The Connected, Collaborative Workflow for Tunnels

Bentley®

SEEQUENT

To bridge the gap between geoscience and infrastructure engineering, you need purpose-built solutions that address underground engineering challenges.

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Challenges and Change

Tunnel construction is becoming more common due to advancements in equipment and techniques, as well as the opportunities that tunnels offer for connecting and improving the quality of life for communities when there is increasing competition for space aboveground. In addition, tunnel lifecycle management is top of mind for stakeholders, as tunnels are expected to be sustainable assets, with a longer life expectancy than a surface facility (125 versus 75 years), so the planning aspects carry long-term effects and risks.

Data Management

File-based exchange and incompatibility, or translation of file formats, is still a daily issue for many. As the 2023 Geoprofessionals Data Management Report revealed, a staggering 67% of civil professionals have data organized in various systems, indicating a lack of centralization. The report also highlights a substantial amount of time spent on data management, with civil geoprofessionals devoting 22% of their time to data management.

It adds up to a significant impact on productivity—even hundreds of hours per year—but more importantly, there is the opportunity cost of spending time on nonvalue-added tasks. You have less time for what really matters, which is the robust engineering thought process required for successful tunnel projects. Things have not changed significantly in the past decade; however, the pandemic saw a big shift in the desire for a centralized single source of truth, as enforced remote working emphasized the realities of data management challenges, and the realization of the associated risks.

Formats remain a challenge and, in particular, the incorporation of ground models into **building information modeling** (BIM) processes.

Data management consumes **1 day out of every 5** for civil geoprofesionals.

Risk and exposure – am I using the **correct version?** Am I using the model for the **intended purpose?** The lack of a single source of truth is an **Achilles heel**.

Document Production

Engineers are often unable to share 3D engineering geology models due to the liability associated with those interpretations. So, professionals often revert to 2D drawings and reports for tendering or when moving to construction. It is a burden both on time and accuracy. Significant knowledge is lost and needs to be recreated from first principals.

If you had a common language and framework around the use of engineering geology 3D models, you could avoid a lot of this redo into the next phase in the same tunnel system.

Cost, Time, Quality, and Sustainability

Engineering professionals are increasingly under pressure and always charged to do more with less, balancing cost, time, and quality.

Sustainability and the carbon footprint of projects are increasingly at the forefront, which creates a greater focus on optimization and advanced analytical modeling included for environmental effects.

Where, when, and how to gather more site investigation data is a constant balancing act to get right. There is almost never sufficient data.

Increasing project workloads and limited skills availability mean that we need to automate or eliminate non-value-added tasks and leverage experience.

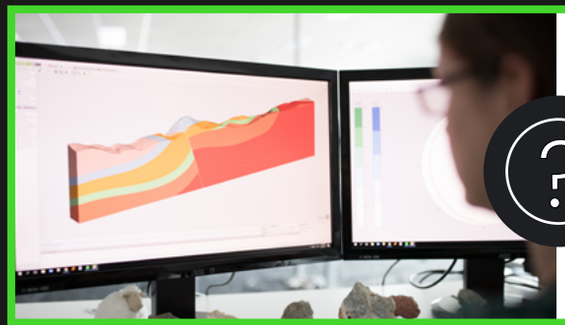
It is no longer sufficient to just balance time and cost with risk; we need to optimize designs and processes for sustainability.

Scarcity of data means that we need to make smart choices about where to invest in new information while also leveraging existing information.

Communication of Subsurface Understanding

Geotechnical engineers have an inherent appreciation for the uncertainty that exists in their models. Others, used to the precision and accuracy of engineering models, do not appreciate this uncertainty. So, the challenge becomes how to integrate with engineering models but retain and communicate uncertainty.

Additionally, nontechnical decision makers struggle to appreciate what they cannot see. This situation is where 3D visualization is critical for communication along with a common language and expectations around the use of 3D engineering geology models on the project.



Uncertainty in interpreted models built from limited data and at a completely different accuracy level to engineering design models.

Nontechnical stakeholders need to understand subsurface to support robust decision-making.

Contracting of risk breaks the flow of information between project phases and parties.

Discover an Integrated Tunneling Workflow

Increased demand for tunneling means changing how they are designed and engineered. It starts with a comprehensive solution for tunnel planning and design that can bring together different disciplines under one interoperable workflow. As we respond to the challenge to do more with less, we can lean on the advantages offered by digital solutions to increase agility while accelerating manual and repetitive tasks and providing engineers with more time to analyze potential errors and create alternatives for optimum design, safety, and performance prior to construction.

