Optimizing the Design of Driven Pile Foundations with Instrumented Static Load Tests

June 16, 2017

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E.L. ROBINSON ENGINEERING

MOT-75-12.00
Dayton, Ohio

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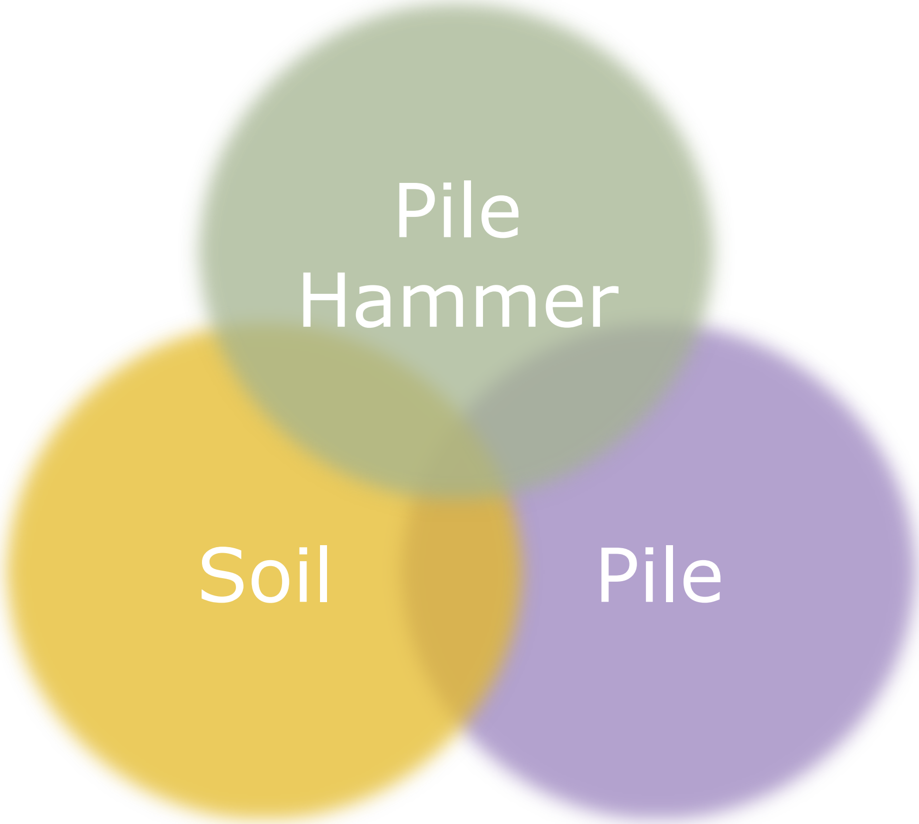
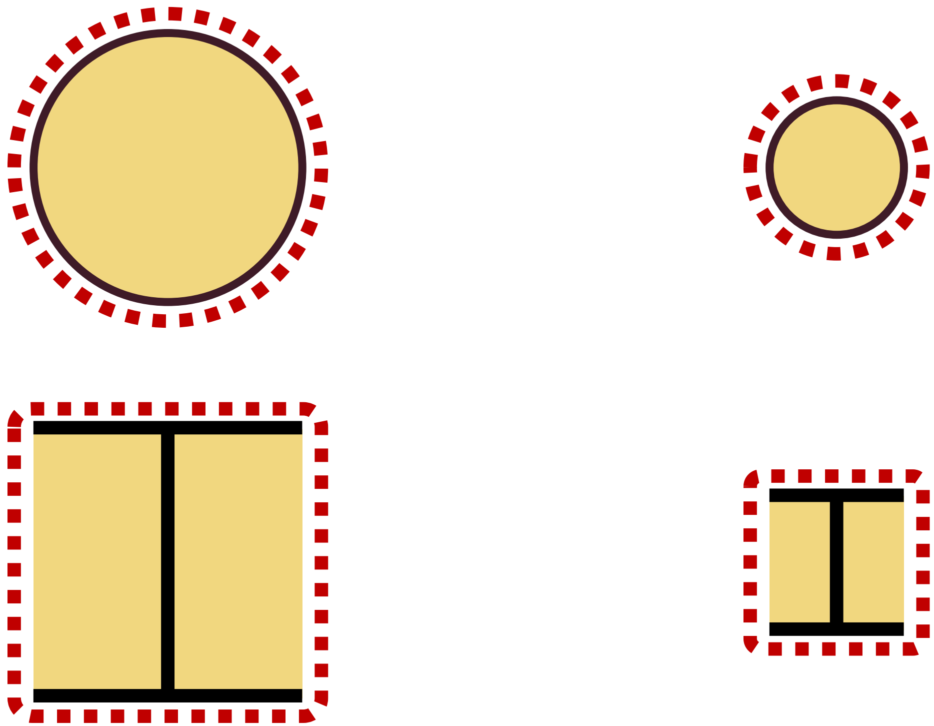
Pile foundation system



Geotechnical resistance



Drivability

- Pile hammer
  - Type and size
- Pile cross-section and material
  - Impedance
- Soil properties
  - Resistance, damping, and quake

Specified minimum Pile wall thickness

Ohio DOT C&MS 507.06

$$t \text{ (in inches)} = \frac{R \text{ (in lb)}}{900{,}000}$$

Based on 12-inch diameter pipe pile
Conservative for larger piles

Cost components

- Steel
- Concrete
- Pile points
- Crew time to unload the piles
- Crew time and cost to drive the pile
- Time and material for splices
- Crew time to fill with concrete

