



BETTER GEOTECHNICAL ENGINEERING

**BEGINS WITH  
INTUITIVE DIGITAL  
WORKFLOWS  
FOR ENHANCED  
COLLABORATION**

BENTLEY'S GEOTECHNICAL ENGINEERING  
APPLICATIONS LET YOU DIG DEEPER FOR  
SAFER SOLUTIONS

**Bentley®**



# GOING DIGITAL WITH **GEOTECHNICAL**

Have you ever wanted a faster way to find your critical area for deeper focused analysis? What about being held up trying to get access to proper data? Or maybe in mid-dig and needing to reassess?

Bentley's geotechnical applications takes your projects from start to finish, with software developed with your challenges in mind. Our digital workflow gives you the capabilities to plan, design, analyze, construct, and operate – taking your project from the first steps of site investigation to the final stages of operation. The entire project lifecycle is addressed, beginning with construction and ongoing operation, onward with asset management, and incorporating BIM methodologies and a digital twin workflow. Geotechnical engineering involves a wide variety of industries, including construction, mining, offshore, rail and transportation, and roads and highways.

Our applications make it simple to manage these infrastructure challenges with an intuitive geotechnical workflow, as well as provide users that work with geotechnical information a single source of truth to integrate subsurface data. Engineers are fully enabled with efficient modeling processes, and the ability to analyze with either 2D or 3D methods to increase efficiency and reliability.

**This e-book looks at how Bentley geotechnical engineering applications support your goals with robust and reliable applications to solve your geotechnical problems.**

EXPLORE MORE >

• • • • •

• • • • •

• • • • •

• • • • •

PLAN

DESIGN

ANALYZE

CONSTRUCT

OPERATE

# GOING DIGITAL WITH **GEOTECHNICAL**

As a geotechnical engineer, you seek reliable solutions that support your designs. You need applications that provide data information and analysis support, reduce risk, and are easy to use, while saving you time and money.

Geotechnical engineering applications offer solutions for importing and managing geotechnical data, designing robust 2D and 3D models, analyzing with sound computation techniques, and ensuring better calculations with meaningful results and higher accuracy.

With the following steps, you can overcome the challenges presented by the infrastructure, mining, landslides, dam and levee, tunneling, offshore, rail, and oil and gas industries. Design and construct large infrastructure projects in a cost-effective manner, while reducing risk and increasing safety during the project's lifecycle.





# GEOTECHNICAL **SUBSURFACE** DIGITAL TWIN WORKFLOWS



## **Plan**

Import, report, manage, and integrate geotechnical data from planning through to site work and reporting. Collaborate with data integrity Ground to Cloud.



## **Design**

Build 3D conceptual models of soil and rock deformation and stability, as well as soil structure interaction, groundwater, and heat flow. Build your model once and use throughout the project.



## **Analyze**

Use sound computational analysis to provide a higher factor of safety with both finite element or limit equilibrium analysis. This practice allows for data-informed decision-making and the ability to adapt designs accordingly.



## **Construct**

Stage and implement simple and complex construction, including excavations, tunnels, foundations, and embankments. You can rely on continuous analysis and real-time monitoring from BIM technology and a digital twin workflow.



