COMSOL CONFERENCE EUROPE 2012

Implementation of an EVP model for soft soils using COMSOL

Mats Olsson

Ind. PhD. student

Chalmers and NCC Construction

Excerpt from the Proceedings of the 2012 COMSOL Conference in Milan

COMSOL CONFERENCE EUROPE 2012

Introduction

- Why do we need a “creep” model?
  - To capture long term settlement in soft soils
  - To capture strain rate effects
- Is this material model enough?

COMSOL CONFERENCE EUROPE 2012

Why?

The isotropic Elastic-ViscoPlastic model (EVP)

- Some basic features:
  - Stress-dependent stiffness
  - Distinction between primary loading and unloading-reloading
  - Viscoplastic “Creep” behaviour
  - Memory of preconsolidation pressure

COMSOL CONFERENCE EUROPE 2012

Equations

$$p^{eq} = p' + \frac{q^2}{M_{cs}^2 p'}$$

Elastic part

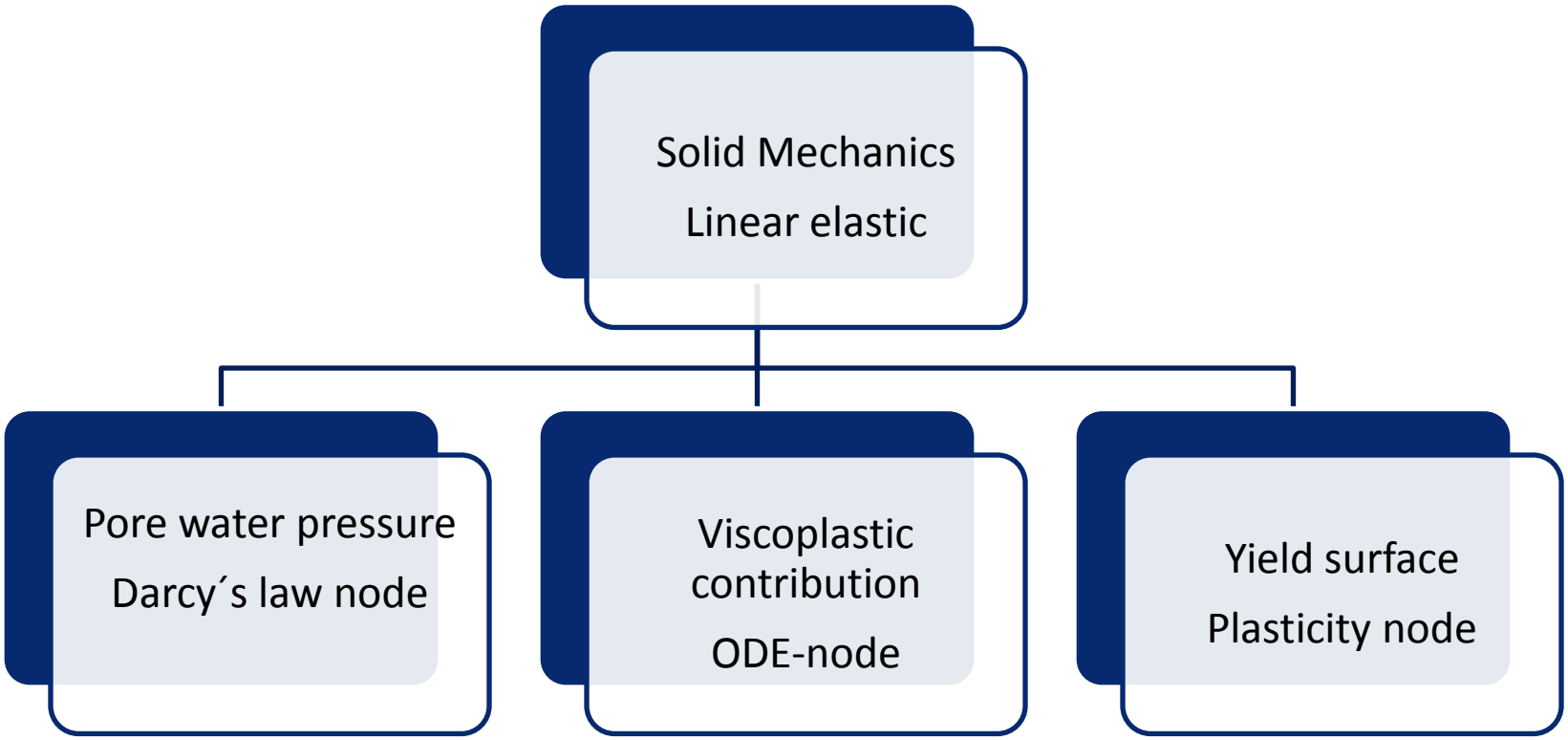
$$\dot{\underline{\varepsilon}} = \dot{\underline{\varepsilon}}^e + \dot{\underline{\varepsilon}}^c = \underline{\underline{D}}^{-1}\dot{\underline{\sigma}}' - \underbrace{\frac{1}{\alpha}\frac{1}{r_s \cdot \tau}\left(\frac{p^{eq}}{p_p^{eq}}\right)^{r_s\cdot\left(\lambda^* - \kappa^*\right)}\frac{\partial p^{eq}}{\partial \underline{\sigma}'}}_{\text{Viscoplastic part}}$$

