

Appendix 1.3 - JAPAN – Yamate Tunnel

1. SUMMARY - A LONG EXPRESSWAY TUNNEL IN AN URBAN AREA

About 30 million people, equivalent to 1/4 of Japan's population, reside in the greater Tokyo region. The Metropolitan Expressway is a network of toll expressways with a total road length of 301.3 km which functions as an arterial route for the traffic system in this region. The expressway network mainly consists of two concentric ring routes; the Inner Circular Route located in the central area of Tokyo and the surrounding Central Circular route which is under construction; and 10 radial routes, connecting various satellite areas to the centre of Tokyo (**Figure 1**). The Central Circular Route has been built to help optimize heavy through traffic flow in the Inner Circular Route and to improve the chronic traffic congestion.

The Yamate Tunnel is a 9.8 km-long tunnel for vehicles in the west part of the Central Circular Route. The tunnel was constructed under the street over the whole route, with a construction period of about 18 years, from 1992 to 2010. The long construction period was a consequence of the complex structure and the difficult construction operations such as the underground connection of tunnels and the simultaneous construction to widen the street above from 22 m to 40 m.

The twin-bore, 11m diameter road tunnels were constructed mainly by shield tunnelling methods. The two tunnels are for the most part side by side and horizontally parallel. However, for a section, the tunnels are stacked vertically because of a diverging or merging point near the junction of the Route No.3 Shibuya Line.

The Yamate Tunnel currently has four entrance portals, five exit portals and two junction connections. After the opening of the 8.4 km-long extended part in 2015 (estimated year of completion) one entrance and two exits will be added and the tunnel will become the longest motorway tunnel in Japan.

