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Static “Micro” Pin-Pile Load Capacity Verification by Dynamic Load Testing

By

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- Historical performance and use.
- Phase I Research Program – data acquisition and review.
- Phase II Research Program – Static load testing.
- Brief introduction to “Micro” Pin-Piles.
- Phase III Research Program – Static and dynamic load testing.
- Summary of results and conclusions.
- Acknowledgements

Historical Performance and Use

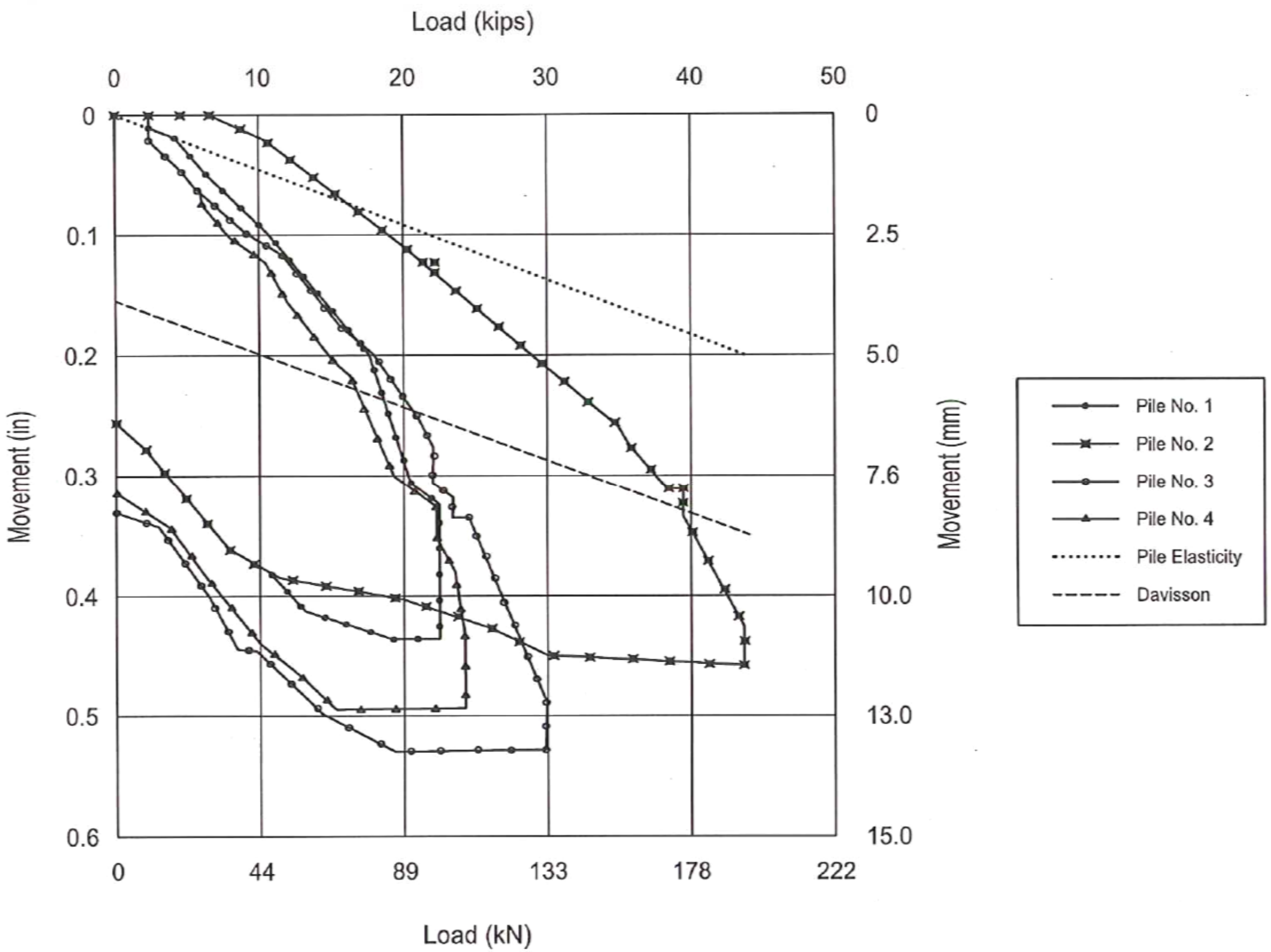
- First reported “engineering” use of pin-piles by Dreubert and Yamane in 1980.
- They were just playing around with a concept – and it stuck.
- Determined an allowable axial capacity of 18 kN [4 kips]
- Capacity achieved at 25 mm [1 inch] penetration after one minute of continuous driving with a 41 kg [90 pound] jack hammer.
- This became the “bible” – and remains in force.

