Laboratory testing of soft soils in geotechnical engineering

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KIVI Geotechnics webinar

24 June 2021

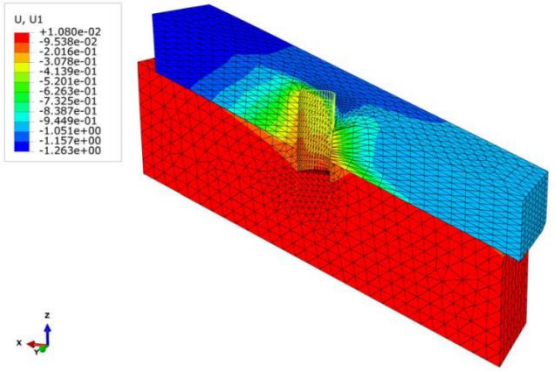
Academic & Engineering background

- **2010 BSc Environmental/Civil Engineering (University of Trento, Italy)**

Analysis of seepage in the embankments of Adige river

- **2012 MSc Environmental/Civil Engineering (University of Trento, Italy)**

Soil structure interaction of passive piles and piers in unstable slopes



Academic & Engineering background

- **2019 PhD Geotechnical Engineering (TU Delft)**

Experimentally based constitutive framework for the deviatoric behaviour of peats

- **2021 Assistant Professor Experimental Soil Mechanics (TU Delft)**

- **24 June 2021** KIVI Webinar “Laboratory testing of soft soils in geotechnical engineering”

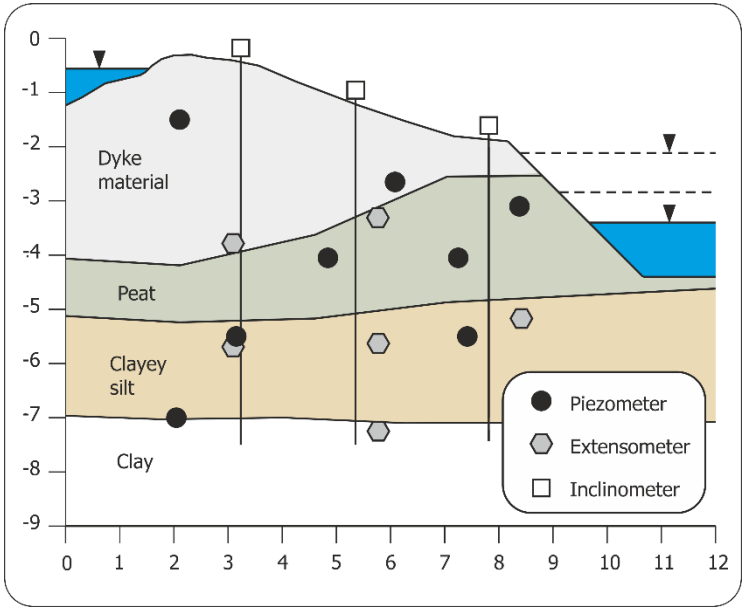
Soft soils & The Netherlands

Variety of soft organic clays and peats

Land subsidence & serviceability and stability problems of infrastructure

Engineering scale

Field stress test at the Leendert de Boerspolder (2015)



- Dyke body — silty sand, traces of gravel and clay, OCR ≅ 1-2, $\rho \cong 1.8$ Mg/m^3
- Peat — 1-2.5 m, OCR ≅ 1-3, OC ≅ 90%, $\rho \cong 1.1$ Mg/m^3
- Clayey silt — 2 m, OCR ≅ 1-3, OC ≅ 5%, $\rho \cong 1.4$ Mg/m^3

