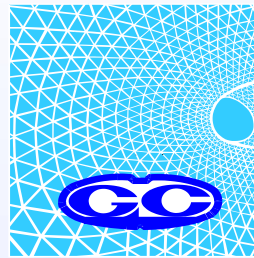


Tunnel Excavation Analysis

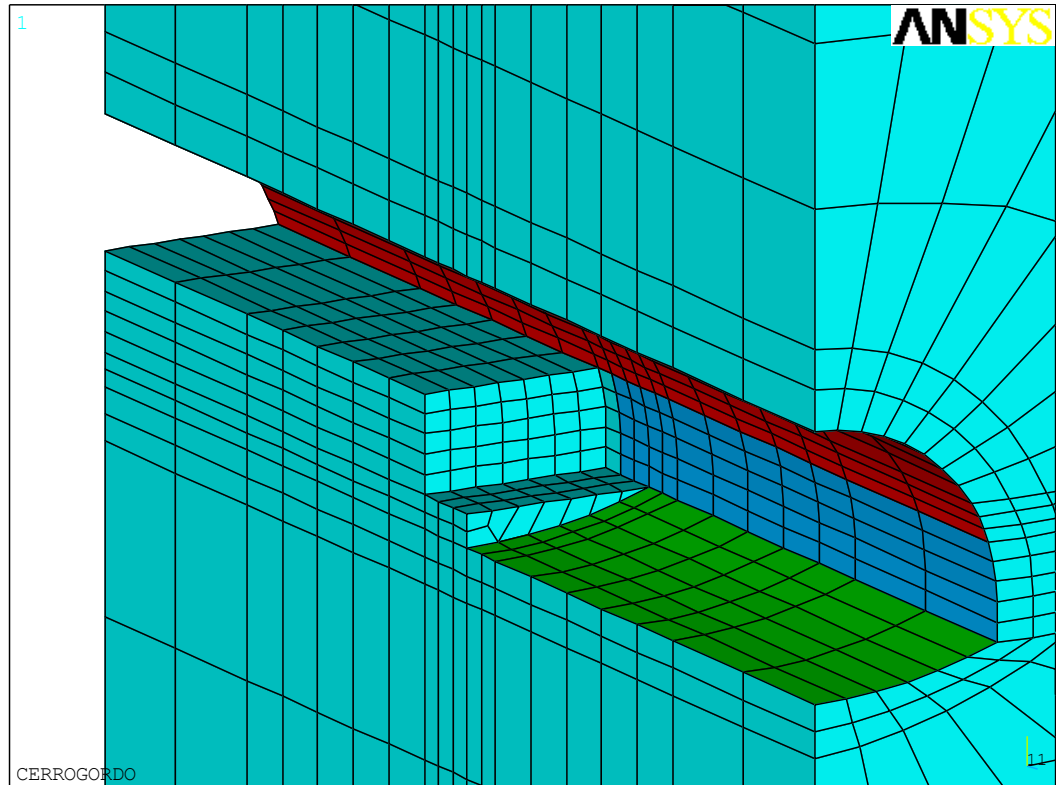


GEOCONSULT ESPAÑA
INGENIEROS CONSULTORES, S.A.