Phase I Research Program - Data Acquisition and Review

- Haggard collected about 50 sets of local load test data – all taken only to twice design load.
- Found mathematical formulae did not “fit” load test results.
- Found that none of the tested piles “plunged”.
- Allowable axial capacities were relatively high – with little pile movement under load.

Phase II Research Program – Static Load Testing

Figure 2: Typical Phase II Load Versus Deflection Curve



Introduction to “Micro” pin-piles and driving equipment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Phase III Static and Dynamic Load Testing

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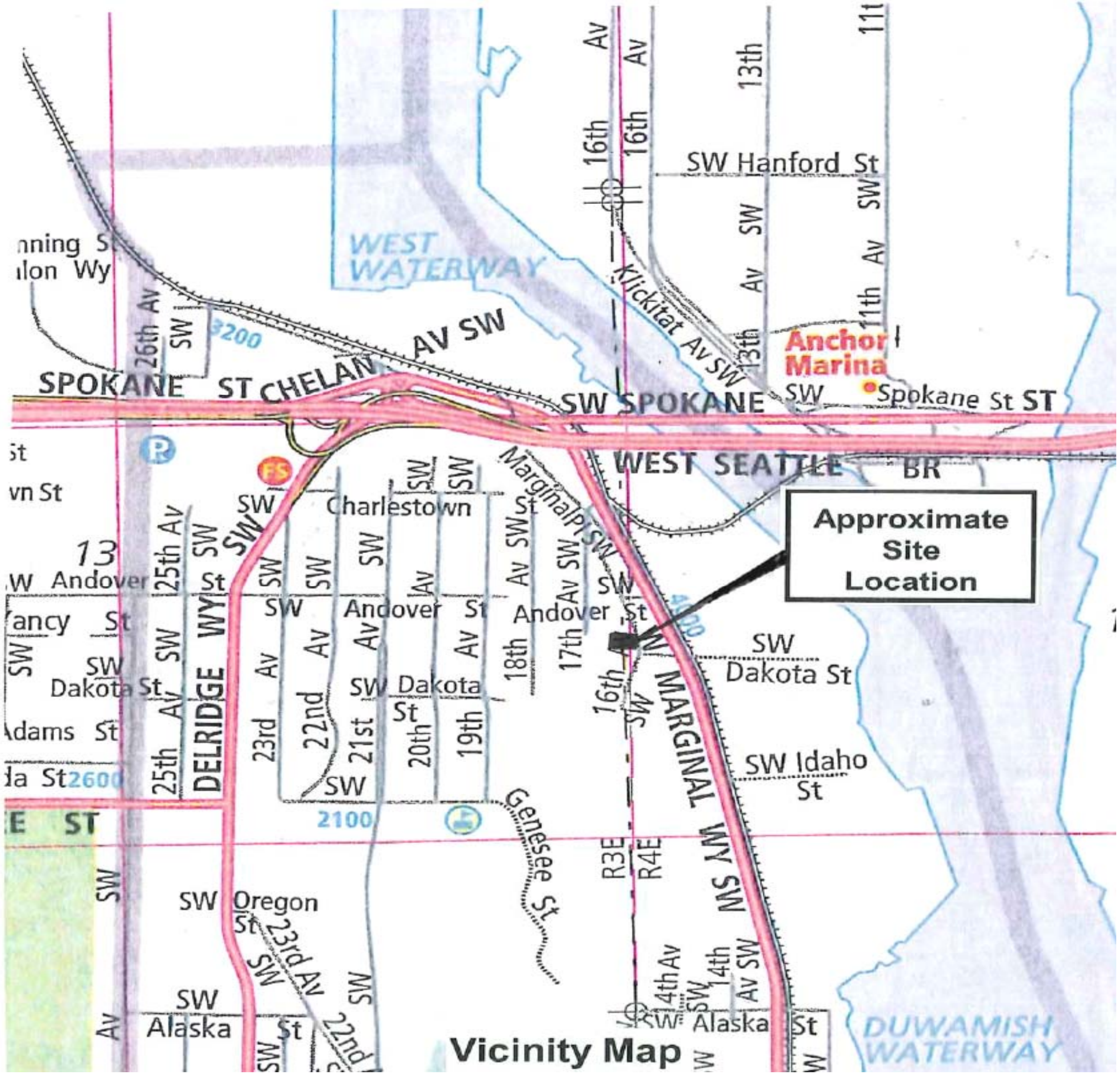
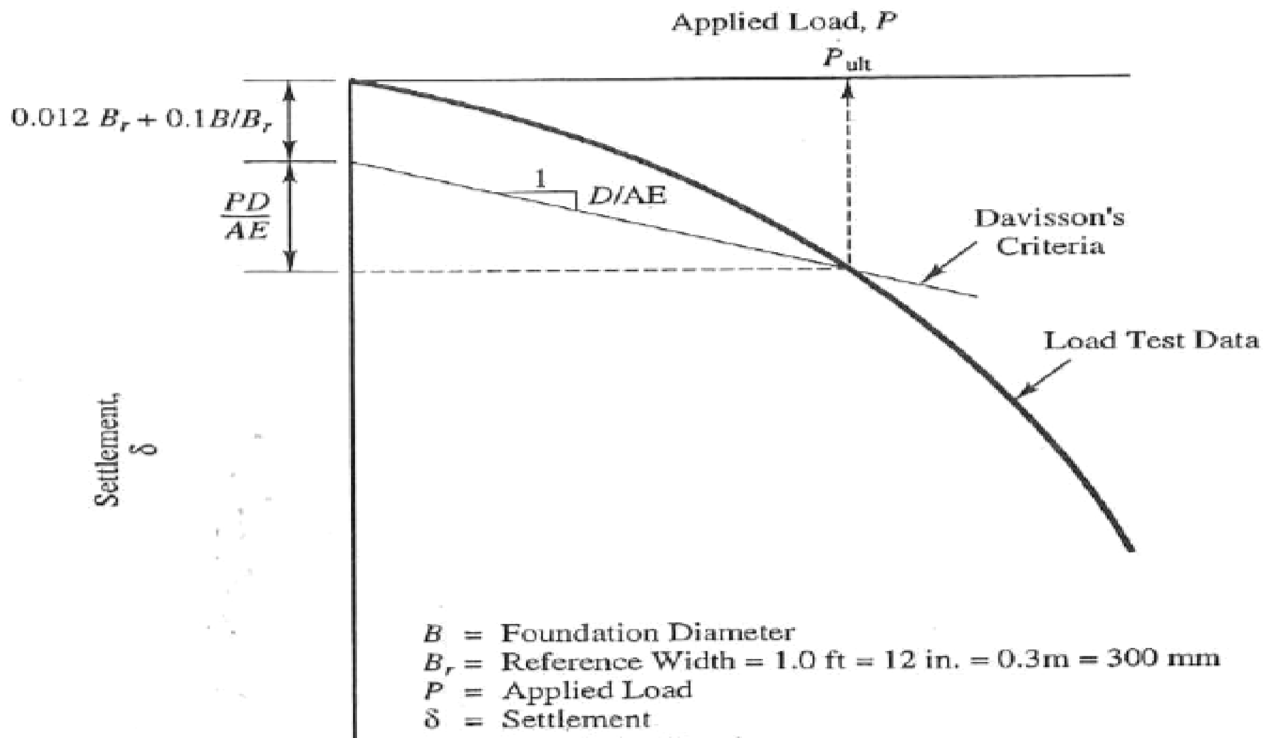


(N) Blows / Ft.	(W) %	Sample Number	Sample Type	Depth (Ft.)	Graph	USCS	Soil Description
							Cement, gravel to - 6".
12	-	1	SPT			SM	Dark gray-brown silty fine to course SAND, moist medium dense, little gravel (Fill).
12	-	2	SPT			ML	Light gray-brown to light brown fine to medium sandy SILT, moist, medium dense, little gravel (FILL).
9	28.1	3	SPT	5		ML	Light brown fine sandy SILT, moist, loose.
5	-	4	SPT				
5	28.3	5	SPT	10		ML	Blue-gray fine to course sandy SILT, wet, loose.
11	-	6	SPT	15			- Becomes medium dense.
33	-	7	SPT	20			- Becomes dense.
32	28.5	8	SPT	25			- LL = 29.0 - PL = 5.0
39	-	9	SPT	30			
				35		BOH	Boring terminated at 31.5 feet below existing grade. No groundwater encountered during drilling. Boring backfilled with cuttings and bentonite chips.



