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Géotechnique

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Monotonic and cyclic lateral loading of piles in low to medium density chalk

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ALPACA:

Lateral cyclic field testing

Dr Ross McAdam

Danish Geotechnical Society Seminar, Gentofte, 2024

ALPACA & ALPACA+ Campaigns (2017 – 2022)

- Imperial College London, Oxford University and 12 industrial partners
- 43 driven piles – 138 mm - 1,800 mm diameter – $L/D = 6 - 20$
- Axial-and-lateral static-and-cyclic testing
- In-situ testing, sampling and advanced lab testing

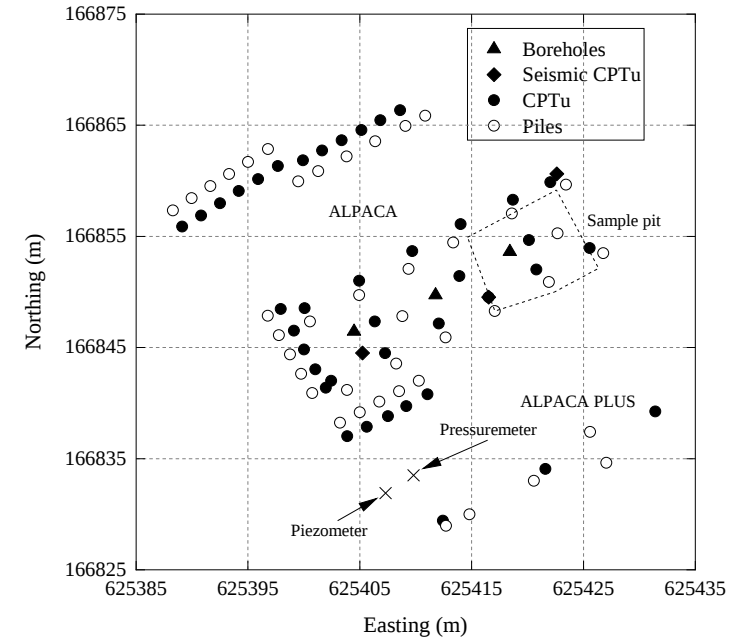
Imperial College
London



EPSRC
Engineering and Physical Sciences
Research Council

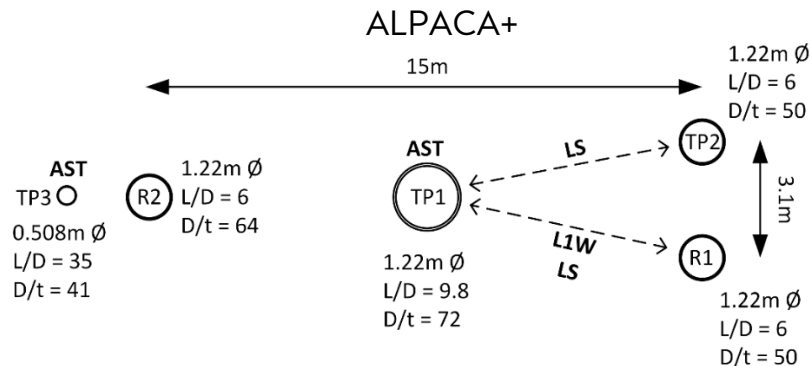
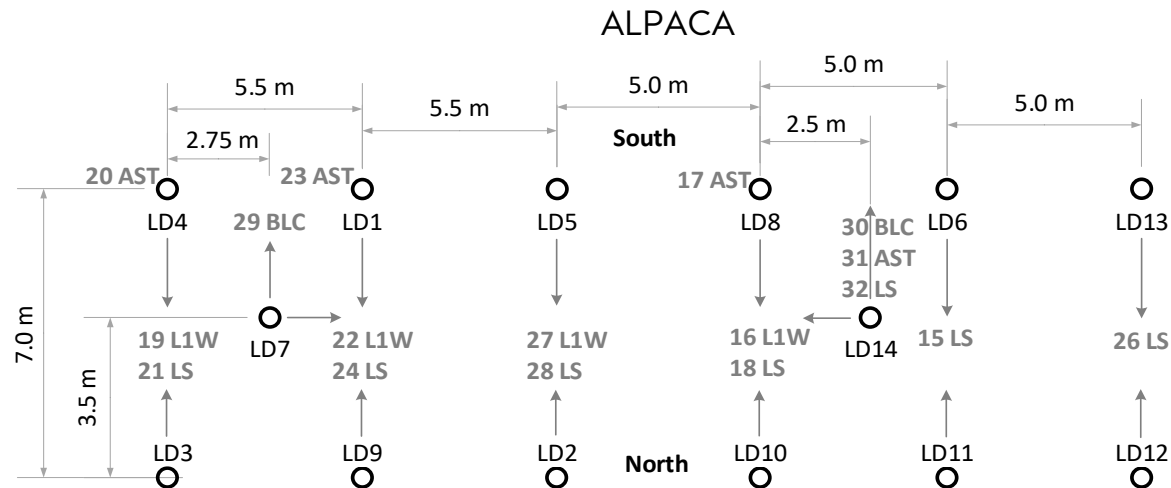