Engineering scale

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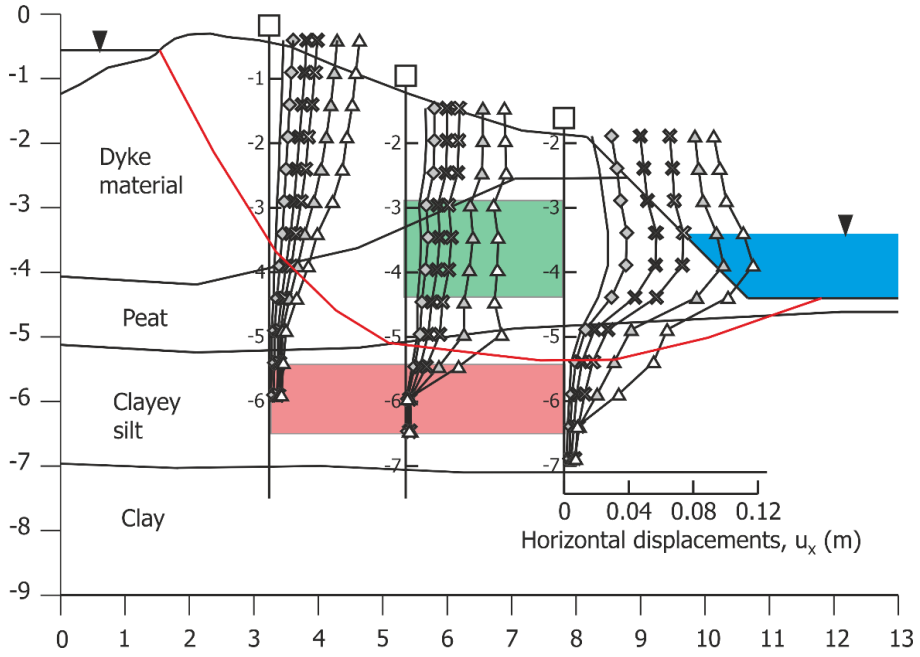
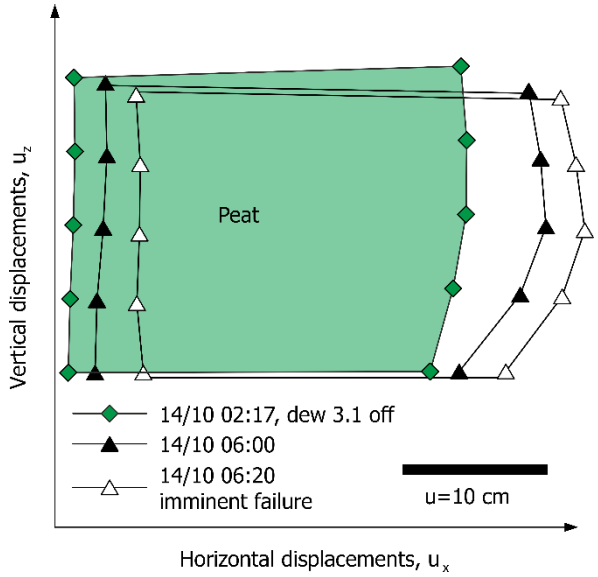
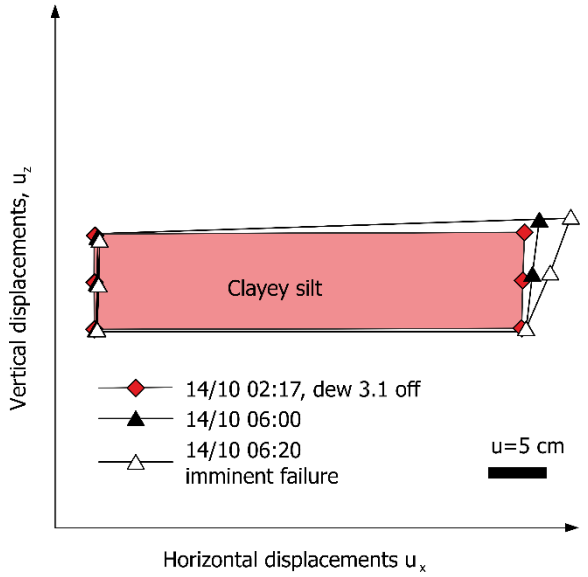
Engineering scale

Failure and pre-failure mechanism







- Failure initiated at the toe of the dyke in clayey silt
- Lateral bulging of peat was the trigger of failure
- Dilatant response of the clayey silt

Road map

1. Field stress-test

- Complex failure mechanism
- Relevance of the pre-failure behaviour

2. Engineering needs: serviceability and safety assessments

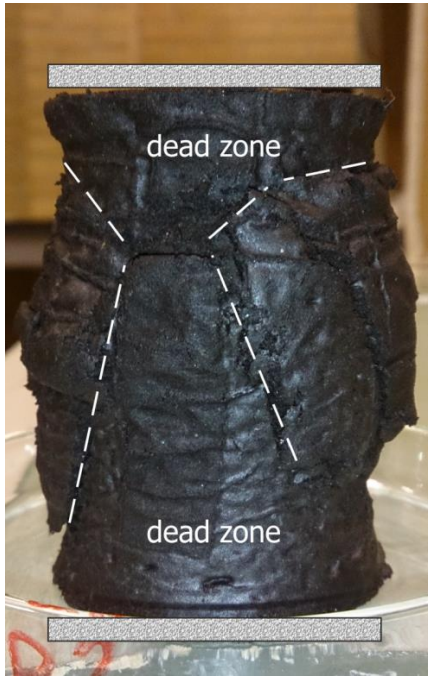
$\Rightarrow$ constitutive-numerical model