Process

1
- Geotechnical resistance with depth

2
- Maximum UBV for pile and hammer

3
- Estimated length for max. UBV

4
- Driving time

5
- Costs for materials, labor, and equipment

6
- Cost per ton

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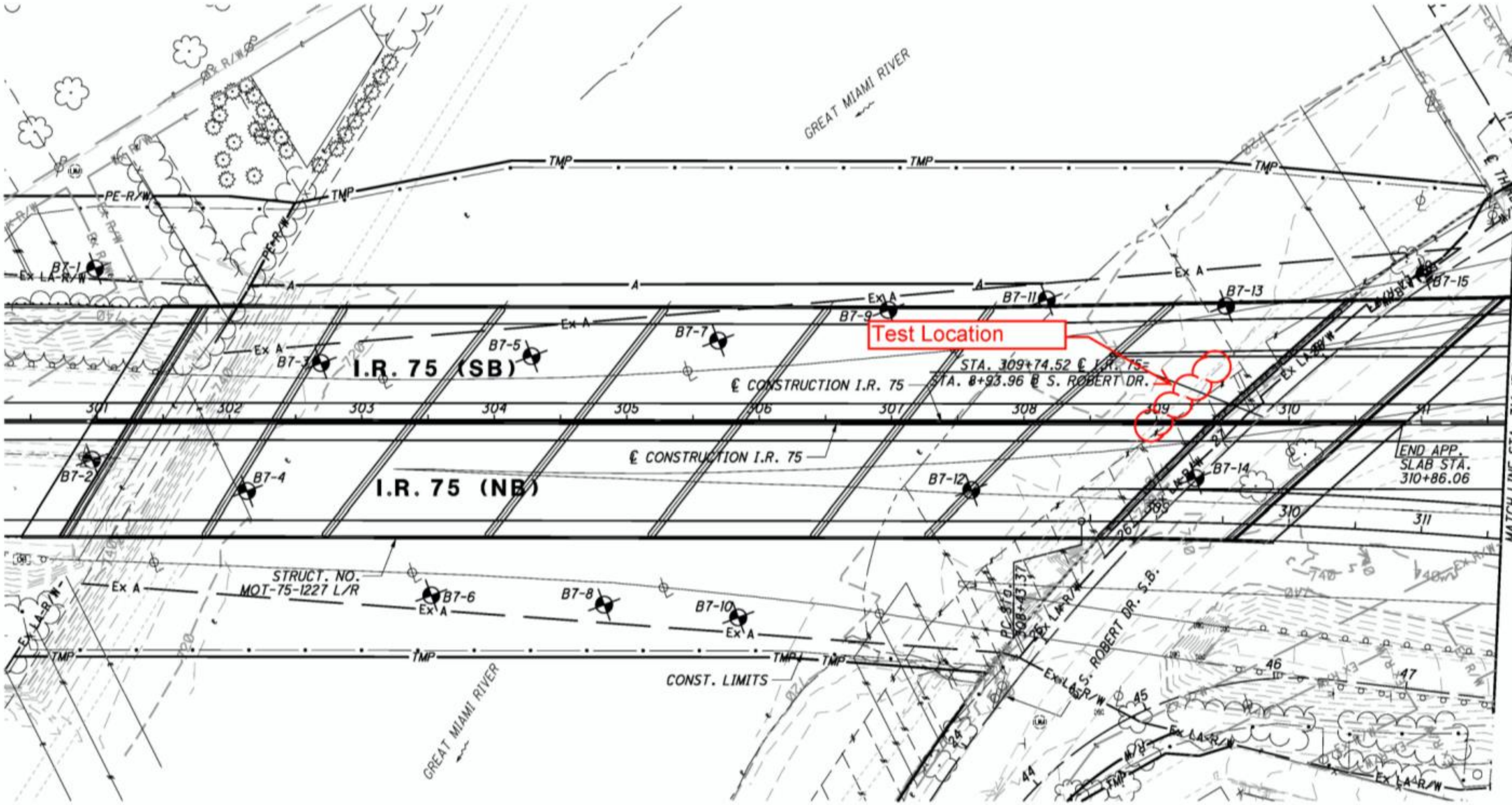
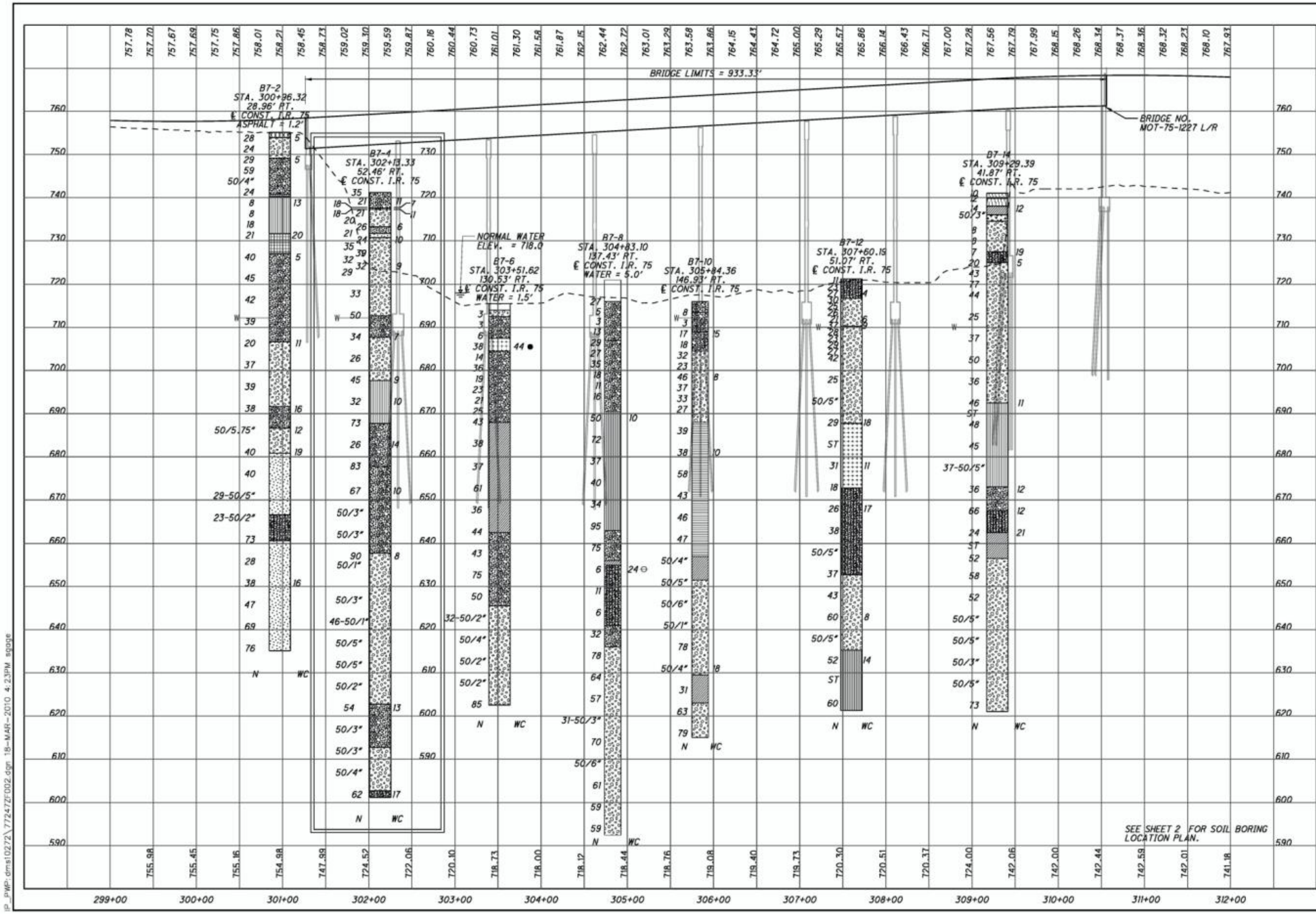

GREAT MIAMI RIVER
TMP
PE-R/W
Ex LA-R/W
Ex A
A
B7-1
B7-2
B7-3
B7-4
B7-5
B7-6
B7-7
B7-8
B7-9
B7-10
B7-11
B7-12
B7-13
B7-14
B7-15
I.R. 75 (SB)
I.R. 75 (NB)
Test Location
STA. 309+74.52 ℄ I.R. 75=
STA. 8+93.96 ℄ S. ROBERT DR.
℄ CONSTRUCTION I.R. 75
301
302
303
304
305
306
307
308
309
310
311
END APP. SLAB STA. 310+86.06
MATCH LINE STA. 314+17.23 I.R. 75
STRUCT. NO. MOT-75-1227 L/R
CONST. LIMITS
S. ROBERT DR. S.B.
PC STA. 308+43.37
GREAT MIAMI RIVER

BORING PLAN



CALCULATED AS
CHECKED RL

STRUCTURE FOUNDATION EXPLORATION
BRIDGE NO. MOT-75-1227 L/R (BRIDGE 7S)

