

Speed, ease and accuracy: Geotechnical tunnel modelling with PLAXIS

Detailed, accurate, and efficient geotechnical models, in your hands faster



PLAXIS®



Fast, detailed, pain-free geotechnical analysis for tunnelling and underground excavations

How PLAXIS makes sure that ease and accuracy go hand in hand

The best geotechnical models are accurate. Adaptable. And produced rapidly, so that geotechnical engineers have the understanding they need to keep their projects moving and begin excavating with confidence.

No tunnelling project can go ahead without a clear, accurate assessment of the long-term impact of the excavation on soil and rock masses.

But turning initial designs into reliable, detailed models of shotcrete and reinforced concrete linings and reinforcements isn't always easy. Without the right tools on your side, the simple process of modelling the safety and impact of a tunnel can bring your entire project grinding to a halt.

The result can be delayed projects. Frustrated engineers. And teams that waste valuable time struggling to build numerical models and run analyses, instead of doing what they really need to do: practical geotechnical engineering.

That's why we created PLAXIS.

For more than 25 years, PLAXIS has been making finite element analysis faster, smoother and more accurate for tunnel engineers.

In this eBook, we'll explore how PLAXIS helps engineers analyse soil, rock and associated structures with accuracy, speed and ease.

Accuracy

Advanced finite element analysis, based on deep geotechnical engineering expertise and sound computational procedures

Speed

Results generated, updated and shared rapidly, thanks to a state-of-the-art analysis engine and market-leading automation techniques

Ease

An intuitive interface and seamless integration with digital workflows makes model generation pain-free

Most importantly, you'll discover why so many geotechnical engineers around the world have made PLAXIS a core part of their workflows.

Let's dive in.

Regards,

The PLAXIS team

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Chapter 1: Meet PLAXIS

- A brief overview of PLAXIS 2D and 3D (and how they make building accurate, reliable models incredibly easy).

Chapter 2: Results you can rely on

- How PLAXIS uses industry-leading analysis and a wide range of modelling techniques to deliver reliable results.

Chapter 3: Smart automation, accessible design

- How an intuitive interface and advanced Python-based automation make it easier than ever for you to create, analyse and post-process models.

Chapter 4: Seamless digital workflows

- How PLAXIS integrates with software from across the Seequent and Bentley ecosystems to build more accurate models and speed up your projects.

Chapter 5: Dedicated customer support

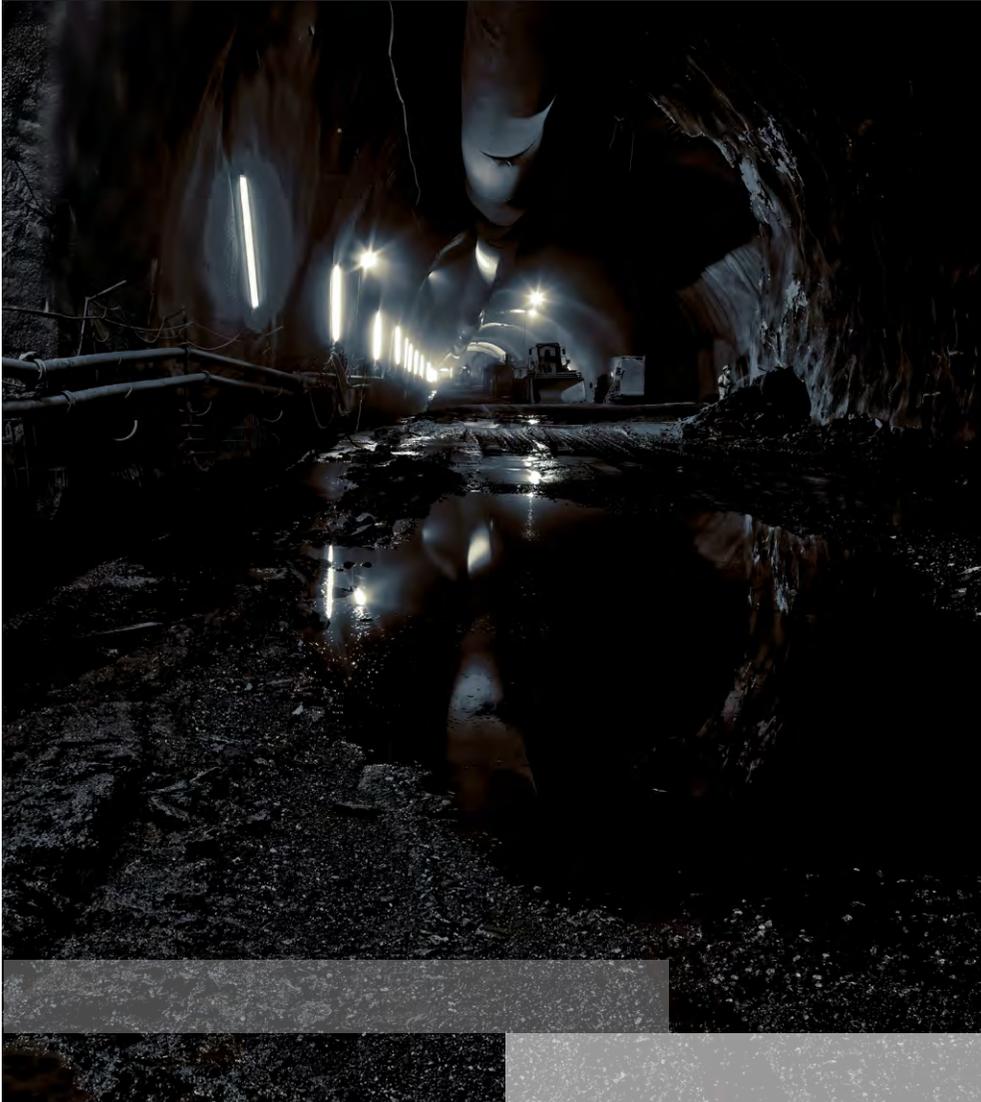
- How our customer support team and thought leadership go above and beyond to make sure you get the most value from PLAXIS.