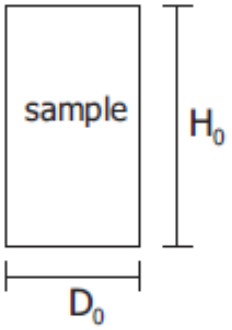
3. Advanced laboratory tests $\Leftrightarrow$ model development

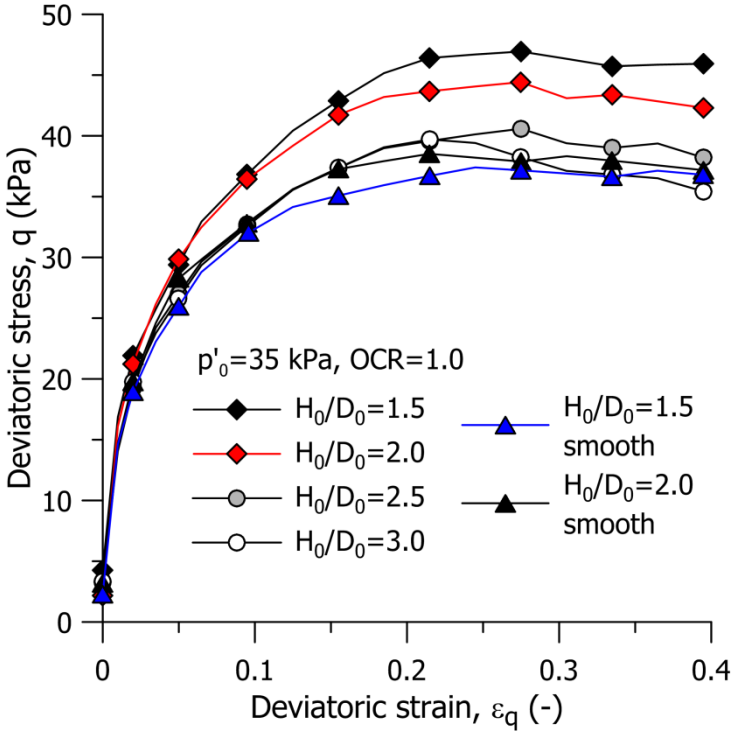
- Small effective confining stress (< 50 kPa)
- Large strains
- Fibres

Laboratory scale - Peat

Triaxial undrained compression tests (TxCU) ($\varphi' > 60°$ from the literature)



