Interpretation of Pile Load Tests

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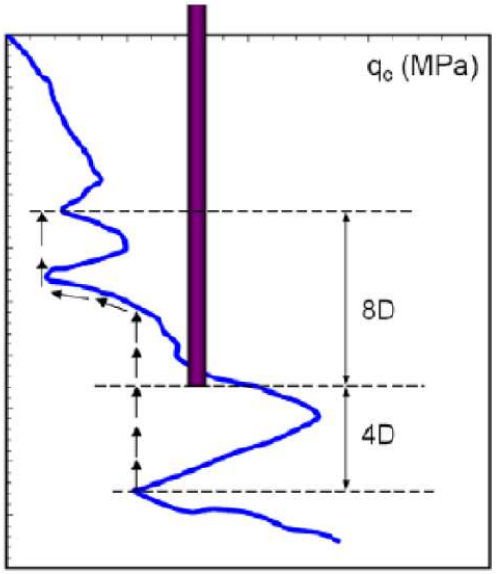
Background

Aim: Consider how pile tests can be used to derive national or international design methods with a focus on base resistance

- Validate design or optimise?
- Project or national application?
- Tests on comparable sites?

Dutch Practice NEN 9997-1

$$q_b = \alpha_p q_{c;Dutch}$$



- Koppejan 4D/8D averaging method
- Limiting base resistance = 15 MPa
- 2016 update: 30% reduction in α_p

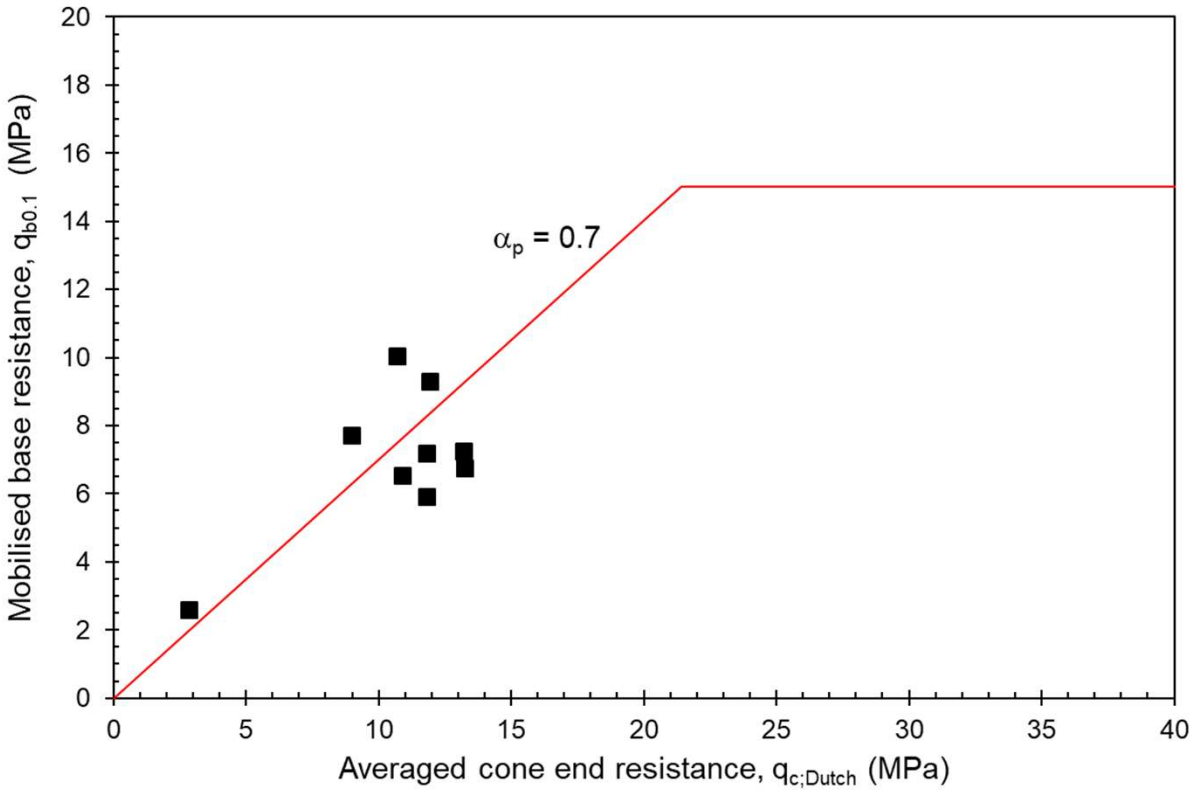
Table 1: Reduction factors for selected pile types from NEN 9997-1

Pile type	α_p	α_s
Bored pile	0.35	
Continuous flight auger	0.56	
Driven cast-in-situ	0.70	
Driven precast	0.70	
Screw injection	0.63	
Steel tubular (open-end)	0.7	

Dutch Database of instrumented pile tests

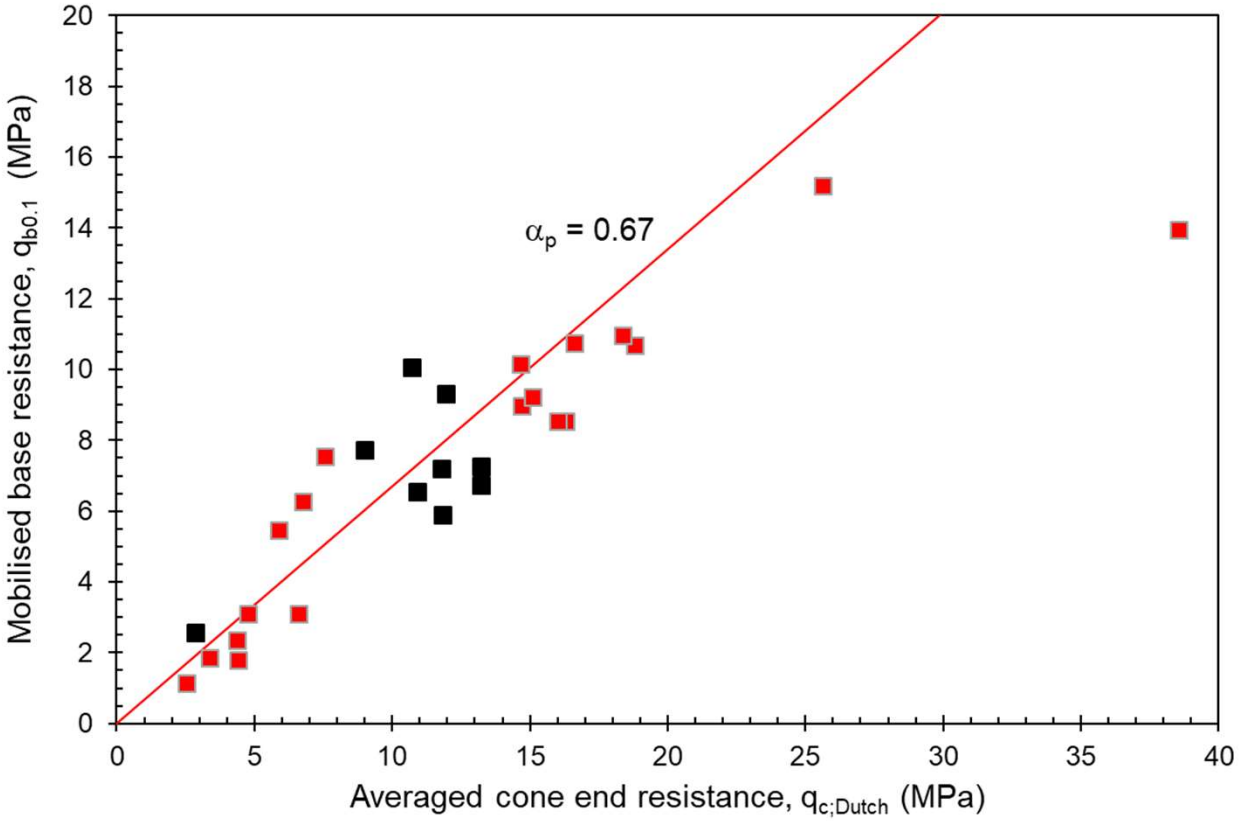
- D_{eq} ranged from 0.28 to 0.45m
- L_{em}/D_{eq} = 1.2 to 21
- $q_{c;Dutch}$ = 2.8 to 13.2 MPa