St. Nicholas at Wade, Kent, UK



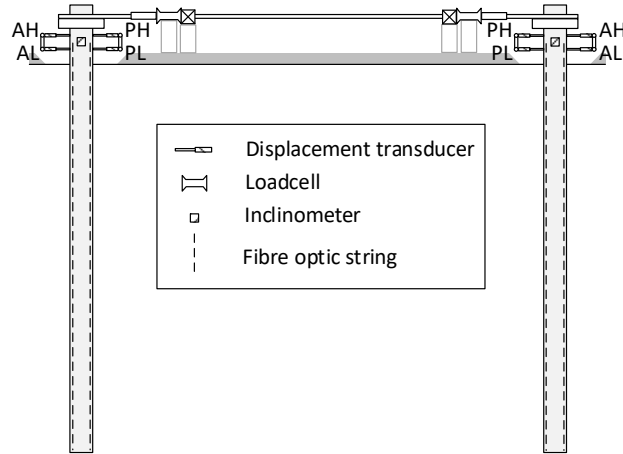
Lateral load tests

- 16 lateral load tests
- Loaded in pairs
- ALPACA: 508mm dia.
 - $L/D = 6$ & 20
- ALPACA+: 1.22m dia.
 - $L/D = 6$
- All post-axial load testing (AST)
- 3 virgin monotonic (LS)
- 5 lateral 1-way cyclic (L1W)
- 6 post-cyclic monotonic (LS)
- 1 bi-axial lateral cyclic (BLC)

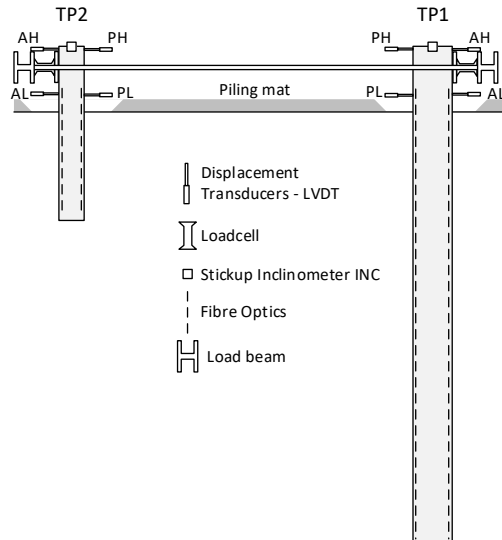


Lateral loading arrangement

ALPACA



ALPACA+



ALPACA



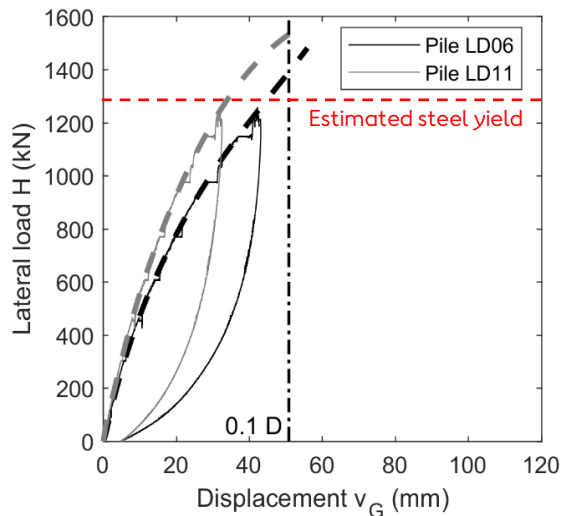
ALPACA+



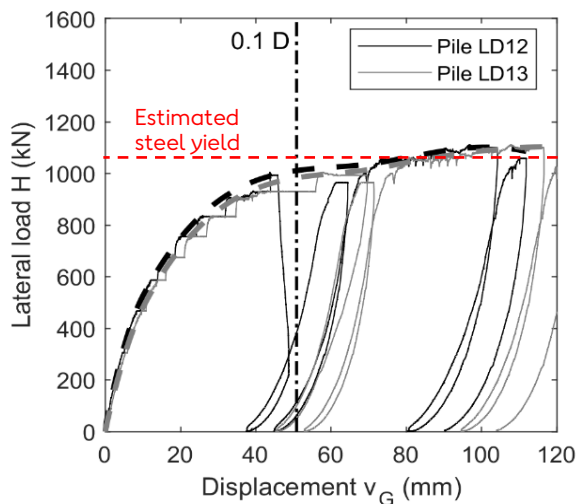
Monotonic response

- Displacement controlled load steps
- Maintained load pauses
- Unload prior to predicted yield
- Reload-unloads to max stroke
- P-v extraction in Géotechnique (McAdam et al. 2024)
- 3D FE analysis in ALPHA (Pedone et al. 2023)