MOT-75-12.00

3/34

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Foundation Costs

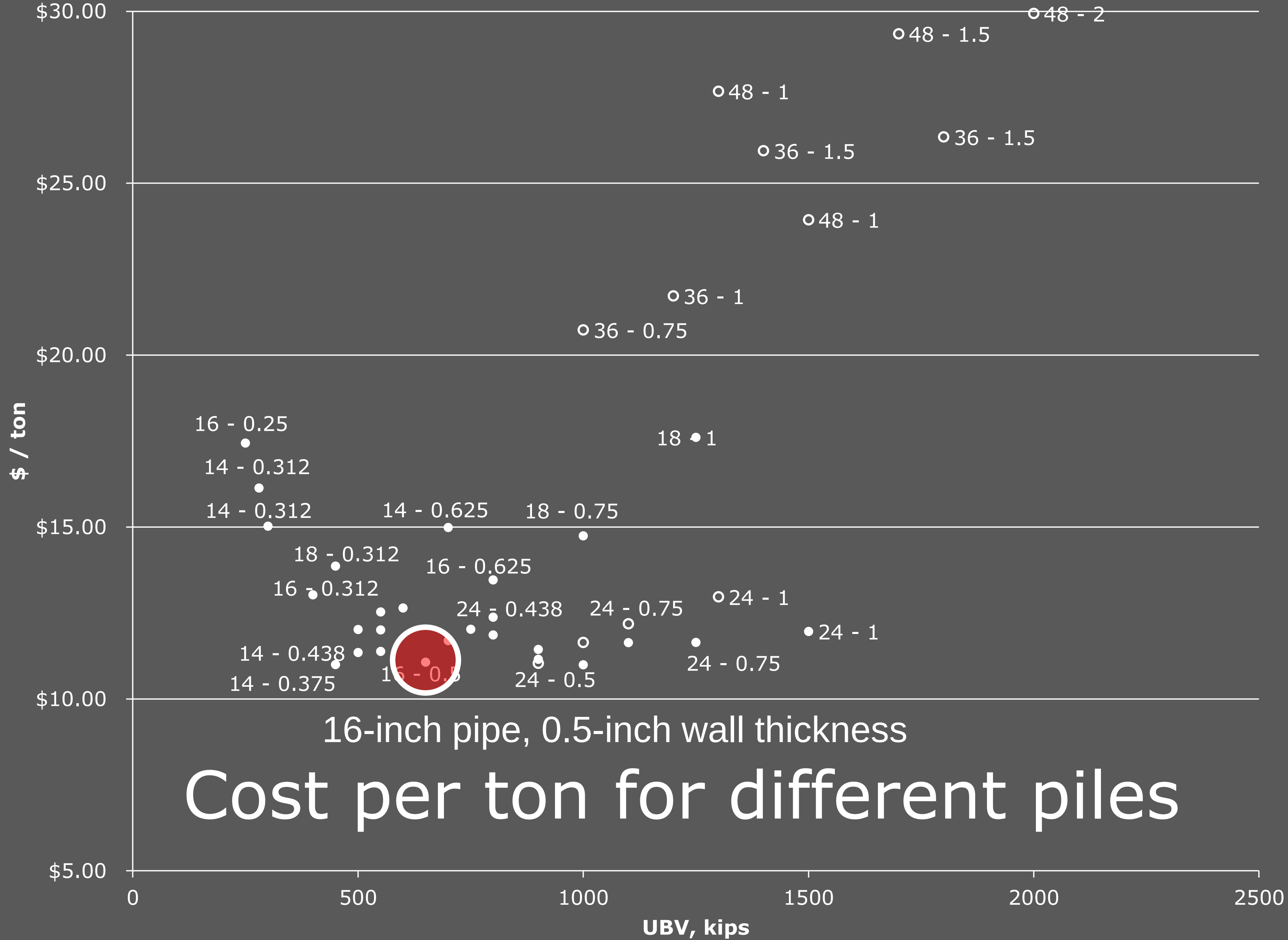
MOT-75-12.00 VE
Bridge No. MOT-75-1227

Pipe pile material is ASTM A252, Grade 3, Fy=45 ksi
Driving stresses limited to 0.85 Fy = 38.25 ksi

Total service load on pier (approximate) 13,125 tons
Based on Boring B7-8

(Lowest 3 in cost are in bold text)

Pile dia. (inch)	Wall thickness (inch)	Min. wall thickness -3% (inch)	Closed or Open End	UBV (kips)	Hammer Model	Hammer Energy (kip-ft)	Est. Length (feet)	Order Length (feet)	Time to drive (min.)	$ / pile (matl')	$ / pile (labor)	No. of piles /pier	Total cost $	$ / ton
14	0.250	0.243	Closed	200	D 19-32	47	45	50	10	$ 1,227	$ 534	264	$ 464,870	$ 17.61
14	0.312	0.303	Closed	280	D 19-32	47	50	55	10	$ 1,636	$ 542	188	$ 409,566	$ 15.56
14	0.312	0.303	Closed	300	D 19-32	47	50	55	10	$ 1,636	$ 542	176	$ 383,412	$ 14.52
14	0.375	0.364	Closed	450	D 19-32	47	50	55	10	$ 1,876	$ 545	118	**$ 285,636**	**$ 10.76**
14	0.438	0.425	Closed	500	D 25-32	62	50	55	10	$ 2,123	$ 657	106	$ 294,727	$ 11.12
14	0.500	0.485	Closed	550	D 36-42	89	50	55	5	$ 2,412	$ 682	96	$ 296,970	$ 11.25
14	0.625	0.606	Closed	700	D 36-42	89	80	85	50	$ 4,273	$ 897	76	$ 392,972	$ 14.77
16	0.250	0.243	Closed	250	D 19-32	47	45	50	15	$ 1,549	$ 544	210	$ 439,611	$ 16.75
16	0.312	0.303	Closed	400	D 19-32	47	50	55	15	$ 1,987	$ 554	132	$ 335,361	$ 12.70
16	0.375	0.364	Closed	500	D 25-32	62	50	55	15	$ 2,276	$ 669	106	$ 312,084	$ 11.78
16	0.438	0.425	Closed	550	D 25-32	62	50	55	15	$ 2,570	$ 673	96	$ 311,275	$ 11.79
16	0.500	0.485	Closed	650	D 36-42	89	50	55	10	$ 2,845	$ 698	82	**$ 290,489**	$ 10.90
16	0.625	0.606	Closed	800	D 36-42	89	70	75	25	$ 4,549	$ 743	66	$ 349,228	$ 13.23
18	0.312	0.303	Closed	450	D 25-32	62	50	55	15	$ 2,337	$ 679	118	$ 355,874	$ 13.40
18	0.375	0.364	Closed	550	D 25-32	62	50	55	15	$ 2,667	$ 685	96	$ 321,828	$ 12.19
18	0.438	0.425	Closed	600	D 36-42	89	50	55	10	$ 2,989	$ 709	88	$ 325,413	$ 12.33
18	0.500	0.485	Closed	700	D 36-42	89	50	55	10	$ 3,292	$ 715	76	$ 304,510	$ 11.45
18	0.625	0.606	Closed	800	D 36-42	89	50	55	10	$ 3,930	$ 726	66	$ 307,282	$ 11.64
18	0.625	0.606	Closed	900	D 46-32	114	55	60	15	$ 4,252	$ 811	60	$ 303,792	$ 11.25
18	0.750	0.728	Closed	1000	D 46-32	114	75	80	30	$ 6,383	$ 878	54	$ 392,087	$ 14.52
18	1.000	0.970	Closed	1250	D 62-42	153	90	95	90	$ 9,425	$ 1,450	42	$ 456,741	$ 17.40
24	0.375	0.364	Closed	750	D 36-42	89	50	55	15	$ 3,657	$ 762	70	$ 309,308	$ 11.78
24	0.438	0.425	Closed	800	D 36-42	89	50	55	15	$ 4,088	$ 769	66	$ 320,581	$ 12.14
24	0.438	0.425	Closed	900	D 46-32	114	50	55	10	$ 4,088	$ 847	60	$ 296,109	$ 10.97
24	0.500	0.485	Closed	1000	D 62-42	153	50	55	10	$ 4,528	$ 885	54	**$ 292,321**	**$ 10.83**
24	0.625	0.606	Closed	1100	D 80-42	198	50	55	5	$ 5,364	$ 951	48	$ 303,126	$ 11.48



Cost per ton for different piles

APE D36-26
89.3 ft-kips Ram 7.94 kips

Piles and points

Dynamic load testing (PDA)

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Static load tests

Strain Gages

Instrumented pile

Instruments at pile top

South side of test pile

North side of test pile

Telltales

Data Acquisition System

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Survey level


BAWANI

Load test results - 1227 Pier 5

	Total Load kips		Side Resistance	Tip Resistance
			R_s , kips	R_p , kips
EOD CAPWAP 3/27/13	638		189	449
BOR CAPWAP 3/27/13 4 hours	646		190	456
BOR CAPWAP 3/29/13	575		298	277
Static Load Test 4/4/13	670	[1]	604	66
	750	[2]	619	131
	830		626	204
	880		604	276
BOR CAPWAP 4/8/13 4 days after SLT	690		355	335

[1] Ultimate capacity determined from alternate method of applying Davisson criteria.
[2] Ultimate capacity determined from Davisson criteria.