Courtesy of Geoconsult España

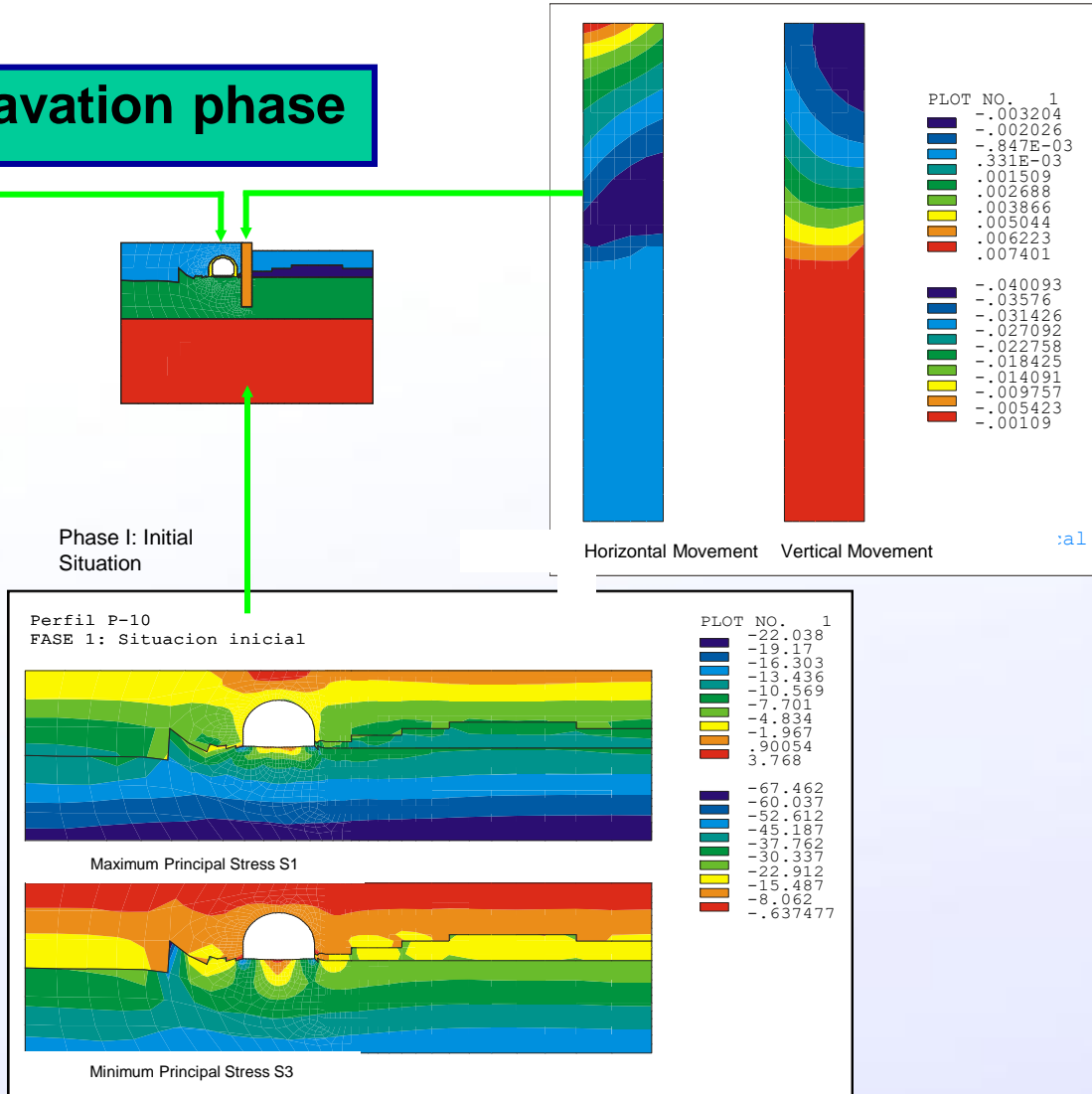
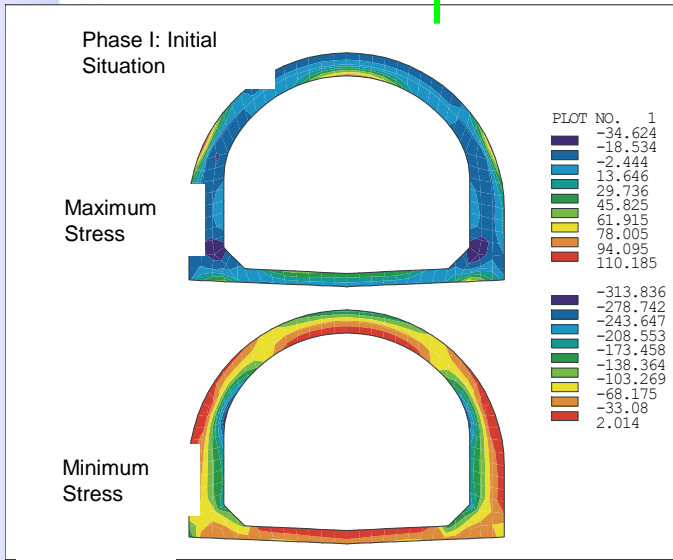
Tunnel Excavation Analysis

CivilFEM with ANSYS team up to simulate the excavation process and obtain the forces and stresses acting on the concrete arch, soil and anchorages.



