

Progress on geotechnical work packages

- IAB Meeting Claytectonics -



06/09/2023

Bruno Stuyts | Professor Offshore Geotechnics

www.owi-lab.be

OVERVIEW OF GEOTECHNICAL WORK

- Literature review
- Data sources
- Onshore sampling campaign
 - Drilling campaign for onshore fracture zone
 - Planning of block sampling campaign
- Laboratory testing planning
- 3D ground modelling with GemPy



LITERATURE REVIEW

- Extensive literature on London Clay
 - Heathrow Terminal 5 extension
 - Characterisation of subhorizontal fracture zone at Prospect Park

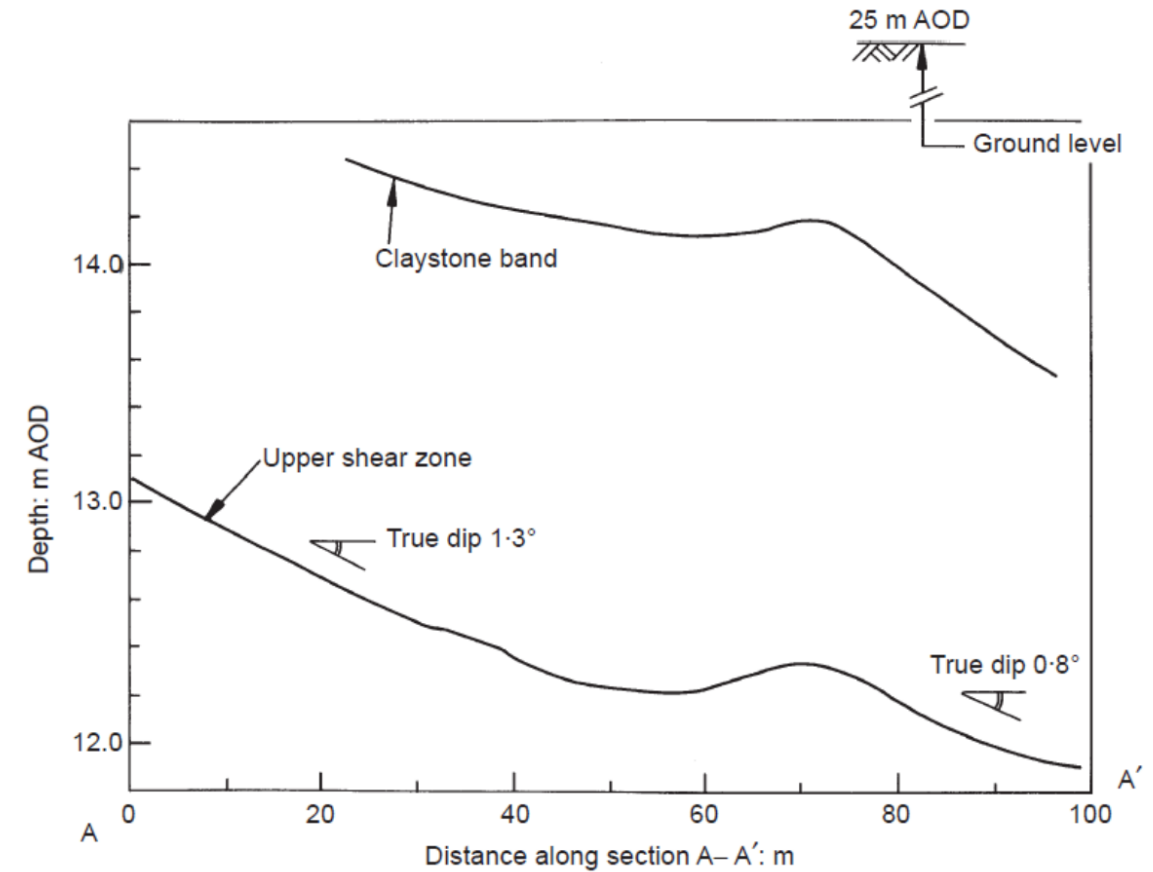


Fig. 7. Prospect Park: section A–A', (see Fig. 6) showing the upper shear zone and a claystone band

LITERATURE REVIEW

- Extensive literature on London Clay
 - Heathrow Terminal 5 extension
 - Characterisation of subhorizontal fracture zone at Prospect Park
- Argile des Flandres (Josseaume, 1998)
 - Extensive laboratory testing on intact clay samples from quay wall construction at Dunkirk
 - Presence of fissures reported and strength along pre-existing fractures quantified
 - Useful benchmark for intact sample testing

