CHALMERS
UNIVERSITY OF TECHNOLOGY

NCC

On the long-term behaviour of tension loaded piles in natural soft soils

- A field study and numerical modelling

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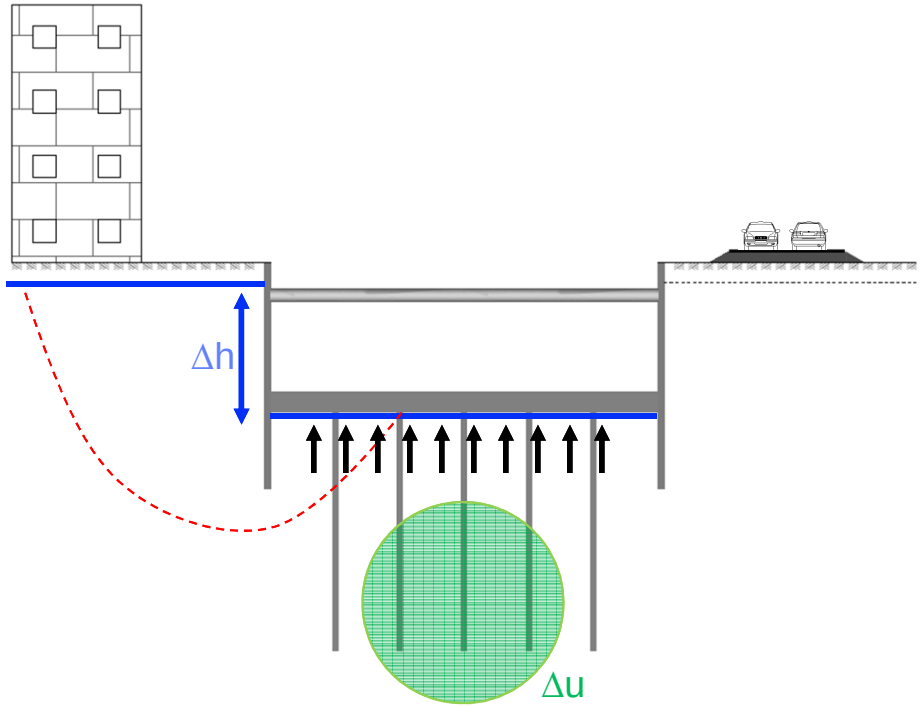
Outline

- Background
- Research program
- Field test
- Results
- Analysis
- Conclusion

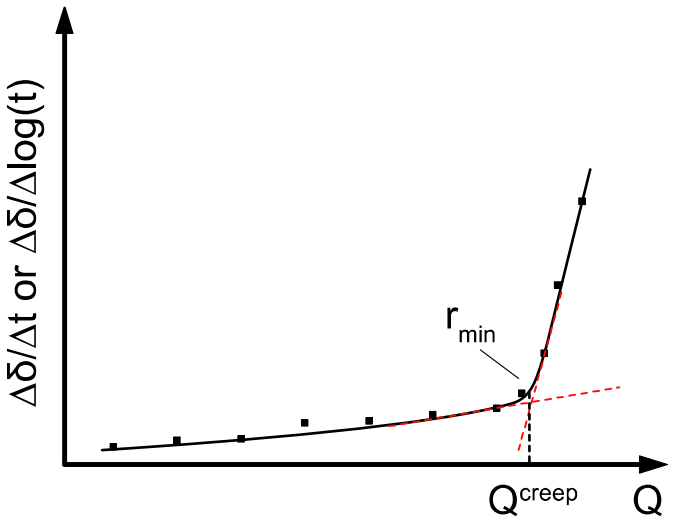
Background

- New **complex infrastructure** projects in densely populated **urban areas** on **soft soil** deposits.
  - Case: ***The West Link railway tunnel in Gothenburg, Sweden.***
- Limited knowledge on the **long-term** behaviour of **permanent tension loaded piles** onshore.