Geotechnical Data Management, Modeling, and Analysis

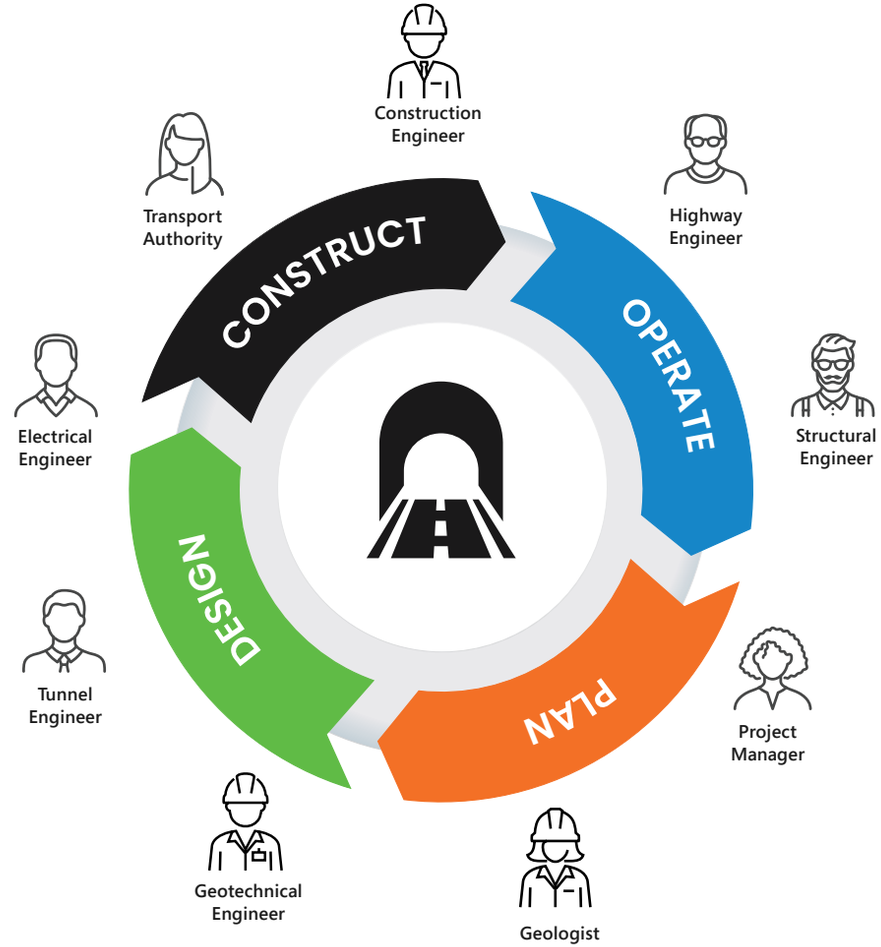
Successful tunneling depends on your ability to predict ground behavior, and it all starts with geotechnical data. Information and models from geophysicists, groundwater/hydrogeology, boreholes, CPTs, and mapping allow for a connected geotechnical workflow that is vital for making informed decisions, minimizing errors, and optimizing efficiency of the design and construction process.

By utilizing solutions such as OpenGround, Leapfrog Works, and PLAXIS, geotechnical engineers can gain a comprehensive understanding of subsurface conditions, allowing them to design and build safe, sustainable, and long-lasting infrastructure.

Tunnel Design and Modeling

A tunnel design and modeling environment is unique. Designers and engineers analyze multiple iterations to understand how the design will behave in a real-world context. The ability to share and consume project data across disciplines in a common data environment means they can deliver projects that are optimized, accurate, and timely.

With OpenTunnel Designer, the only purpose-built software for tunnel modeling and design, along with the subsurface insight of Leapfrog Works, engineers can model, simulate, detail, and document tunnel projects in an intuitive solution set.



Collaborate Effectively

For tunnel projects, it is critical to bring teams and data together for a single source of truth. You need to be able to visualize, track, integrate, and manage your geoscience data from a centralized, auditable environment.

Leveraging Seequent Central provides the next level of collaboration, with a shared workspace across disciplines and across the world.

The Digital Twin Imperative

Connecting the physical and virtual worlds enables you to synchronize work, gain greater visibility, and make sense of the right data at the right time.

