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Gotthard Base Tunnel, Switzerland

Allplan in practice

THE GROUNDBREAKING TUNNEL

"In Amsteg, where two adits meet two tunnel tubes, the 3D model created with Allplan Engineering was very useful to us." Raphael Wick, Gähler und Partner AG

The scheduled commissioning on December 11, 2016, marked the end of the project of the century – the Gotthard Base Tunnel – after nearly 20 years of building time. Its route length of 57 kilometers through the Saint-Gotthard Massif between Erstfeld and Bodio makes the Gotthard Base Tunnel the longest rail tunnel in the world. The engineering consortium Gotthard-Basistunnel Nord, headed by Gähler und Partner AG, based in Ennetbaden, was responsible for the planning work and local site management of the northern sections Erstfeld and Amsteg. Other partners of the engineering consortium were Gruner AG, Rothpletz, Lienhard + Cie AG, and CES Bauingenieur AG.

Allplan Engineering, the BIM CAD software, provided Gähler und Partner AG with valuable support in the development of sometimes highly complex execution plans and ensured smooth data exchange within the engineering consortium.

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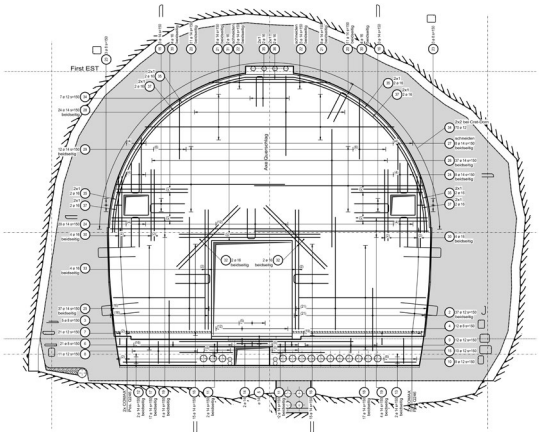

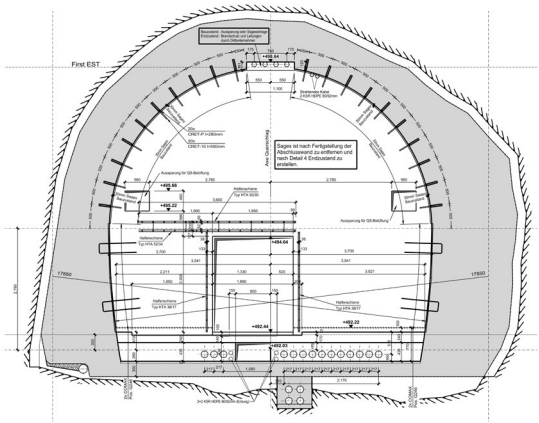

Left:
Cross-section of Amsteg eastern single-track tunnel, reinforcement
(Allplan BIM software)

Right:
Cross-section of Amsteg eastern single-track tunnel, formwork
(Allplan BIM software)

Raphael Wick is CEO of Gähler und Partner AG and was also the overall project manager of the GBT Nord engineering consortium. Mr Wick looks back on the development, planning and execution time, which began in 1989 with studies and audit mandates and in 1994 with placing orders for the planning of both northern lots, with pride and satisfaction but also with some relief.

LONGEST RAIL TUNNEL IN THE WORLD

To enable operation of the system with two single-track tunnels, each 57 kilometers in length, more than 150 kilometers of tunnels, adits, cross-passages and shafts had to be excavated during construction of the Gotthard Base Tunnel. 28 million tons of rock was blasted out or cut away by the four tunnel boring machines. Two multifunction stations in Faido and Sedrun subdivide the two tunnel tubes into three sections of approximately equal lengths. The emergency stop stations and two track crossovers per tunnel tube are located here. They allow trains to travel from one single-track tunnel to the other so that maintenance work can be carried out in the tubes without any rail traffic, for example. The supply and exhaust air system as well as numerous technical installations are also located here. The base tunnel is connected to the existing SBB main line via the open connecting lines north and south of the two portals in Erstfeld and Bodio. For planning and construction purposes, the client AlpTransit Gotthard AG arranged the Gotthard Base Tunnel into the following sections: Gotthard North (open track 4.4 km), Erstfeld (7.8 km), Amsteg (11.3 km), Sedrun (8.5 km), Faido (13.5 km), Bodio (15.9 km) and Gotthard South (open track 7.8 km). To save time and money, the construction work on the different sections was coordinated and sometimes carried out simultaneously. Up to 2,600 people were involved in the implementation of the construction project of the century during the main construction phase. The engineering consortium GBT Nord has collaborated with specialists from more than a dozen trades over the last 25 years while working on the Erstfeld and Amsteg sections. Around 500 man-years of work has been carried out by the engineering consortium during this time: "For many employees, the Gotthard Base Tunnel has been their life's work," says Raphael Wick, overall project manager of the engineering consortium GBT Nord and representative of Gähler und Partner.

