Pressure group

ABB pumping stations remove water from world's longest railroad tunnel

Christopher Ganz

Sitting astride the Alps, Switzerland has earned a considerable reputation for tunnel building down the centuries. Nothing as yet, however, can compare with the alpine project now under way there as part of the north-south European high-speed rail network. Known as the Gotthard Base Tunnel and 57 kilometers long, it will, when completed, be the longest tunnel in the world!

Building a tunnel this long requires special expertise. Water – huge amounts of it – may lie deep in the alpine rock. If it breaks through the rock during excavation and can't be pumped out quickly, the tunnel will flood, endangering human life and ruining equipment. Because of the special way in which the tunnel is being constructed, the only safe solution is to pump the water 850 meters up a vertical shaft. Innovative engineering from ABB solves the problem.

As general contractor for the supply of pumping stations for geological and process water removal, ABB is playing an important role in the construction of the Gotthard Base Tunnel through the Swiss Alps. The railroad tunnel, which will be the world's longest, is at the heart of the AlpTransit project, a new transalpine route that will double present capacity and should considerably reduce traffic on the now heavily congested north-south highway (see panel).

Special techniques for a special project

Building a tunnel of this magnitude calls for special techniques. Simply starting at one or both ends is not enough. To be sure of completing the massive project on time, it was decided to divide the tunnel into five sections and, with one exception, have boring machines work from each end of them. The exception is the 6 kilometers long Sedrun section 1, where conventional blasting will be used because of the unstable nature of the rock there. Also, unlike the other sections, the Sedrun section of the tunnel is not accessed horizontally, but by two 850-meters high vertical shafts.

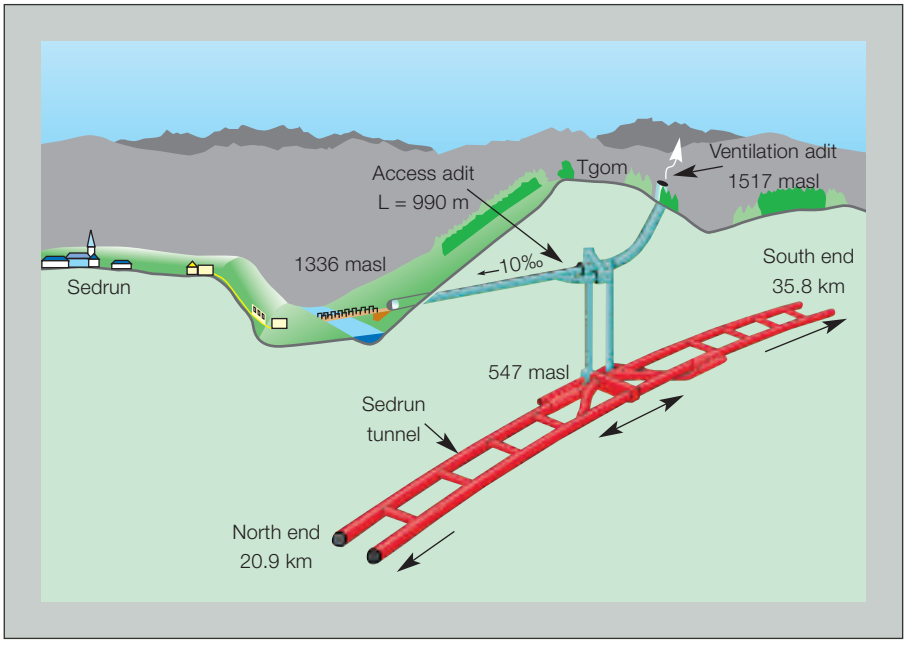
All technical equipment and personnel are moved via these shafts, as is all the excavated material. The power used to drive the tunneling equipment is also supplied through the shafts.

When completed, the Sedrun section will have an emergency train station with escape elevators. It will also be possible here for the trains to cross over to the other tunnel.

