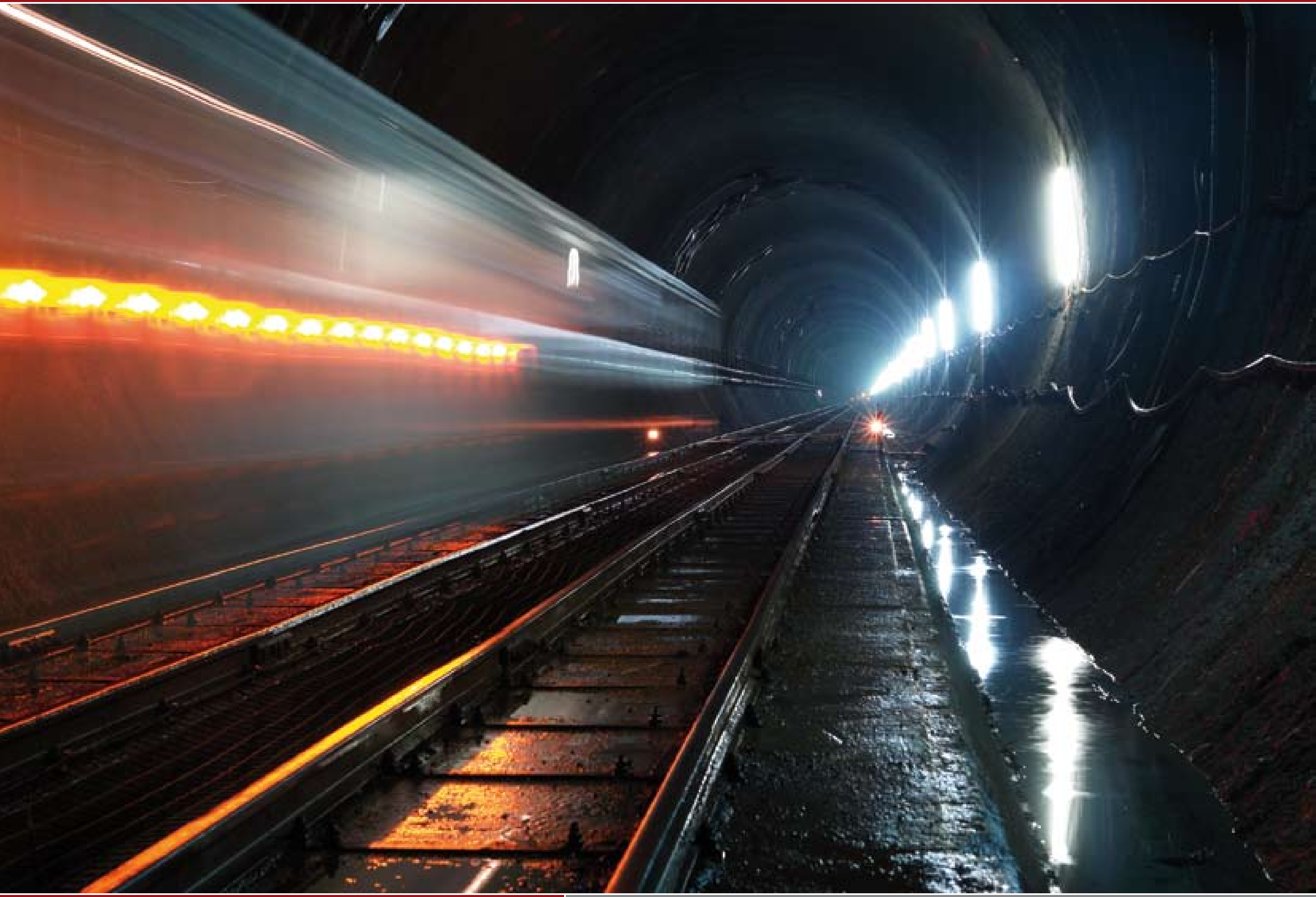


Gotthard Base Tunnel, Switzerland

Gähler und Partner AG, Ennetbaden, Switzerland

The Tunnel of Superlatives

The project of the century began at the end of the 1990s, and started from multiple sites simultaneously. By 2017, trains will be traveling at up to 250 km/h through the Gotthard Base Tunnel. And Gähler and Partner supported by Allplan Engineering software will be able to claim a major part in the final success of the project.

The Gotthard Base Tunnel is regarded as a pioneering achievement of the 21st century. Once it is completed, its 57 kilometer length will make it the longest tunnel in the world and the fastest way to cross the Alps on land. The aim of the project is to link Switzerland to the high-speed rail networks of the rest of Europe, and to shift the growing flows of traffic across the Alps from road to rail to the greatest extent possible. The possibility of using faster and longer trains on the new line will mean that goods traffic can be more than doubled, while for passengers the journey time between Zurich and Milan, for example, will be cut from more than four hours at present to less than three.