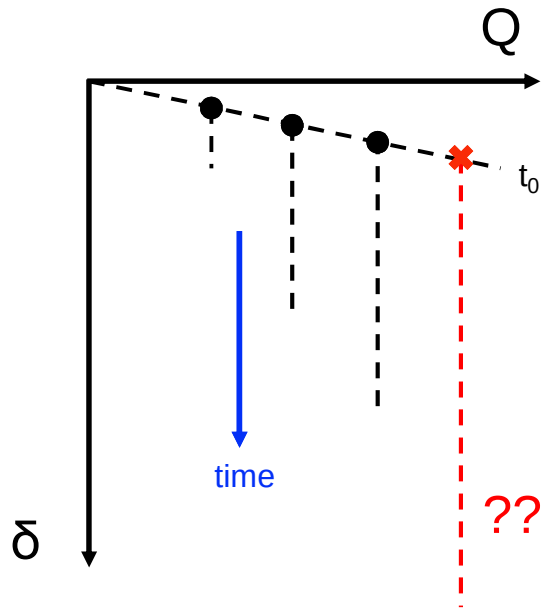
Today´s experience

- **Large amount of knowledge in relation to compression loaded piles.**
  - **Calibrated empirical methods based on local conditions, e.g. α - method.**
- **Main research centred on single piles and short-term loading.**
  - **Long-term related to pile “creep” load, e.g. 80% of Q_{ult}.**



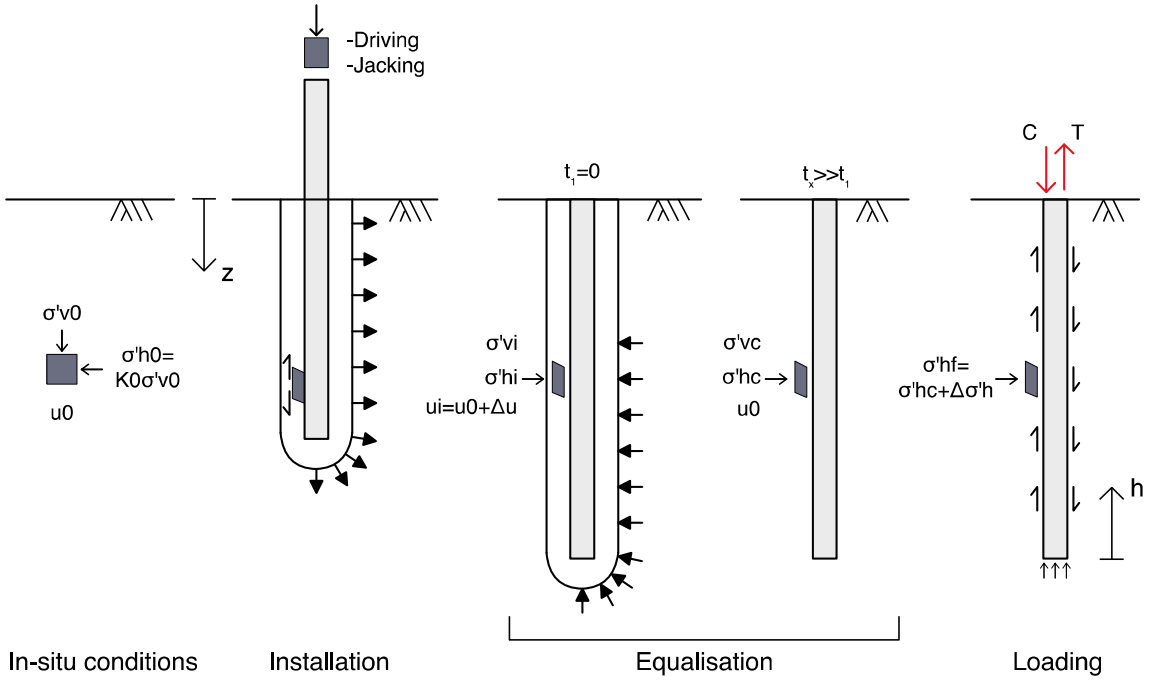
What about tension loaded piles?

- **Short-term tests have shown same behaviour as compression piles.**
- **Used in temporary works effectively, e.g. Nordstan.**
- **However, uncertainties in long-term deformation and bearing capacity.**



