Influences of the Urban Environment on the Emme Tunnel

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1. Description

The 47 km long new railway line between Bern and Zürich is one of the main part of the project Rail 2000 developed by the Swiss Federal Railway Company. Near Kirchberg, this new railway line is crossing the Emme river, in addition the busiest highway of the country, local roads, an existing railway bridge, various public utilities and two towns. Due to the density of this urban environment and, as most of the crossed infrastructure has to remain in service during construction, a tunnel of 1628 m length in granular soil was planned as shown in *Fig. 1*.

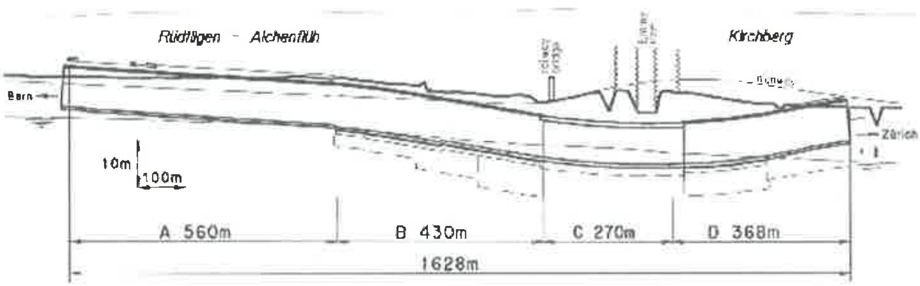

Fig. 1 Longitudinal profile of the Emme tunnel

2. Tunnel without waterproofing membrane and expansion joints

After defining all project parameters, general concepts were developed considering the environmental aspects. A major issue was the concept for waterproofness of the tunnel which is ensured by the concrete liner itself without membranes. Thus, retrofitting limited lifetime waterproofing will be avoided.

3. Various developed construction methods

The density of the environment asked for different construction methods. One section of the tunnel was built in standard cut-and-cover technique with a vault profile as illustrated in *Fig. 2*. With increasing depth of the construction pit, tunnel construction was executed between anchored sheet piling and in areas with groundwater level on top of an underwater-base slab. The middle section of the tunnel was built using a top-down construction method with a rectangular tunnel cross-section as illustrated in *Fig. 3*. After the top slab was poured between slurry walls the previous terrain was re-established in order to minimise interference with the highway and the river. Soil excavation below the top slab was performed applying air overpressure to lower the groundwater level.

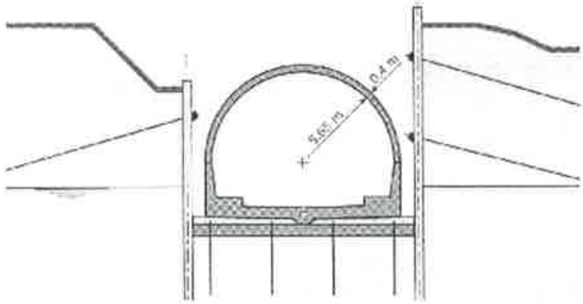

Fig. 2 Cut-and-cover method between sheet piling (parts B, D)

1. Driving sheet piling
2. Excavation and setting the anchors layers
3. Underwater excavation up to the bottom of the tunnel
4. Underwater-base slab made with fibber concrete
5. Setting the vertical soil anchors to resist buoyancy
6. Once the cross-section is watertight, pumping the water
7. Constructing the tunnel

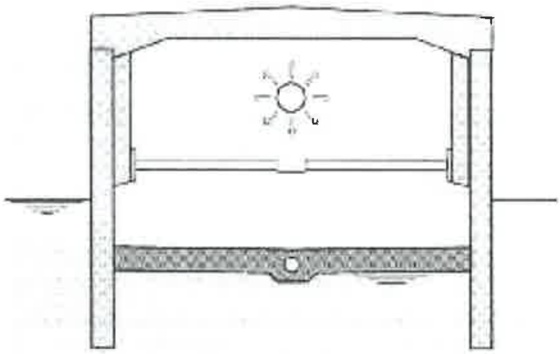

Fig. 3 Top-down construction method with air overpressure

1. Excavation up to the bottom of the top slab and construction of slurry walls
2. Construction of the top slab on the ground
3. Backfill
4. Excavating below the top slab up to the ground water level and construction of the upper part of the walls with SCC
5. Installation of the air overpressure system for lowering groundwater table
6. Setting temporary horizontal struts and excavation up to the bottom of the tunnel
7. Construction of the bottom slab and the internal part of the tunnel

4. Conclusion

The complexity of construction methods, construction staging, environmental, soil, and groundwater conditions required non-linear finite element simulations for estimation of interaction between tunnel and existing structures. Furthermore, field measurements were performed to check the results of the computation.

The realisation of such a project was successfully achieved thanks to a perfect collaboration between all the partners. The construction of everybody who took part to the design and the realisation of the tunnel is greatly acknowledged.

Client: Swiss Federal Railway Company, Department "Neubaustrecken"

Engineers: Emch+Berger AG Bern

Contractor: ARGE Emmequerung (Marti AG, Frutiger AG and Koenig AG)