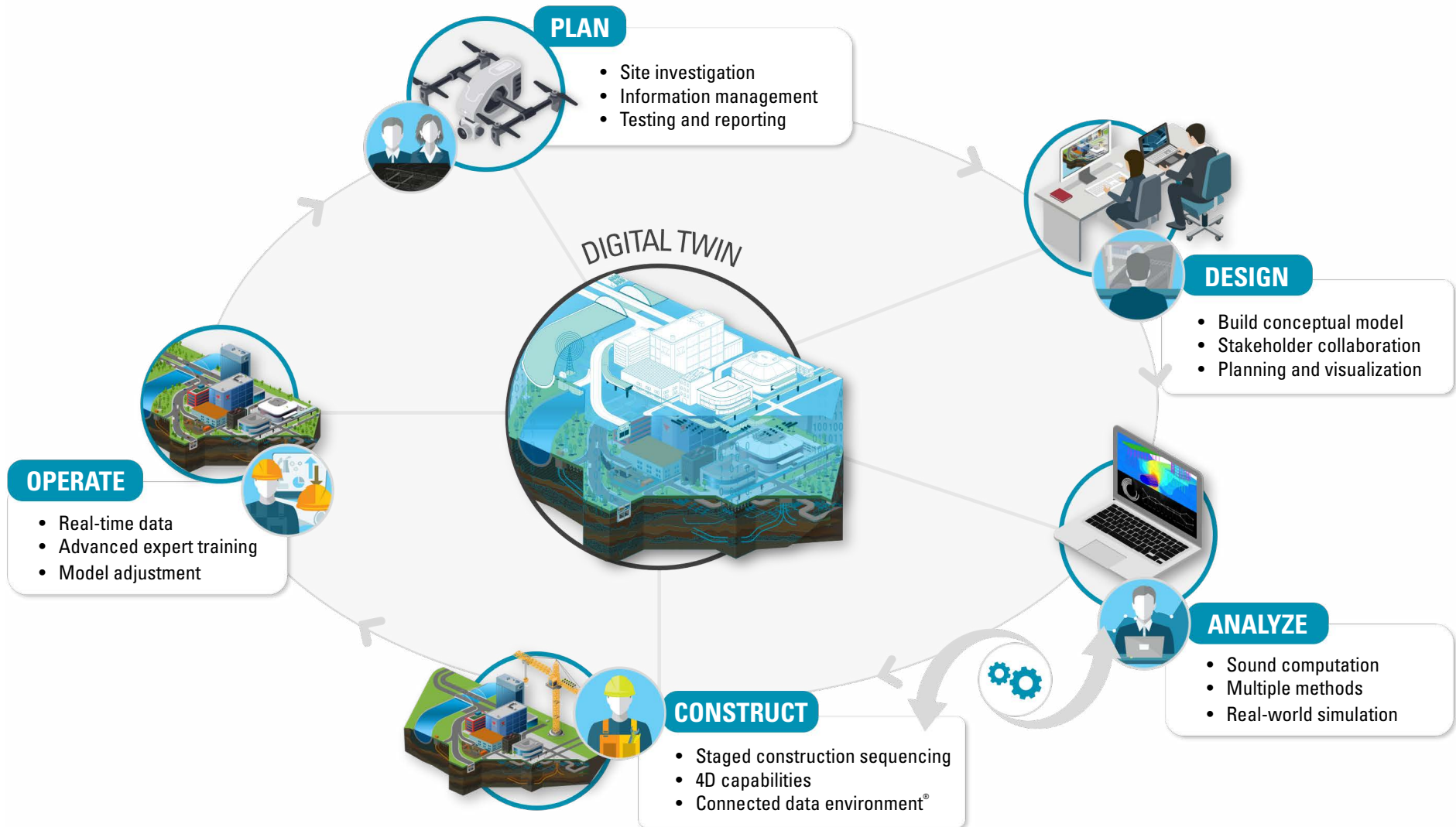
## **Operate**

Digital twins can span the entire asset lifecycle starting as a “project digital twin” and eventually becoming a “performance digital twin.” Create your model once and integrate data as required like monitoring settlement and ground changes. Bentley offers expert services and educational resources to accelerate your current and ongoing projects.



# GEOTECHNICAL SUBSURFACE DIGITAL TWIN WORKFLOWS

Applications span the entire asset lifecycle. Users at all stages can make more informed decisions for better outcomes.





# PLAN

## Geotechnical Data Information Management

Accessing digital information as a geotechnical professional is crucial. Whether engineers are investigating a site and require consistent uploads, or stakeholders must review the most up-to-date project reports, the need for an accessible, cloud-based data management application is vital.

OpenGround®, Bentley's collection of geotechnical applications, provides a comprehensive solution for collecting, managing, visualizing, analyzing, and accessing data. Our advanced digital workflows combine subsurface and surface data into one cohesive design.



# PLAN



## Access Reporting Anywhere

Build log, section, site plan, and data analysis reports using best practices to streamline production with any device. Establish enterprise-wide reporting and integrate digital workflows to streamline report production.



## Centralize Information

Enable your organization to store your site investigation archive in a single spatially aware, geotechnical repository, making access and usage easier for all collaborators.



## Enable Digital Workflows

Simplify and integrate your data entry and improve data reliability by entering it only once on site, or in the office. Instant access to your data in other apps will transform your geotechnical workflows and efficiency.