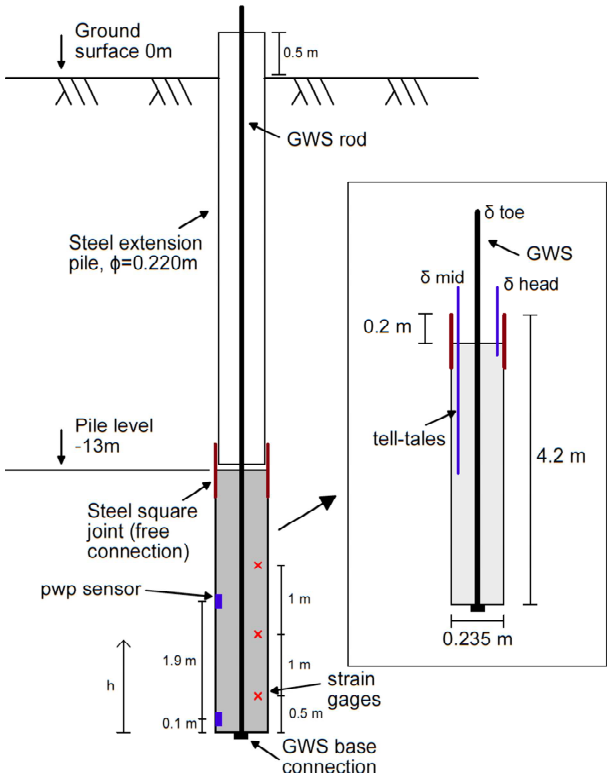
Research: tension loaded piles

- **Field test: Reproduce the complex pile cycle in relevant soil and stress conditions.**
  1. ***Soil distortion and excess pore water pressure.***
  2. ***Soil consolidation.***
  3. ***Soil shearing.***