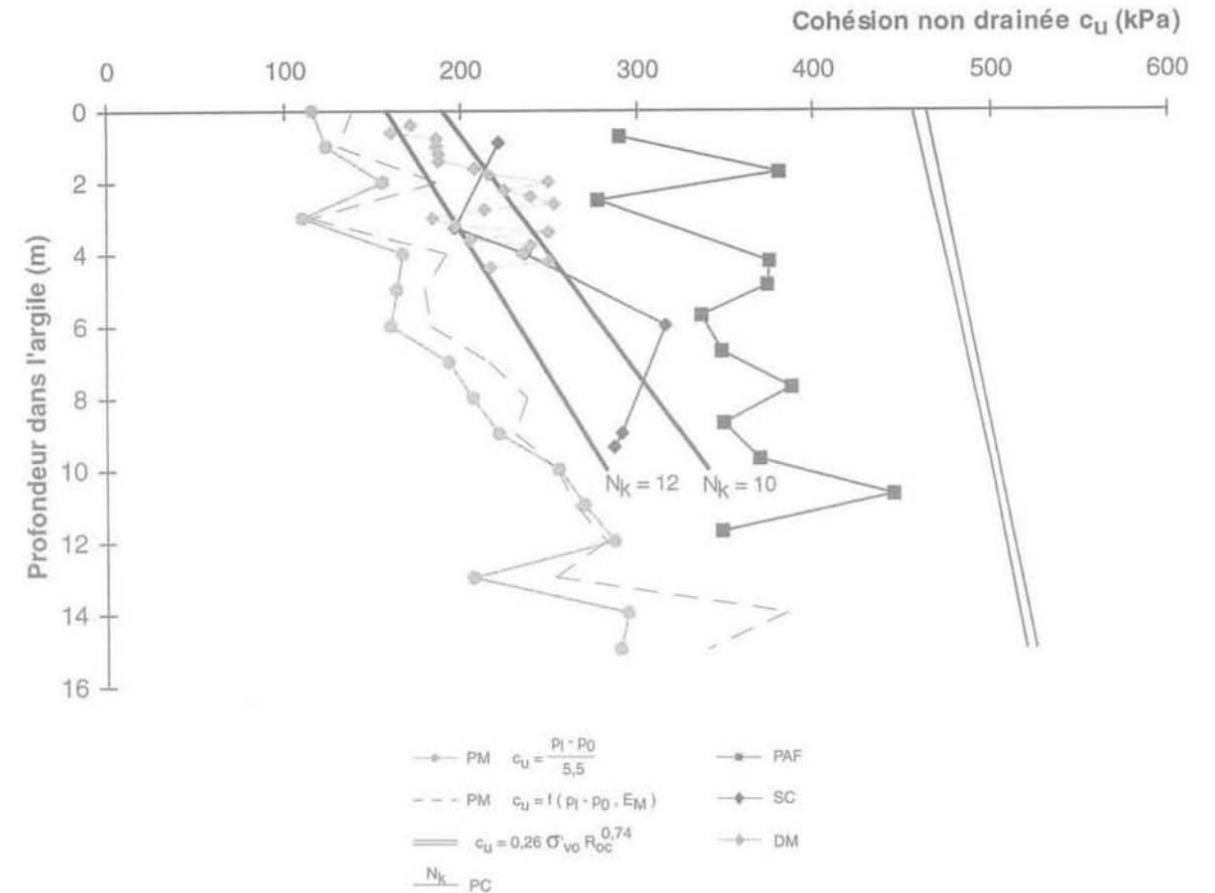


FIG. 11 Variation avec la profondeur de la cohésion non drainée déterminée à partir des essais en place : essais au scissomètre de chantier (SC), au pressiomètre autoforeur (PAF), au pressiomètre Ménard (PM), au dilatomètre Marchetti (DM) et au piézocône (PC). Tous ces essais ont été réalisés à Calais à l'exception des essais au pressiomètre autoforeur qui ont été effectués à Dunkerque.

Undrained shear strength derived from in situ tests – field vane tests (SC), selfboring pressuremeter tests (PAF), Ménard pressuremeter tests (PM), Marchetti dilatometer tests (DM) and piezocone tests (PC) – versus depth. All these tests were performed at Calais save the selfboring pressuremeter tests which were carried out at Dunkirk.

LITERATURE REVIEW

- Extensive literature on London Clay
 - Heathrow Terminal 5 extension
 - Characterisation of subhorizontal fracture zone at Prospect Park
- Argile des Flandres (Josseaume, 1998)
 - Extensive laboratory testing on intact clay samples from quay wall construction at Dunkirk
 - Presence of fissures reported and strength along pre-existing fractures quantified
 - Useful benchmark for intact sample testing

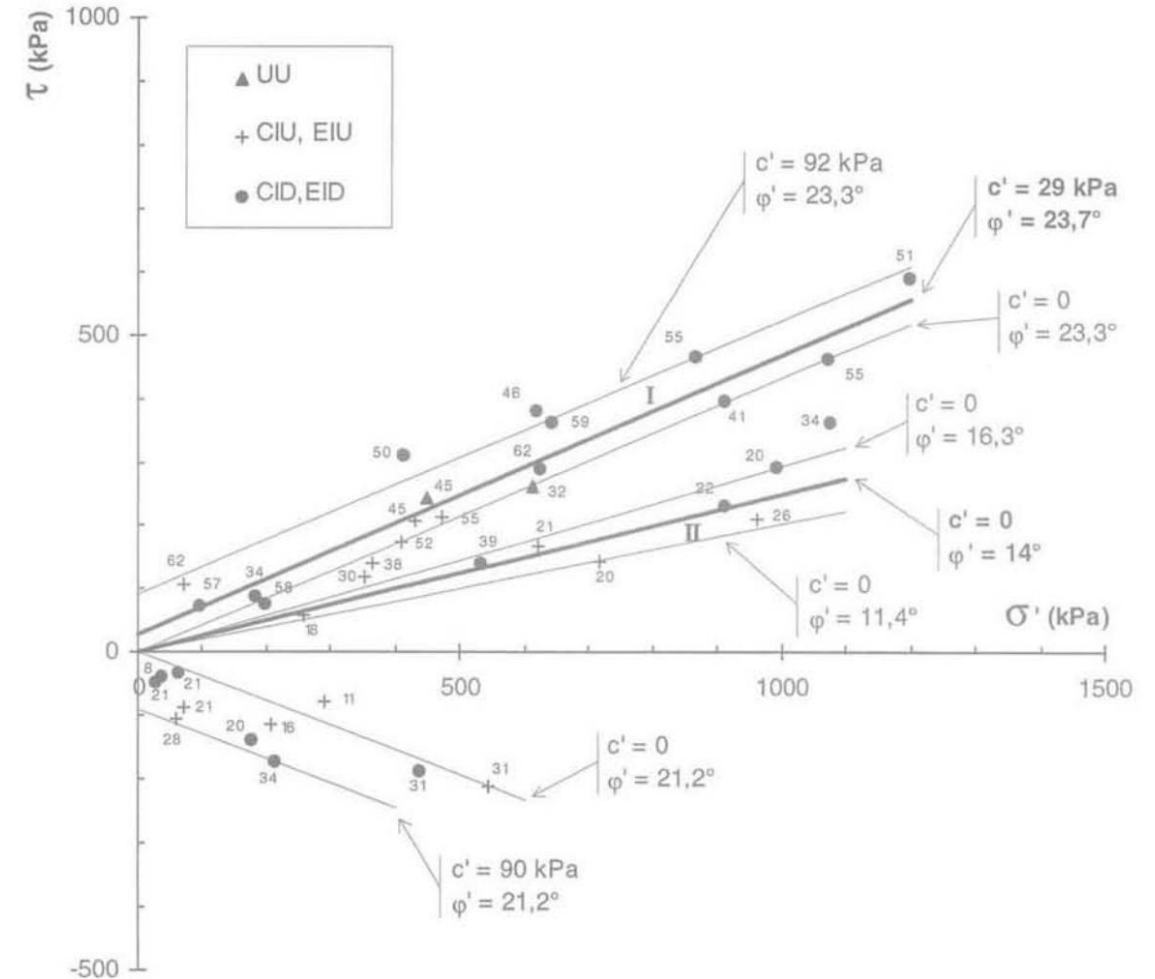
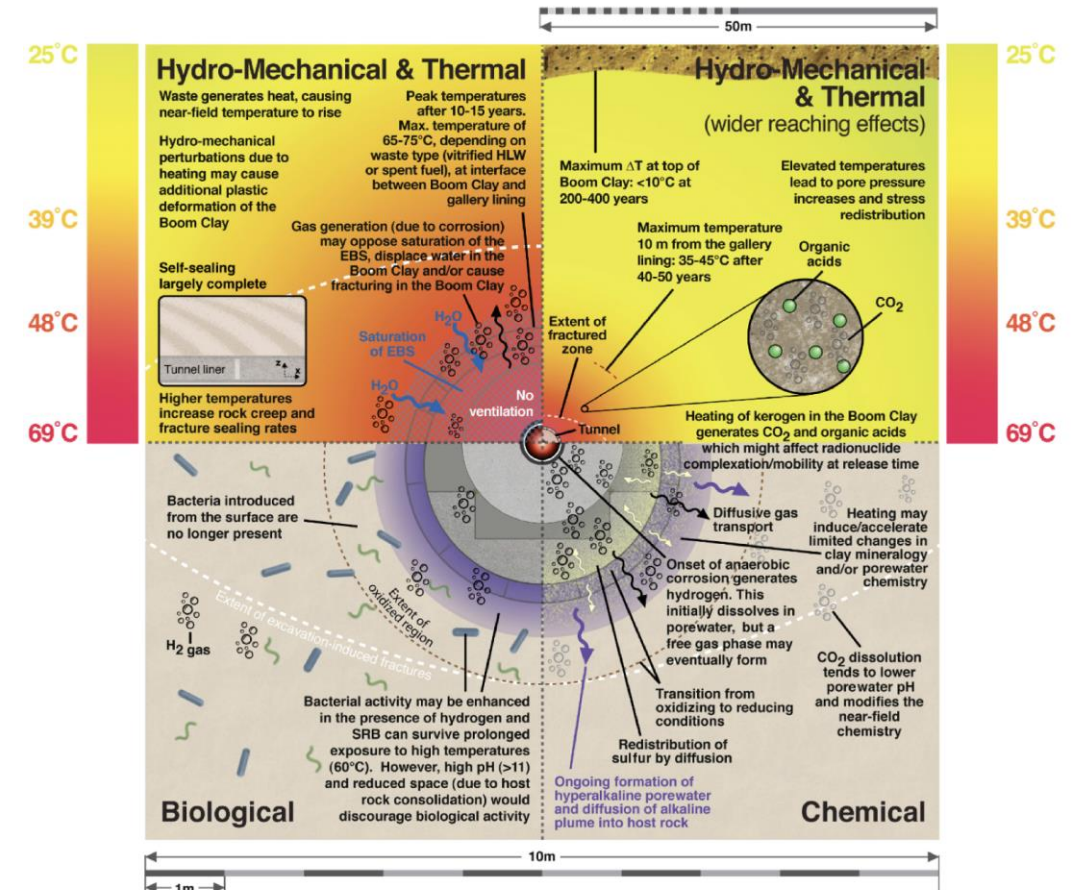