$$p_p^{eq} = p_{p0}^{eq} \cdot \exp\left(\frac{\Delta\varepsilon_v^c}{\lambda^* - \kappa^*}\right)$$

Viscoplastic strains control the preconsolidation pressure i.e. the size of the ellipse

COMSOL CONFERENCE EUROPE 2012

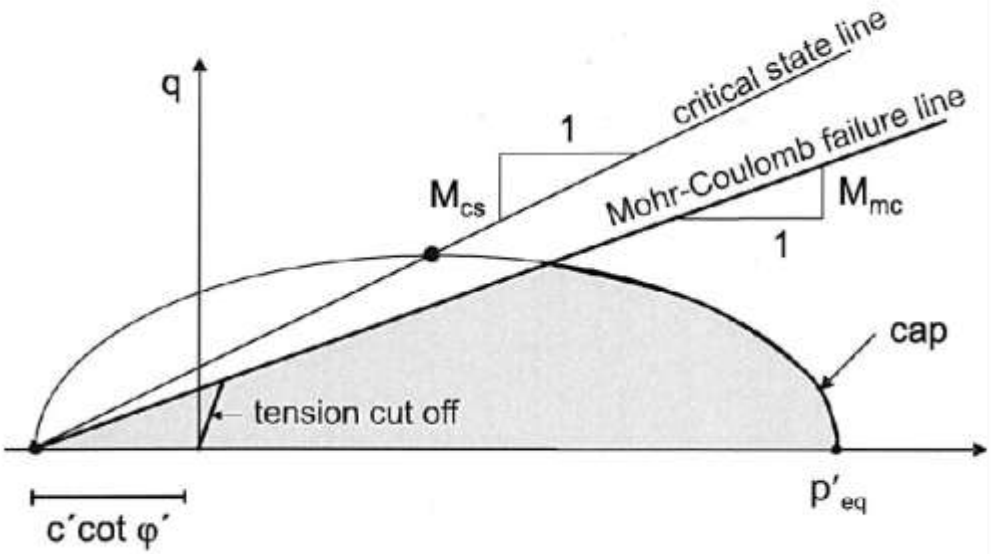
Implementation in COMSOL

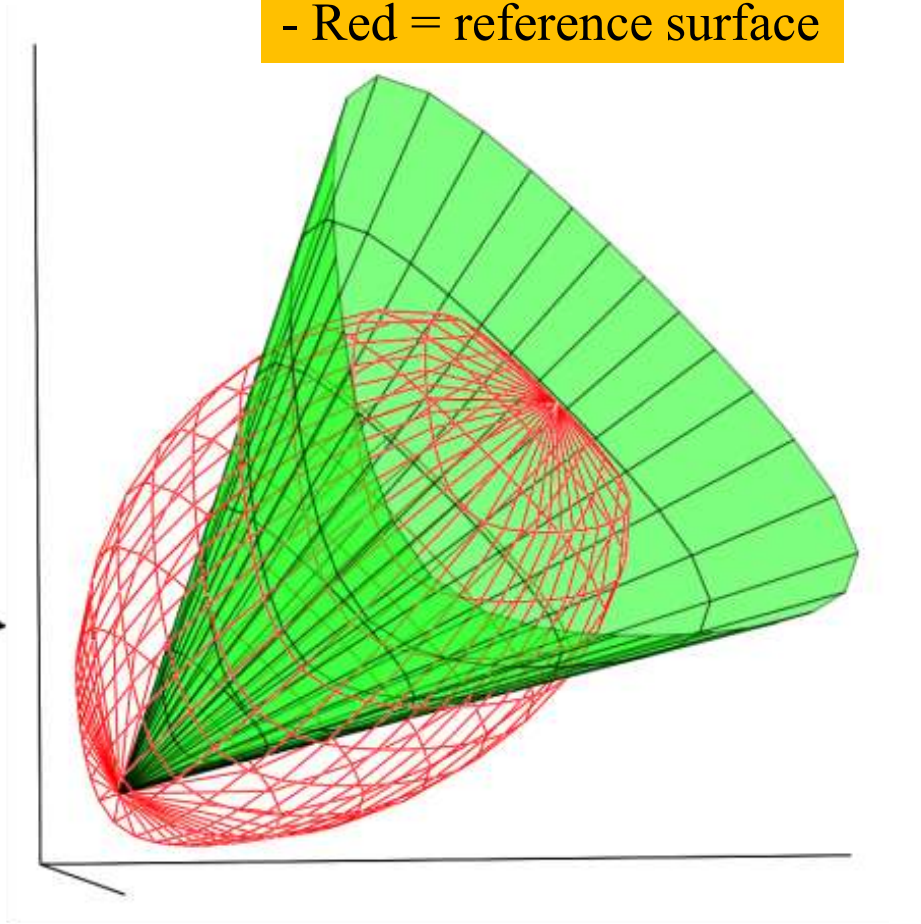


COMSOL CONFERENCE EUROPE 2012

Failure and reference surface

- Green = yield surface
