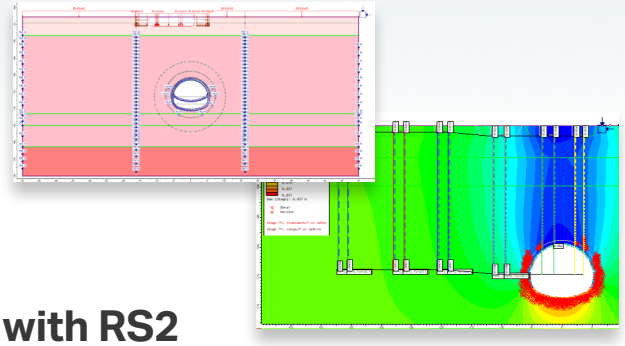
ROCSCIENCE



WEBINAR

Mastering Tunnel Design and Analysis with RS2

Q1: How does RS2 account for hydraulic conductivity, strength, and stiffness changes due to water content changes?

A1: Hydraulic Conductivity can be affected by using different conductivity functions in RS2 (e.g., van Genuchten) that depend on the matric suction and water content. Strength of material can be affected by Phi_parameter for unsaturated cases. The definition of effective stress can also be related to the degree of saturation.

Q2: When do you recommend switching from 2D to 3D modeling? What's the order of magnitude of the differences for stress distribution, settlement, etc between 2D and 3D?

A2: Choosing between 2D and 3D modeling in geotechnical analysis is not simply a matter of accuracy—rather, it fundamentally depends on the nature and complexity of the problem at hand. For projects involving long, uniform structures such as tunnels in homogeneous ground, a 2D plane strain model in RS2 is typically more than sufficient. However, for complex geometries or boundary interactions (e.g., metro stations, intersections), 3D becomes essential for capturing real stress redistributions and failure mechanisms.

Q3: Is there a guide on core softening simulations?

A3: Yes, there are tutorials on the subject in RS2 help and documentation.

Q4: Question for Gabriela. Do you integrate Python scripting in your work with RS2?

A4: Yes, we are currently integrating Python scripting into our workflow with RS2. We've developed a script that reads material parameters from Excel and inputs them automatically.

Q5: Is there an RS2 guide on core softening simulations?

A5: Yes, Alireza's presentation covered this and RS2 includes a tutorial: "3D Tunnel Simulation using Core Replacement" which models tunnel deformation using modulus reduction.

Q6: Is there any difference between the load split and core softening in the result?

A6: They are not exactly the same, but both effectively capture similar effects.

Q7: Hello, Andrea here: Have you ever modeled a tunnel with a primary and a final liner, where the primary liner needs to be "deactivated" to check the forces acting only on the final liner?

A7: Yes, RS2 allows for this using the composite liner feature. You can stage installation/removal and observe stress redistribution once the primary liner is removed.

Q8: Does RS2 integrate with other geotechnical software or BIM platforms to streamline the tunnel design workflow?

A8: Not currently, but integration with internal and external tools is being developed.

Q9: Is there a way in RS2 to apply time series of displacement or stress inputs for cyclic or dynamic analysis?

A9: Yes, displacements can be applied and staged.

Q10: Does RS2 allow implementation of user-defined constitutive models?

A10: Yes, user-defined material models can be implemented.

Q11: What is your recommended approach for modeling excavation or blast-induced damaged zones?

A11: Model as softened elasto-plastic zones with reduced stiffness and strength. RS2 supports this through custom materials or joint models.

Q12: For relaxation simulation, is it also applicable to straight wall tunneling if it's related to radius of tunnel geometry?

A12: Yes, the concept is applicable.

Q13: Can we do overbreak prediction numerical analysis in RS2?

A13: Yes, through plastic zone analysis or fracture networks. For complex 3D cases, consider RocTunnel3 with ShapeMetriX.

Q14: Can we do creep analysis in RS2 by reducing modulus value as a time-based relationship?

A14: Yes, you can stage modulus and other properties to simulate time-dependent behavior.

Q15: How can we address the spiling dowels used during tunneling through weak rock mass in RS2 modeling?

A15: Define a region for the dowels and use stronger equivalent material.

Q16: What on-field parameters/testing can be used as input to ascertain soil parameters in back analysis?

A16: SPT, CPT, pressuremeter, vane shear, plate load, pump tests, along with monitoring data like settlement plates, inclinometers, and piezometers.

Q17: What precautions should we take when encountering a transverse structure causing large water leaks during tunneling? Can this be simulated in RS2?

A17: In practice, adjust excavation sequencing and prepare for grouting or dewatering. In RS2, simulate with transient seepage analysis using varied permeability, drainage bolts, and discharge sections. See Alireza's LinkedIn post for examples here.

Q18: Any recommendations for 3D tunnel advance when using a joint network, when you have explicit joints in the model—how would you do the convergence-confinement analysis?

A18: The methods presented can be applied to this scenario as well. However, this is a more complex situation. There should be more consideration, as the individual 3D blocks cannot be fully modeled in 2D. Other 3D tools are available for these cases.

Q19: Thanks for introducing Python scripting. We worked with it but had a lot of issues—there are mismatches between the packages. Is there an issue forum (like GitHub) where we could report this and get help?

A19: Great idea. A forum is something we've been discussing internally and hope to implement soon. For now, please use our technical support channel—our team will be happy to assist.