FIG. 15 Envelopes de rupture obtenues en tenant compte de l'inclinaison réelle α des plans de rupture. Les nombres accolés aux points du diagramme sont les valeurs de α exprimées en degrés.
Failure envelopes taking into account the actual inclination α of the failure planes. The numbers next to the points of the diagram are the values of α expressed in degrees.

LITERATURE REVIEW

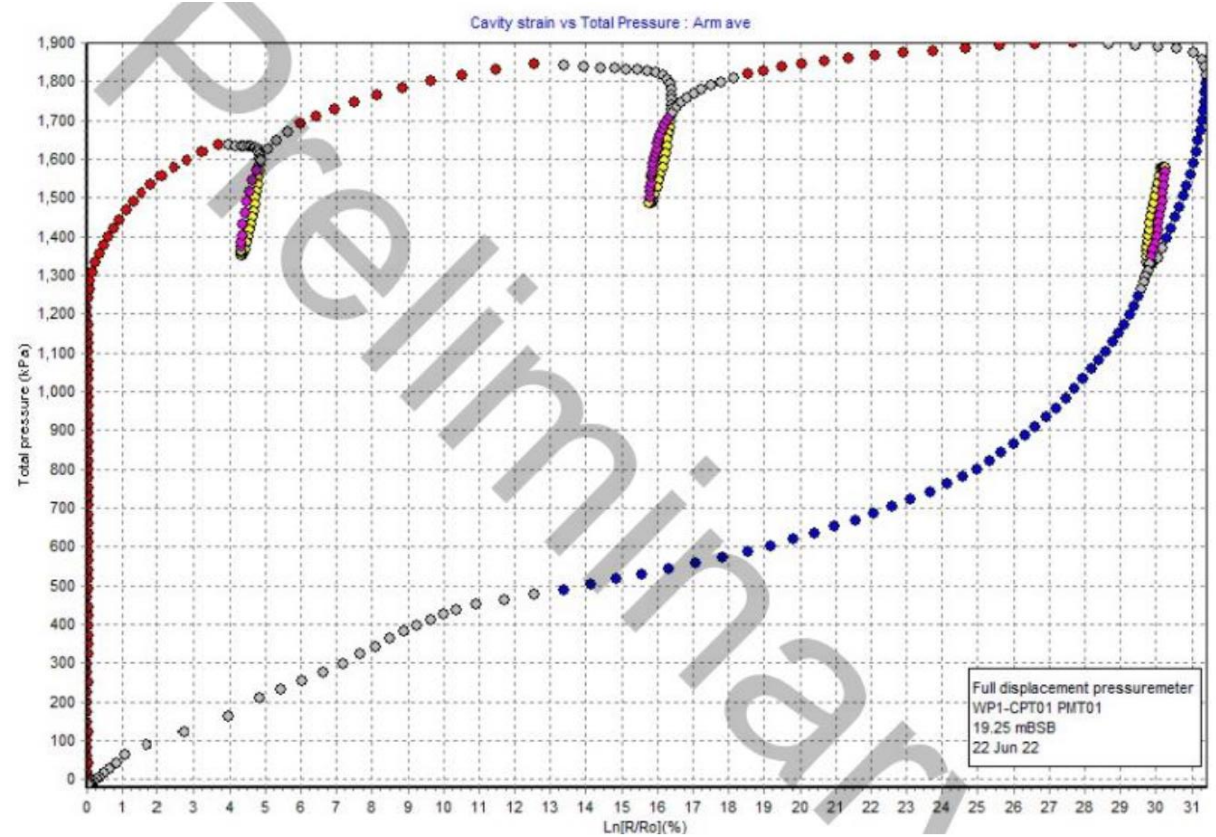
- Extensive literature on London Clay
 - Heathrow Terminal 5 extension
 - Characterisation of subhorizontal fracture zone at Prospect Park
- Argile des Flandres (Josseaume, 1998)
 - Extensive laboratory testing on intact clay samples from quay wall construction at Dunkirk
 - Presence of fissures reported and strength along pre-existing fractures quantified
 - Useful benchmark for intact sample testing
- Boom clay
 - Extensive experience on Boom clay at EURIDICE
 - Visit being planned