THE ERSTFELD SECTION

The Erstfeld section is 7.8 kilometers long. The first 600 meters of the Gotthard Base Tunnel started as a cut-and-cover tunnel in an open excavation pit. This then merges into the tunnel tubes, both around 7.1 kilometers long and excavated using mining techniques. Their cross-section, with an excavation diameter of 9.58 meters, was excavated with the same two tunnel boring machines that had already opened up the Amsteg section. Due to the favorable geological forecasts, many tunnelers referred to the Erstfeld section as the "sprinter stretch". In fact, the holing-through of both tubes was celebrated around six months earlier than planned, with an average output of 18.27 meters per working day in the eastern tube and 16.27 meters in the western tube. In July 2009, the miners in the western tube set a new world record with an advance rate of 56 meters within 24 hours.

Gotthard Base Tunnel
northern side portals
near Erstfeld

The unexpectedly high flow of water during tunneling in this section caused Raphael Wick and his team concern. This volume of water reached up to 450 liters/second during the thaw period.

THE AMSTEG SECTION

The two tunnel tubes of the Gotthard Base Tunnel, which interconnect every 325 meters, form the centerpiece of the Amsteg section, which is roughly 11 kilometers long. Before the tunneling towards Sedrun could begin, a 1.8-kilometer-long access adit had to be built. Then came the excavation of a "base point" with rail technology caverns, construction adits and intersections. A tunnel boring machine with a diameter of 3.7 meters drilled a 1.8-kilometer-long cable adit to connect to the underground center of the Amsteg power station for subsequent traction supply. During blasting, the first 400 meters of each tunnel tube and the assembly caverns for setting up the tunnel boring machines were excavated. Both tunnel boring machines started driving at full capacity towards Sedrun at three-month intervals. After crossing a predicted fault zone without any problems in the western tube, tunneling came to a surprising standstill when a water ingress washed loose material into the drill head and caused a blockage. To free the tunnel boring machine, it was driven backwards out of the eastern tube, and the entire loosened zone was strengthened with massive injections. Tunneling could resume again after a standstill of around six months. Thanks to an average daily output of 11.05 meters, the holing-through of both tubes to the Sedrun section was celebrated several months ahead of schedule, despite the standstill.

COST OPTIMIZATION WITH CAD FOR TUNNEL LINING

The entire base tunnel, including cross-passages and multifunction stations, is double-walled. After the excavation support, a seal and an in-situ concrete tunnel lining were installed. In the Erstfeld and Amsteg sections, the contractor used three formwork units, each with two 10-meter-long formwork carriages, for the cladding and tunnel lining. In an ultimate feat of logistics, up to 60 meters of cladding was concreted per day. That is to say, for every ten months of building time, over 22 kilometers of tunnel lining were laid per tube. Thanks to the geometric optimization of the tunnel lining and the support from Allplan Engineering, a total of 89,000 cubic meters of concrete, amounting to around CHF 19 million, was saved in the Erstfeld and Amsteg sections. Raphael Wick describes the method selected for this purpose as follows: "The exact position of the excavation support was incorporated with a digital surface measurement. This data was read into Allplan Engineering and stored in the standard profiles. Taking all the specifications that had to be met into account, the optimum formwork configuration was then determined and passed on to the building site for implementation." The engineers from Gähler und Partner used planning in 3D anywhere there were difficult sections or problem areas to be able to best edit these components with the help of visualizations. Raphael Wick lists some examples: "That was the case in Erstfeld and Amsteg, for example, when planning the complex spatial cable runs. In Amsteg, the 3D model was very useful to us where two adits meet at both tunnel tubes. The resulting spatial intersections of the various

structures were ideally presented and edited in the 3D visualization. But the 3D system also gave us the assurance that the drawn reinforcement would really fit when developing the reinforcement plans."