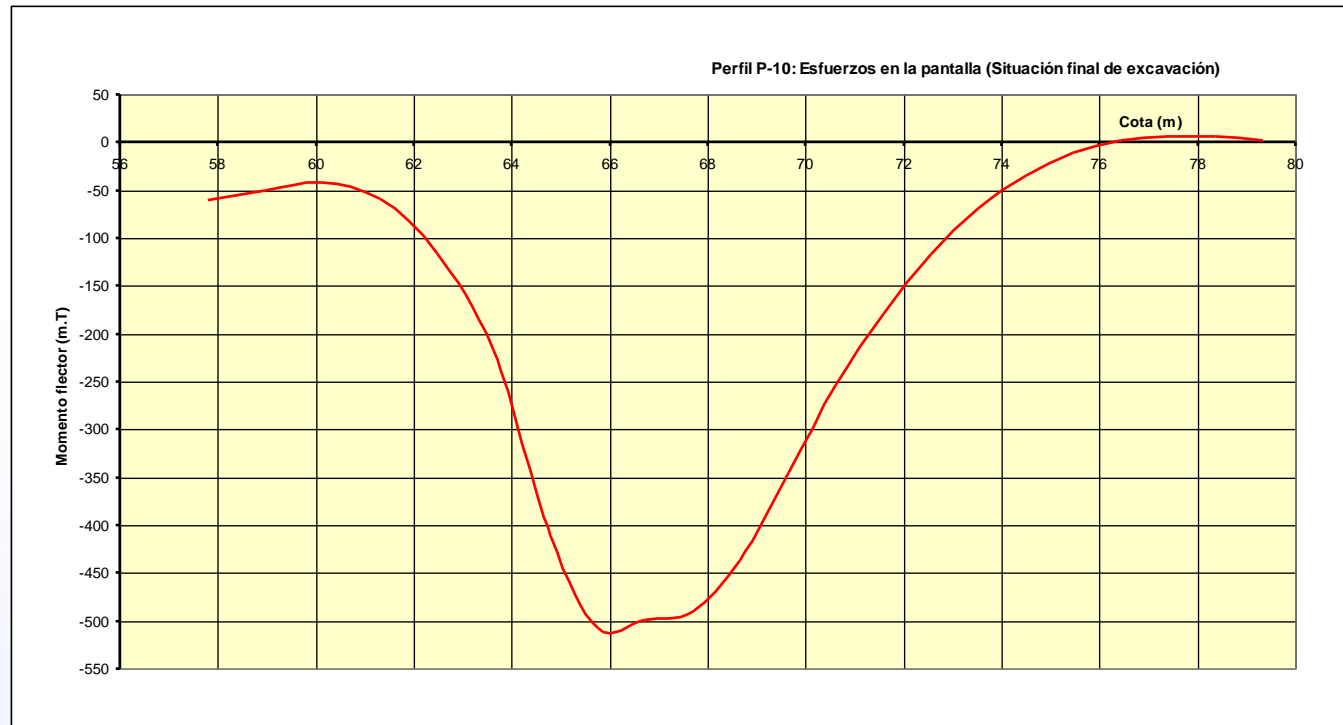
Tunnel Excavation Analysis

Excavation phase



Tunnel Excavation Analysis

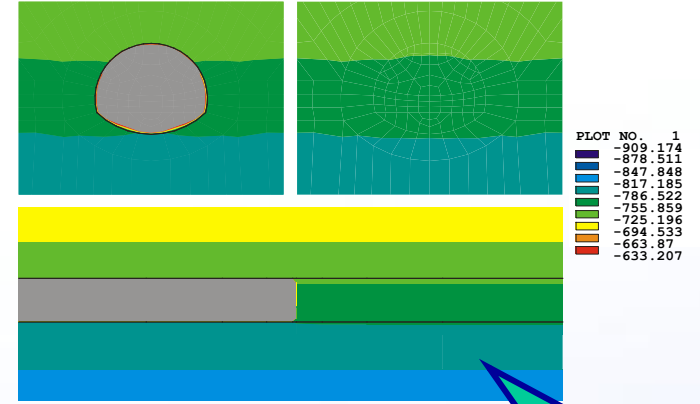
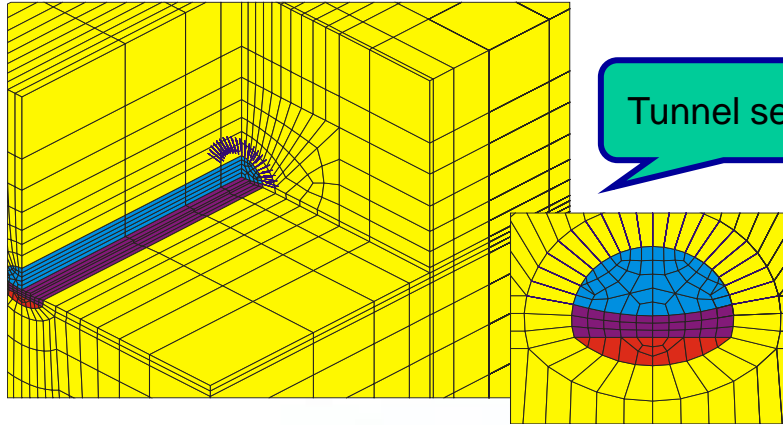
The graph shown below was obtained after running a finite element analysis of the excavation model.