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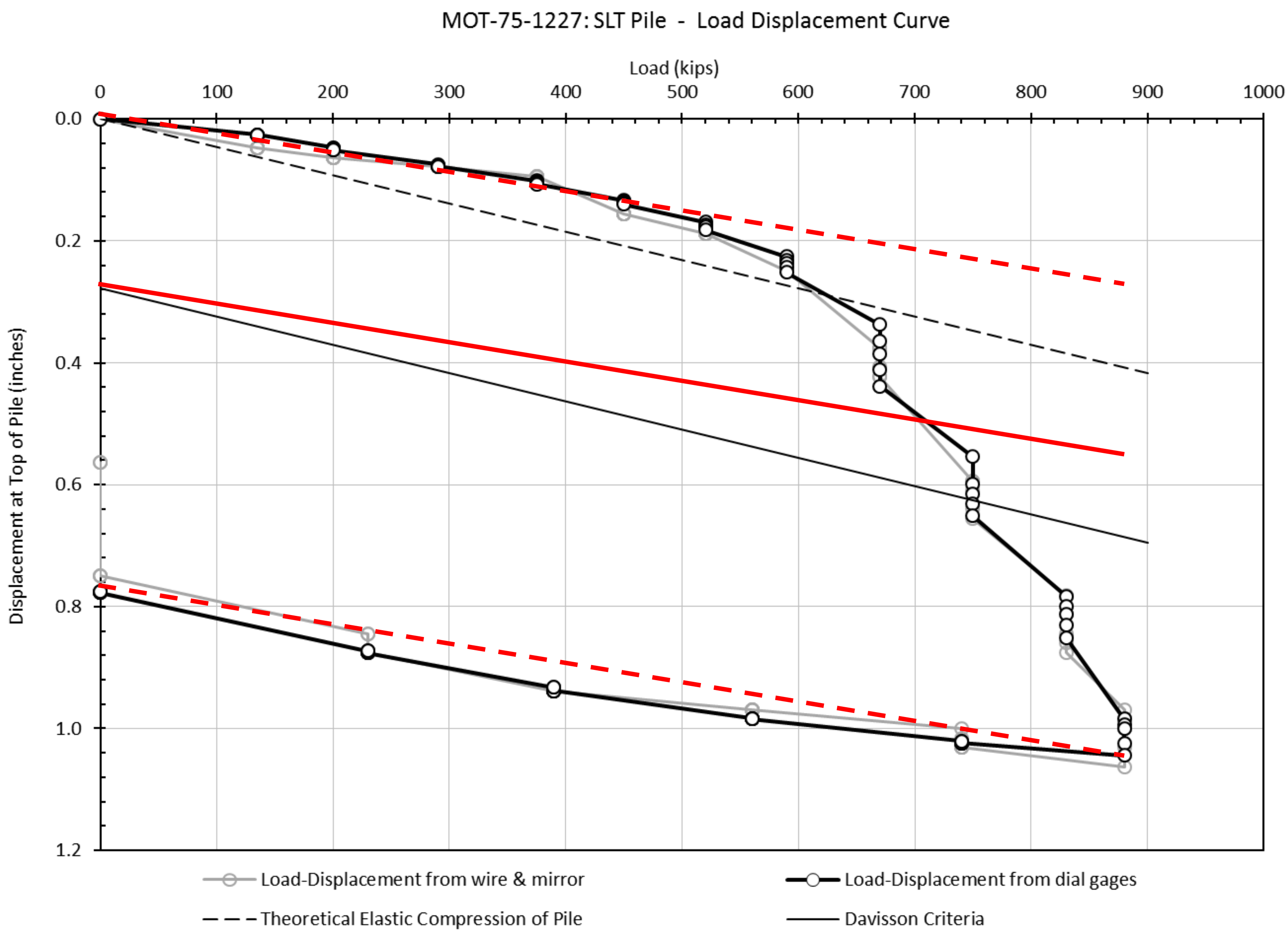

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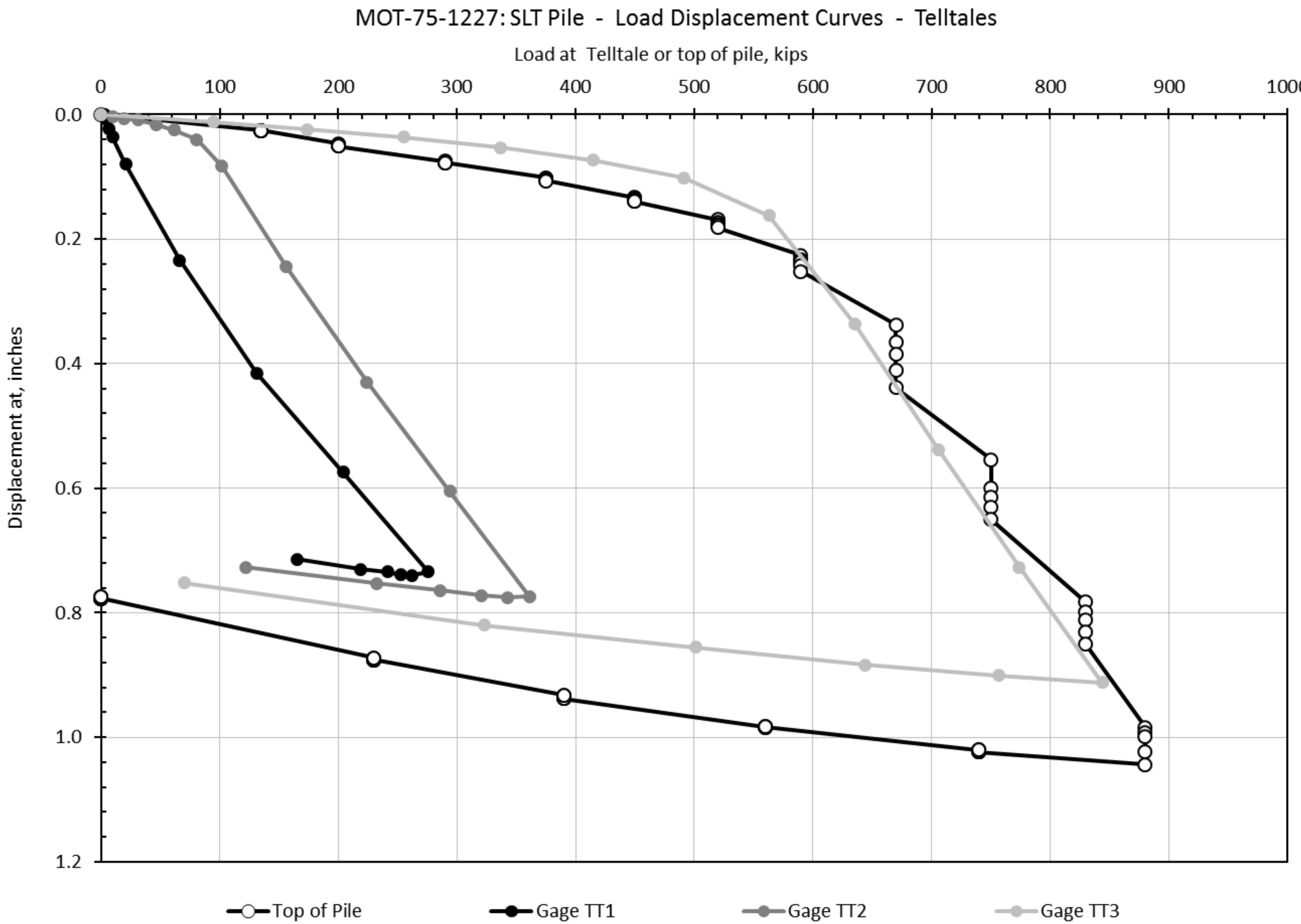

