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NUMERICS IN GEOTECHNICS & STRUCTURES
ZSOIL user meeting
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Zsoil in today's projects

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1. *INTRODUCTION*
2. *DIFFERENT PROJECTS – PROBLEMS - SOFTWARES*
3. *PHASE2*
4. *PLAXIS 3D*
5. *SOFISTIK*
6. *ZSOIL*
7. *CONCLUSIONS - DEBATE*

CONTENTS

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- Elea iC participates as part of several larger international teams of experts for designing and checking of bigger tunnelling projects in Europe.
- In terms of numerical analyses for underground structures various software packages are used.
- For every project different code is used, sometimes even two or three at the same time. Some options introduced lately in Zsoil gave us confidence and some problems are solved quite elegant, sometimes also with a help of reliable on-line support.
- During the course we realized that some additional improvements would make analyses even more sophisticated but realistic and simple at the same time.
- Short projects descriptions will be presented with emphasis on ZSoil capabilities and possible future development.

INTRODUCTION

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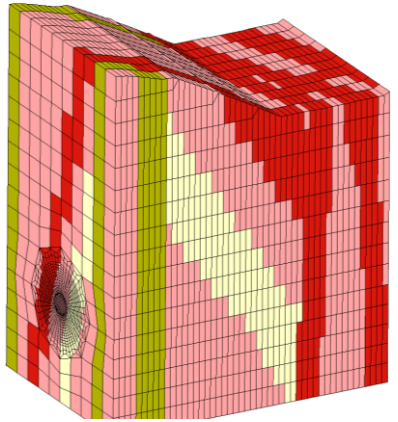
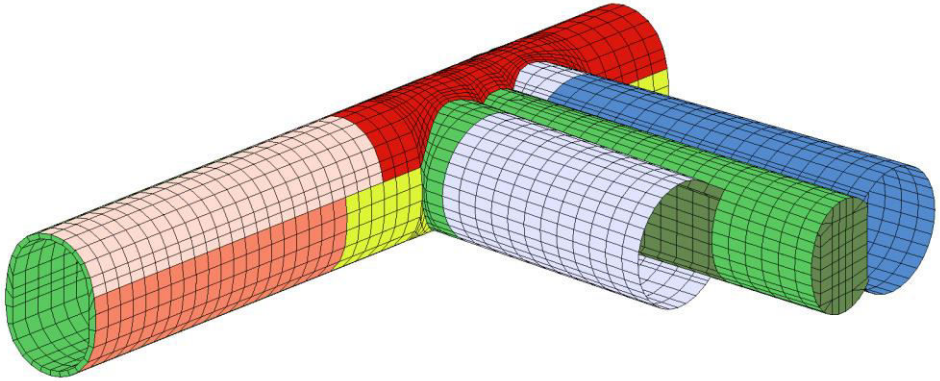
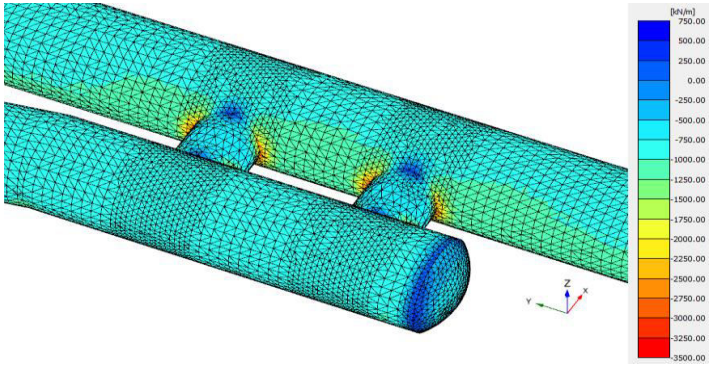
- Phase 2 due to design team requirements and some project specifics
- Plaxis (3D) due to design team requirements
- Sofistik due to clients requirements and ground conditions
- 3DEC
- Zsoil as preferred and in some cases as an „emergency exit“







VARIOUS REQUIREMENTS AND BC

- Different approaches to capture all load cases:
  - Full overburden - wished in place
  - Expected upper bound
  - Compensation grouting
  - Stability assessment analyses
  - For primary and secondary lining
- Time dependent lining stiffness
- Time dependent lining thickness
- Undrained and drained behaviour