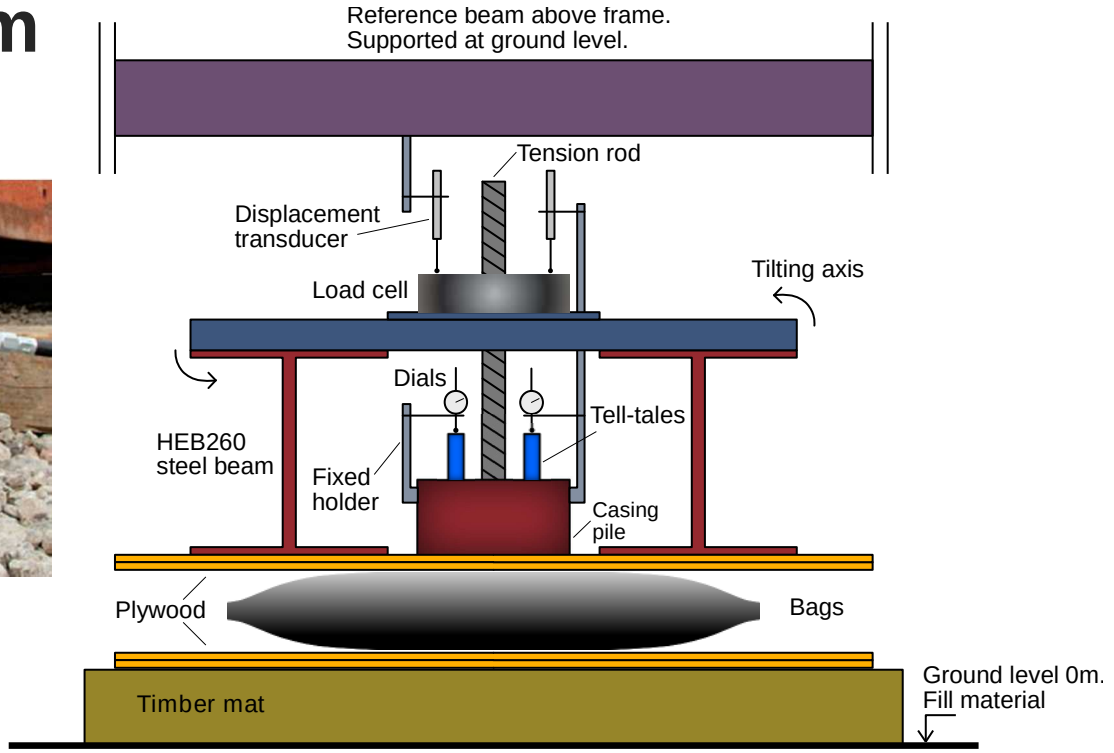


Research: objectives

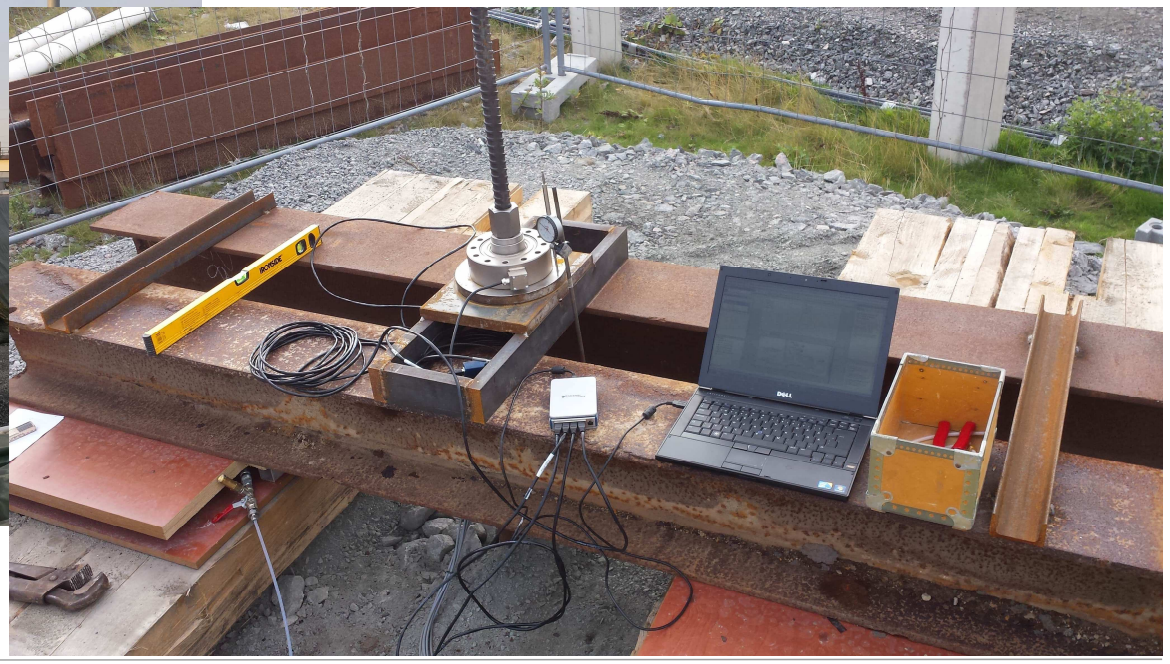
- Obtain **quantitative experimental data** on the long-term behaviour of piles under sustained tension loads.
- Interpretation of gathered data using a **rational framework and contemporary soft soil modelling**.



