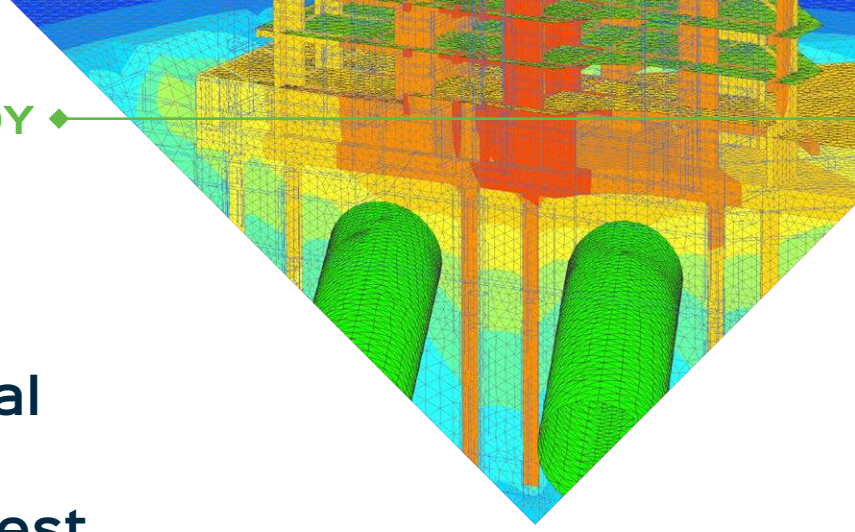
Bentley
Advancing Infrastructure

CASE STUDY



SAIDEL Engineering Designs First Residential Building above Subway Tunnels in West Bucharest

PLAXIS® Provides Industry Model Promoting Future Development over City Tunnels

PIONEERING DEVELOPMENT OVER CITY TUNNELS

In western Bucharest, Romania, a land developer initiated a EUR 2.5 million project to construct the city's first residential building over the subway tunnels. The structure was initially planned as a 10-story building with a basement for parking. As a pioneer project located in the tunnel protection zone, it presented an irregular footprint and required approval from the subway operator, needing to demonstrate minimal displacing of the tunnels and effect on the structural forces. SAIDEL Engineering was tasked with providing structural and geotechnical design, with the goal of reducing the overall effect of the building on the tunnel lining by providing a safe and cost-efficient foundation.

The project was complex, requiring SAIDEL Engineering to modify the shape of the footprint to reduce the irregularity of the building, while still complying with its functional and architectural needs, compounded by the mandate to obtain the conservative subway operator's approval. Having previously been rejected, it subsequently lingered for two years before SAIDEL Engineering's involvement. To enable the project to proceed as quickly as possible, they needed to determine an innovative excavation plan and conceptual design for the foundation that was acceptable to the subway operator, Metrorex.

ENHANCING ACCURACY AND OPTIMIZING DESIGN

Due to Metrorex's strict demands to minimize impact on the tunnels, SAIDEL Engineering initially performed 2D geotechnical analysis to determine and present feasible solutions for both the excavation and foundation that complied with the displacement and structural requirements. However, they wanted to increase the safety of the conceptual foundation design through 3D geotechnical modeling and analysis. While they received approval for the excavation, SAIDEL Engineering sought to develop 3D models for improved accuracy and optimization for the geotechnical design to be approved as well. "Given the sensitivity of the project, we desired to increase the safety of the solution," explained Şerban Nicolau, FEM design engineer at SAIDEL Engineering.

However, SAIDEL Engineering faced numerous obstacles when modeling the piles and pier loads, as well as challenges given the size of the model, which features more than 1.1 million elements and 1.5 million nodes. They needed an advanced geotechnical engineering application to provide the subway operator with accurate, quality design and documentation, proving that the structural foundation and 10-story residential building atop of it would have minimal influence on the tunnel lining.

ADVANCING GEOTECHNICAL MODELING AND ANALYSIS

As a PLAXIS user for almost a decade, SAIDEL Engineering knew that Bentley's geotechnical application was the best choice for this project. "PLAXIS 3D analysis was the natural step for us to take," commented Nicolau. Using the software, they performed plane strain analysis and developed 3D models for improved accuracy and optimization, comparing the 3D analysis with the original 2D models to provide further confidence in the project's foundation. They evaluated the feasibility of using a simple raft or raft on piles, considering various diameters and lengths, with or without base enlargement. They also analyzed the possibility of using a 15-centimeter-thick layer of Styrofoam under the raft between the foundation piles that encase the tunnels. For the soil structure interaction, they performed nonlinear analysis using the unique constitutive soil modeling feature in PLAXIS.

PROJECT SUMMARY

ORGANIZATION
SAIDEL Engineering

SOLUTION
Geotechnical Engineering

LOCATION
Bucharest, Romania

PROJECT OBJECTIVES

- To provide a safe and cost-efficient foundation solution approved by the subway operator.
- To integrate 3D geotechnical modeling for improved accuracy and design optimization.

PROJECT PLAYBOOK
PLAXIS

FAST FACTS

- SAIDEL Engineering performed geotechnical structural analysis for the first residential building being constructed over the subway tunnels in West Bucharest.
- The project presented complex geotechnical challenges determining an excavation plan and foundation design that met the subway operator's approval.
- Conducting 2D analysis and 3D modeling enabled SAIDEL Engineering to reduce the building's overall effect on the tunnel lining.

