Test Report Number: R25-07-01-S1

Test Request Number: R25-07-01

Test Report Date: July 23, 2025

Sample Description:	GroutForce™ RS4500.337 Screw Displacement Pile C1073732 – Lead, RS4500.337 x 8.63 OD, 16 x 5FT C1073733 – Extension, RS4500.337 x 8.63 OD, 16 x 5FT C1072468NGCU – Extension, RS4500.337, 7FT C1073743 – Washer, Displacement, RS4500.337 x 8.63 OD GroutForce™ SS225 Screw Displacement Pile C1073734 – Lead, SS225 x 8.63 OD, 16 x 5FT C1073735 – Extension, SS225 x 8.63 OD, 16 x 5FT C1140245 – Extension, SS225, 6.5FT C1073745 – Washer, Displacement, SS225 x 8.63 OD GroutForce™ RS6625.280 Screw Displacement Pile C1073738 – Lead, RS6625.280 x 12.75 OD, 20 x 5FT C1073739 – Extension, RS6625.280 x 12.75 OD, 20 x 5FT C1073741 – Extension, RS6625.280, 7FT
Applicable Standards:	ASTM D3689 – Standard Test Methods for Deep Foundations Under Static Axial Tensile Load ASTM D1143 – Standard Test Methods for Deep Foundation Elements Under Static Axial Compressive Loads
Purpose of Test:	Determine the installation efficiency and frictional bond values of GroutForce Displacement piles in both cohesive and non-cohesive soils.
Tested for:	Hubbell 210 North Allen Street Centralia, MO 65240
Tested by:	Jason Herron, Staff Engineer Ben Jennings, Application engineer Mitch Westhues, Product Engineer
Report Written by:	Jason Herron, Staff Engineer Ben Jennings, Application Engineer
Report Approved by:	Gary L. Seider, Director of Engineering

1. Abstract

Compression and tension tests of GroutForce Screw Displacement Piles were conducted in 2023, 2024, and 2025 at sites in Centralia, MO and Lakeville, MN to determine the adhesion and friction bond values in both cohesive and non-cohesive soils and compared to theoretical pile resistance. Pile types consisted of both 8.63-inch diameter and 12.75-inch diameter grout columns formed by the displacement casings. The RS4500.337 GroutForce pile has a 4-inch nominal, 0.337 wall HSS structural tubing as the central steel shaft. The SS225 GroutForce Pile has a 2-1/4-inch Round Cornered Square steel bar as the central shaft. Both the RS4500.337 and SS225 GroutForce piles use 8.63-inch displacement casings, centralizer plates, and two 16-inch diameter helical plates to create the 8.63-inch diameter grout column. The RS6625.280 GroutForce pile uses a 6-inch nominal, 0.280 wall HSS structural pipe as the central steel shaft and 12.75-inch displacement casings, centralizing couplings, and two 20-inch diameter helical plates to create the 12.75-inch diameter grout column. At the Centralia, MO site, five 8.63-inch diameter displacement piles and one 12.75-inch diameter displacement pile were tested at varying installation depths and install torques. The Centralia, MO site consists of medium stiff to stiff clays and a sand "pit" consisting of loose to medium-dense sand that extends to a depth of 7 feet below grade. At the Lakeville, MN site, two 8.63-inch diameter displacement piles were installed to 12 feet and 16.5 feet embedment when maximum install torque was achieved, followed by compression tests. The Lakeville, MN site consists of medium dense to dense granular material.

2. Approval Signature

The enclosed Test Report has been reviewed by:

Gary L. Seider, Director of Engineering
Hubbell Power Systems, Inc.

- Test data presented is within ±3% unless otherwise specified.
- Sample identification was provided by the Customer identified in this report.
- This report applies only to the item(s) tested, as representatives of current product design.
- All instruments and recording devices used in this testing program are within a valid calibration period.
- All samples were new and in excellent condition when tested, except as otherwise noted in the sample description.

3. Equipment List

- 1989 Altec Digger Derrek Truck
- 2023 Terrex Digger Derrek Truck
- Motionics PileSense Wireless Static Pile Load Test Kit (Data Acquisition System)
- CHANCE® Torque Indicator with Bluetooth display
- Power Team RD1506 Double Acting 150 Ton Cylinder

4. Summary of Test Piles

- RS4500.337 X 8.63 OD
    - C1073732 – Lead, RS4500.337 x 8.63 OD, 16 x 5FT
        - Quantity – 1
    - C1073733 – Extension, RS4500.337 x 8.63 OD, 16 x 5FT
        - Quantity – 1
    - C1072468NGCU – Extension, RS4500.337, 7FT
        - Quantity – Number required to reach embedment depth
    - C1073743 – Washer, Displacement, RS4500.337 x 8.63 OD
        - Quantity – Equal to the number of C1072468NGCU
- SS225 X 8.63 OD
    - C1073734 – Lead, SS225 x 8.63 OD, 16 x 5FT
        - Quantity – 1
    - C1073735 – Extension, SS225 x 8.63 OD, 16 x 5FT
        - Quantity – 1
    - C1140245 – Extension, SS225, 6.5FT
        - Quantity – Number required to reach embedment depth
    - C1073745 – Washer, Displacement, SS225 x 8.63 OD
        - Quantity – Equal to the number of C1140245
- RS6625.280 x 12.75 OD
    - C1073738 – Lead, RS6625.280 x 12.75 OD, 20 x 5FT
        - Quantity – 1
    - C1073739 – Extension, RS6625.280 x 12.75 OD, 20 x 5FT
        - Quantity – 1
    - C1073741 – Extension, RS6625.280, 7FT
        - Quantity – Number required to reach embedment depth

5. Location:

- Centralia, MO

- Clay site testing was completed in the center of the “Clay Field Test” location shown in Figure 1
- Sand site testing was completed in the area labeled “Sand Pit” in Figure 1.

CLAY FIELD AND SAND PIT LOCATIONS

Address: 599 Wilson St, Centralia, MO.

Clay field coordinates: 39.2145, -92.1417

Sand pit coordinates: 39.2144, -92.1447

Figure 1: Centralia, MO Test Location

- General Soil Properties
  - Sand Pit
    - Friction Angle: 30 degrees
    - Unit Weight: 110 pcf
  - Clay Field
    - Cohesion: 1 ksf
    - Unit Weight: 100 pcf
  - See Appendix B for further details.

- Lakeville, MN
  - Sand testing was completed in area labeled “Sand Test Area” in Figure 2.

SAND TEST LOCATION

Address: 23976 Natchez Ave, Lakeville MN

Coordinates: 44.60308, -93.34014

Figure 2: Lakeville, MN Test Location

- General Soil Properties
  - Sand
    - Friction Angle: 30 degrees
    - Unit Weight: 110 pcf
  - See Appendix B for further details.

6. Test Procedure and Method

- Summary of Installation
  - Marked location of pile to install with ground marking paint
  - Installation of GroutForce Displacement Pile
    - Pile Sections
      - (1) Lead Displacement Section
      - (1) Extension Displacement Section
      - Number of plain extensions required for embedment depth
      - Pile finished with pile cap to sufficient to transfer tension or compression load
    - For RS4500.337 and SS225 plain extension sections, an extension displacement plate is added at the coupling of each section.