- Red = reference surface





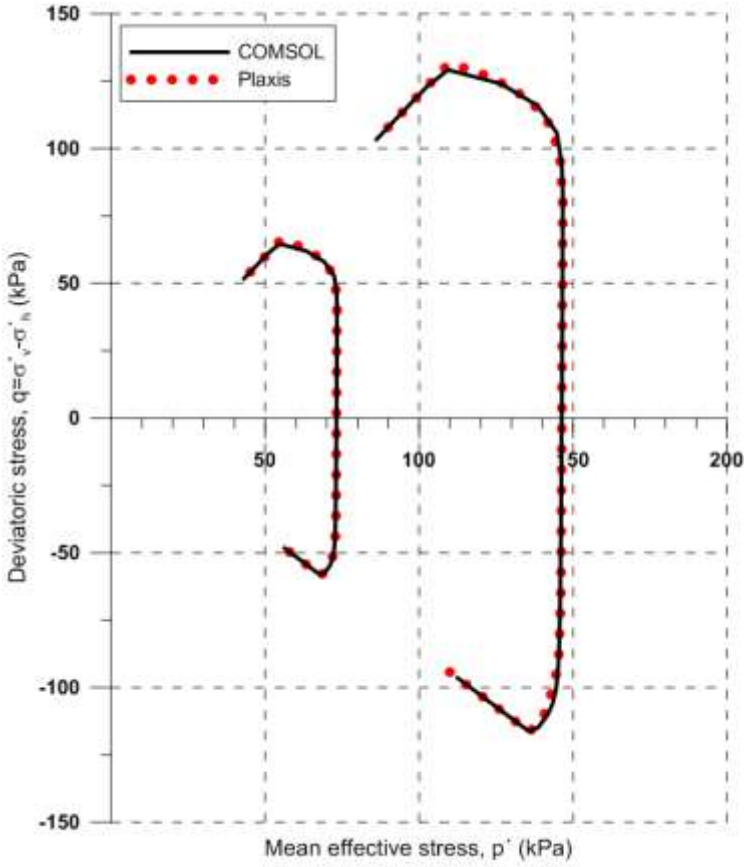
COMSOL CONFERENCE EUROPE 2012

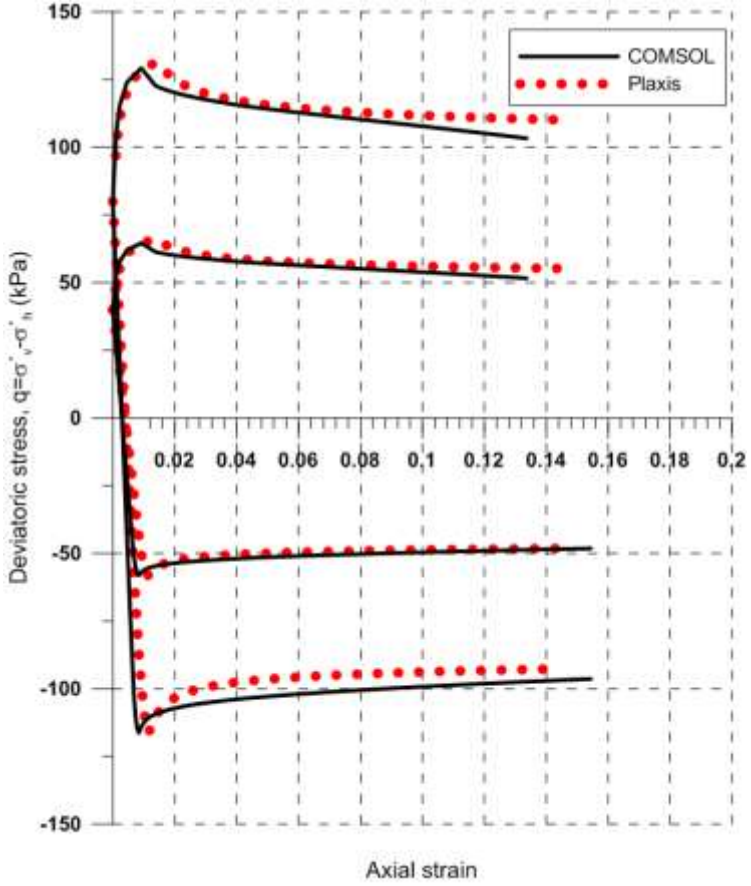
Benchmark

- Implementation is benchmarked against a commercial FE-code, Plaxis BV, with a very similar material model.
- Comparison between laboratory test and simulations, undrained triaxial test.
- Laboratory tests are modelled with axisymmetric conditions.
- Exact same material properties are used.

