Rowa
Customer Day

Inclined Shaft Limberg without Fear of Heights

Risk Management for an Anti Slip-Back System

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September 13, 2007
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1 Overview Installation

The Limberg project is presently the largest hydraulic power construction site in Europe. The aim is to create a power-station by connecting the two existing reservoirs with a pressure pipe. With such an installation, 10% of Austria’s peak power demand could be met. In this pressure pipe, water is forced through a 5.4 km long pressure tunnel with a diameter of 7m. The tunnel is to be constructed from the upper reservoir with a TBM and an already existing Rowa back-up. Central to the installation, however, is the anti slip-back system in the pressurized water tunnel which penetrates uphill over 770 m from the cavern side at a 45 degree angle with a diameter of 5.8 m.

Customer:
VERBUND-Austrian Hydro Power AG
Construction Time:
March 2006 - December 2012
Project Type:
Power Station

Performance of the pumping operation increases from 130 MW to 610 MW (10% of Austria’s peak power).

Pressure tunnel

45° steep pressurized shaft with a diameter of 5.80 meters
2 Rowa’s Assignment

Rowa’s assignment was the construction of an anti slip-back system for inclined shaft installation.

Special influencing factors:
- Ascending gradient 45 degrees (when standing in the tunnel, 45 degrees feels like a vertical drop).
- Under such ascending gradient conditions, a mechanical heading with a boring diameter of 5.8 m is, as far as we know, the largest ever achieved with a single cut.
- The heading installation will be extremely heavy, due to the TBM used (Jarva machine) in combination with the safety preconditions required by EN815, totalling 560 tons.

The back-up must meet the special preconditions of EN815 which decisively influences planning and design:
- Factors dictated by norm EN815 for inclined shafts must be taken into account when planning and designing.
- The entire back-up must be constructed such that, in case of malfunctioning of a support or a connecting butt strap, a second and independent construction is able to take over the loads.

In order to reach and supply the back-up during heading operation, a material- and passenger train in form of a funicular must be planned and installed.
3 The Project

Back-up Installation

The back-up installation is assembled as follows:

7 sledges (whereby sledge 1 is connected firmly with the RFS) and the rail sledges for the funicular.

Sledge 1
Sledge 1 is firmly connected to the anti slip-back system and transfers the cutting torque acting on the anti slip-back system to the tunnel floor. The operating platform, power packs for TBM and anti slip-back system as well as a work station for maintenance are placed on this sledge.

Sledge 2:
The shotcrete manipulator is assembled on this sledge.

Sledge 3:
Concrete transloading sledge for preparation of shotcrete from a dry mix supplied in big packs.

Sledge 4:
Infrastructure sledge for the frequency converters of TBM and various control boxes.

Sledge 5:
Infrastructure sledge for water supply, team container and the three TBM transformer stations.

Sledge 6:
Infrastructure sledge for ventilation and dusting.

Sledge 7:
Track installation site for passenger and material train with boarding and disembarking sites.
**Trailing**

The back-up is attached at the casing of the main bearing and, therefore, is located at the boring head. A double traction rod is connected flexibly with the TBM head with a 200 mm bolt.

Norm EN815 always demands two independent systems which must be able to hold the entire weight in case of necessity. For this reason, two additional 150 mm bolts are mounted for security in case of malfunction of the main bolt.

Along the left and right of the TBM, the two traction rods are directed towards the anti-slip-back system and connected with it through two trailing cylinders.
**Anti Slip-Back Systems**

Because of the extreme weight of the heading installation and the rising gradient of 100%, the anti slip-back system must exert 800 tons through each of its pressure jaws into the tunnel wall to guarantee safe holding friction. 800 tons are the same as lifting 20 inter-city truck trains. A special pressure cylinder ensures that the pressed plates build up holding friction on the tunnel wall.

The main force transferred onto the tunnel wall occurs through the mechanical expansion lever system.

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**Trailing Cylinder**

In the picture below, you have a view from the TBM working platform towards the portal. In the foreground, one of the two trailing cylinders with a piston diameter of 360 mm can be seen. In the background, the anti slip-back system is visible.
4 Safety

Safety is always the best method to prevent fear of heights in inclined shafts.

The anti slip-back system is designed in a way that its nitrogen filled pressure cylinder will brace, independent of external energy sources such as hydraulic pump or electricity supply. The pressure cylinders always brace, except during change over.

The anti slip-back system wedges itself tightly through its mechanical lever system, as soon as the holding friction on the tunnel walls is achieved. Therefore, the pressure cylinders merely have an initial function.

During the design phase, examination of plans, of constructions, of production and assembly is crucial and always must take place on various non inter-dependent stages, and wherever possible, by independent authorities (i.e. testing statics).

With a risk analysis, measures and strategies for normal as well as malfunction cases are developed.

With such a systematic procedure, installations in inclined shafts are becoming safe!

5 Conclusion

The need for ever bigger boring diameters in combination with high rising gradients poses great challenges to anti slip-back systems.

• The weight of the heading installations to be secured increases proportionately to the boring diameter.
• Therefore, enormous contact pressures of the anti slip-back system pressure plates are needed. The combination of lifting movement and pressing force of the pressure cylinders with the necessary nitrogen volume for bracing are conflicting parameters to be optimized.

Mechanical implementation of a technically functioning and economically feasible combination is a great challenge.

• An anti slip-back system with the relevant heading installations is an engineering specialty which, besides a systematic approach, also requires distinct overview of safety engineering.

Thank you very much.