        - Nominal void or annulus displaced by pile and internal diameter of pipe shaft was fully filled with grout as pile advanced.
        - Use of grout reservoir larger than the helix diameters was required. The reservoir was embedded into the soil 3 to 6 inches to minimize spillage.
        - Grout was transported from mixer via 5-gallon buckets and logged upon pouring on foot-by-foot pile advancement intervals. It was assumed for calculation that the buckets held 4.5 gallons of grout.
        - Torque was monitored on a foot-by-foot of pile advancement.
        - Revolutions were counted on a foot-by-foot of pile advancement.
        - Upon completion, the pile was terminated at grade level with a steel pile cap.
    - Cementitious Cure Time
        - Grout was allowed a minimum of 28 days cure time in Centralia, MO and 14 days in Lakeville, MN
- Summary of Testing
    - Compression Test
        - Tension reaction anchors set at adequate spacing for testing with a capacity equal to a minimum 600 kips.
        - Two spreader beams on each end of the load beam were used to connect the tension reaction anchors.
        - Install calibrated hydraulic load jack and data acquisition system.
        - Use a minimum of 2 displacement measuring devices positioned equal distance from the center of the pile and parallel to each other and the center of the pile.
        - Set measuring devices to zero.
        - Axial Load conducted by loading the helical pile in a stepwise fashion with hold times of 4 minutes. Pile head deflection was recorded at the beginning and end of the 4-minute interval.
        - Test load was applied until the 300 kip max test load of the Centralia load frame was achieved or the pile showed continuous creep.
        - The applied test load was typically removed in a minimum of four approximately equal decrements. Decrements used a hold time of 1 minute.
    - Tension Test
        - The same procedure was used for the tension test with the exception the tension reaction anchors were not needed. Wood dunnage was placed under the beam on either end.
        - Load was applied via a central threadbar through the load beam and hydraulic cylinder.

7. Test Results

The results of the tests can be seen in Tables 1, 2 and 3.

Test Number	Sample Type	Test Location	Soil Type	Helix Diameters (in.)	Overall Length (ft)	Grouted Shaft Dia. (in.)
1	RS4500.337 x 8.63 O.D.	Centralia, MO	Clay	16,16	33	8.63
2	RS4500.337 x 8.63 O.D.	Centralia, MO	Clay	16,16	22	8.63
3	RS4500.337 x 8.63 O.D.	Lakeville, MN	Sand	16,16	16.5	8.63
4	RS4500.337 x 8.63 O.D.	Lakeville, MN	Sand	16,16	12	8.63
5	SS225 x 8.63 O.D.	Centralia, MO	Clay	16,16	20	8.63
6	SS225 x 8.63 O.D.	Centralia, MO	Clay	16,16	32.5	8.63
7	SS225 x 8.63 O.D.	Centralia, MO	Sand	16,16	6	8.63
8	RS6625.280 x 12.75 O.D.	Centralia, MO	Clay	20,20	25	12.75

Table 1: Pile Details

Test Number	Sample Type	Installation Date	Grouted Shaft Length (ft)	Effective Torque (ft-lb)	Grout Efficiency*	Average Installation Rotations Per Foot
1	RS4500.337 x 8.63 O.D.	9/15/2023	31.5	14,800	107%	NA
2	RS4500.337 x 8.63 O.D.	12/14/2023	20.5	10,800	102%	4.00
3	RS4500.337 x 8.63 O.D.	9/24/2024	15	24,200	150%	6.50
4	RS4500.337 x 8.63 O.D.	9/24/2024	10.5	20,100	169%	8.25
5	SS225 x 8.63 O.D.	4/16/2025	18.5	9,600	114%	4.17
6	SS225 x 8.63 O.D.	4/16/2025	31	13,200	110%	4.48
7	SS225 x 8.63 O.D.	4/16/2025	4.5	6,400	175%	4.69
8	RS6625.280 x 12.75 O.D.	9/8/2024	23	22,200	108%	2.68

Table 2: Installation Details

*Grout Efficiency is defined as the measured volume of grout during pile install divided by the theoretical grout required x 100%.

$$\frac{\text{Measured Grout Volume}}{\text{Theoretical Grout Volume}} \text{ X } 100\%$$

Test Number	Sample Type	Test Date	Test Type	Load Max Applied (kips)	Load at <1/2" Deflection (kips)	Frictional Bond <1/2" Deflection (ksf)	Load at PL/AE+0.4 (kips)	Frictional Bond PL/AE+0.4 (ksf)	Load at 1" Deflection (kips)
1	RS4500.337 x 8.63 O.D.	10/23/2023	Compression Clay Centralia, MO	239	218	2.93	239	3.21	NA
2	RS4500.337 x 8.63 O.D.	2/14/2024	Compression Clay Centralia, MO	194	183	3.68	186	3.74	191
3	RS4500.337 x 8.63 O.D.	10/4/2024	Compression Sand Lakeville, MN	338	180	4.83	206	5.53	255
4	RS4500.337 x 8.63 O.D.	10/4/2024	Compression Sand Lakeville, MN	300	142	5.24	145	5.35	197
5	SS225 x 8.63 O.D.	5/5/2025	Compression Clay Centralia, MO	159	140	3.10	147	3.26	156
6	SS225 x 8.63 O.D.	6/24/2025	Compression Clay Centralia, MO	293	220	3.00	270	3.68	270
7	SS225 x 8.63 O.D.	5/5/2025	Tension Sand Pit Centralia, MO	28	28	2.07	NA	NA	NA
8	RS6625.280 x 12.75 O.D.	10/16/2024	Compression Sand Pit Centralia, MO	291	246	2.95	246	2.95	277

Table 3: Test Results

8. Conclusions

The installation and testing of the GroutForce Screw Displacement Piles in this Report was to confirm the rate of installation, grout take efficiency, and mobilized bond values. The RS4500.337 x 8.63 OD and SS225 x 8.63 OD pile types have a helix pitch of 3-inches and thus have a theoretical penetration rate of 4 revolutions per foot. The average rate of penetration for these pile types varied from 4 to 8.25 revolutions per foot. The least efficient installation rates were in the medium dense to dense sand soils at the Lakeville, MN site. This was likely due to gravel and cobbles that were present causing resistance to penetration. Soil types that were more uniform such as the Centralia Clay and Sand pit resulted in greater installation efficiency. The RS6625.280 x 12.75 OD has a helix pitch of 6-inches and has a theoretical rate of penetration of 2 revolutions per foot. The average penetration rate was 2.68 revolutions per foot.

The grout take efficiency is the percentage of actual installed grout volume divided by the theoretical grout volume x 100. Theoretical grout volume was assumed to be the area of nominal pile diameter of 8.63-inch or 12.75-inch casing times the grout column depth minus the volume of steel in the central shaft. The grout column depth is equal to the embedment depth minus the length of the first casing displacement assembly of the lead section. The length of the first casing section on the first displacement assembly was 1.5 feet for RS4500.337 x 8.63 OD and SS225 x 8.63 OD pile types, and 2 feet for RS6625.280 x 12.75 OD pile type. The grout efficiency for all soil types exceeded 100%, meaning the actual grout volume exceeded the theoretical. In clay the grout take efficiency varied from 102% to 114%. In sand the grout take efficiency was higher and varied from 150% to 175%. When excavating piles in the clay, it was noted that the soil around the grout column was densified to a diameter equal to the diameter of the helices. In sand, it was noted that there was grout/soil mixing or grout migration out to a width equal to the diameter of the helices.