- SCL works
- Crossrail (CRL) is a new east-west rail link across London
- The central section of the route passes beneath central London
- Six new deep stations; they are Paddington, Bond Street, Tottenham Court Road, Farringdon, Liverpool Street and Whitechapel.
- Outside of the central section, two further deep stations at Canary Wharf and Woolwich
- Cross passages, some ventilation addits and shafts

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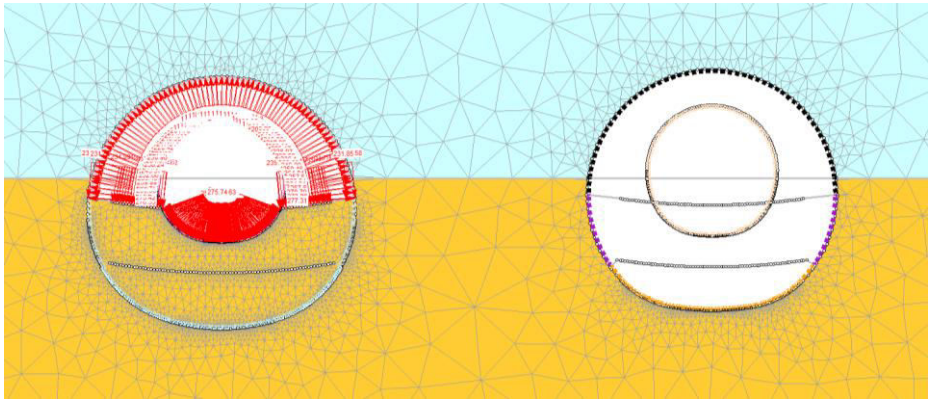
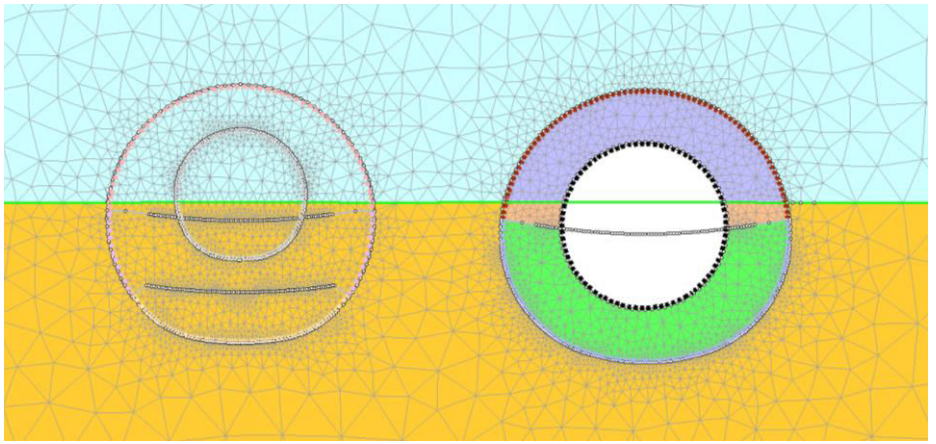
- Phase 2 for the majority of analyses
- Suitable for 2D problems
- Mohr-Coulomb material model
- No coupled analyses
- Use of stress relaxation for staged excavation models
- Faulted and unfaulted ground
- Unstable conditions in faulted ground
- Not possible to use the contribution of structures in front of the face
- Use of „core replacement“