A digital twin is a realistic and dynamic digital representation of a physical asset, system, or city. It enables you to create the visibility and insights for data-driven decisions that make infrastructure sustainable and resilient.

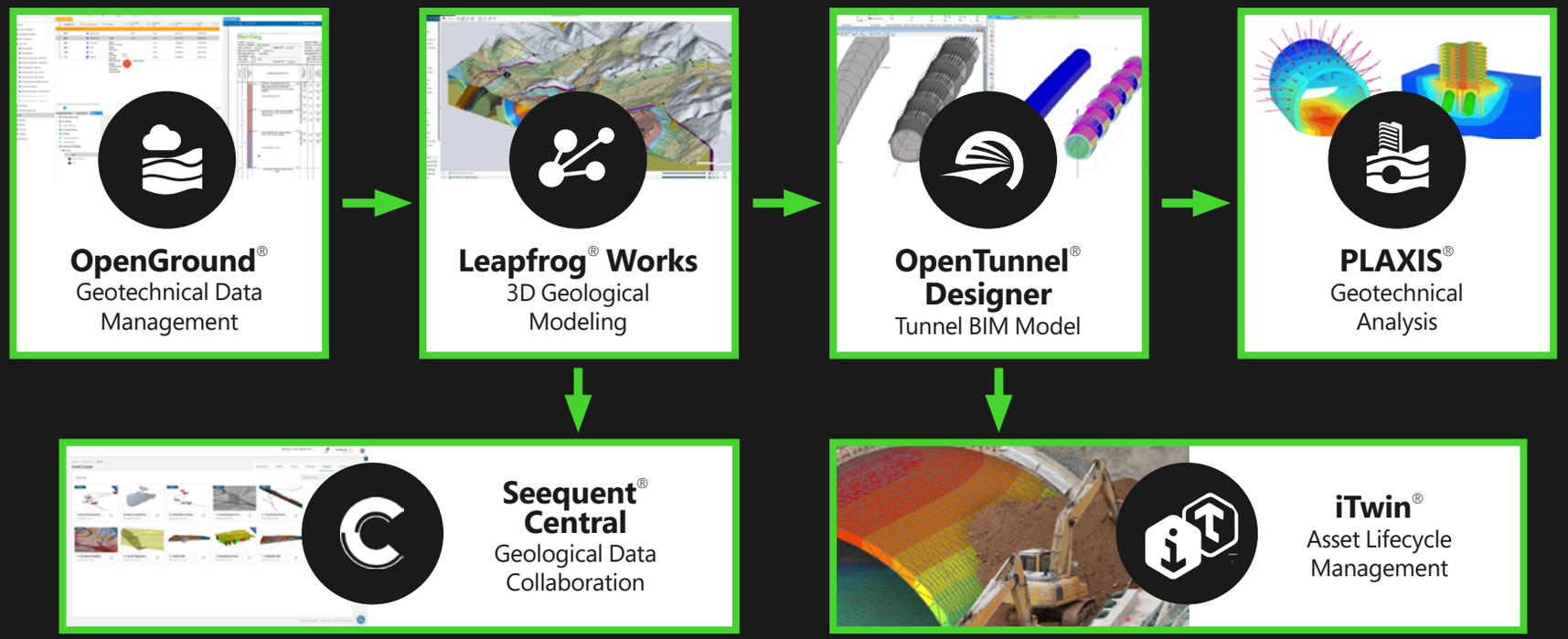
Bentley's iTwin Platform is a proven digital twin foundation – and the place where you want to start.

Civil Engineering

Every tunnel is connected to a road, rail network, or bridge, involving thousands of decisions and changes for design, aesthetics, structural integrity, material choices, and safety. Bentley's civil solutions, such as OpenRail™, OpenRoads™, and OpenBridge®, allow you to manage all the data, from concept through construction, in a single composite model.

Easily collaborate with multidiscipline teams to understand how all project elements work together to prevent conflicts early in the design phase. No more data transfers, no more communication lags, and no more cost overruns. Just straight collaboration improving efficiency, quality, and confidence across all project stakeholders.

With each of these solutions feeding into a connected workflow, transportation designers, geotechnical engineers, asset owners, and other stakeholders have the end-to-end capabilities to make better and more confident decisions; thereby reducing risk, controlling costs, and protecting project timelines.