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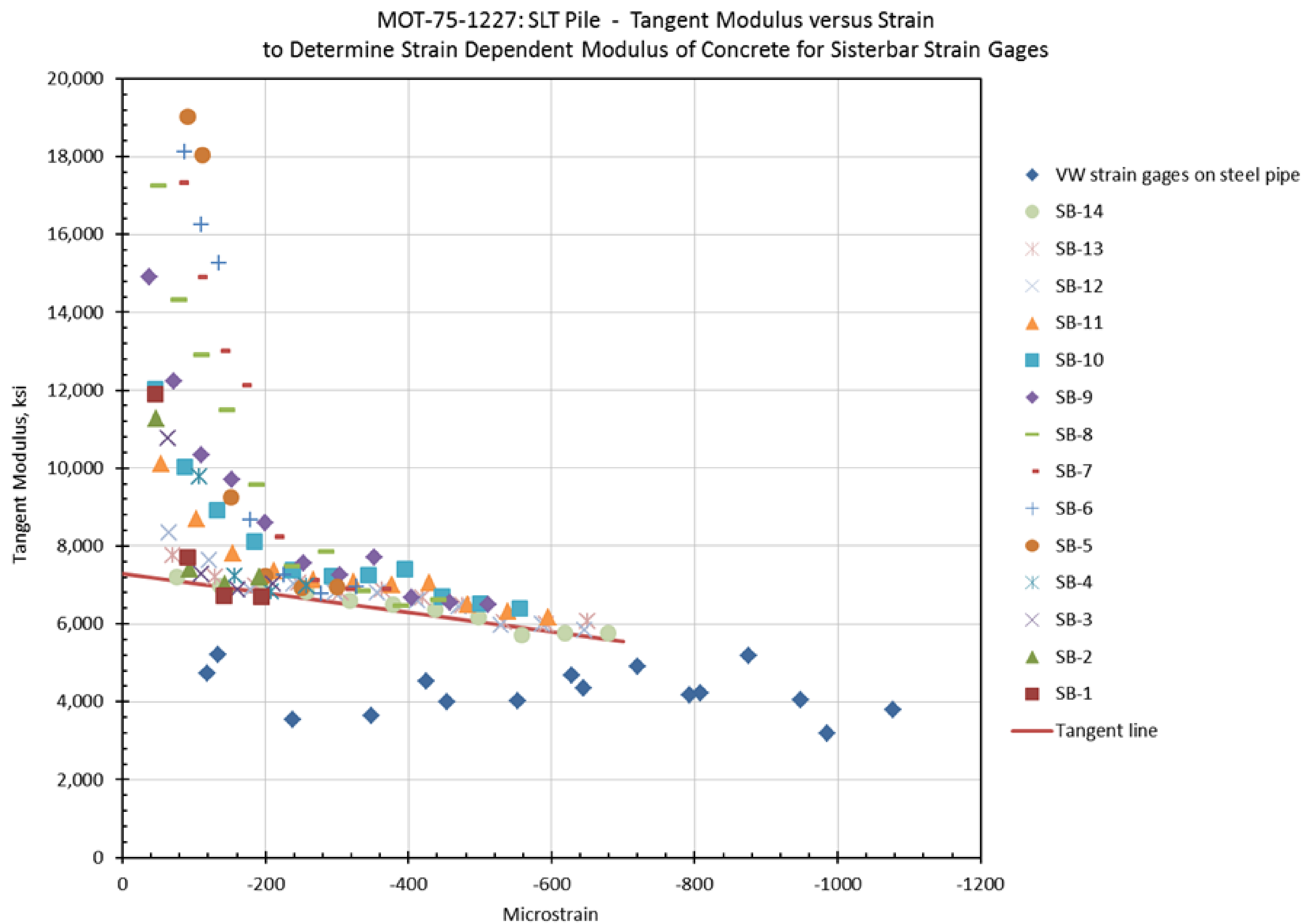
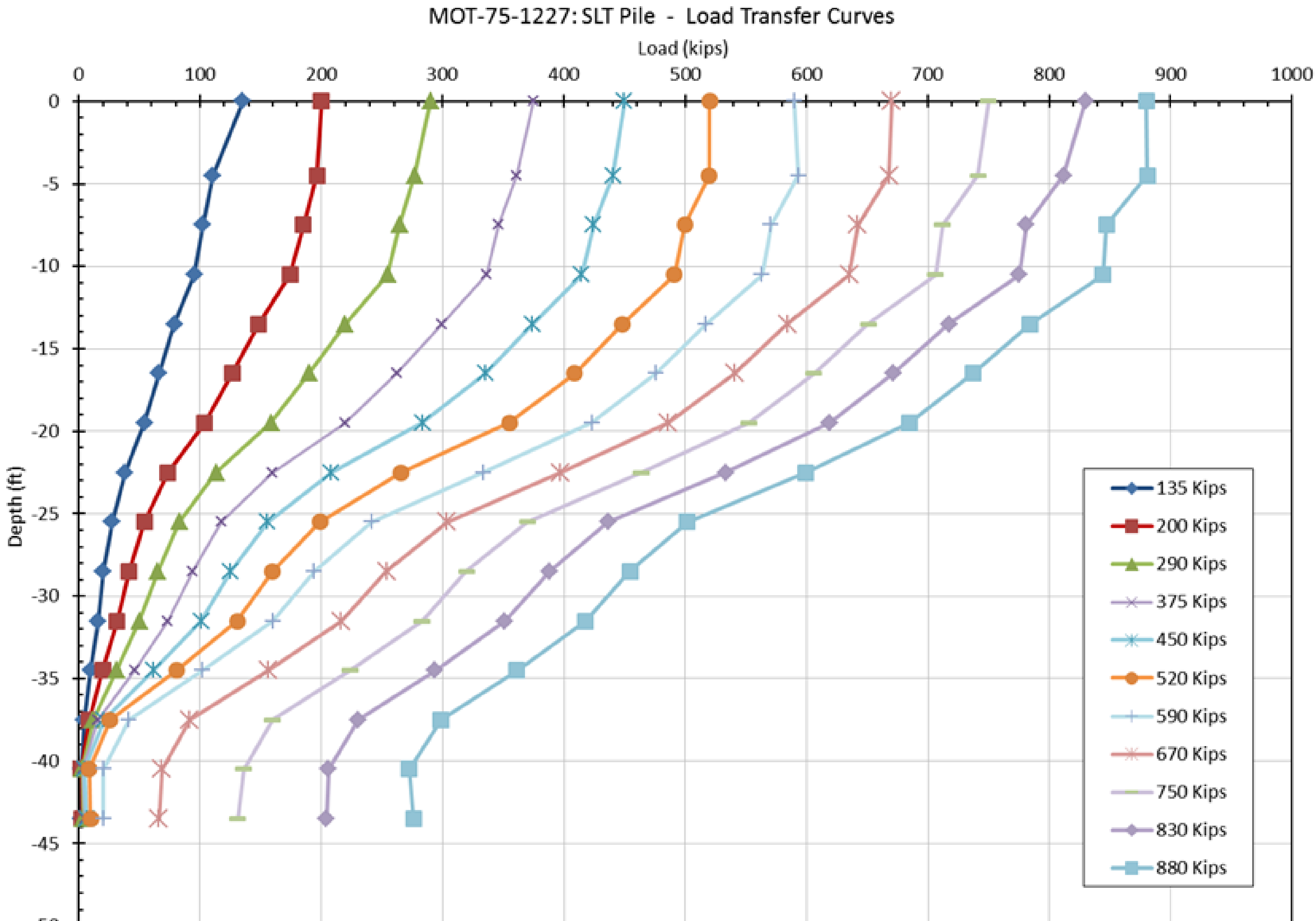

MOT-75-1227: SLT Pile - Tangent Modulus versus Strain
to Determine Strain Dependent Modulus of Concrete for Sisterbar Strain Gages
Tangent Modulus, ksi
Microstrain
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
0
-200
-400
-600
-800
-1000
-1200
VW strain gages on steel pipe
SB-14
SB-13
SB-12
SB-11
SB-10
SB-9
SB-8
SB-7
SB-6
SB-5
SB-4
SB-3
SB-2
SB-1
Tangent line