## Deploy Standardization

Standardize field data collection, office data entry, reports, storing, and accessing geotechnical information. Streamline quality assurance and quality control through common digital workflows. Use best practices to share workload across teams and locales.

**ACCELERATE GOING DIGITAL WITH YOUR ACCESSIBLE SINGLE SOURCE OF TRUTH FOR GEOTECHNICAL INFORMATION MANAGEMENT >**



**DOWNLOAD INFOGRAPHIC  
OPENGROUND CLOUD**



# REAL-WORLD PROJECTS WITH **OpenGround Cloud**

## **Building the Biggest UK Road Infrastructure Project through Collaboration and Optimized Workflows**

Arcadis, Cowi & Jacobs

*London, United Kingdom*

The Lower Thames Crossing project (LTC) developed a large database of ground investigation data that multidiscipline teams needed to access and utilize.

The project team migrated the project to OpenGround Cloud to solve issues with different organizations that needed to access the project, as well as to improve the quality of outputs and enhance efficiency across the project.

The cloud-based solution offered key benefits, including allowing team members to access the single source of truth database with appropriate levels of access. The OpenGround approach improved the workflow for all team members. The application also improved security by automatically preventing access to the system once users stopped working on the project. **Project Playbook: OpenGround Cloud**

**“OpenGround Cloud improved the workflow for all members of the team. The various add-ins are faster within the cloud version of the database, which is useful when dealing with large datasets such as CPT data.”**

*– Cedric Allenou, Ground Engineering Lead, Lower Thames Crossing project*





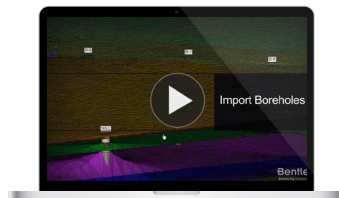
# DESIGN

## Import and Create Geotechnical Models

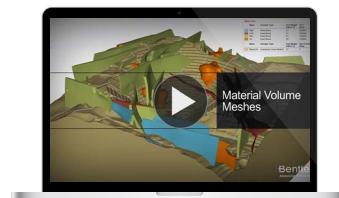
As a geotechnical engineer, your expertise is working with topology, boreholes, piezometers, and other field instrumentation data. Your challenge lies in organizing the data and utilizing simple and complex geometry to create conceptual models of soil and rock. With Bentley's open modeling environment, you gain the ability to visualize and manipulate geotechnical site data.

With Bentley's geotechnical engineering applications, users can easily import common file types and borehole data directly into our geometry modeling applications. The comprehensive interface allows boreholes to be located on a site, visualized in 3D, and integrated with design or topology data. The import feature allows you to transition borehole data into a full 3D conceptual model of a site for subsequent numerical modeling. The most common 3D file storage types are supported to ensure easy import including glINT®, Keynetix, and OpenGround Cloud.

Geostrata can be imported based on borehole data, or from one of many different file formats. Surfaces can be represented as grids or as triangulated surfaces (TINs). Once 3D geometry is created, it can be exported to numerical models in the form of 2D slices or as full 3D models. Overall design and prototyping time are reduced in this system. Your time and expertise are valuable – spend it analyzing for better solutions, not modeling geometry.



**WATCH VIDEO  
IMPORT BOREHOLES**



**WATCH VIDEO  
MATERIAL VOLUME MESHES**

# ANALYZE

## Perform Advanced Limit Equilibrium or Finite Element Analysis

With Bentley geotechnical applications, you can easily model and analyze any geotechnical challenge.

One common geotechnical challenge involves assessing slope stability of structures such as dams, levees, reinforced walls and slopes, mines, and excavations. To design and evaluate slopes with high levels of precision and accuracy, engineers rely upon numerical modeling.

With Bentley geotechnical analysis you can handle common and complex geotechnical analysis of soil or rock slopes using either the limit equilibrium method (LEM) or the finite element method (FEM). Three-dimensional LEM analysis allows you to solve directly for the safety factor of a trial slip surface, until you find the critical one. The process ensures that you are keeping infrastructure safe and reliable. Discover precise and complete slope stability analysis with Bentley.

Similarly, some complex geotechnical problems, might require displacements/settlements, soil-structure interaction or even dynamic analysis, where finite element software is required.





