Repairing of hydrostatic water retaining tunnels in Asia

Ostrava, 2008

Minova CarboTech GmbH
Dipl.-Ing. Dipl.-Wi.-Ing. (FH) Thorsten Tatzki

Solutions from materials technology
Example tunnel in Japan

Hachioji Joseki Tunnel
Length: 2.4 km
Street tunnel, connection between the highway and beltway network

Membrane supplier
Minova CT Chemical Grout
Local Partner
End customer

Knowledge transfer
Communication

Project

Tokyo
Example tunnel in Japan

Hachioji Joseki Tunnel

**Target:** First 100% sealed hydrostatic water retained tunnel in Japan!

- **Low grade**
  - Drainage tunnel
    - Mountain tunnel. It is possible to drain it by the inclination.
  - e.g. Ujigawa tunnel
    - Use of a plastic waterproofing membrane with drainage pipes in the invert.

- **High grade**
  - Hydrostatic water retaining tunnel due to the high value of the environment.
Example tunnel in Japan

Hachioji Joseki Tunnel

Longitudinal geological Profile
Example tunnel in Japan

Hachioji Joseki Tunnel

Underground water level

2005.OCT.19
Reaming excavation

Tunnel construction

Watertight completion
Example tunnel in Japan

Hachioji Joseki Tunnel

Cross section

Longitudinal section

Injection desk

Management box

Grouting hose

Injection tube

Barrier

Membrane

Repair System
Example tunnel in Taiwan

Injection Work
Railway tunnel / Taiwan

- Injection of injection hoses in block joints
- Injection of special plate construction, 24 for one tunnel block

Linkou Tunnel

- The project THSR C 210 is in total 6.5 km long.
Example tunnel in Taiwan

Linkou Tunnel

The special design of the HDPE – membrane was done with:

- Tunnel consultant
- Membrane producer
- Grout producer
Waterstop System

Setup of the Waterstop System

- Geomembrane (non-woven) with a plastic waterproofing membrane e.g. VLDPE, HDPE
- Joint strips with integrated grouting hoses e.g. PREDIMAX 11
- Injection plates fixed in a grid on the membrane surface
- Grouting and injection lines
- Suitable injection product e.g. CarboCrack Seal NV
- Injection equipment
- Trained injection team
- Supervising and monitoring of the application
Waterstop System

- PVC water stop with fixing element for PREDIMAX
- Filling hoses for injection plate
- Reinforcement bars
- PREDIMAX Injection hose
- Detail Block joint with PVC water stop and HDPE membrane (grey)
Waterstop System in Japan

Detail Block joint with PVC water stop and HDPE membrane (blue) and PREDIMAX
Waterstop System

Plate, fixed on the membrane

Detail Block with injection plate system and filling hoses

Filling hoses, before concreting
Waterstop System

Detail Block with injection plate system and filling hoses

Filling hoses before concreting

Filling hoses after concreting, with connectors
Waterstop System

Reasons for faults

- Reinforcement: reinforcement steel, spacers, later adjustment of the bars, floating during concreting...
- Pouring the concrete: concrete pressure, later adjustment of the formwork, floating of the formwork, vibration during concreting, mistakes during the pouring procedure e.g. gaps in the roof zone of the tunnel...
- Installation: missing knowledge, waste during the installation on the membrane, wrong position of the joint strips...
- Waterstop System: cheap material quality, too long injection hose sections, incompatible parts e.g. filling hose with the injection hose, mistakes during the injection of the resin...
Damaging

Final Tunnel shell with wet areas

Detail: Water is behind the concrete shell!
Pressure water!

Corrosion because of water in the concrete
Example injection work

Injection work – schedule in Japan

Test injection in 18.-22.12.2006
- Supervising by Minova-CT
- Developed a method statement

Start injection work 15.01.2007
- 8 teams /24hours
- ~ 4 tons of product in 12 hours
- CarboStop F: Stopping pressure water
- CarboCrack Seal NV: Permanent sealing
Example injection work

**Injection work proposal**

**Injection through the injection plate with CarboCrack Seal NV**

1. **Injection hose for pipes in the wall**
   - Left block
   - Right block

2. **Control in the beginning of the injection pipe:**
   - Initial pressure: 15 bar
   - Material starts running for the injection plate.

3. **Start with the injection on the deepest point from left or right side.**

4. **Stop pumping as soon as:**
   - Pressure increase
   - Material stops
   - Material flows away

5. **After injection:**
   - 25° litre without any pressure increase
   - Move to the next plate, see the schedule above.

**Example injection work**

1. **Injection hose 1:**
   - CarboStop F / initial pressure +3 bar
   - Material forms up in water contact and stops the water.
   - Finish the injection not before the water flow is stopped.
   - Wait 10 minutes after injection.

2. **Injection hose 2:**
   - CarboCrack Seal NV; 15 mm / initial pressure +3 bar
   - Water in water contact and stops the water.
   - Finish the injection not before the water flow is stopped.
   - Wait 10 minutes after injection.

3. **Injection hose 3:**
   - CarboCrack Seal NV; 5 min / initial pressure +3 bar

4. **Injection hose 4:**
   - CarboCrack Seal NV; 5 min / initial pressure +3 bar

*The volume has to be agreed with the responsible site engineer.*
Example injection work

Injection of the block joint from 22pm to 2am
Example injection work

Injection work with Minova pump

Filling hoses for the injection plates
Example injection work

Training by Minova staff

Injection connector
Example injection work

CarboStop F penetrates outside of the block joint
Injection work

Average pressure: 8-10 kg/cm²

Theoretical gap between concrete and membrane: 2 mm

Practical gap between concrete and membrane: 5 mm
Result

Hachioji Joseki Tunnel

Hydraulic pressure measurement

For example:
Point DW 4
Pressure 0.53 MPa
Linkou Tunnel Taiwan

Questions are welcome!