Monitoring at the exploration tunnels Aicha - Mauls Preliminary results

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1 General

The understanding of the rock mass behaviour during excavation is one of the most important information to be gained from an exploration tunnel in view of the long base tunnel to be designed and excavated. Therefore, a monitoring programme was planned for the exploration tunnels Aicha-Mauls consisting of the 10 km long TBM drive through the nearly unalterated Brixen granite and the conventional excavation of the access gallery in Mauls (1.8 km in length). The geotechnical aspects regarding these main workings will be addressed in the following.

2 Monitoring the Aicha tunnel

2.1 Execution

2.1.1 Portal

The wall at the tunnel portal was constructed with secant piles and monitored with several geodetic targets, an inclinometer and a piezometer hole. The targets were placed at the top anchor beam of the 15m high wall and several single targets were distributed on the piles of the secant wall. On the right hand side an inclinometer with a total length of 27m was installed. In this way the slope can be monitored nearly 11m below the gallery. On the left hand side a 30m long borehole was drilled and equipped with a piezometer in order to monitor the water table in the slope. The borehole ends nearly at the level of the river “Eisack”, which crosses the tunnel axis just in front of the portal.

2.1.2 Tunnel

According to design, in every fault zone two rings with instrumented precast segments and 3 magnetic extensometers (crown, right and left side wall, each with a total length of 12m and 8 points) were to be installed in conjunction with thermometers for the measurement of the rock temperature and, in case of water, piezometers. Thermometers were also to be installed at selected points along the tunnel axis; similarly, piezometers were to be placed in zones with significant water inflows. According to geological prognosis six fault zones are expected to be crossed up to chainage 4,500 m.
At present, 3 instrumented precast segments, one magnetic extensometer (crown, 7m, with 7 points) and 13 thermometers (at a depth ranging between 0.80 and 2 m) have been installed in the tunnel. A piezometer is ready to be installed. At a first sight this seems not to be in accordance with expectations which called for the installation of 12 instrumented precast segments and 36 magnetic extensometers, but there are a number of geological reasons for this. The rock mass quality is pretty better than expected, with only very few faults and dissected, jointed rocks being crossed so far by the TBM-drive.

2.2 Results

2.2.1 Portal

The geodetic survey of the secant pile wall at the portal shows only very low movements of a few millimetres. The water table in the first few months of monitoring is about 2-3 m below the invert, to become dry in August 2008. In the same period some slope movements were monitored at the inclinometer hole, which are not clearly explainable. During the mentioned time period the tunnel driving was 600-700 m away from the area. Although, some water flow of up to 2 m/s was observed to occur several times.

2.2.2 Tunnel

The rock temperature shows some correlation with the overburden. The temperature is in the 18-20°C range with a maximum overburden of 660m. The instrumented precast segments are indicating an increasing maximum stress after continuation of the tunnel drive. Any statement about the stress distribution is difficult due to missing accessibility after passing of the TBM. The extensometer shows very low deformation with a maximum value of 1.5 mm/m. The displacement stops already in a clearance of the tunnel drive of about 50m ahead.

3 Monitoring the Mauls access gallery

3.1 Execution

3.1.1 Portal

No monitoring of the entry cut and of the rock mass above the portal was foreseen for the access tunnel Mauls. Some geodetic targets were however placed on the crown anchor beam of the 14m high wall and on some boulders above the portal. Due to the dry rock conditions no inclinometers or piezometers were installed.

3.1.2 Tunnel

In Mauls the main focus is on a number of monitoring sections, designed for controlling the rock mass and the lining behaviour every 300m and in the enlargements. Altogether eleven monitoring sections are planned. These comprise three pressure cells (crown, left and right wall) installed in the rock mass and five pairs of strain gages in the shotcrete lining, when fair to good rock mass conditions are encountered.
In poor rock mass conditions, where the steel sets are installed, the monitoring plan calls for the installation of five pairs of strain gages and two load cells. As for Aicha, thermometers have to be installed in selected spots and piezometers in section with main water inflows. Additionally, convergence monitoring (five targets) is to be carried out in sections every 20m or 30m, depending on the rock mass quality
At present, with the face at chainage 1,500m, five main monitoring sections have been installed. Additionally, 10 thermometers for the measurement of rock temperature have been placed in boreholes at depth 0.8-2.0m. No piezometers have been installed due to the fact that no significant water inflow has been encountered.

3.2 Results

3.2.1 Portal

Following tunnel excavation of the first 15m, a maximum displacement of a few mm occurred on the anchor beam as well as on the monitored boulders. Dry to wet water conditions were experienced. However, due to the poor rock mass quality and the low overburden, during and after heavy rainfall water inflow took place.

3.2.2 Tunnel

The results of geotechnical monitoring show no anomalies so far. The rock temperature increases with the overburden. Near the portal the temperature is 13°C, to become 22°C with a 1000m overburden. The maximum convergences measured are 6mm, well in accordance with expectations coming from numerical considerations.
Under respect of the monitoring results considered meanwhile, it is assumed that major parts of stress and resulting deformation do occur immediately after excavation, before a zero reading is done. After the installation of strain gages and pressure cells, only small changes of the measured quantities are observed.
With the excavation being resumed, a rapid stress increase takes place. The maximum stress increases mostly at the crown. The stress changes in the strain gages are quite the same. With the face 200m ahead of the monitored section only a low stress increase is observed.

4 Conclusions

For the Aicha tunnel, geotechnical monitoring differs from the planning; the reasons for this are the favourable geological conditions encountered and the start-up difficulties of any large tunnel project. Solutions need to be prepared and implemented.
For the Mauls access gallery, geotechnical monitoring is considered to be along the line. Despite the installation of a smaller number of main monitoring sections with respect to the monitoring program, the data available of fair to good quality allows to assess the rock mass behaviour in compliance with the design of the Brenner Base Tunnel.