# ANALYZE

PLAXIS® 2D/3D offers fast and reliable finite element method (FEM) analysis and more than 16 constitutive models. Users can choose among a variety of structural elements, including anchors, beams, plates, geogrids, interfaces, and rigid bodies. Access a breadth of capabilities, with solutions for roads and highways, buildings and foundations, rail and transit, tunnels and excavations, and dams and reservoirs.

Our applications can analyze models using both LEM and FEM. While users may choose to analyze in one method, it is beneficial to run both methods in a combined analysis and provide a robust, thorough, and fully informed report for all involved stakeholders.

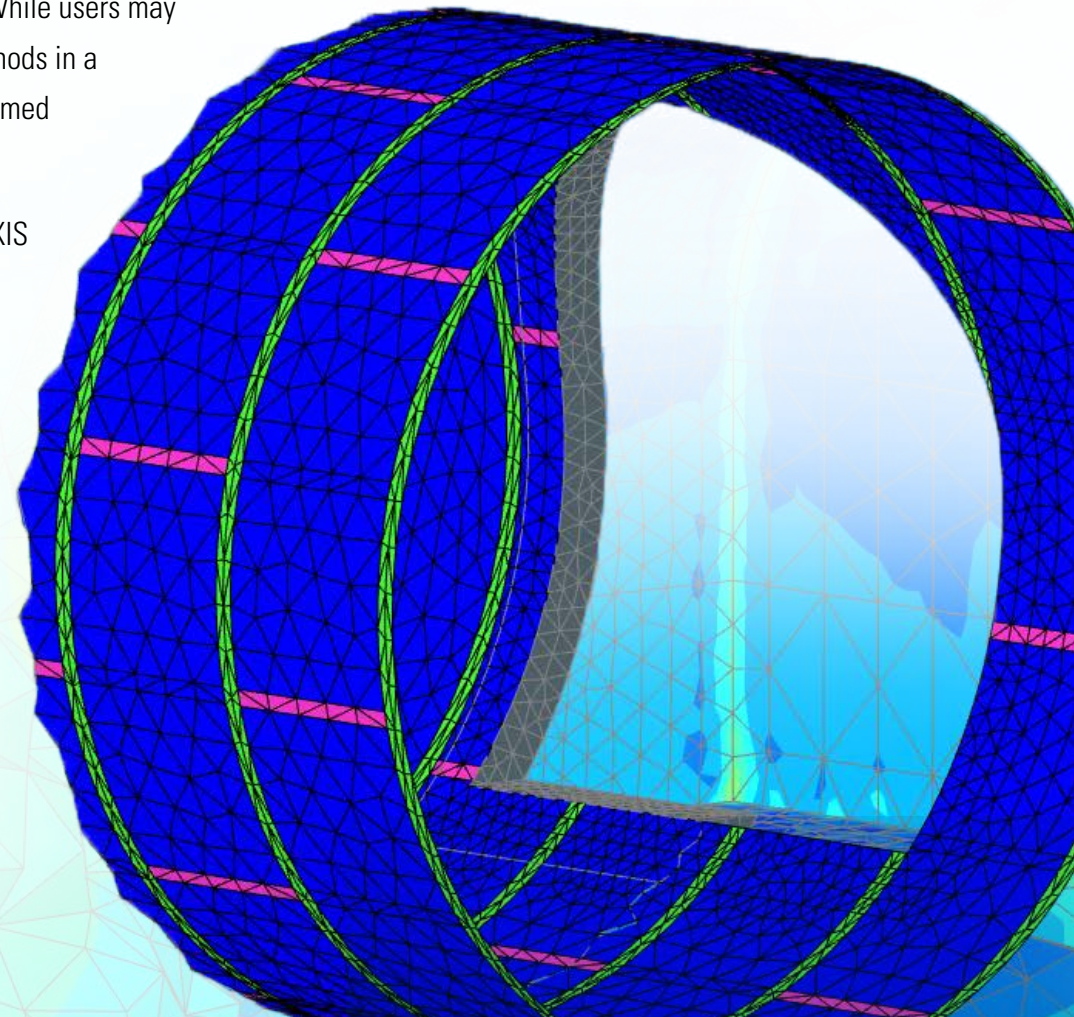
With powerful analytics and expert support, the return on a PLAXIS investment is clear. You will gain a powerful advantage with interoperability and multidiscipline workflows, and easily extract the necessary information to judge the soundness of your design with powerful post-processing capabilities.