Dutch Database of instrumented pile tests



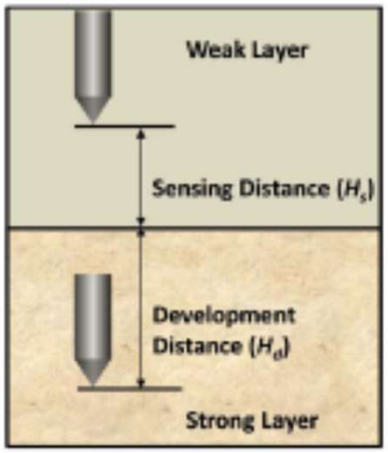
- α_p = 0.7 gives reasonable fit
- $q_{b0.1}$ is limited to 15 Mpa which translates to constant value for $q_{c;dutch}$ values over 21.4 MPa

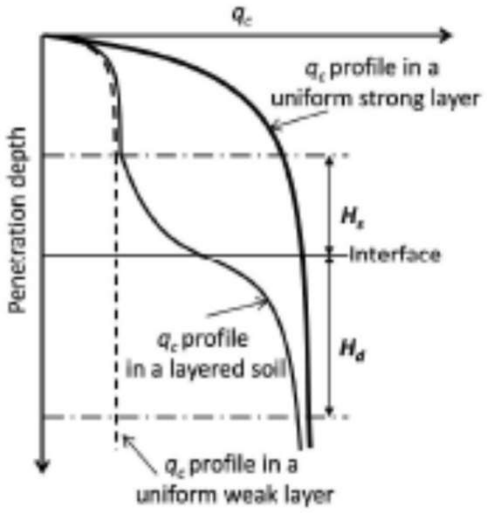
Compare Dutch and ISO Databases $q_{c;Dutch}$

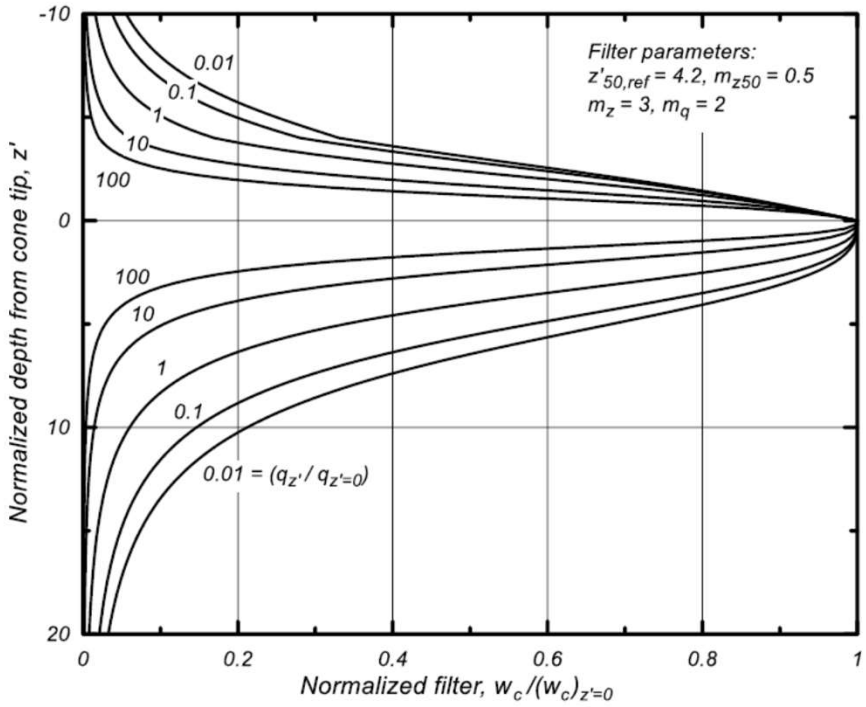


- D from 0.2 to 0.7m
- L_{em}/D_{eq} = 11 to 55
- $q_{c;Dutch}$ = 2.5 to 38.6 MPa
- α_p = 0.67 gives best-fit
- $q_{b0.1}$ is not limited in the ISO code (but database appears to suggest it should be!)
- Statistically better fit using a filtering technique to get q_c

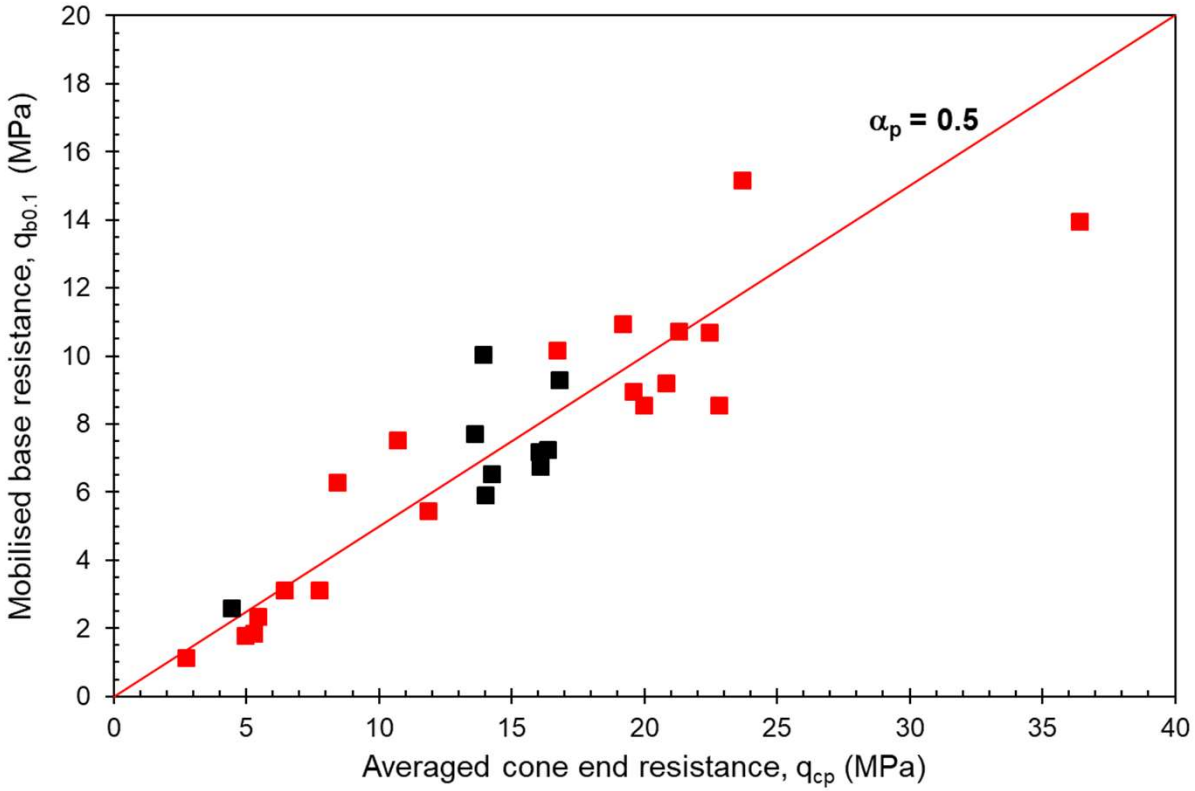
Compare Dutch and ISO Database $q_{c;p}$





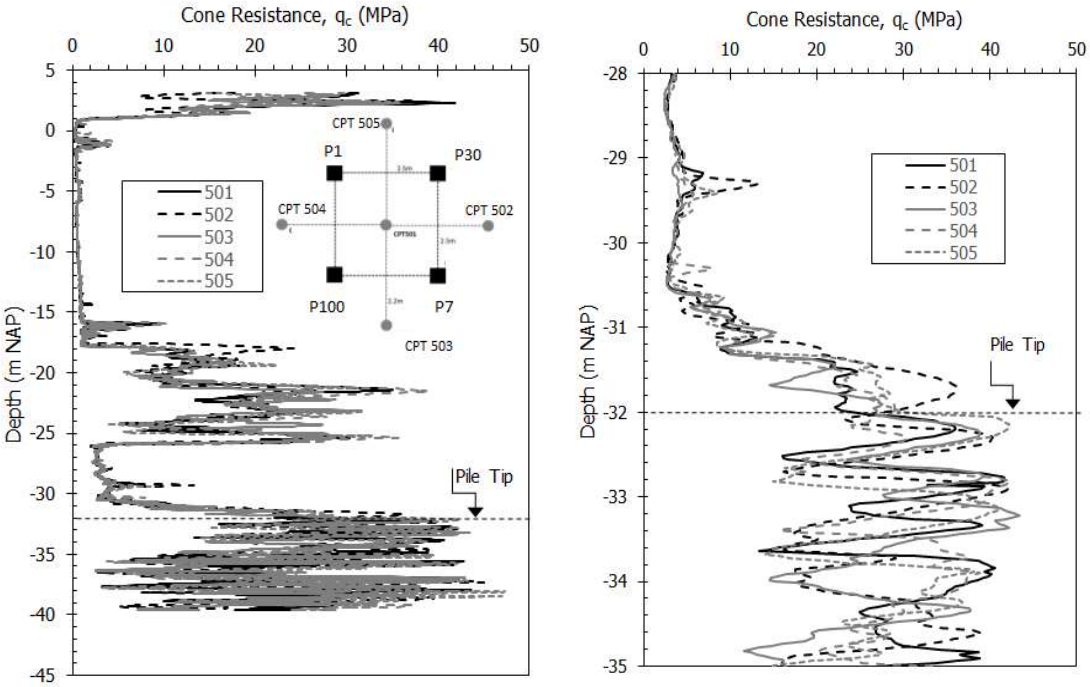


Compare Dutch and ISO Database $q_{c;p}$



- $q_{c;p}$ = 2.7 to 36.9 MPa
- α_p = 0.5 gives best-fit
- $q_{b0.1}$ is not limited in the code (database support this)

