Shield Tunnel

TOKYO RING ROAD

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Tomei JCT Side Launching Section

Master Line Tunnel (South Bound) Tomei North Construction Project
Special Construction Work Joint Venture of Kajima Corporation, Maki Corporation, Sumitomo Mitsui Construction Co., Ltd., Tehkan Corporation, and Kobe Construction Co., Ltd. for Tokyo Ring Road Master Line Tunnel (South Bound) Tomi North Construction

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Osuzu JCT side Launching Section

Master Line Tunnel (South Bound) Osuzu South Construction Project
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Developing Expressway Network in the Tokyo Metropolitan Area

Tokyo Ring Road is a part of the expressway network composed of three (3) ring roads and nine (9) radial roads projected originally in 1963 as a framework for road transportation in the greater Tokyo area. Tokyo Ring Road will finally extend about 85 km in total length, which passes through the area about 15 km from central Tokyo, and become a critical road for relieving congestion, improving the environment, and realizing a smooth transportation network. Tokyo Ring Road (section from Kan-Etsu Expressway to Tomei Expressway) is about 16 km in length as tunnel, thereby contributing to a more comfortable environment and less environmental impact in Tokyo.

Expected Benefits from this Project

Relieving Congestion
Development of Tokyo Ring Road will control the inflow of through-traffic to central Tokyo.

Reducing Travel Time and Improving Environment
Tokyo Ring Road make the traffic flow smoother. Shorter travel time contributes to reduced CO₂ emissions.

Improving Safety of Residential Roads
The number of vehicles that use residential roads as shortcuts for arterial roads will decrease.

Disaster-resistant City
A ring road secures a detour to any destination with rapid movement even in the event of discontinuity in any section due to disaster, accident or other reasons.
Adoption of the Tunnel Structure in Consideration of the Roadside Environment

Tokyo Ring Road (Section from Kan-Etsu Expressway to Tomi Expressway) has adopted a tunnel structure with less impact upon the natural environment on the ground as compared with the elevated road design. In the construction of Main Line tunnels, the shield tunneling method has been adopted rather than the method of excavation from the ground surface. Thus, it contributes to suppressed influence on the groundwater compared to the open-cut method.
Construction of 16 km Tunnels

Shield Tunnel Method
By the shield method, a tunnel with a diameter of 15.8 m is constructed to form a road tunnel of 3 lanes with each direction. Most of sections run deeper than 40 meters below the surface of the ground.

Tunnel outer diameter
15.8 m
Total tunnel length about
16.2 km

Concrete Slab Construction
Concrete slabs form the road surfaces on which vehicles pass. In parallel with the tunnel excavation, concrete slabs will be installed.

Underground Joining Work
The shield machines, starting from Tomei Vertical Shaft and Ozumi Vertical Shaft, meet face to face at the target point near underground of Inokashira-dori Road. After freezing the surrounding soil by auxiliary method (freezing method), the shield machines are dismantled, and tunnel connecting work are completed.

Cross Passage
Cross passage is intended to facilitate the evacuation in case of an emergency to the tunnel on the other side.

Main Tunnel is composed of the North-Bound Tunnel extending the north from Tomei JCT* and the South-Bound Tunnel extending south from Ozumi JCT, forming the road of 3 lanes for each direction, and 6 lanes in total. The two tunnels will be excavated from Tomei Vertical Shaft and Ozumi Vertical Shaft, and will join near the Inokashira-dori Road. The construction work also includes assembling of slabs to form the road surfaces and construction of cross passages to connect between the North-Bound and the South-Bound Tunnels.
A Safe Construction Method Achieved by Building the Tunnel Walls during Excavation

How the Shield Machine Works

- **Cutter Head** [Shaving off the earth]
  - The cutter head contains the blades (cutting bits) of about 10 to 15 cm arranged in radial alternation, 8 pipes through the ground walls shaving off the soil/rock layers.

- **Screw Conveyor** [Conveying the excavated soil]
  - The screw conveyor works to take the soil excavated by the cutter head into the shield machine and carry it to the rear. It can adjust the volume of soil to be taken into the shield machine by controlling the rotation of the screw.

- **Erector** [Fabricating the tunnel wall]
  - The sections from which the soil is shaved off, panels called segments [see Page 11] are fabricated to form the tunnel wall. Segments are fabricated by the erector.