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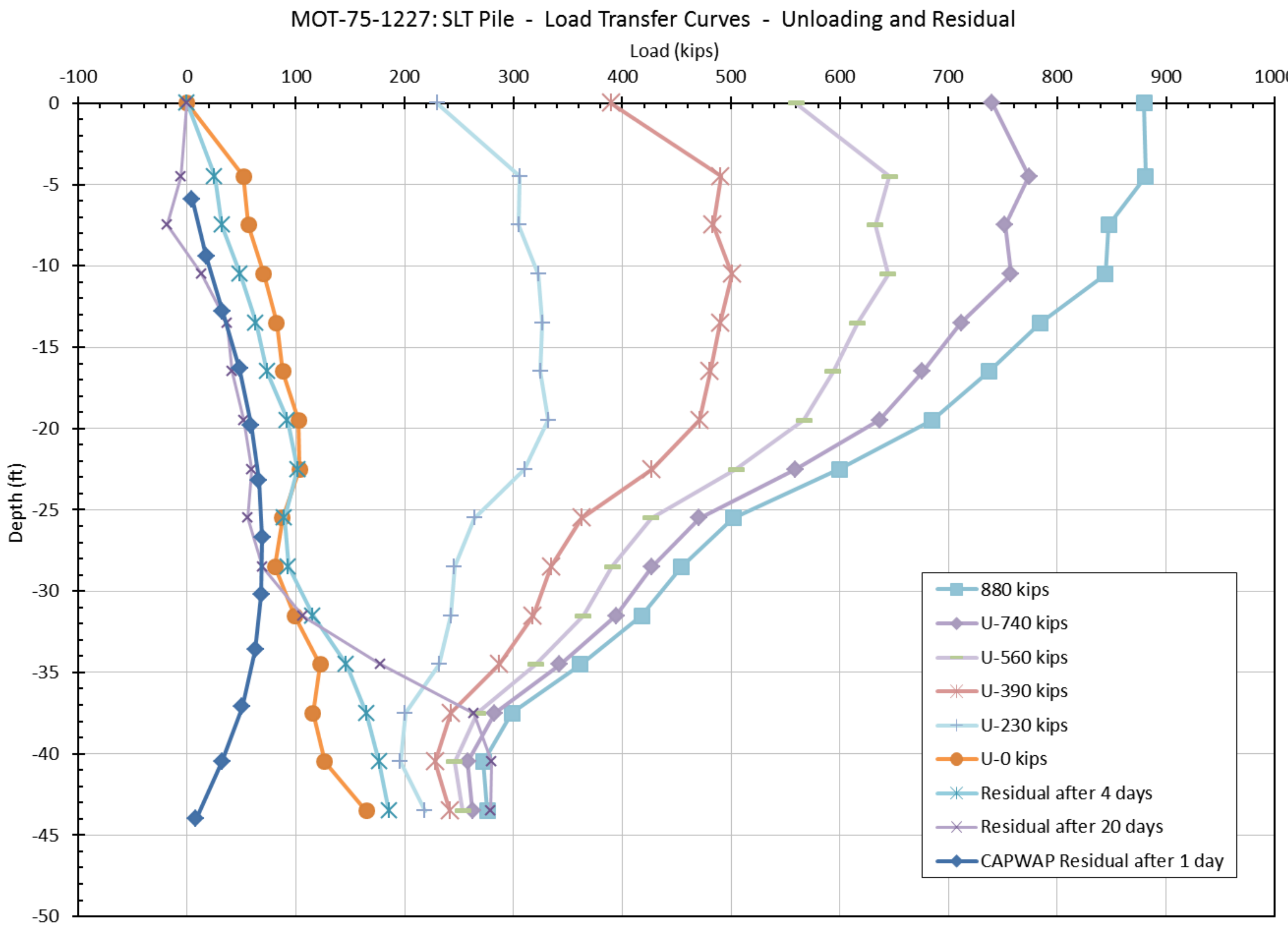

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Load test results - 1282 Pier 8

	Total Load kips		Side Resistance	Tip Resistance
			R_s , kips	R_p , kips
EOD CAPWAP 4/2/13	760		116	644
BOR CAPWAP 4/3/13	750		154	596
BOR CAPWAP 4/4/13	870		278	592
Static Load Test 4/10/13	1103	[1]	536	567
	1166		546	620
BOR CAPWAP 4/30/13 20 days after SLT	865		312	553

[1] Ultimate capacity determined from Davisson criteria.

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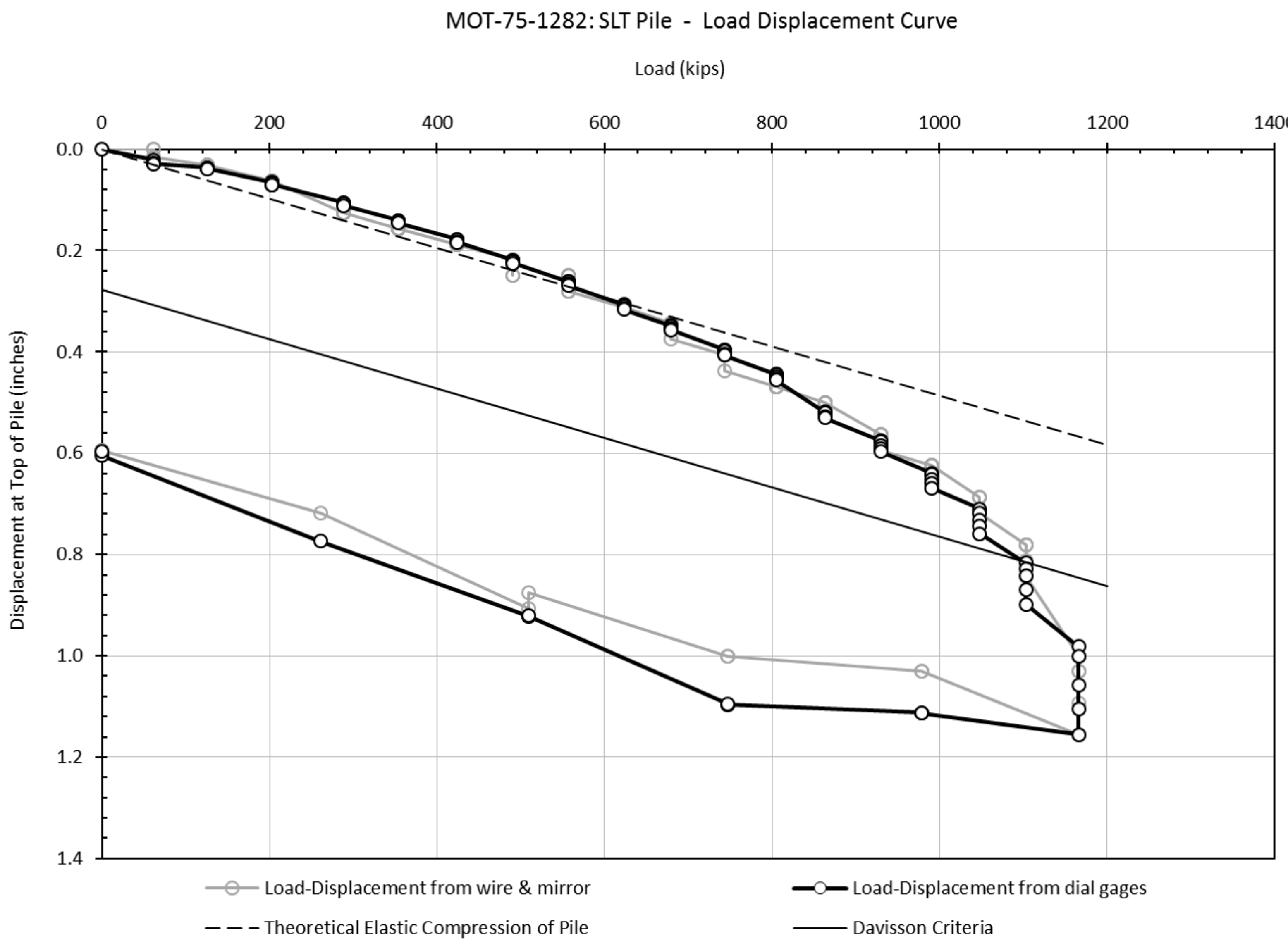