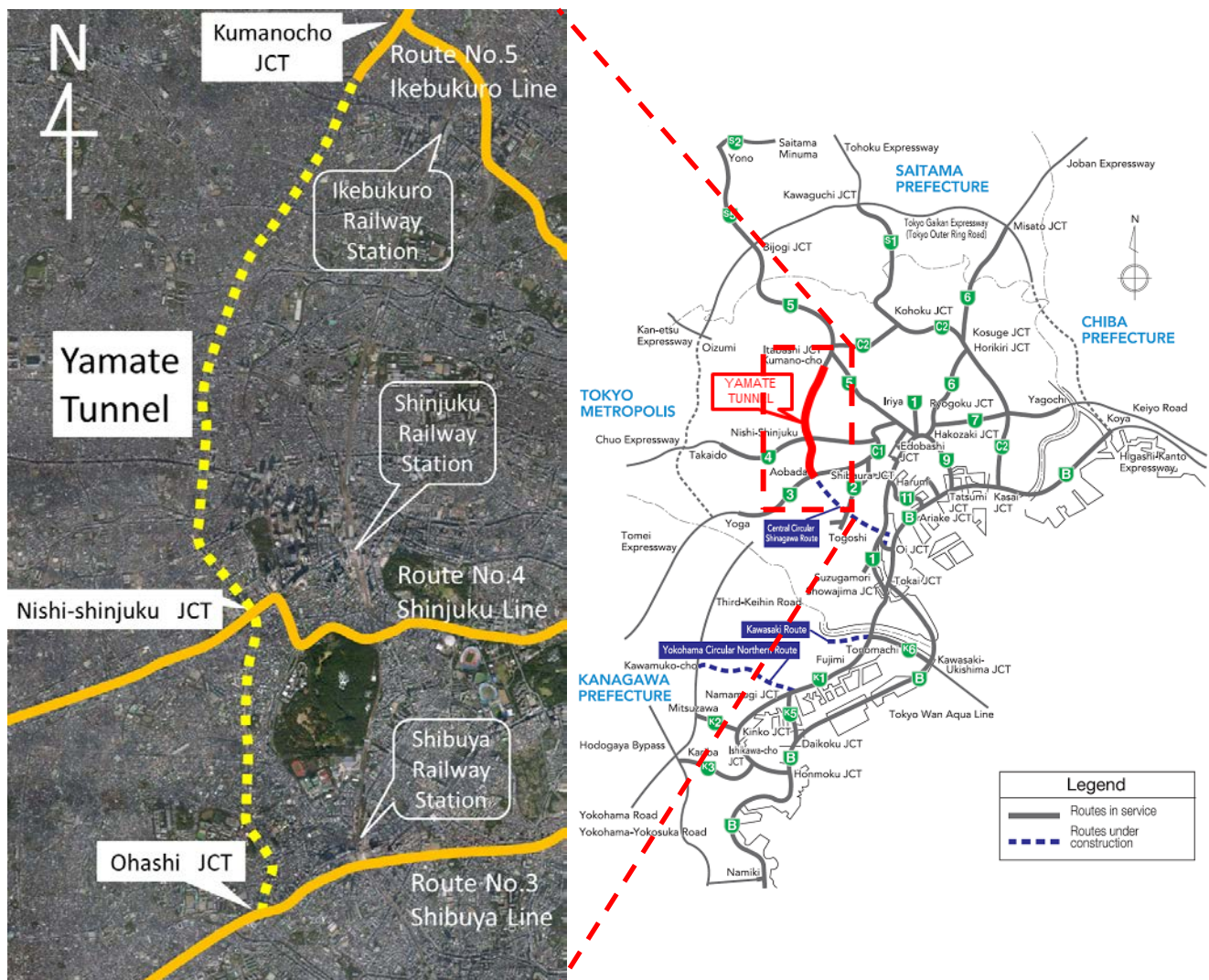


Figure 1 - Yamate tunnel situation

2. MAIN CHARACTERISTICS

2.1 GEOMETRY

- Tunnel length: 9.8 km
- Maximum gradient: 6%
- Minimum radius of curve: 204m

The general horizontal alignment of the tunnel is shown in **Figure 2** below. The Figure also shows the four entrances, five exits and two junction connections.

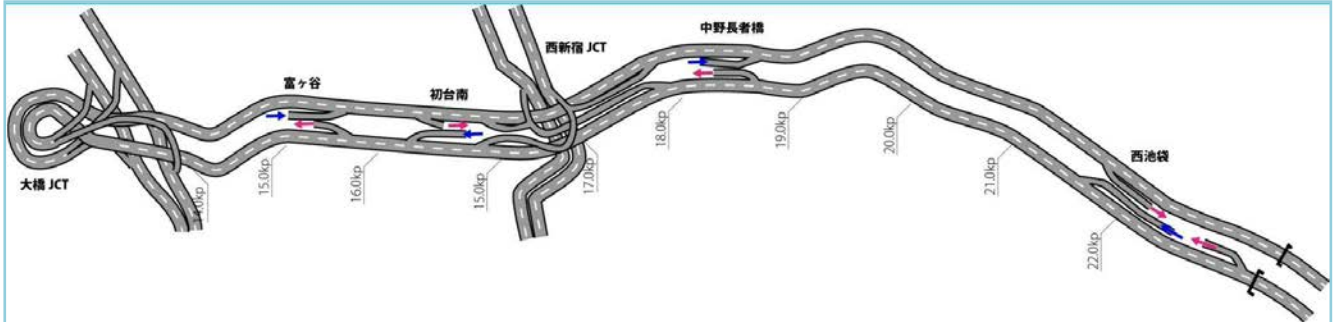


Figure 2 – general vertical alignment of the Yamate tunnel

2.2 CROSS SECTION

The cross section of the part of the tunnel constructed with a shield is shown **Figure 3**. The cross section includes:

- Number of unidirectional lanes (per tube): 2
- Width of one lane: 3,25 m
- Vertical clearance 4,50 m (+0.2m for design)
- Dangerous Goods vehicles prohibited

2.3 ESCAPE ROUTES

- Distance between emergency exit doors along the tunnel: about 350m
- Type of escape route: isolated corridors within the tunnel, cross-passages between the two tubes, direct stair shafts to the ground level, depending on the location
- All the emergency exits are closed by doors and pressurised.

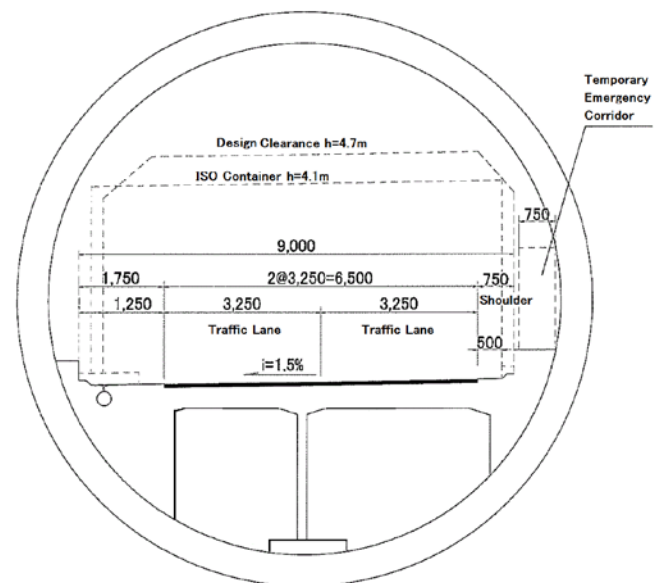


Figure 3 – Cross section shield construction method

Figure 4 below shows the main equipment for safety and operation.