- **Shield Jack** [Moving the shield machine forward]
  - The shield jack can expand and contract freely by hydraulic pressure and it works to push the shield machine forward while taking reaction force against the wall of the tunnel.

Comparison of Shield Machine Construction by Excavated Distance and Tunnel Cross Section per Machine

<table>
<thead>
<tr>
<th>Shield Machine Construction</th>
<th>Excavated Distance</th>
<th>Tunnel Cross Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.6m</td>
<td>4.5m</td>
<td></td>
</tr>
<tr>
<td>12.3m</td>
<td>3.0m</td>
<td></td>
</tr>
<tr>
<td>12.6m</td>
<td>3.6m</td>
<td></td>
</tr>
<tr>
<td>13.8m</td>
<td>3.4m</td>
<td></td>
</tr>
<tr>
<td>14.7m</td>
<td>3.8m</td>
<td></td>
</tr>
</tbody>
</table>

Applications of Shield Tunneling Method

- **Road tunnels**
- **Railway tunnels**
- **Life lines**

Shelter tunneling method has been applied for not only road tunnels but also railway tunnels and water supply and sewerage systems.

How the Shield Machine Excavates a Tunnel

**Step 1 Shaving off the Earth**
- The cutter head on the front face of the shield machine rotates to shave off the soil.

**Step 2 Conveying the Excavated Soil**
- The screw conveyor carries the excavated soil to the rear of the shield machine and loads it onto the belt conveyor extending to the surface of the ground.

**Step 3 Moving forward**
- The shield jack is pressed against the fabricated tunnel wall and is expanded to allow the shield machine to move forward.

**Step 4 Fabricating the Tunnel Wall**
- In the space created as the shield machine moves forward, segments are fabricated in an annular pattern by the erector.
Shield Segments for Tunnel Structure

The tunnel structure is made of segments which are annularly arranged precast concrete panels. For the specific purpose and/or conditions of the place of construction, appropriate types of segments are applied.

**For Normal Sections**

**RC (reinforced concrete) Segments**

- Girder height: 650 mm
- Width: 1,600 mm
- Arc length: 4,062 mm
- Joint: Cone connector and pin joint system

RC segments are made from reinforced concrete, featuring high rigidity and excellent compressive resistance and durability. They are applied to normal sections in the entire tunnel.

**For Heavy Loaded Sections**

**Composite Segments**

- Girder height: 650 mm
- Width: 1,800 mm
- Arc length: 4,062 mm
- Joint: Fitting system

Composite segments are hybrid of steel and concrete. They are applied to these sections over which high-rise buildings or other heavy-duty structures could be constructed.

**For Cross Passages and Widened Sections**

**Steel Segments**

- Girder height: 650 mm
- Width: 1,000 mm to 1,800 mm
- Arc length: 4,062 mm
- Joint: Belts

Steel segments are highly flexible in design; they are applied in the cross passages requiring openings and the underground widened sections requiring cutting and removal.

**Countermeasures against Tunnel Fires**

When a fire breaks out in the tunnel, the tunnel may collapse if the segments get damaged due to heat. Thus, the segments shall have proper fire-resistant performance, ensuring that the tunnel is resistant to fire.

**Fire-resistant Segment**

**Steel Segment**

Fire-resistant panels are installed on the inner wall of the tunnel.
Carrying in Materials and Equipment and Carrying out Excavated Soil

The excavated soil is carried to the vertical shaft by a belt conveyor installed in the tunnel interior. At the tunnel vertical shaft, the excavated soil is carried up to the surface by the vertical belt conveyor and accumulated at the soil pit, and then loaded in dump trucks. Meanwhile, the shield segments and other materials and equipment for tunneling are carried down from the surface to the tunnel interior by a lift and are then carried by an automated vehicle along the tunnel.

Concrete Slab Work is Carried out in Parallel with Tunneling Work

Concrete slabs, which form road surfaces, consist of concrete slab, mid wall, side wall, and RC invert. In the present tunneling work, precast concrete slab work is carried out in parallel with shield excavation work, and then the precast members (members prefabricated at factories) are adopted for concrete slab and mid wall.

Concrete Slab Work is Carried out behind the Shield Machine.

Invert and side wall concrete are placed in situ and then precast members are installed in the order of mid wall and precast road slab.

1. Placing the invert and side wall concrete
2. Installing the mid wall
3. Installing the precast road slab