

UPGRADING THE SWISS NORTH-SOUTH ROUTE: KIRCHENWALD TUNNEL -
TURNING THE MOUNTAIN BETWEEN THE LAKES INTO SWISS CHEESE

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ABSTRACT: Situations in which underground space is limited are especially common in urban environments. Apart from the general rule, in this presentation a large project will be described, which is situated in the Swiss Pre-Alps at a key point in the Swiss national roadway system.

The primary motorway of the North-South axis, which has been menaced by steep slopes and falling rocks for the past four decades, will now be transferred into the Kirchenwald Tunnel for safety reasons.

1. THE KIRCHENWALD TUNNEL AND ITS ENVIRONMENT

It occurs more and more frequently, in certain key areas, that new transportation tunnels must be constructed in the vicinity of existing ones. The new structures must be implemented with care so as not to disturb the existing tunnels. This generally leads to complex construction situations. Consequently, it is possible to have tunnel systems, which are strongly influenced by each other. A certain amount of synergy is possible, if some service installations may be shared among the systems, e.g., technical spaces, evacuation routes or ventilation systems. On the other hand, negative influences must be limited, such as the damaging effects of settlement, vibrations, etc.

Situations in which underground space is limited are especially common in urban environments.

In the Swiss Pre-Alps, the Kirchenwald tunnel is an important project, which will be carried out at a key point in the Swiss national roadway system. At this location the Lopper Mountain forms a natural barrier, which impedes direct access to several important Alpine passes. This obstacle has already been crossed by various transportation tunnels in the past.

2. MENACING DANGER

Approximately 80% of the transit traffic crossing the Alps along the North-South axis is obliged to pass either on the A4 motorway and along the Axenstrasse, or, as the majority actually does, on the A2 motorway and along the Lopper northern hillside, heading toward the Gotthard Tunnel and Italy. The extent to which habitual daily traffic can be affected by natural events was impressively shown by the complete blocking of the Axenstrasse during a menacing rock fall in 1992. During the stabilization works, which lasted several months, the entire North-South traffic to and from the Gotthard Tunnel was then rerouted through the Luzern bottleneck. This led to frequent traffic jams and an increase in traffic accidents.

Similar natural events could also occur along the Lopper northern hillside and thus interrupt traffic on the A2 motorway. At the present, this scenario would have unforeseen effects on the road traffic and the affected region. Actually, the existing, open stretch of the A2 national highway along the northern hillside of the Lopper Mountain is permanently menaced by rock fall and debris events. A real danger exists that the roadway structure, especially the viaduct, will be so strongly struck one or more times during its lifetime that the crucial traffic links will be interrupted for long periods.

Based on this evaluation, a study was carried out to explore the possibility of placing the endangered zone between Hergiswil and Acheregg underground in two double lane tunnels.

At the present, a direct national road link from the A2 to the A8 motorways does not exist. Since no environmentally acceptable above ground solution was able to be found for this link, an underground trajectory is planned between the national highways A2 and A8 in the Brünig/Interlaken direction.