**WATCH VIDEO  
PLAXIS 3D**



**WATCH VIDEO  
SVSLOPE® QUICKBYTE**



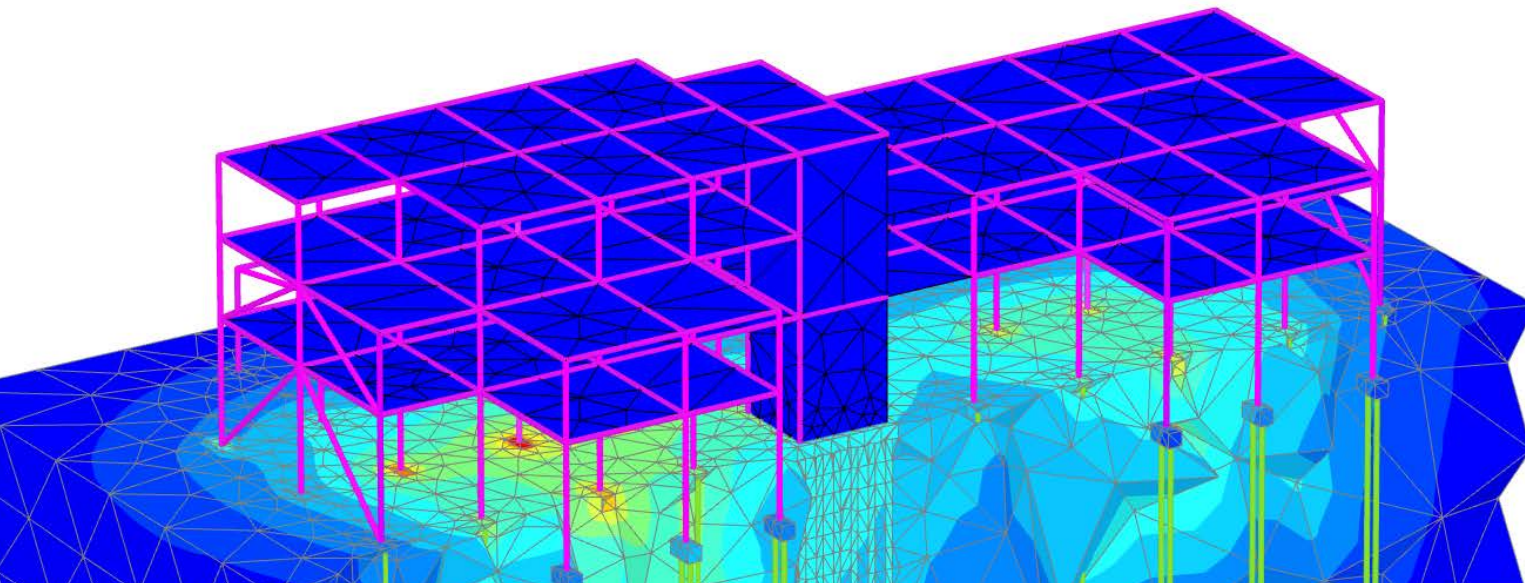
# CONSTRUCT

When planning and designing for construction, engineers experience many challenges. Common challenges include foundations and fill materials costs, weather conditions, budget and time constraints, and government regulations.

Take control of your construction projects with Bentley's geotechnical engineering applications. Rely on sound computation and more robust calculations to solidify your construction projections and ensure safety standards are met. Access reporting and investigation tools to gain an accurate representation of groundwater, subsurface conditions, weather influences, and excavation projections.

A digital twin workflow, powerful automation, and customization for any geotechnical construction project is possible. Utilizing a digital twin model provides users with a reliable source to assess and mirror subsurface construction projections. In addition, iTwin® and BIM integration enables users to react faster to potential issues on site, understand the ground behavior, and gain a more complete picture of the project.

PLAXIS' unique process of staged construction provides you with the ability to conquer geotechnical construction challenges with reliable calculations for timely, data-driven decision-making.