Li et al. (2023) <https://doi.org/10.1144/SP536-2022-103>

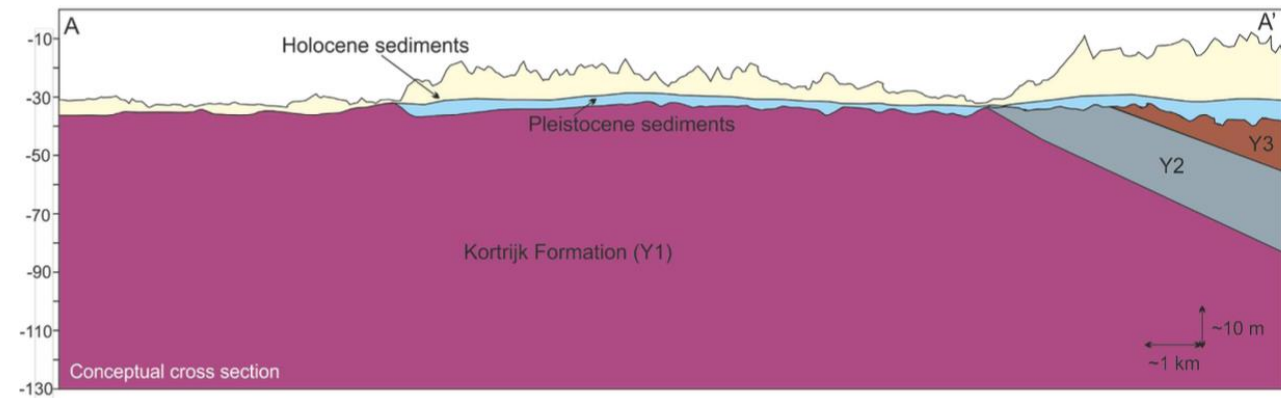
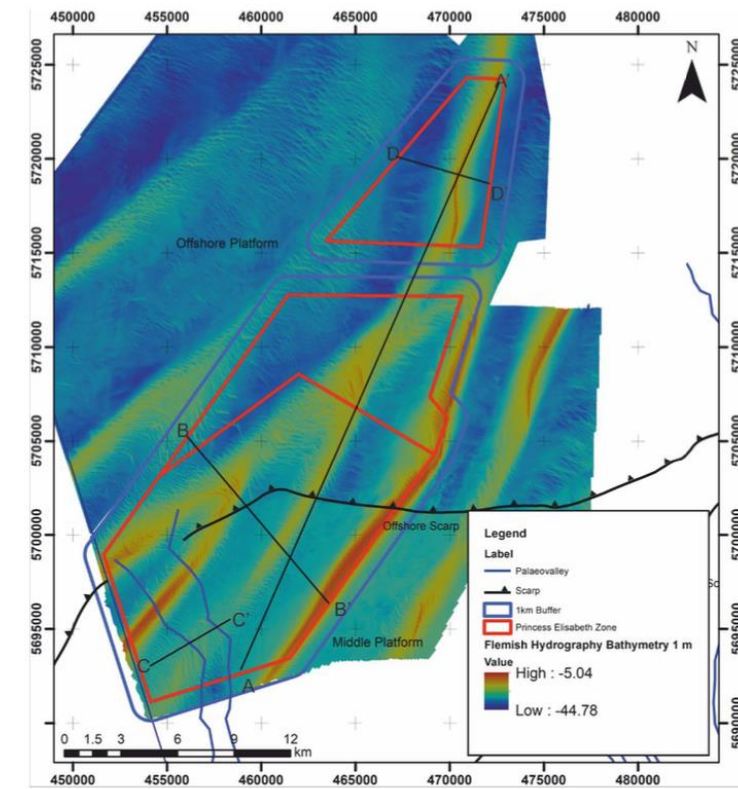
DATA SOURCES

- DTA with Elia signed for PEZ geotechnical data
 - CPT data
 - HPD data (larger zone of influence)



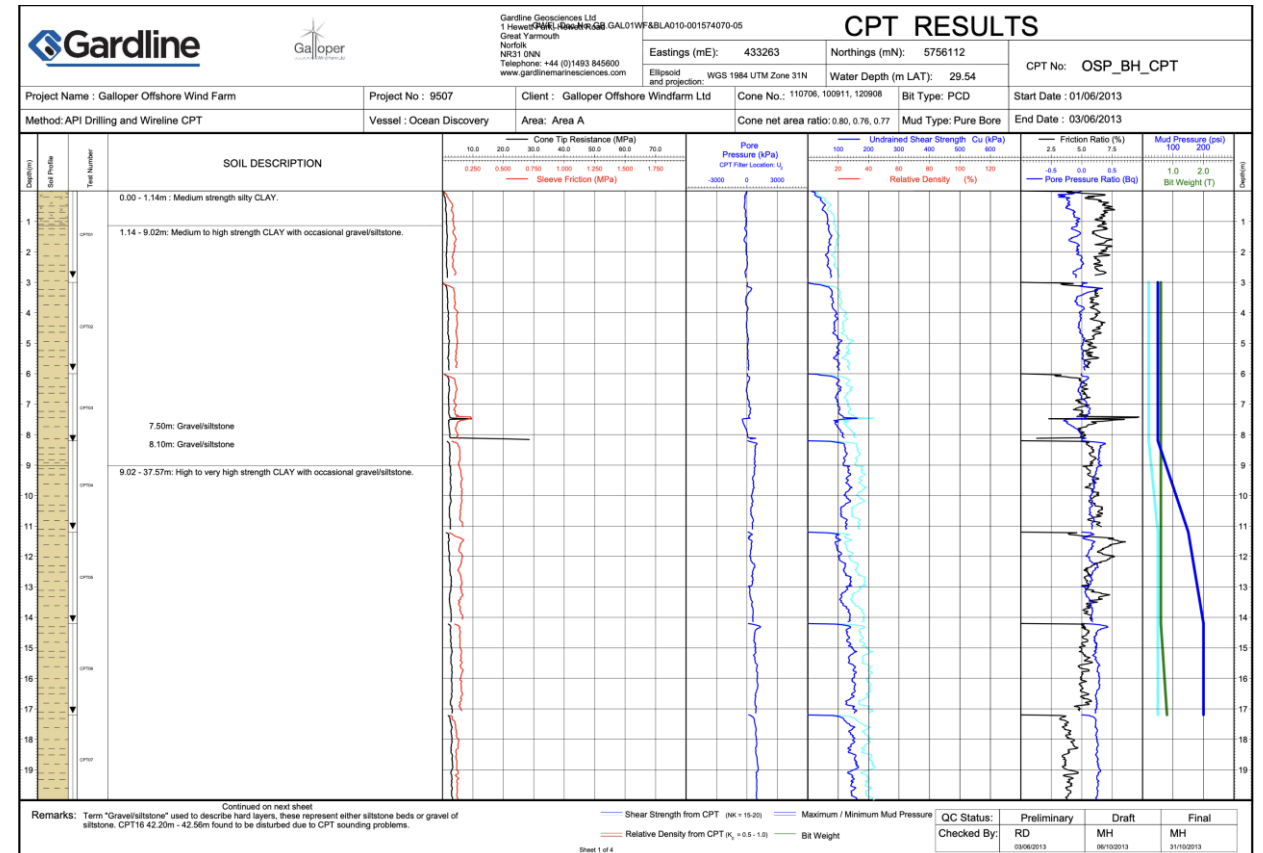
DATA SOURCES

- DTA with Elia signed for PEZ geotechnical data
 - CPT data
 - HPD data (larger zone of influence)
- Awaiting PEZ wind farm zone geotechnical data from FOD Economie (IMDC as coordinator)
 - CPT tests
 - Continuous sampling boreholes
 - Combined CPT + sampling holes with P-S logging