Forces acting on the sheet pile at end of excavation phase

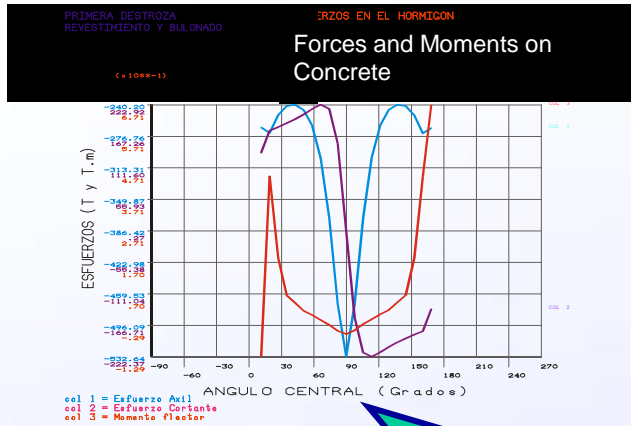
Tunnel Excavation Analysis

MODELO DE CALCULO: DETALLES

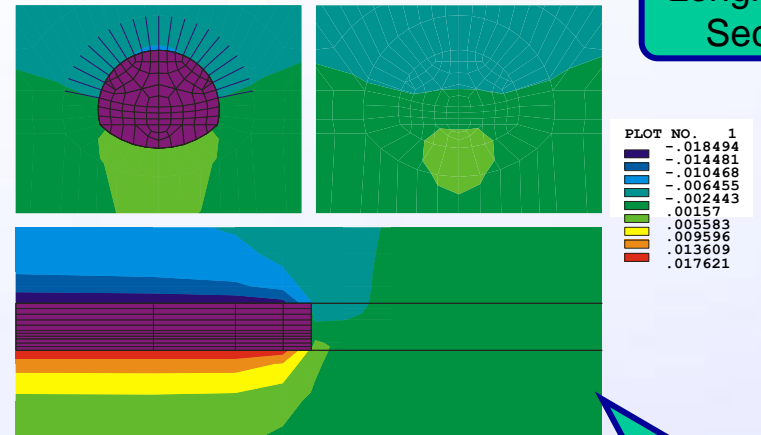


Vertical Stress. Tunnel Advancement