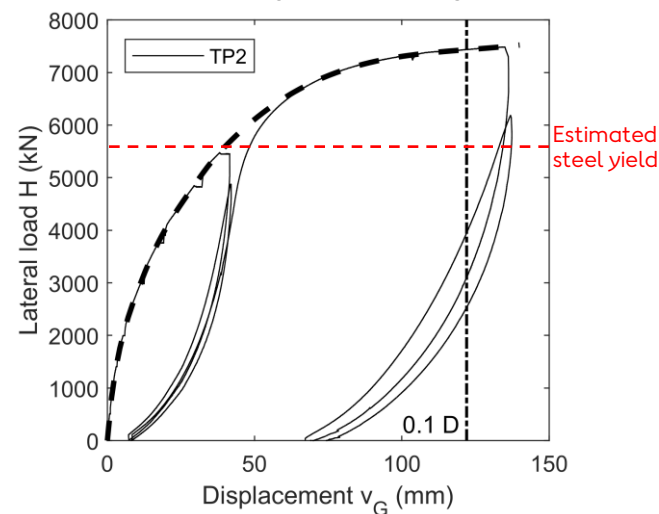
ALPACA
D = 508mm L/D = 20



ALPACA
D = 508mm L/D = 6

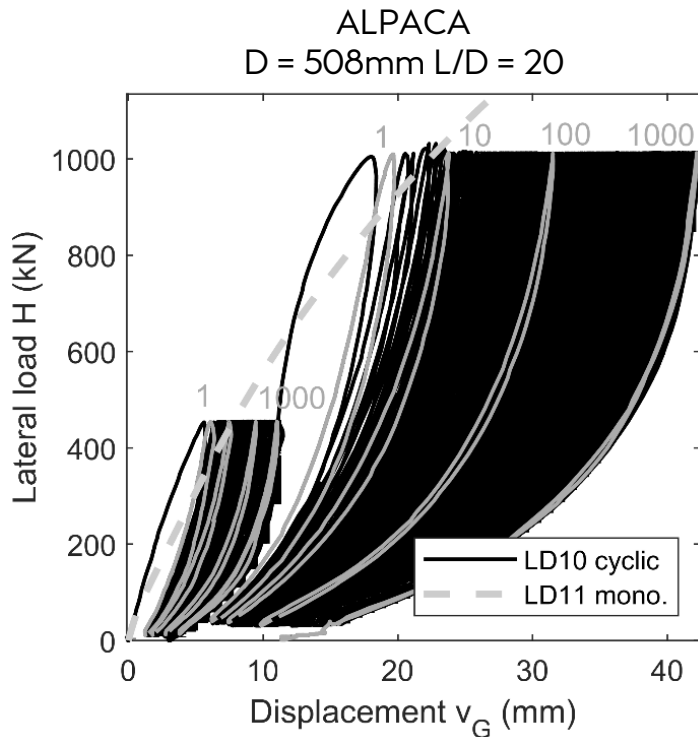


ALPACA+
D = 1220mm L/D = 6

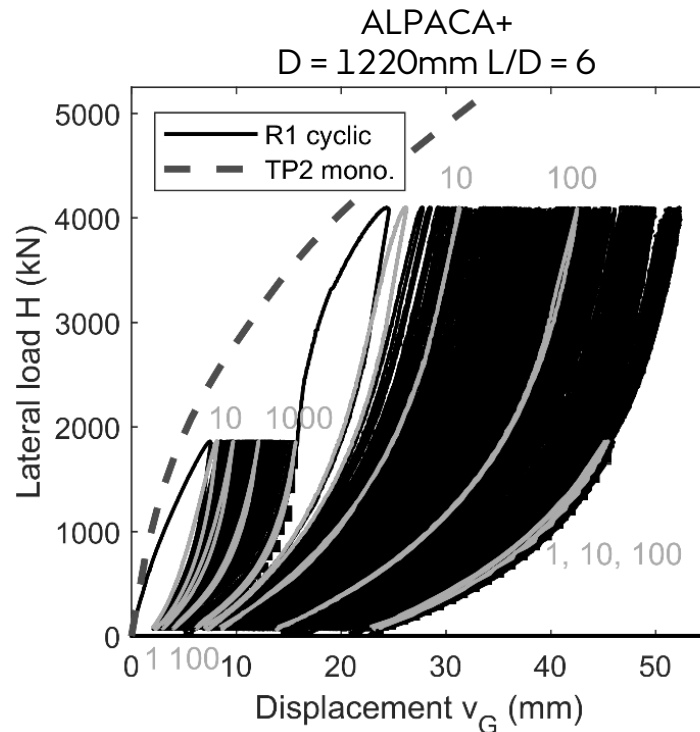


Lateral cyclic loading tests (L1W)

