City-Tunnel Leipzig

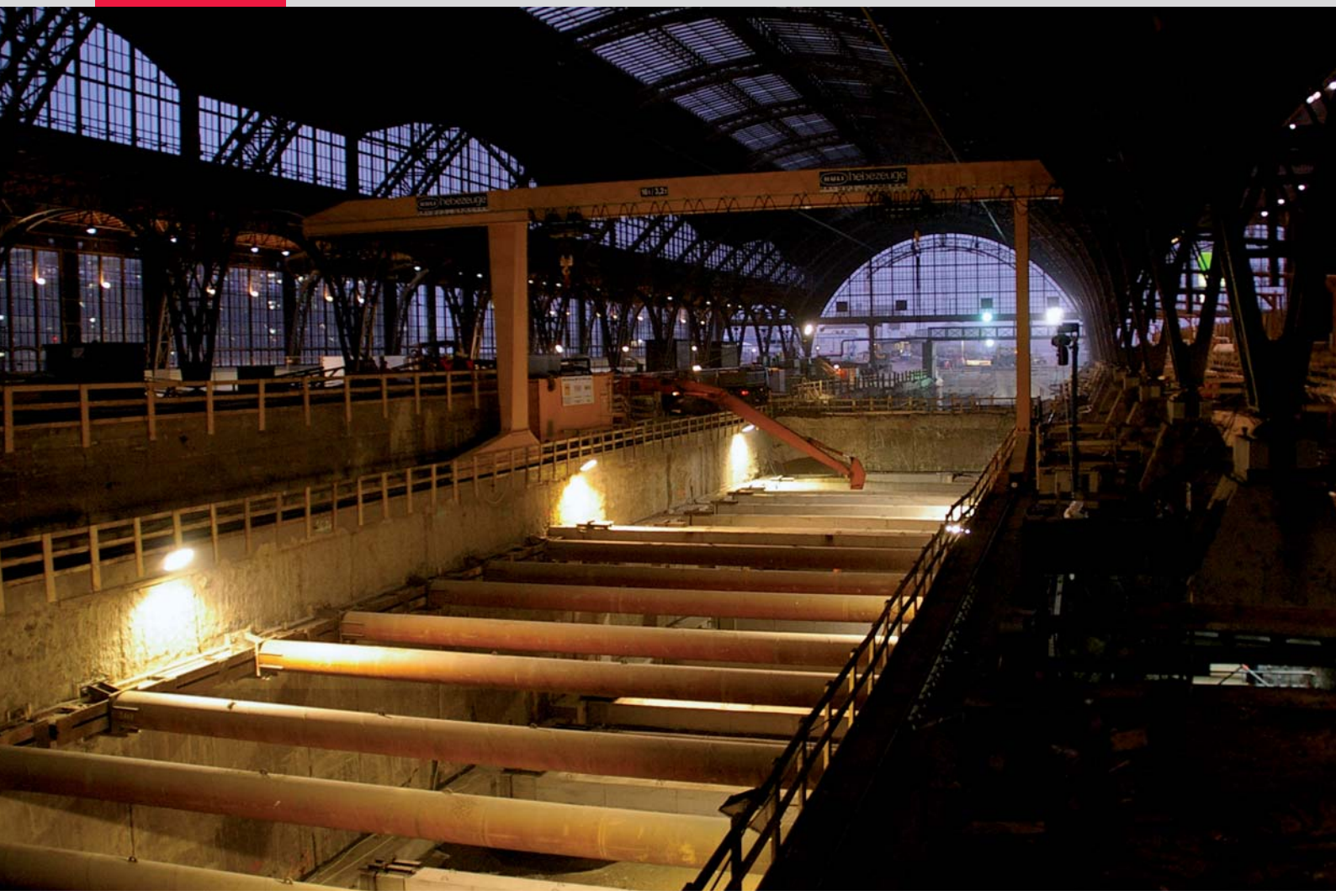
by Michael Amrhein, Guido von Gösseln and Dieter Heinz

Ranked among the largest stub terminals in Europe, Leipzig's main rail station is one of the most important transportation nodes in Central Germany's regional and long-distance public transport system. The stub terminal certainly offers travellers easy access and convenient connections but its architecture makes changes in the direction of travel very time-consuming and takes up a much greater area than a through station would. One of Germany's most complex tunnel projects shall end this situation: The City-Tunnel Leipzig.

During the construction of the main station (1902-1915), the possibility of a direct connection to Leipzig's Bayerischer Bahnhof (Bavarian station) to link the north and the south of the city was already being explored, but two world wars prevented this idea from being realised. With the establishment of S-Bahn Tunnel GmbH (SBTL) in 1996, the City-Tunnel Leipzig project was resurrected and preliminary investigations conducted into its feasibility and financial viability. In 2003 a green light was finally given for the works to go ahead.

The City-Tunnel Leipzig project (CTL) consists of three sections: the entry section to the south of the Bayerischer Bahnhof (Contract A); the main part of project (Contract B) with two shield-driven tunnels (each approx. 1'500 m) and 4 stations; and the third section (Contract C) comprising the route under the main station after which the tunnel emerges to connect to the existing track system. The completion of such a project represents an extreme challenge to all engineers involved, especially if – as in the case of the CTL – work is carried out below a city of half a million people.

All surveying for the three contracts was undertaken by Angermeier Ingenieure GmbH (Contract B in a joint venture with Geodata ZT). This task also included the relocation of the porticus at Bayerischer Bahnhof. The relocation of this listed structure



was necessary to build one of the four stations and its progress was keenly followed by Leipzig's population and media alike.

