Paierdorf, Koralrn rail tunnel, Austria (Shaft shield)

**Editorial**

Dear reader

This issue is dedicated to the Koralrn rail tunnel project in Carinthia. In connection with this project, Rowa Tunnelling Logistics AG was entrusted with the development, manufacture, supply, installation and starting-up of an innovative shaft shield.

Your Rowa team

**Project and objective**

The two 32,8 km long single track tunnels of the project Koralrn rail tunnel in Carinthia are the key element of the new rail link between Graz and Klagenfurt.

For this key element of the new high-performance railway line between the two provincial capitals Klagenfurt and Graz Rowa supplied the most up-to-date technology in connection with the sinking of the prospective shaft Paierdorf, which with its depth of 120 m and its interior diameter of 9 m, crossing soft sediments, represents a very challenging engineering work. As an alternative construction method a shield advance with placing of lining segments was chosen. The work could be finished successfully in September 2004.

**Statement of the customer**

Manfred Jäger, Jäger Bau GmbH

Rowa Tunnelling Logistics AG was ready to develop, together with us, a new construction method. During this cooperation, Rowa proved to be prepared to take risks and worked in a highly professional way. This resulted in a very economic and competitive solution. Thanks to the flexible cooperation and the speedy handling of the work it was possible to achieve a very short delivery time. All the deadlines, for supply, for installation and for starting-up, could be kept without any exception. During the work on this interesting project Rowa proved once more to be a very reliable partner from the first project idea up to the end of the construction work.
Specific features

Innovative construction method
The use of a shield with placing of lining segments for the sinking of a vertical shaft is new and has been realized for the first time in history. Jäger Bau GmbH ordered Rowa to develop and manufacture the shield. During this work, which took place in close cooperation, new ground was walked on. The principle of the vertical shield is similar to the principle of a classical shield for horizontal advance. Owing to the advance direction, following the line of gravity, there were, however, entirely new challenges to be met concerning operation and construction of the shield.

Specific conditions
At the beginning, there was a fundamental question: What happens with a shield when it is used vertically? Or in other words: What are the boundary conditions for the use of a shield?
The following determining factors for the dimensioning of the shield were among the most important boundary conditions:
- Indentations active
- Hydrostatic water pressure
- Injection pressure annular gap grouting
- Mantle friction resulting from active earth pressures
- Passive earth pressures owing to directional movements of the shield

The most important boundary conditions for functioning and for geometric design of the shield, which were analyzed in detail, are:
- The optimizing of the size of annular gap between sufficient free space for the directional movements and the minimum volume of annular gap back-filling
- The construction cycle study with the following operating sequences:
  - Excavation
  - Muck handling (transport through shaft)
  - Ring placing
  - Annular gap grouting
  - Shield logistics, supply and removal
Conceptual study for the execution

Performance specifications
The performance specifications had to include all relevant requirements. The highest challenge was to recognize all requirements resulting from the various construction situations and their influences on the shield. Fortunately, the cooperation between the specialists responsible for geotechnology, tunnel construction, special civil engineering, equipment construction and an experienced shield specialist proved to be excellent. Rowa was entrusted with the task of coordinating these various specialists and was able to contribute its know-how in equipment construction, tunnel construction and special civil engineering.

Shield equipment
The shield was equipped with the following main features:
– The shield hydraulic is equipped with a sector control, similar to the situation in a horizontal shield, with 4x3 communicating cylinders. It is pressure controlled with visual monitoring of the verticality.
– Turntable platform, supporting the excavator and the infrastructure, serves in addition as a working platform for placing the lining segments, the annular gap grouting, the water containment and the performance guidance.

Project data

Shaft Paierdorf
Depth of vertical shaft 121 m
Lining segments single-shell, screwed together
Interior diameter 9'100 mm
Outer diameter 9'700 mm
Thickness of lining segments 300 mm
Length of lining segments 1'000 mm
Distribution of lining segments 6 x 60°
Shaft shield Diameter of shield blade 9'960 mm
Length of outer mantle of shield 4'300 mm
Shield tail sealing inside and outside
Number of advance cylinders 12 units
Stroke of advance cylinders 1'100 mm
Max advance force, total 24'000 kN
Excavator platform 360° turnable
Weight of hydraulic excavator approx. 7 t
Shield movement
The weight of the shield with all its superstructures is about 150 t. The frictional forces (resulting from cohesion and earth pressure) between shield mantle and earth, including the shield blade supporting force have to be higher than the gravity resulting from the shield weight. The shield can be pushed forward in a controlled way by means of the advance cylinders, starting from the last lining segment.

Lining segments
The positioning of the lining segments takes place under the protection of the shield tail. The lining segment is then screwed onto the previously placed and back-filled ring.

Excavation of the bottom
During the movement of the shield the bottom is excavated by degrees and continuously. For the excavation and the feeding of the muck buckets, the excavator has at its disposal a window of 2 x 90°. Owing to the excavator platform being turnable by 360°, the bottom is practically accessible without any impediment. The bottom can be excavated over the whole area of about 78 m² at the level of the shield blade in a relatively regular and even way.

Experiences
Summary of the firm Jäger about the experiences during the operation
Our experiences demonstrate that the vertical shield advance with lining with pre-assembled units allowed a very safe and comfortable construction method. This could be seen especially in the about 15 m thick, slightly aquiferous pebbles layer between level 35,0 m and level 50 m. This is especially the case in comparison with a conventional solution (consolidation with sprayed concrete), where the lowering of the shaft would have been possible only in partial steps and with additional measures, while the shaft shield allowed the crossing of this layer practically without any problems. The working conditions created by the steel shield and the lining with preassembled units were an additional important advantage. It is possible to practically carry out all the works from the turnable platform. This proved to make things much easier, especially in the quaternary zone, where the material was drenched and thus rather soft.

Cited: Mr. Di Christian Schönlechner, manager construction site EKS Paierdorf.