COMSOL CONFERENCE EUROPE 2012

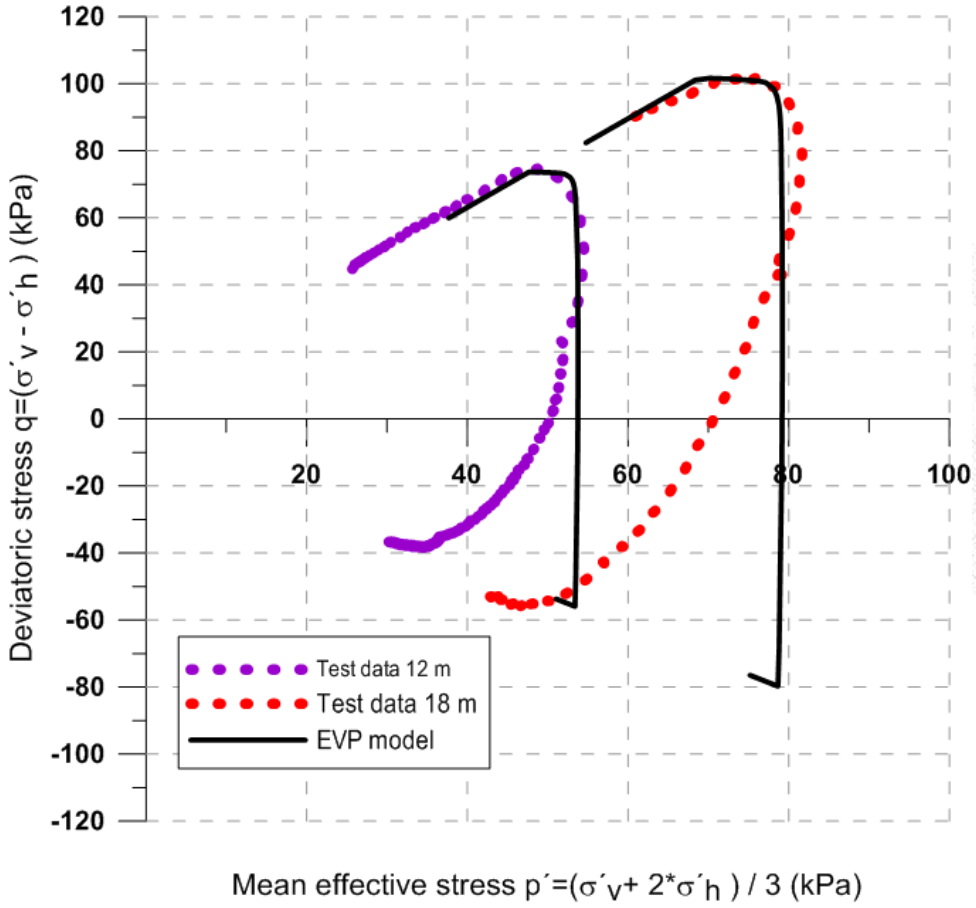
Benchmark results

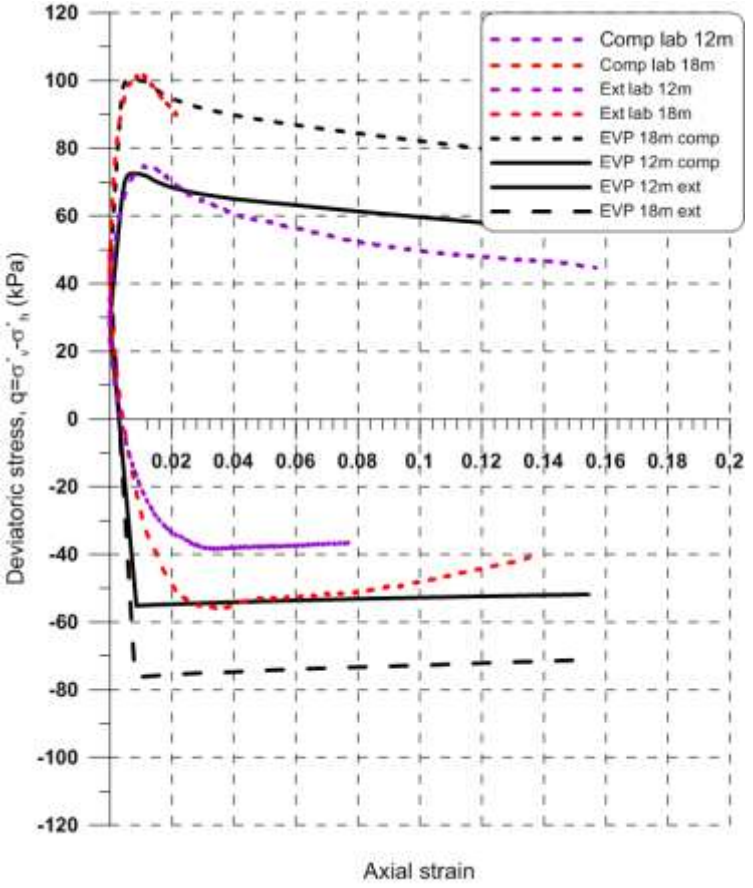




Comparison with laboratory results – Triaxial tests

COMSOL CONFERENCE EUROPE 2012

