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## Durable Watertight Lining System for Tokyo Wan Aqua-Line Shield Tunnel

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### Abstract

Tokyo Wan Aqua-Line, a dual highway with two lanes in each direction, was constructed across Tokyo Bay which sits on an active earthquake area. Its total length is 15.1 km, of which 9.4 km is for the tunnel section, 2x0.2 km for the man-made islands, 4.4 km for the bridge and 0.9 km for the land access.

The tunnel section, consisting of two parallel tunnels, was driven through very soft ground 9.4 m to 18 m below the seabed under 0.6-MPa water pressure. Eight world's largest slurry shield machines with a diameter of 14.14 m were used for boring. To shorten the construction period, the shield machines were advanced from the vertical shafts both at the land area and the man-made islands. Underground shield machine docking was carried out below the seabed under high water pressure.

To achieve durability and watertightness of tunnel linings under such a severe condition, special considerations were given to various items from mix proportion of segment concrete to membrane waterproofing.

The authors will present these considerations including the following:

- 1) Admixture for segment concrete  
Blast-furnace slag powder was mixed to give concrete a lower coefficient of permeability, thereby increasing its anti-corrosion.
- 2) Backfill grout holes  
The number of holes was limited to four per ring. And to give watertightness, a butyl-based, hydro-expansive rubber seal was set around the grout pipe.
- 3) Watertight gasket  
A hydro-expansive seal, which would swell when it got wet, was set along each liner segment.
- 4) Steel materials  
-The covering of iron bar for the segment was set at 5 cm.  
-A semi-permanent anti-rust coating was applied to the segment bolts.
- 5) Shield machine docking below the seabed  
Skin plates of the machines were connected to one another by welding. Some flexibility was provided in the joint section.
- 6) Watertight membrane  
A watertight membrane was laid between the primary and secondary liners to lead unexpected water leak down for drainage.

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