Phase2

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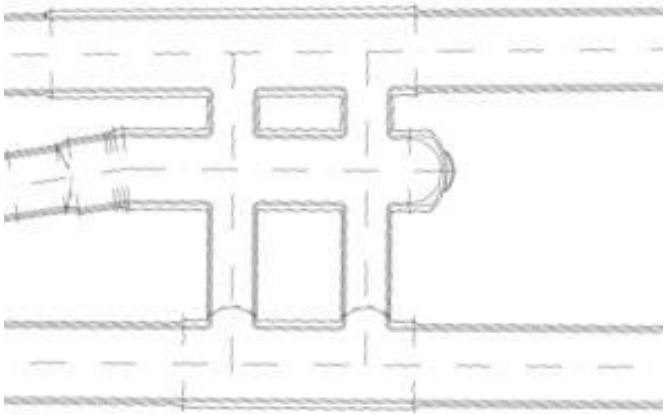
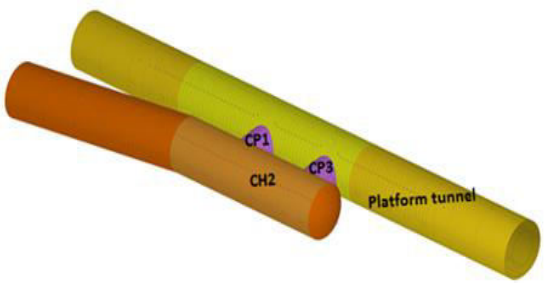
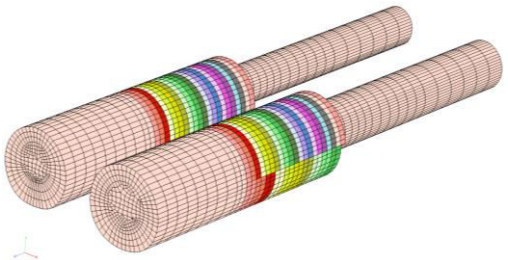
- From 2D to 3D
- More complex geometry:
  - Parallel tunnels with small soil pillar
  - Junctions, Cross passages
  - Headwalls
  - Over-under crossing
- Changed construction sequence
- Poor ground conditions
- Defining advance rates
- Real time consolidation analyses







Phase2→Plaxis 3D→Zsoil 3D

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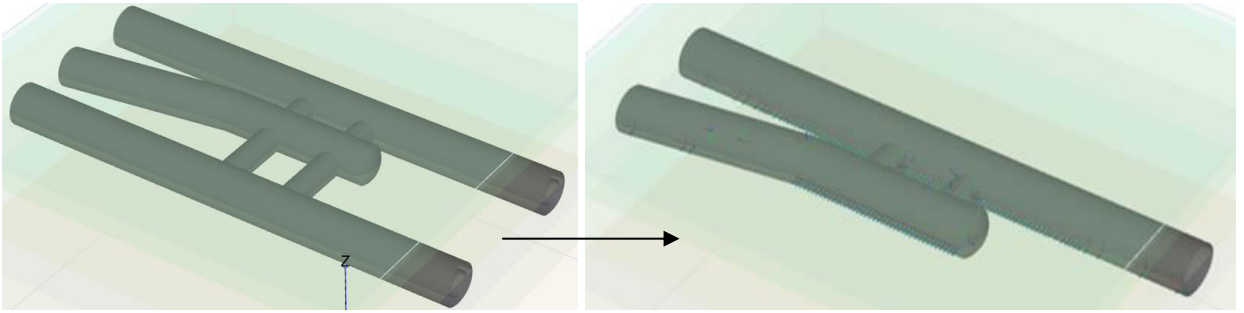
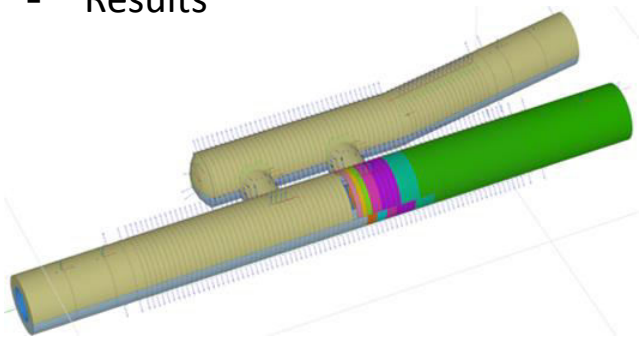
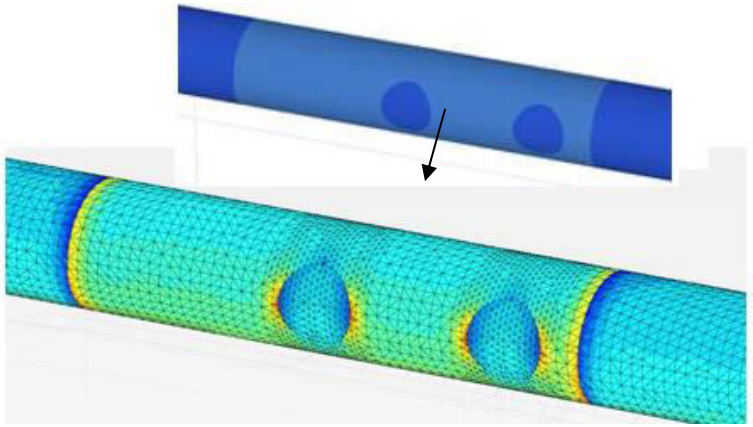
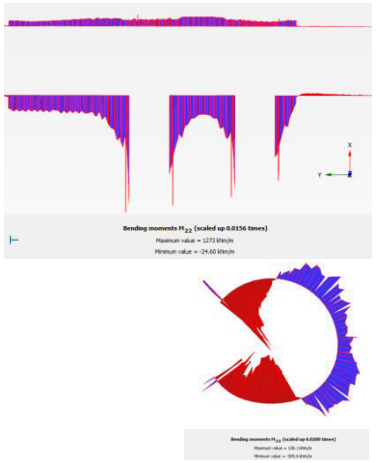
- Limitation in number of elements
- Defining excavation steps
  - time consuming
  - internal memory problems
  - mesh