All the surveying work is based on surveying programmes in which all the geodetic tasks are precisely described and specified. Approval is given by a representative of the client, DEGES (Deutsche Einheit Fernstraßenplanungs- und -bau GmbH). The scope of the surveying programmes – there were more than 20 in all – makes clear the scale of this project and impressively demonstrates the high demands placed upon the work of the surveying engineers.

The geodetic network

The starting point for all measurements was the highly accurate geodetic network provided by the client. The basic network was made more detailed with two further large networks extending over all the works contracts, each surveyed in three separate and independent surveying campaigns. The resulting information was used to control the tunnel boring machine (TBM) and the surveying for all the deformation monitoring and construction setting out. Positional surveying was performed using Leica TCA 2003 total stations in conjunction with GPH1-P precision prisms and GPS surveys (Leica GPS 500, Leica GPS1200). Level surveys were carried out in 2 campaigns using digital levels (Leica DNA03) using invar staffs and the BFFB-levelling method. The network survey data provided accuracies of approximately 1-2 mm in position and 0.5 mm in level.

The surveying tasks on the City-Tunnel Leipzig generally fell into one of two principle types. On the one hand, there was surveying for construction and the subsequent checking of the constructed works against the drawings. And on the other hand, there was surveying for the monitoring of movement and deformation, since, with a project of this magnitude, deformation at surface level and subsidence of buildings must be taken into account.

Minimising risk

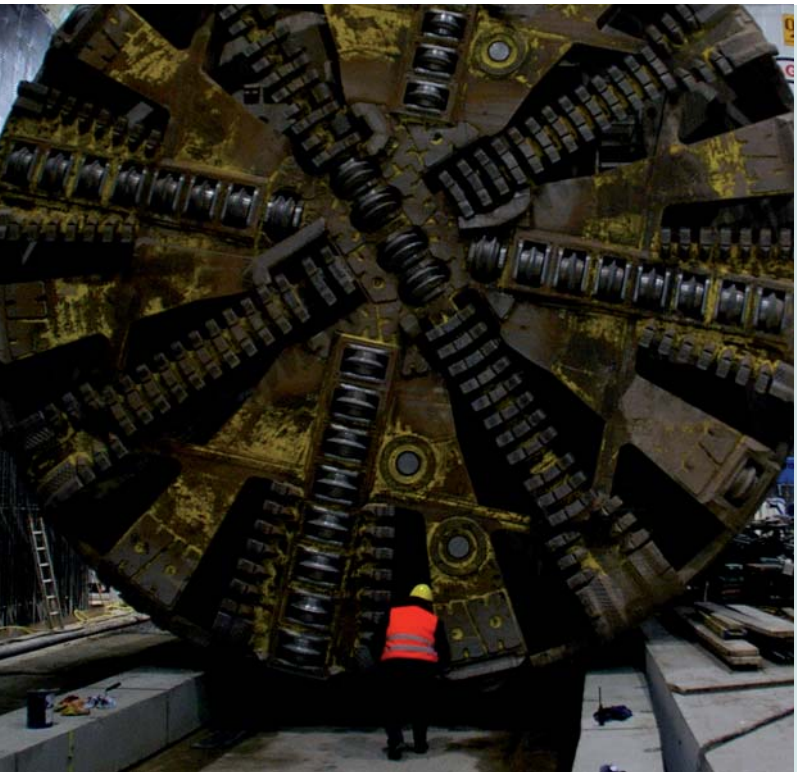
The reduction of risk to a minimum was accomplished using a comprehensive safety and monitoring con-

cept in which more than 60 buildings and items of engineering infrastructure were precisely monitored using tacheometric surveying and precision levelling. Upon completion of the approximately 6 km long project, it is estimated that up to 8'000 km of levelling will have taken place. Compensation grouting is used to counteract any building subsidence. This process involves drilling horizontally under all building foundations from a total of 12 shafts. A cement suspension grout is introduced into these holes to stabilise the ground. If any subsidence occurs, the buildings standing on this ground can be returned to their original position by inserting further grout into the holes. This system was used on 35 buildings in total and over 1'350 hydrostatic levelling gauges had to be controlled and monitored. These hydrostatic levelling systems were installed and continuously maintained by Angermeier Ingenieure GmbH. In critical situations they supply measurements every 45 seconds to a central analysis program. By the end of the project over 400 gigabytes of data will have been collected.

Tacheometric monitoring

A further highly sensitive area in the construction of the underground station is the west wing of Leipzig's main rail station. A tacheometric monitoring system consisting of 12 total stations (Leica TCA2003) was set up to monitor the work. Measurements are taken, processed and automatically evaluated every hour. This enables estimates of possible deformations of the works themselves or loadbearing components, such as roof supports, to be made at any time. The system has about 200 deformation points and 60 fixed points, all of which are fitted with Leica GPH121 reflectors. High precision and fully automatic operation is achieved by using more than 12 Leica Geosystems total stations, which have already proved to be very reliable. That this system does not interfere in any way with the operation of the station as far as the travelling public is concerned, demonstrates the excellence of the concept and its implementation. ■

About the authors:
Michael Amrhein (Managing Director), Guido von Gösseln and Dieter Heinz work for Angermeier Ingenieure GmbH. The company's activities centre on the areas of engineering surveying (tunnels, tracks), the design and installation of systems for monitoring construction works and the geometric control of large infrastructure projects.



High effort for safety

The City-Tunnel Leipzig project is one of the most complex tunnelling projects in the field of infrastructure modernisation in the Federal Republic of Germany. The requirements placed on the surveying engineers, both from the engineering point of view and in respect of the continuous responsibility for protection against personal injury or death and financial damages, are immense. For the inhabitants of Leipzig and its visitors however, all this effort is a small price to pay for safety.

■ **The tunnel boring machine just before deployment.**