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THE GOTTHARD LOW-LEVEL TUNNEL *(PART ONE)*

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During the early part of the 1940's SBB engineering staff began a study into the probability that the tunnel located between Göschenen and Airolo would not be able to provide the anticipated capacity for the immediate future expansion of both passenger and freight traffic. However, the study revealed that traffic at that time was well below the limit that the tunnel was capable of handling, and with the war raging around Switzerland traffic growth over the next ten or so years proved difficult to accurately predict so the project was shelved. With the implementation of the "Motorail" service between Göschenen and Airolo in 1957 the main tunnel was handling approximately 300 trains per day. Some years later a proposal to replace regional passenger trains with buses was discussed, in order that more paths would be available for freight traffic.

Various ideas came and went during the next few years, but it was not until the 1970's when traffic delays were starting to appear that another project was launched. The proposal was to divert all transit traffic away from the present tunnel and to route it via a low-level tunnel between the stations of Erstfeld at the start of the north ramp to a point South of Bodio at the base of the southern ramp. This proposal - called "Project 72" - almost stalled with: first the opening in 1980 of the road tunnel at Göschenen and second the twinning of the tracks with the greatly increased capacity over the Lötschberg route - from Frutigen to Brig - that resulted from that.

Switzerland is currently handling 20% of all trans-alpine traffic, but now that an agreement has been signed with the EEC, that level is expected to increase to at least 50% by the year 2010. In the days of the construction of the Gotthardbahn the financial burden fell mainly on the government of Italy with 60% of the cost, and then Germany and Switzerland with assistance from private railway companies to cover the balance. Today the cost will have to be met by the Swiss Federal and Cantonal governments, who are committing themselves to a debt of SFr12 billion for the Gotthard and a similar amount for the Lötschberg route. The building of new or improved connecting routes and the low-level tunnel has been marketed under the name of "Alp Transit". To help offset this debt a tax on heavy vehicles using the alpine routes is to be levied.

For the past fifteen years the Swiss Federal railways has been carrying out a separate project called Bahn 2000, which is the improvement of the whole railway network within Switzerland in both quality of passenger trains and the reduction of timings between stations as well as vast improvements in the handling of freight.

The building of the low-level tunnel will compliment that program by reducing the transit times between Zürich and Milan from the current 4 hrs 10 mins to 2 hrs 40 mins. As these times are city centre to city centre, they should prove to be of great interest to the air passenger, as the train offers better comfort and en-route facilities plus a view that is far superior to that from an aircraft. For the shipping agents freight will speed through the country far quicker and so reduce the time between factory and recipient.

The final plan for the "Basis Tunnel" that is now under construction is for two single track bores, separated from each other by 30-60 metres to be constructed between the towns of Erstfeld