Figure 4 – main safety and operation equipment in Yamate Tunnel

2.4 TRAFFIC CONDITIONS

2.4.1 General data

- AADT (annual average daily traffic): 35,000 veh. / day
- Speed limit 60 km/h
- Access prohibited for bicycles and pedestrians
- No regular traffic queuing inside the tunnel

2.4.2 Distribution of the traffic during the day

The hourly daily average traffic distribution is shown **figure 5**.

The upper diagram shows the traffic volume in the anti-clockwise direction and the lower diagram in the clockwise direction

2.4.3 Accidents

The analysis of traffic incidents shows the following information:

- Average of 17 traffic incidents in the anti-clockwise direction, with 7 accidents in the area of the curve with the radius of 270 m,
- Average of 10 traffic incidents in the clockwise direction, with a homogenous distribution along the tunnel,
- No particular concentration of accidents in the merging or exit zones.

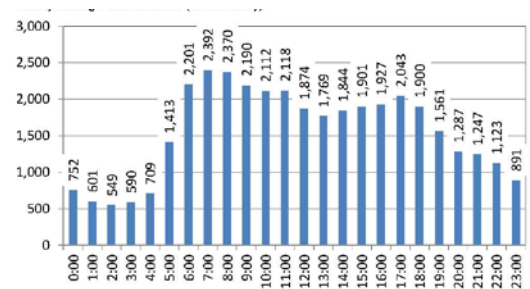
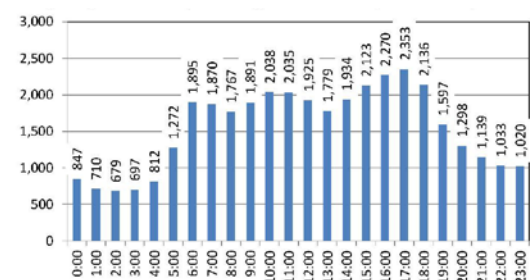


Figure 5 – hourly daily traffic distribution



2.5 VENTILATION

The transverse ventilation system includes air cleaning facilities.

- Number of ventilation stations: 9
- Type of ventilation system: transverse ventilation
- Low-concentration nitrogen dioxide (NO₂) removal system, air cleaner and noise suppressor installed at each ventilation station (**Figures 6 & 7**). The system removes more than 90% of NO₂ and filters out more than 80% of the suspended particulate matter (SPM) on a daily average basis.



Figure 6 – Ventilation Tower and Noise Suppressor

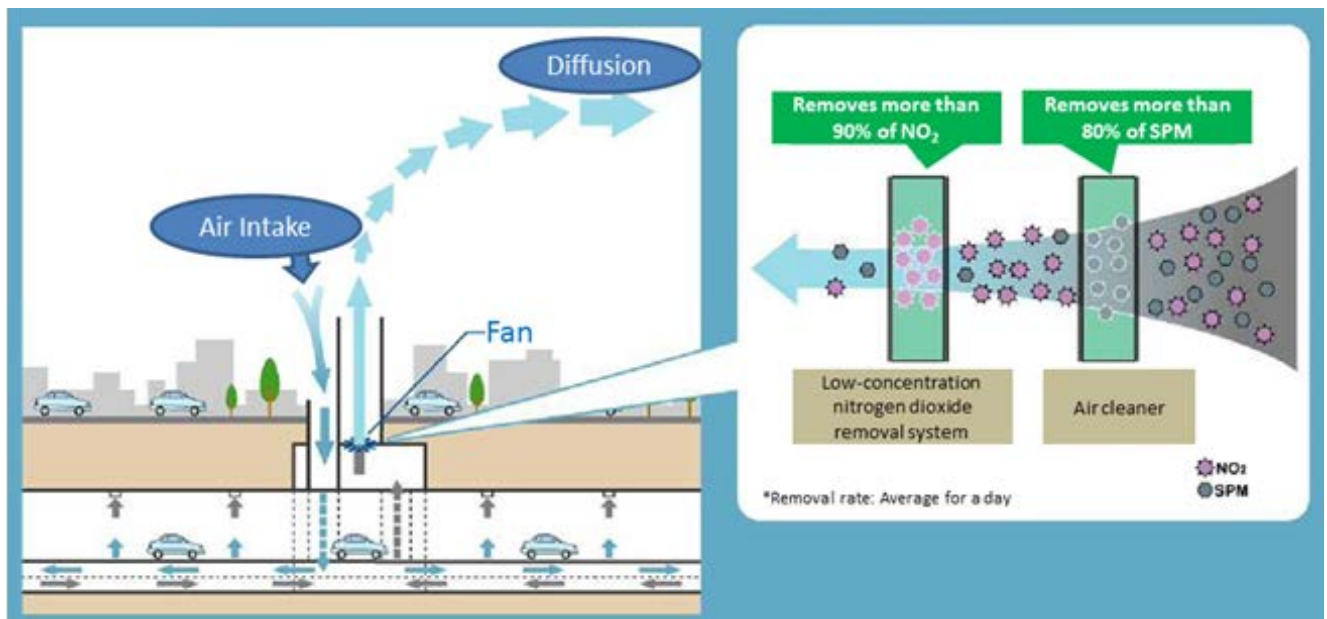


Figure 7 – sketch of the air cleaning system

2.6 ADDITIONAL FACILITIES

2.6.1 Water sprinkler system

The Yamate tunnel is equipped with a water sprinkler system, the objectives of which are:

- limitation of the temperature,
- suppression of the fire,
- limitation of fire spread,
- protection of the structure and facilities.