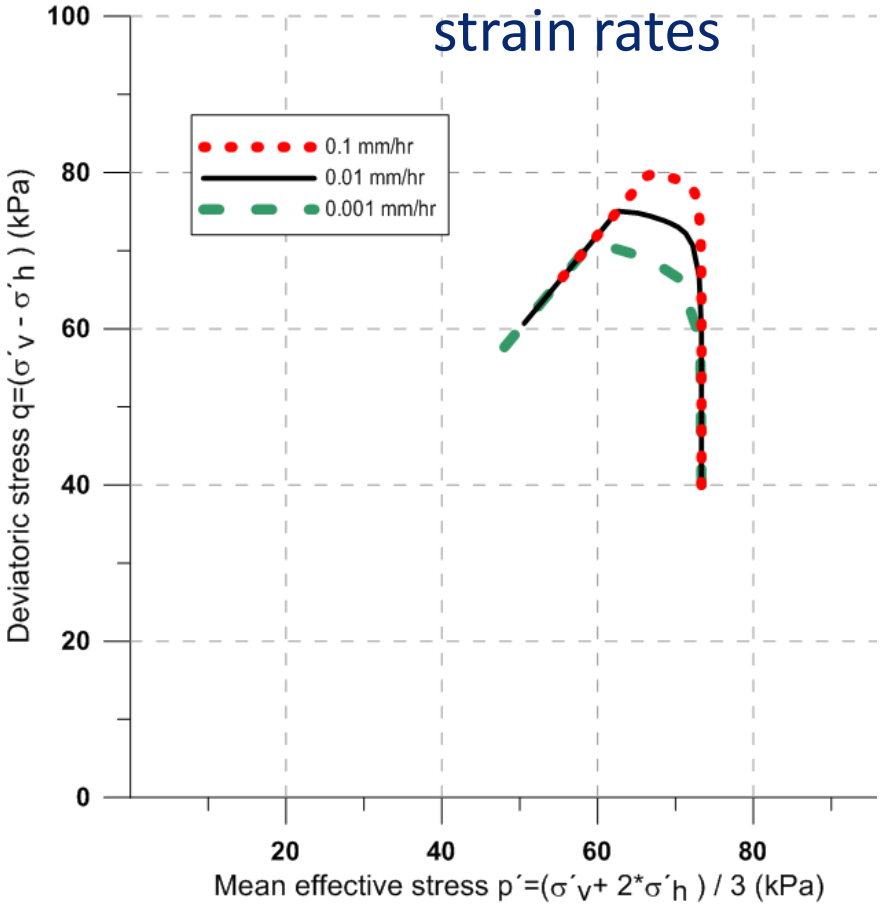


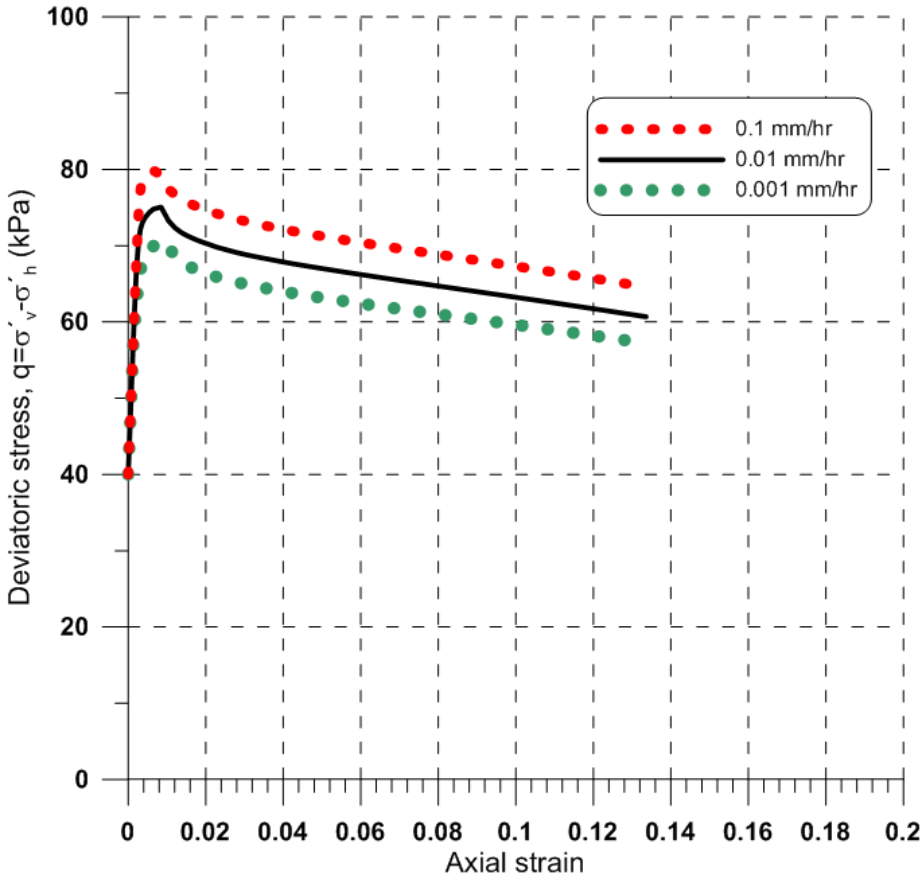


COMSOL CONFERENCE EUROPE 2012

Effect of strain rate

Undrained triaxial test with different strain rates