Longitudinal Section



Forces acting on concrete tunnel



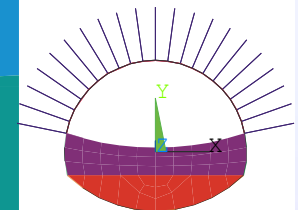
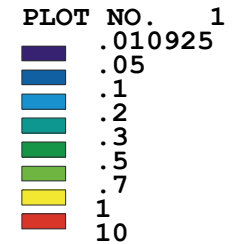
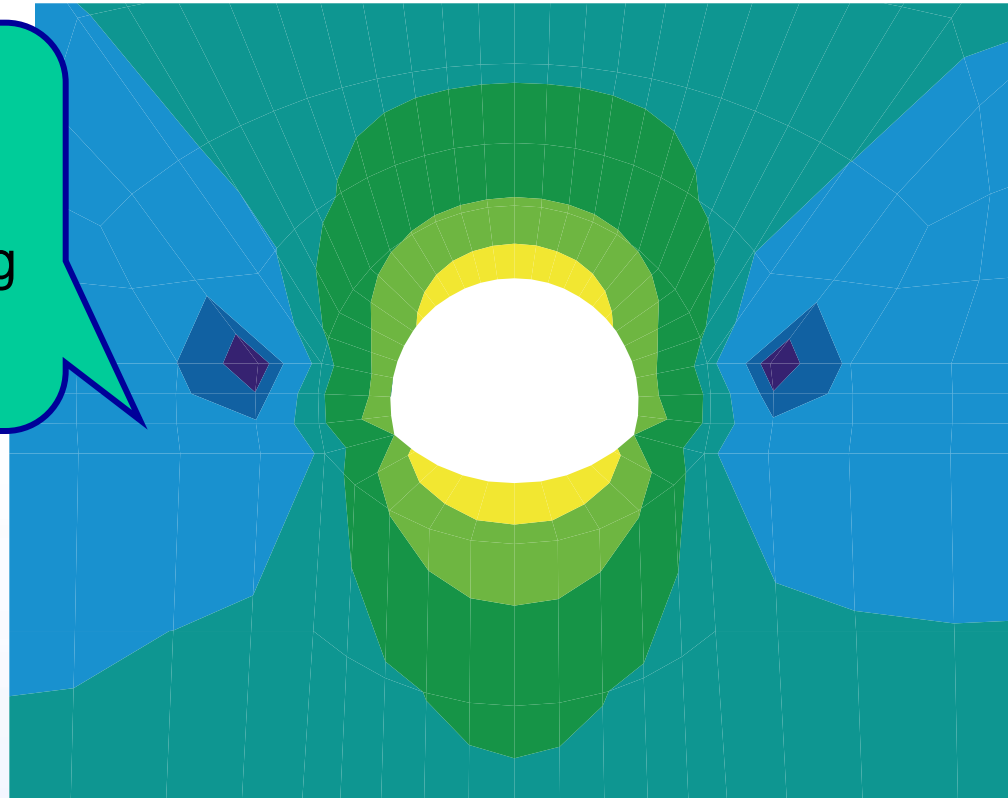
Vertical Movement. Tunnel Advancement