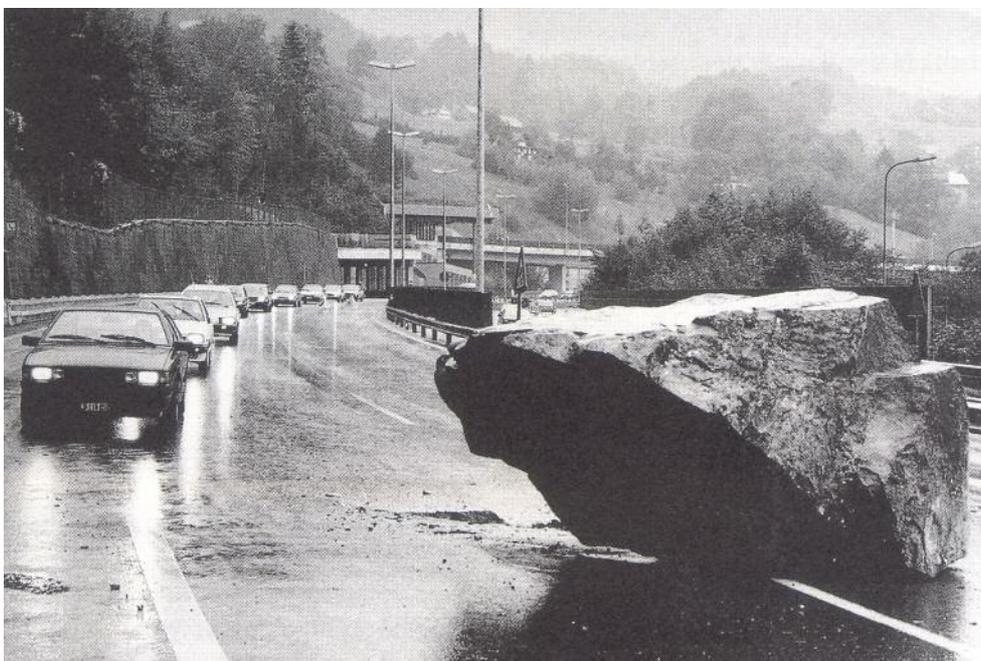


Figure 1: Rockfall event at Lopper in 1986, fortunately without mayor damages and casualties.

3. GENERAL PROJECT DESCRIPTION

3.1 Trace

The major part (84%) of the planned tunnel lies in Canton Nidwalden. The rest (16%), especially the A2/A8 connecting tunnel, will be constructed in Canton Obwald.

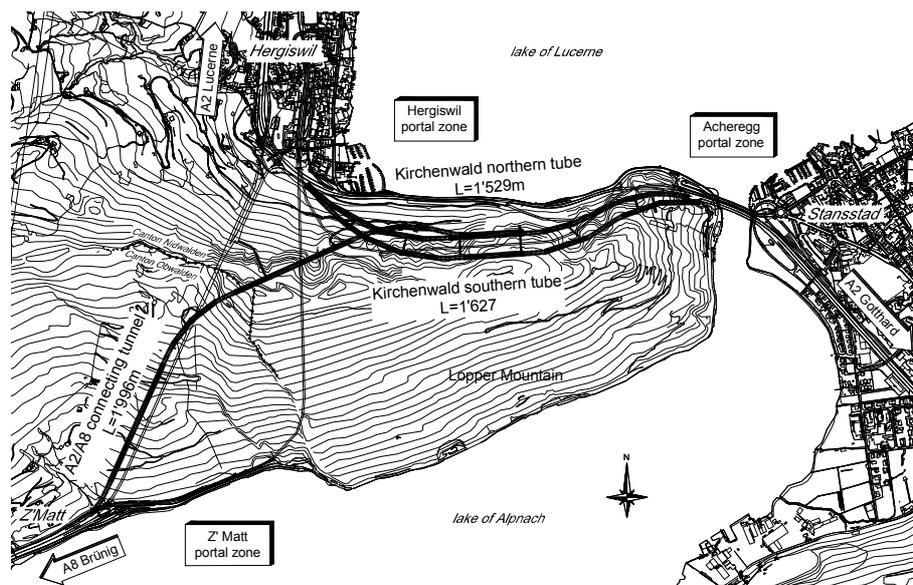


Figure 2: Situation, project overview.

The possibilities for setting the horizontal and vertical axes of both tubes of the Kirchenwald Tunnel, through the portals in Hergiswil and Acheregg, as well as in the middle tunnel segment through the various existing tunnel installations in the Lopper Mountain, are very limited. Approximately 90% of both of the 1.6 km long two-lane tunnel tubes can be excavated in geotechnically favourable siliceous limestone, while about 150 m of tunnel near the Hergiswil portal must be constructed in quaternary formations. The northern tube connects underground with the existing A2 Acheregg Mountain tube and uses about 0.35 km of this structure.

The one lane A2/A8 connecting tunnel branches off more or less in the middle of the northern tube of the Kirchenwald Tunnel, crossing over all of the existing and projected tunnels and runs parallel to the existing A8 Lopper Tunnel until the Z'Matt portal. The tunnel is approximately 2 km long and can be completely constructed in rock.

The minimum curve radii provide sufficient visual conditions for the project speed of 80 km/h.