Field test: long-term

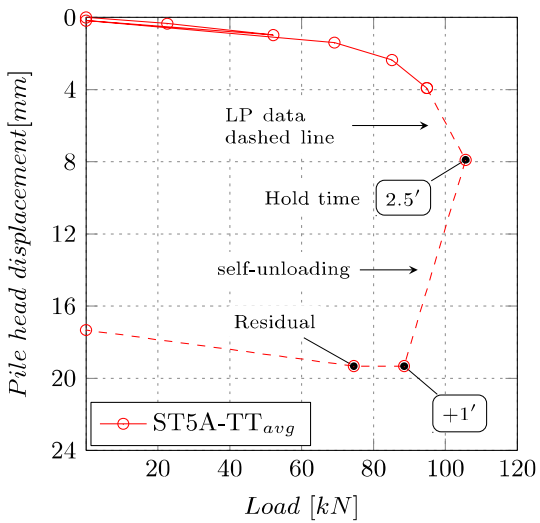


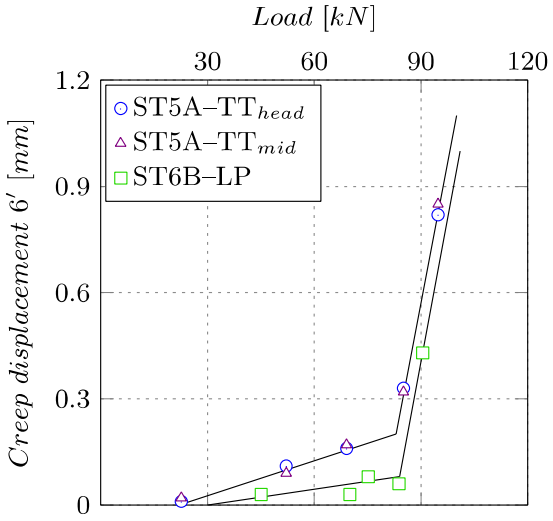
Field test



Short-term (QML): reference case

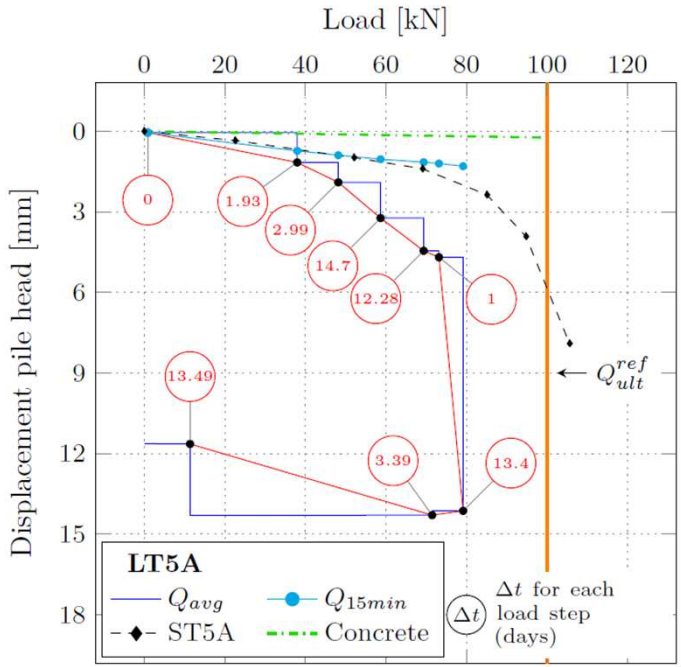
- $Q_{ult} \approx 100$ kN
  $\alpha \approx 0.85$*
- $\delta_{ult} \approx 4$-8 mm
  2% D_{eqv}
- $Q_{creep} \approx 80$ kN
  80% Q_{ult}

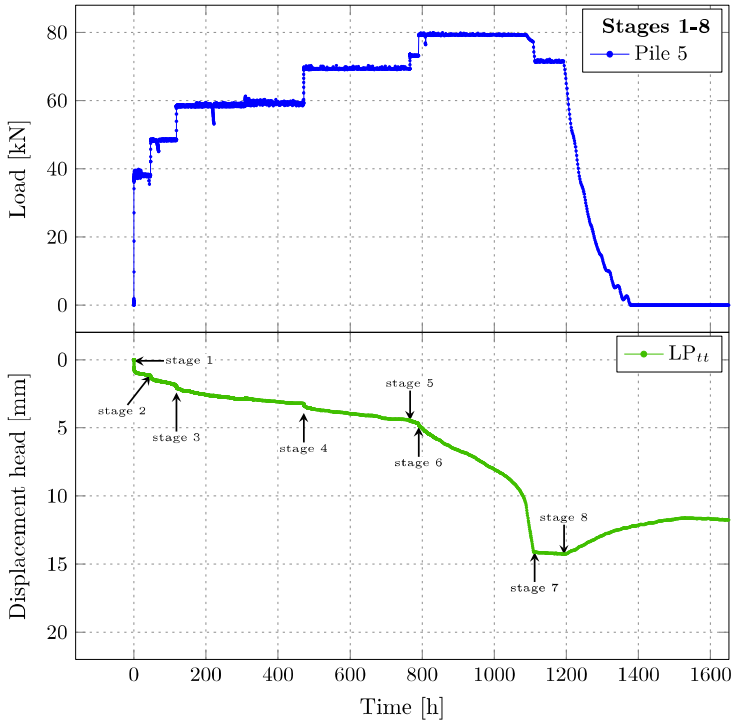




*Uncorrected vane and good quality DSS.