Geotechnical Data Management

OpenGround

OpenGround is the foundation of your digital twin that leverages the value of your geotechnical data. It allows you to identify site constraints early and understand financial implications, leveraging a fully managed and scalable cloud platform to meet security and compliance requirements. Manage your site investigation supply chain of custody and lab data collaboratively for confident geotechnical data reporting.

Manage Workflows

Work with intelligent data that integrates into the full context of the design. Provide dynamic visualizations and standardized enterprise reporting from trusted data. Increase collaboration throughout a connected geotechnical data lifecycle.

Centralize Data

Maintain an accessible single source of truth for all your geotechnical data. Save time, collect, and synchronize while on site. Control access to federated data across distributed teams and the supply chain.

Report

Produce quality reports quickly — including logs, sections, site plans, summary sheets, and charts — and access fast graphical log previews and PDF printing. You can standardize logs and sections with fixed or dynamic content using your standardized templates and dynamic data strips. This standardization process ensures corporate standards are met while giving project managers the flexibility to change what is reported when required.

Integrate

It is your data, so future-proof it with open access via API or use off-the-shelf integrations with industry-standard applications like Leapfrog Works or Autodesk's Civil 3D, for 3D geological modeling to drive efficiency and increase the value of geotechnical data in your organization.

Geological Modeling

Leapfrog Works

Leapfrog Works provides fast, dynamic 3D geological modeling that easily combines disparate subsurface datasets with intuitive interpretation, even for complex geology encountered in tunneling.

Save Time for Analysis

Change how you look and work with data by using streamlined workflows specifically designed for working with subsurface data types, which enable you to rapidly generate data-driven geological models in 3D.

As new observational data is input, your geological interpretation adapts to the new measurements and outputs, such as cross sections, are dynamically updated without needing to recreate them, letting you focus on analysis and applying your engineering judgement.

Communicate Clearly

Seeing subsurface insights in 3D brings clarity to even complex data, giving you a higher level of understanding.

Highly visual 3D subsurface models help you better interpret ground conditions. Clearly communicate risks to all stakeholders using free visualization capabilities, including Leapfrog Viewer, and movies, as well as produce high quality images and section layouts for reports and presentations.

Take on Uncertainty

Uncertainty is part of tunneling. Dynamic geological modeling shows where the data supports your conceptual model and where it doesn't so you can target further investigations or flag risk with confidence.

For Geologists, by Geologists

Intuitive modeling based on underlying geological concepts means Leapfrog Works is easy to learn for geoprofessionals, and it handles complex modeling of natural formations, such as fault systems, veins erosions, and deposits.

Tunnel Modeling, Analysis, and Design

OpenTunnel Designer

OpenTunnel Designer is purpose-built software for modeling and designing tunnels. It is the first software of its kind that works within a single common data environment, so all stakeholders can consume and share the most up-to-date information. Engineers can produce intelligent, parametric models that are rich in engineering content and properties for various tunnel components. Model, analyze, and design as a true 3D solution, as well as perform clash detection with other structures, objects, and utilities to eliminate problems before they occur.