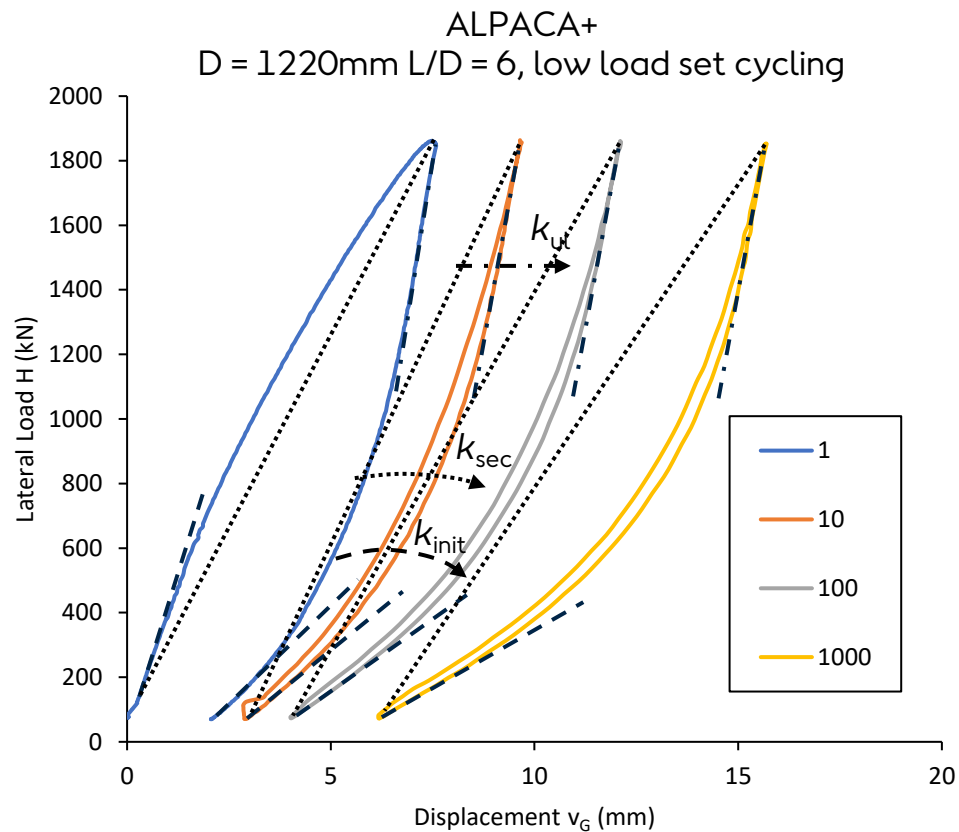
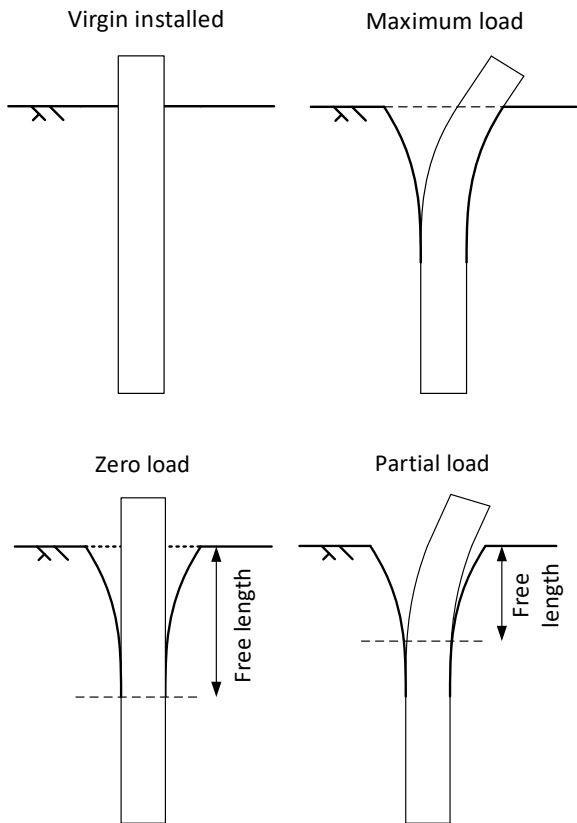
- 10s period sinusoidal single amplitude
- Typically two load levels (≈ 1000 cycles)