Bond values generated in clay ranged from 2.95 ksf to 3.68 ksf at 0.5-inch gross displacement and 2.95 ksf to 3.74 ksf at a displacement of elastic pile deformation plus 0.4 inches. These bond values generated for clay are approximately 1.5 to 2 times higher than typical bond values using traditional frictional calculation methods for grouted shafts. The higher bond values are likely attributable in clay to localized densification of the surrounding clay layer caused by the displacement of soil during installation. Bond values generated in sand ranged from 2.07 ksf to 5.24 ksf at 0.5-inch gross displacement and 2.07 ksf to 5.53 ksf at a displacement of elastic pile deformation plus 0.4 inches. Bond values from the sand pit installation in Centralia, MO were lower than Lakeville, MN site. This is likely attributable to the looser and less angular nature of the river dredged sand that fills the pit. These bond values generated for sand are approximately 1.5 to 2 times higher than typical bond values using traditional frictional calculation methods and are likely attributable to densification and grout/soil mixing.

9. Pictures

Photo 1: Installation at Centralia, MO Site

Photo 2: RS4500.337 x 8.63 OD Lead Section and Grout Reservoir

Photo 3: Typical Compression Test Setup

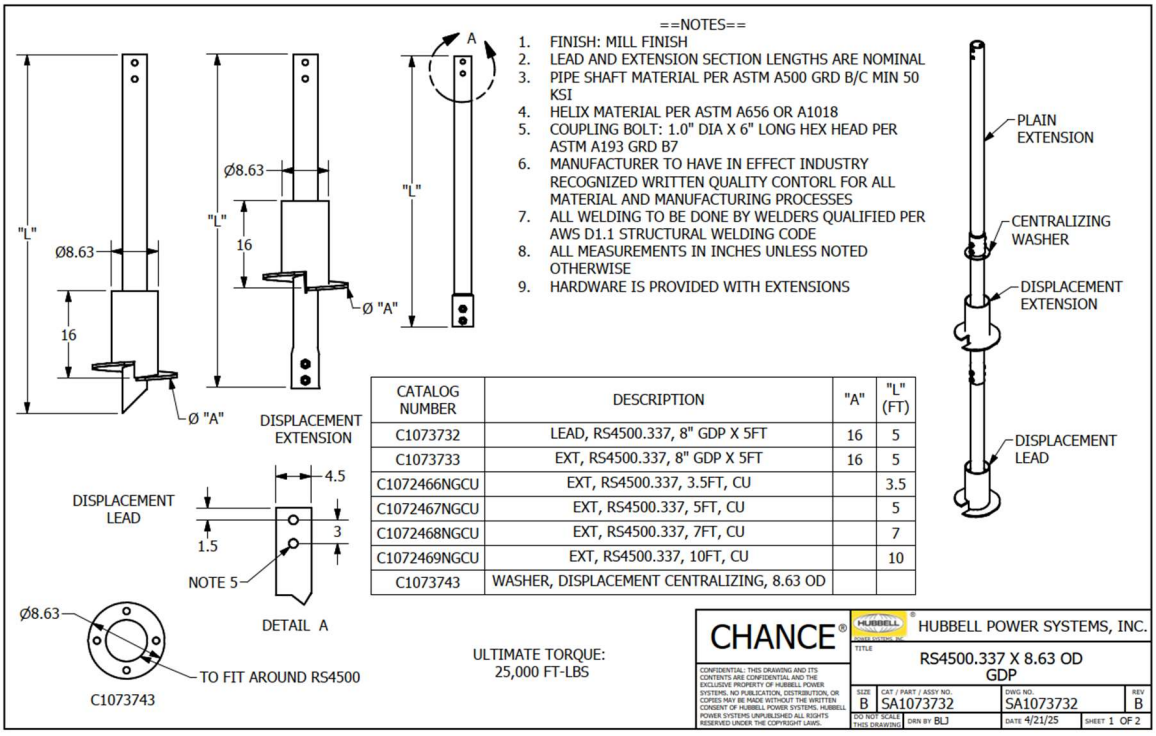
Photo 4: Tension Test Setup

Photo 5: Excavated Tension Test Pile

Photo 6: Excavated RS6625.280 x 12.75 OD Test Pile

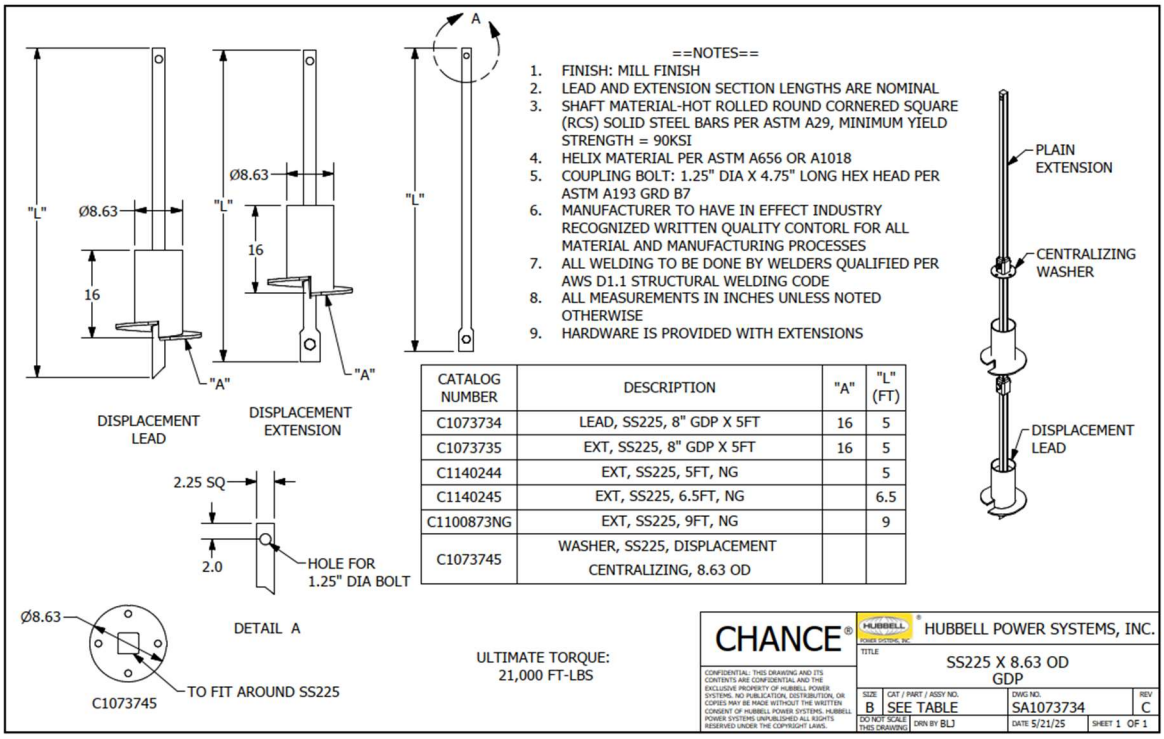
Photo 7: Installation of SS225 x 8.63 OD Test Pile