DATA SOURCES

- DTA with Elia signed for PEZ geotechnical data
 - CPT data
 - HPD data (larger zone of influence)
- Awaiting PEZ wind farm zone geotechnical data from FOD Economie (IMDC as coordinator)
 - CPT tests
 - Continuous sampling boreholes
 - Combined CPT + sampling holes with P-S logging
- Galloper public-domain data from Crown Estate
 - CPT tests
 - Laboratory tests



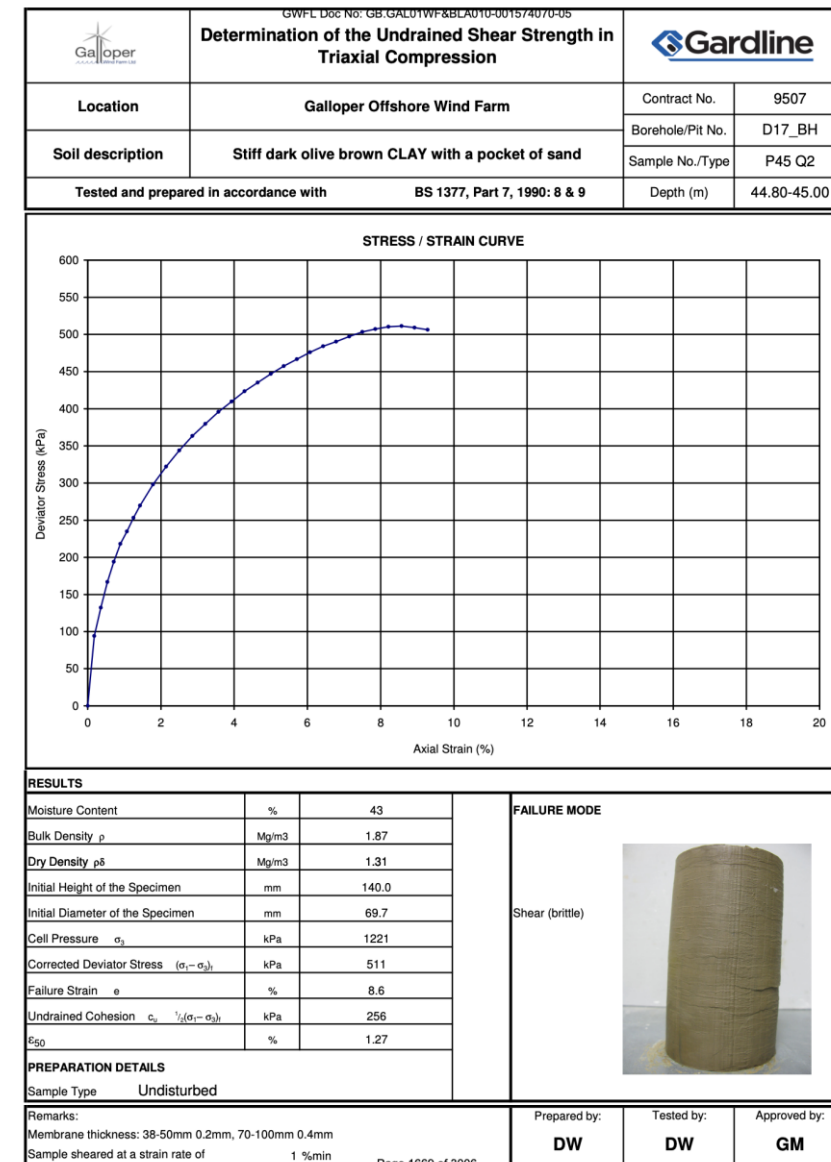
DATA SOURCES

- DTA with Elia signed for PEZ geotechnical data
 - CPT data
 - HPD data (larger zone of influence)
- Awaiting PEZ wind farm zone geotechnical data from FOD Economie (IMDC as coordinator)
 - CPT tests
 - Continuous sampling boreholes
 - Combined CPT + sampling holes with P-S logging
- Galloper public-domain data from Crown Estate
 - CPT tests
 - Laboratory tests