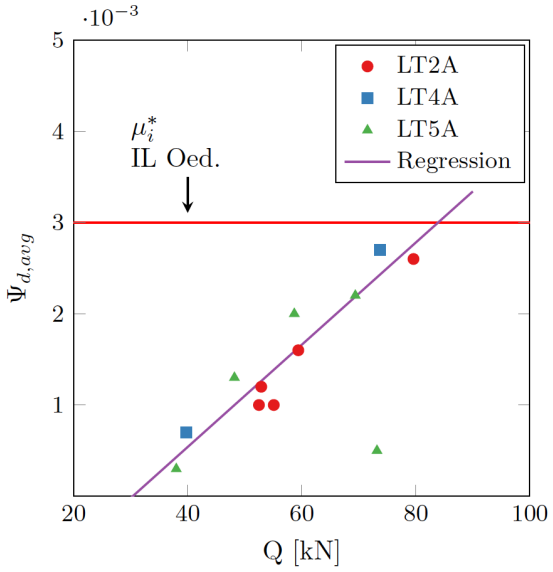
Long-term: 4-6 months

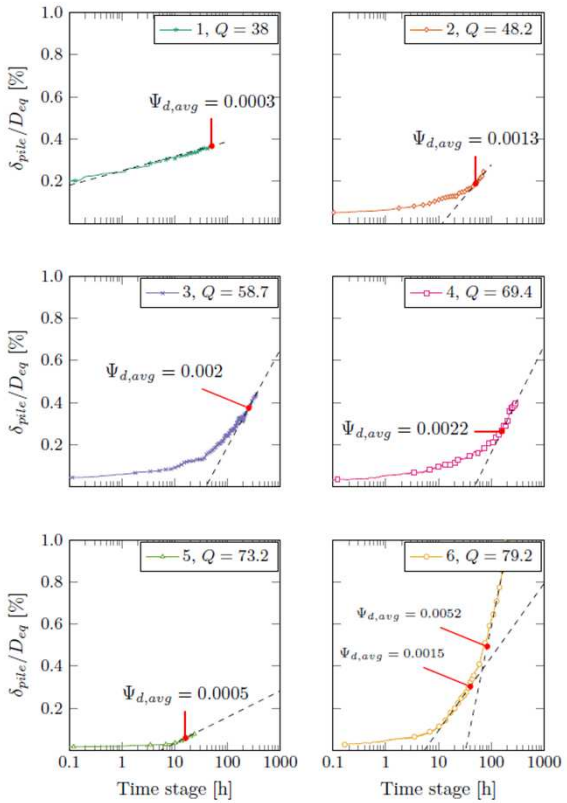




Long-term

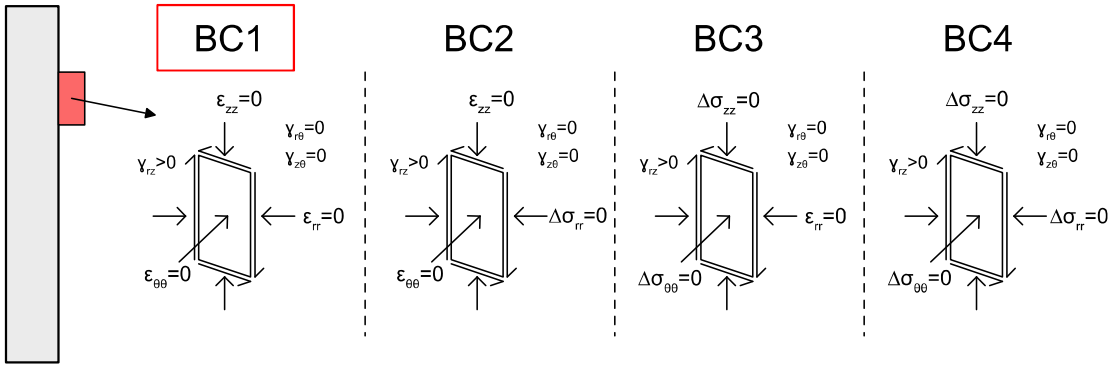
- $Q_{sls} \approx$ 70-80% Q_{ult}
- **Linear pile head creep** in semi-log plot for pile-soil interaction. Very small in magnitud.
- Creep rate tends to **intrinsic**.