Appendix A: Sales Drawing for Tested Product



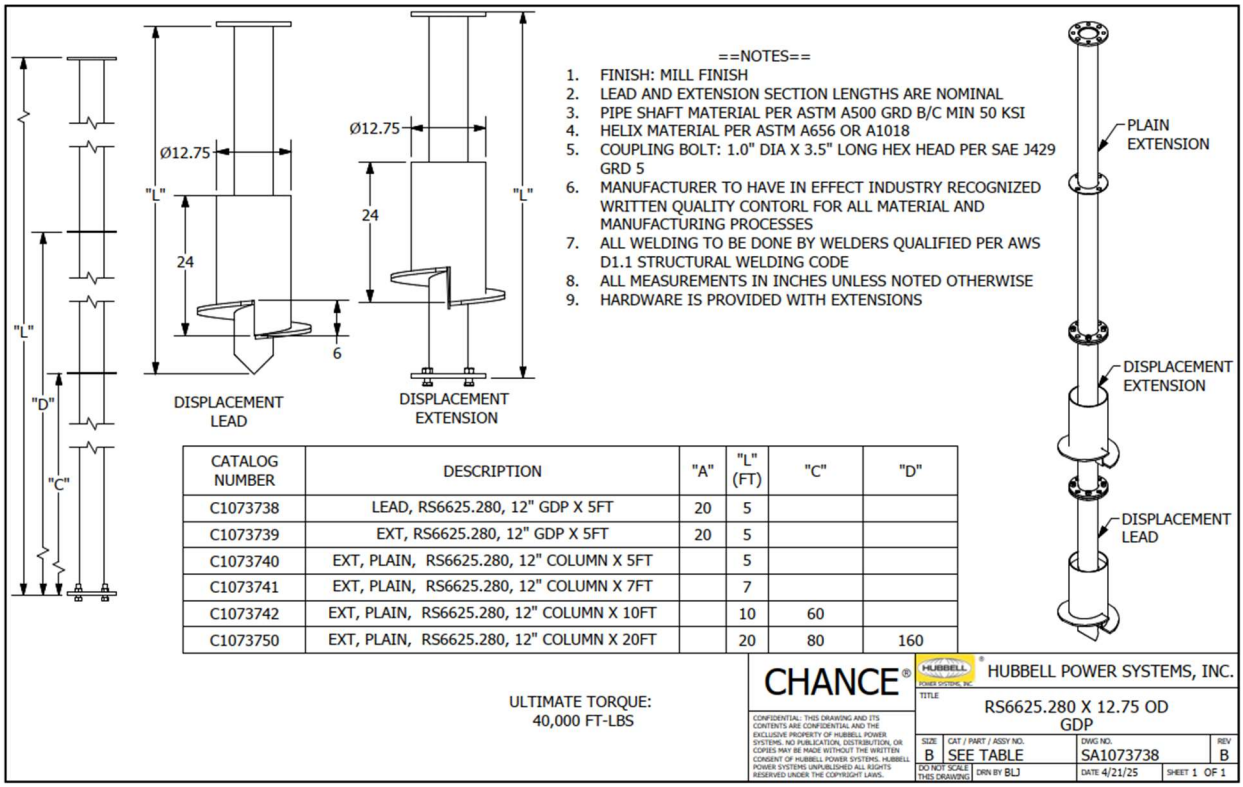
CATALOG NUMBER	DESCRIPTION	"A"	"L" (FT)
C1073732	LEAD, RS4500.337, 8" GDP X 5FT	16	5
C1073733	EXT, RS4500.337, 8" GDP X 5FT	16	5
C1072466NGCU	EXT, RS4500.337, 3.5FT, CU		3.5
C1072467NGCU	EXT, RS4500.337, 5FT, CU		5
C1072468NGCU	EXT, RS4500.337, 7FT, CU		7
C1072469NGCU	EXT, RS4500.337, 10FT, CU		10
C1073743	WASHER, DISPLACEMENT CENTRALIZING, 8.63 OD		

Figure A-1: RS4500.337 X 8.63 OD



CATALOG NUMBER	DESCRIPTION	"A"	"L" (FT)
C1073734	LEAD, SS225, 8" GDP X 5FT	16	5
C1073735	EXT, SS225, 8" GDP X 5FT	16	5
C1140244	EXT, SS225, 5FT, NG		5
C1140245	EXT, SS225, 6.5FT, NG		6.5
C1100873NG	EXT, SS225, 9FT, NG		9
C1073745	WASHER, SS225, DISPLACEMENT CENTRALIZING, 8.63 OD		

Figure A-2: SS225 X 8.63 OD



CATALOG NUMBER	DESCRIPTION	"A"	"L" (FT)	"C"	"D"
C1073738	LEAD, RS6625.280, 12" GDP X 5FT	20	5		
C1073739	EXT, RS6625.280, 12" GDP X 5FT	20	5		
C1073740	EXT, PLAIN, RS6625.280, 12" COLUMN X 5FT		5		
C1073741	EXT, PLAIN, RS6625.280, 12" COLUMN X 7FT		7		
C1073742	EXT, PLAIN, RS6625.280, 12" COLUMN X 10FT		10	60	
C1073750	EXT, PLAIN, RS6625.280, 12" COLUMN X 20FT		20	80	160