Wallhaven Pile tests 2017



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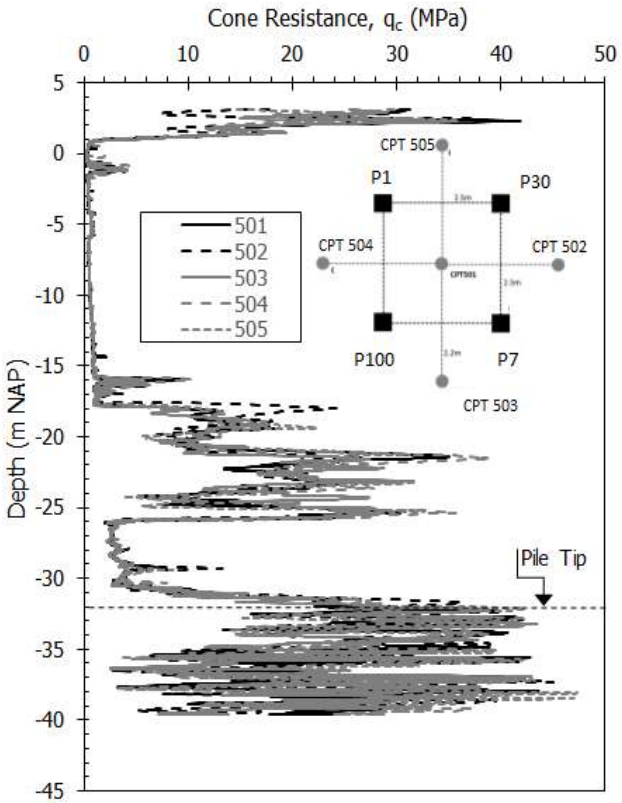

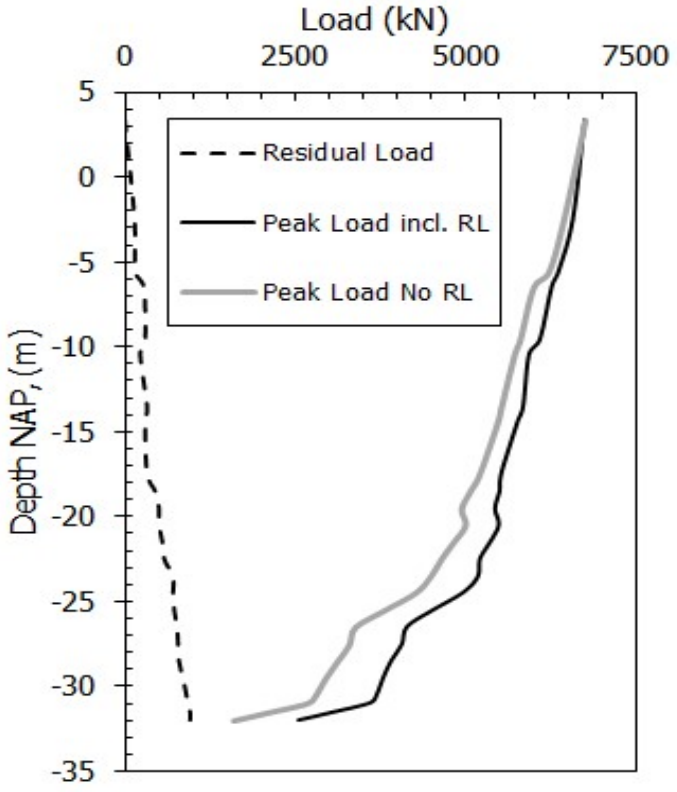

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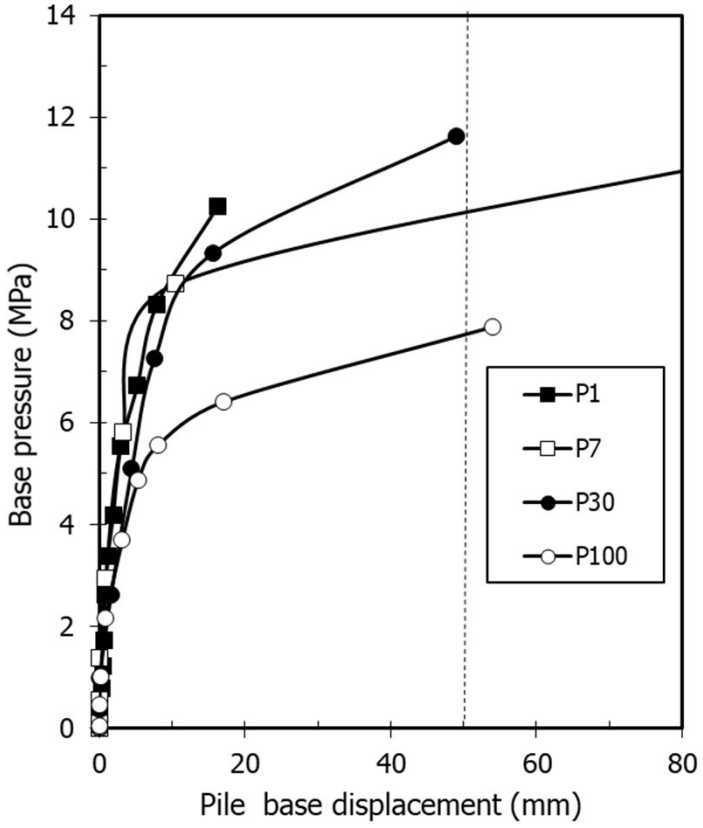