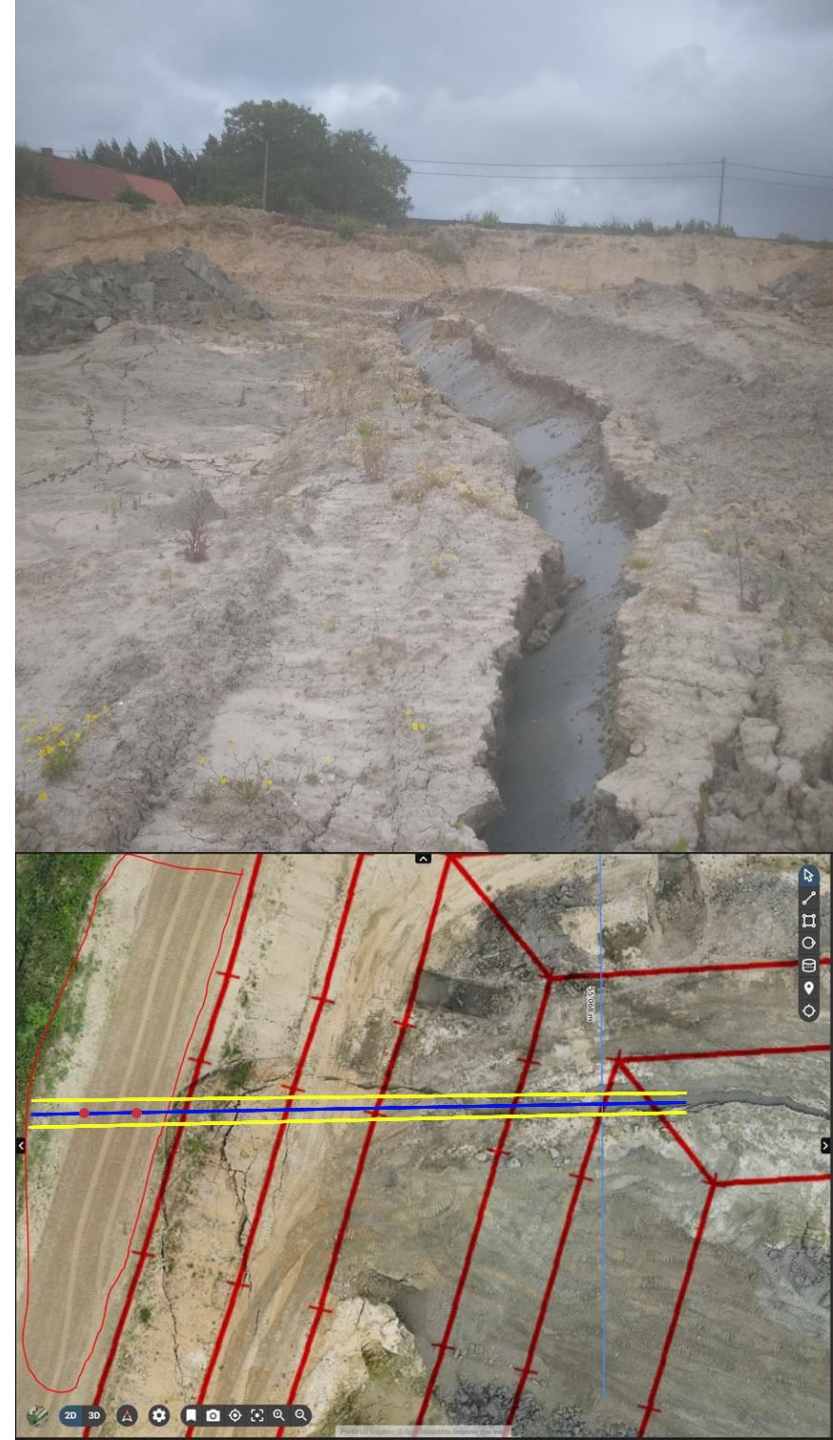
DATA SOURCES

- DTA with Elia signed for PEZ geotechnical data
 - CPT data
 - HPD data (larger zone of influence)
- Awaiting PEZ wind farm zone geotechnical data from FOD Economie (IMDC as coordinator)
 - CPT tests
 - Continuous sampling boreholes
 - Combined CPT + sampling holes with P-S logging
- Galloper public-domain data from Crown Estate
 - CPT tests
 - Laboratory tests



ONSHORE SAMPLING CAMPAIGN – PUSH SAMPLES

- Subvertical fracture was observed onshore in a clay pit in Rumbeke
- Location of the fracture has been covered with asbestos waste
- Planned geotechnical works (soilmix wall installation + inclinometer installation) provided an opportunity to perform geotechnical drilling to the fracture surface
- Extrapolation of position of the fracture surface from satellite imagery



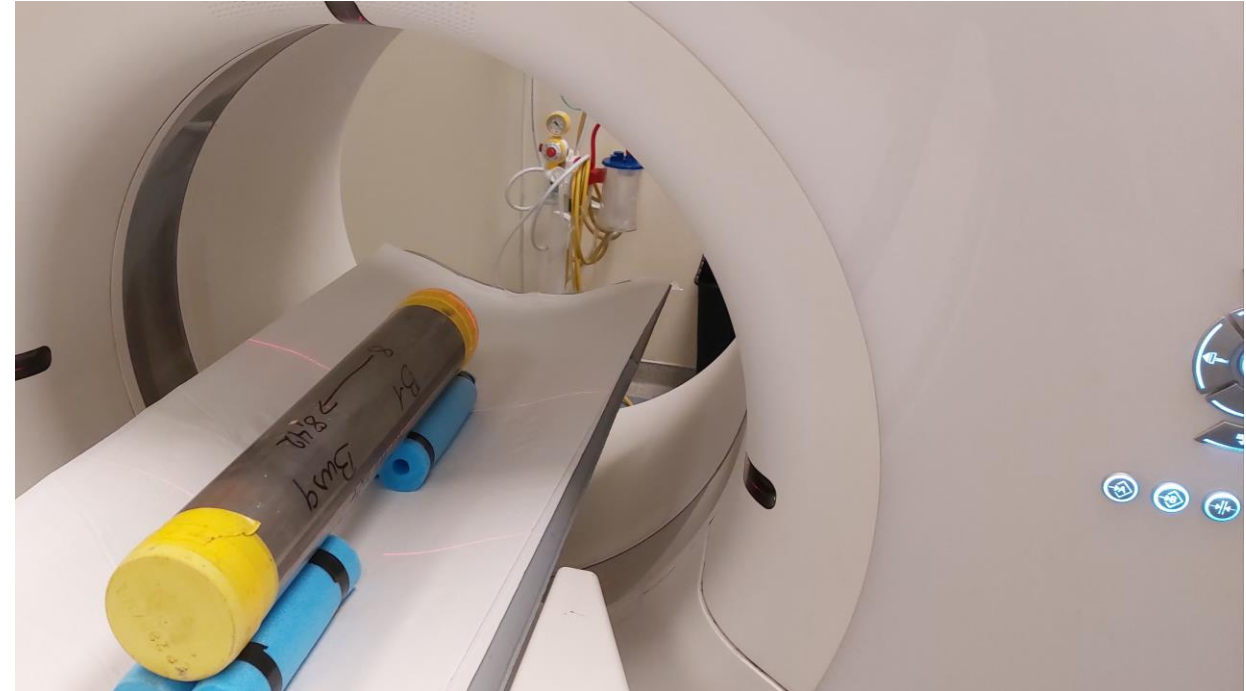
ONSHORE SAMPLING CAMPAIGN – PUSH SAMPLES

- Two boreholes planned
 - Destructive drilling to the top of the Tertiary clay (~4m depth)
 - Undisturbed push samples to (~10m depth)
 - 12no
 - 50cm length
 - 108mm outer diameter
 - Only one borehole executed due to adverse weather
 - Samples immediately taken to UGent Geotechnics Lab (storage in 10°C room with high humidity)
- X-ray scanning of sample tubes to detect possible fracture zone prior to sample extrusion