Chapter 6: PLAXIS in action

- The full process of building a model and simulating an underground excavation in PLAXIS.

Meet PLAXIS

The faster, easier way to build accurate geotechnical tunnel models



PLAXIS is built to solve the problems that geotechnical engineers face every day – including the challenges of de-risking tunnelling projects.

So you can efficiently create, analyse and post-process tunnel finite element models – without spending hours correcting mistakes or repeating the same low-value tasks.

With PLAXIS, you can model and analyse every aspect of tunnel design.

- Define complex ground profiles and geotechnical cross sections
- Explore the impact of adding structural elements like steel sets, umbrella arches and rock bolts
- Analyse the effect of human-made or seismic vibration on soil, rock or associated structures
- Perform flow and/or deformation analysis to assess the impact of dewatering or any other sources of water level variations
- Organise tunnel construction elements efficiently in PLAXIS Tunnel Designer for optimised geometry definition, time-effective meshing, efficient phase generation and fast streamlined model creation



What makes PLAXIS special?

Over the next few chapters, we'll break down the features that make PLAXIS the best solution for geotechnical engineers.

More reliable results

By running complex analyses based on tried-and-tested techniques, PLAXIS allows you to model the construction and impact of your tunnel at new levels of accuracy.

More integrated workflows

PLAXIS is geared towards effective integration with software from across the Seequent ecosystem, using upstream data to build more accurate models, and feeding data from PLAXIS models into the next stage of design.

Smart automation

PLAXIS lets you fully automate the process of model generation using Python-based scripting. And, with more resources from the PLAXIS community available every day, automating your modelling workflow is becoming simpler and simpler.

Powerful and accessible

Every aspect of the PLAXIS interface is chosen to make building models smooth and simple – and to make it easy for you to start modelling straight away.

Expert customer support

Run into a problem? Looking for tips and tricks? Get fast, expert advice from our multidisciplinary customer service team, based all over the globe.

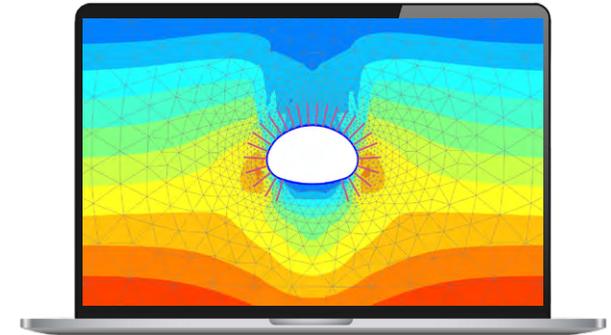
How deep will you dive?