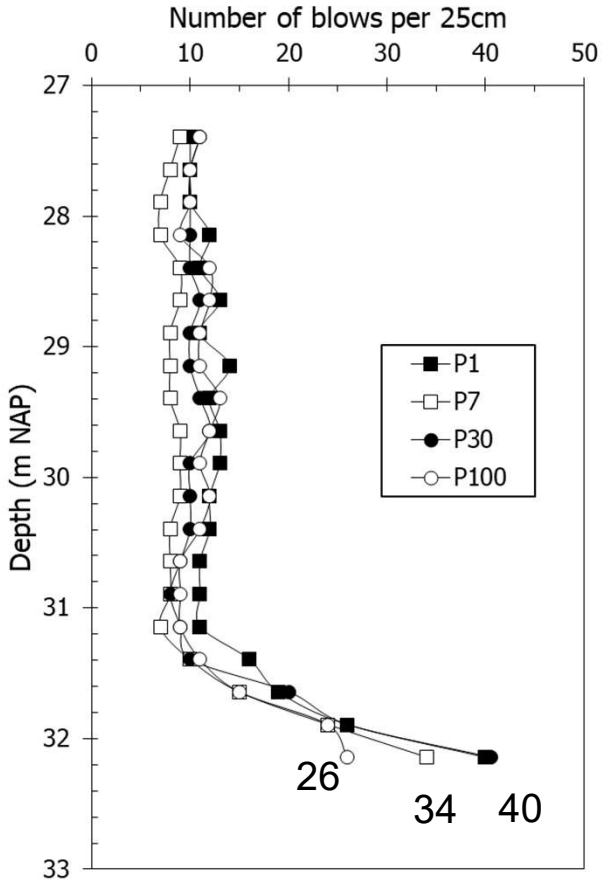

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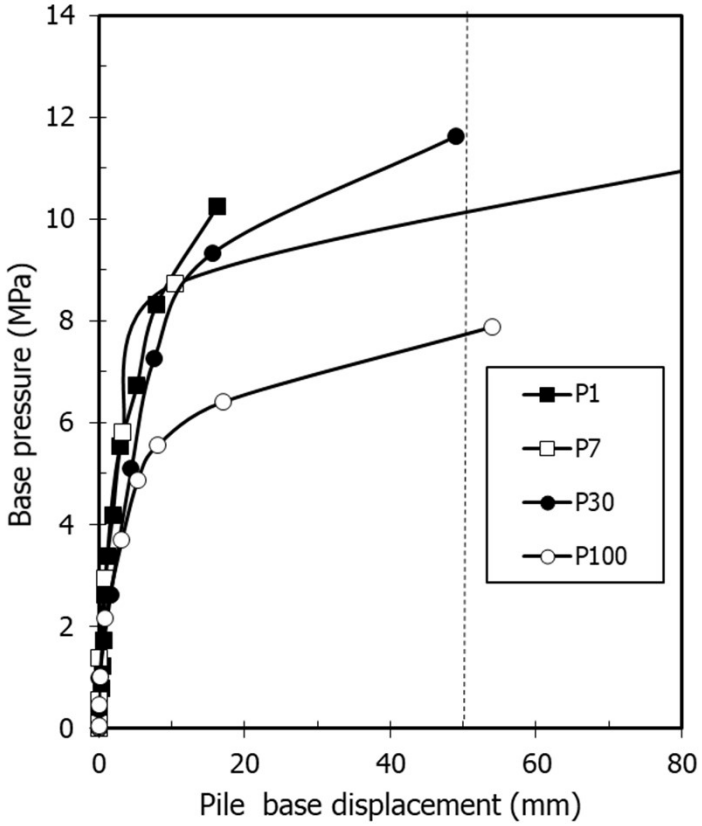
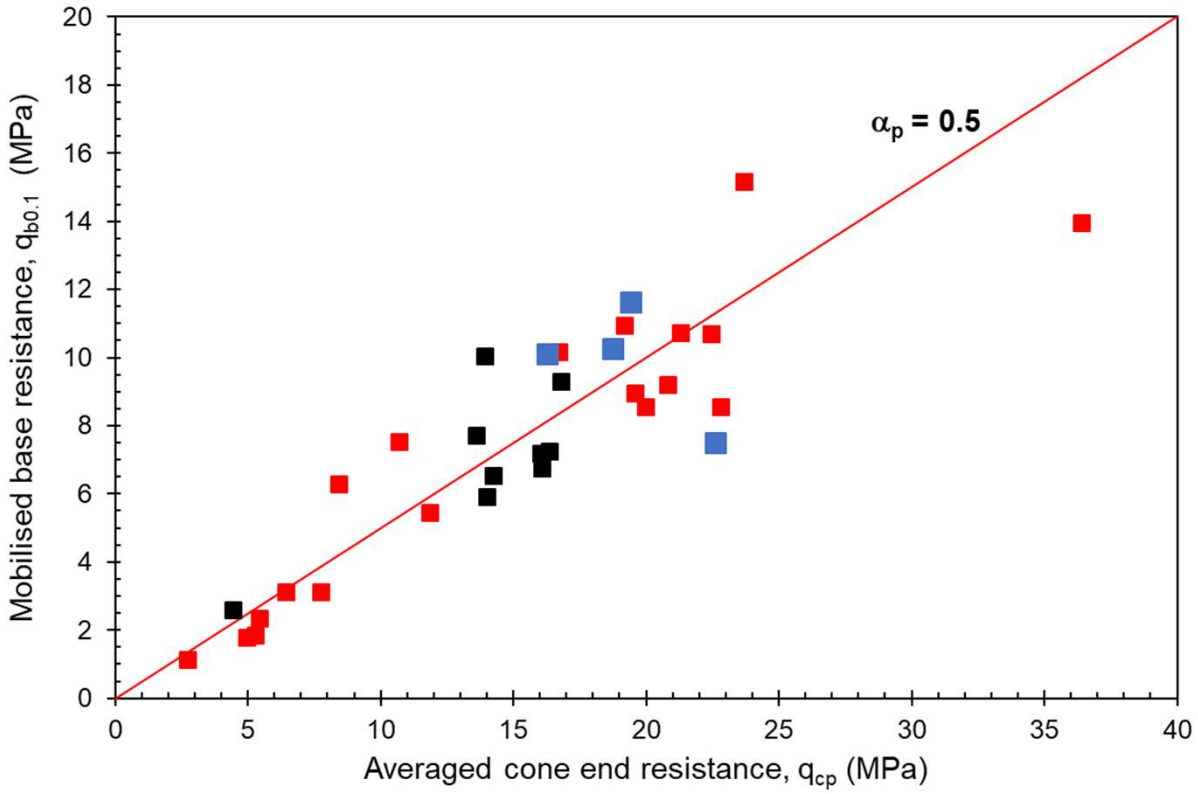


Pile No.	q_{bL} (MPa) excluding residual	q_c;p (MPa)	α_p
P1	10.26*	18.74	0.55
P7	10.12	16.29	0.62
P30	11.62	19.41	0.60
P100	7.49	22.59	0.33
Ave	**9.87**	**19.26**	**0.52**

Wallhaven Pile tests 2017



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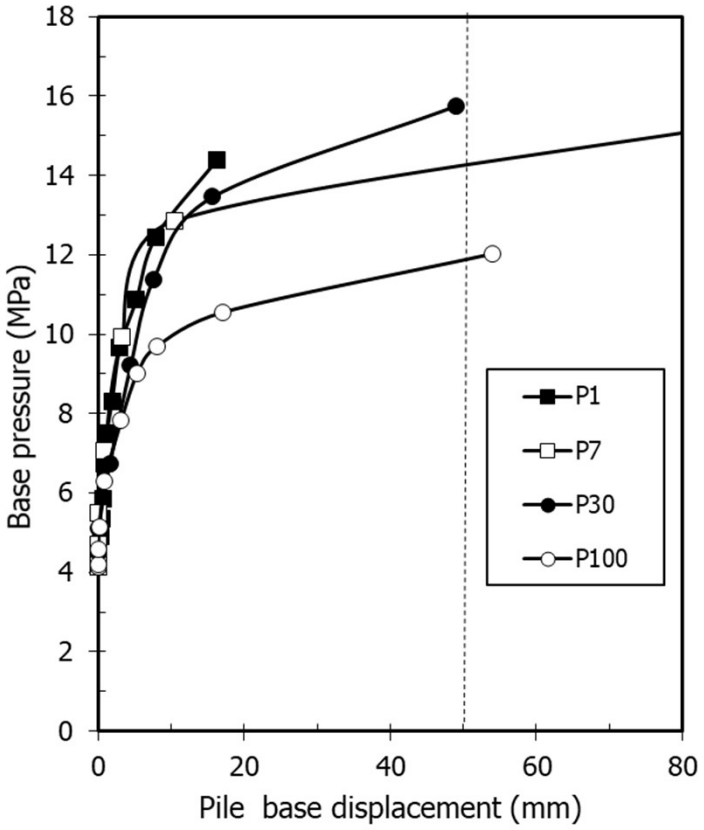
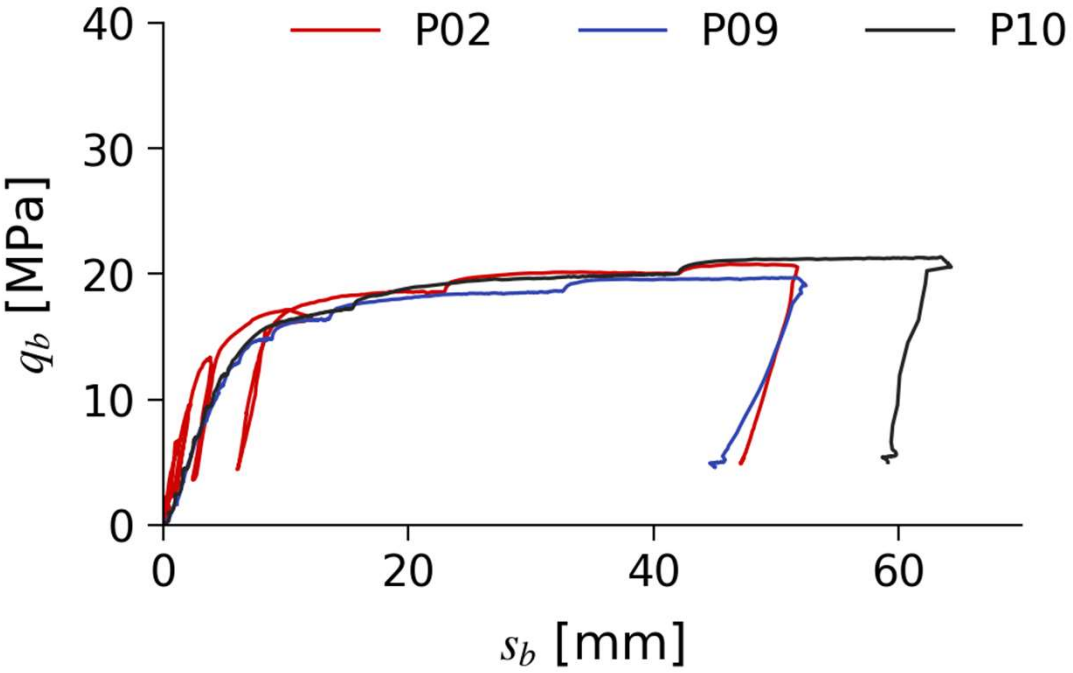