# REAL-WORLD PROJECTS WITH **PLAXIS**

## Delivering Optimized Design for Complex Basement under the Iconic Admiralty Arch

WSP

*London, United Kingdom*

Prime Investors Capital is building a 96-room Waldorf Astoria hotel alongside London's historic Admiralty Arch. The landmark is located on The Mall, which connects Buckingham Palace and Trafalgar Square. The arch incorporates three archways accessing six levels and two basements. WSP is providing structural engineering for two new basements on either side of the arch, below an existing road and above two London Underground tunnels. At an estimated GBP 20 million, the basements will house a pool, spa, ballroom, hotel services, and physical plant.

To conquer such a complex project in a congested area, it was critical for WSP to leverage geotechnical analysis, as well as a reliable structural solution. WSP completed the design using RAM, creating models for each construction stage. The team addressed the challenge of acoustically isolating the basements by designing a box-in-box system. WSP used PLAXIS to assess forces and stresses on the system, and RAM to model an innovative structural solution. Combining the strengths of PLAXIS and RAM saved 25% of the structural design time, allowing WSP to complete the design phase one month ahead of schedule. **Project Playbook:** PLAXIS, RAM®



# OPERATE

## One Digital Twin Supports Your Entire Asset Lifecycle

Bentley's geotechnical digital solutions allow you to store, manage, and report post-construction geotechnical analysis and monitoring data. And, with our most advanced cloud solutions you can have instant access and share up-to-date data on geotechnical conditions.

Resulting data can be analyzed to determine buildings' settlements or effect on adjacent buildings. And, Bentley's geotechnical analysis solutions in both 3D and 2D can provide you with robust results in any geotechnical investigation.

Thought leaders provide continuous development and support for maximizing your return on investment. Users can access expert services and rely on professional advice on valuable projects and can thereby maintain on-going operation of geotechnical projects.

Efficiently manage your asset lifecycle with support from our experts.





# REAL-WORLD PROJECTS WITH **PLAXIS, gINT**

## Designing a Strong Foundation for Singapore's Largest Tower

Arup Singapore

*Singapore*

Arup Singapore Pte. Ltd. provided civil and structural services for the SGD 3.2 billion Guoco Tower development, a 64-story, 290-meter mixed-use office and residential complex. The government mandated that excavation and construction of the foundation limit movement of the station and existing buildings to as low as 15 millimeters. But, the variable nature of soil in the area made projecting performance difficult using traditional methods. The project team performed a comprehensive geotechnical study of the surroundings, which resulted in designing a pile-raft foundation. The data analysis and 3D simulation enabled the team to predict soil stresses and how the foundation interacted with nearby structures.

The detailed soil analysis enabled the team to optimize the placement of each pile and reduce loads by 30% to 35%. Despite the massive volume excavated, plans created using geotechnical analysis kept movement of the adjoining structures well below government requirements. Arup Singapore used gINT to manage all geotechnical data, along with sensor data to produce soil simulations in PLAXIS.

**Project Playbook:** gINT, MicroStation®, PLAXIS

**"Bentley's geotechnical software enhanced the design methodology and drove efficiencies through digital workflows, which helped us to deliver a safe and cost-effective solution for basement construction, as well as resolve site issues and challenges encountered during construction."**

*— Ei Sandar Aung Win, Senior Geotechnical Engineer, Arup Singapore*





# GEOTECHNICAL ENGINEERING

Embrace confidence, credibility, and control in your geotechnical applications. With Bentley's geotechnical engineering software, users can access a complete digital workflow. By utilizing our applications users can rely on secure solutions for data-driven decisions through enhanced collaboration – when and where it is needed. Users can add layers of safety and reduce risk by accessing a connected data environment where applications offer advanced interoperability and integration. Advanced expertise and methods of sound computation are delivered by a trusted team of experts, ensuring they are easier to use and provide more robust 3D modeling and analysis.

**Use our applications to plan, design, analyze, construct, and operate for increased safety and reliability in projects.**

1-800-BENTLEY (1 800 236 8539)

© 2020 Bentley Systems, Incorporated. Bentley, the Bentley logo, gINT, iTwin, Keynetix, MicroStation, OpenGround, OpenGround Cloud, PLAXIS, PLAXIS 2D, PLAXIS 3D, RAM, and SVSLOPE are either registered or unregistered trademarks or service marks of Bentley Systems, Incorporated or one of its direct or indirect wholly owned subsidiaries. Other brands and product names are trademarks of their respective owners. 08/20