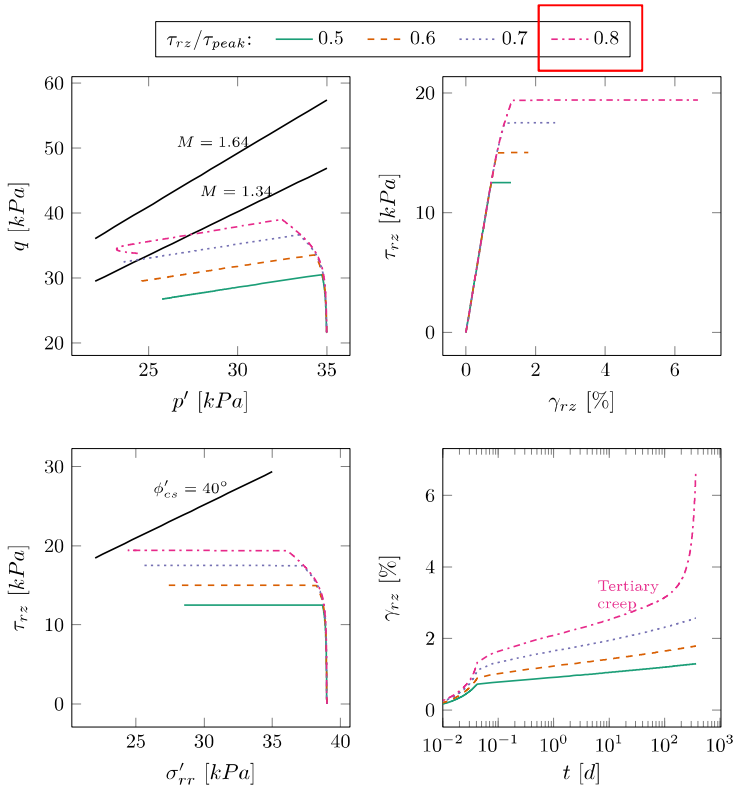




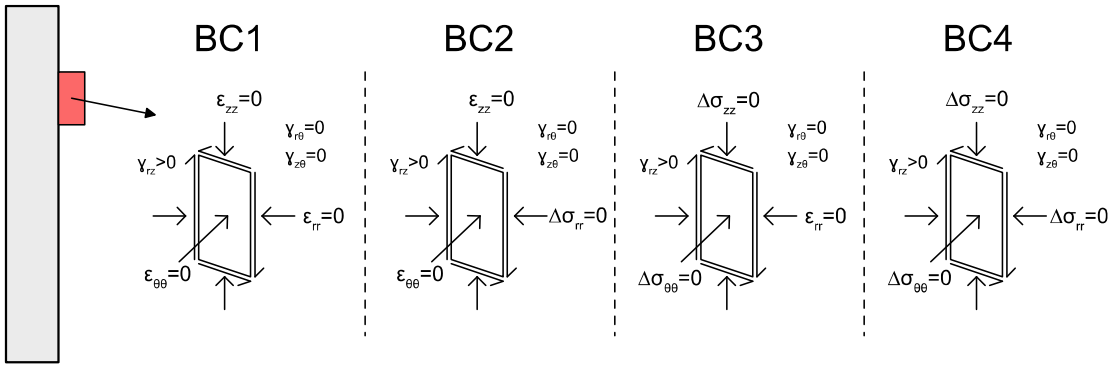
Numerical modelling

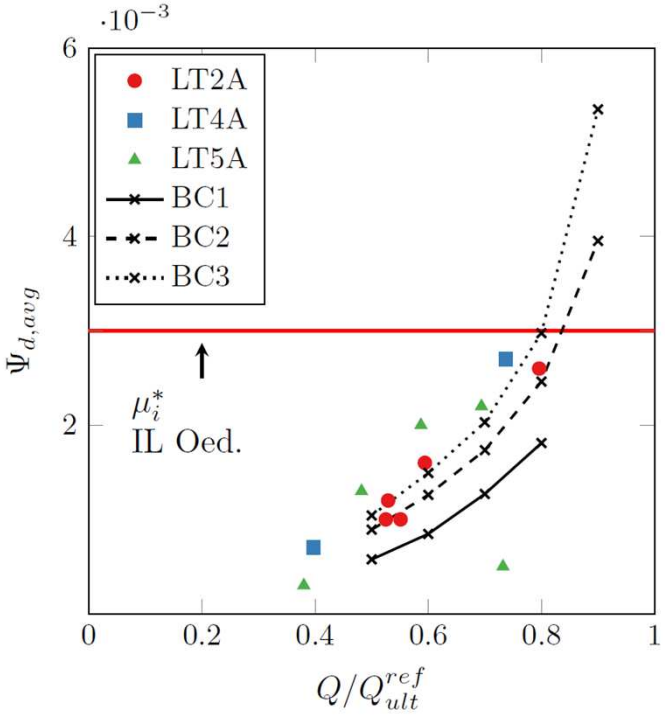
- **Installation: Strain Path Method**
- **DSS analogy – single integration point**
- **SCLAY1S and CREEP-SCLAY1S**