Pile No.	q_{bL} Res (MPa)	$\alpha_{p;}$
P1	14.39*	0.77
P7	14.25	0.87
P30	15.76	0.81
P100	12.01	0.53
Ave	**14.10**	**0.75**

Including residual load

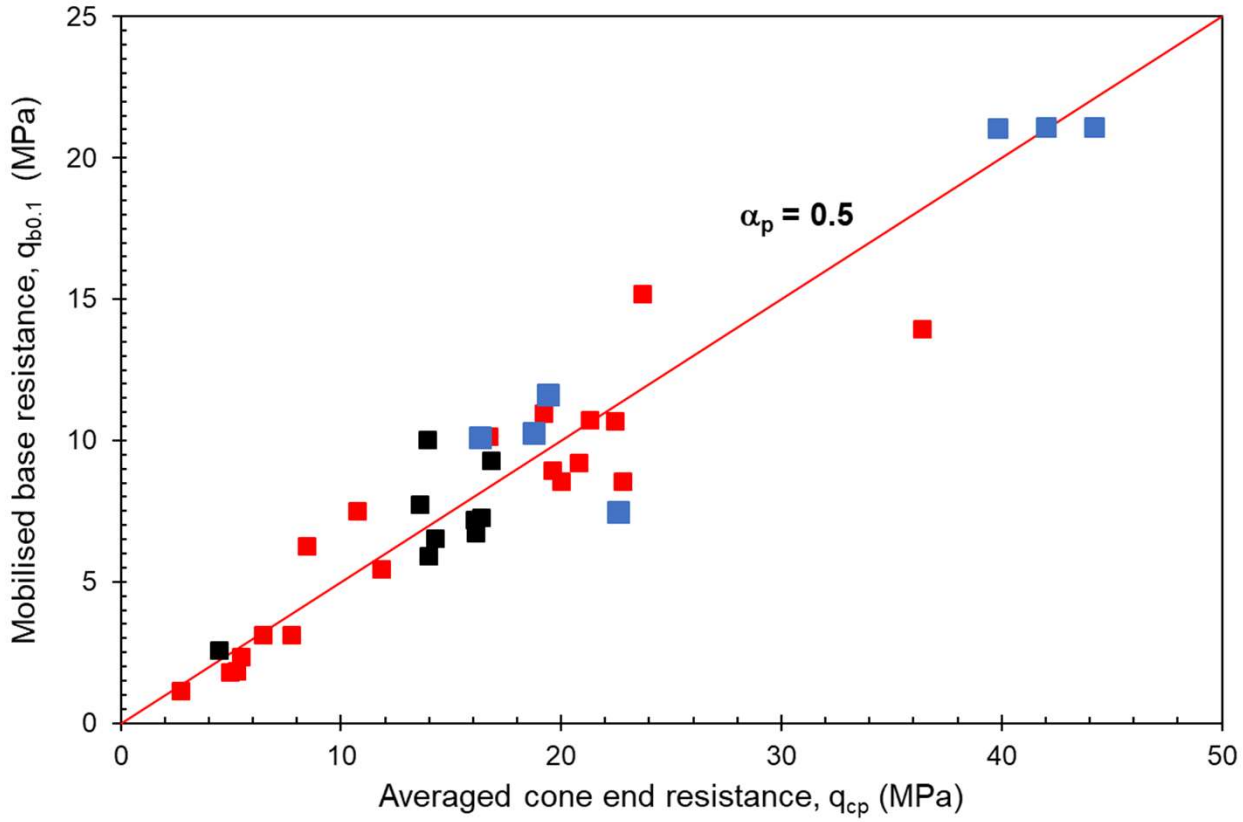
Massvlakte II Pile Tests 2019

Massvlakte II Pile Tests 2019

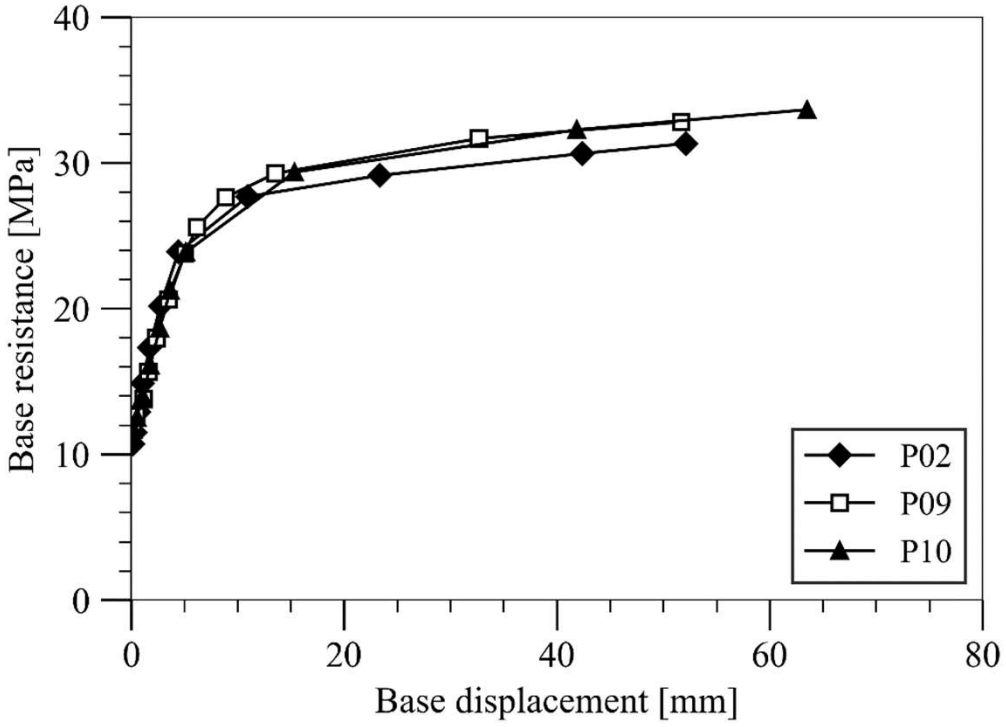


Pile No.	$q_{b0.1}$ (MPa) excluding residual	$q_{c;p}$ (MPa)	α_p
P02	21.9	42	0.52
P09	21.6	39.8	0.54
P10	21.9	44.2	0.50
Ave			**0.52**