Simplify Your Design Process

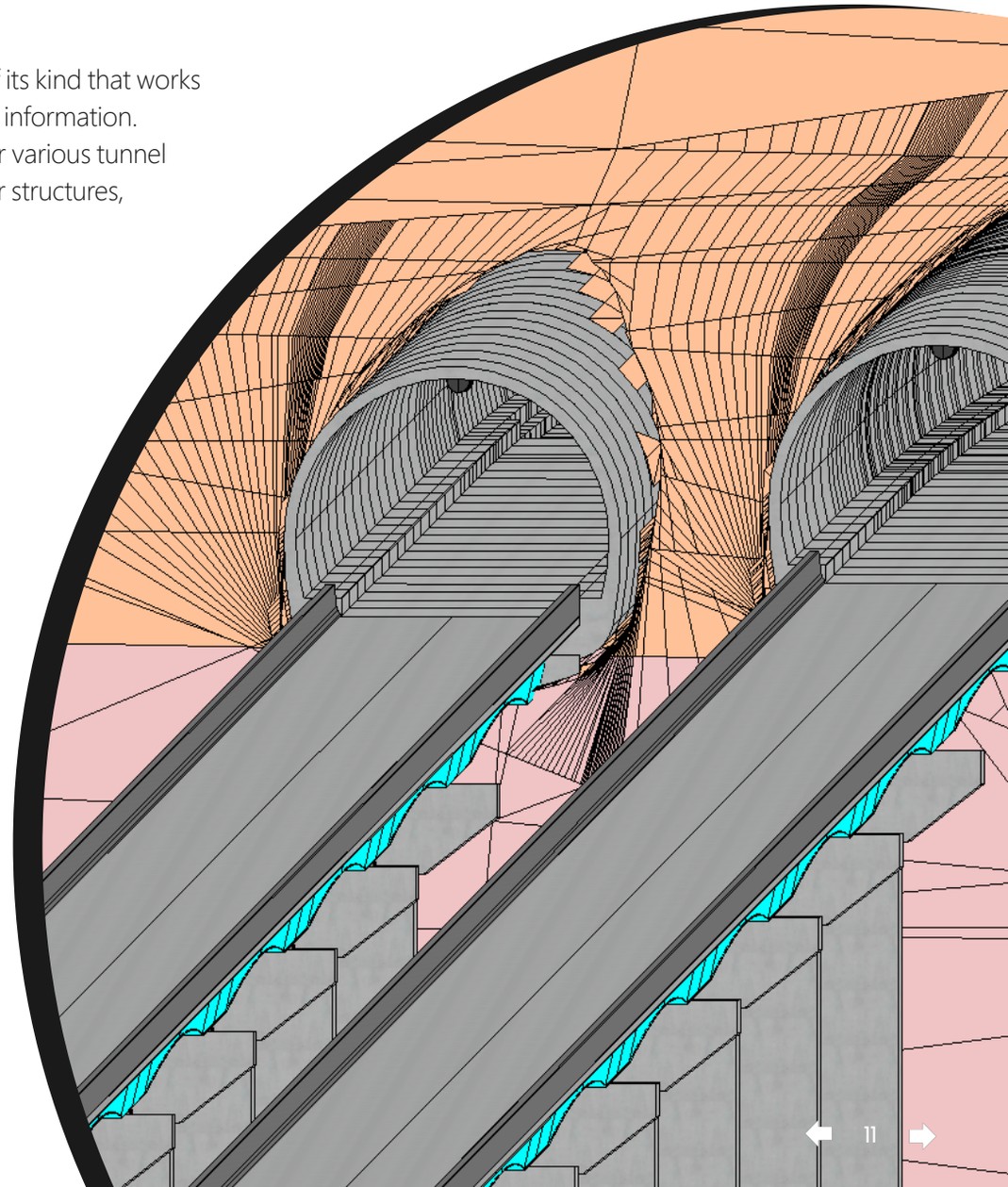
Easily use data from various contributors and collaborators, maintaining relevant and up-to-date geometry within a single model. Comprehensive and automated design capabilities remove the need for scripting specialists. Matched with dynamic change management, it mitigates rework and reduces time delays with complete coordination of team member input through ProjectWise® – one connected, intuitive application.

A Connected Workflow Enables Efficient Collaboration

Easily exchange information with Leapfrog, PLAXIS, OpenRoads, OpenRail, OpenBridge, iTwin, and ProStructures for seamless collaboration across related projects. If civil design reference data changes, the parametric and rule-based tunnel model automatically updates. OpenTunnel Designer and PLAXIS are interoperable enabling an all-in-one workflow for modeling, design, and analysis. With your already existing model in OpenTunnel, you can generate your analytical model in PLAXIS with a click of a button.

Improve Deliverables Production

Modeling in a 3D environment helps rapidly verify tunnel geometry. The tunnel is seen in plan, elevation, and cross-section views. It also facilitates the evaluation of multiple tunnel alternatives, costs reports, and well-organized analysis and design reports. Generate iModels for integrated 4D design reviews using ProjectWise, and deliver reports as PDFs, HTML, or export them as your client prefers.



Geological Data Collaboration and Management

Seequent Central

Visualize, track, integrate, and manage your geological models from a centralized, auditable environment. Seequent Central provides the next level of collaboration, with a shared workspace across disciplines and across the world. Now, you can ensure that there is a single source of geological understanding for your projects.

Interactive Visualization in the Cloud

Easily share your project from the Central Portal with colleagues and stakeholders. They can open and interact with it directly in a web browser, wherever they are and with no training required.

Access historical model versions in 3D and interrogate it using intuitive tools. See how understanding has evolved and establish what was known and when.

Approve and Share

From geologists and geotechnical engineers, to project and BIM managers — the right people see the latest approved geological model version at the right time. Notifications let you know when a new revision is available, so you are never working from the wrong version. Understand when and why decisions were made, view past annotations, and visually compare versions of your model.