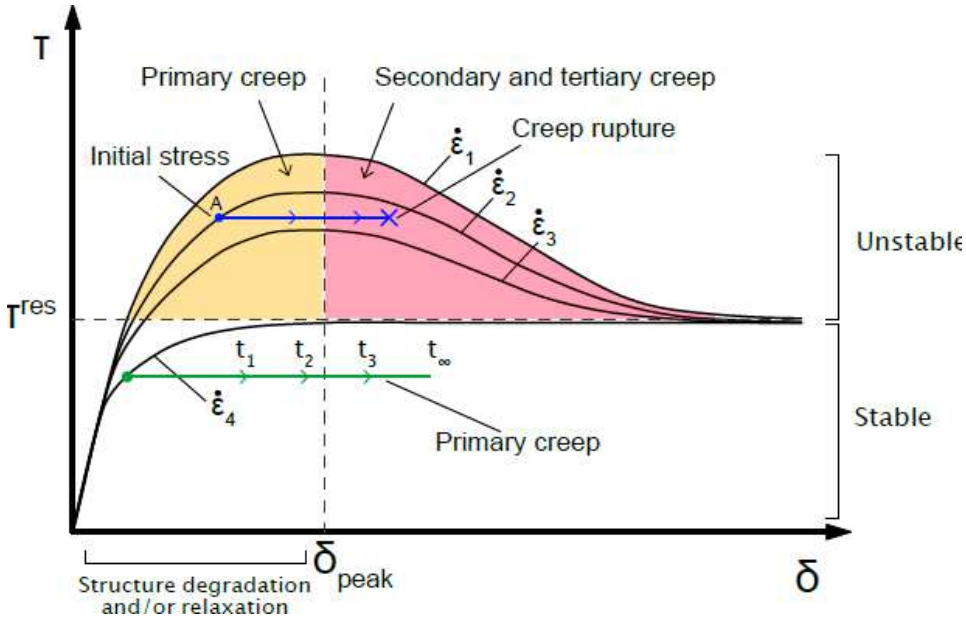


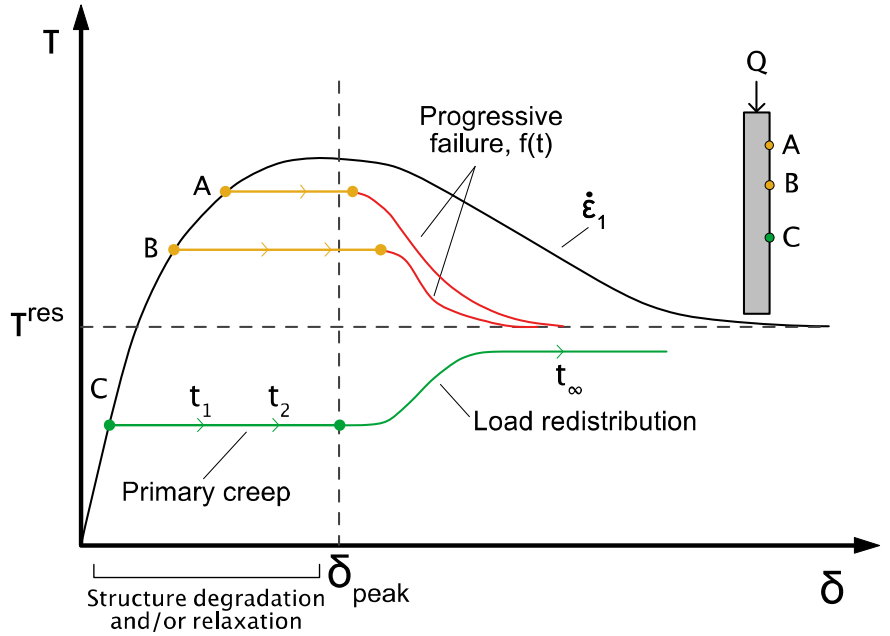
Numerical modelling





Creep criterion





Conclusion

- **The field test properly incorporated the pile cycle.**
- **A new non-standard, cost-effective and scalable mechanical loading setup was developed for tension piles in soft clays.**
- **The long-term pile response is dominated by the creep deformations in the soil adjacent to the pile shaft.**
  - **The long-term pile capacity for the test site is approximately 70-80% Q_{ult}. Below this limit, small creep displacements occur.**
- **Based on simulations, the reduction in bearing capacity is caused by stress relaxation from creep deformations.**

PÅLDAG 17

pålgrundläggning

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