The problem with water

As they dig through the various geological zones of the Alps 2, the boring machines will encounter various difficulties. Varying rock consistency will not be a problem for the machines; however, they have not been built to bore through zones in which significant amounts of water could lie. Geologists estimate that, in the worst case, 1000 l/s of water could break through and enter the tunnel. To prevent the tunnel from flooding, this water has to

1	Gotthard Base Tunnel. During construction, water is pumped out of the tunnel up through an 850-meters long vertical shaft.



St. Gotthard Base Tunnel

The shortest route from northern to southern Europe is through Switzerland, via the St. Gotthard pass. For centuries, this has been one of the most important passages through the Alps. Ever since the first bridge was built on this route in the early 13th century, the mountain terrain and harsh weather have combined to challenge man's ingenuity and engineering ability.

After centuries spent improving the route over the mountains, the Swiss built the first tunnel, for trains, below the St. Gotthard Pass in the 19th century, followed by a road tunnel in the 1980s.

Trains and cars using these tunnels still have to climb to 1150 meters, prohibiting high speeds as well as high-volume traffic. Only base tunnels can overcome this problem and, after a long period of planning, construction of a new railroad tunnel at an elevation of just 550 meters began in 1999. The 57 km twin tubes, about 40 meters apart and 9 meters in diameter, will be connected by cross passages every 325 meters. The maximum speed for passenger trains will be 250 km/h and for freight trains 160 km/h.

Together with the Lötschberg Tunnel, which is due to be commissioned in 2007, the Gotthard Base Tunnel will connect central Switzerland with the cantons of Valais and Ticino in the south. An essential part of the north-south European high-speed rail network known as NEAT, it should contribute substantially to transferring traffic from Swiss highways to the railways.

be pumped 850 meters up the shafts. The formidable problems involved made tendering for the contract a challenge in itself.

What was needed was a pump system supplier with a solid track record for handling complex projects like this, as well as the technologies needed to provide a superior automation solution. ABB in Baden, Switzerland, was subsequently awarded a contract to supply the complete system, including the pumps, piping, electrical installations and automation equipment.

Pumps to overcome a height of 850 meters

At the heart of the system is a pumping station with eight high-pressure pumps dimensioned to provide at least the 85 bar required to pump the water 850 meters up the shafts, after which it is treated and fed into the upper Rhine 3. High system reliability is achieved by having two independent four-pump units, one unit being redundant. Each unit has its own, independent mechanical, electrical, hydraulic and automation system.

Apart from the high-pressure pumps and piping, ABB was also contracted to supply all of the electrical equipment required to operate the station, including frequency converters, feed transformers and cabling.

Modular low-pressure pumps are added as tunneling progresses

As tunneling progresses, the water – process as well as geological – has to be pumped from the boring head to the central high-pressure pumping station. However, the water has first to be collected, and to this end basins are excavated in the caverns connecting the two main tubes.

New basins are built at regular intervals as the miners dig deeper into the mountain. From the new basins, the water is pumped back to the previous basins. In the final stage of the project, there will be a total of ten low-pressure pumping stations in the tunnel, three in the northern part and seven in the southern part.

The modular design of the stations ensures that a new, identical station can be quickly installed as tunneling advances. All the electrical equipment required to operate the low-pressure pumping stations is also being supplied by ABB.

Installation of the pumping stations is scheduled to follow the tunneling work and will be completed in 2008.

> Thanks to ABB's Industrial^{IT} technology, all modifications during commissioning are automatically mapped into the systems scheduled for later installation.