Data Interoperability

Providing a single source of truth for site understanding, you can connect directly from GeoStudio® or PLAXIS to accelerate set up and solving of analyses for factors of safety, settlements, or stress and deformation when tunneling or excavating.

Engage a Wider Audience with Subsurface Insights

Transform how you engage with all stakeholders on a project by publicly sharing 3D scenes of your model. Whether you need to engage a wider stakeholder group for faster decisions or communicate with the general public, you can now make it happen through sharing a simple public link.

Geotechnical Design and Analysis

PLAXIS

Managing the design and analysis of tunneling requires comprehensive and intuitive tools that will equip users with confidence and credibility. OpenTunnel Designer and PLAXIS are interoperable, enabling an all-in-one workflow for modeling, design, and analysis. With your already existing model in OpenTunnel Designer, generate your analytical model in PLAXIS with a click of a button so you have more time to identify errors and create alternatives for optimum design, safety, and performance prior to construction.

Powerful Analysis

Every project is challenging, but the geotechnical analysis doesn't have to be. PLAXIS 2D provides the power of fast computations. Perform advanced finite element soil and rock deformation and stability, as well as soil structure interaction, groundwater, and heat flow.

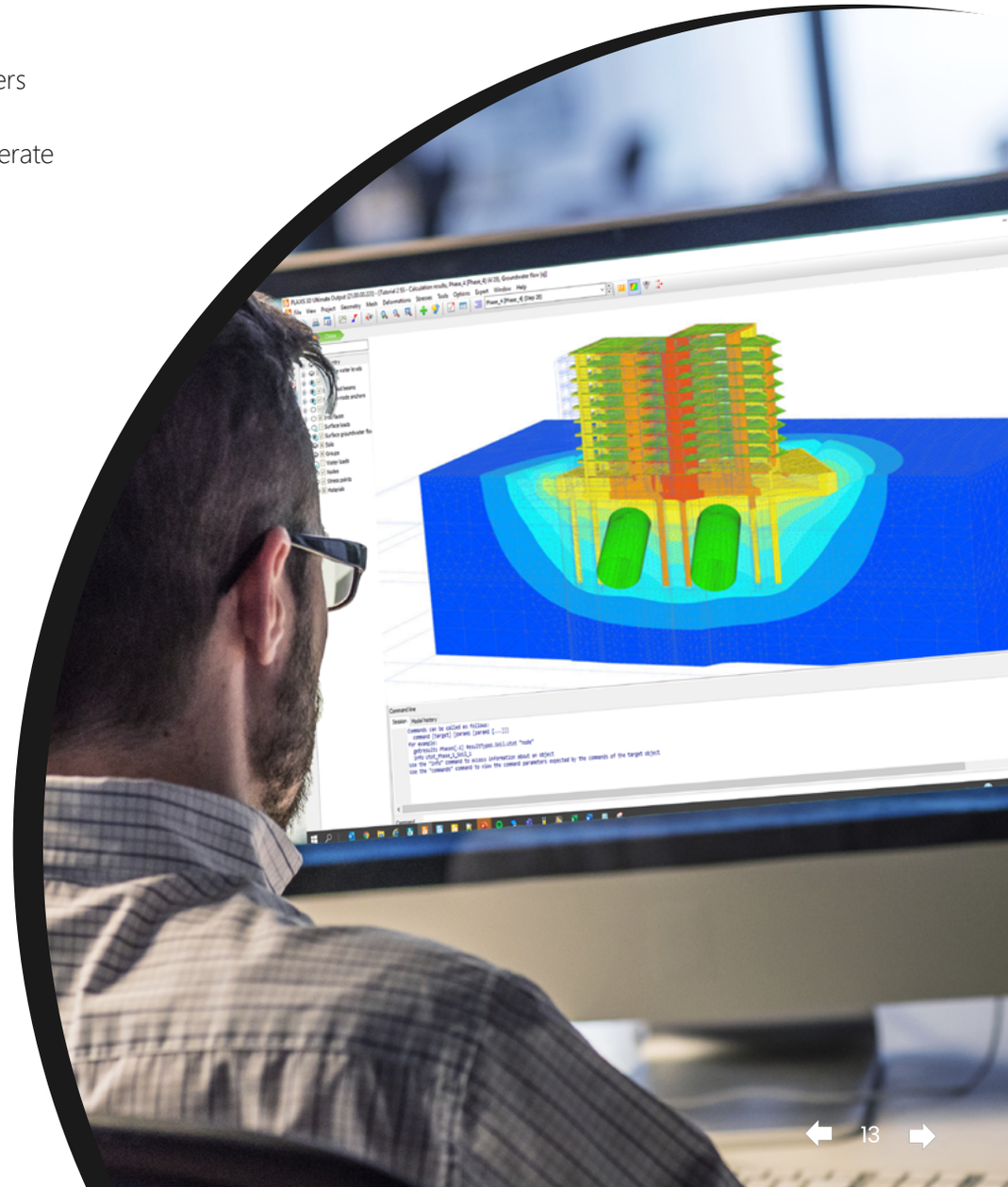
Rock, Soil, Steel, and Concrete

PLAXIS 3D includes the most essential functionality to perform everyday deformation and safety analysis for soil and rock, making it easy to model in 3D.

PLAXIS 3D Advanced includes everything that is included in PLAXIS 3D, plus it enhances your geotechnical design capabilities with more advanced features and material models. You can consider creep or flow-deformation coupling through consolidation analysis. Solve your problems faster by leveraging the multicore solver.

Complex Interactions with Neighboring Structures

Extend the capabilities of PLAXIS 3D Advanced to analyze the effects of vibrations in the soil, like earthquakes and moving traffic loads. Simulate complex hydrological conditions through time-dependent variations of water levels or flow functions on model boundaries, as well as soil boundaries.



Infrastructure Digital Twin Platform

iTwin

The iTwin Platform provides the foundation for building SaaS solutions to design, build, and operate infrastructure assets. Accelerate application development by letting the iTwin Platform handle data integration, visualization, change tracking, security, and other complex challenges. Whether you are building SaaS solutions for your clients, advancing their digital twin initiatives, or leveraging the innovation of Bentley's connected, civil solutions, this platform supports infrastructure.

Develop on an Open Platform