Compare Dutch and ISO Database

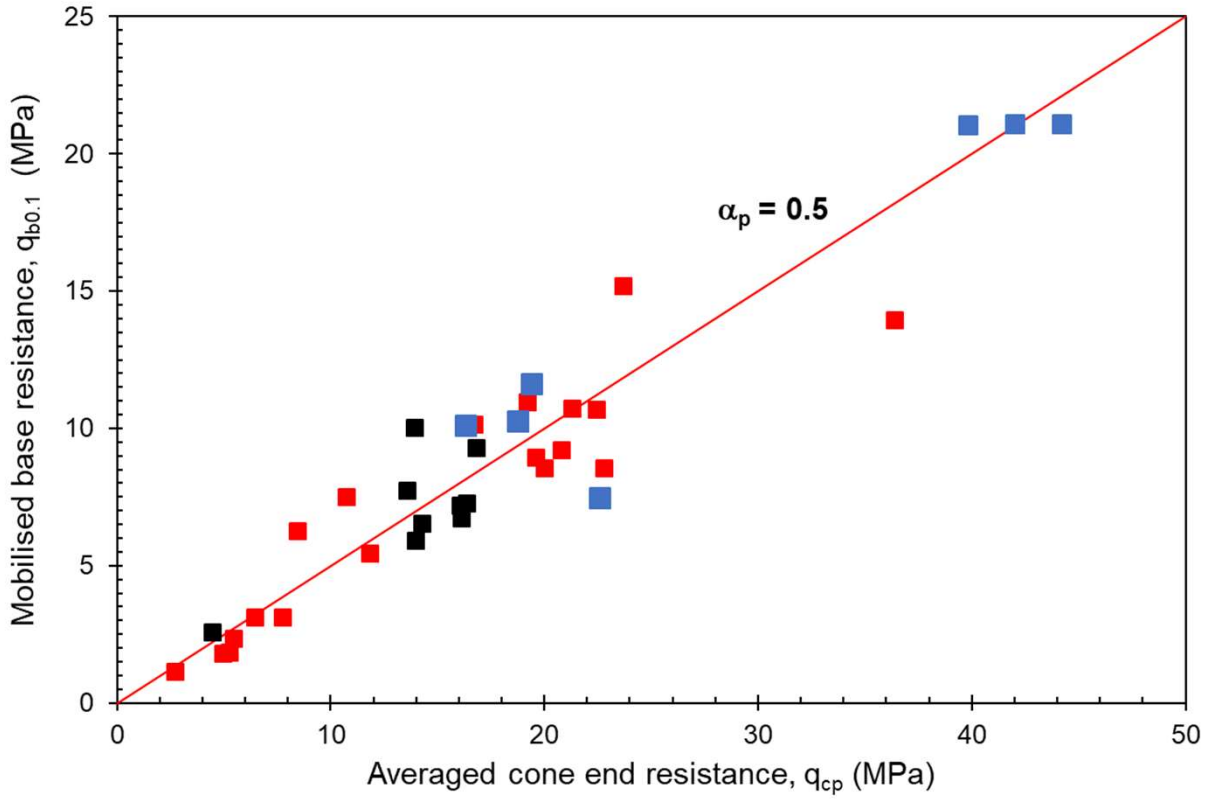


Massvlakte II Pile Tests 2019

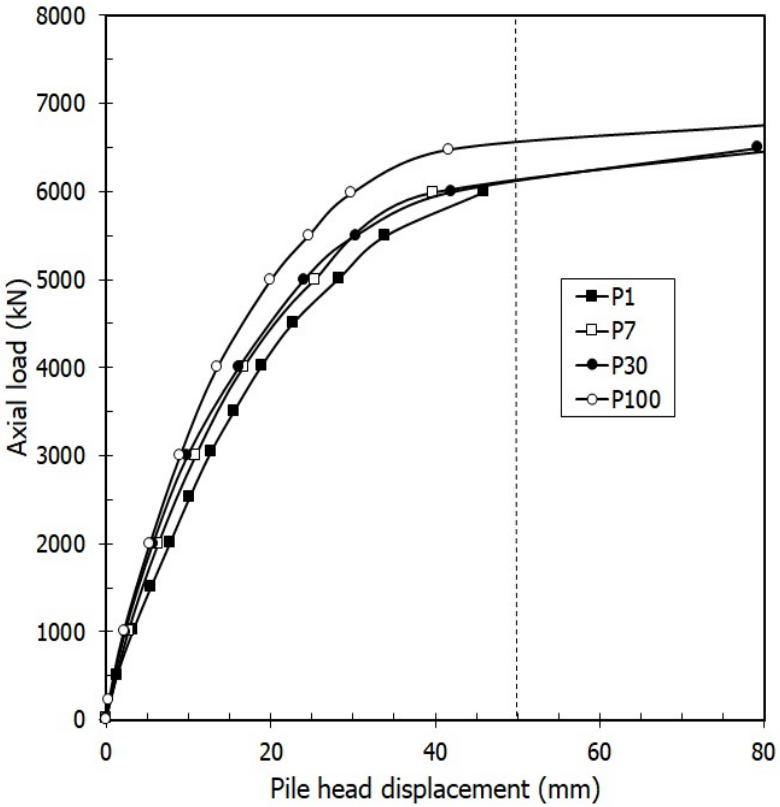


Pile No.	$q_{b0.1}$ (MPa) excluding residual	$q_{c;p}$ (MPa)	α_p
P02	31.9	42	0.76
P09	31.6	39.8	0.72
P10	31.9	44.2	0.72
Ave			**0.73**

Base resistance of pre-cast concrete piles



What about disappointing results?



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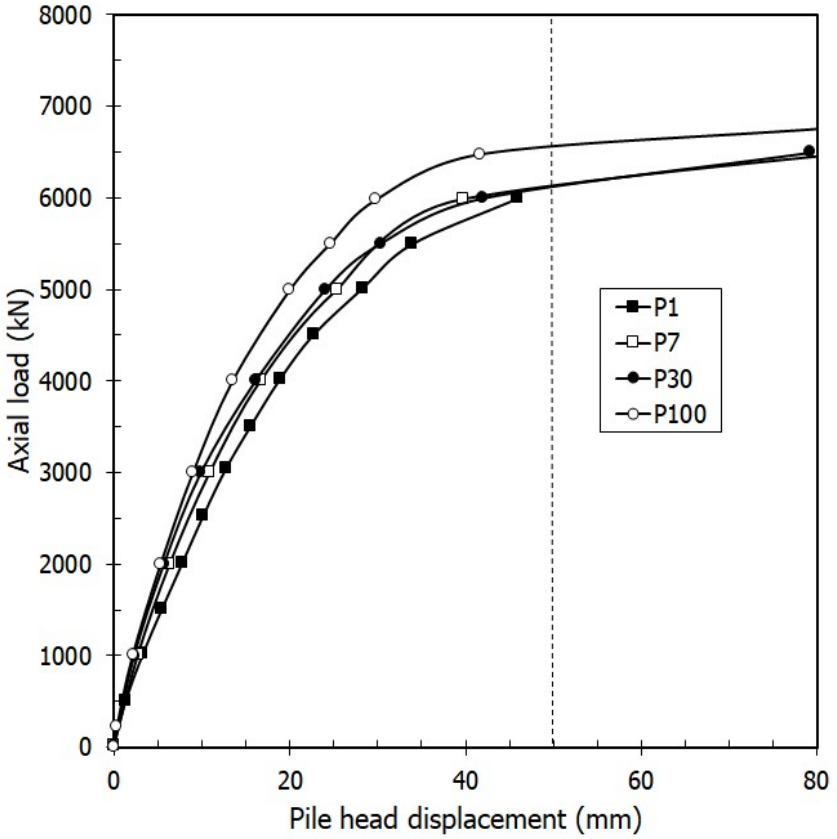

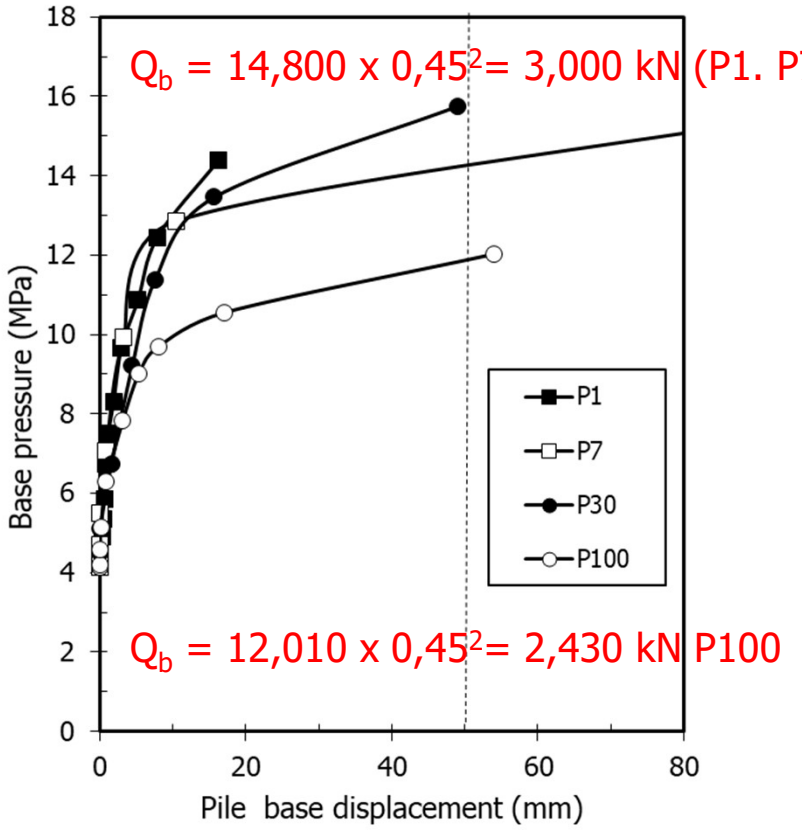

Q_b = 14,800 x 0,45^2= 3,000 kN (P1. P7 and P30)

