Automatic Internal Lining System
( Polyurea NNT Method )

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NIPPON PAINT CO. LTD.
Functions of Secondary concrete coverings

at Sewage shield tunnel

<table>
<thead>
<tr>
<th>Expected Functions</th>
<th>Pros &amp; Cons</th>
<th>Trend of Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meandering adjustment</td>
<td>○</td>
<td>down</td>
</tr>
<tr>
<td>Internal smoothing</td>
<td>○</td>
<td>down</td>
</tr>
<tr>
<td>Watertight</td>
<td>○</td>
<td>down</td>
</tr>
<tr>
<td>Anti-Corrosion</td>
<td>×</td>
<td>up</td>
</tr>
<tr>
<td>Reinforcement</td>
<td>△</td>
<td>down</td>
</tr>
</tbody>
</table>

Secondary concrete covering becomes less important with developments in accurate excavation technology

Increasing needs for Anti-Corrosion & Reinforcement i.e. new method
Types of Corrosion Environment used by Japan Sewage Works Agency

<table>
<thead>
<tr>
<th>Types</th>
<th>Corrosion Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Extreme harsh condition by sulfuric acid at Av. more than 50 ppm of H2S gas</td>
</tr>
<tr>
<td>II</td>
<td>Very harsh condition by sulfuric acid at Av. 10—50 ppm of H2S gas</td>
</tr>
<tr>
<td>III</td>
<td>Harsh condition by sulfuric acid at Av. Less than 50 ppm of H2S gas</td>
</tr>
<tr>
<td>IV</td>
<td>Acid condition but not sulfuric acid</td>
</tr>
</tbody>
</table>

Corrosion environment type I  
In-operation

Corrosion environment type 1  
After wash down
The standard of Anti-corrosive materials approved by JSWA

<table>
<thead>
<tr>
<th>Corrosion types</th>
<th>I &amp; II</th>
<th>II &amp; III</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Types of materials</td>
<td>D</td>
<td>C</td>
<td>B</td>
<td>A</td>
</tr>
</tbody>
</table>

Polyurea: 3mm DFT

- Restore concrete
- Restore reinforced bar
- Primer coating by roller
Polyurea and spraying

After Polyurea lining

restart operation
Old method vs. new internal lining system

Old method

- Secondary concrete covering
  - $t = 250\text{mm}$
- Primary covering
  - $t = 150\text{mm}$

New lining system

- Internal lining
  - $t = 3\text{mm}$

Old method vs. new internal lining system

Reduce thickness / Increase efficiency

New excavation technology, lining system, is the solution for:

* High durability against corrosion and waterproofing
* Cost reduction and reduction of total working time from reduction in drill diameter of tunnel
Permeability of Sulfur (EPMA measurement)  
420 days  10% Sulfuric acid
Permeability of Sulfur (EPMA measurement)

Immersion Time $X = \sqrt{T}$ (days) in 10% Sulfuric acid

$y = 8.57x - 3.03$

1154 microns

135X135 = 1823 days

50 years
Diagram of Automatic lining system

- Whirling motor for spray gun
- Pipe segments
- Component A
- Component B
- Truck
- Control box
- Truck wheel
- Wheel ring
- Spray gun
- Polyurea lining surface
FLOW CHART -- Polyurea NNT Method

- Start
  - Safety switch
  - Whirling motor Start
  - Reach speed (rpm)
  - Truck Wheel Start
  - Spray gun--Stop
  - Truck wheel--Stop
  - Whirling ring--Stop

- Emergency stop switch
- Lining operation
- DATA Recording

Polyurea Discharge rate
Whirling ring speed (rpm)
Truck wheel speed

CONSTANT
High quality
Uniform quality of Polyurea lining film

HALT
- Spray gun--Stop
- Truck wheel--Stop
- Whirling ring--Stop
Middle Pipes (D=3-5m) Automatic lining equipment \( \varphi = 0.8 \sim 2 \text{ m} \)
Middle Pipes (D=3-5m) Automatic Lining Equipment
Small Pipes (D=0.8-2.0m) Automatic lining equipment
Polyurea NNT Method
Joint R&D by Nippon Kokan Koji/Nippon Paint/Taisei Corporation

Polyurea lining
- High durability of Anti-corrosion and Waterproofing
- Cost reduction and reduction of total working time

Ultimate efficiency

Polyurea NNT Method
Automatic Internal Non-solvent Lining System

- Ultimate quality due to uniformity of lining film
- Ultimate efficiency due to the Automatic system