The iTwin Platform is built on open APIs and libraries purpose-made for digital twin applications that create, visualize, and analyze digital twins of infrastructure assets. Building on iTwin means you hold the keys to your digital twin applications, while your clients hold the keys to their data.

Deliver with Confidence

iTwin provides instant access to large-scale datasets for visualization and insights. Your digital twins are continuously synchronized and federated across repositories on their native formats while supporting complex user workflows. We know because we use it to build our own SaaS solutions.

We Take Care of the Heavy Lift

The iTwin Platform takes care of the rest, such as back-end security, infrastructure, and data integration needs. You focus on the applications that bring value to your client or organization. The iTwin Platform will help you reduce overhead for building and maintaining your technology stack.

Capabilities At-A-Glance

	OpenGround	Leapfrog Works	Seequent Central	OpenTunnel Designer	PLAXIS	iTwin Platform
Typical Users	Geotechnical data producers, managers, and asset owners	Engineering geologists	Geotechnical engineering teams	Tunnel engineers/designers and drafters	Tunnel, geotechnical, rock, and mining engineers	Project partners and owners, and asset owners
Solution Focus	Cloud-based single source of truth for factual geotechnical data	Dynamic 3D geological modeling	Cloud-based geological model management	Integrated parametric BIM tunnel designer	Numerical finite element analysis for tunneling and underground spaces	Open platform for infrastructure digital twins
Primary Connections	OpenGround Collector OpenGround Collaborator Leapfrog Works	OpenGround Seequent Central	Leapfrog Works PLAXIS	PLAXIS Civil WorkSuite ProStructures ProjectWise iTwin	OpenTunnel Designer Seequent Central	OpenTunnel Designer Infrastructure IoT AssetWise®
Major Advantages	Collaborative, secure, and scalable, seamless borehole log production	Fast and intuitive synthesis of disparate subsurface data into clear concise 3D models	Coordinate geological model reviews and multiuser modeling with remote teams	Rapid physical modeling highly adaptable to changing requirements and information at the heart of a connected workflow	Comprehensive soil and rock analysis from 2D and 3D numerical models with staged excavation	Accessible, fully federated digital twin providing critical project or asset information to key stakeholders
Problems Solved	Timely access to high quality geotechnical data and reports	Understanding and communication of subsurface conditions and uncertainties	Full audit trail of evolving subsurface understanding and uncertainties	Productivity of modeling and drawing production, as well as analysis	Validate tunnel design and evaluate ground movements and their impact on existing assets	Client, partner, and end-user engagement
	Learn More ▸	Learn More ▸	Learn More ▸	Learn More ▸	Learn More ▸	Learn More ▸