Choose the PLAXIS software that's right for you.

PLAXIS 2D

Perform rigorous 2D finite element analysis of deformation and stability

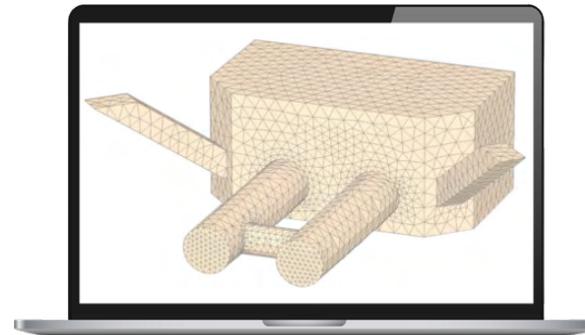
- Create models fast and analyse deformation and stability from sketching on the 2D plane
- Conduct cost-effective dynamic analysis
- Optimise excavation support and ground reinforcement through sensitivity analysis



PLAXIS 3D

Carry out accurate 3D finite element analysis of deformation and stability

- Build detailed, hyper-accurate models in 3D and explore the impact of your project from every angle
- Take advantage of geotechnical engineering and rock mechanics with fully automated meshing procedures and state-of-the-art solvers for cost-effective generation of output results
- Efficiently define geometry by importing sub-surface and tunnel components from other pieces of software in Seequent and Bentley's broad, connected ecosystem



Results you can rely on

How PLAXIS' hyper-accurate modelling helps you excavate with confidence



Spending hours triple-checking figures or doing manual calculations can be an enormous drain on time – and on a geotechnical engineer's patience.

When the safety of the project relies on your models, you need data you can trust completely.

That's why PLAXIS is built around the latest research, proven analysis methods and the field experience of the industry's best geotechnical engineers. And it pays off: our numerical models consistently line up with in-situ measured data from the sites of our customers' underground excavations.

The result? You can move to the next stage of your project with complete confidence that your tunnel will be efficiently designed and meet all your safety expectations

What makes PLAXIS analysis so accurate?

Industry-leading techniques

Every insight that PLAXIS generates is based on the finite element method (FEM), which has been tried, tested and proven by numerous independent studies and field tests.

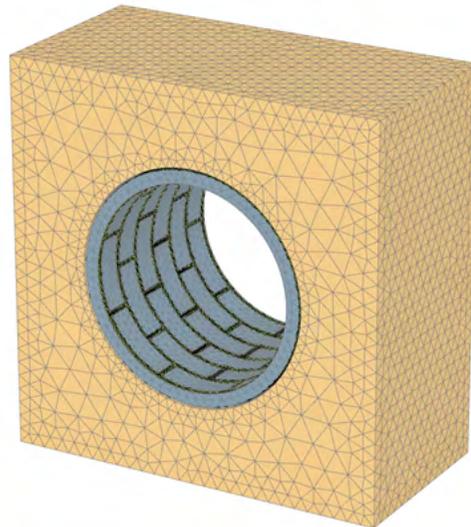
It also comes equipped with an automated meshing procedure that takes care of generating the appropriate mesh density at the right location using high order finite elements.

Advanced constitutive models

Model the impact of a tunnel's design on a large range of soil and rock types. PLAXIS goes beyond simple models to accurately simulate the behaviour of soil and rock, giving you a more accurate understanding of how the material responds to tunnel installations or excavations.

Take advantage of sophisticated constitutive models using specific features like:

- Strain and stress-dependency of stiffness
- Strain-hardening and softening
- Memory of pre-consolidation
- Critical state
- Creep
- Swelling and shrinkage
- Anisotropy, including multi-directional joint sets



User-defined soil models

Need a model that's not in our library? Program your own user-defined soil model (UDSM) to build more accurate predictions and deepen your analysis.

