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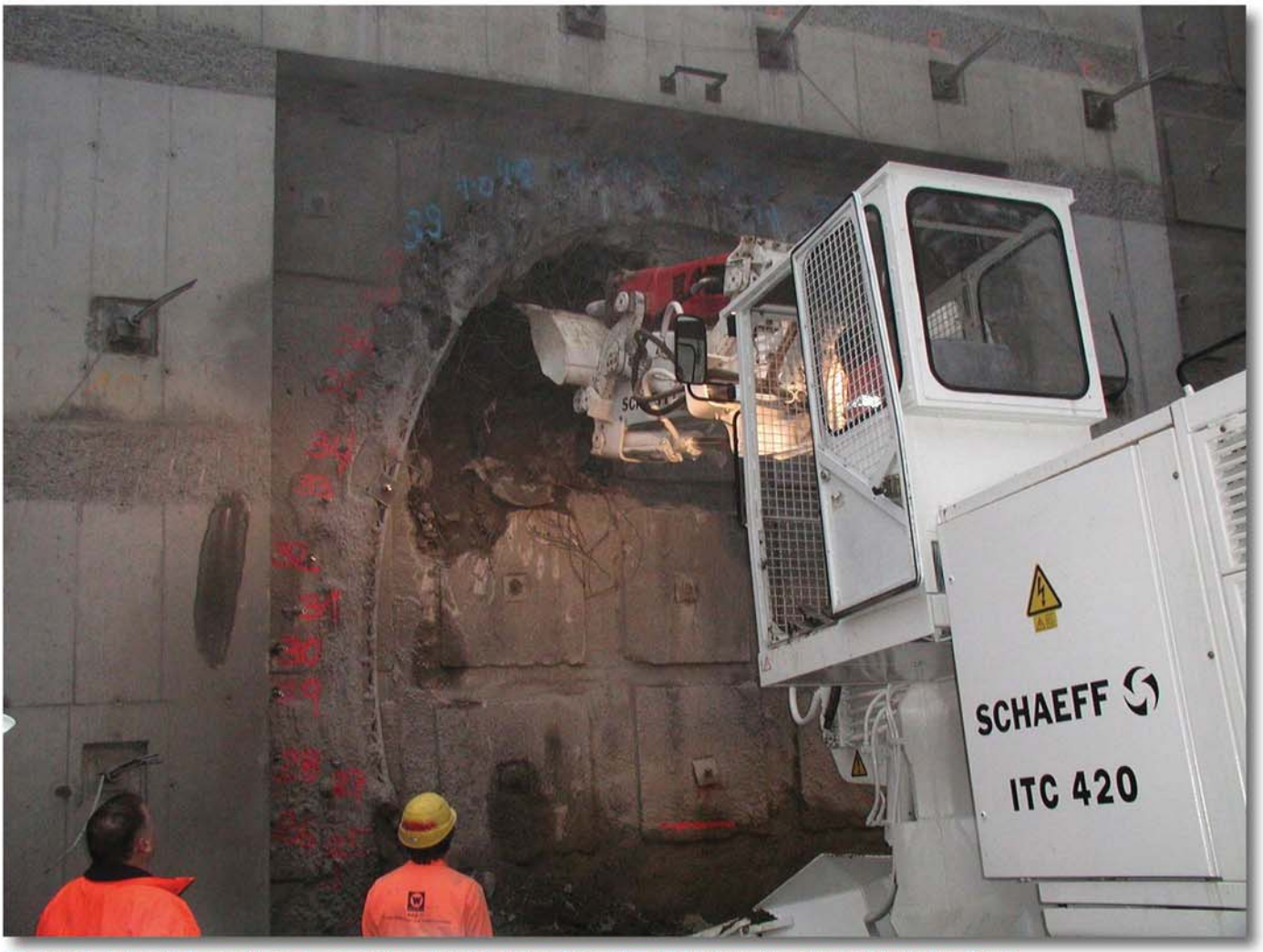
ITC NEWS

- 17 - 2003

Steep Incline Tunnel Consortium
(LSE) Luzern-Stans-Engelberg Railway
Blast Tunneling in the South, Rip Tunneling in the North



Picture 1: Schaeff Tunnel Heading and Loading Machine Type ITC 420 in machine tunneling in the South

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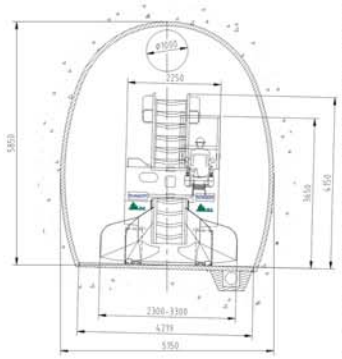


Fig. 2: ITC 312 in Conventional Tunneling

SUMMARY

The LSE Rail is traveling into a new future with the construction of the Engelberg tunnel. The project comprises a 4,043 m long tunnel segment that will lead from Grafenort into the Boden region before Engelberg. The new line management and retraction of maximum gradient from 246 to 105 per mil bring operational advantages to the railway system:

- Increase of transport capacity from 400 today to about 1,000 people per hour, which meets an urgent need.
- Optimization of the timetable and departure times
- Better protection of the route against climatic exposure, such as falling rocks, snow, wind-blown timber, etc.
- Increased flexibility through replacement of rolling stock with the Brünig railway and the Berner-Oberland railway.
- Utilization of synergies in vehicle acquisition.