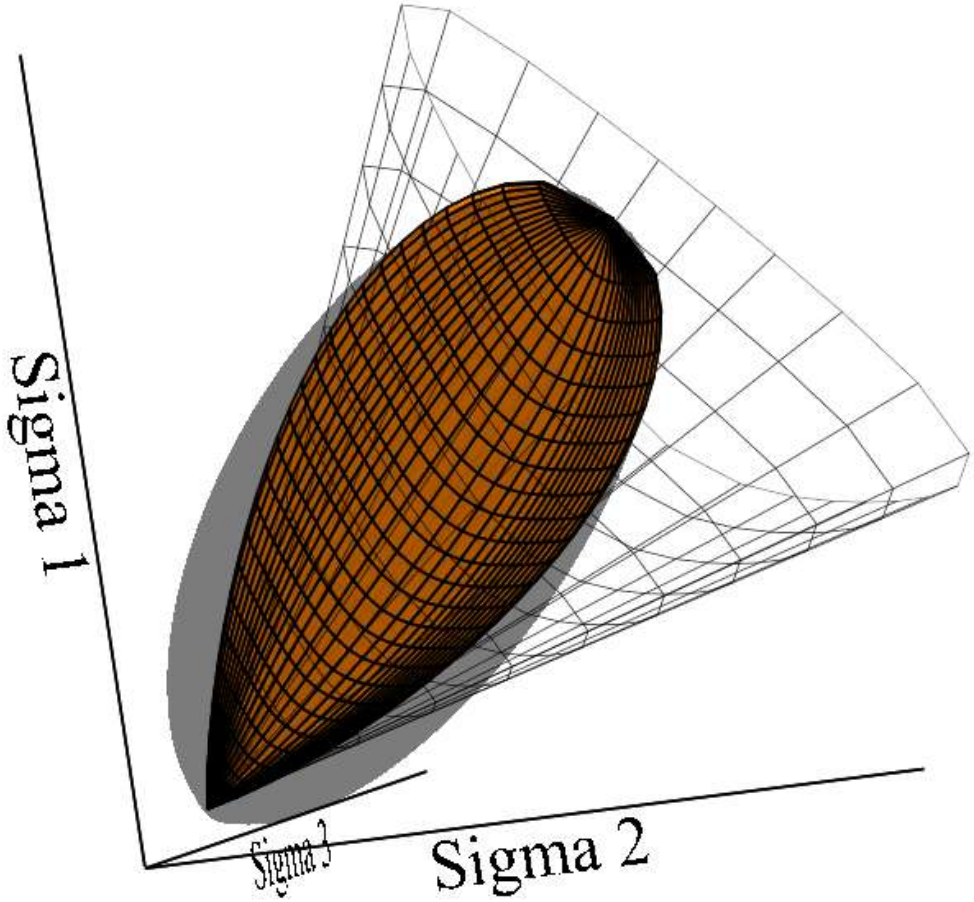
COMSOL CONFERENCE EUROPE 2012

Conclusions

- The implementation seems to be satisfactory.
- The Benchmark gives very similar results
- Comparison of laboratory tests
  - Compression tests is captured reasonably good
  - Extension tests is NOT captured at all
- Further research

COMSOL CONFERENCE EUROPE

Example of reference surfaces



COMSOL CONFERENCE EUROPE 2012

Thank you