Water pressure modelling

Use powerful pore-pressure modelling features (based on Terzaghi's principle) and efficiently account for the behaviour of groundwater and its impact on your structure. PLAXIS can model:

- Drained behaviour
- Undrained behaviour using both effective stress and total stress approaches
- Dewatering and its influence on soil mechanical behaviour, taking into account permeability values, porosity, and unsaturated zone behaviour

Analysis from every angle

Explore every aspect of your tunnel's design. Choose from:

- Plastic analysis
- Safety analysis
- Dynamic analysis with optional consolidation analysis
- Fully coupled flow-deformation analysis

Accurate, robust results – also in natural ground

Compared to more stable engineering materials like steel and concrete, natural materials like rock and soil are highly unpredictable. Without sufficiently complex geotechnical analysis, your tunnel could face some potentially catastrophic problems:

1. Overprediction of soil's undrained shear strength
2. Inaccurate prediction of deformations and unrealistic predictions of actions on the lining and the settlements of the ground behind it
3. Uncontrolled settlement trough at surface level, tilting and potentially damaging buildings and structures above
4. Underprediction of volume loss

PLAXIS can model deformation and stability in most materials and environments, including in challenging materials like soil and rock.

PLAXIS uses advanced constitutive models like the Soft Soil model and the Hardening Soil model with small-strain stiffness (HSsmall) – ranging from simple linear to highly advanced nonlinear models, to accurately simulate almost any soil or rock type.

Smart automation, accessible design

How PLAXIS removes the roadblocks to efficient geotechnical analysis for tunnelling



Models are essential for de-risking any tunnelling project – but that doesn't mean geotechnical engineers should waste precious time struggling with unintuitive software or manually performing the same simple tasks.

But, without the right tools, the process of building, analysing and updating a model can be complex and time-consuming.

With state-of-the-art technology and market-leading automation, PLAXIS removes the roadblocks that make modelling time-consuming and makes it easy to spin up detailed, accurate models.

“

“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.”

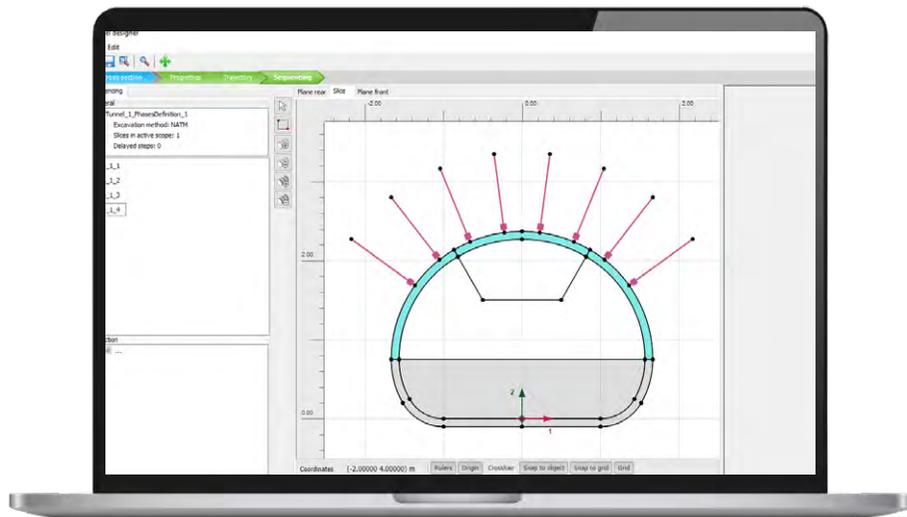
– Şerban Nicolau
FEM Design Engineer, SAIDEL Engineering.

User-friendly design

Advanced analysis, wrapped up in user-friendly design. PLAXIS puts all your most-used tools at your fingertips – and makes it easy to add data, update designs, or dive deeper into your analysis.

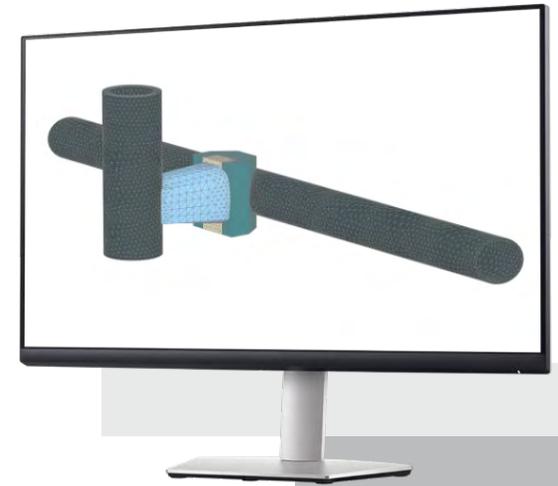
Modelling

- Design arbitrary geometries using Combine, Intersect, Extrude, Loft, Blend Surfaces, and Revolve around axis tools
- Polar and rectangular array
- Tunnel Designer with easy definition of rock bolts, umbrella arches and girders
- Define the excavation sequence in the Tunnel Designer
- Generate staged construction phases for tunnels automatically
- Elastoplasticity analysis for beams and plates
- Activate and prestress cable bolts