Q20: Based on your experience, what is your allowable strain (deformation) percentage to decide at what stage to install the support?

A20: This depends on soil/rock properties, yield radius, tunnel radius, and excavation step. For elastic behavior, it's assumed you have at least 30% of the final displacement before support installation. Refer to longitudinal displacement profile (LDP) literature: Panet (1995), Corbetta et al (1991), Clachopoulos & Diederich, Carranza-Torrez & Fairhurst (2000).

Q21: When should we use axisymmetric analysis? Can we compare it to plane strain analysis?

A21: Use axisymmetric analysis when the geometry is rotationally symmetric (e.g., circular shafts). It simplifies 3D problems using a 2D approach. Plane strain applies to long structures where geometry doesn't vary along one direction.
RS2 has a tutorial comparing both here.

Q22: Can you clarify how to determine stress relaxation in a 2D model?

A22: This RS2 tutorial walks through it step by step here.

Q23: Can you share links or examples of real tunnel design reports that show how to integrate models and results into a report?

A23: Yes. This paper is a good example here.

Q24: Is there a crude (hand-check) method to verify modeling results?

A24: Not for full models. FEM is used because hand calculations become impractical. However, simplified hand checks (e.g., beam deflections, bending moments) can validate portions of the model. Also, building a simplified version of your model in software can help you understand and verify behavior.

Q25: Have you used the Hardening Soil (HS) model in RS2? Is it effective?

A25: Yes, we've used it. It's more advanced than Mohr-Coulomb, better capturing nonlinear behavior—but requires more input data (e.g., from advanced lab tests). Without such data, estimated parameters may introduce uncertainty. Often, using a simplified Mohr-Coulomb model with refined stiffness estimates is more practical if only basic field data (like SPT) is available.

Q26: There's a loading field stress issue—gravity loading doesn't seem to use material unit weight.

A26: RS2 offers several loading options:

- Field Stress Only: Ignores unit weight
- Body Force Only: Uses material's unit weight
- Field Stress & Body Force: Applies both
- None: No initial loading

More here.

Q27: How do we model the arching effect in 2D?

A27: 1. Transversal (cross-sectional): Use plane strain
2. Longitudinal: Use axisymmetric
3. Use the "Principal Stress Trajectories" tool in RS2 to visualize the arching effect.

Q28: During core softening/internal pressure methods, the model sometimes fails to converge at a load factor of 1. What stage should be used to determine maximum closure?

A28: Use the last converged stage as the reference. Support installation should occur well before this point.

Q29: Can we model excavation step and support installation time lag together in 2D with stress relief? Also, is Mohr-Coulomb suitable for residual soils?

A29: Tunneling simulations are complex, and model complexity should reflect the project's risk level. If advanced data isn't available, a calibrated Mohr-Coulomb model can outperform poorly informed advanced models. Choose a model that matches your available data and site conditions.

Q30: LDPs are based on circular tunnels under isotropic stress. How do we adjust for non-circular tunnels under anisotropic stress in 2D?

A30: LDPs and CCMs are approximations. Applying them directly to non-circular or anisotropic cases may not be accurate. Use engineering judgment or switch to 3D modeling when needed. See:

- Application of Convergence–Confinement Method in Analysis of Shallow Non-circular Tunnels
- Appropriate uses and practical limitations of 2D numerical analysis of tunnels

Q31: If there are impermeable liners between support and ground, can RS2 add water loads to the lining?

A31: Yes. You can define joint interfaces and assign them impermeable properties. RS2 will apply water pressure to the liner accordingly.

Q32: If a tunnel has both shallow and deep cover, how should we model it in 2D?

A32: Use separate 2D sections to represent each cover depth. Set field stress accordingly—gravity for shallow, constant stress for deep. Compare scenarios to determine where design approaches need to shift.

Q33: How do we model pressure shaft tunnels in RS2?

A33: Apply internal water pressure directly to the liner. Define impermeable joint interfaces if needed to separate the shaft from surrounding ground and simulate realistic pressure conditions.

Q34: How was the flow rate defined for boundary conditions with deep drains?

A34: Flow rate was based on field measurements. If unavailable, calibrate through sensitivity analyses using observed drawdown data.

Q35: What lab test is used to determine unloading modulus?

A35: Triaxial test with unloading cycles is standard. Choose the unloading direction and strain level appropriately for your analysis needs.

Q36: How long does it take to build and run a model like Gabriela's project?

A36: With all data ready, model setup takes around 1 hour. Run time ranges from 5 to 45 minutes depending on complexity. Back analysis takes longer due to iteration and calibration.

Q37: Can RS2 tunnel liner forces be trusted compared to other software or closed-form solutions?

A37: Yes. Liner forces from RS2 are consistent with other tools and closed-form methods. Differences usually stem from modeling assumptions. Always verify against codes and, when possible, with alternative methods.

Q38: How do you model rigidity interaction between piles and foundation?

A38: Use "Define Pile Properties" to select:

- Free: No interaction
- Hinged: Transfers force, not moment
- Rigid: Transfers both
- Semi-Rigid: Transfers forces and partial moment (define MMax)

Q39: Issue with HS model: can't get full parameters from lab tests due to cost. Any advice?

A39: This is common. If you lack lab data, estimating HS parameters introduces risk. Better to use a well-calibrated Mohr-Coulomb model with adjusted stiffness than use HS with weak inputs. Model complexity should match data quality.