3.2 Tunnel profile

The tunnel tubes have a normal horseshoe shape. The excavation section of both Kirchenwald Tunnel tubes measures approximately 80 m² in rock and about 135 m² in quaternary formations. The A2/A8 connecting tunnel, with an excavation section of about 65 m², has a

smaller profile. In accordance with the Swiss Standard for National Highway Tunnels, the tunnel will be made up of a double lining divided by a watertight sheet. The usual electrical wires, tunnel drainage and pressurised water duct are located in both lateral side-walks.

3.3 *Auxiliary constructions*

In addition to the several existing tunnels in proximity, various auxiliary constructions emphasize the complexity of the project:

- 6 regularly spaced cross-passages approximately every 250 m between the Kirchenwald Tunnel tubes permit tunnel users to evacuate into the neighbouring tubes in case of fire or accident. Along the A2/A8 connecting tunnel are 5 evacuation tunnels in case of need for emergency exits into neighbouring underground installations.
- Where the A2 highway branches underground in the direction of Luzern, the excavation profile of the 260 m long pre-selection lane measures approximately 200 m².
- The junction of the new Kirchenwald northern tube in each of the existing A2 motorway Acheregg Mountain tubes necessitates extensive conformation works.
- An underground ventilation station in the Acheregg portal zone to extract the exhaust air of both Kirchenwald Tunnel tubes through an approximately 130 m high vertical shaft.

4. TUNNEL VENTILATION

North of the Kirchenwald Tunnels, the A2 motorway leads over a covered bridge connecting the latter with a partially enclosed noise protection gallery. This motorway stretch through the Hergiswil Municipality must be rehabilitated for noise. The intention exists to completely cover the motorway over all of the length so that the Kirchenwald Tunnel would be linked in terms of ventilation with the northern, covered stretch.

At the present time, since two horrible fire accidents in motorway tunnels in neighbouring countries have again brought the possible dangers while driving through such tunnels to the attention of both engineers and tunnel users, the Swiss Federal Roadway Office ASTRA is in the process of updating a new guideline for tunnel ventilation. On the basis of these new guidelines, the length of prospective ventilation section and the evaluation of a relatively large risk of traffic jam in the new tunnels, the project owner has recently decided to place an intermediate ceiling with motorised dampers in both Kirchenwald Tunnel tubes. Thus the smoke from any tunnel accidents involving fire would be able to be suctioned efficiently in separate waste air ducts.

5. QUATERNARY SECTOR

The underground crossing of the Hergiswil quaternary sector presents special challenges for the planning and construction work due to the geology and topography of the region. The ground is made up of loosely consolidated detrital slope, principally composed of loosely bedded stones and blocks, but has also shown itself to be relatively cohesive over some stretches.



Figure 3: Tunnel portal in the Hergiswil quaternary sector.

Based on the predetermined portal positions, it could not be avoided that both Kirchenwald Tunnel tubes enter the hillside at a rather unfavourable angle for construction. Therefore extremely large, asymmetrical forces act on the tunnel linings, which necessitate costly measures for the safety of the excavated opening. These will be implemented just in front of the tunnel face and reinforced immediately after the excavation. Moreover, the overburden is only several metres thick in the portal zones up to a maximum of approximately 50 m before the tunnels enter into the deep lying rock.

The excavation will be carried out according to the German construction method, which should permit large excavation sections of about 13 m wide and 11 m high to be accomplished in safety. The floor heading will be carried out under the protection of an injected grout skirt. In spite of this, some limited, localised breakthroughs cannot be avoided.

Based on the newest contact with the construction ground in the floor heading, it is being currently discussed whether the support measures should be replaced by jet grouting in the upcoming roof heading excavation.

6. EXCAVATION IN ROCK

As difficult the construction ground appears to be over a short distance in the Hergiswil portal zone, so should the geology be without particular problems for the construction of the remaining tunnel length. As a matter of fact, the Lopper Mountain is so well known, that geological surprises can be rather excluded. The siliceous limestone to be traversed is known to be a hard and brittle rock. This rock is often worked in the region and prepared as

concrete aggregate as well as railroad ballast. Thus, the tunnel excavation spoils are in great demand. Only the A2/A8 connecting tunnel will pass through swelling flysch in the Z' Matt portal zone, which then leads to a section in Schrattekalk and well-known karst.