Figure A-3: RS6625 X 12.75 OD

Appendix B: Soil Details

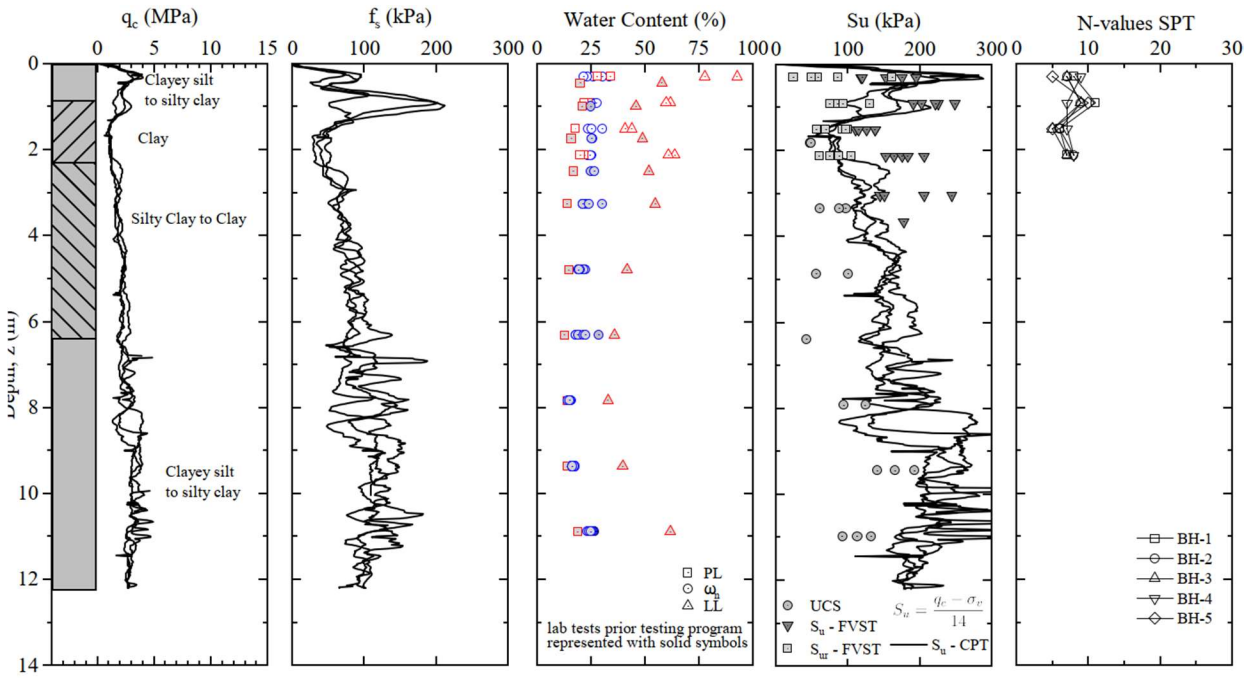


Figure B-1: CPT for Centralia, MO Clay Soils

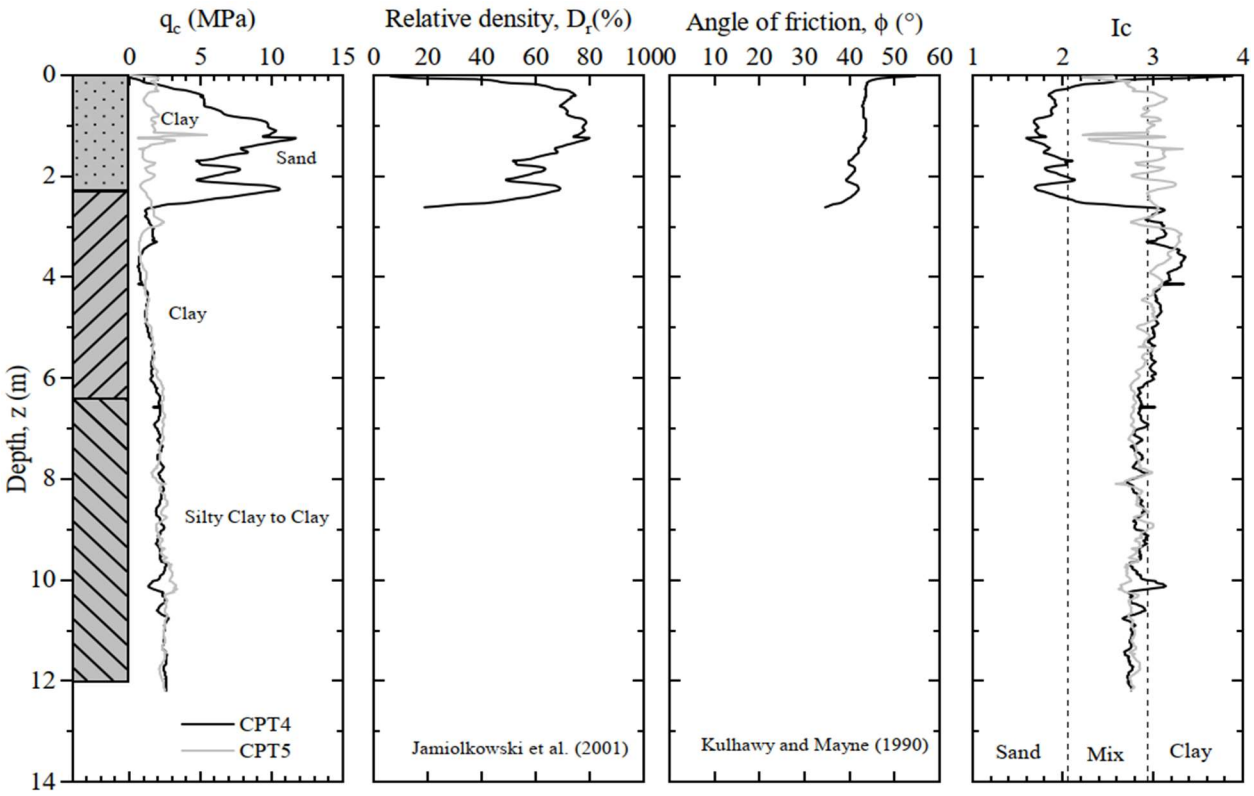


Figure B-2: CPT for Centralia, MO Sand Pit

GeoServices

Project: 24ODP003 - Lakeville, Minnesota

LOG OF BORING: B-1
SHEET 1 OF 2
DRILLER: M.K.
TECHNICIAN: A.K.
DRY ON COMPLETION: Yes

LOCATION: 23976 Natchez Avenue MOVED N/A
DATE: September 30, 2024 SURFACE ELEV: FT.
REFUSAL: No DEPTH: FT. REFUSAL ELEV: FT.
SAMPLED TO: 36.0 FT. SAMPLED ELEV: 0.0 FT.

BORING TIME: 9:02 AM

BOTTOM OF HOLE DEPTH 34.5 FT. HOLE ELEV. -34.5 FT.
BORING ADVANCED BY: POWER AUGERING X

WATER LEVEL DATA (IF APPLICABLE)
DURING DRILLING: DEPTH 12.0 FT.
ELEV. FT.
AFTER DRILLING: DEPTH 10.0 FT.
ELEV. FT.
CAVE-IN: DEPTH 10.0 FT.

STRATUM DEPTH FT.	STRATUM DEPTH ELEV.	SAMPLE DEPTH FROM FT.	SAMPLE DEPTH TO FT.	SAMPLE NUMBER	SAMPLE TYPE	FIELD RESULTS Rec"	FIELD RESULTS N-Value	STRATUM DESCRIPTION
0.0	0.0	0.0	1.5	1	Grab	18	X	18" Silty Sand with little Gravel, brown, dry (No topsoil)
2.5	-2.5	2.0	3.5	2	SPT	8	8	FILL, Clayey Sand, trace gravel, brown, moist Poorly Graded Sand, brown, moist
5.0	-5.0	4.5	6.0	3	SPT	9	10	FILL, Poorly Graded Sand with Clay, brown, moist
7.5	-7.5	7.0	8.5	4	SPT	7	10	FILL, Poorly Graded Sand with pieces of Clay, iron oxide staining, brown, moist
10.0	-10.0	9.5	11.0	5	SPT	11	11	(SP) POORLY GRADED SAND WITH TRACE GRAVEL, fine to medium grained, brown, wet, medium dense.
12.5	-12.5	12	13.5	6	SPT	11	12	(SP) POORLY GRADED SAND WITH TRACE GRAVEL, fine to medium grained, brown, wet, medium dense.
15.0	-15.0	14.5	16.0	7	SPT	14	13	(SP) POORLY GRADED SAND WITH TRACE GRAVEL, fine to medium grained, brown, wet, medium dense.
19.5	-19.5	19.5	21.0	8	SPT	7	16	(SP) POORLY GRADED SAND WITH TRACE GRAVEL, fine to medium grained, brown, wet, medium dense.
24.5	-24.5	24.5	26.0	9	SPT	14	19	(CL) SANDY LEAN CLAY, gray, moist, hard
29.5	-29.5	29.5	31.0	10	SPT	13	17	(CL) SANDY LEAN CLAY, gray, moist, hard