B = Foundation Diameter
B_r = Reference Width = 1.0 ft = 12 in. = 0.3m = 300 mm
P = Applied Load
δ = Settlement
D = Foundation Depth
A = Foundation Cross-Section Area
E = Foundation Modulus of Elasticity
= 29,000,000 lb/in.^{2} (200,000 MPa) for Steel
= $15{,}200\, \sigma_r (f'_c/\sigma_r)^{0.5}$ for Concrete
= 1,600,000 lb/in.^{2} (11,000 MPa) for Pine or Fir
σ_r = 14 lb/in.^{2} = 0.1 MPa

Figure 13.5 Davisson's method of interpreting pile load test data.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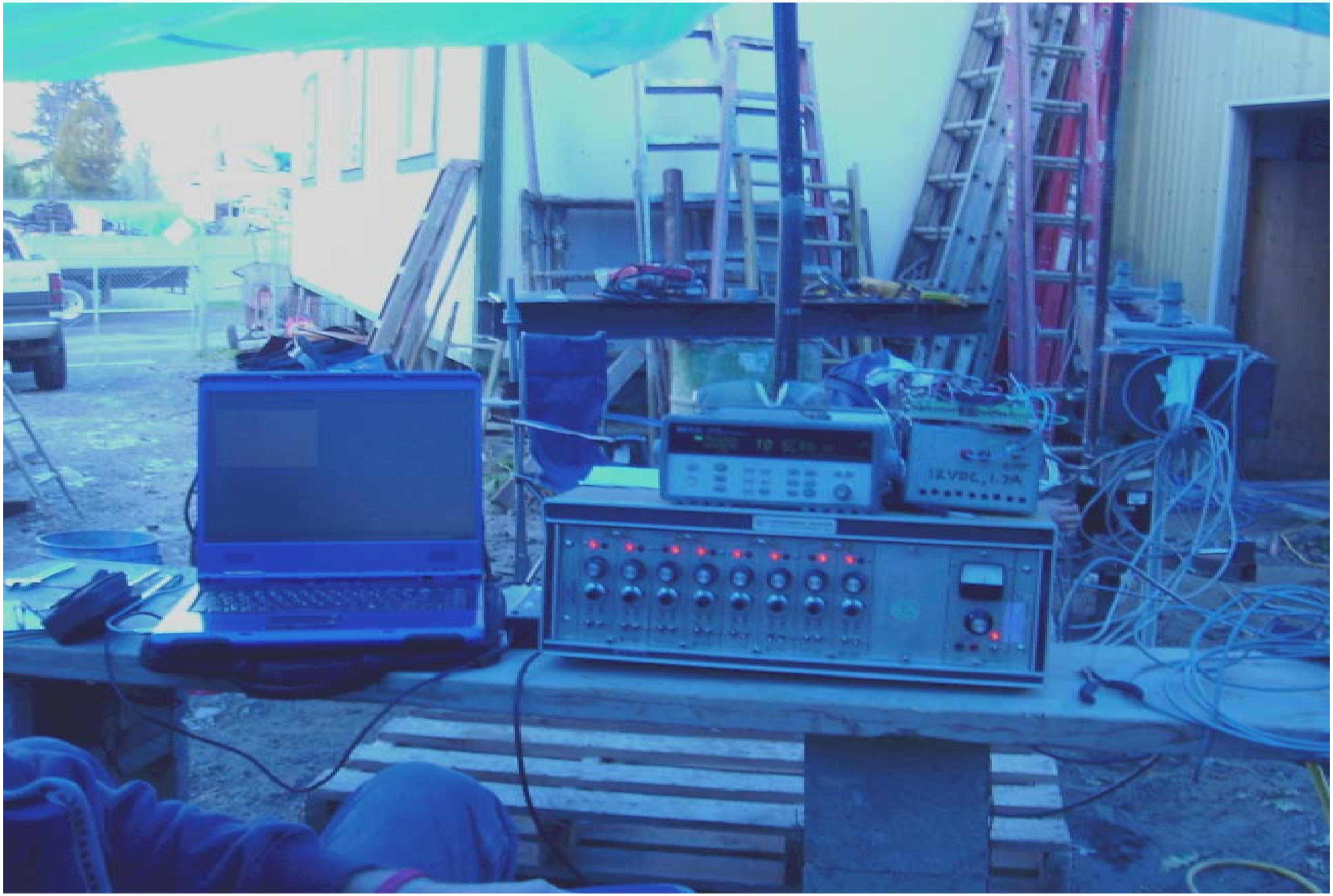
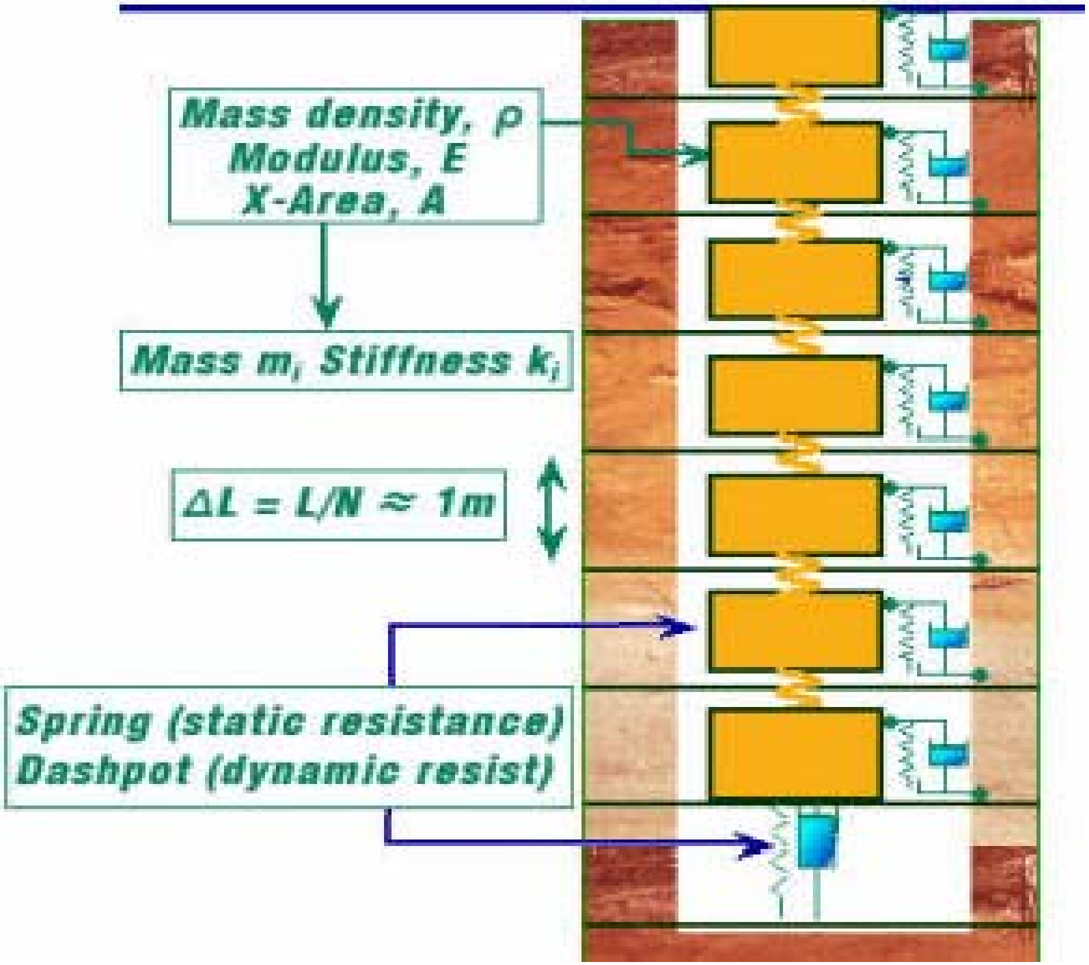


