Appendix 1-4 – South Korea - Seoul - Shinlim-Bongchun and Shimlin-2 tunnels

1. SUMMARY

Seoul is the capital and the largest city (10 million) in Korea. Seoul city government is planning to build an urban underground road tunnel network. The 3 x 3 tunnel network will be composed of nine tunnels which will have a total length of 148.7km. The Shinlim-Bongchun tunnel is the first step in the development of the urban underground tunnel network in Seoul. The east portal of the Shinlim-Bongchun tunnel is connected with the west portal of the Shinlim-2 tunnel. **Figure 1** shows the location of two tunnels.

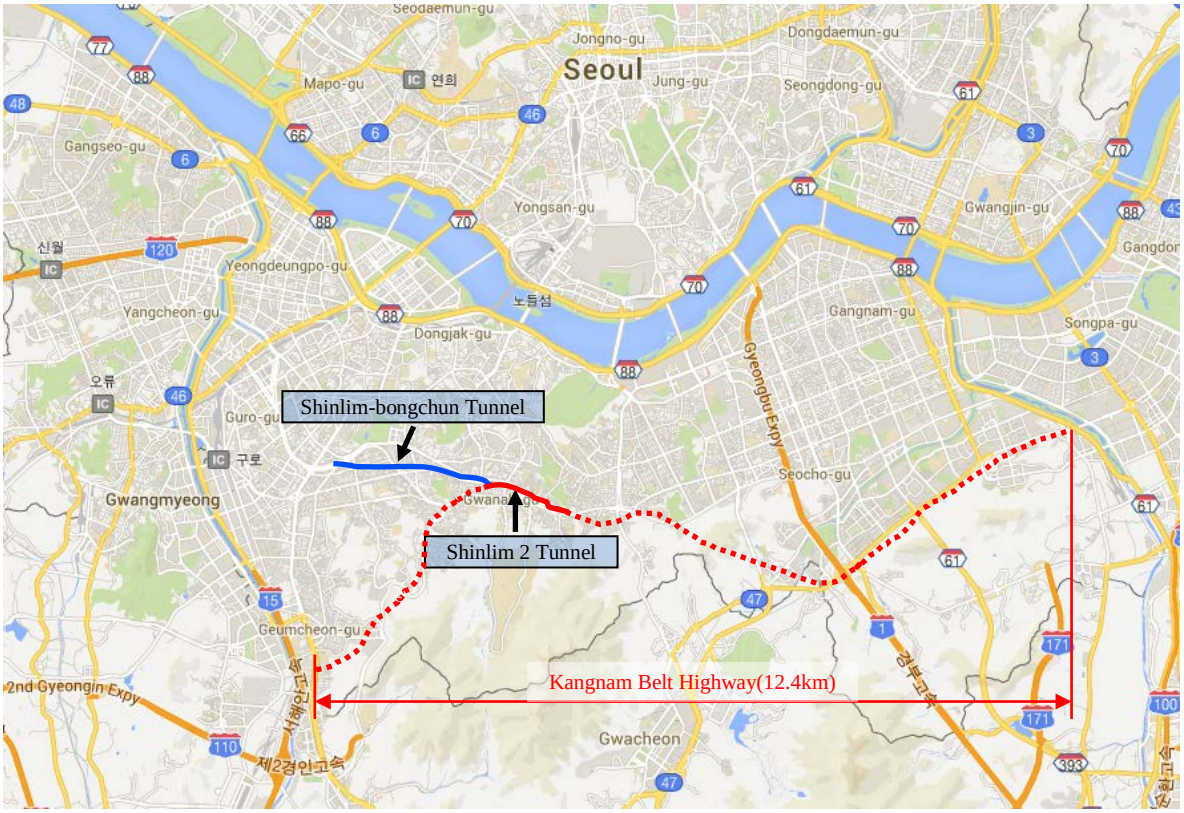


Figure 1 - "Shinlim-bongchun tunnel" and "Shinlim 2 tunnel" geographical location

The "Kangnam Belt highway" including the Shinlim-2 tunnel is under construction, and the Shinlim-Bongchun tunnel is currently ready for construction as of 2014. The Shinlim-2 tunnel is designed as a twin tube unidirectional tunnel with a longitudinal ventilation system using jet fans. Special ventilation conditions are considered; such as combined smoke extraction/control system operating strategies, pressurisation in the case of fire near the merging ramp and air pollution management for connected tunnels (Shinlim-2 tunnel). Heavy goods vehicles (HGVs) and buses will not be allowed to enter the Shinlim-Bongchun tunnel in order to control the air pollution levels in the connected tunnel.