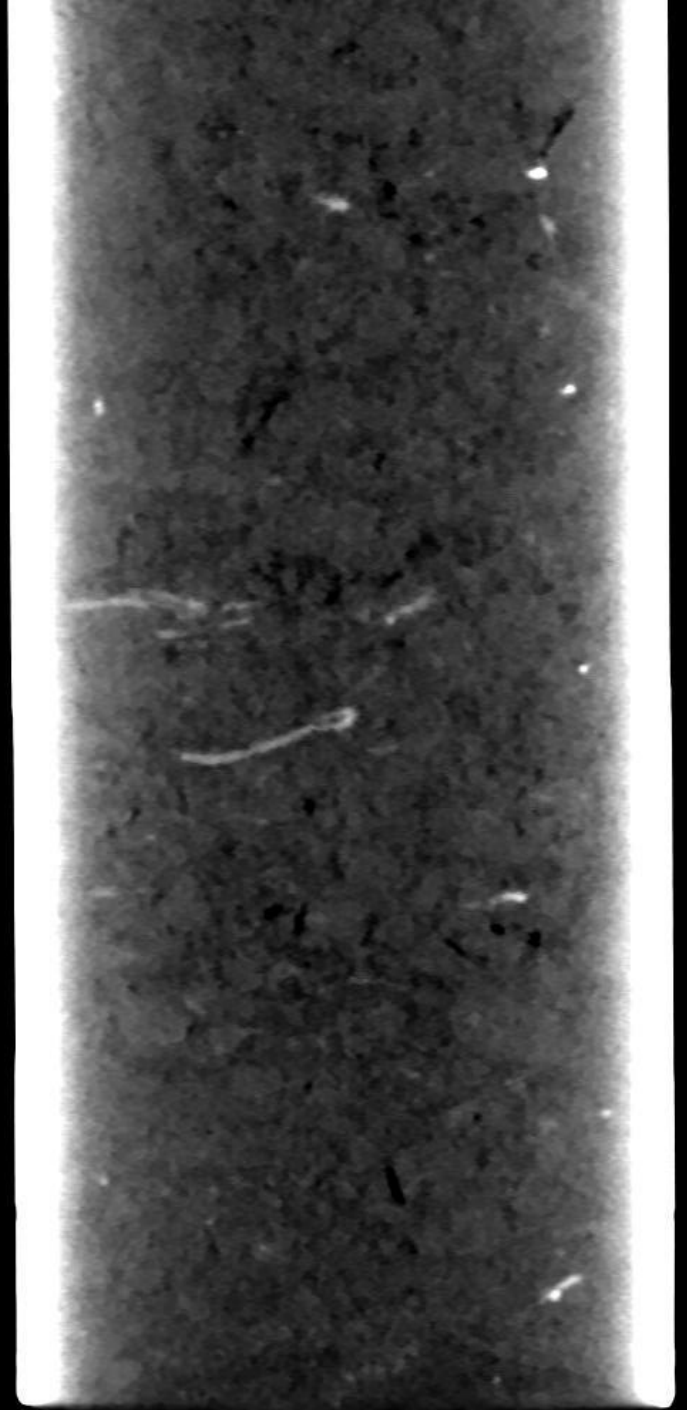
ONSHORE SAMPLING CAMPAIGN – PUSH SAMPLES

- Two boreholes planned
 - Destructive drilling to the top of the Tertiary clay (~4m depth)
 - Undisturbed push samples to (~10m depth)
 - 12no
 - 50cm length
 - 108mm outer diameter
 - Only one borehole executed due to adverse weather
 - Samples immediately taken to UGent Geotechnics Lab (storage in 10°C room with high humidity)
- X-ray scanning of sample tubes (kudos to Maarten Van Daele!) to detect possible fracture zone prior to sample extrusion



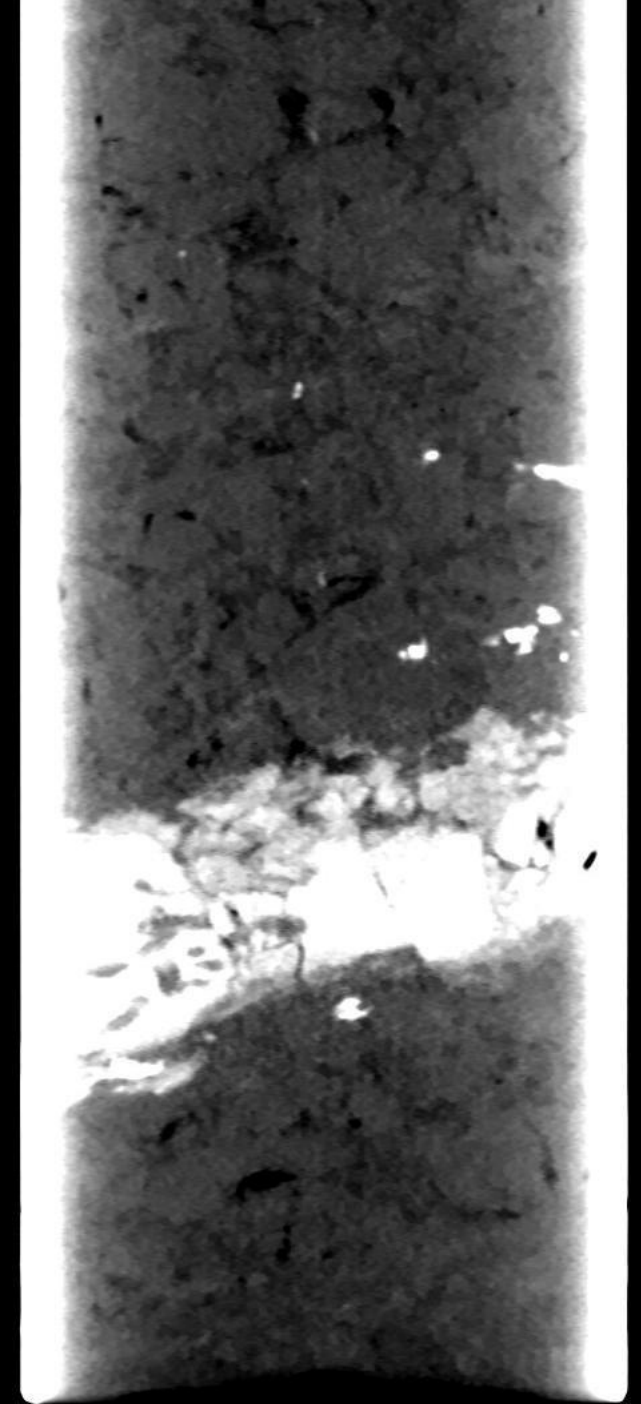
ONSHORE SAMPLING CAMPAIGN – PUSH SAMPLES

- Several small fractures and fissures visible in all samples



ONSHORE SAMPLING CAMPAIGN – PUSH SAMPLES

- Several small fractures and fissures visible in all samples
- In sample S6 a zone with different density is clearly observed



ONSHORE SAMPLING CAMPAIGN – PUSH SAMPLES

- Several small fractures and fissures visible in all samples
- In sample S6 a zone with different density is clearly observed
- Laboratory testing coordinated with UGent Geology department
- One CU triaxial test started from deepest sample
 - Long saturation and consolidation times