- Lining thickening
- One shell
- Results

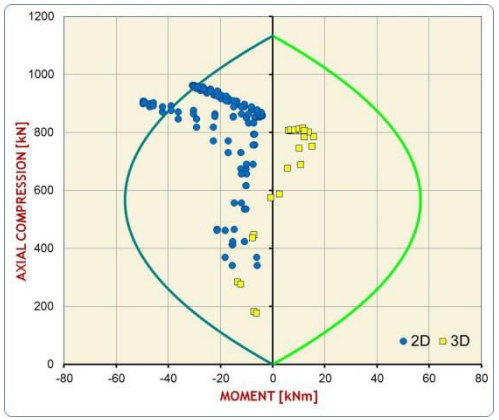


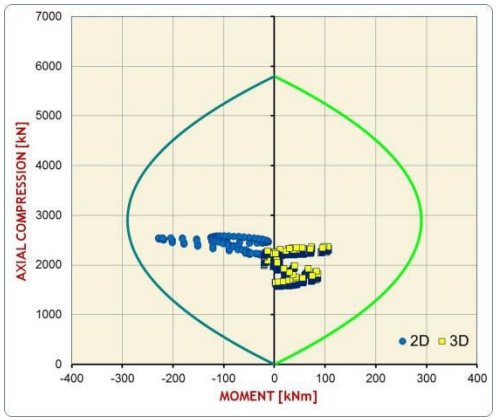


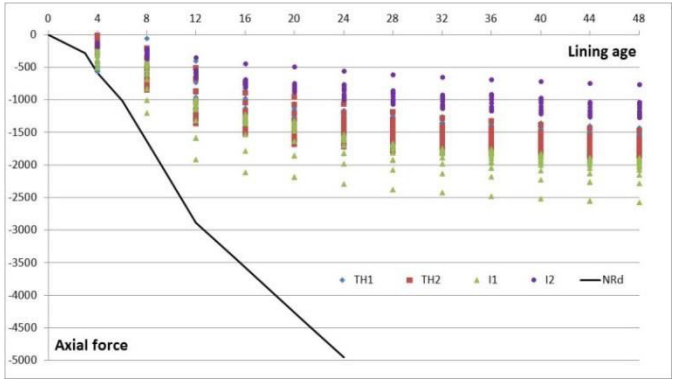


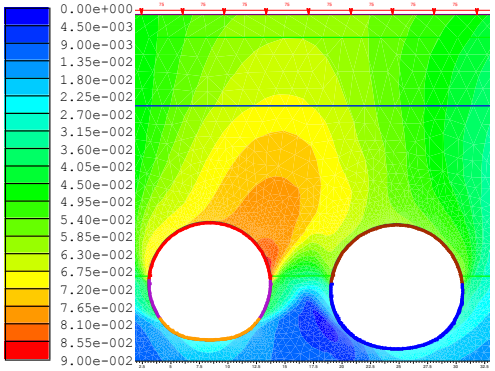
Plaxis 3D

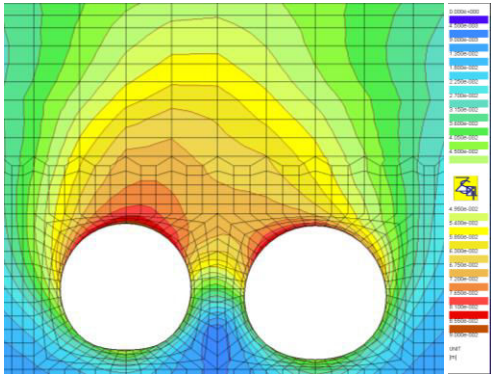
- Comparison between 2D and 3D:
  - Similar tunnel deformations
  - High volume losses from the face
  - In 3D smaller bending moments and slightly smaller axial forces
- Advance rates