2. MAIN CHARACTERISTICS

2.1 GEOMETRY

Shinlim-Bongchun tunnel

- Length 4,905 m,
- 2 tubes with 2 lanes each,
- Maximum longitudinal gradients: -4.9% ~ +4.0%.

Shinlim-2 tunnel

- Length 2,200 m,
- 2 tubes with 4 lanes each,
- Maximum longitudinal gradients: -0.33% ~ +0.34%.

2.2 CROSS SECTION

Figure 2 shows the geometry of the merging ramp and **figure 3** shows typical cross sections of the two tunnels.

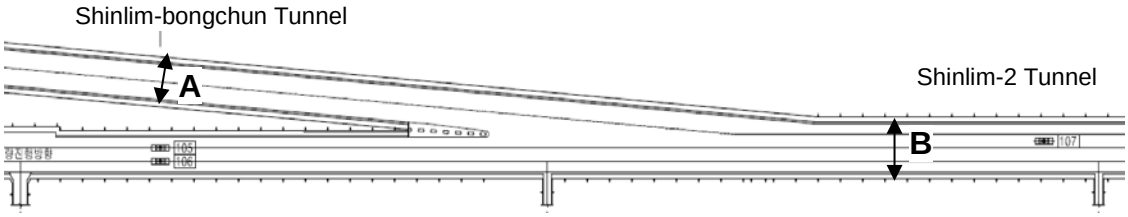


Figure 2 - Geometry of merging lamp

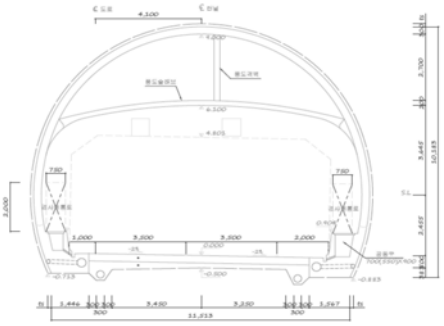
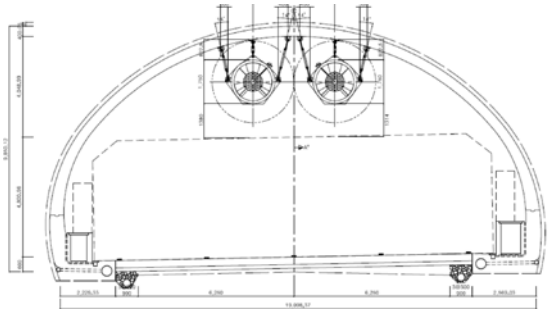
cross-section of "**A**" : Shinlim-Bongchun tunnel	cross section of "**B**" : Shinlim 2 tunnel
	
2 Lanes, Vertical Clearance : 4.8 m Transverse ventilation	4 Lanes, Vertical Clearance : 4.8 m Longitudinal ventilation

Figure 3 - Typical cross section

3. VENTILATION SYSTEM

3.1 VENTILATION SYSTEM DESCRIPTION

The Shinlim-Bongchun tunnel is equipped with ventilation plant for transverse ventilation with different capacities in each plant. **Figure 4** shows the ventilation systems of each tube.

