



Calculation Methods for Tunnel Design

The objective of this training session is to present the design methods commonly used to assess tunnel stability.

Each method is illustrated by an example. Advantages and difficulties when applied to a tunnel project will be highlighted.

This course requires no prior knowledge or specific skills in numerical simulation or calculation methods as it is an introduction to these issues. Numerical Simulation is dealt with on a more in-depth level in the course programme entitled “Numerical Simulation for Tunnel Design”.

Session 1: 27th April - (9:00-13:00 CDT time (16:00- 20:00 CEST time))

09:00 -10:45 Chap 1: Introduction – Robert Galler (ITA-CET Committee chairman)

- Welcome and opening
- Introduction to the different types of ground: soil and rock (scale effects)
- Overview of the constitutive models for ground, concrete, steel and interfaces
(+ short/long term behaviour + sensitivity studies)
- Introduction to the different calculation methods

10:45-11:15 Coffee Break

11:15-13:00 Chap 2: Geomechanical classifications – Chrysothemis Paraskevopoulou

- RMR, Q system, GSI
- Failure criteria (Mohr-Coulomb, Hoek-Brown)
- Empirical Correlations
- Application fields and limits of the method

Session 2: 29th April – 9h00-13h00 CDT time (16:00- 20:00 CEST time)

09:00 -10:45 Chap 3 : Rock stability analysis - Chrysothemis Paraskevopoulou

- Structural analysis of the rock mass
- Stereographical projection
- Equilibrium
- Application fields and limits of the method

10:45-11:15 Coffee Break

11:15-13:00 Chap 4: Modulus reaction method – Nicolas Berthoz

- Active loads (Terzaghi...)
- Reaction modulus
- Lining modelling



- Lining design
- Application fields and limits of the method

Session 3: 4th May – 9h00-13h00 CDT time (16:00- 20:00 CEST time)

09:00 -10:45 Chap 5: Convergence confinement method – *Daniele Peila & Daniela Boldini*

- Principles of the method
- Determination of the ground reaction curve
- Determination of “lining confinement curve”
- Evaluation of the stress release coefficient
- Isotropic or anisotropic state of stress
- Application fields and limits of the method

10:45-11:15 Coffee Break

11:15-13:00 Chap 6: Numerical methods - *François Laigle*

- Continuous approach (FEM, FDM), discontinuous approach (DEM)
- Model definition : mesh, initial and limit conditions, loading
- Simulation of construction phases
- 2D numerical models in plane deformations: use of the decompression rate
- 3D numerical models
- Application fields and limits of the method

Session 4: 6th May – 9h00-13h00 CDT time (16:00- 20:00 CEST time)

09:00 -10:15 Chap 7: Face stability – *Wout Broere*

- Observed failure mechanisms
- Limit equilibrium methods
- Plastic limit analysis
- Application fields and limits of the method

10:15-10:30 Coffee Break

10:30 -11:45 Chap 8: Settlements – *Benoit Jones*

- Real ground movements around tunnels
- The Gaussian settlement trough – transverse and longitudinal settlements
- Estimating volume loss using the load factor approach
- Long-term settlements

11:45 – 12:00 Coffee break

12:00 – 13:00 Chap 9: Conclusion – *Robert Galler (ITA-CET Committee chairman)*

- Progressive use of the different methods in a tunnel project
- Relationship between the different approaches (empirical, analytical and numerical)