High volume water and mud ingress in early 2020 halted Lötschberg rail traffic to investigate, clean up and repair the lining breech

Lötschberg water breach repair complete

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Shani Wallis, *TunnelTalk*

After two breaches of water and sediment ingress through a failed joint in the final lining of the east tube of the 13-year old Lötschberg twin tube high-speed rail link in Switzerland in early 2020, construction of a CHF15 million (about US$16.7 million) permanent solution has been completed. Starting in early September 2020, BLS, the the owner and operator of the Bern-Lötschberg-Simplon rail line, gave notice to its contractor Frutiger to begin excavation of the parallel water and sediment management cavern solution designed by its design consultants srp engineers, Emch + Berger and Pini Swiss Engineering, and its geotechnical consultant Kellerhals + Haefeli.

The permanent solution for continuing safe operation of the railway and management of the geological ground water hydrology within the overburden is to breakout of the existing east tube running tunnel at two points and excavate a cavern to house a set of water and sedimentation settling tanks. The cavern, with its sloping invert, is 89m long x 11.40m wide x 5.7m to 11.50m deep and the settling basin has a capacity of more than 2,000m^3 from which settled water will continue to be channelled to the surface outside the south Raron portal of the railway and from there into the River Rhone, which passes about 400m from the portal. Sediment will be cleared regularly as it builds up (Fig 1). As an immediate remedy in the east tube, BLS installed a steel sedimentation tank in the affected area to permit rail traffic until closed again for the cavern excavation works.

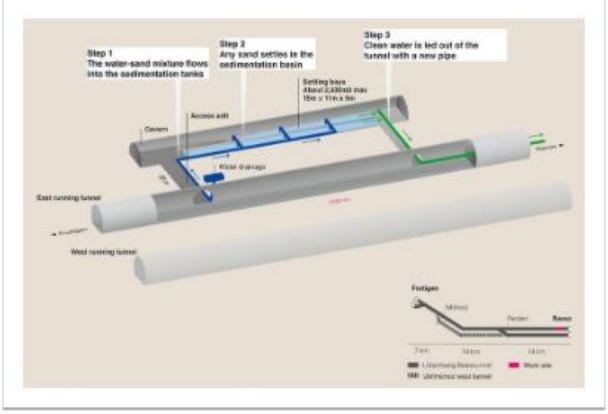


Fig 1. Design of the permanent management works

Under its negotiated construction contract of about CHF12 million, Frutiger began with the two breakouts, of about 25m wide each, from the main running tunnel in early September and completed about 10,000m^3 of drill+blast excavation and the casting of the internal concrete works by end of January (Fig 1). Works included excavation of a cavity of about 8m x 4m x 2m above the crown of the east running tunnel at the point of the lining breach, in which karst water is to be collected and piped to the sedimentation basin.

Works begin with breakout of the east tube lining

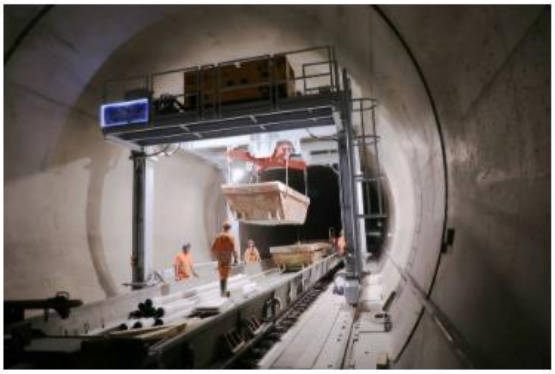
Drill+blast excavation progress

Mucking out into the main tunnel working area

The contractor for the M&E technical equipment, including measurement and control technology, and water pipe systems is Rhomberg Bahntechnik and InfraTech working to designs completed by consultant eprotraffic and the BLS specialist services. Completion of all works is expected by end of February. This will be in time and in readiness for the Spring snowmelt on the mountains above. About 2,700m of 400mm diameter steel pipework with an internal mortar coating has been installed as part of the works, with another 300m of 250mm diameter Inox-tubes in the cavern.