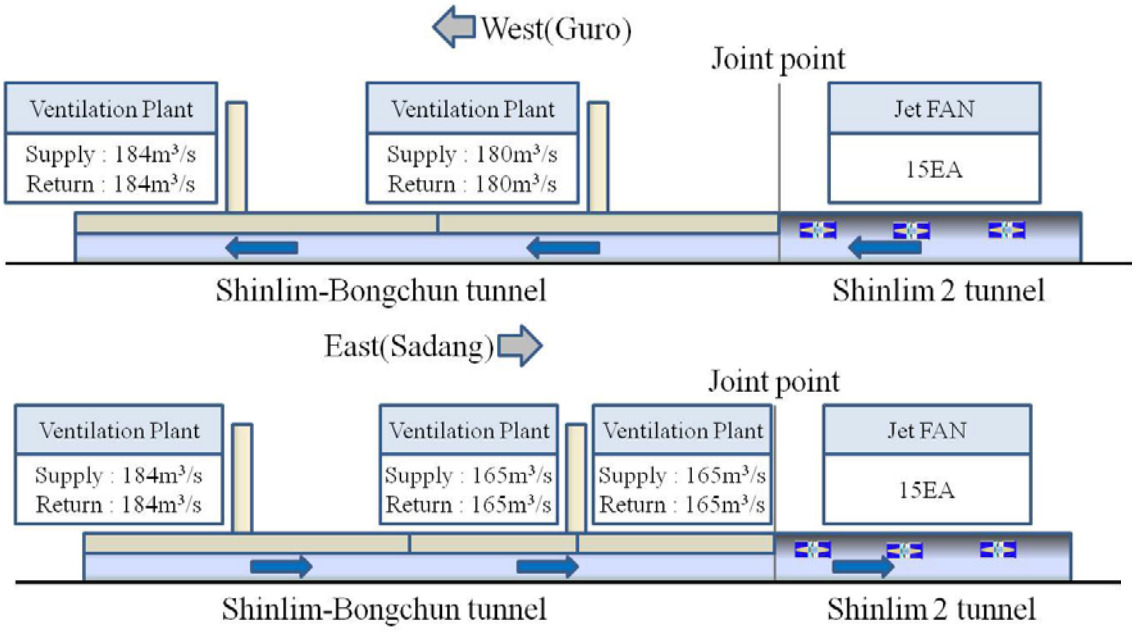


Figure 4 - Ventilation equipment schematic

In the east (Sadang) direction tube, there are 3 ventilation zones (2 vertical shafts with dust removing filters) to decrease the air pollution level in the Shinlim-2 tunnel. The West (Guro) direction has 2 ventilation zones.

3.2 AIR POLLUTION MANAGEMENT DURING NORMAL MODE OPERATIONS

In normal traffic operation, air pollution is removed by the piston effect. To decrease the air pollution level in the connected tunnel, the ventilation system will be operated - even though the air pollution level of the Shinlim-Bongchun tunnel is lower than the environment regulation standards.

In Heavy traffic conditions, the ventilation system will be operated in transverse mode (fresh air supply and polluted air extract). **Figure 5** shows the ventilation mode operating strategies.