Longitudinal Section

Tunnel Excavation Analysis

Lining and Reinforcement

Safety Factor concerning Plasticity

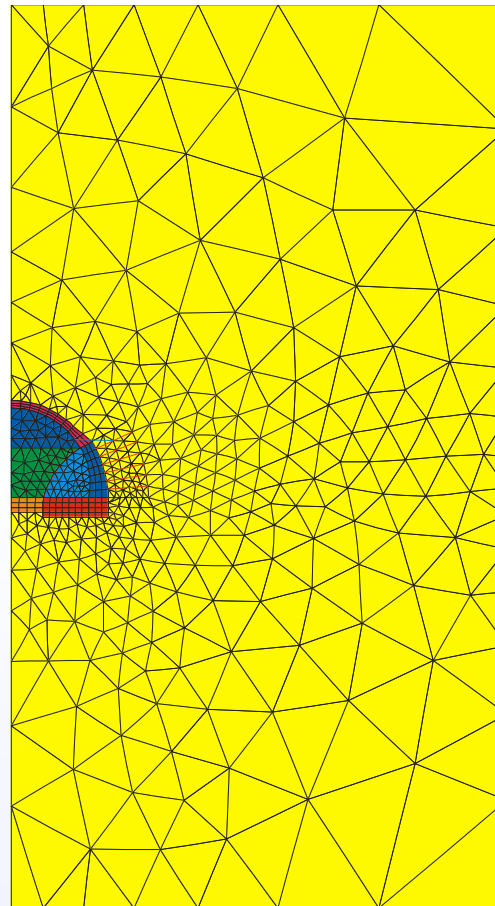


Inverse of Factor of Safety (>1 Plasticity)

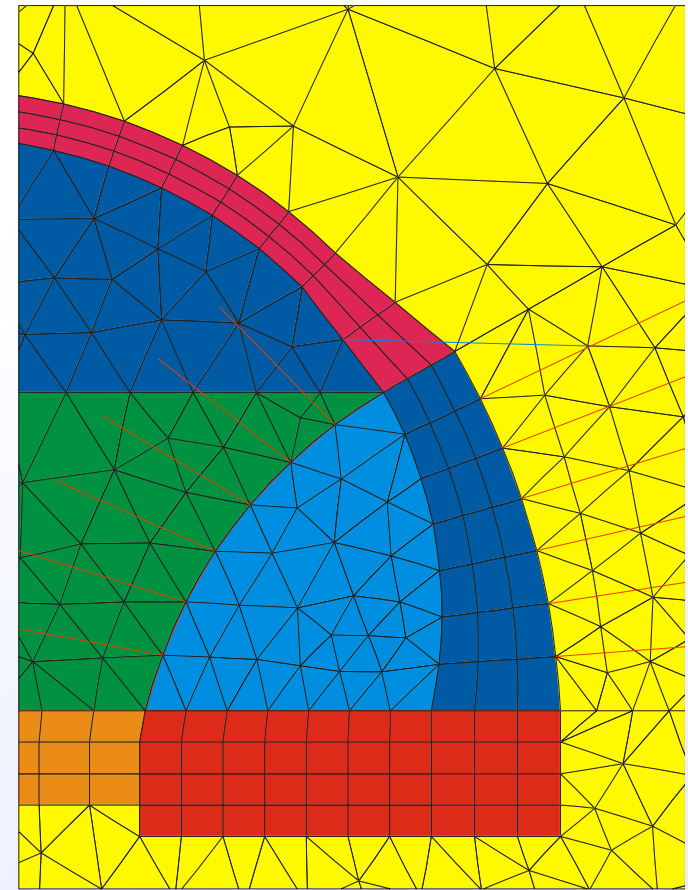
Tunnel Excavation Analysis

Model Geometry

CivilFEM with ANSYS meshing capabilities allow to combine simultaneously automatic and user defined meshes. This fact allows good simulation of the model's real behavior.



Complete model



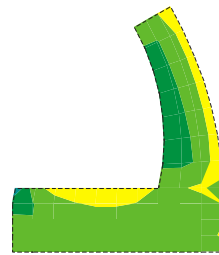
Detail

Tunnel Excavation Analysis

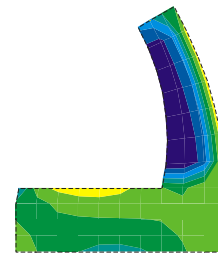
Revestimiento de Hormigón.
Tensión Principal S1

Concrete Lining
Principal Stress S1

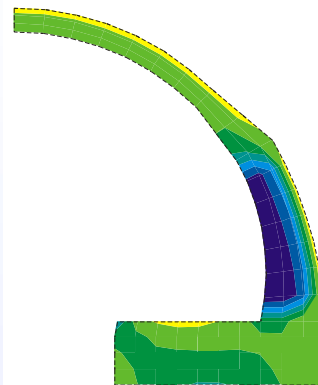
Stresses on concrete arch during the different construction phases