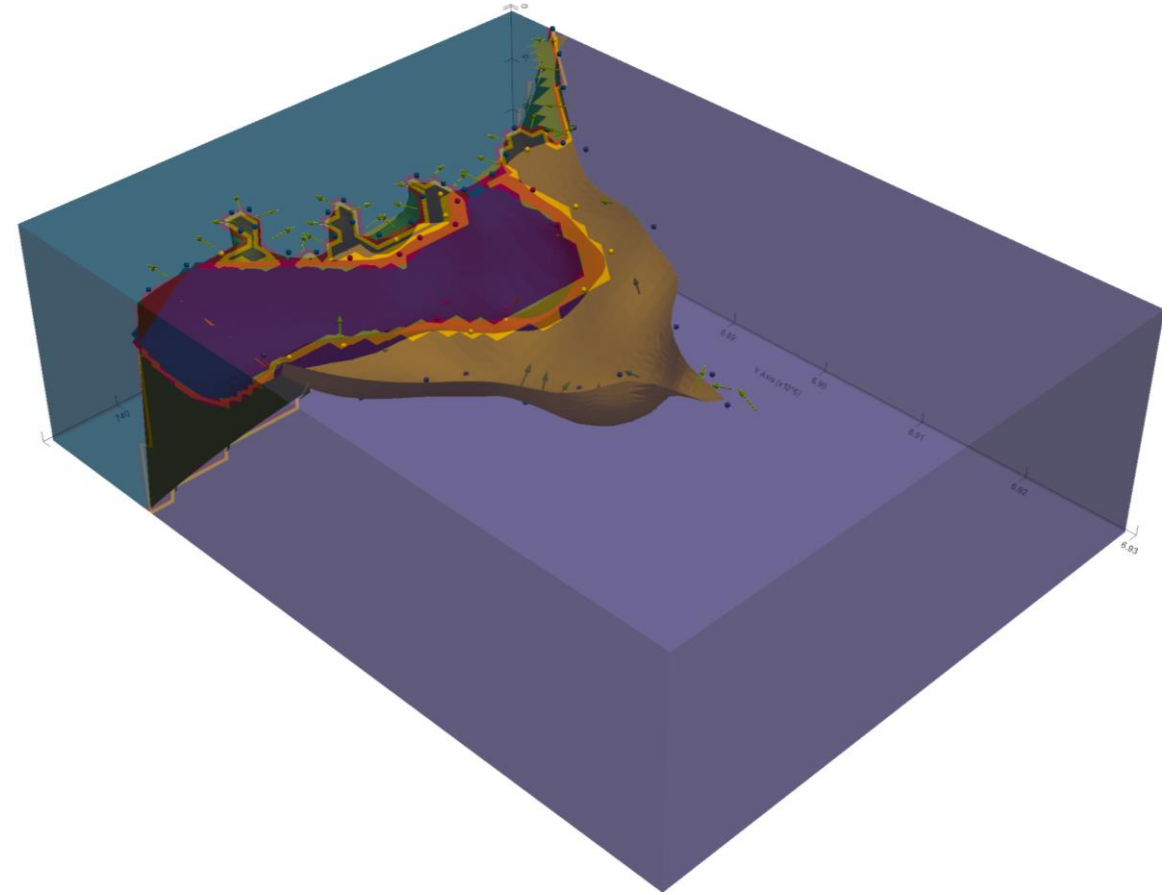


ONSHORE SAMPLING CAMPAIGN – BLOCK SAMPLES

- Large block samplers to take samples in the clay pit
- Sampling campaign to be planned after results of geotechnical tests on push samples are available

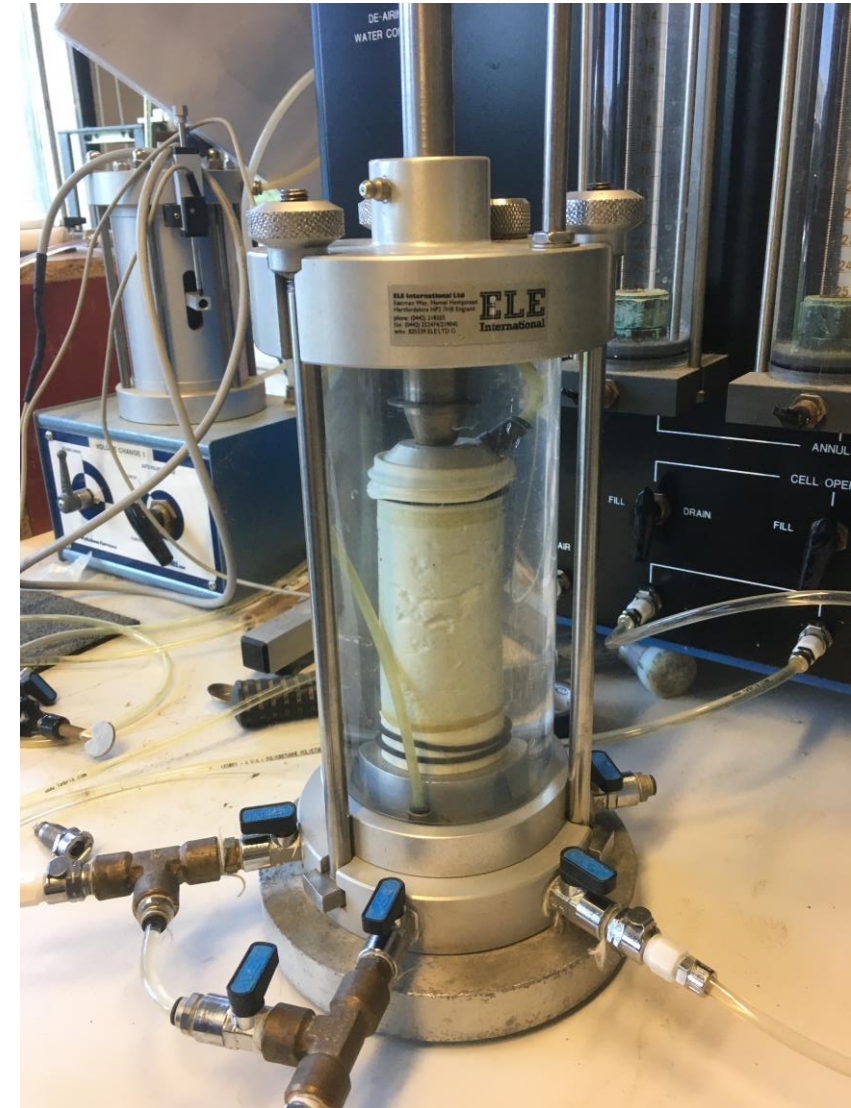
3D GROUND MODELLING WITH GEMPY

- Exploration of the GemPy package for ground modelling
 - Add layer (geological unit) interfaces
 - Add fracture orientations
- Based on a universal cokriging method devised by Lajaunie et al. (1997)
- Can be used to represent the geological structure of the site from the geotechnical and geological data



CONCLUSIONS

- Geotechnical work started, driven by available window for sampling of the fracture surface
- Planning and execution of laboratory testing on push samples awaiting execution
 - Water content
 - Atterberg limits (liquid & plastic limit)
 - Shear box testing (special attention for possible fracture zone)
- Data ingestion for Energy Island, PEZ and Galloper planned
- Basics of 3D ground modelling learnt, 3D FEA to follow



Thank you !



bruno.stuyts@vub.be

<https://www.linkedin.com/in/bruno-stuyts/>

www.owi-lab.be (looking for expertise, knowledge, test-infrastructure?)