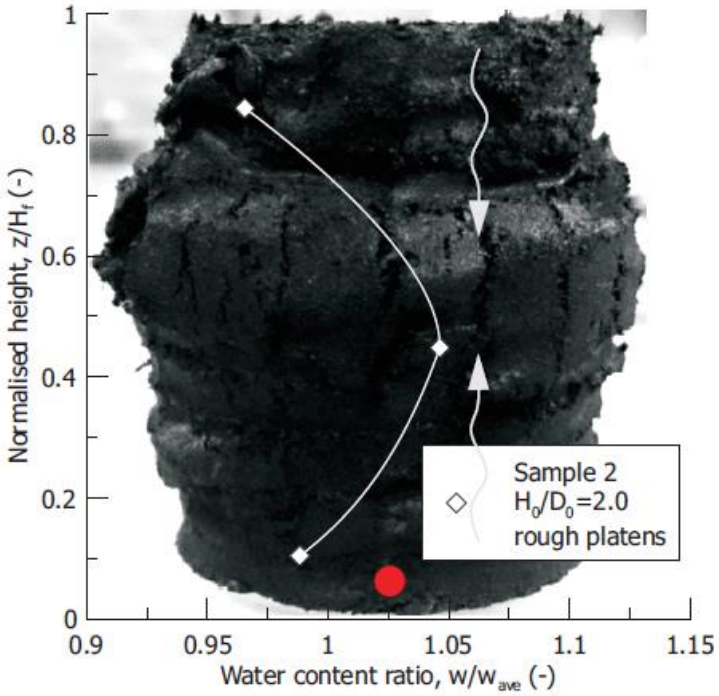


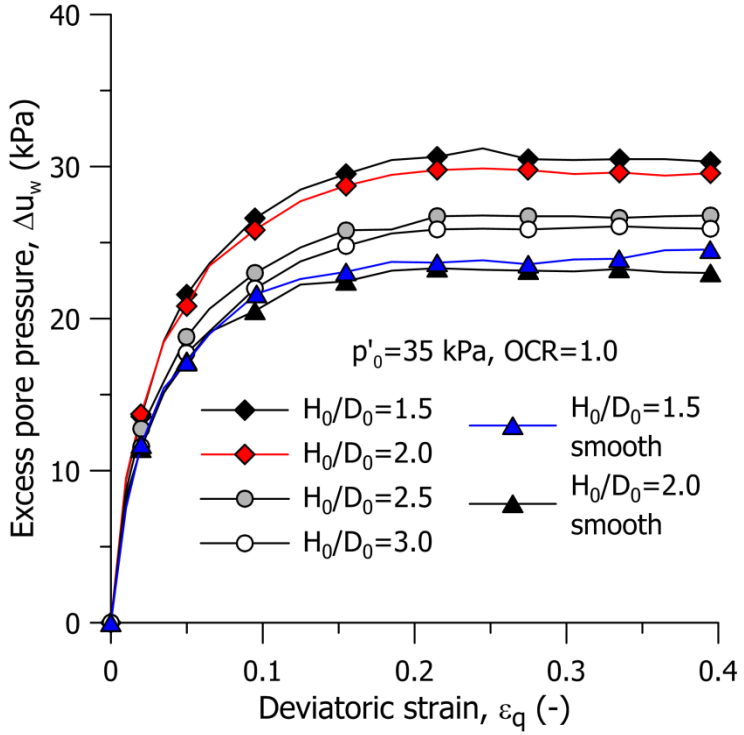


- Inhomogeneous deformation field due to end restraints
- Overestimation of the deviatoric stress