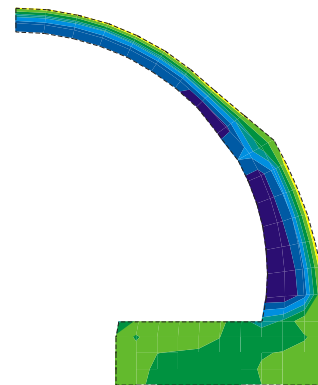
Fase 3



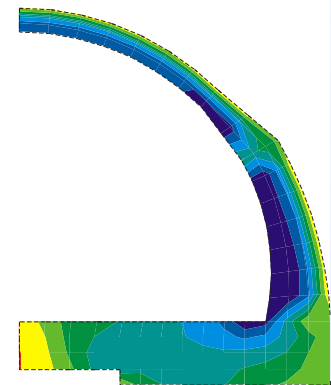
Fase 4



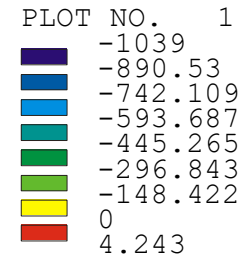
Fase 5



Fase 6

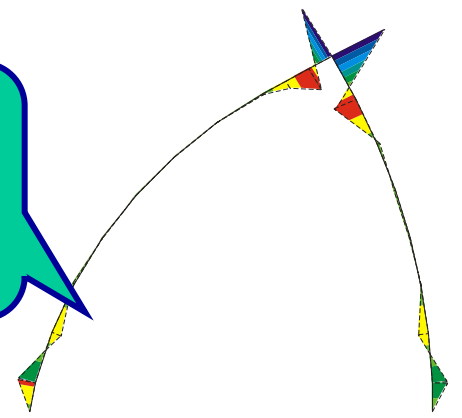
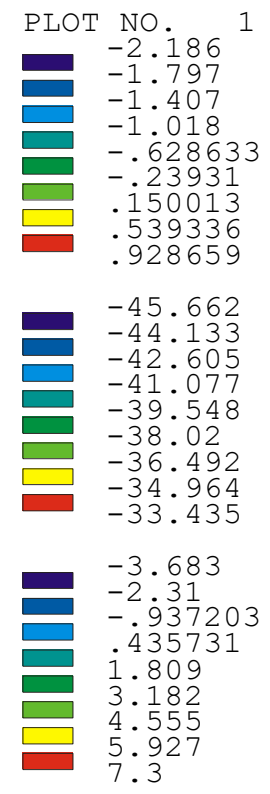


Fase 7



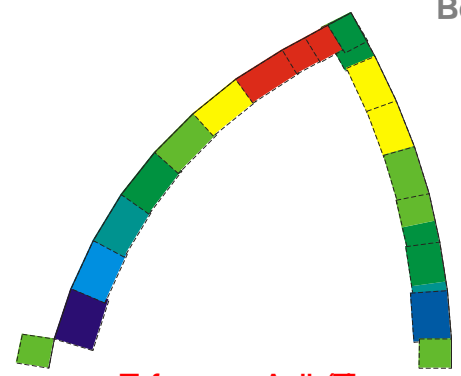
Tunnel Excavation Analysis

Fase 2: Gunita y Bulones Phase 2: Concrete Reinforcement
Esfuerzos en el homigón proyectado Forces and moments on Shortcreeet



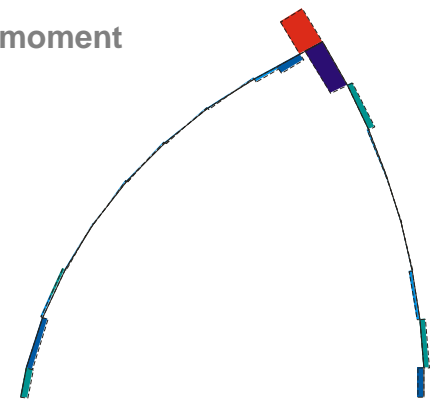
Momento Flector (m, T)