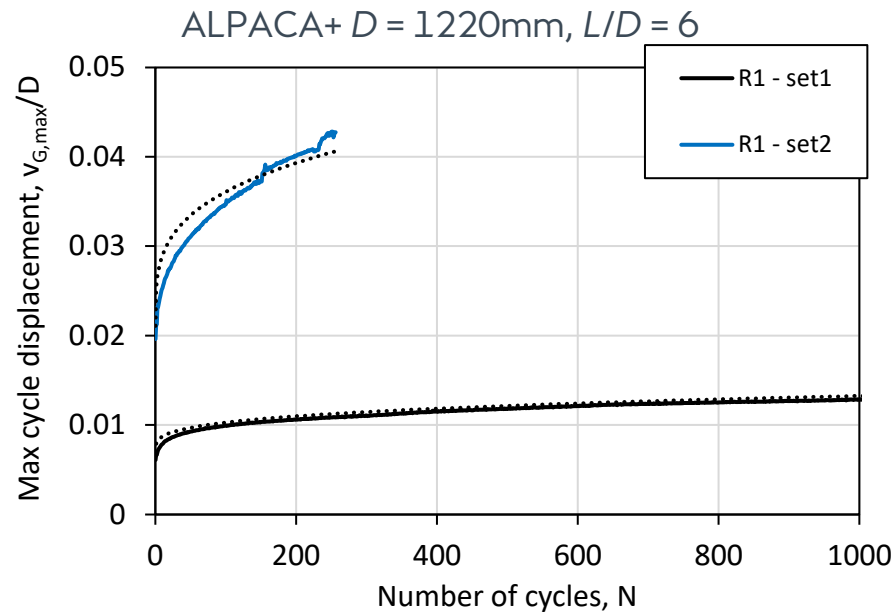
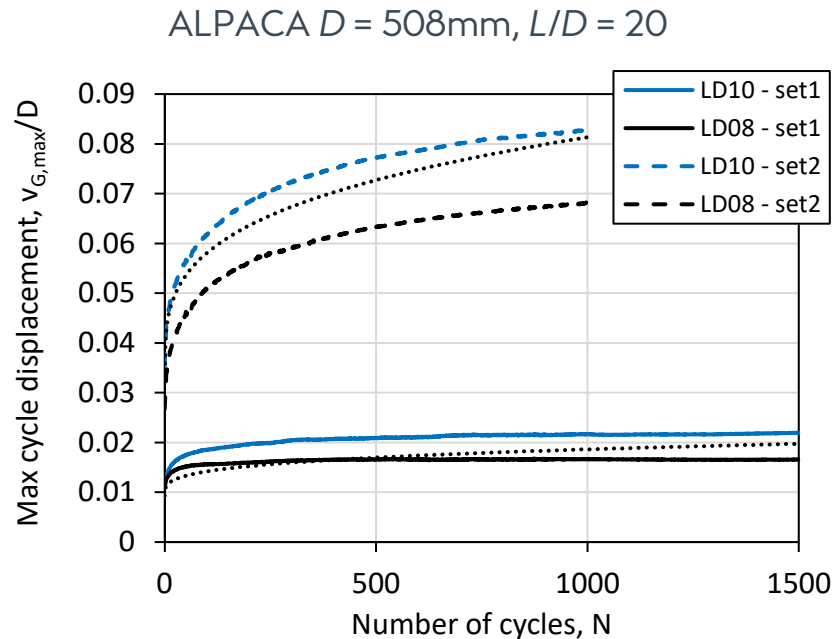
- Up to $H_{\text{mean}}/H_{D/10} = 0.54$ & $H_{\text{cyc}}/H_{D/10} = 0.42$
- Significant change in loop shape



Influence of gapping



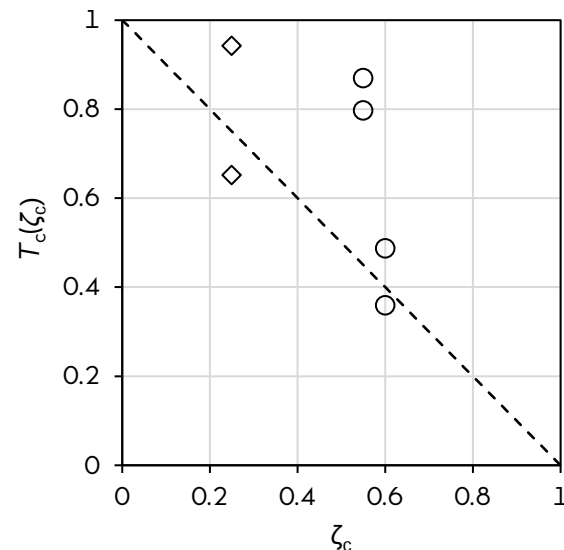
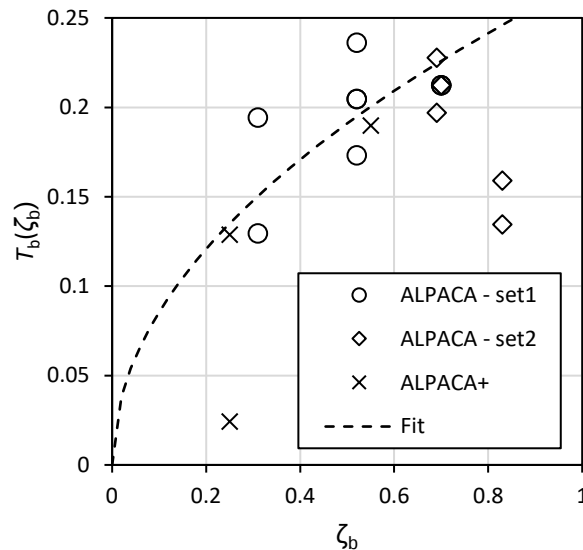
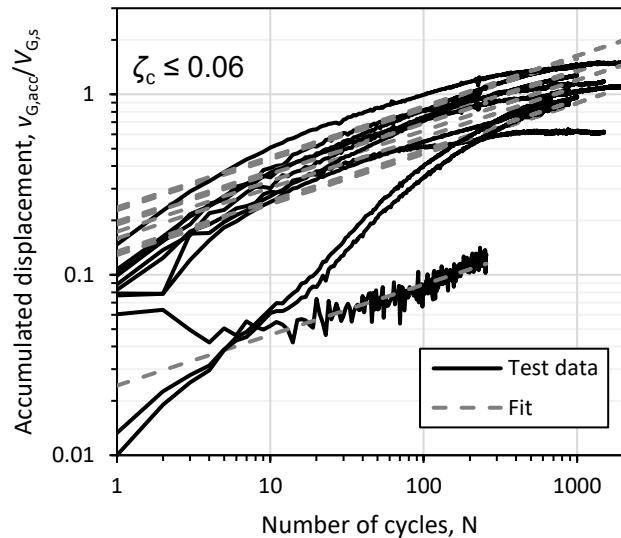
Cyclic accumulation (ratcheting)



$$\frac{v_{G,acc}}{v_{G,s}} = \frac{v_G(N) - v_{G0}}{v_{G,s}} = T_b(\zeta_b)T_c(\zeta_c)N^\alpha$$