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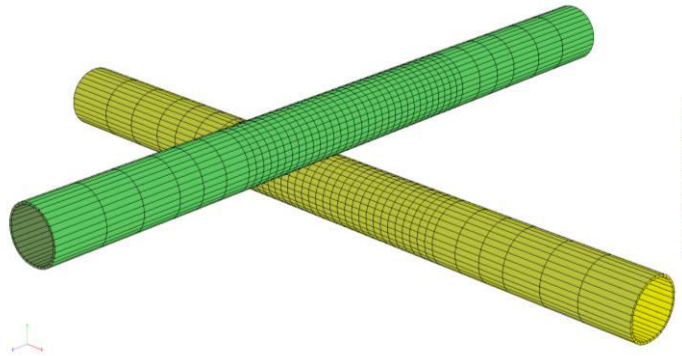
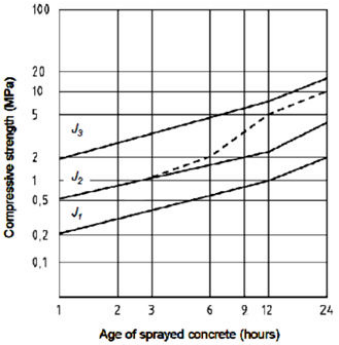
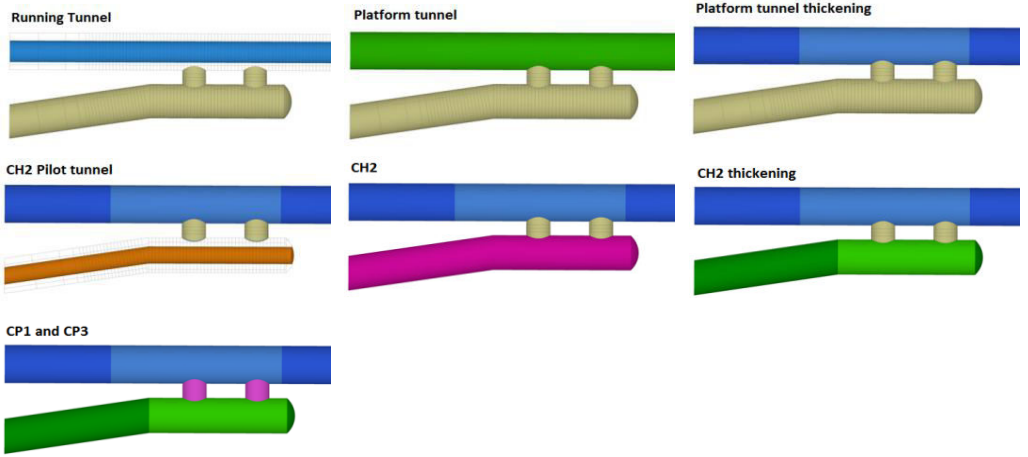
+ Time dependent material properties
+ Thick shell
+ Aging concrete
+ EF easy to define and modify staged construction
+ Better control over FE mesh
+ Reliable online support
? Stiffness reduction
? Seepage elements
? Two, three layers of shell with interfaces
? Cu increases with depth
? Tension cut-off in interface