The Pile and Soil Model

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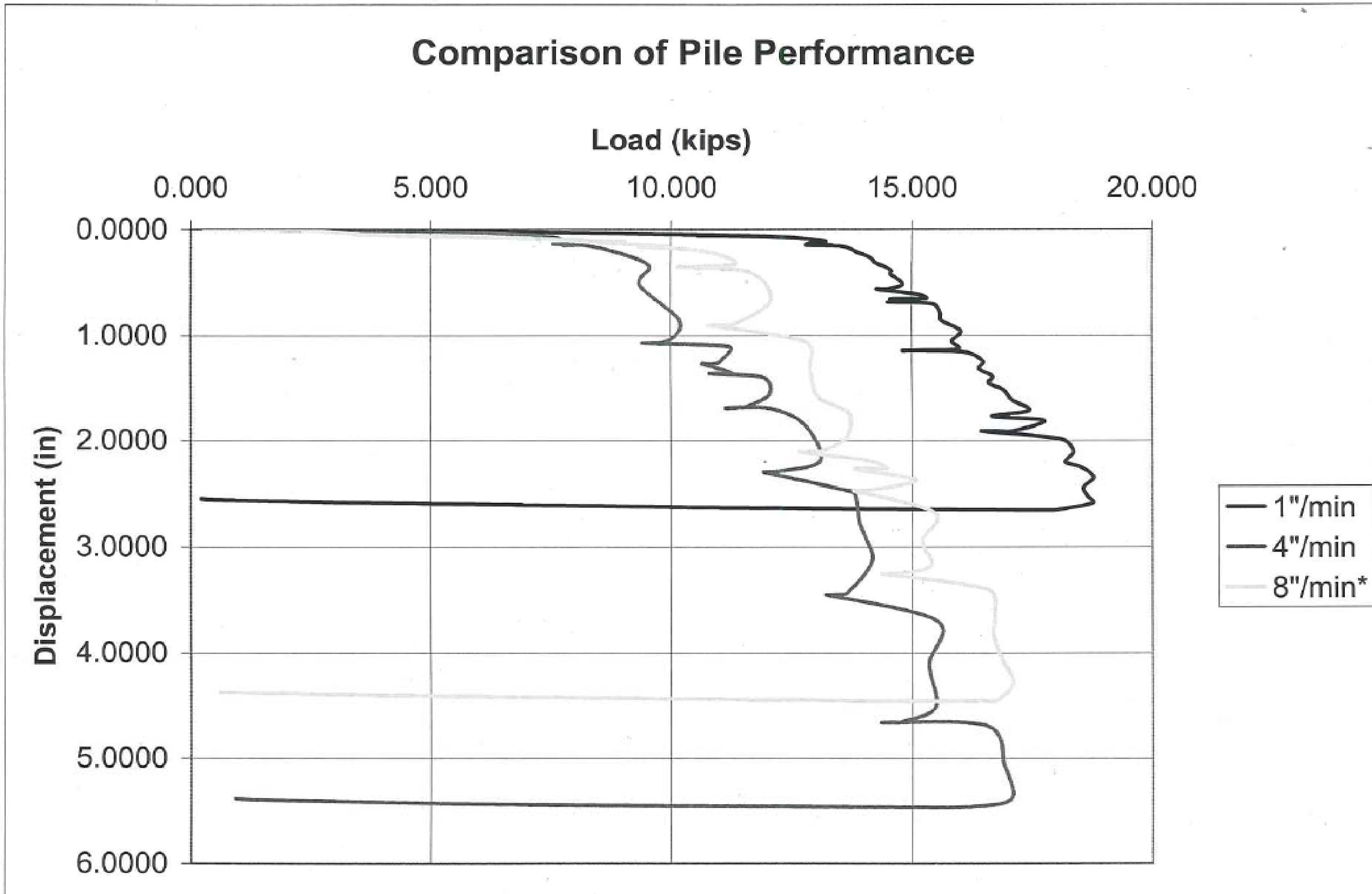
Summary of Results and Conclusions