Q_b = 12,010 x 0,45^2= 2,430 kN P100

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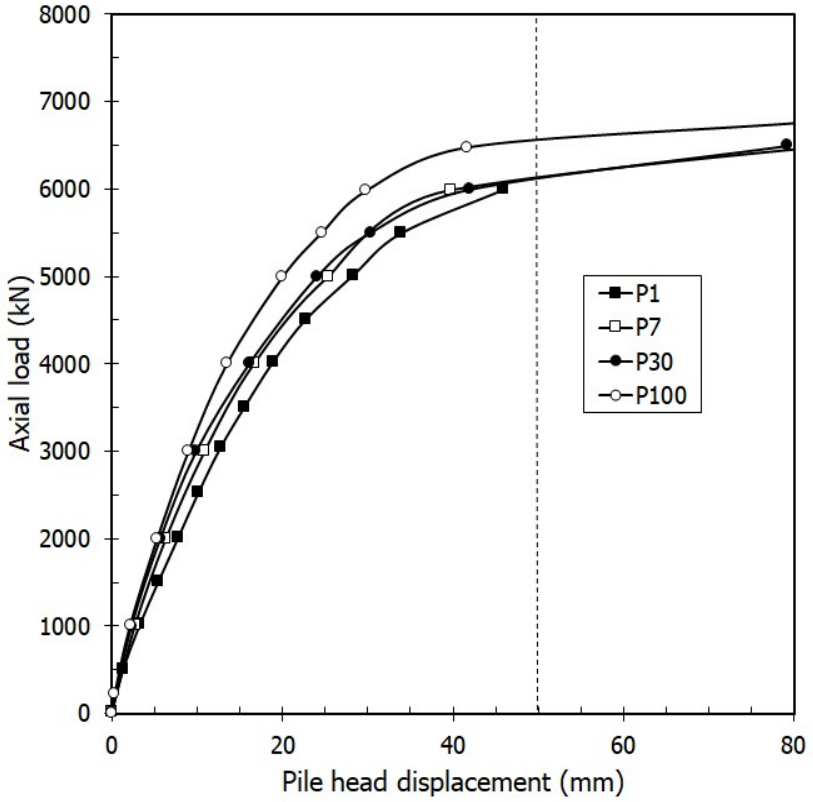
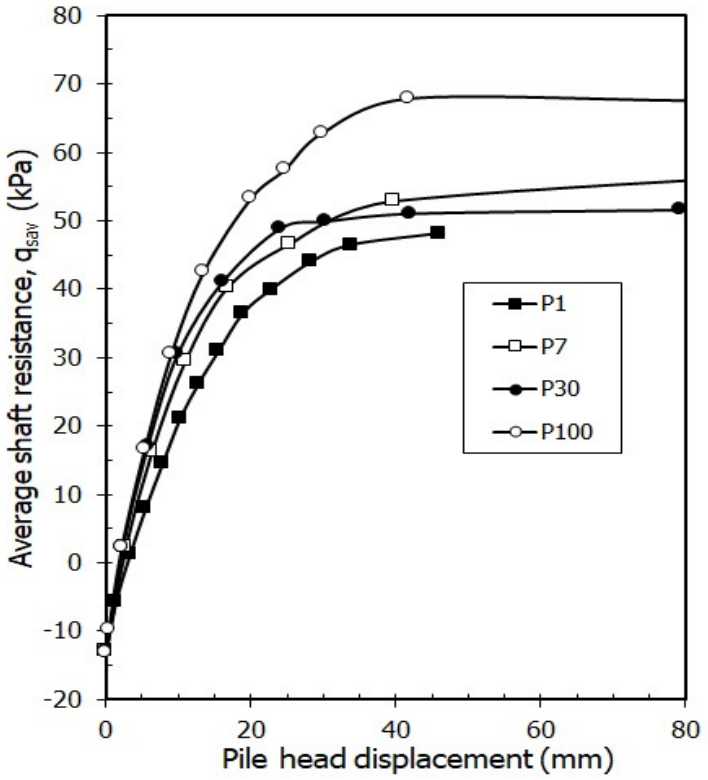
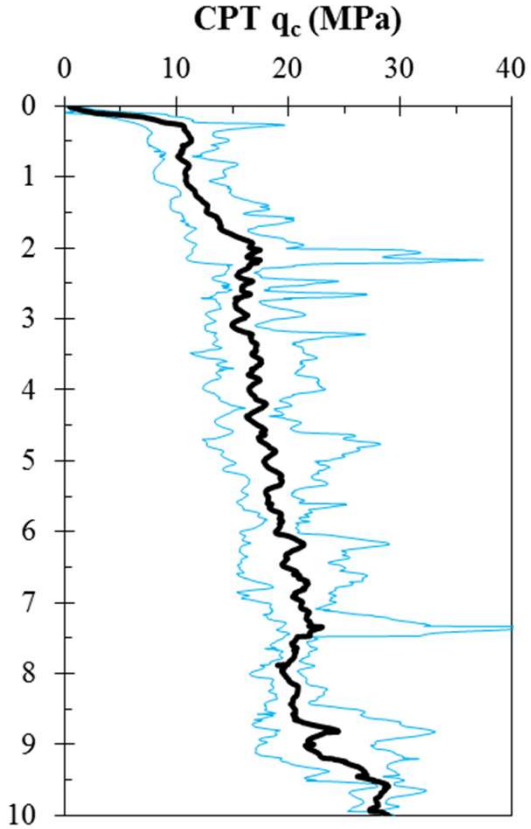
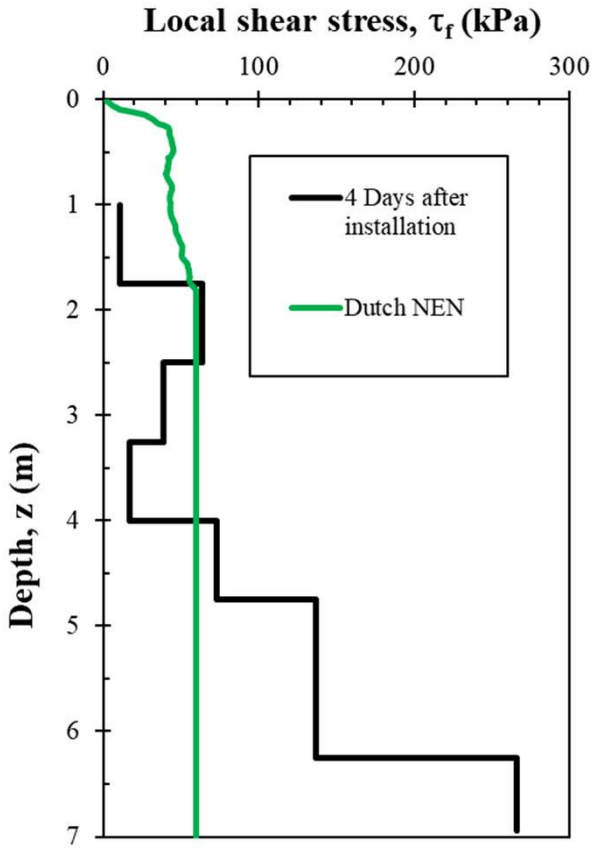