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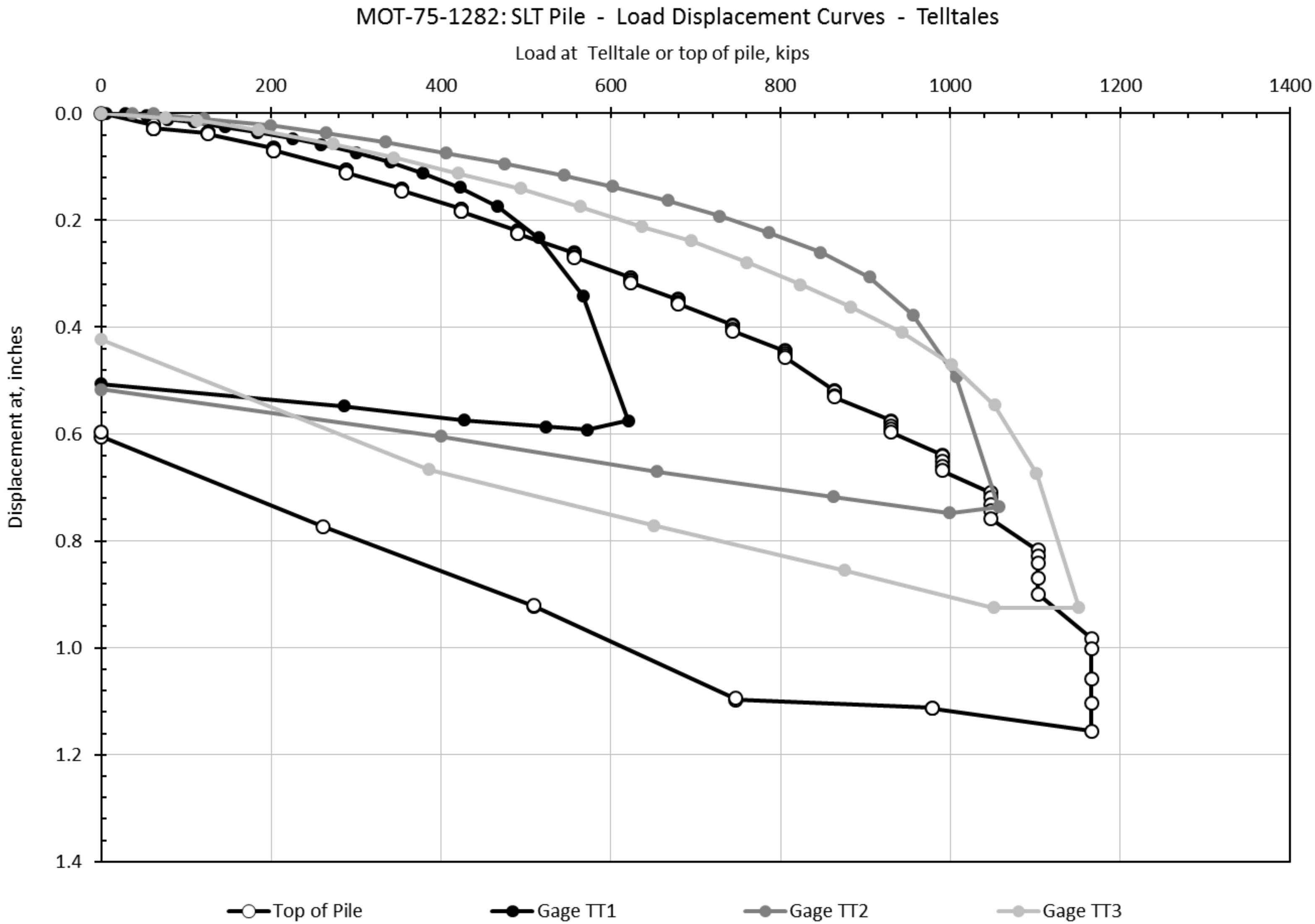

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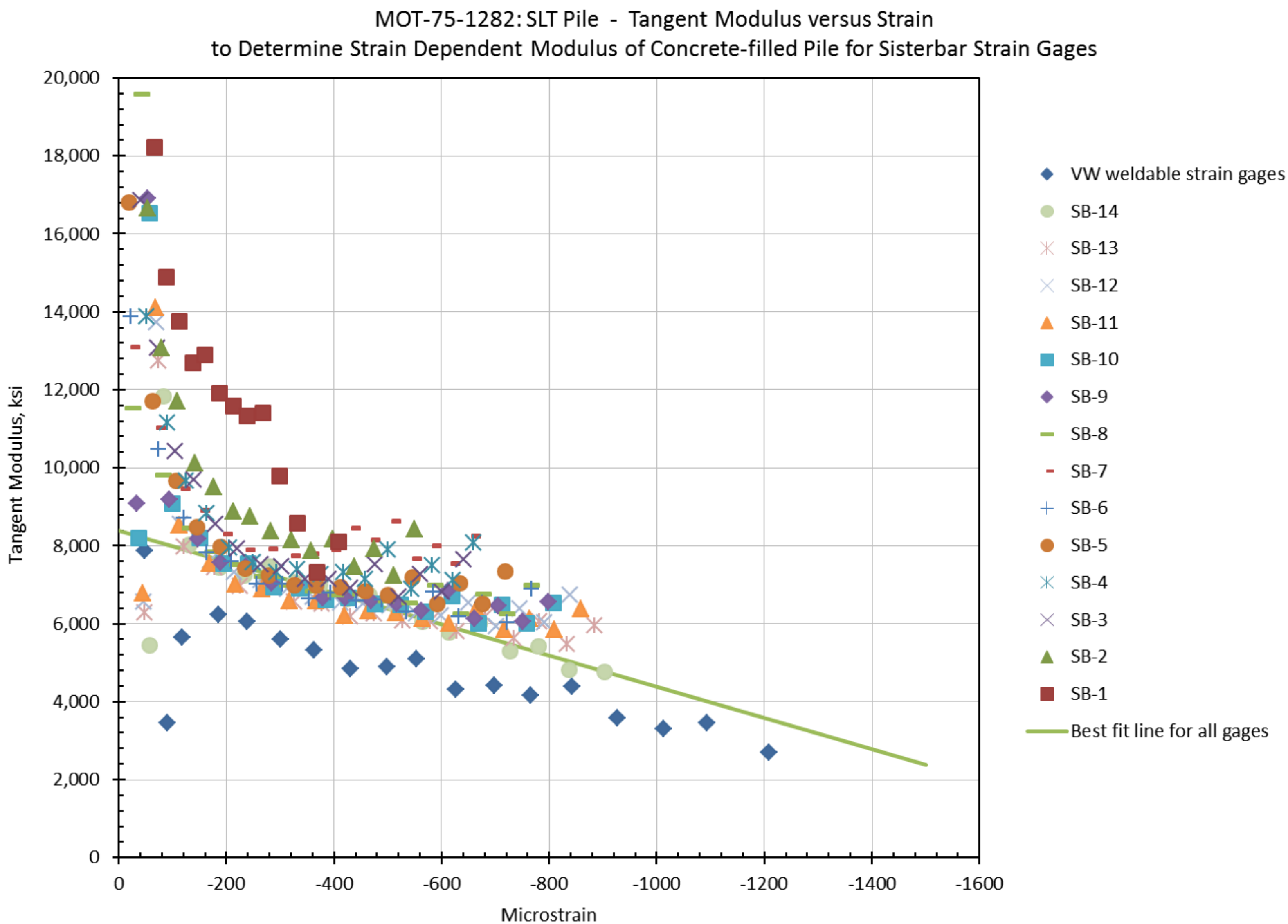