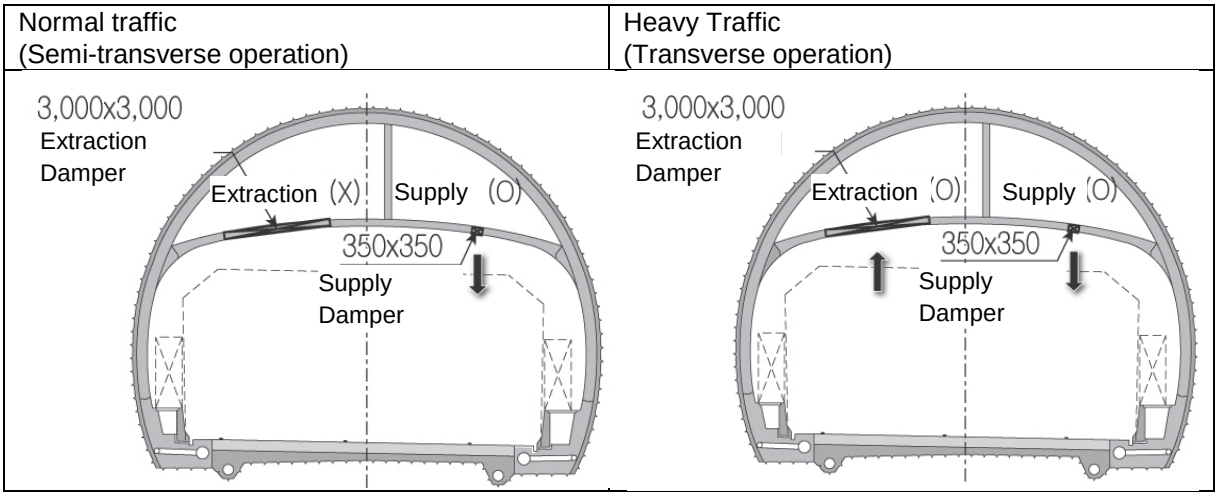


Figure 5 - Air pollution management ventilation strategies

3.3 SMOKE MANAGEMENT

Smoke management in the Shinlim-Bongchun tunnel is very difficult because one tunnel has a transverse ventilation system and the connected tunnel has a longitudinal ventilation system. The smoke management system in the Shinlim-Bongchun tunnel varies depending on the fire location. During a fire, seven extraction dampers are opened near the location of the fire and all other extraction dampers are closed. Extraction dampers are installed every 50m; so during a fire, dampers will open over a 300m long zone and smoke will be removed through the extraction duct.

Figure 6 shows smoke extraction for a 300m zone inside the tunnel

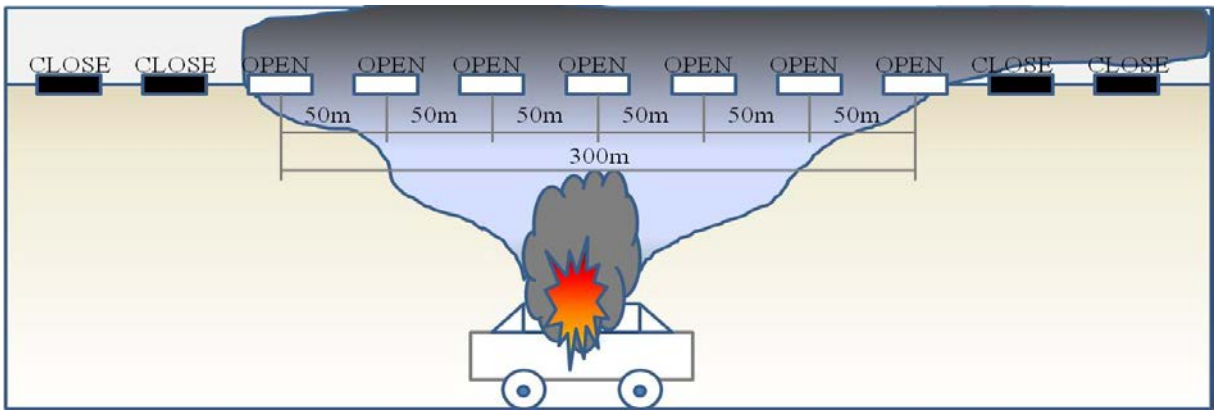


Figure 6 - Fire between a portal and the consecutive shaft: Ventilation strategies

For a fire near the merging ramp of the two tunnels, the ventilation system response is more complex. **Figure 7** illustrates how the two different tunnel ventilation systems operate for this case.