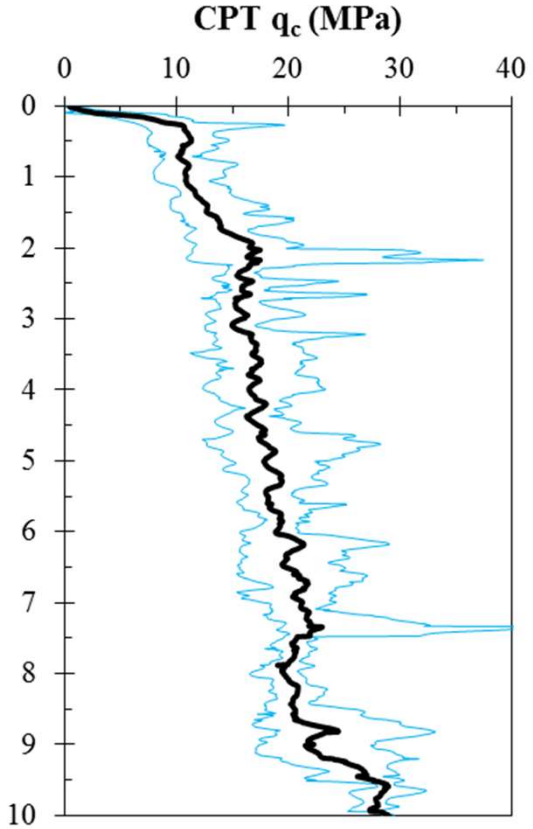

Lloyd Acoustics

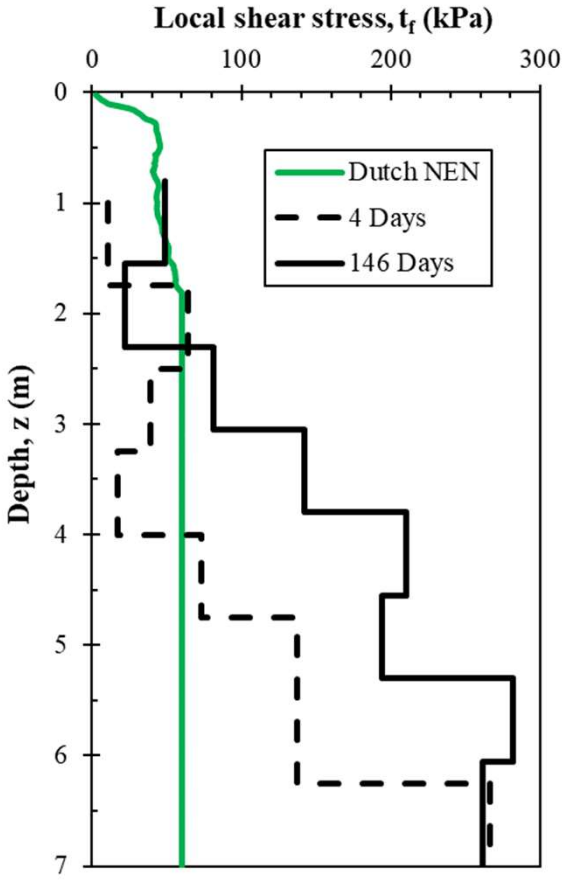
Tension Tests on Open-Tube Piles





Tension Tests on Open-Tube Piles





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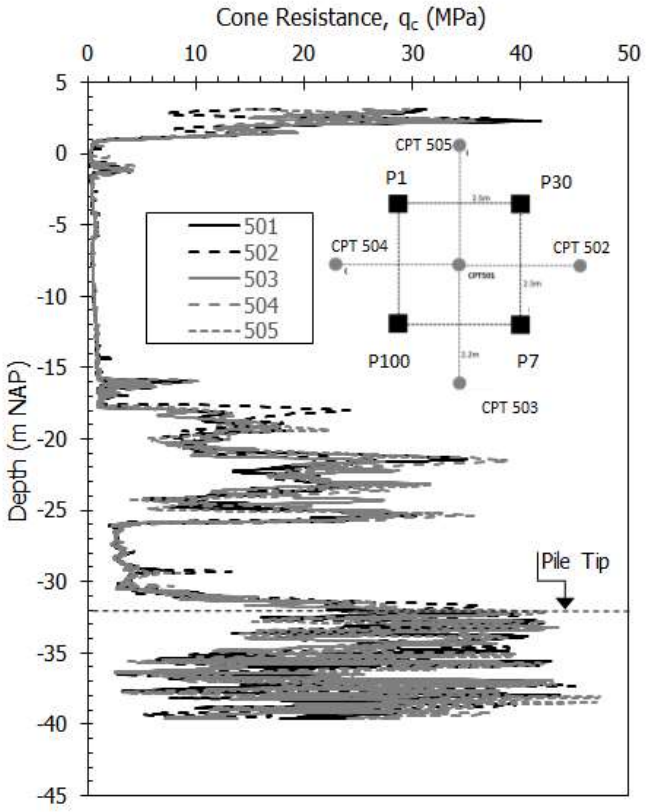

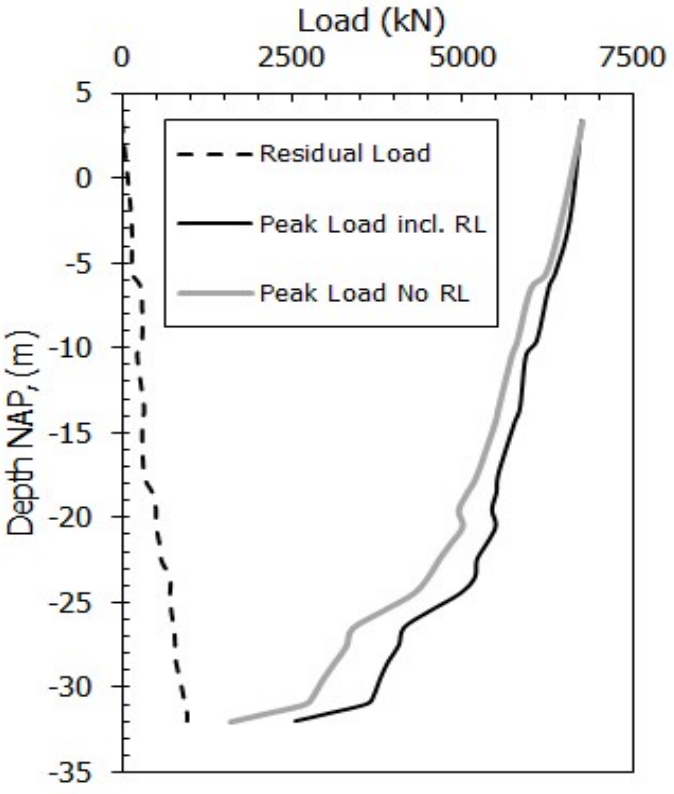

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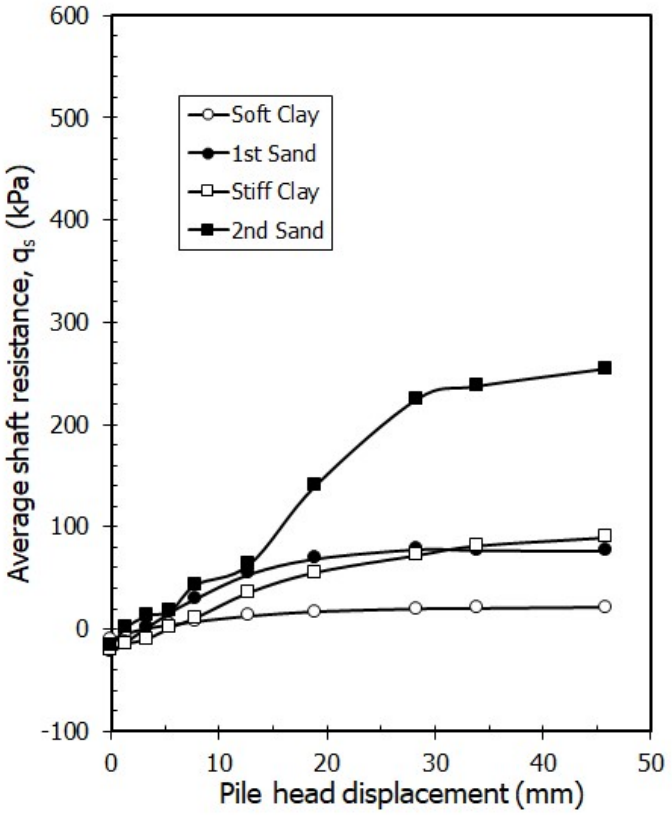

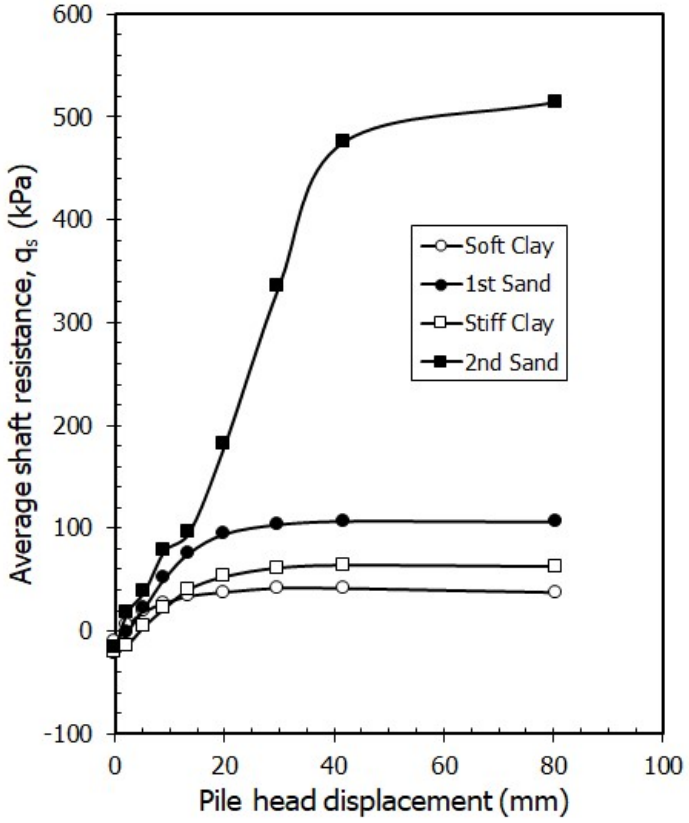

Can we use test results widely?

- PISA project Oxord/Imperial/Delft
- Load tests on 0.273, 0.762 and 2m
- Two sites, one dense sand and one

stiff clay

- Method was adopted for design around the world before the end of the project
- Now used in all offshore wind projects for pile +10m

Conclusions

Base Resistance

- Results from international database of end bearing resistance in very good agreement with Dutch database
- α_p = 0.5 with no limiting value of base resistance
- Where we measure residual loads carefully it base resistance was typically 40% higher than predicted using this approach

Instrumentation gives clear insight into mechanisms controlling pile capacity

Questions?