Mesh creation

- Automatic Swept Meshing helps you create efficient meshes faster
- Manual mesh refinements give you total control
- Automatic generation of irregular, regular or swept meshes
- Capabilities to support inspection of mesh quality

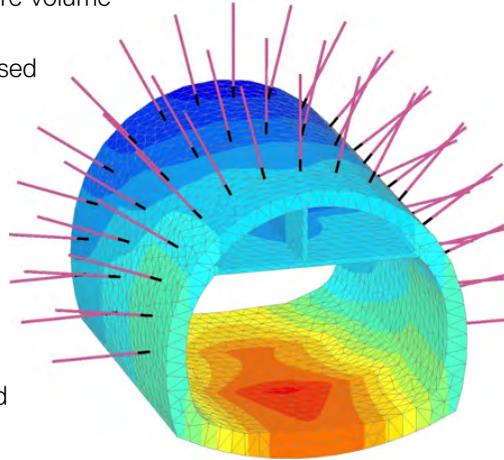


Calculating

- Well-proven and robust calculation procedures
- Multicore computing
- K0, gravity loading and field stress for initial stress calculations
- Displacement, coupled flow-deformation and safety analysis
- Facilities for steady-state or transient groundwater flow calculations, including flow-related material parameters, boundary conditions, drains, and wells
- Pseudo-static and dynamic analysis, including dynamics with consolidation and free field and compliant base boundary conditions, and moving point or line loads
- Specify load, acceleration or head variations through time with linear, harmonic, or table functions
- Convenient and intuitive phase explorer
- Automatic regeneration of construction stages for geometric changes

Analysis of results

- Get a realistic assessment of stresses and displacements
- See vector, contour, and iso-surfaces plots of displacement, stress, pore pressure, or acceleration
- Analyse structural forces from cylindrical and square volume piles
- Use Curves Manager to see the displacement caused by different loads
- See pseudospectral acceleration plots or cross-section curves
- Dive into the analysis with advanced data slicing
- Explore from every angle with movable cross-sections
- Extensive report and movie generator for easy, efficient data sharing
- Share the results of projects with stakeholders and investors via PLAXIS' free Output Viewer



Advanced automation

PLAXIS fully automates the model generation process, from model build-up to results extraction and reporting.

Python-based scripting lets you automate your most commonly used processes in both the Input and Output program, so you can save time by cutting down on lower-value, time-consuming jobs like:

- **Variable changes**

Create scripts that predict the impact of changes to variables like soil competency or concrete thickness.

- **Frequently used material parameters**

Modelling lots of similar structures? Entering the same material parameters over and over again? Create a script that reads material parameters straight from your company database.