Gotthard Low-level tunnel

Erstfeld - Bodio
Single track, twin bore
Length 57 kilometres

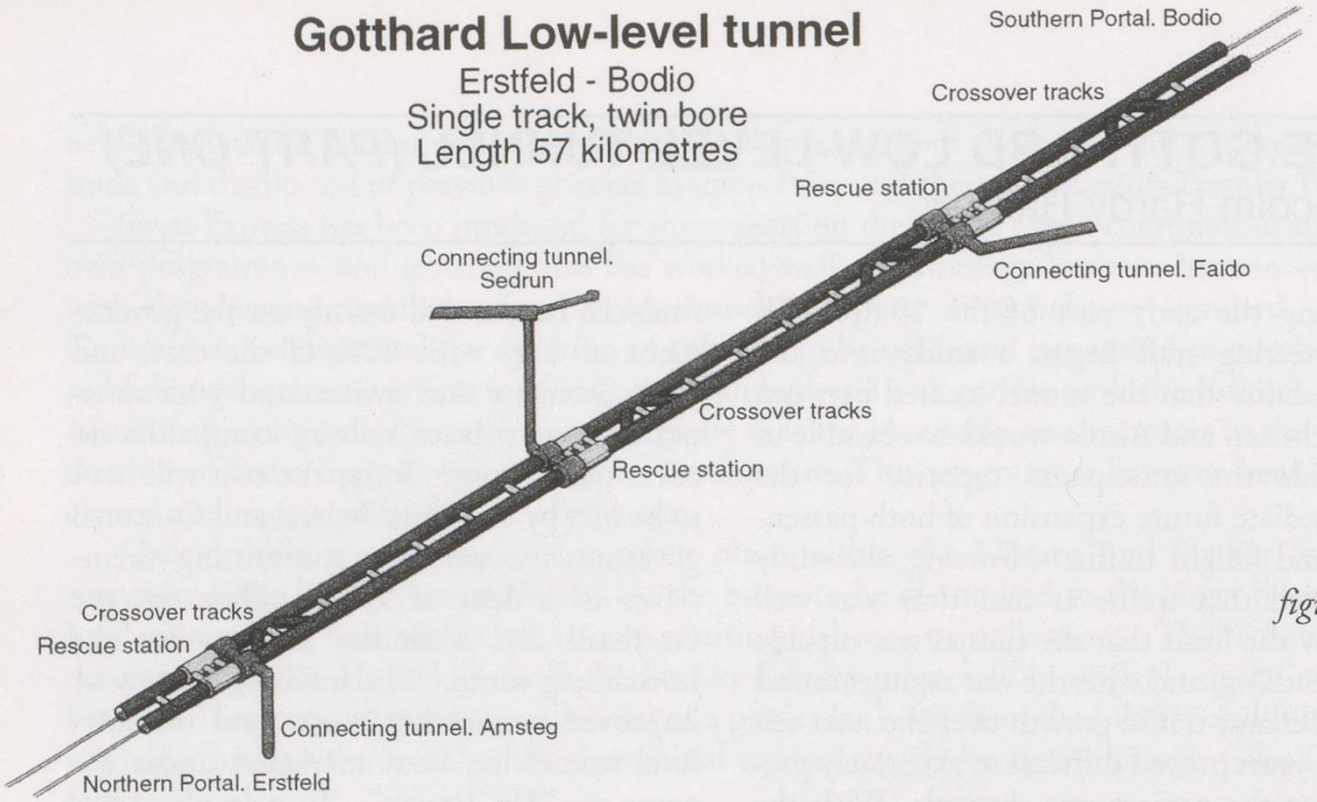


figure 1

Gotthard Main-line profile.

figure 2

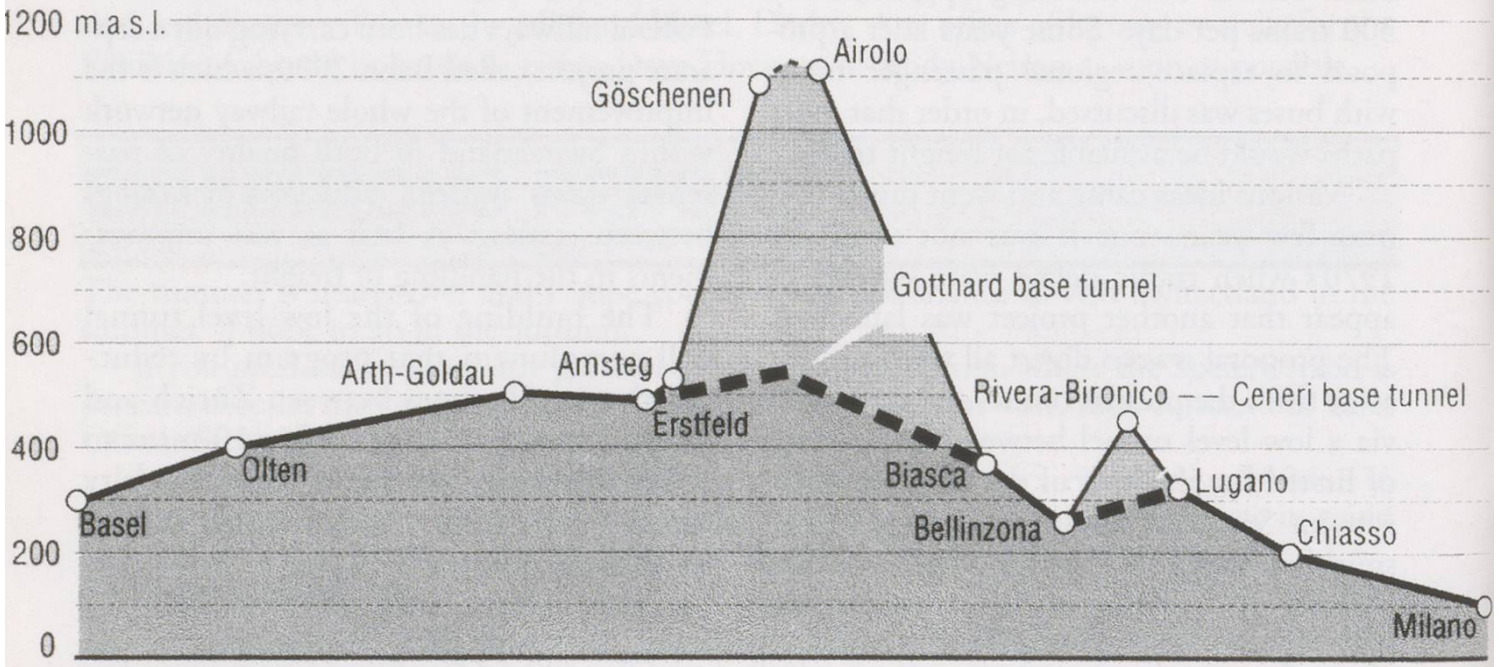
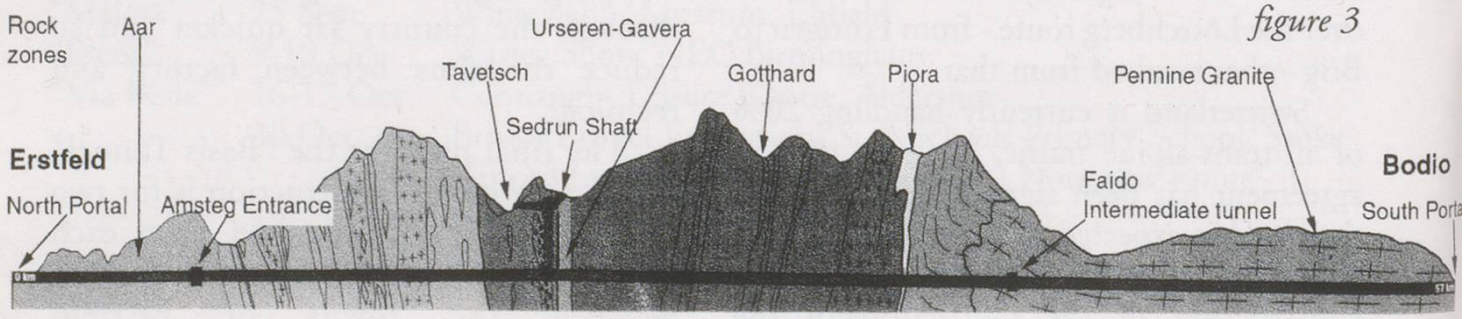