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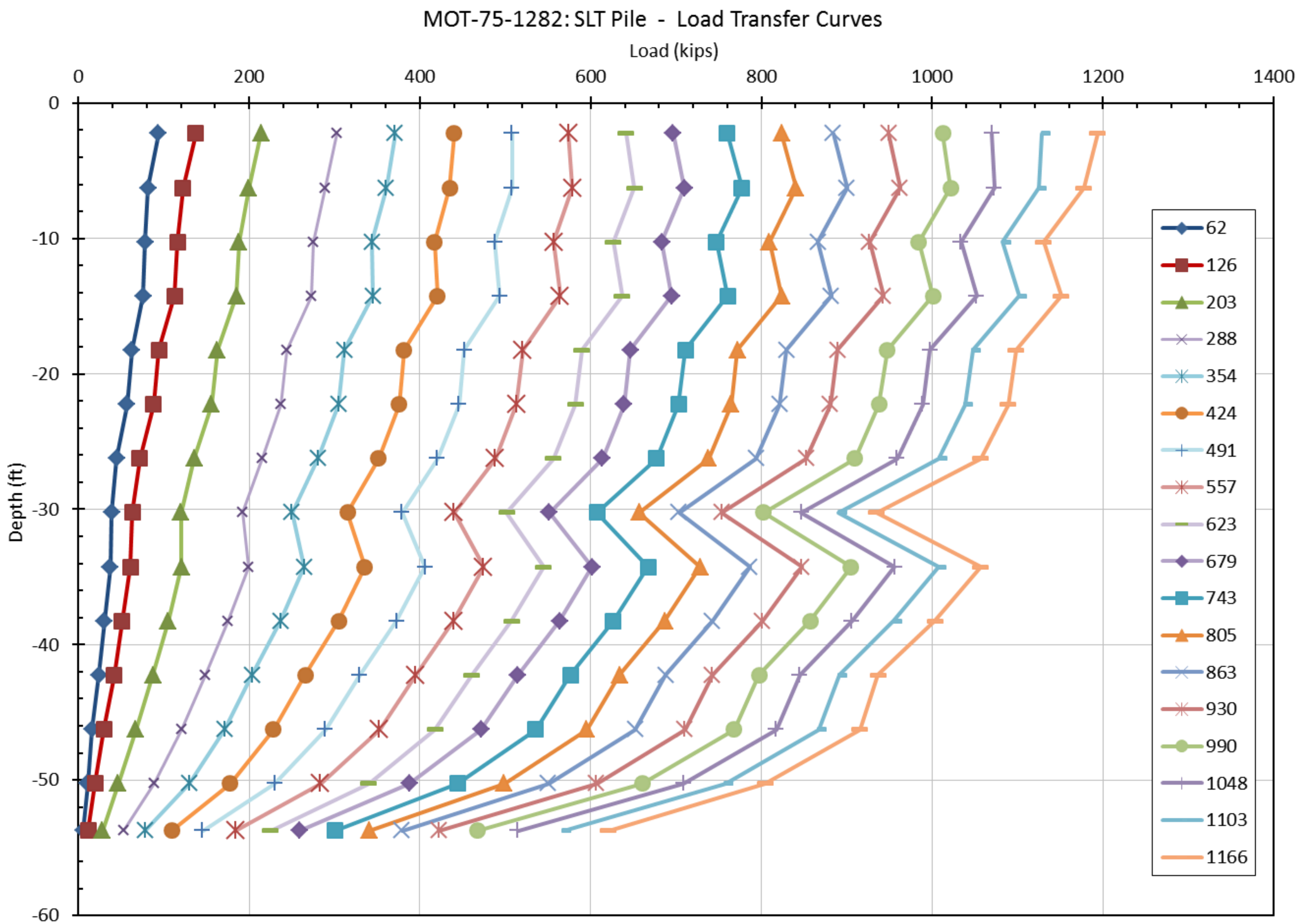

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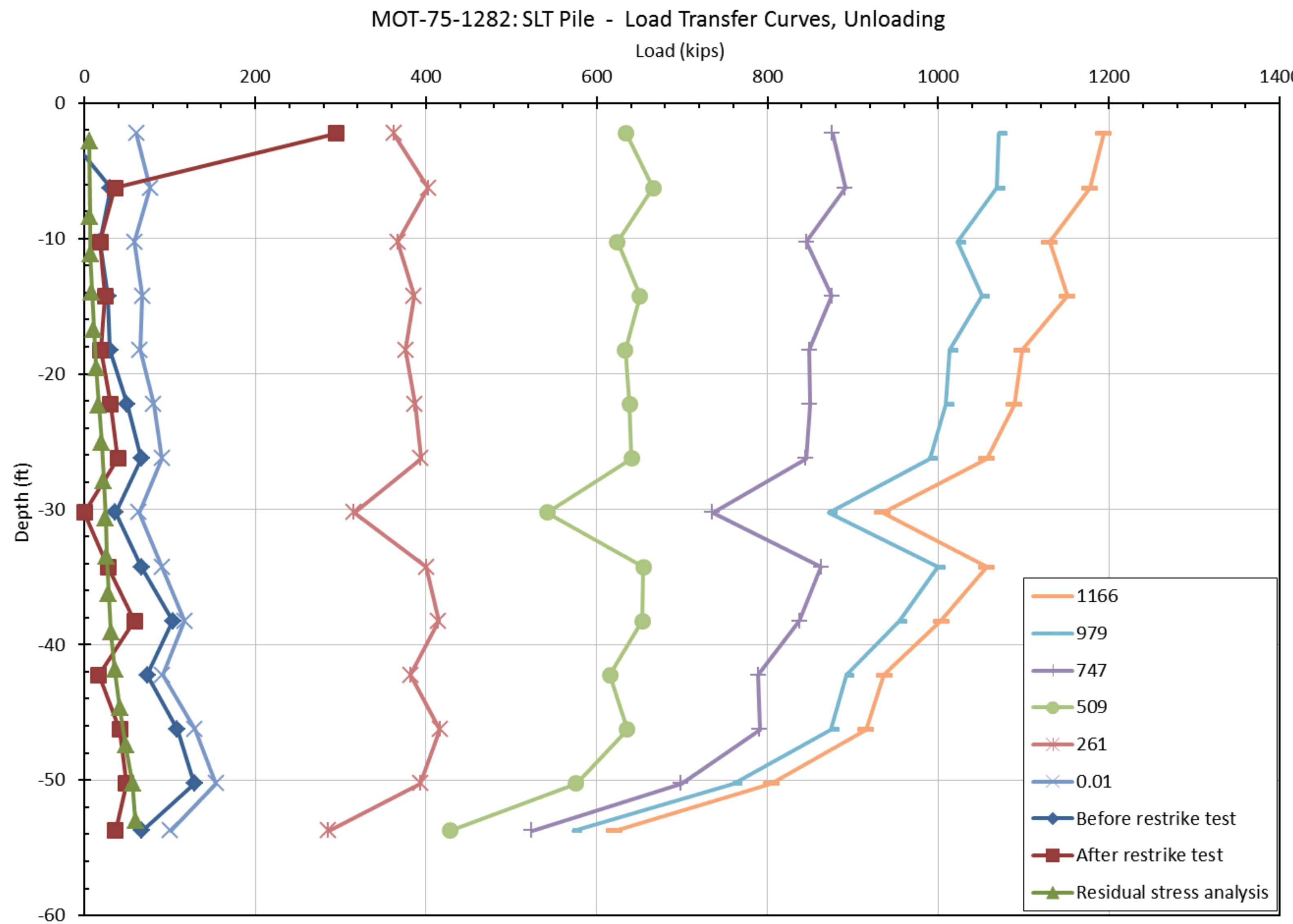

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GROVE


kokosing


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Thank you
Questions?

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