Working on five fronts and with extensive logistics

To make this mighty project a reality within the shortest time possible, it was divided into five sections. From north to south, these are Erstfeld (7.4 km), Amsteg (11.4 km), Sedrun (8.8 k), Faido (14.6 km), and Bodio (16.6 km). The three middle sections will be tunneled via intermediate incisions. The extraordinary dimensions involved mean that the logistics are immense. There is a need for more of everything than would otherwise be usual in tunnel construction: More fresh air, because of the larger tunnel volume that must be ventilated, more transport resources for personnel, construction material and spoil, more rescue equipment, and more cooling.

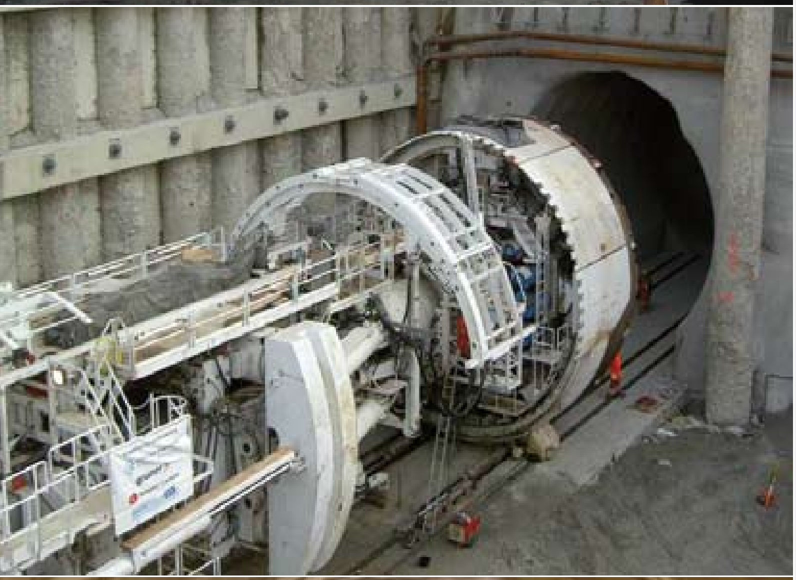
Erstfeld and Amsteg

It was in 1994 that the Gotthard Base Tunnel North engineering consortium, under the management of Gähler and Partner AG, won the order for the planning work and the local construction management of the northern sections of the tunnel, Erstfeld and Amsteg. The order also included the environmental engineering management and geological work associated with the main project. The Erstfeld section, at 7.4 kilometers long, involves not only two single-track tunnel bores and 22 transverse tunnels, but also an underground branch project for the future extension of the tunnel in a northerly direction. Likewise included in the planning are the 600 meter long open-cut tunnel, the North Portal, and all the outside installations required for the construction operations. These include the construction site railway station, the preparation of the concrete, and water treatment plants. The next section, Amsteg (with a length of 11.4 kilometers), includes the actual tunnel with 38 transverse tunnels and a power cable gallery (1.9 km), as well as the northern intermediate incision. This consists of a 1.8 km long access gallery, all the outside installations, and a number of adaptations to the local municipal infrastructure. For example, one of the Cantonal highways had to be diverted because its original course clashed with the entrance to the access gallery.

Within the engineering consortium, Gähler and Partner AG planned the two main tunnels at Erstfeld and Amsteg, as well as all the outdoor projects at Amsteg. These included highway diversions and new link roads, installation areas, spaces for accommodation, canteens and offices, the adaptation of the existing industrial railroad between Erstfeld and Amsteg and the construction site station itself.

Gähler and Partner AG use Allplan Engineering (with 18 licenses) in all their civil engineering projects, as well as for the planning of load-bearing structures, for domestic engineering, and for excavation and underground works. The operations at Amsteg had originally been planned with Speedikon, with the switch to Allplan taking place towards the end of the construction work at Amsteg and the start of performance planning at Erstfeld. The new software passed its christening of fire with no difficulty at all. All the plans from the first construction section were adopted without a hitch and could be integrated smoothly into the second section. “The fact that the data transfer from this comparatively alien and old software system functioned so well was a major success for us,” recalls Raphael Wick, lead project manager at Gähler and Partner AG.

Gähler and Partner are also benefiting from the dependability of Allplan with regard to data exchange when it comes to co-operation within the engineering consortium and the other companies involved in the work. “There are a considerable number of programs and different versions being used in the project, which makes it all the more important for the plans to



be exchanged with perfect quality. It would be unbelievably laborious if the plans had to be re-edited because details like color shading and color intensities did not match, or because of distorted text. But with Allplan we have experienced no problems with this at all," comments Raphael Wick.