figure 3



(Schattdorf) and Bodio a distance of 57 kilometres through some really tough rock conditions*(see figure 1)*. This tunnel will be supplemented by the building of a 20 kilometre long tunnel under the Zimmerberg - from Zürich-Lochergut to Litti - providing a new connecting route from the north, and a 15 kilometre long low-level tunnel under the Ceneris between Giubiasco and Lugano.

The main Gotthard tunnel will have a maximum elevation of 550 metres above sea level - nearly 500 metres below the current tunnel - a maximum incline of 12.5%, a minimum radius of 4000 metres except where exploratory drilling dictates otherwise *(see figure 2)*. This will permit speeds on the route to be increased from the present 80 km/h allowed on the 26% ramps to 160 km/h for freight traffic and up to 250 km/h for passenger trains.

The Rock structure.

The twin bores of the Gotthard tunnel will be drilled through rock that is crystalline in the main, but with narrow sedimentary rock zones interspersed across the route. The tunnel path is through three big Palaeozoic age geological areas comprised of the Aare-massif in the north, the Gotthard-massif in the centre and the Pennine granite area in the south.*(see figure 3)*

Located in between the main rock structures in areas such as the Inche zone - in the centre of the Aare-massif - are narrow seams of Vulcanite and Carbon sediments. On the southern side of the massif the rock structure becomes Tectonic. Lying on the southern edge of the Gotthard-massif at Piora-Mulde where the rock structure is in the main Dolomite and Anhydrite is a segment of water-logged sugar type rock that measures 250 metres across. The Pennine area is comprised of stable granite rock formations.

The one place of real concern in the entire route was the area around Piora-Mulde, and this is where exploratory drilling took place to ascertain just how wide and deep the sugar-like rock was. It was thought that the Dolomite sugar crystal rock formation with its attendant high pressure water content did not extend down to the line of the tunnel. To this end drilling took place to ascertain the true nature of the rock and how far the problem area extended. On the 31st March 1996 it became obvious when after a small explosion in one of the exploration tunnels water and powder-like sand at a pressure of approximately 100 atmospheres broke out of the 96 mm wide drill hole. After 4 hours a total of 9600 cubic metres of water and sand had poured out of the bore-hole. Fortunately nobody was injured and the waste material was able to escape via the tunnel entrance. The £1million drilling machine was buried in sand and badly damaged placing a long delay on the whole program. Drilling in the area continues so that the extent of this waterlogged rock strata can be mapped to see if the line of the main tunnel will need to be adjusted. You can imagine the relief felt by the engineers when they found that the sugar rock did not extend to the region that would contain the main bores of the tunnel. This fact removed the problem of the engineers of having to bore through extremely unstable and water-logged rock - that would result in major drilling problems and associated high costs - when the drilling of the main bores takes place. Both bores in this area will pass through area of Dolomite Marble or Anhydrite rock and not exposed to high-pressure water.