REMARKS:

Figure B-3: Lakeville, MN Soil Boring (Continued on Next Page)

GeoServices

Project: 24ODP003 - Lakeville, Minnesota

LOG OF BORING: B-1
SHEET 2 OF 2

DRILLER: M.K.
TECHNICIAN: A.K.
DRY ON COMPLETION: Yes

LOCATION: 23976 Natchez Avenue MOVED N/A
DATE: September 30, 2024 SURFACE ELEV: ____ FT.
REFUSAL: No DEPTH: ____ FT. REFUSAL ELEV: ____ FT.
SAMPLED TO: 36.0 FT. SAMPLED ELEV: 0.0 FT.

BORING TIME: 9:02 AM

BOTTOM OF HOLE DEPTH 34.5 FT. HOLE ELEV. -34.5 FT.
BORING ADVANCED BY: POWER AUGERING X

WATER LEVEL DATA (IF APPLICABLE)
DURING DRILLING: DEPTH 12.0 FT.
ELEV. ____ FT.
AFTER DRILLING: DEPTH 10.0 FT.
ELEV. ____ FT.
CAVE-IN: DEPTH 10.0 FT.

STRATUM DEPTH FT.	STRATUM DEPTH ELEV.	SAMPLE DEPTH FROM FT.	SAMPLE DEPTH TO FT.	SAMPLE NUMBER	SAMPLE TYPE	FIELD RESULTS Rec"	FIELD RESULTS N-Value	STRATUM DESCRIPTION
34.5	-34.5	34.5	36.0	11	SPT	13	18	(CL) SANDY LEAN CLAY WITH TRACE GRAVEL, gray, moist, hard
24.5	-24.5	39.5	41.0	12	SPT			
44.5	-44.5	44.5	46.0	13	SPT			
49.5	-49.5	49.5	51.0	14	SPT			
54.5	-54.5	54.5	56.0	15	SPT			
59.5	-59.5	59.5	61.0	16	SPT			

REMARKS:

Figure B-3 Continued: Lakeville, MN Soil Boring

Appendix C: Load vs. Deflection Plots

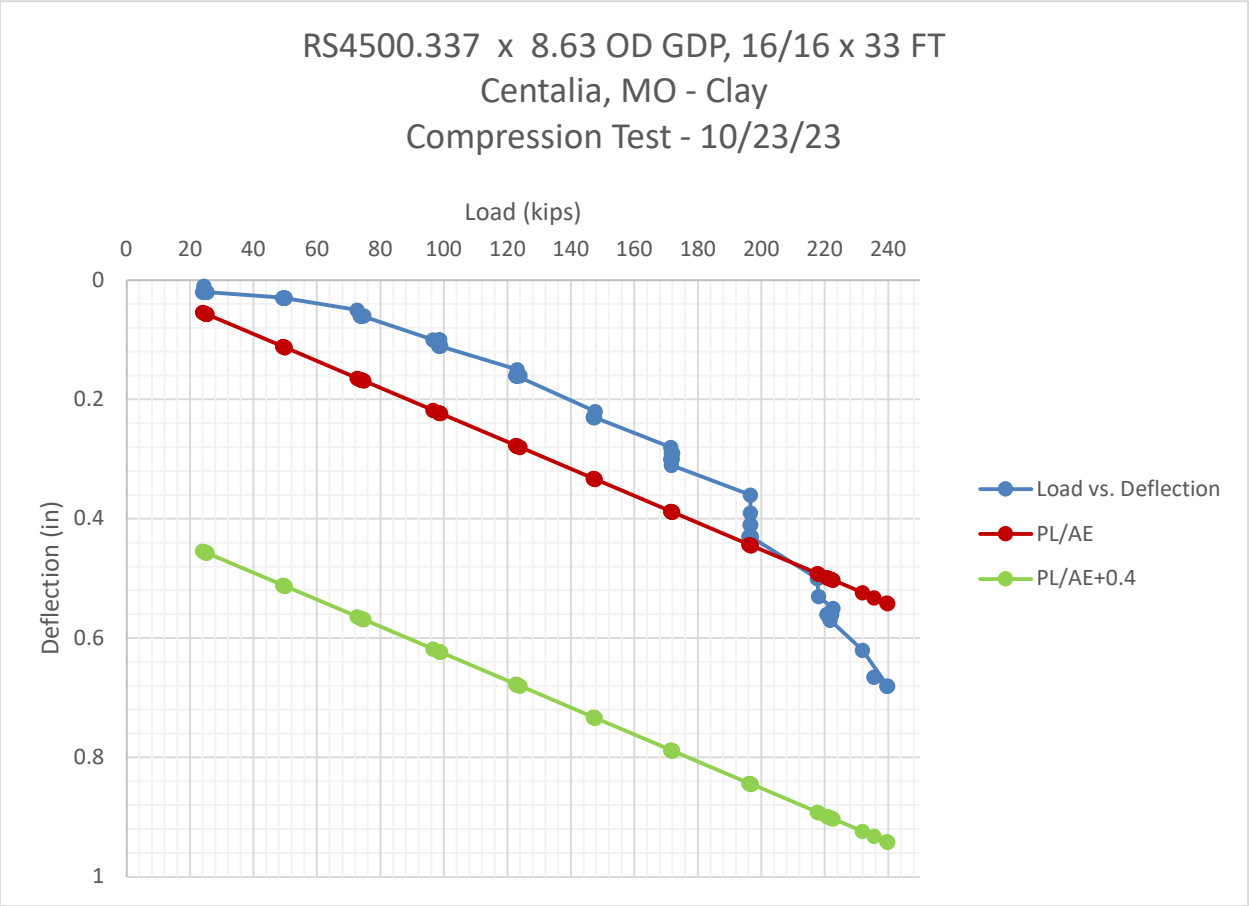


Figure C-1: Test Number 1

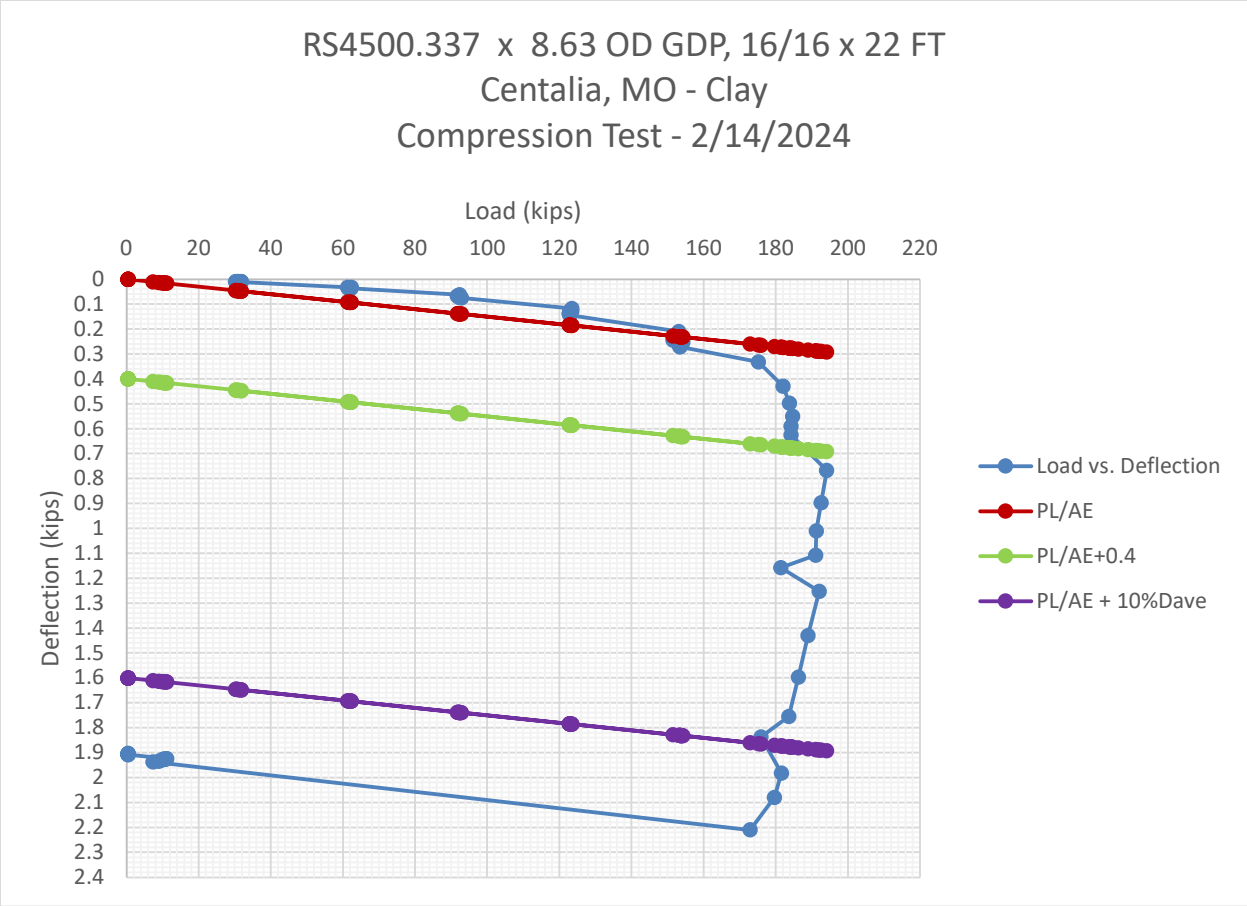


Figure C-2: Test Number 2