The costs for the entire tunnel project amount to 68.1 million Francs. 85% of

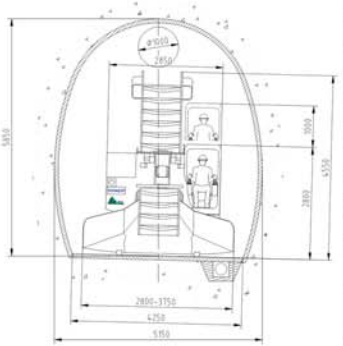


Fig. 3: ITC 420 in Mechanical Excavation. Cross-Section 26.5 m²

Ill. 1:

that are being covered by the federal government. 50% of the remaining costs are being distributed each to the cantons of Obwalden and Nidwalden, whereby the community of Engelberg is participating with 1.065 mil. Francs in Obwalden's share.

Conventional Tunnel Heading in the North

For the most part, the tunnel exhibits favorable technical construction conditions from the northern portal. Therefore, the excavation is being carried out with drilling and blasting. Three teams of 7-8 men each work in three-shift operation on site – six days per week. 90 holes are drilled per round and detonated with liquid explosive, breaking out an average of 3 meters of tunnel. Each shift generally completes 1 round, which includes tunnel safeguarding measures and material removal.

As an efficient piece of equipment, the

SCHAEFF Type ITC 312 TUNNEL LOADING MACHINE

is employed in collaboration with a 25 t load capacity, center pivot steered tunnel skip truck.

The dumper loading time is 2-2.5 minutes on average, which equals an average loading performance of approx. 5-6 loose m³/min. During contests between the drivers, the loading time of one dumper was able to be reduced to approx. 90 seconds.

The rising heading of approx. 10.5% has no influence on the loading performance.

Subsequently, the machine is employed for a wide range of additional work, such as floor cleaning, top heading and working face safeguarding, etc..

Mechanical Excavation in the South.

The southern contract section faces what are comparatively more difficult geological conditions. The landslide mass that must be penetrated makes mechanical top heading with laborious safeguarding measures necessary, which is naturally not nearly as efficient as drill and blast heading.

Two shifts each work 9 hours, starting at 5:00 in the morning. 8-man teams are also employed here – six days per week. A heading efficiency of approx. 1 meter is achieved per day.

The

SCHAEFF Type ITC 420 TUNNEL HEADING AND LOADING MACHINE

is employed for mechanical excavation. At first it was thought it would be possible to work without the hammer. Soon after cutting in, however, it became clear that the combination of bucket and hammer was the right answer. The patented hammer/bucket combination delivers the ideal solution here, with ultra-fast changeovers from percussive loosening to ripping loosening and loading.

The decisive advantage of this solution is the constant thrust = hammer pressure.

Both ITC machines have two drive assemblies:

- Electrical drive for zero-emission work on site and
- Diesel drive for traveling on site, as well as for work without electrical network.

Demanding Geology

The 4,043 m long mined tunnel segment runs for the most part in the stratigraphic sequence of the Axendecke, a helvetic alpine nappe. The northern portal can be implemented following a short insection directly into the in-situ lime mass and executed with conventional heading by means of drilling and blasting. Contrastingly, the southern portal is located in landslide deposits and in a settlement mass, which makes top heading with leading pipe umbrella and mechanical excavation necessary. A total of about 400,000 tons of excavated material will accumulate. A large portion of that can be used for concrete additives or road building materials, as well as for fill.

2nd Structure

The structure clearance of the LSE trains requires an average tunnel width of 5 meters and a height of 6 meters. In addition to this single-track profile of up to 32 m² of excavation area, a correspondingly larger profile of about 52 m² of excavation area is planned for the two planned turnouts of 260 m of effective length each. The tunnel will also be equipped with the necessary additional structures such as niches and chambers, which serve purposes of safety and operation during construction.

In Operation Around the Clock – Day After Day

There are people behind every project. The construction of the Engelberg tunnel is no different. More than 80 people from many different nations and with many different responsibilities work around the clock to make it happen, day after day. A glance behind the scenes allows an impression of the complex daily and operational routines.

Back Office Workshop

Well maintained machines and equipment are indispensable for smooth operating schedules – likewise the quick servicing of defective components.

Self-Contained Concrete Production

The shotcrete required to line the exposed tunnel walls is produced right on site.

Construction Office Control Room

As chief of operations for the tunnel construction, the Austrian Franz Kapfinger from the company Swietelsky ensures that the operation runs smoothly – both at the installation site and during heading in the tunnel.