How to script with PLAXIS

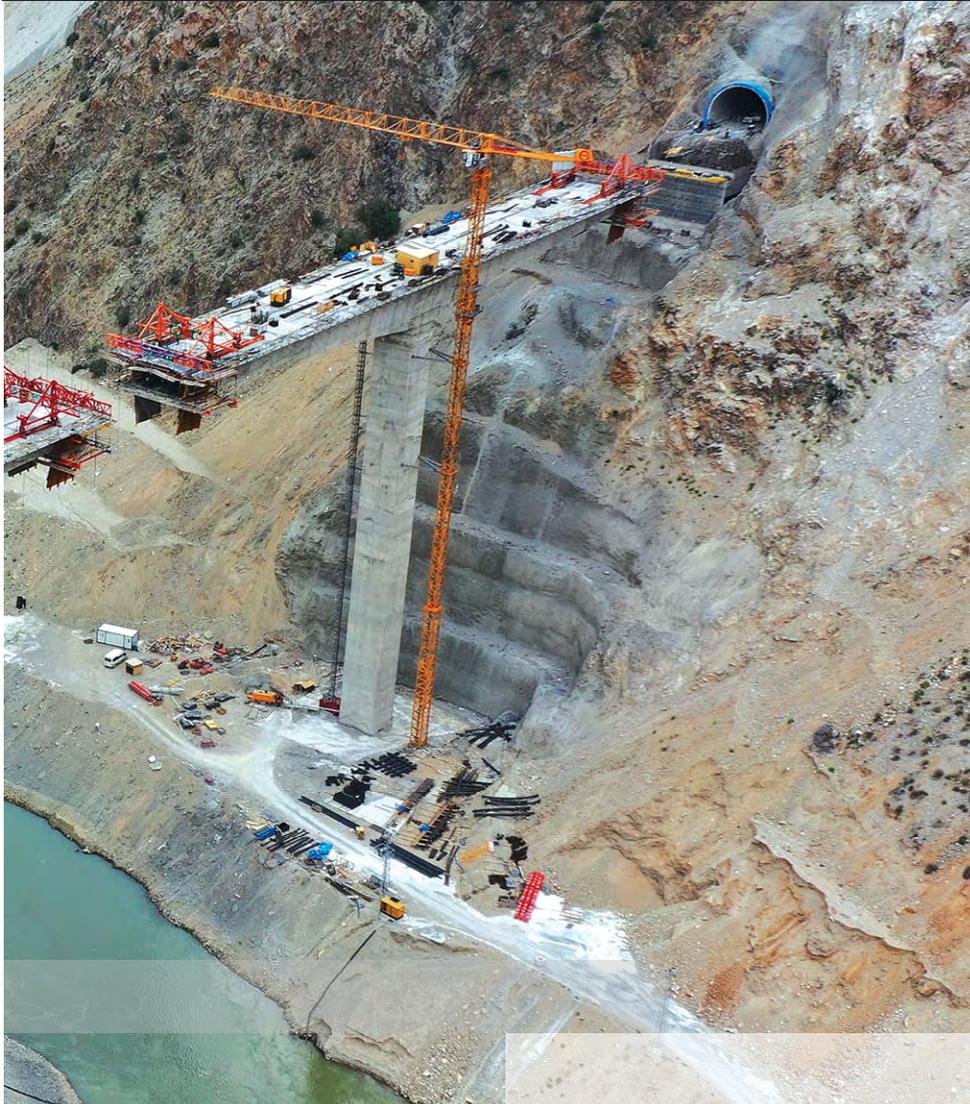
Automating the tunnel modelling process with PLAXIS is simple for anyone with a basic knowledge of Python.

Know what you want to automate? In less than 10 steps, you'll have a new script up and running.

1. **Identify the command you want to run.** You can use the Graphic User Interface (GUI) to check the command line session, or head to Help > Command reference to check you're on the right track.
2. **Go to the PLAXIS Input program.** It's here that you'll configure your script.
3. **Open the Help menu and select 'Scripting reference'**
4. **Set up the configure remote scripting server window**
5. **Find the command for Input or Output.** This list is arranged in alphabetical order, so it's easier to find what you're looking for.
6. **Click on the command name.** This will open an example in a new tab.
7. **Select cell > Run All**
8. **Jupyter notebook runs the example and provides the response(s) from PLAXIS**
9. **Check PLAXIS Input/Output to see the example**
10. **Put the script to work,** adapting the example to the problem or process you wish to address with automation.

Seamless digital workflows

How PLAXIS slots into (and upgrades) your geotechnical engineering process



The more data you feed into your model, the more accurate your analysis becomes. But moving data from one piece of software to another often costs precious time. How much time do you lose transferring design data into your tunnel model? Or making updates to your model when design requirements change? Or passing on the results of your analysis to the next stage of the project?