Laboratory scale - Peat

Pore pressure at the bottom of the sample

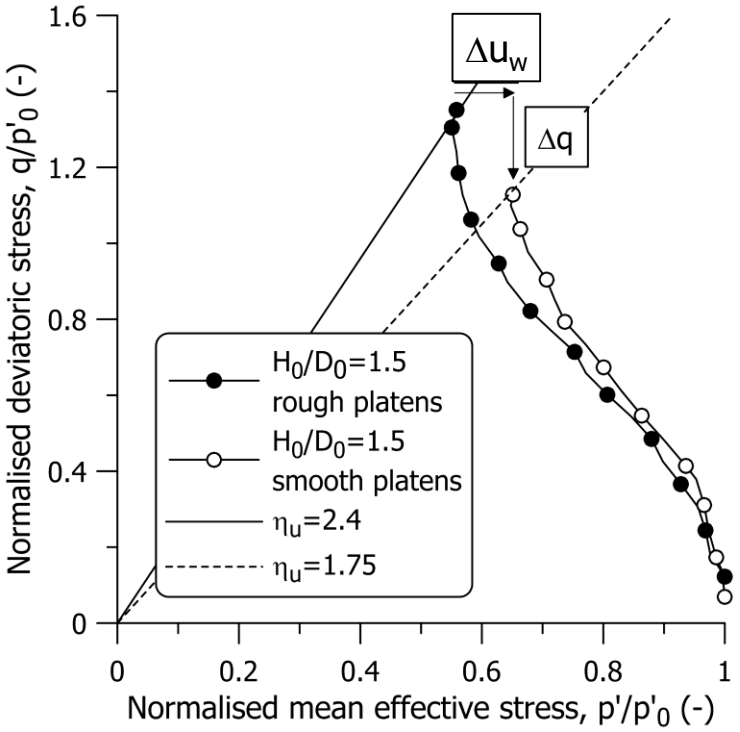


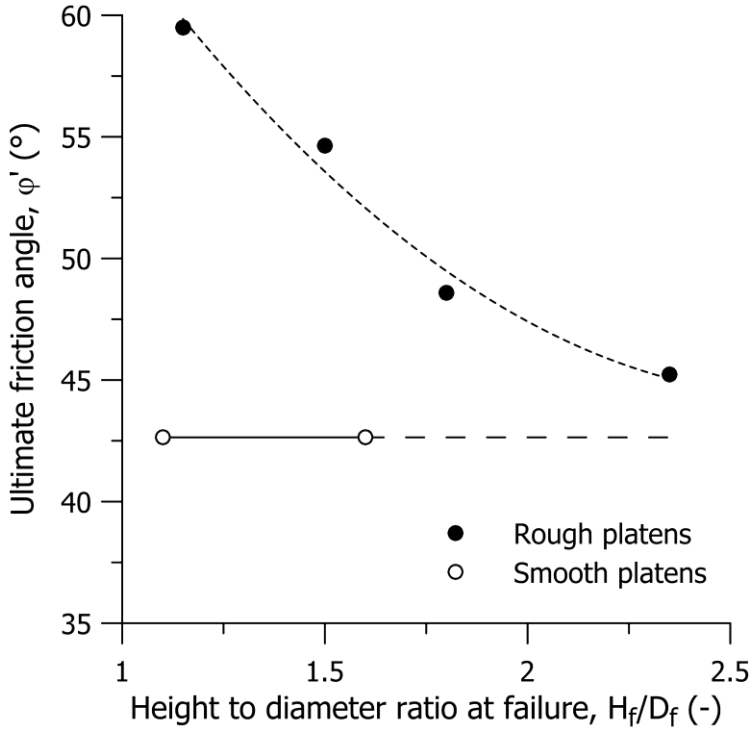


- Internal water migration
- Overestimation of the pore pressure

Laboratory scale - Peat

End restraint effects on shear strength

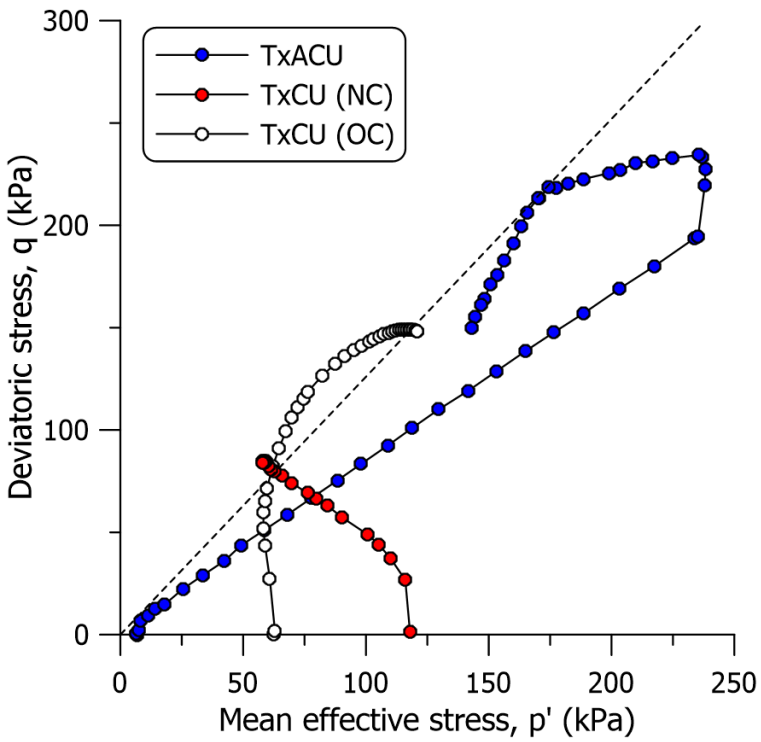


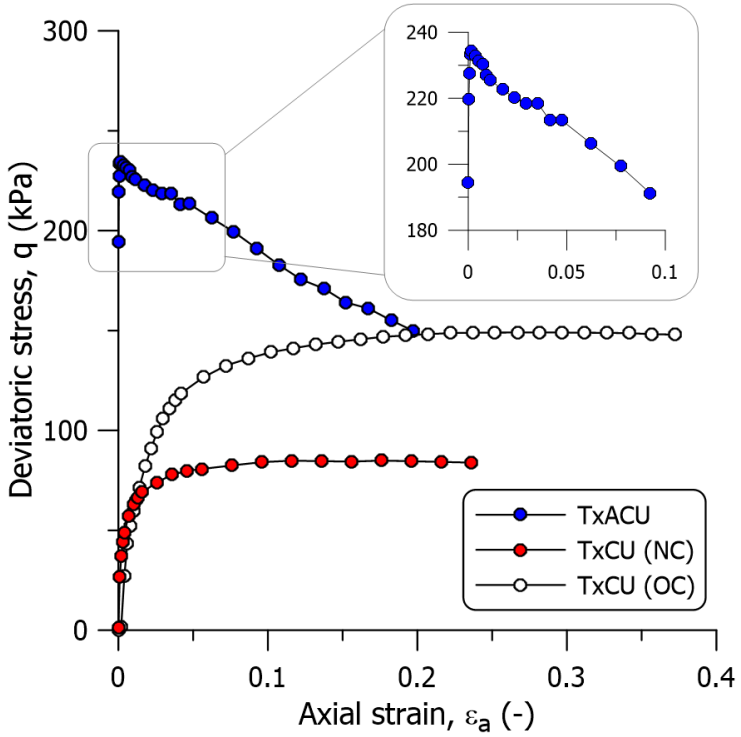


- Bias in the ultimate friction angle φ'= 55° to φ'= 42°

Laboratory scale – Organic silt/clay