Comparison of Pile Performance
Load (kips)
0.000
5.000
10.000
15.000
20.000
0.0000
1.0000
2.0000
3.0000
4.0000
5.0000
6.0000
Displacement (in)
1"/min
4"/min
8"/min*

Pin-Pile Number	Top-of-Pile Deflection [mm (ins)]	Tip-of-Pile Deflection [mm (ins)]
1	7 (0.263)	4.5 (0.175)
2	8 (0.315)	6.8 (0.266)
3	7.5 (0.297)	6.5 (0.244)

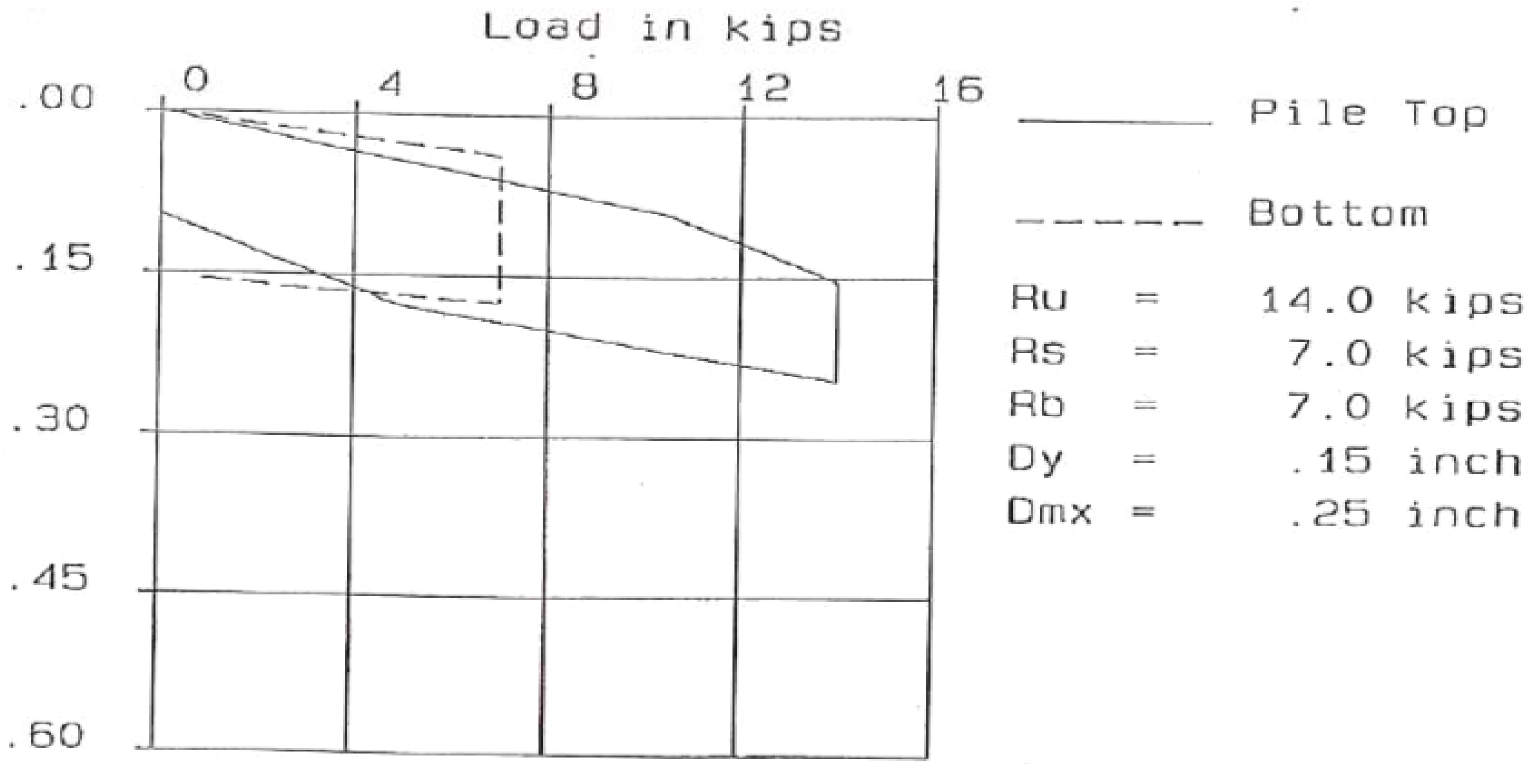


Figure 7: Dynamic load versus deflection for pin-pile #1.