Zsoil – advantages and possible improvements

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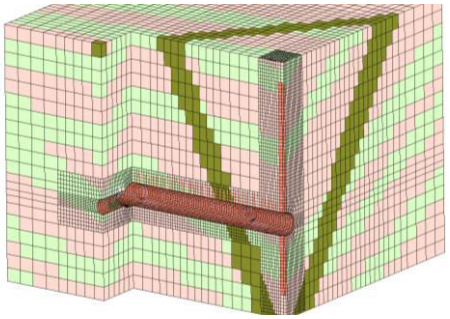
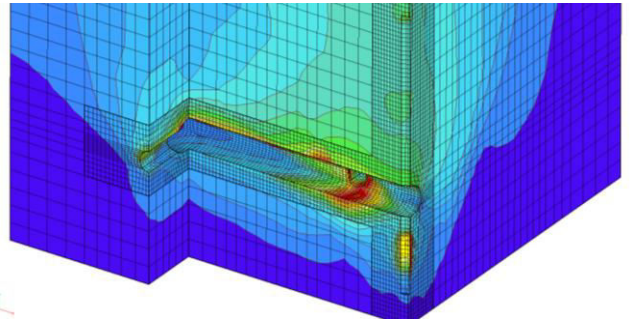
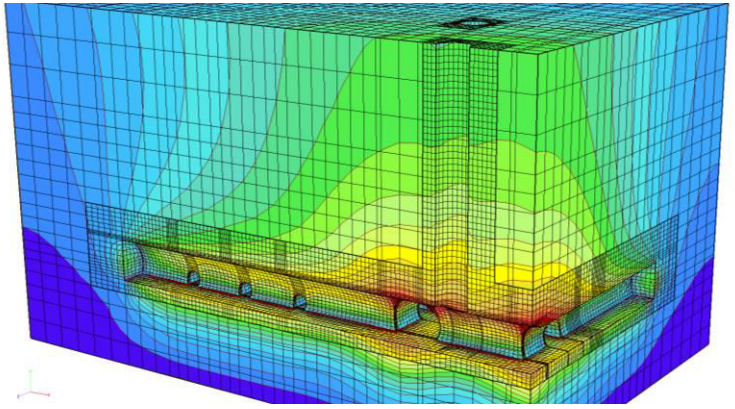
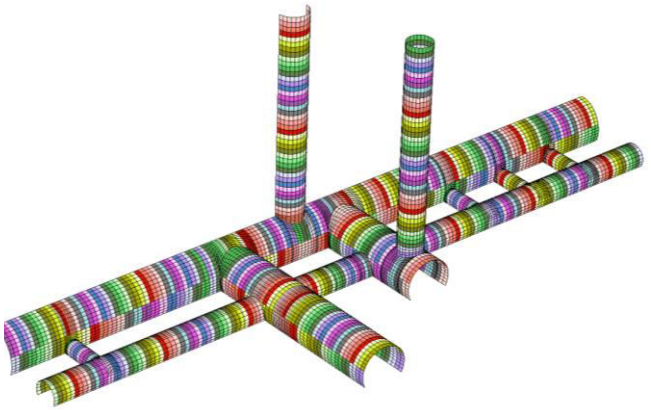
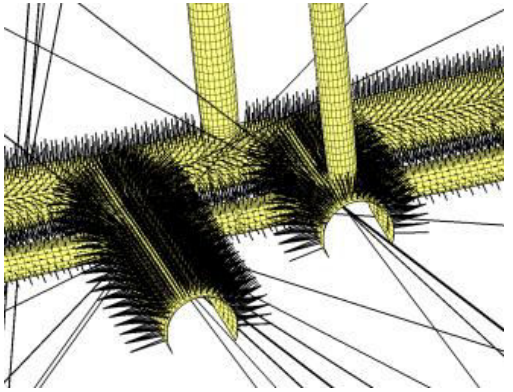
- Complex cavern systems and geological structures
- Encountered problems
  - Modification of nails properties
  - Problems with nails during computation