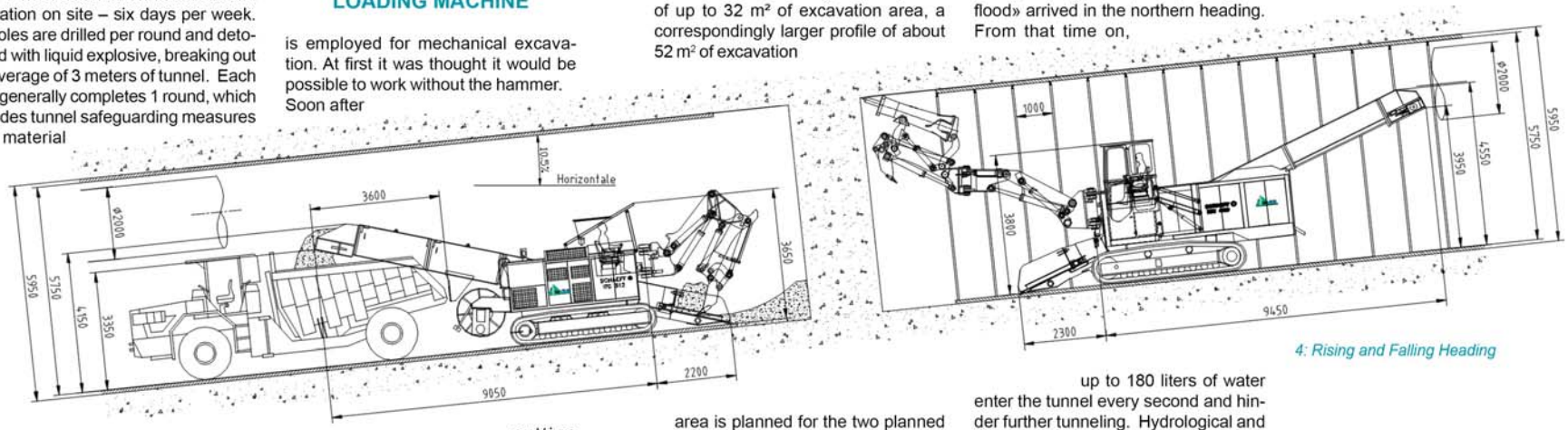
The Day of the Great Flood

Practically everything went as planned for 16 months of the construction of the LSE Engelberg tunnel. About half of the tunnel had already been broken out when, on August 31, 2002, the «great flood» arrived in the northern heading. From that time on, up to 180 liters of water enter the tunnel every second and hinder further tunneling. Hydrological and geological research has revealed that the influx to the water bearing system is located at a relatively high altitude. Additionally, the presence of water reacts quickly to climatic influences, which gives hope for a recession during the winter months. This time must then be utilized immediately for continued tunneling. Seismic analyses indicate, however, that such anomalies are to be expected again at a distance of 55 and 88 meters. Sounding bores along the tunnel segment should provide detailed findings to this regard.

With decreasing water pressure, the rock mass can be injected around the margins of future excavation. The injections serve to displace water and solidify the rock.

In order to diminish the water pressure, the water must be discharged under controlled conditions. The drainage bores and the diversion system are required for this reason. The drainage bores can divert approx. 500 l/sec. Additionally, an orbicular tunnel profile must be created in the karst zone for static reasons.

Status of Construction on January 1, 2004 **(approx. 71 %)**
North tunnel: 2,300 m
South tunnel: 576 m



4: Rising and Falling Heading

More Info :
www.lse-bahn.ch - www.itcsa.com
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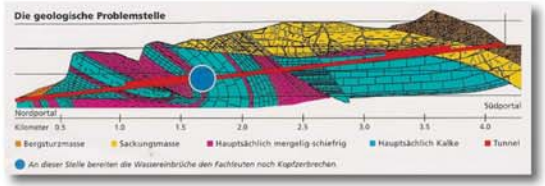


TUNNEL HEADING and LOADING MACHINE SCHAEFF Type ITC 420
TUNNEL LOADING MACHINE SCHAEFF Type ITC 312 N2

6: ITC 312 in North Heading, Ripping

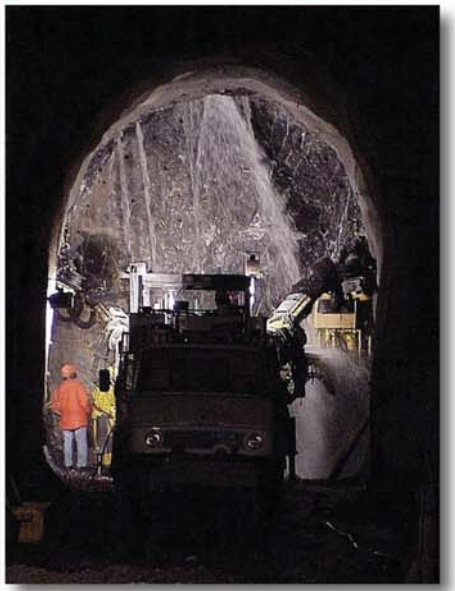
7: ITC 420 in South Heading, Loosening

Picture 8: Typical Railway Cross-Section

Picture 9: ITC 420 in South Heading, Loading

Picture10: ITC 420 in South Heading

Picture 11: ITC 312 in North Heading, in Water



Pictures 12-13-14: The Great Flood