Anisotropic behaviour (collaboration with Ching-Yu Chao, Prof. Jommi)

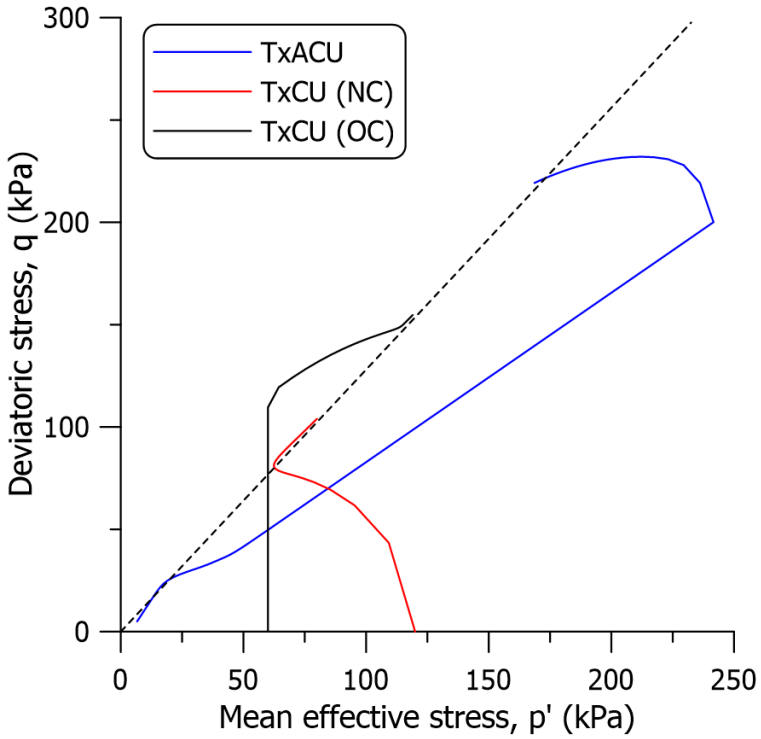


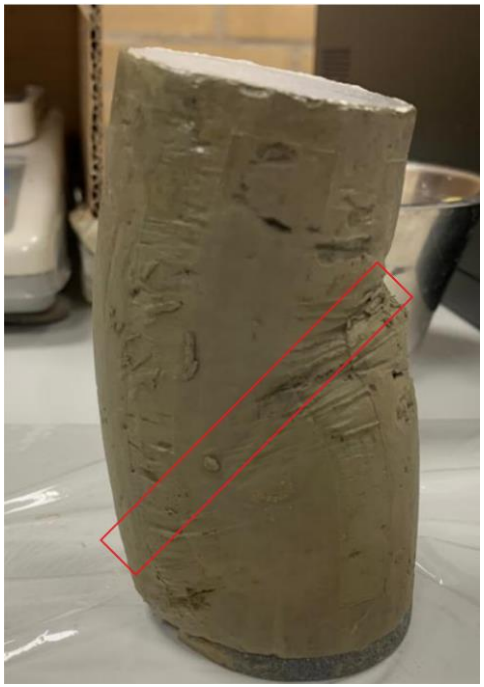


- Importance of the previous consolidation stage (isotropic *vs* anisotropic)

Laboratory scale – Organic silt/clay

Advanced constitutive models for soft soils (collaboration with Ching-Yu Chao, Prof. Jommi)





- Implementation in FEM for numerical simulations

New research lines

- **Organic soils and climate stresses** (temperature, heat waves, drying, drought)