Industry Leaders Like You Use Bentley and Seequent Solutions

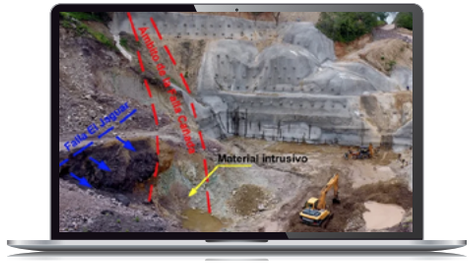
Here's Why

The switch to 3D digital models has changed the way engineering consultants at Aurecon are moving forward with projects. The benefits were quickly realized on Auckland's City Rail Link project.

"We've moved with the times in technology. Modeling is fantastic. It's absolutely a change and we're not going back to the traditional ways."

— Philip Kirk, *Technical Director, Ground & Underground Engineering, Aurecon*

Watch The Video



During the construction of a road in the Mexican state of Nayarit, a considerable mass of rock started sliding close to a tunnel portal, putting the construction site at risk. To find a solution, the team created a 3D model with PLAXIS to accurately represent the movement of the rock mass, as well as 2D PLAXIS cross sections to complement the 3D model. These models were used to calculate the new excavations, structures, and compacted fills of the project.

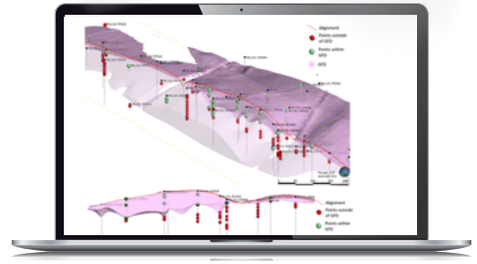
Read Case Study

Setec/Terrasol of France offer a offers a multidiscipline approach to tunnel projects. Their designers, geologists, and engineers leverage the power of Bentley solutions to do just that.

"OpenTunnel can help professionals [...] transfer of the geometry of the works directly into PLAXIS without the need to redo it, as is the case today, leaving engineers to concentrate on the geotechnical and structural aspects."

— Jean-Pierre Janin, *Former Manager of the Underground Structures Unit, Setec/Terrasol*

Watch The Video



High Speed 2 is the largest infrastructure project currently being developed in Europe. On this project, over 21 million cubic meters of material would need to be excavated. The project team created a new geoBIM assessment technique using Bentley and Seequent solutions to integrate geological information and building information modeling. By lessening the need for material haulage, they are helping meet the goal of reducing carbon emissions by 50%.

Read Case Study

Envisioning Success

With tunneling, the stakes are higher and the ground conditions are more critical than for other kinds of infrastructure projects. Additionally, the industry must deal with more uncertainty in complex geological settings or areas of high overburden.

Bentley and Seequent continue to develop and deliver on the vision of enabling more productive and streamlined workflows that connect project teams, enabling them to collaborate while delivering the unique pieces of the puzzle for which each is responsible. Every team member can achieve their own vision of success and connect the pieces for the success of the whole.

- **Reduce Risk and Costs**
- **Optimize Resources**
- **Meet Deliverable Requirements**

Integrated **tunnel design workflows** optimized to **reduce risk** and **meet deliverable requirements**.

Enable more **productive value engineering** for tunnels to **decrease cost** while **increasing optimization** of material inputs and resources through **connected analytical models**.

A whole of life subsurface digital twin approach that treats **ground information** and **knowledge** as a **value asset**.

Tunnels have never been more sophisticated, and tunnel design and engineering has never been simpler, faster, or more intelligent than with the complete, connected workflow of Bentley and Seequent solutions.

Getting Started

Seequent is The Bentley Subsurface Company, and Bentley is the infrastructure engineering software company. Together, we provide all the solutions that you need, all designed to work together, and to work the way you do. We make it easy for organizations to find the product licenses that offer the best options, affordable prices, and the training that you need to be successful.

LEARN MORE ABOUT EACH PRODUCT WITHIN OUR TUNNELING WORKFLOW SOLUTION SET:

- **OpenGround**
- **Leapfrog Works**
- **OpenTunnel Designer**
- **Seequent Central**
- **PLAXIS**
- **iTwin Platform**

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