENCES

[1] NFPA 130
[2] Singapore Standard for Fire Safety in Rapid Transit Systems

BIBLIOGRAPHIES

[1] NFPA 130 - Standard for Fixed Guideway Transit and Passenger Rail Systems
[2] Standard for Fire Safety in Rapid Transit Systems (Singapore)

Author's Biodata

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