(Leblanc et al. 2010)

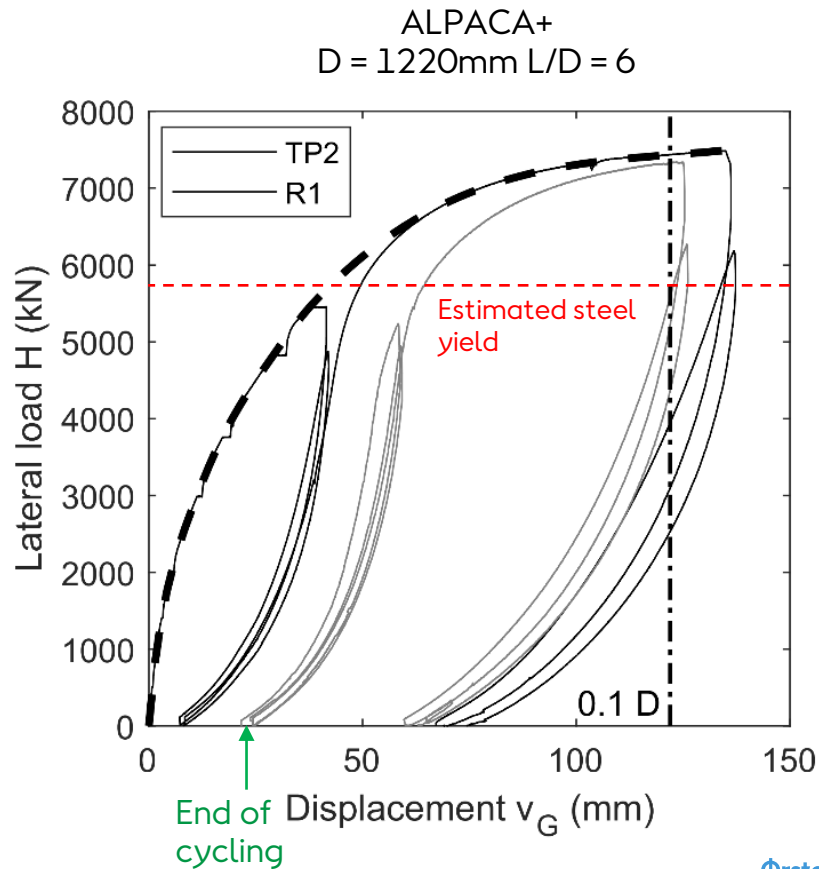
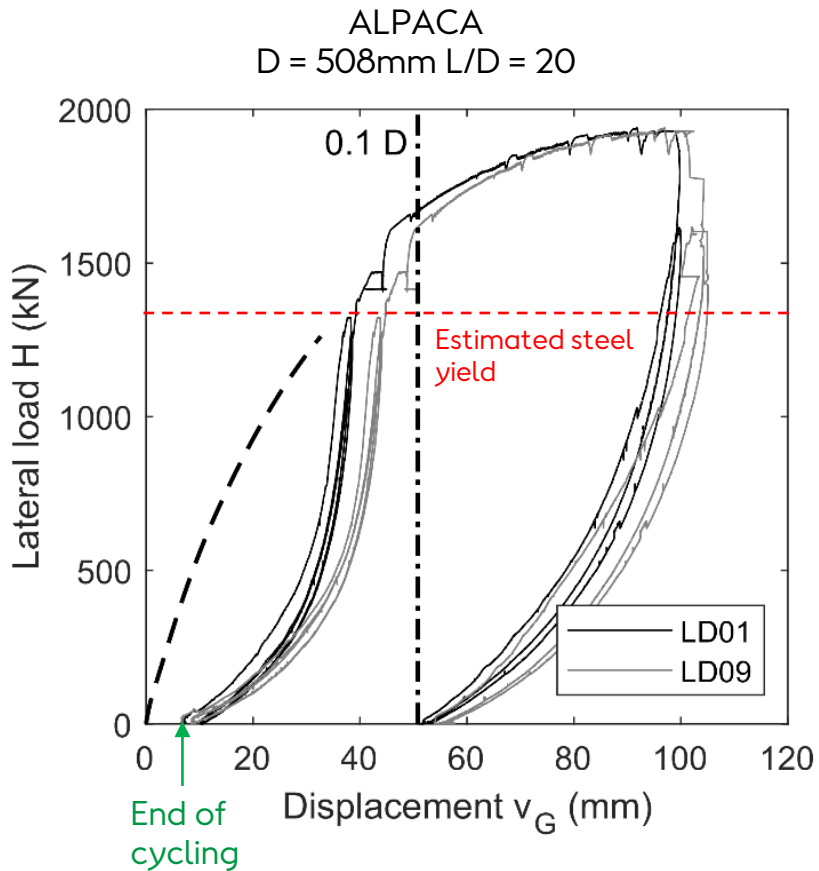
Ratcheting model calibration