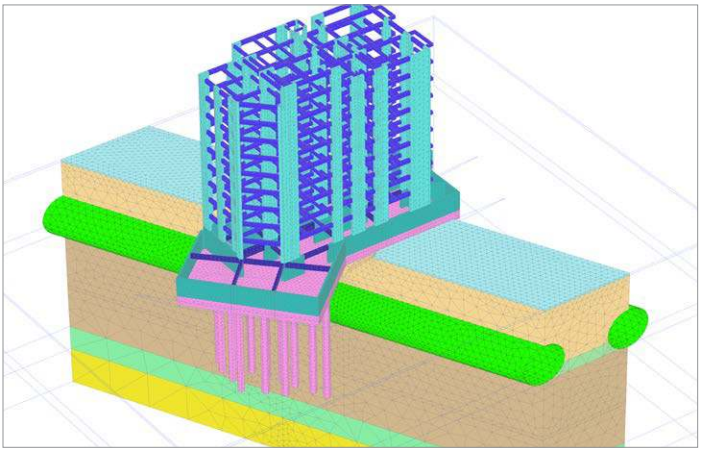
ROI

- Using PLAXIS, SAIDEL Engineering delivered a design solution that achieved the subway operator's approval within three months.
- The application's advanced geotechnical modeling and analysis features accelerated finite element modeling and ensured accurate deliverables.
- SAIDEL Engineering design concept reduced the building's influence to the tunnel lining by half in terms of displacement and structural forces.

PLAXIS is the best tool the geotechnical software market has to offer to expert geotechnical engineering teams who want a competitive edge over their peers.

-Șerban Nicolau, FEM Design Engineer, SAIDEL Engineering

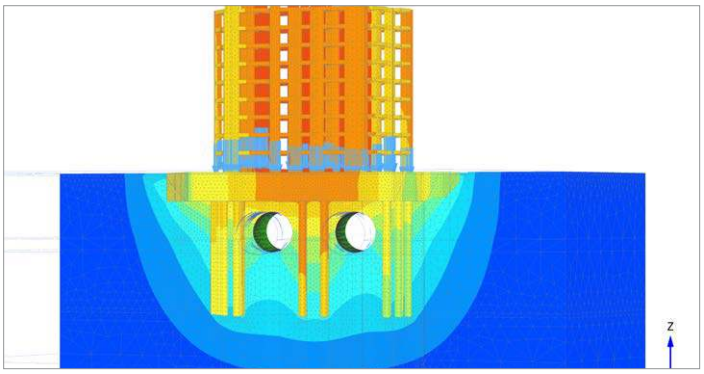
To overcome the modeling obstacles, SAIDEL Engineering utilized additional advanced capabilities within PLAXIS, including hexagonal prisms to model the piles and a rigid bodies feature for the pier loads to ensure convergence. The software enabled them to accurately model and analyze potential solutions and their influence on the tunnel lining throughout all stages of construction and lifecycle operations, resulting in a design concept approved by the subway operator. The accepted solution is a 1.5-meter-thick raft on 37 piles, with a 1,080-millimeter diameter, and 18 meters in length. The firm 3D calculation showed that this design resulted in just over approximately 6 millimeters of uplift during excavation and settlement during building service, minimally impacting the subway tunnels.



Using PLAXIS, SAIDEL Engineering delivered a design solution that achieved the subway operator's approval within three months.

UNLOCKING POTENTIAL FOR FUTURE DEVELOPMENT

Using PLAXIS facilitated highly accurate modeling and analysis that enabled SAIDEL Engineering to achieve approval of the project and get it back on track in just three months, after a lingering two-year hiatus. The software's highly advanced soil models and dynamic construction simulation provided a fast, user-friendly, and reliable engineering environment that accelerated precise finite element modeling, improving overall geotechnical and structural iterations.



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"Our team members have been successfully using PLAXIS since 2000 for various international projects and the most complex deep excavation works and foundation systems for tall buildings in Romania," explained Ion Răileanu, executive manager and head of design at SAIDEL Engineering. "Through monitoring during both the construction and service periods, the results of the geotechnical analyses were confirmed. Thus, expertise was gained in safe and economical modeling for the benefit of our clients and of the environment. The features of PLAXIS software—namely advanced constitutive models for the simulation of nonlinear behavior of soils, joint elements to model soil-structure interaction, staged construction enabling a realistic simulation of construction, and other special elements—make it suitable for the numerical analysis of all geotechnical analyses."

With their design solution, SAIDEL Engineering reduced the influence on the tunnel lining by 50% in terms of displacements and structural forces. The analysis results led to a decision to reduce the number of building stories from 10 to nine, minimizing seismic loads on the tunnels. Furthermore, it resulted in the reduction of raft thickness from 2 meters to 1.5 meters, using less concrete and reinforcements. As a pioneer residential project for the city, it unlocks the potential for future development over the Bucharest subway tunnels. Through their successful 3D geotechnical modeling solutions supported by PLAXIS, SAIDEL Engineering increased their visibility as an organization, driving emulation of their methods and geotechnical competition. The project provides a model for future endeavors to follow.