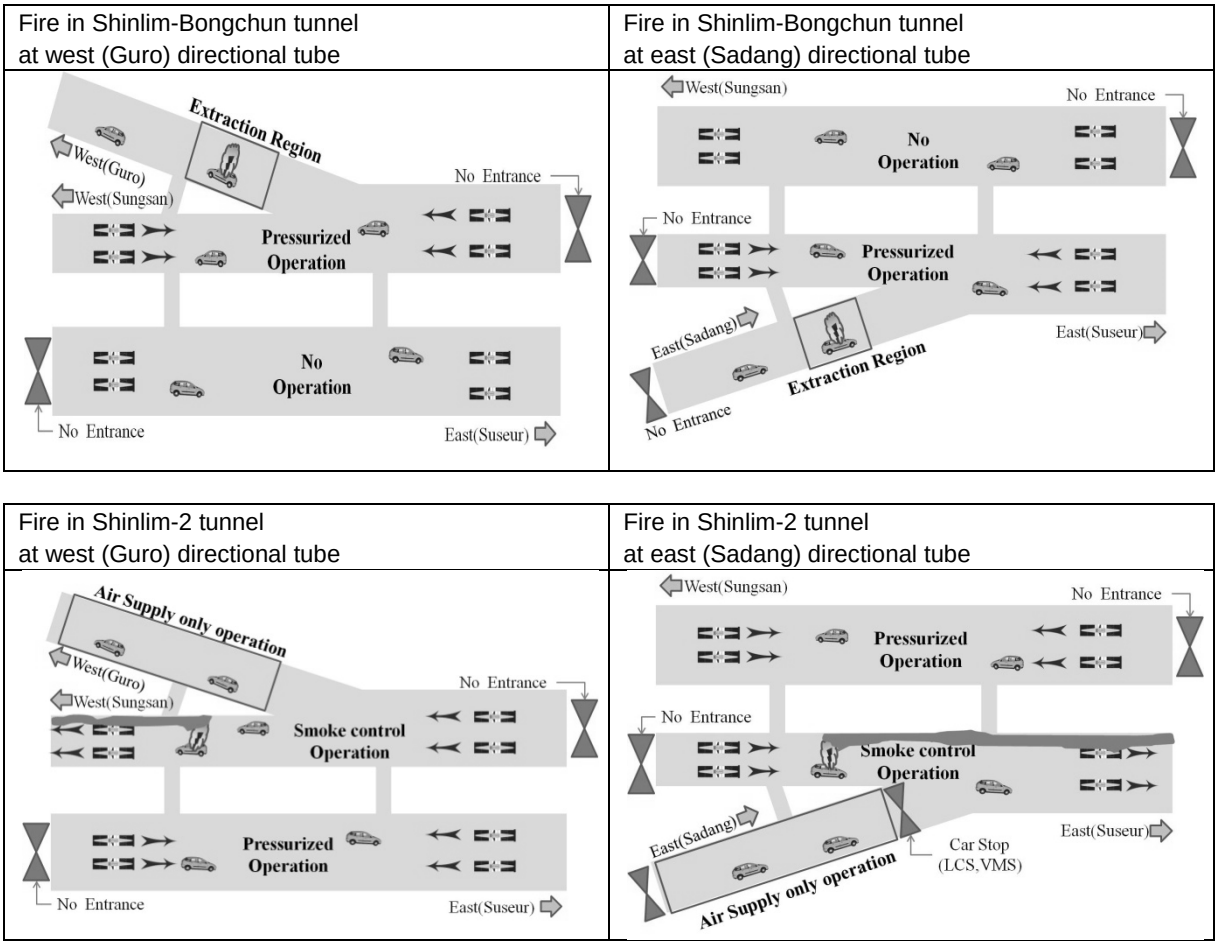


Figure 7 - Fire near the merging ramp: Ventilation strategies

In the case of a fire in the Shinlim-Bongchun tunnel in the west (Guro) direction tube near the merging ramp, the ventilation system of the Shinlim-Bongchun tunnel extracts the smoke in the fire regions and jet fans of the Shinlim-2 tunnel will be operated in the opposite direction to pressurize the tunnel. Jet fans near the entrance portal will be operated in the direction of traffic, but Jet fans near the exit portal will be operated in the reverse direction. Cars are not allowed to enter the tunnel at any point. If fire is located in the east (Sadang) direction tube of the Shinlim-Bongchun tunnel, ventilation strategies are the same.

In case of fire in the Shinlim-2 tunnel in the west (Sungsan) direction tube near the merging ramp, jet fans in the Shinlim-2 tunnel will be operated in the direction of traffic to control smoke. The ventilation system of the Shinlim-Bongchun tunnel will be operated in semi-transverse mode (air supply only) to pressurize the Shinlim-Bongchun tunnel. The jet fans in the non-incident tube of the Shinlim-2 tunnel will be operated in the reverse direction to pressurize the tunnel. For a fire in the east (Suseur) direction tube of the Shinlim-2 tunnel, the ventilation strategies are the same, but traffic control using LCS (Lane Control Signals), VMS (Variable Message Signs) and entry barrier systems are essential to avoid vehicles entering the Shinlim-2 tunnel where there will be smoke .