Zsoil

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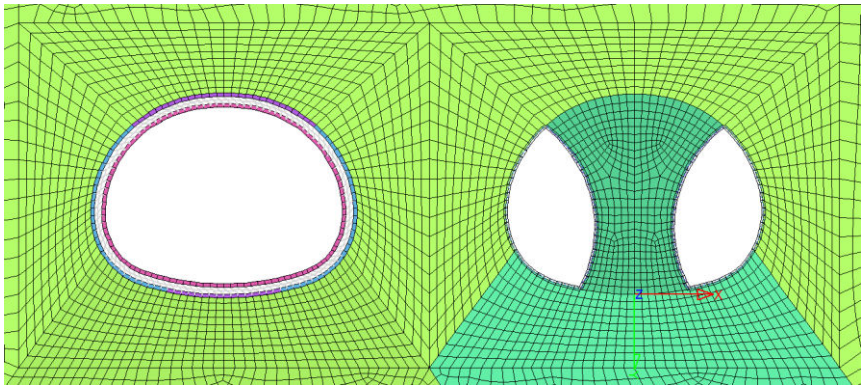
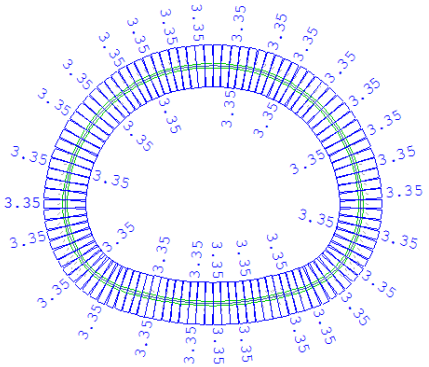
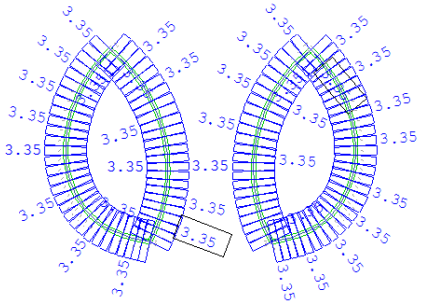
- Mostly suitable for 2D problems
- »only« Mohr-Coulomb material (possibility of multilaminate soil with anisotropic E modulus)
- Soil stiffness reduction
- Design of concrete lining
- Nonlinear behaviour of reinforced concrete
- Spring connection between linings
- More convergence problems







Sofistik

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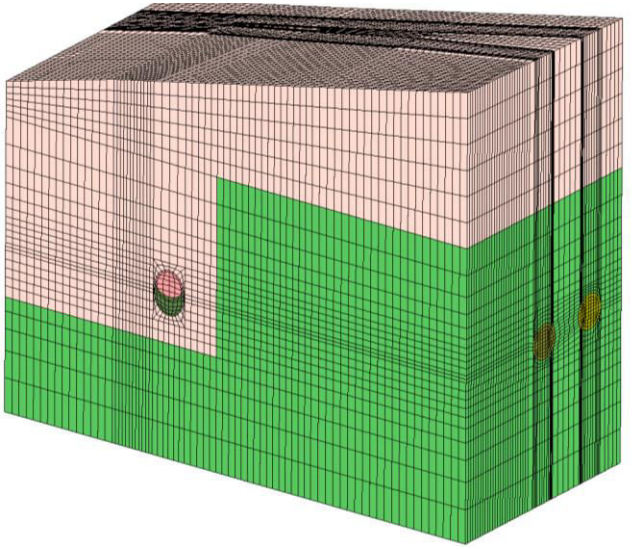
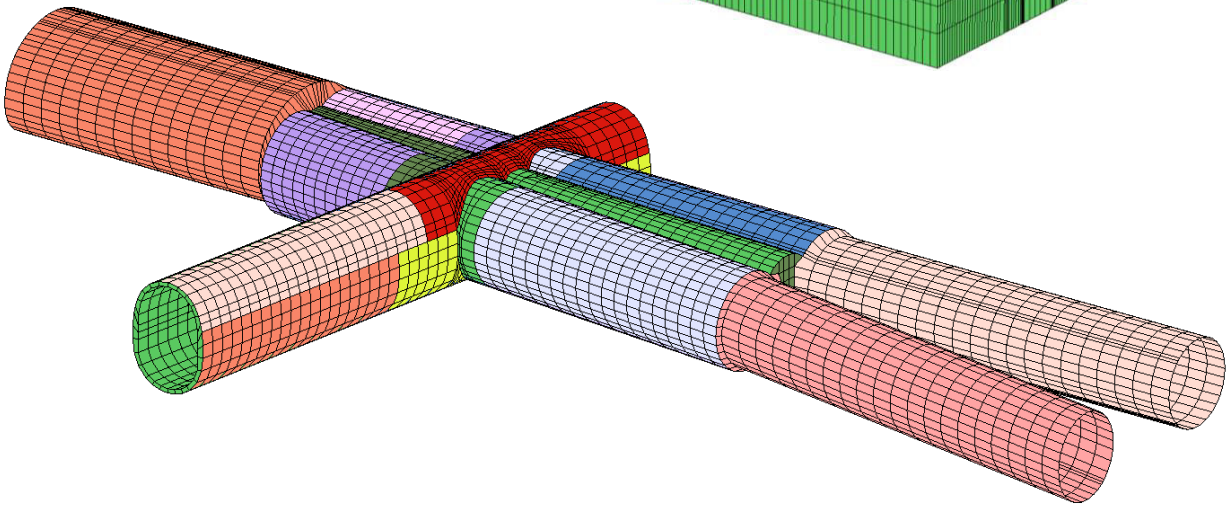
Criteria for software selection:

- Complex 3D geometry

  (model generation, visibility options, control of EF in MS Excel)
- Multilaminate Mohr-Coulomb material
- Time dependent material characteristics

  (LF for E-modulus and cohesion)
- Inner lining and pillars with frictionless contact





Sofistik → Zsoil 3D

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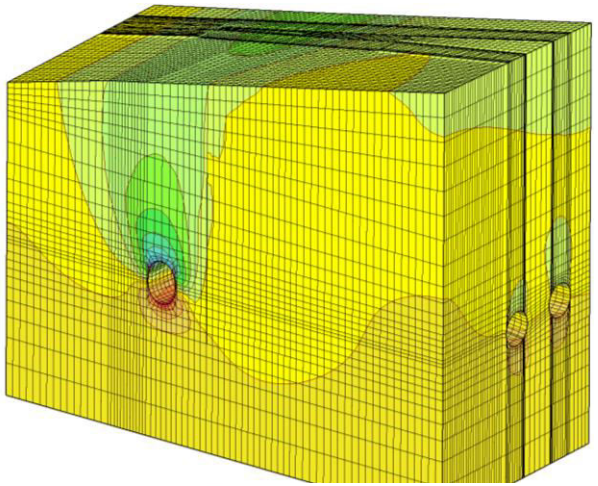
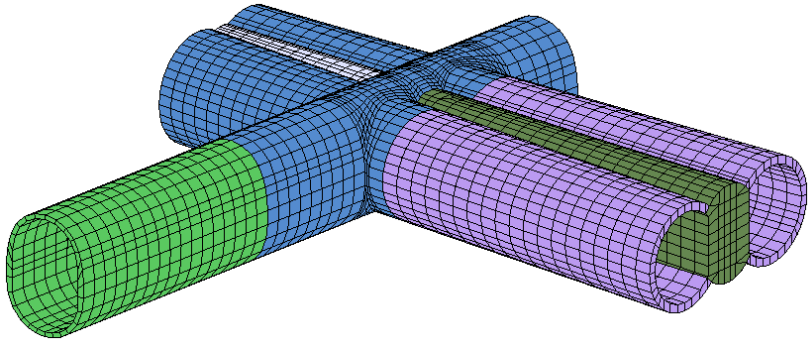
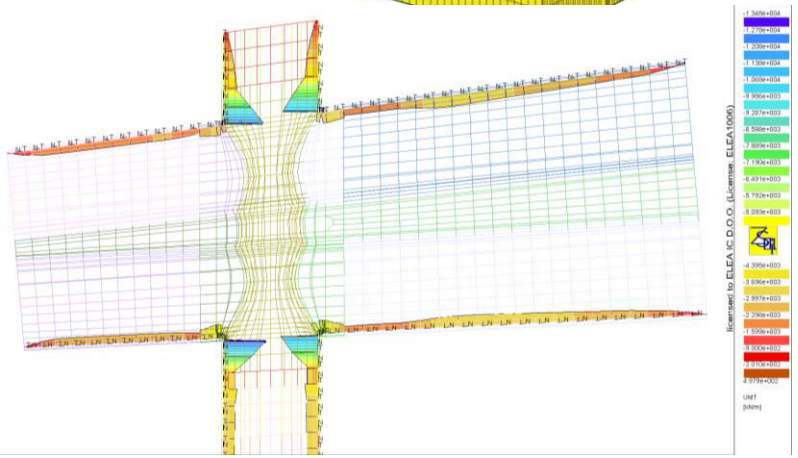
Required results:

- Feasibility of excavation (convergency)
- Settlements
- Design of primary lining (increase of thickness ,reinforcement)
- Detailed design of inner lining (ULS, SLS, Fire) !?







- With Zsoil able to resolve miscellaneous problems with a complex geometry and construction sequences:
  - Good model control
  - Time dependent material properties
  - Thick shell
- Potentials improvements:
  - Stiffness reduction
  - More Shell layers
  - Different definition for seepage
  - Anisotropy
  - Strain in shell

CONCLUSION - DEBATE