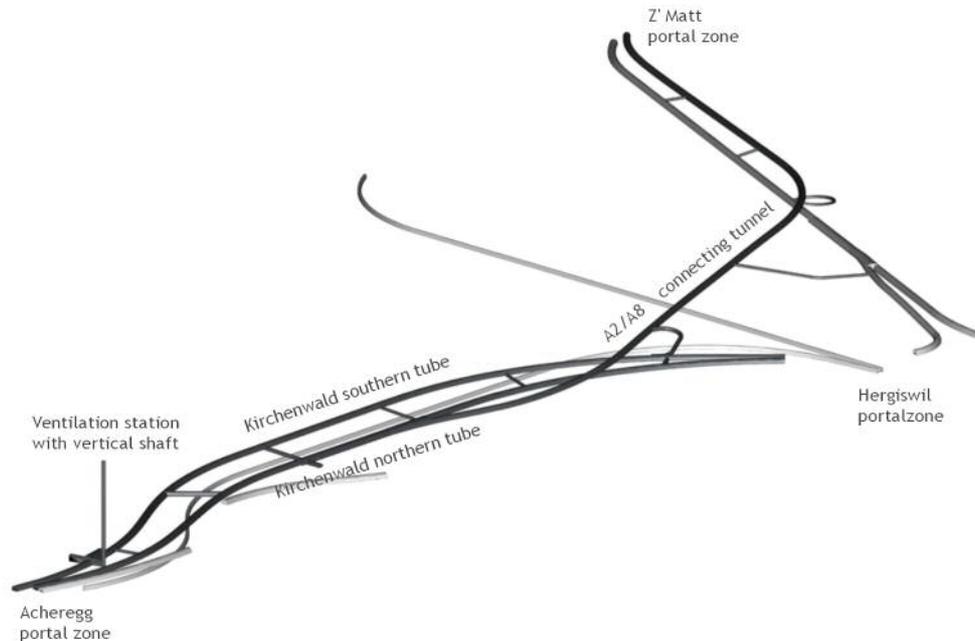


Figure 4: Existing and designed tunnels.

All tunnel tubes in rock as well as the auxiliary constructions will be excavated using the drill and blast procedure. Full section detonation will be applied, i.e. one charge will be detonated which will extend immediately over the entire tunnel profile. Severe limit values will be given to the contractor for the explosion vibrations due to the proximity of the existing rail and roadway tunnels. Finally, each explosion and the subsequent vibrations will be registered in case of future claims. In particular, the existing Luzern-Stans-Engelberg Railway tunnel will be crossed over by the cross-drifts as well as by the Kirchenwald Tunnel southern tube in some points at a minimum distance of only 4 m. The responsibility for eventual damages to the existing constructions was agreed upon by the project owner and the railway through a written convention. Due to the proximity of the excavation to the critical crossing points, the contractor must adhere rigidly to the imposed security measures. This is an enormous challenge for minute planning, disciplined communication and precise loading for each explosive charge. Only after the passage of a train in the railway tunnel the next charge will be permitted.

The ventilation shaft can be mentioned as a particular part of the works. It will be built by a raise-drill and reamed by drilling and blasting. The top of the shaft lies high over the lake of Lucerne and is made accessible by a cable car.

7. CONSTRUCTION PERIOD AND COSTS

Preliminary work in both the Acheregg and Hergiswil portal was already begun in the summer of 1998. First, the preparation of the access to the tunnel portals enabled the installation of the construction site equipment for the actual underground work.

In the autumn of 1999 the Hergiswil quaternary sector was begun and in the autumn of 2000 work in rock from the Acheregg side was also undertaken.

The excavation work for the A2/A8 connecting tunnel from the Z'Matt portal is not on the critical path and will begin in the autumn of 2003.

The Kirchenwald southern tunnel tube should be put into service at the end of 2005, thus a construction period of about 7½ years has been planned for. The northern tube will be put into service two years later, simultaneously with the opening of the A2/A8 connecting tunnel.

The total cost of the three tunnel tubes including external works amounts to approximately 350 Mio CHF (230 Mio EU).