Overview of tunnel safety measures in Japan
- Various attempts made by the East Nippon Expressway Company -

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Contents

The following items for promoting tunnel safety are explained.

1. Prevention measures in normal time
   1-1. Ensuring smooth traffic flow
   1-2. Safety awareness activities and education for road users

2. Mitigation measures in case of emergency
   2-1. Tunnel safety standard and facilities
   2-2. Emergency tunnel facilities operation
   2-3. Consistent maintenance of facilities.

3. Concluding remarks
1-1. Ensuring smooth traffic flow

• Creating a smooth traffic flow in a tunnel would contribute to the prevention of traffic accidents and safety enhancement.

• In order to ensure smooth traffic flow in a tunnel, several facilities such as ventilation, lighting and so on are properly installed and controlled.

• One of the most recent and remarkable trials is to adopt the “Pacemaker Light” which could ease traffic congestion in the Tokyo Wan Aqua-line tunnel.
1-1. Ensuring smooth traffic flow

The “Pacemaker Light” uses LED lamps installed on the side walls of the tunnel which illuminates as if moving with the vehicle in the same travelling direction. Vehicles follow the lights moving at various speeds such as 80km/h and drivers’ subconscious speed reduction at an upslope could be prevented well.

![Graph showing traffic volume improvement with Pacemaker Light](chart.png)

-90% decrease in congestion volume in weekend.
1-2. Safety awareness activities and education for road users

- Education for drivers as well as passengers regarding safety procedures in case of fire would be essential. Various activities such as displaying instructions in a rest area on an expressway, distributing leaflets, showing the tunnel safety instruction video on H.P. and so forth are comprehensively carried out.

Safety instruction display
Safety instruction leaflet
1-2. Safety awareness activities and education for road users

Some snapshots from safety instruction video provided by NEXCO Research Institute

What if you find fire in a tunnel?

Explanation of spreading smoke

Explanation of evacuation

Explanation of emergency exit
2-1. Tunnel safety standard and facilities

Installation categories

Safety facilities of NEXCO

<table>
<thead>
<tr>
<th>Safety facility</th>
<th>Classification</th>
<th>AA</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>Remarks</th>
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<tr>
<td>Emergency telephone</td>
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<td>O</td>
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<td>Push button</td>
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<td>Not necessary in tunnels with L &lt;= 200m</td>
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<td>Necessary in A-Class tunnels with L &gt;= 3,000m</td>
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<td>Fire hydrant</td>
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<td>To be installed in B-Class tunnels with L &lt;= 1,000m</td>
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<td>To be installed in tunnels with evacuation routes</td>
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<td>Guide board (B)</td>
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<td>Smoke extractor, evacuation route</td>
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<td>Evacuation routes installed in tunnels with L &gt;= 750m</td>
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<td>Smoke extraction installed in tunnels with L &lt;= 1,500m</td>
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<td>Install evacuation routes in AA-Class tunnels and in A-Class tunnels</td>
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<td>with L &gt;= 3,000m, with bi-directional traffic and longitudinal ventilation</td>
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<td>Water supply hydrant</td>
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<td>To be installed in B-Class tunnels with L &lt;= 1,000m (water ports near portal)</td>
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<td>Leaky feeder system</td>
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<td>Entrance/exit telephone</td>
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<td>Radio (re-) broadcast</td>
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<td>O</td>
<td>Installed in tunnels with radio (re-broadcasting equipment)</td>
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<td>Necessary in bi-directional A-Class tunnels with L &gt;= 3,000m and more than 4,000 vehicles/day</td>
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<td>Monitoring equipment</td>
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<td>Installed in tunnels with sprinklers</td>
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<tr>
<td>Monitoring equipment</td>
<td>Type B (at lay-by)</td>
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<td>Necessary in A-Class tunnels with L &gt;= 3,000m</td>
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<tr>
<td>Monitoring equipment</td>
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<td>O</td>
<td>O</td>
<td>O</td>
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<td>Installed in tunnels with L &gt;= 3,000m</td>
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<td>Emergency lighting equipment</td>
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<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>Installed in tunnels with L &gt;= 3,000m</td>
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<td>Emergency lighting equipment</td>
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<td>O</td>
<td>O</td>
<td>O</td>
<td>Installed in tunnels with L &gt;= 3,000m</td>
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<tr>
<td>Emergency power supply</td>
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<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>Installed in tunnels with L &gt;= 3,000m</td>
</tr>
</tbody>
</table>