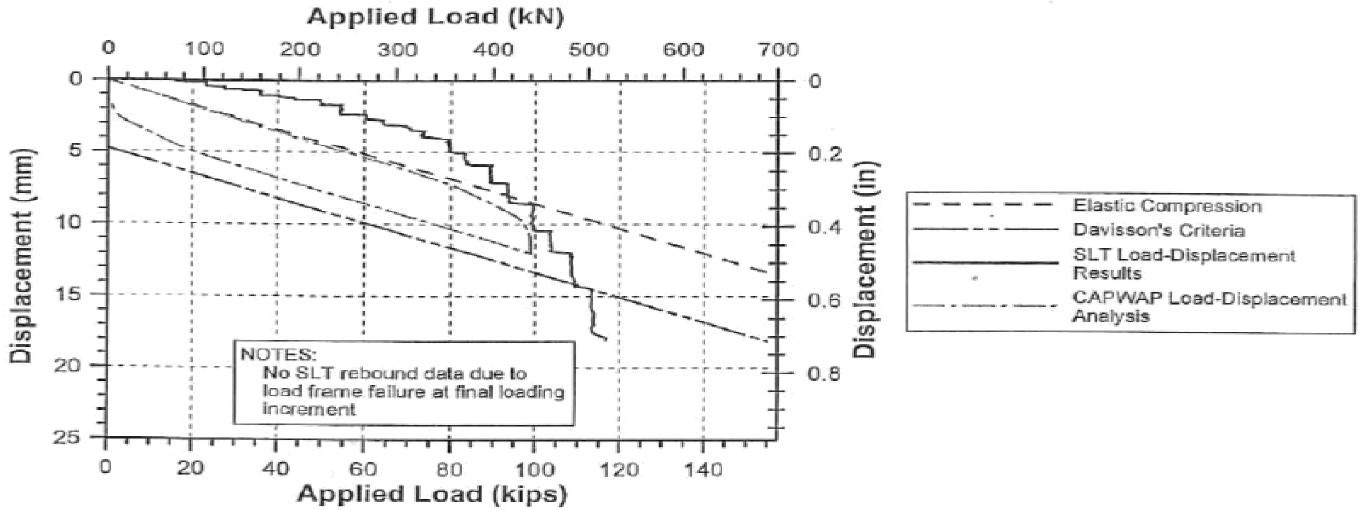


Figure 5. TP6 Static Load Test Results.

Table 3. Summary of TP6 Dynamic Testing Results

Blow	Observed Blow Count bp100mm (bpi)	Drop Height m (ft)	EMX[1] kN-m (kip-ft)	ETR[2] (%)	CAPWAP Capacity kN (kips)		
					Side	Tip	Total
5	126 (32)	1.1 (3.5)	(2.2)	63	387 (87)	53 (12)	440 (99)

NOTES:
1. EMX = Maximum Energy delivered to pile.
2. ETR = Energy Transfer Ratio = EMX/Rated Energy

- The static loads were on the order of 2.25 to 3.2 kN [10 and 14 kips] before the piles moved significantly.
- The “average” dynamic loads were on the order of 84 to 117 kN [18.9 to 26.4 kips].
- The Dynamic [CAPWAP and PDA] results were a reasonable match to the static load test results, though typically a little higher.
- Higher allowable design axial load capacities may, and should, be allowed without the need for a load static test.
- Dynamic [CAPWAP and PDA] load testing is a practical and economical means of load testing.
- A reduction in the driving “refusal” criterion should be allowed to reduce the detrimental impacts on materials, equipment and workmen with no loss of capacity.

Acknowledgements

- We wish to thank Cemrock, Inc., and Terra Firma for providing the site and pile installation, Davies Drilling for providing the boring at cost, the ASCE Seattle Geotechnical Section for financial support, and Robert Miner Dynamic Testing, Inc., for providing the PDA services. Without these firms none of this research would have been possible.

- I appreciate your attention and thank you for spending the time to listen to this presentation.
- If any of you have questions – now is the time! I'll also be available throughout the remainder of this meeting.
- Thank You!