Effortless, seamless digital data flow

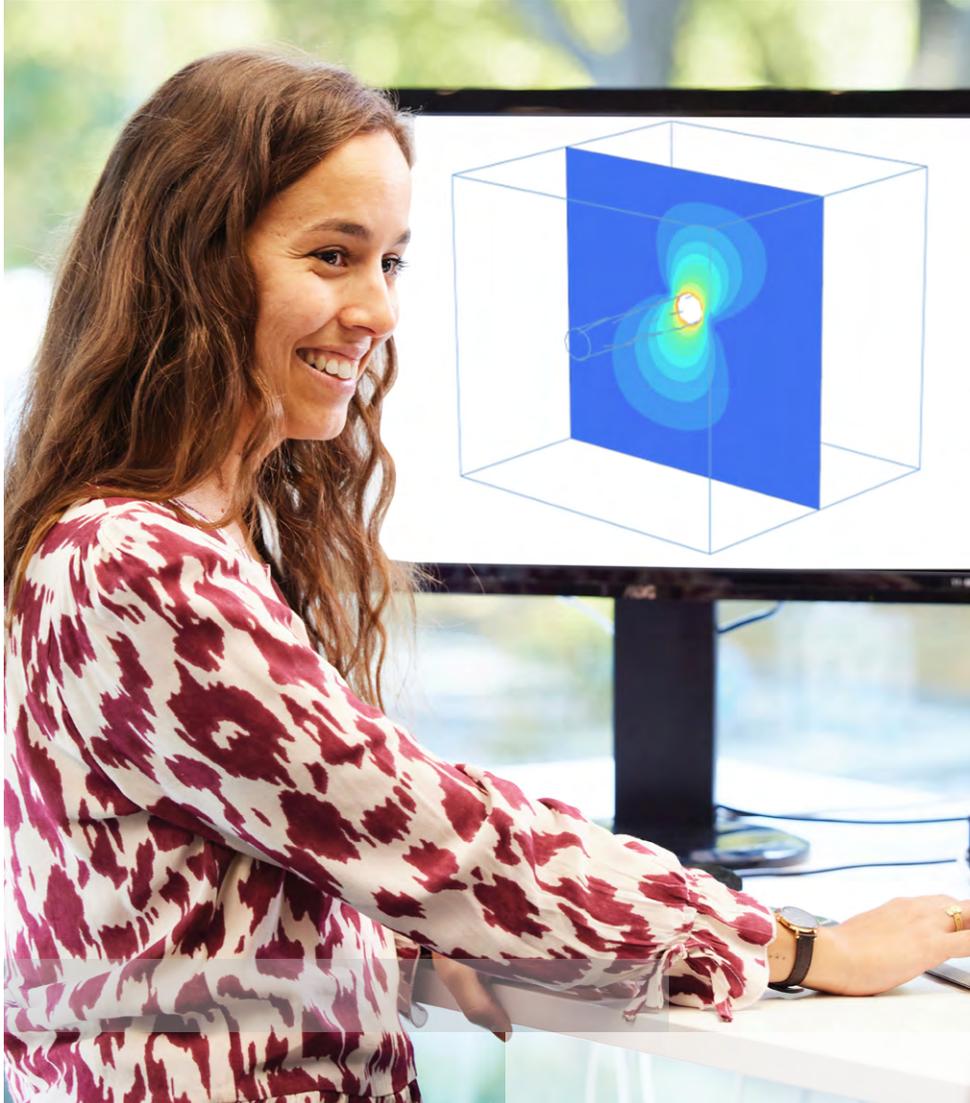
Because PLAXIS is part of the Seequent and Bentley ecosystem, it's geared to integrate with the most popular platforms for everything from geological modelling to digital twin generation.



- Expand your model with geotechnical information obtained from site investigation, surveys and plans
- Deepen your analysis with geological modelling data pulled from Leapfrog
- Create your entire tunnel infrastructure model in OpenTunnel Designer and generate an analytical model in PLAXIS with a click of a button
- Perform limit equilibrium slope stability analyses with GeoStudio
- Pass on the results of your analysis to other teams

Dedicated customer support

How the expert PLAXIS support team helps you get the most from your software



Got a question about PLAXIS? Looking for ways to play around with Python scripts or expand your models? Our customer support team is always here to help.

- **Backed by geotechnical engineering expertise**
We're not just experts in PLAXIS. Our support team is made up of geotechnical engineers with deep industry experience.
- **Worldwide support**
No outsourced call centres. Just local, dedicated support. Our support teams are based all around the world, so you can reach out to someone in your region.
- **Fast response**
We'll never let unresponsive customer support slow down your project. We'll get back to you fast and help you solve the problem as soon as possible, so you can get back to work.
- **Bespoke support**
We don't do one-size-fits-all advice. We'll get to know you, your project, and your processes, so we can provide bespoke support on everything from implementing PLAXIS to the right model type for your project.