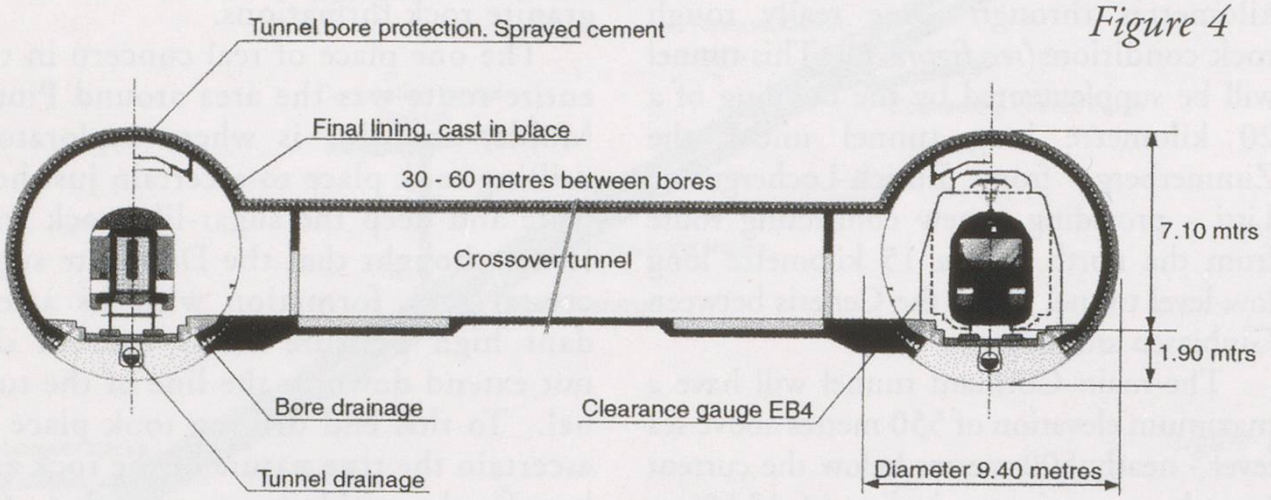


Figure 4

The Tunnel Bores *(figure 4)*

Each of the two single track bores measures 9.4 metres in diameter and has a separation distance of 30-60 metres from its twin. Located at intervals of approximately 325 metres are connecting tunnels between the two bores, giving access to either tunnel for maintenance or evacuation in the event of an accident.

So that any part of the tunnels may be closed for repair or maintenance, provision has been made for trains to cross to either tunnel at various points within the main tunnel route. These crossover sections are located near Bodio, Faido, Sedrun and Erstfeld. Also built into the tunnel route are three rescue and service areas at Amsteg, Sedrun and Faido. In the case of Amsteg and Faido escape would be via a connecting tunnel to the outside, but at Sedrun escape would be either via a 784 metre (2,587 feet) long lift shaft to the surface or on a relief/rescue train through the other tunnel to the nearest portal. In the escape areas the special connecting tunnels have been provided with fresh-air supplies as well as water and electricity.

Drilling of the two bores will be by two methods the first of which is the conventional method of drilling and blasting the rock face, the second method is to employ a rotary head drilling machine or a grinding machine. The tunnel bores from the north portal near Ertsfeld to a point approximately 6,646 metres into the tunnel route at Amsteg-Silenen will be drilled by using the conventional method. The bores are to be drilled out by miners operating from both Amsteg and Erstfeld. Rock excavated from the tunnel is being hauled away from Amsteg on a connecting track to the freight yard at Ertsfeld, and from there onto a special depot near Zürich where it will be used for various engineering projects. From Amsteg to a point 12,434 metres into the tunnel route the drilling will be done by atunnel boring machine that will give a round profile of 9 metres in diameter. From a point just north of Sedrun for the next 6,530 metres the bores will be drilled by the conventional methods that will result in a tunnel profile more elliptical than that of the boring machine profile. From the end of this section of the tunnel for the next 14,532 metres to the Faido connecting tunnel system the drilling will be carried out by boring machine as will be the case for the remaining 16,748 metres to the southern portal at Bodio.

TO BE CONTINUED - DECEMBER 1999