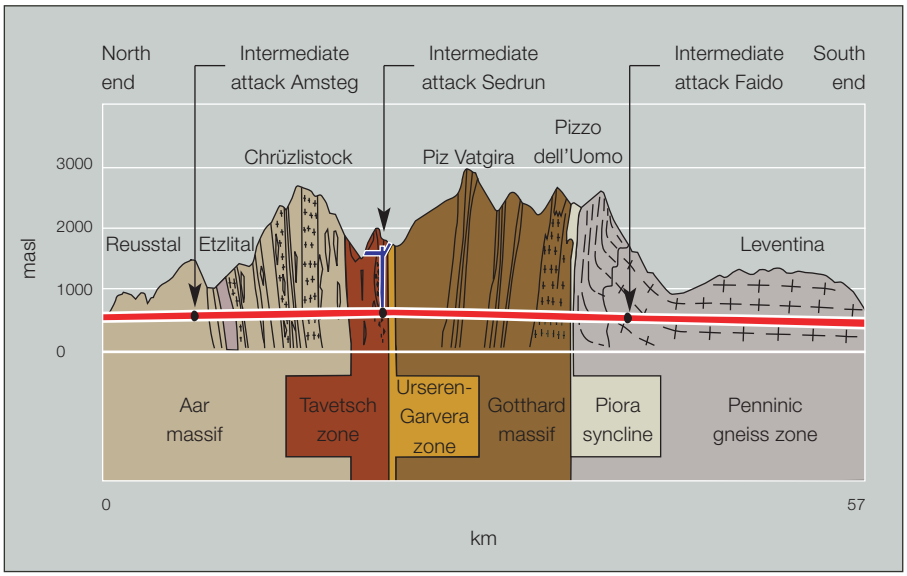
Automation – a special challenge

Designing the automation system presented a special challenge as the control stations not only vary in size and complexity but also make different demands on redundancy and are widely distributed. On top of all this, they have to function in a less than friendly environment where the average temperature is 35 °C, humidity is very high, and the air is heavily laden with dust.

ABB's AC800 system meets these requirements in an optimal way. Four AC800M controllers were installed in the high-pressure pumping station, two for each of the four-pump units.

Each low-pressure station has one AC800M installed in it to control the pumps. The overall set-up is standardized to allow simple installation of preconfigured packages every time a new station is built along the tunnel.

2 Geological formations through which the Gotthard Base Tunnel passes



To guarantee that the system will still be working properly when the last controller is installed five years from now, all the controllers are configured and tested in the same engineering laboratory at ABB in Baden. New low-pressure stations can therefore be installed without having to modify any of the equipment already in place.

The modular system architecture required for this project is efficiently supported by ABB's Industrial^{IT} technology. Pumps, even the complete pumping station, are depicted as Objects and stored in a library. As soon as the first low-pressure pumping station is successfully commissioned, all modifications that become necessary during commissioning will automatically be mapped into the systems scheduled for later installation.

The pumping station sites are also where all the power distribution equipment for the tunnel and the power feed to the boring equipment is installed. Scaling up from the automation system for the pumping station to a fully integrated automation system for the entire power supply and distribution was easily accomplished. For example, the controllers used to switch the draining water pumps are the same as those used to control the medium-voltage distribution.

The scalability and modular structure of the automation system chosen for the pumping stations met all of the customer's expectations, and led to the order being expanded to include control of the substation feeding the Sedrun site. This added another eight controllers to the overall installation and extended the control network by a few extra kilometers.

Local operation is possible

The overall system is operated by two Operate^{IT} Process Portal stations, one located at the vertical shaft base, and the other in the operations center located above ground in Sedrun.

3	Site of the high-pressure pumping station, at the foot of an 800-meters long vertical shaft

To enable the system to be accessed by personnel in the tunnel itself, each low-pressure pumping station is additionally equipped with an active mimic panel for local supervision and manual operation of each pump.

And when the tunnel is completed?

Once the tunnel is finished the pumping stations will no longer be required. On completion, the tunnel should be well insulated and any water that does seep through the walls will be able to flow out through the tunnel openings. The support station that now contains the high-pressure pumps will be transformed into a so-called multifunctional structure where passengers can be evacuated in an emergency. All the equipment installed in the high-pressure pumping station and in the low-pressure stations will be dismantled.

An ABB technologies showcase

The Gotthard Base Tunnel is a high-profile project that is certain to enhance Switzerland's already rock-solid reputation as a pioneer of tunnel building. Through this project ABB, as main contractor for the supply of the pumping stations, is able not only to demonstrate its ability to successfully execute highly complex projects but also to showcase some of its advanced technologies.

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