O: must be installed, Δ: installed if deemed necessary
2-1. Tunnel safety standard and facilities

Mutual backup between regional control centres

Regional control centre
2-1. Tunnel safety standard and facilities

- The purposes of water spray system are as follows:
  1. To suppress and cool down the fire.
  2. To prevent expansion of the fire.
  3. To support the fire fighting activities.
  4. To protect tunnel structure and facilities.
2-1. Tunnel safety standard and facilities

- Flame detecting device for rapid and accurate identification of fire location is adopted

- Flame detecting  
  × Heat detecting

- Flame detecting device

- Spray head
- Fire detector
- Traffic lane

- Spectrum of a flame
  - High-temperature body (1000°C)
  - Carbon dioxide resonant radiation
  - Sunlight
  - Flame
  - Low temperature body (30°C)
2-1. Tunnel safety standard and facilities

- Special tunnel lighting to top vehicles entering

Upper row: **Tunnel information**
Middle row: **Do not enter the tunnel**
Lower row: **Fire**
2-2. Emergency tunnel facilities operation

- Fire occurrence and appropriate correspondence
2-2. Emergency tunnel facilities operation

- Emergency ventilation

  - Longitudinal ventilation unidirectional traffic (2m/s)

  ![Diagram of emergency ventilation unidirectional traffic]

  - Natural wind

  - Emergency Exit

  - Emergency Exit

- Longitudinal ventilation bi-directional traffic (zero flow strategy)

  ![Diagram of emergency ventilation bi-directional traffic]

  - Natural wind

  - Emergency Exit

  - Emergency Exit
2-2. Emergency tunnel facilities operation

- Automatic water spray discharge

**Spraying water 3 minutes after fire detection for one-way and 10 minutes for two-way**

- Phase-in spraying for preventing secondly traffic accidents

[Images showing weak spraying at the beginning and full spraying after 10 seconds]
2-2. Emergency tunnel facilities operation

- Actual fire properly coped with the water spray system
2-2. Emergency tunnel facilities operation

- Operation training and fire drills
  - A complex tunnel fire simulator creating a realistic integrated training environment is built to train operators efficiently.

- Fire drills in collaboration with relevant organizations are conducted
2-3. Consistent maintenance of facilities

- Inspection and maintenance for facilities

In order to ensure a safe, reliable and comfortable driving environment, several facilities must be inspected and/or maintained properly on a predetermined maintenance cycle. We conduct the following two kinds of inspection.

- Facility functional inspection
- Facility structural soundness inspection

The recorded results of these inspections along with historical data identifying past facilities conditions are used to devise plans to repair or replace (upgrade) facilities systematically.

*As necessary, outsource repairs to manufacturers, etc.*
2-3. Consistent maintenance of facilities

- Development of specialized vehicles for effective inspection

We are continuously searching for effective methods to inspect facilities. As an example, annual water spray testing is carried out special vehicles which can check water volume and related maintenance works in the traffic restricted one lane without a tunnel complete closure.
3. Concluding remarks

- Comprehensive approaches pursuing for tunnel safety would be indispensable. This partly means that we should focus on not only emergency measures, but also ordinary measures, and they both ought to be appropriately carried out to mitigate a fire accident.

- Most safety measures could be the same worldwide, and advanced effective approaches in one country ought to be adopted and further improved in another country as well, and then newly obtained knowledge has to be re-shared.

- We all here could be responsible for tunnel safety in some way, so it seems essential to devote our attention to tackle the issue by concentrating with our wisdom.
Thank you for your attention