

# Prof. Quick und Kollegen Establish a Digital Twin for a New German High-speed Rail Line to Shorten Travel Times

Leveraging PLAXIS<sup>®</sup> and Leapfrog<sup>®</sup> Works  
for Geotechnical BIM Optimized Productivity,  
Efficiency, and Risk Management

## ADAPTING RAIL INFRASTRUCTURE TO ACCOMMODATE GROWTH

Known for its location around the confluence of the rivers Rhine and Main in Hesse, Germany, Rhine-Main is a metropolitan area with excellent integrated public transportation that supports regional tourism and the economy. The Gelnhausen-Fulda railroad line is a central link in that transport system and one of the most important and busiest routes in the country. With passenger traffic in Rhine-Maine forecasted to grow 30% by 2030, German Railways' Deutsch Ban (DB) initiated a project to build a new high-speed traffic line. The 240-kilometer-per hour, double-tracked railway will be built between the cities of Gelnhausen and Fulda, eliminating bottlenecks and shortening journey times.

DB commissioned specialist civil and geotechnical engineering consultancy Prof. Quick und Kollegen (PQK) to determine an optimal route option and explore the geotechnical feasibility of tunnels—all while protecting the local environment and the community. The scope of the project required evaluating two 50-kilometer route possibilities, with about 70% of each line running through tunnels to avoid impacting the environment and local residents. "The exploration campaign included coordinating and assessing drilling, geophysical surveys, borehole testing, and laboratory testing," said Thomas Schneider, geologist at PQK. The goal is to provide an accurate 3D digital twin to decide on the optimal selection of one of the two track alignments.

## COMPLEX GEOLOGY, DATA INTEGRATION, AND COORDINATION CHALLENGES

With two-thirds of the approximately 100-kilometer investigated route options running through

tunnels, PQK faced multiple complex subsoil, data, and coordination challenges when creating their 3D geotechnical models. Compounding these engineering difficulties was the digital transformation required to achieve the 3D deliverables, as this project was a pioneer for BIM in geotechnical engineering in Germany. "Up to this project, the presentation of the results was done in 2D paper or 2D data format, [and] the communication and coordination was not done with all project participants simultaneously," said Schneider. While their field investigations and archival records offered insight into the geological underground of the area, they were only available in 2D format for isolated viewing.

Given the sheer scale of the project along with the geological complexities, PQK realized that the voluminous data and information from the various disciplines could not remain siloed. They needed to establish a collaborative, connected data environment for all participants to work simultaneously and access all project information at any time, from any place, to generate their geological digital twin. "Creating a 3D ground model, as well as a 3D groundwater model, as a digital twin requires one or more suitable software solutions," said Schneider. It was crucial that their 3D technology solution supported collaborative workflows and multidiscipline, multisourced data integration for a comprehensive geotechnical feasibility study. To generate a 3D model that incorporated 15 lithological layers and accurately captured the complex subsoil with all 88 fault blocks within the fault system, as well as supported the creation and maintenance of tunnel boreholes, PQK required an integrated and dynamic geotechnical BIM technology solution.

## PROJECT SUMMARY ORGANIZATION

Prof. Quick und Kollegen

## SOLUTION

Subsurface Modeling and Analysis

## LOCATION

Gelnhausen, Hesse, Germany

## PROJECT OBJECTIVES

- ◆ To accommodate passenger increase and alleviate traffic congestion along the Gelnhausen-Fulda railroad line.
- ◆ To provide an accurate geological digital twin to decide on an optimal rail route option.

## PROJECT PLAYBOOK

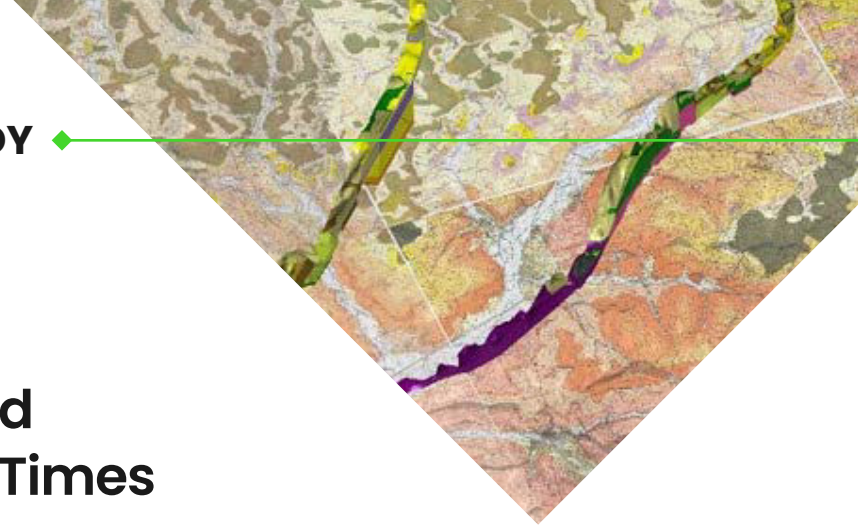
Leapfrog, PLAXIS

## FAST FACTS

- ◆ The Gelnhausen-Fulda railway line in the Rhine-Main area of Hesse is one of the busiest routes in Germany.
- ◆ A new high-speed rail line is being built to accommodate passenger growth and alleviate traffic congestion.
- ◆ Prof. Quick und Kollegen was commissioned to lead the geotechnical investigation of two potential rail route options, each comprised of 70% tunnels.
- ◆ Leveraging PLAXIS and Leapfrog, the team introduced a geotechnical BIM methodology to explore the feasibility of tunnels and determine the optimal route.