MORE THAN 1,000 LAYOUTS CREATED

Gähler und Partner AG also use Allplan, with 24 licenses, in other projects in building construction, structural design, civil engineering and underground mining. The firm, taken over in December 1988 in a management buyout by senior executives, currently employs around 110 members of staff. Around half of them work in building construction, with tunnel construction being counted among the core competencies in infrastructure construction. Around 60 different programs from various specialist software providers, which are maintained by two internal specialists, are available to employees for handling these projects. The layout editing for the Amsteg section was still carried out using the CAD software Speedikon. Allplan Engineering was first used towards the end of the work in Amsteg and the beginning of execution planning in Erstfeld. The new program went through its baptism of fire straight away: all the layouts were taken over without any errors and were further edited without any problems. "The fact that the data transfer worked so well was a significant success factor for us," recalls Raphael Wick. Also in the cooperative relationship within the engineering consortium and with other project partners, Gähler und Partner AG profited from the reliability of Allplan Engineering when exchanging data. "A multitude of programs in an extremely wide range of versions were used in the project. Accordingly, it was important that the layouts could be exchanged in perfect quality and without data losses. With Allplan Engineering, there were no problems with that," says the civil engineer, discussing the experiences, before going on to add: "We created a total of around 120 different block layouts and over 1,000 layouts for both sections of the base tunnel. This was a huge volume of data which the program managed to cope with without any problems."

PROJECT INFORMATION AT A GLANCE

- **Software used:** Allplan Engineering

GOTTHARD BASE TUNNEL FACTS AND FIGURES

- **Length:** 57 kilometers (longest rail tunnel in the world)
- **Duration of journey through tunnel:** 20 minutes for passenger trains
- **Maximum speed:** Passenger trains up to 250 km/h
- **Maximum rock cover:** 2,450 meters
- **Building time:** 17 years
- **Excavated material:** 28 million tonnes
- **Involved in construction:** 2,600 people
- **Commissioned on:** December 11, 2016
- **Costs:** Total NRLA with Lötschberg, Gotthard and Ceneri Base Tunnels: roughly CHF 24 billion
- **Client:** AlpTransit Gotthard AG
- **Planning and site management of the Erstfeld and Amsteg sections:** Gotthard-Basistunnel Nord engineering consortium: Gähler und Partner AG (lead); Gruner AG; Rothpletz, Lienhard + Cie AG and CES Bauingenieur AG
- **Information:** Allplan Engineering, the BIM software, provided Gähler und Partner AG with valuable support in the development of highly complex execution plans and ensured smooth data exchange within the engineering consortium.

"We managed to cope with the huge volume of data without any problems using Allplan Engineering."

Raphael Wick,
Gähler und Partner AG

A SUPPORTING STRUCTURE VOLUME OF CHF 1.5 BILLION EDITED

The engineering consortium Gotthard-Basistunnel Nord edited a supporting structure volume of around CHF 1.5 billion over the 15 years or so of building time in the Erstfeld and Amsteg sections. Raphael Wick, responsible overall project manager, is filled with pride to have been so heavily involved in such a major project. In hindsight, what was crucial to the success of this major project? "Many problems aren't problems at all if a culture of fairness and collaborative partnership is cultivated among all project partners. That also means we don't need any lawyers," responds Raphael Wick. He also measures the success of the project by the fact that the projects overseen were processed on schedule and within the given budget, and that all the quality requirements were also met.

ABOUT ALLPLAN

ALLPLAN is a global provider of BIM design software for the AEC industry. True to our "Design to Build" claim, we cover the entire process from the first concept to final detailed design for the construction site and for prefabrication. Allplan users create deliverables of the highest quality and level of detail thanks to lean workflows. ALLPLAN offers powerful integrated cloud technology to support interdisciplinary collaboration on building and civil engineering projects. Around the world over 500 dedicated employees continue to write the ALLPLAN success story. Headquartered in Munich, Germany, ALLPLAN is part of the Nemetschek Group which is a pioneer for digital transformation in the construction sector.

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