Shrinkage-swelling due to drying and wetting cycles

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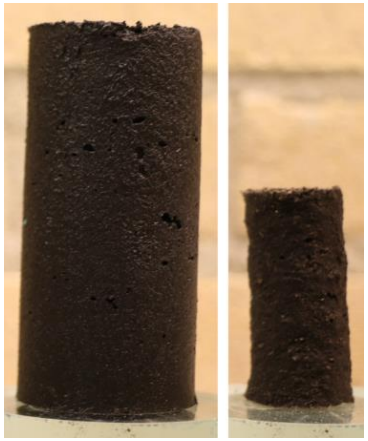
"Unsaturated soils"



Degradation of the organic matter with gas production (CH_4, H_2S, CO_2)

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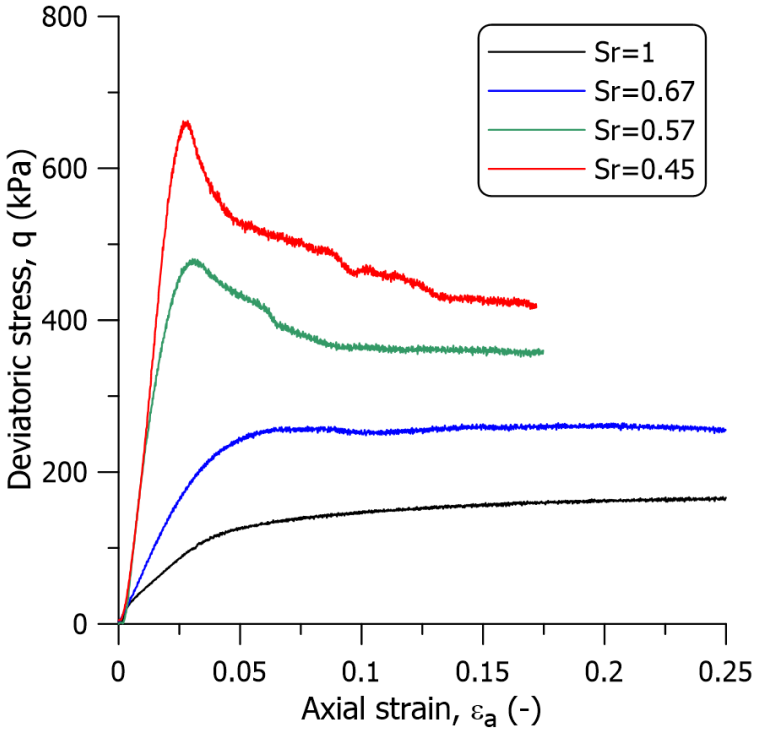
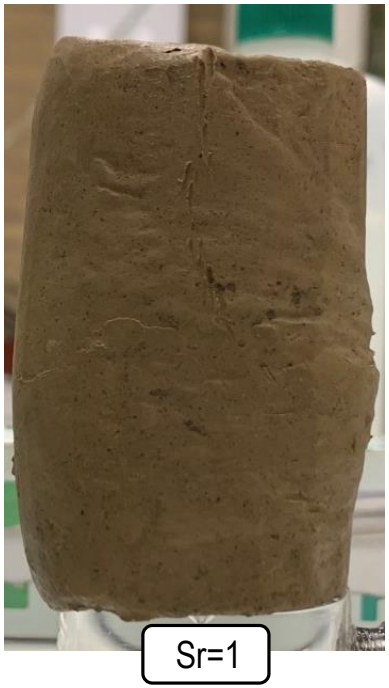
"Gassy soils"

Effects of drying

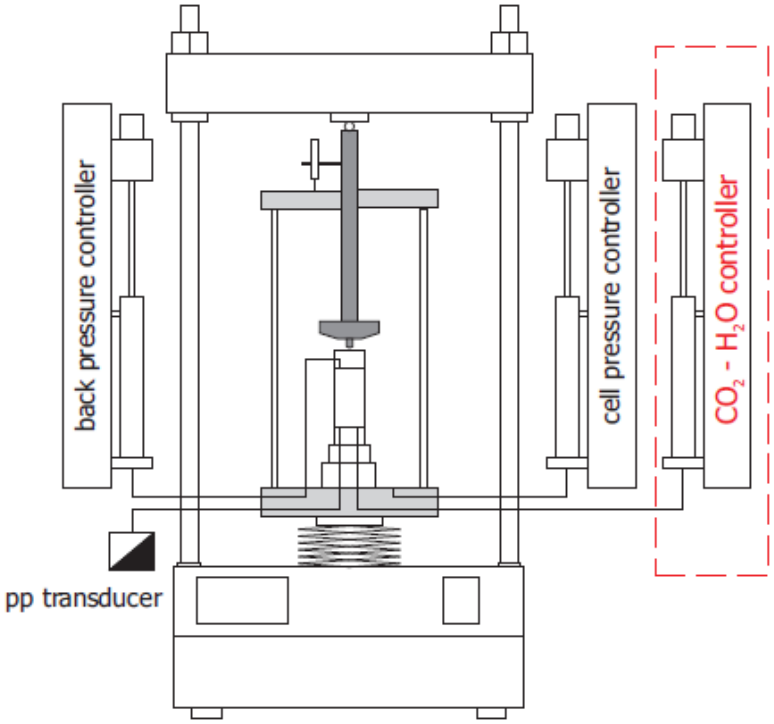
Triaxial tests on initially unsaturated clayey silt samples (collaboration with Van Duinen, Dr. Broere, Chao)