During the works, the east tube of the operating railway was closed, with trains either diverted to other lines or running in a managed bi-directional operation in the west tube alone, providing 24hr/day, 7 day/week access for the works. Drill+blast excavation of the cavern progressed on a topheading and bench sequence with muck transported out via railbound works trains through the Raron portal about 2km to the south. The existing operating tracks at the works site were covered with temporary backfill to permit excavators and drilling equipment traffic. "It was a logistical challenge to get all the materials in and out of the tunnel by train," reported Stefan Irngartinger, the works Project Manager for BLS, "but with experience, logistics ran very well." According to Irngartinger, there were only minor water inflows from joints during excavation, with a 10cm karst joint encountered at the north end of the cavern. Blasting vibrations had to be well controlled to permit train operations in the west tunnel at about 40m parallel.

Primary support in the cavern topheading



Works train in the main running tunnel

Access provided via the closed east tube from the Raron portal of the railway

After main excavation works, the plan was to open the east tube to traffic and use engineering hours to complete finishing works. BLS however decided to keep the east tube closed until all work was completed. The works programme includes rehabilitation of the east tube to repair its final lining, to finalise the junction of the two permanent adit openings into the sedimentation cavern, and to reinstall the overhead catenary power supply and radio and the signalling cables, which were removed for the construction work. An intense cleaning of the east running tunnel was also then required before its reopening. "The original plan was to carry out this work during night shifts in order to be able to resume rail traffic in the eastern tube during the day," said Irngartinger. "However, since there was a good experience of the closure of the east tube and the single-track bi-directional operation in the west tube, permitted by reduced train traffic - not least due to the corona pandemic and with redirection of traffic through the Gotthard baseline railway - it was decided to continue full closure of the eastern tube until the end of February to carry out these final works more efficiently on 24hr/day operation." There are no doors in the two adit openings in the running tunnel. As Irngartinger explained; "if there were doors, ventilators would have been required for the cavern's climatization. The main openings are left open so that the cavern is ventilated by suction and pressure of the train traffic."

A press release from BLS stated that, "with the implemented cavern solution and its large settling basins, BLS reacted quickly to the natural events of the Spring last year and within a year. In the future, this solution should prevent mountain water from entering the main running tunnel carriageway, and direct it rather from the crown area of the running tunnel into the sedimentation basin. If the water is mixed with sand, it settles in the pool and the cleaned mountain water is drained out of the tunnel. However, BLS admits, the geological situation still harbours risks, which is why BLS is investigating the effectiveness of the system after the resumption of rail operations."

Works begin on the internal structures

Settlement basin structure

Completed settlement basin and its pipework

In response to questions asked by *TunnelTalk*, BLS said that a detailed measurement of water inflow was not possible during the construction period and that monitoring and measurement instrumentation has been installed as part of the operational equipment of the basins. "We estimate an inflow of 20 litre/sec to 40 litres/sec."

The basins have a sedimentation volume of about 2,000m^3 (2 x 1000m^3) and BLS said that it is impossible to estimate the volume of sediment washed in during an incident. "We will start clearing sediment from the basin when it is half filled. If there are no larger incidents, we will clean the basins once a year. We need to gain experience with the sediment washed in during the Summer and Winter for future operation of the basin. Maintenance works in the basin cavern will be carried out by loaders and works trains during the eight hours of engineering periods in the operating railway on Sunday/Monday night each week."

Finalising work at the breakout adit junction with the main running tunnel

Temporary sedimentation tanks in the east running tunnel ahead of the permanent works

With completion of the excavations works, questions remain about the long term draining of the ground water and washout of sediment from the mountain and the potential consequences. The permanent works also raise queries about the environmental regulations for management of natural water regimes around excavation projects both in Switzerland and internationally. Regulations to protect the natural environment have been strengthened in recent decades and complying with these regulations are significant and important processes to be managed by owners and developers of new underground infrastructure.

References

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