Bending moment



Esfuerzo Axil (T)

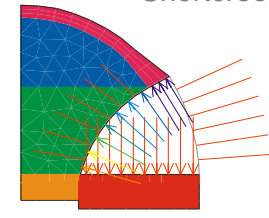
Axial Force



Esfuerzo Cortante (T)

Shear Force

Forces acting on projected concrete

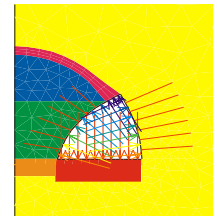


Tunnel Excavation Analysis

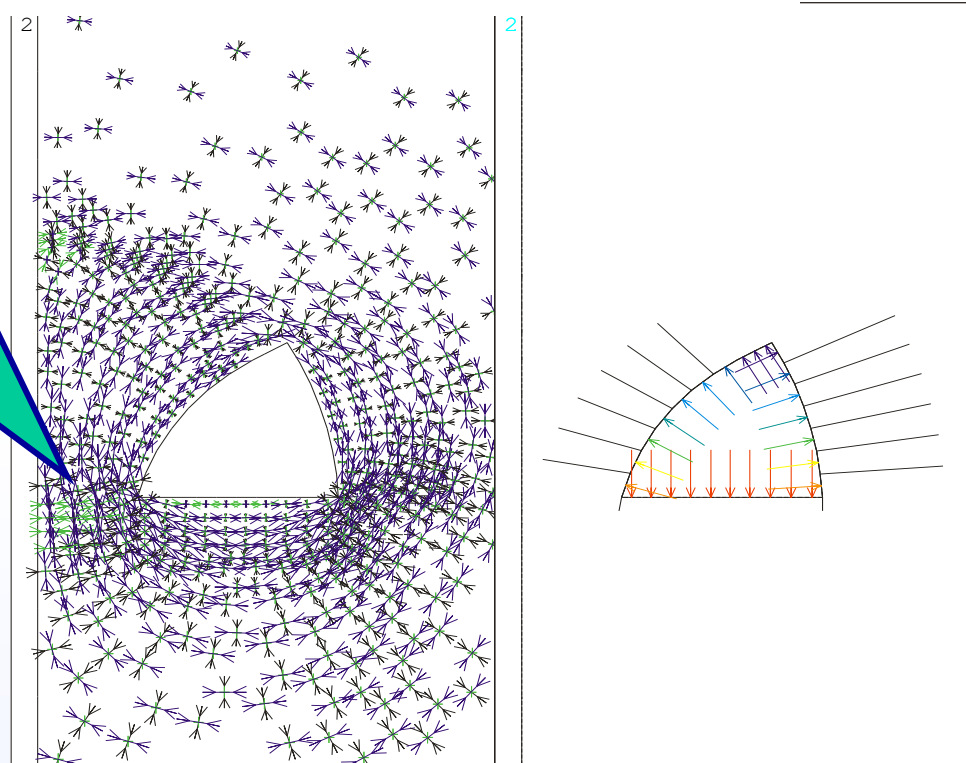
Phase 2: Soil Reinforcement

PLOT NO. 5

PRES
 20.305
 20.632
 20.959
 21.287
 21.614
 21.941
 22.269
 22.596
 22.923



Principal directions and plastic deformation



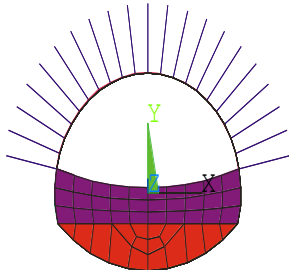
Direcciones Principales

Deformación Plástica

Principal Stresses
 Deformation

Plastic

Conclusions



- CivilFEM with ANSYS tools allow carrying out sophisticated and precise analysis to simulate excavation phases. Postprocessing of results, are automatically carried out for solid, beam and shell elements.
- Tunnel reinforcement is calculated and checked by code automatically using CivilFEM with ANSYS .
- Advanced analysis leads to cost and time optimization.
- Parametric analysis allows changing material properties and construction process easily.