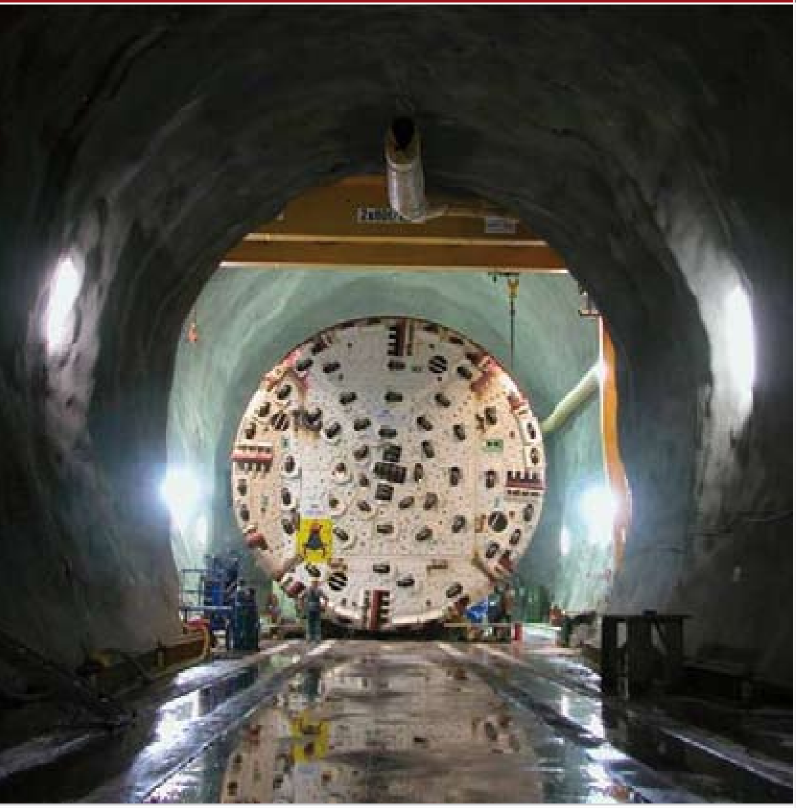
"Allplan also makes plan preparation and editing easier, and reduces the risk of errors. Despite standardization, we still have around 120 different block plans and we've produced more than 1000 plans in total. It's a huge amount of data, but the program deals with it effortlessly," says the engineer.

Cost optimization with CAD

To optimize the use of concrete and therefore the costs, the engineers have developed a system of size-adjustable formwork elements. The determination of the individual formwork geometry is carried out using Allplan. A digital surface survey, which shows the precise location of the securing structure for the tunneling work, is read into Allplan and stored with the normal standard profiles. Then, taking account the minimum component dimensions and the geometrical peripheral conditions from the operational section, the ideal formwork configuration is worked out.

Tough geotechnical demands are under control

"The large overlying layers of up to 2400 meters involved in the Gotthard project in disturbance zones can lead to unusually high stress areas. At some points the high pressure has led to massive solid steel profiles being deformed within just a matter of a few weeks, and the need to re-profile and secure tunneling systems therefore being necessary," comments Raphael Wick. With the support of Allplan, the engineers are tackling such challenges in two ways: By introducing appropriately strong resistance into the planning at the susceptible locations in the form of steel arches, reinforcement, and sprayed concrete or Shotcrete, or by introducing soft areas within which the rock formations which are allowed to deform. Special steel profiles are used for this, which can be compressed like shock-absorbers.



Additional reinforcements then prevent any residual movements. In such areas with tough geotechnical challenges, the internal arch or vaulting has been reinforced, and the reinforcement has been designed with the aid of the Allplan reinforcement module. As well as the possibility of 3D representation of complex elements, it was extremely helpful that the software could automatically produce the parts lists for the reinforcement elements and thereby avoid the need for manual calculations.

2D for standard planning, 3D for something special

For standard planning work, Gähler and Partner prepare plan views, sectional views, and other details using the 2D mode in Allplan. At complex points, or in order to illustrate problem areas, the engineers prefer 3D planning and work with visualizations. This means, for example, that a geometric test can be carried out to determine whether there is sufficient space available, whether the arch and vaulting thicknesses and strength values and clearance values are correct, and whether it is possible to run cable ducts in the desired locations.

In particular with regard to cable pipe installations that change direction, planning challenges are constantly arising. For example, the ducts might start off running horizontally on the floor of the tunnel, but end up vertical in the vaulted roof of the tunnel, and then keep changing direction. It can also be the case that protective cable pipes initially run parallel in the same cross-section before separating at a specific point and continuing in different directions. And to make things more difficult, the maximum bending radii also need to be taken into account depending on the type of cable involved.

Another example of a difficult location has been at Amsteg, where the access galleries and a cable gallery for the rail power supply encounter the two tunnel bores. The resulting spatial intersections between the different structures were also planned using 3D.

Raphael Wick comments: “I can remember in January of 2002 exactly when I was standing in the cavern at Amsteg and I thought: So from here on there’s another 50 kilometers to go through the rock. It looks as if we shall have completed our planning work at Erstfeld and Amsteg by 2014. Hopefully the entire project will then be completed in 2017, and operations can commence in the tunnel. It is undoubtedly the largest underground project of my life.”