The water flow rate of the system is 6 litres / minute / m² for 40 minutes.

Sprinklers are activated through remote operation from the control room as soon as a fire is detected. Mist is emitted within a 50 m section and prevents the fire spreading and expanding.

2.6.2 Signalling

A Pro-beam lighting system is installed at the tunnel entrances and at the merging and diverging sections to warn the drivers and prevent rear-end traffic incidents.

3. OPERATION

3.1 GENERAL ORGANISATION

The Yamate tunnel is under the supervision of a control centre manned 24 hours a day.

Traffic information is shared with other highway companies, NEXCO East and West. Two police officers are stationed in the traffic control centre of the Metropolitan Expressway, as traffic control officials.

3.2 CONDITIONS IN CASE OF INCIDENTS OR EMERGENCY

CCTV, vehicles detectors and automatic fire detectors are installed in the tunnel to enable immediate detection and monitoring of traffic congestion and traffic incidents by the operators of the control room.

For drivers, fire extinguishers, push button alarms, emergency phones and emergency exits are also installed. Instructions are given by operators to drivers through loud speakers and a radio rebroadcasting system in case of fire or other state of emergency.

Unusual phenomena in the tunnel, such as traffic incidents or fire, are automatically detected by AIDS “Automatic Incident Detection System” (**Figure 9**) through CCTV image processing, and then shown on monitors in the operating room.

Patrol motorcycles (**Figure 8**) can rapidly reach the location of an incident, even during congested traffic.

3.3 CONCEPT OF THE AIDS

The objective is to detect automatically and immediately:



Figure 8 – Patrol motorcycles

- Stopped vehicles,
- Slow moving vehicles,
- Congestion
- Swerving vehicles

355 cameras are installed along the 10 km tunnel section with no blind-spots (Figure 9).

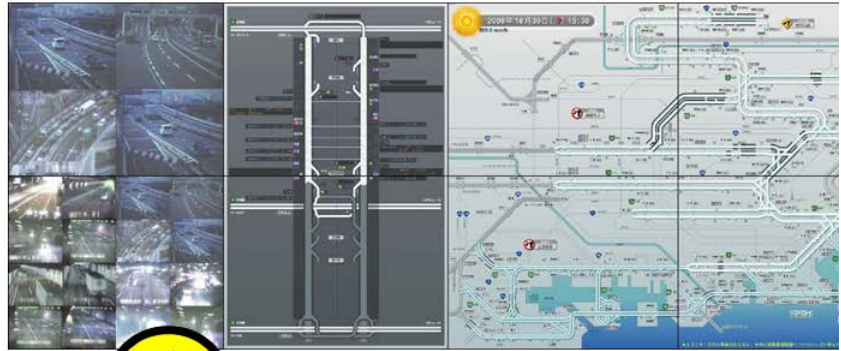


Yamate Tunnel
- 10km length
- 355 cameras

Figure 9 - Automatic Incidents Detection System

Figure 10 shows the information given by the SCADA system in the control room under normal conditions (above) and in the case where an incident has been detected (below).

Normal



With detecting Incidents

3 monitors locked

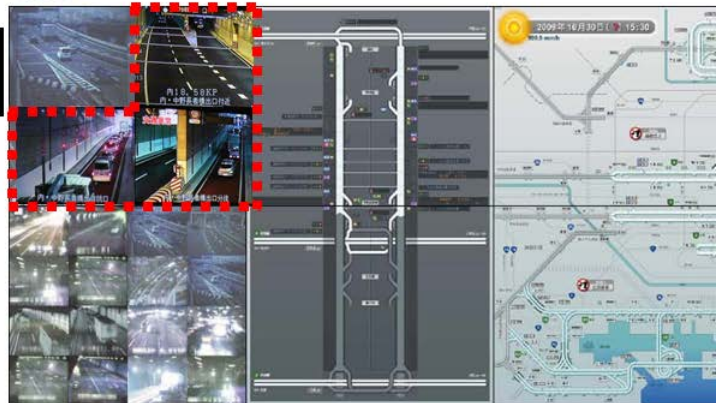


Figure 10 - Automatic Incident Detection System – information shown by the SCADA system