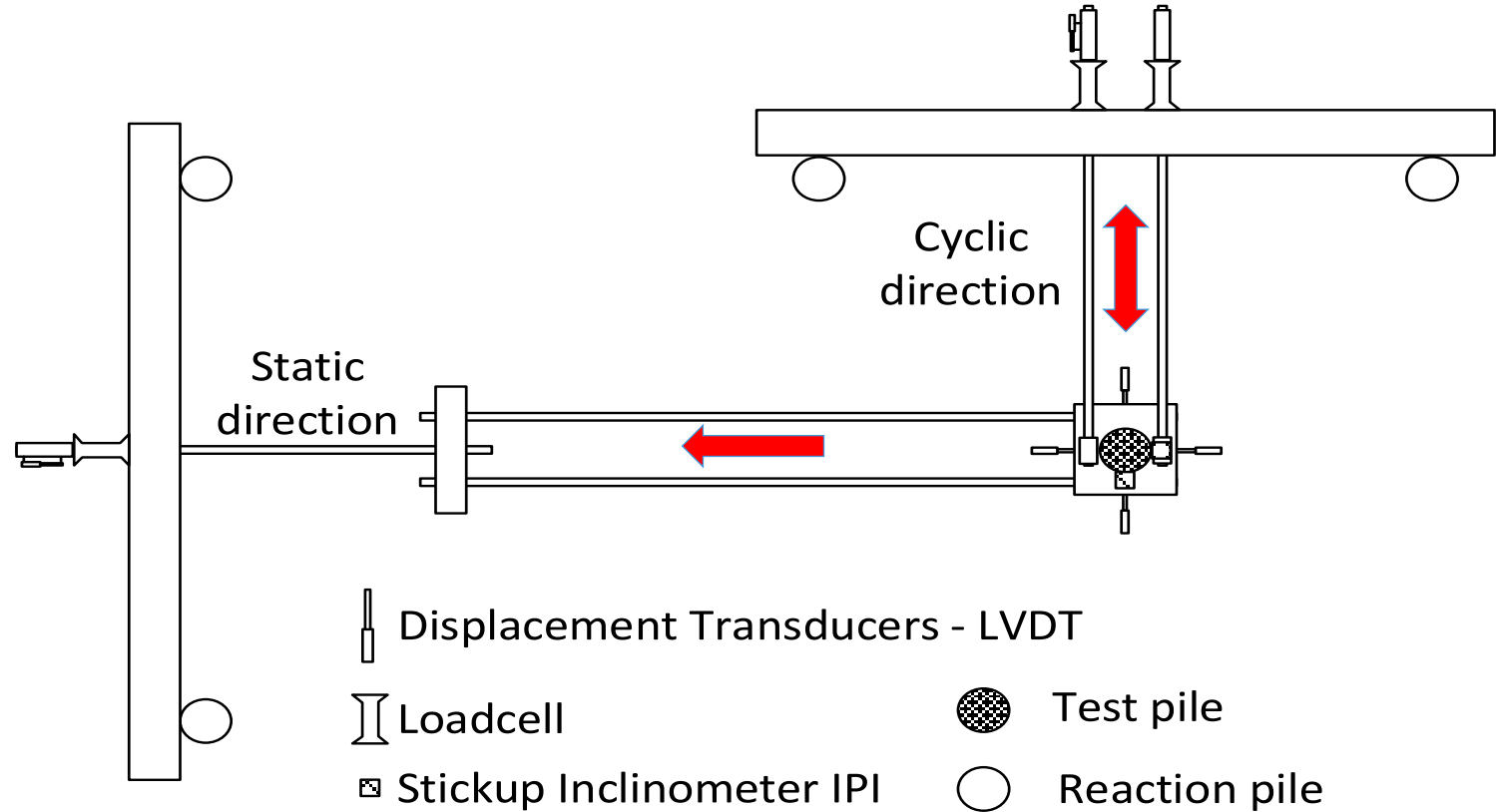
$$\frac{v_{G,acc}}{v_{G,s}} = \frac{v_G(N) - v_{G0}}{v_{G,s}} = T_b(\zeta_b)T_c(\zeta_c)N^{\alpha}$$

Type	Material	Dia. (mm)	Source	α
Field monopile	Clay	762	PISA Cowden (Beuckelaers 2017)	0.31
	Sand	762	PISA Dunkirk (Beuckelaers 2017)	0.31
	Chalk	508, 1220	ALPACA (McAdam et al. 2024)	0.28
1g model monopile	Sand	80	LeBlanc et al. (2010)	0.31
		77	Abadie (2015)	0.31
		80	Richards (2019)	0.25-0.30