PLAXIS in action

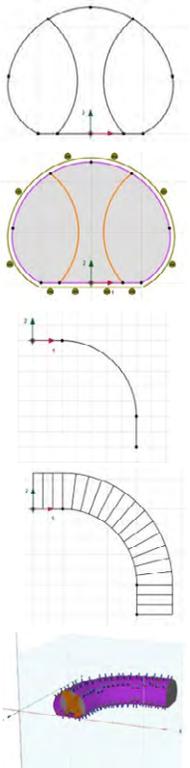
How to design and analyse your tunnel in PLAXIS



Now that you're familiar with the features that make PLAXIS one of the industry's most popular geotechnical simulation platforms, we'll show you how it works in practice.

Let's run through the process of modelling a tunnel, step by step.

- 1. Use Tunnel Designer to define the tunnel geometry**
Enter values for the contours of your tunnel, its positioning, and your engineering materials. Define the frontview geometry of your tunnel and create inner excavation contours.
- 2. Generate and place structural elements**
Define the makeup of rock bolts and other structural elements and their placement on your tunnel.
- 3. Define the trajectory of your tunnel**
Here is where you'll set the trajectory of your tunnel in topview.
- 4. Define the sequencing in 3D**
Enter staged excavation mode and simulate the excavation slice by slice. You'll be able to assess the deformation of the surrounding rock or soil and the overall impact of your design choices at each stage of the excavation.
- 5. Generate your tunnel**
Time to put it all together and turn all of the parameters you've entered into a complete model.

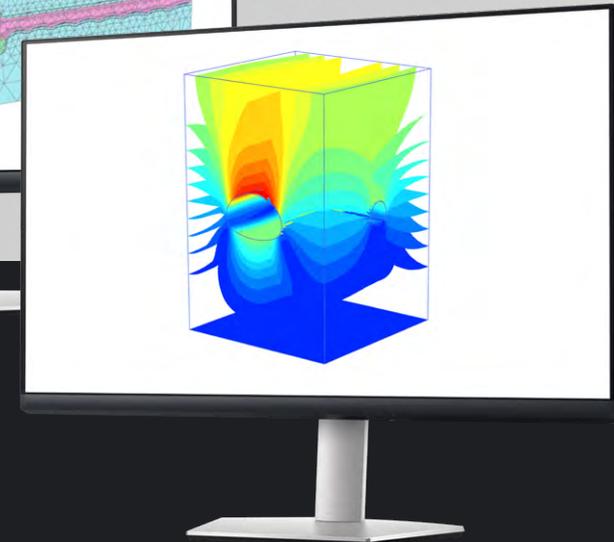
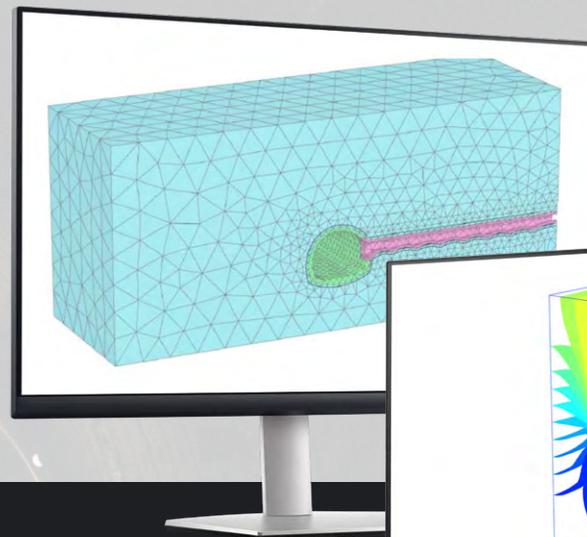


Ready for easier, more accurate tunnel modelling?

Faster. Easier. More accurate. It's time to upgrade your tunnel analysis software.

Whether you are considering traditional or mechanised excavation techniques, shotcrete or precast concrete segment lining, PLAXIS makes it easy to quickly understand the impact of your design choices.

Ready to join the engineers worldwide using PLAXIS to de-risk their tunnelling projects?



**Your free trial of PLAXIS 2D or PLAXIS 3D
is waiting for you.**

Get started



A better understanding of the Earth
creates a better world for all

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