## ROI

- ◆ The solution helped Prof. Quick und Kollegen explore 100 boreholes, define excavated materials, and perform risk management.



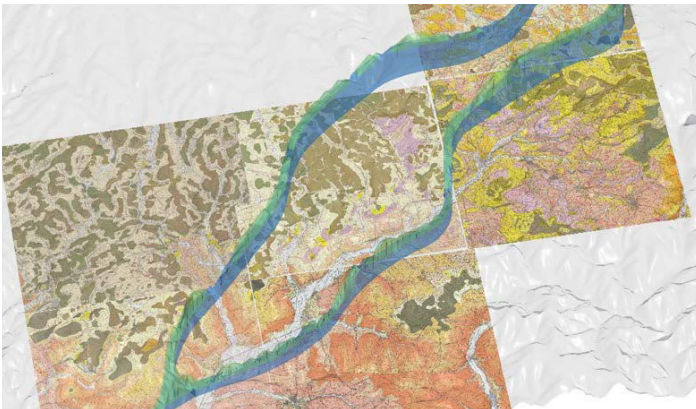
“Bentley’s and Seequent’s [PLAXIS and] Leapfrog Works helped us to go digital in geotechnics.”

– Thomas Schneider, Geologist, Prof. Quick und Kollegen

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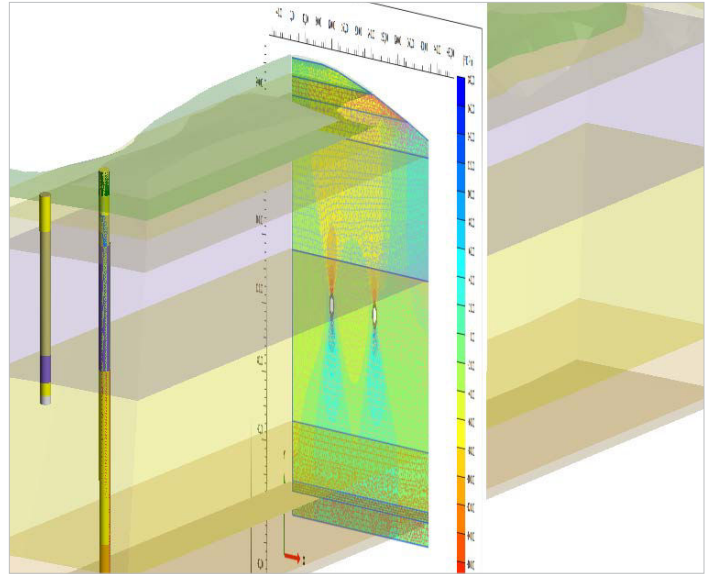
## ESTABLISHING DIGITAL GEOTECHNICAL BIM WORKFLOWS

Leveraging PLAXIS and Leapfrog Works, PQQ established a single source of truth for all geotechnical information, building a 3D ground model used to perform accurate geotechnical calculations. Using the applications, they digitized the exploration of over 100 boreholes, capturing all the lithological layers and incredibly complex fault system within the model, to create an accurate digital twin of a very complex geological situation. “Our BIM model shows the whole geological situation of the project area, the various fault blocks, lithologies, and tunnels,” said Schneider. They loaded the topography of the project area as a digital terrain model into Leapfrog, integrating the drone-scanned route plan. The team then georeferenced the geological maps and archival borehole information to create geological profiles aligned with the planned railway lines.



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The interoperability between PLAXIS and Leapfrog provided a collaborative digital environment to develop geotechnical BIM workflows for accurate, streamlined geotechnical calculations and modeling. Using the 3D model and its attributes, PQQ defined the tunnel positioning within the subsurface, determined excavated material quantities, and were able pursue digital risk management. “We were able to build up a subsurface model as one single source of truth [and] integrate the groundwater measurements continuously during the realization of the railroad line, creating an attributed groundwater model [to] use as a source of monitoring,” said Schneider. The outcome was a highly detailed subsurface 3D model, including cross sections, long sections, and alignment serial sections that comprehensively captures the 200-meter area aligned with the railroads.



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## PIONEER PROJECT DRIVES SAVINGS, SUSTAINABILITY, AND INDUSTRY DIGITIZATION

“We now have an accurate digital twin of the two railroad line options, within a seamless digital workflow and a common, collaborative data environment that is accessible to all project stakeholders that can continue to support all stages of the project,” said Schneider. The BIM model contains all the information needed in a connected data platform accessible to all project participants, ensuring accuracy and transparency throughout the project, improving efficiency and productivity. From this single source of truth, PQQ can see which decisions will protect the environment, the people, and resources in the best possible way, saving time and money, while minimizing environmental and social impact, ensuring sustainability.

Through the introduction of BIM methodology, PQQ simplified and streamlined workflows and communication between internal and external stakeholders. As a pioneer project for geotechnical BIM implementation using Bentley’s and Seequent’s applications, PQQ is advancing digital geoenvironmental workflows and expects to see many more quantitative advantages as the railway project progresses. “We hope our Leapfrog story helps motivate other geotechnical engineering companies and teams to also adapt their way of working to BIM methods so that they, and especially the environment, can benefit from the same advantages,” said Schneider.

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