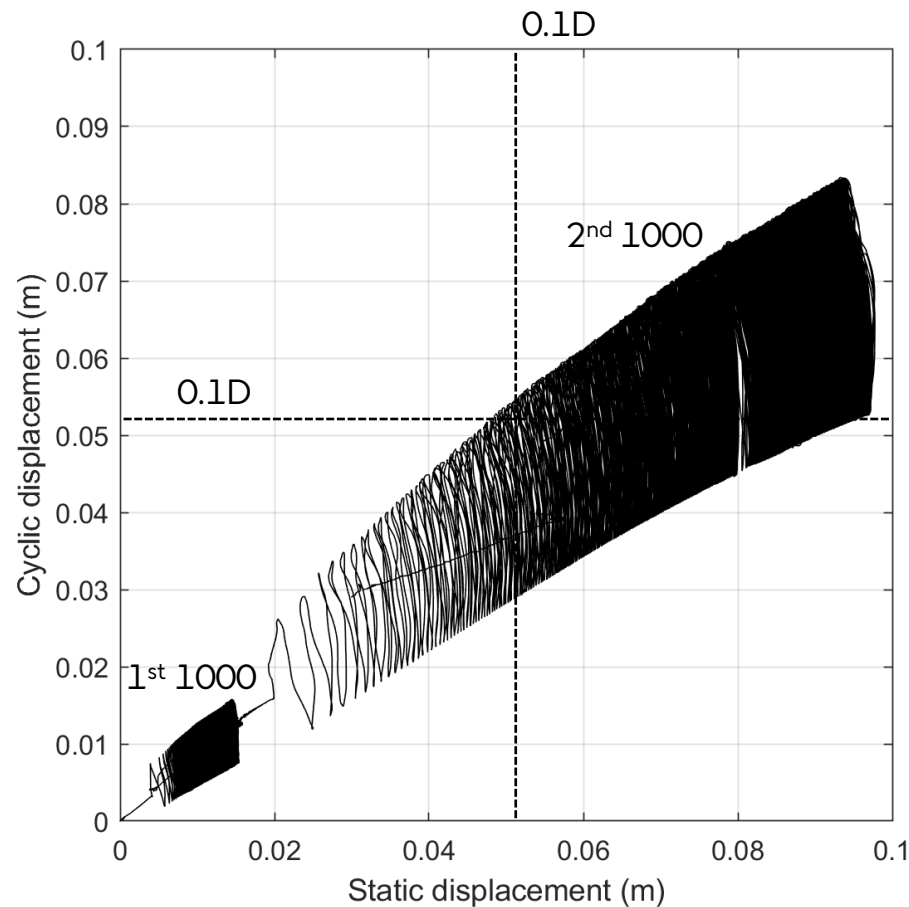
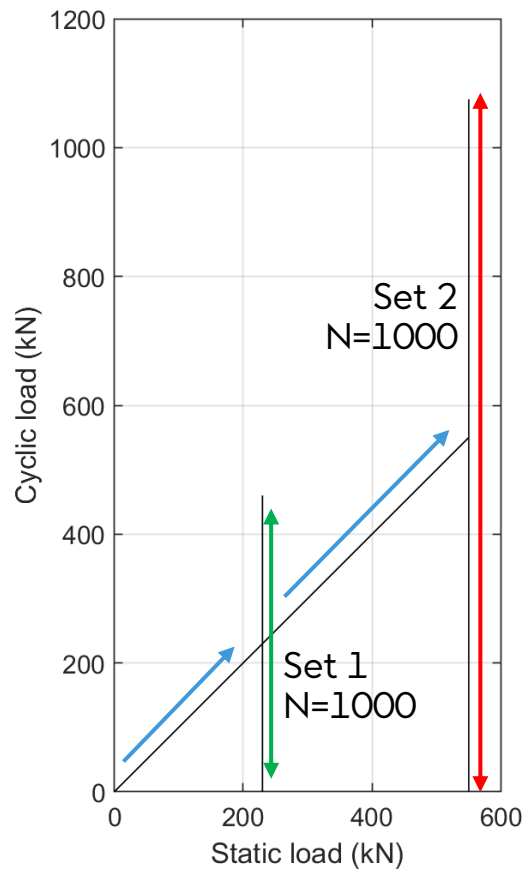
Post-cyclic monotonic



Biaxial lateral cyclic loading tests



Biaxial lateral cyclic loading tests



Summary

- Paper presenting lateral load test data in chalk available online, including monotonic and cyclic interpretation
- Gapping has significant influence on initial stiffness
 - Lesser influence on secant or unload stiffness
- Meta-stable single axis cycling observed
 - Rate of accumulated deformation similar to other soils
- No indication of post-cyclic strength reduction
- Multi-axial loading trends show similar behaviour to existing tests (e.g. Richards (2019))

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- Marmota Industries

<https://www.imperial.ac.uk/geotechnics/research/research-projects/alpaca/>

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Buckley, Róisín M., et al. "Axial cyclic loading of piles in low-to-medium-density chalk."



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