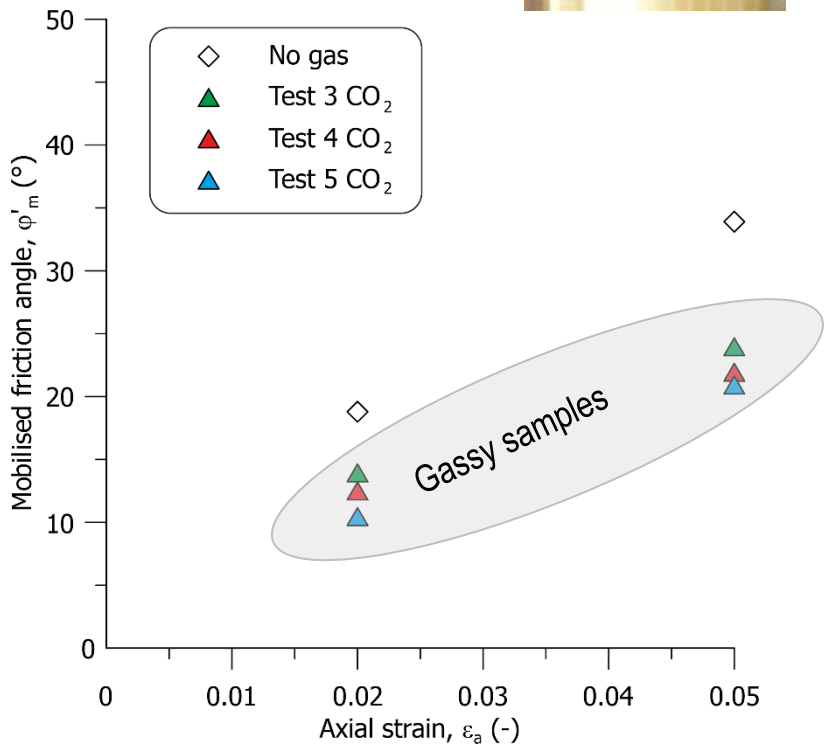




Effects of gas generation

Triaxial tests on gassy-CO_2 charged peat samples

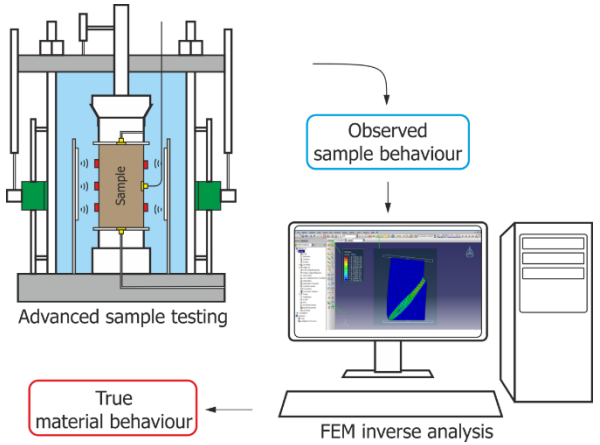




(To me)… Laboratory testing of soft soils

- **Challenging**
  - End restraint (rough platens and membrane)
  - Large strains and very low confining stress
  - Fibres stretching
  - Samples size compared to fibres length

- **Careful interpretation of the experimental data**
  - Advanced testing apparatuses with local sensors (e.g. displacement, pore pressure)
  - Back analysis of the results with a sound constitutive model and numerical tool (e.g. FEM)



- New **fascinating** research in **multiphase soft soil behaviour**

Acknowledgements

KIVI Geotechnics

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Tom de Gast

Ching-Yu Chao

Hongfen Zhao

Elisa Ponzoni

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Thank you for your attention