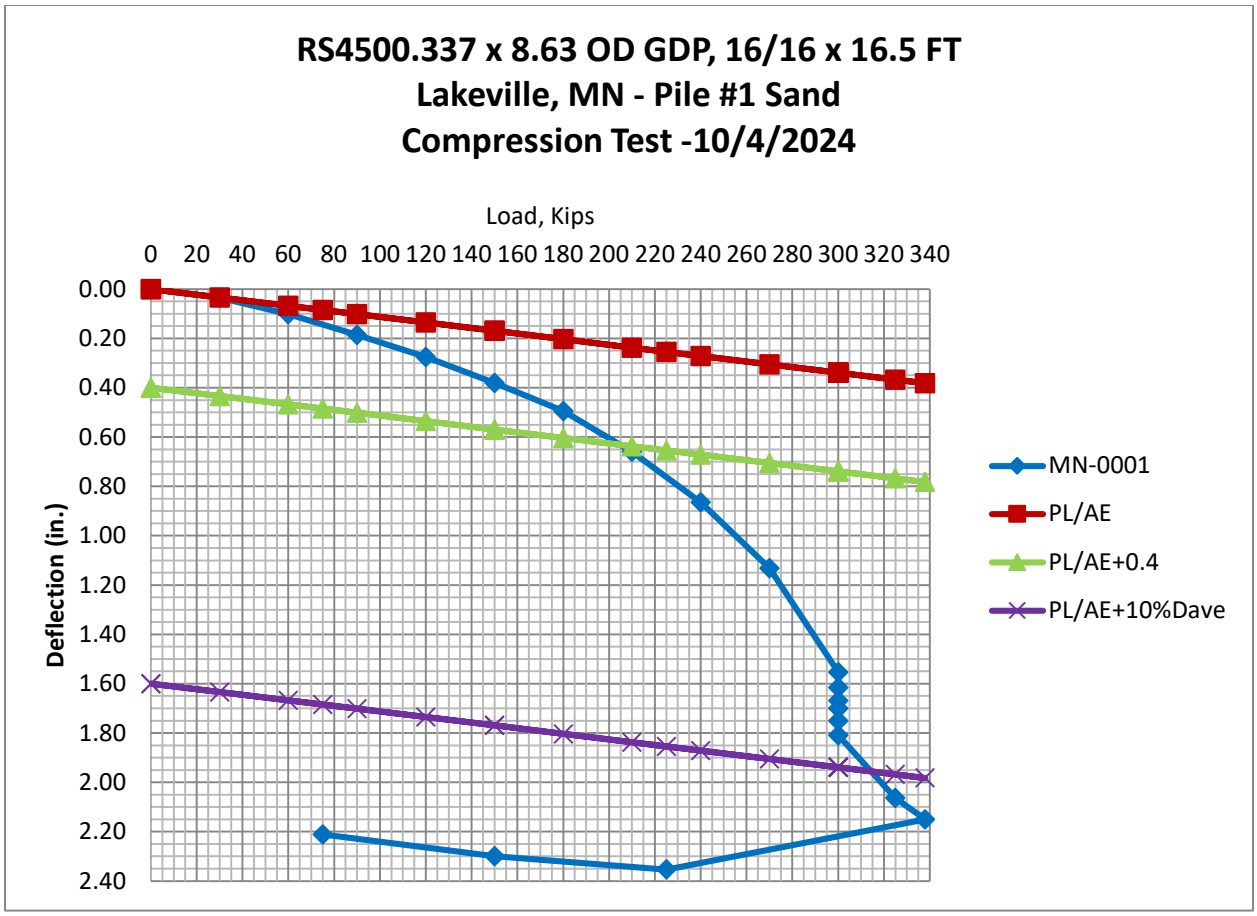


Figure C-3: Test Number 3

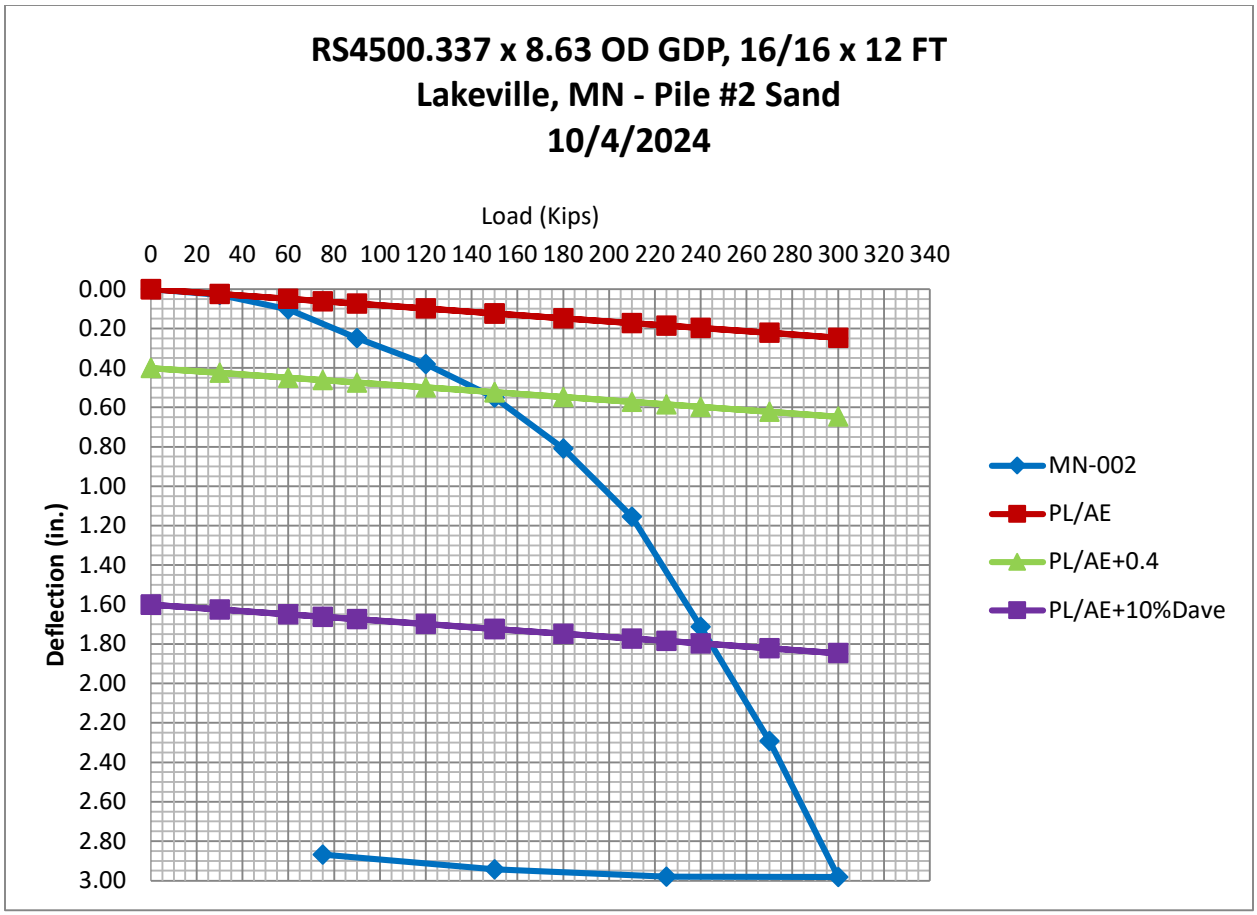


Figure C-4: Test Number 4

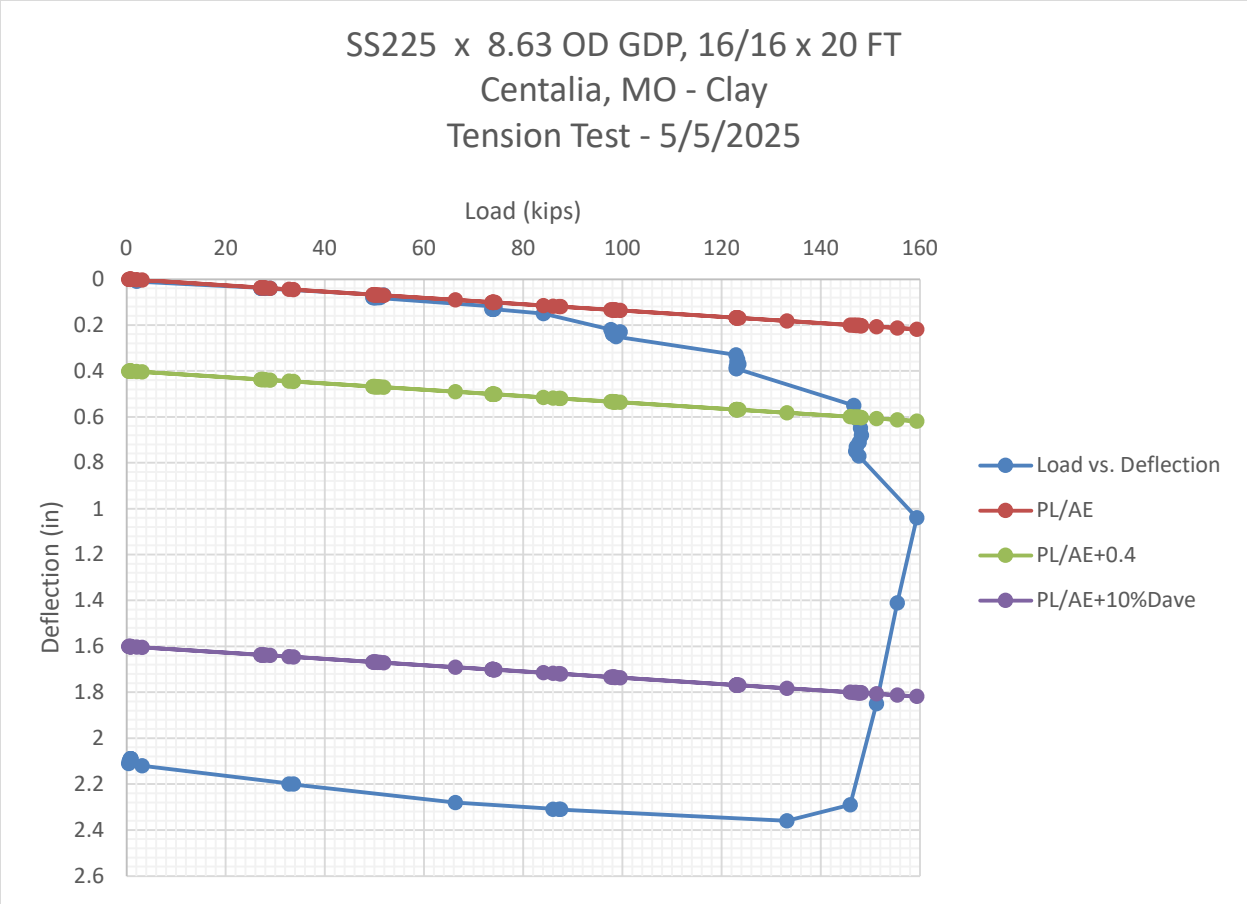


Figure C-5: Test Number 5

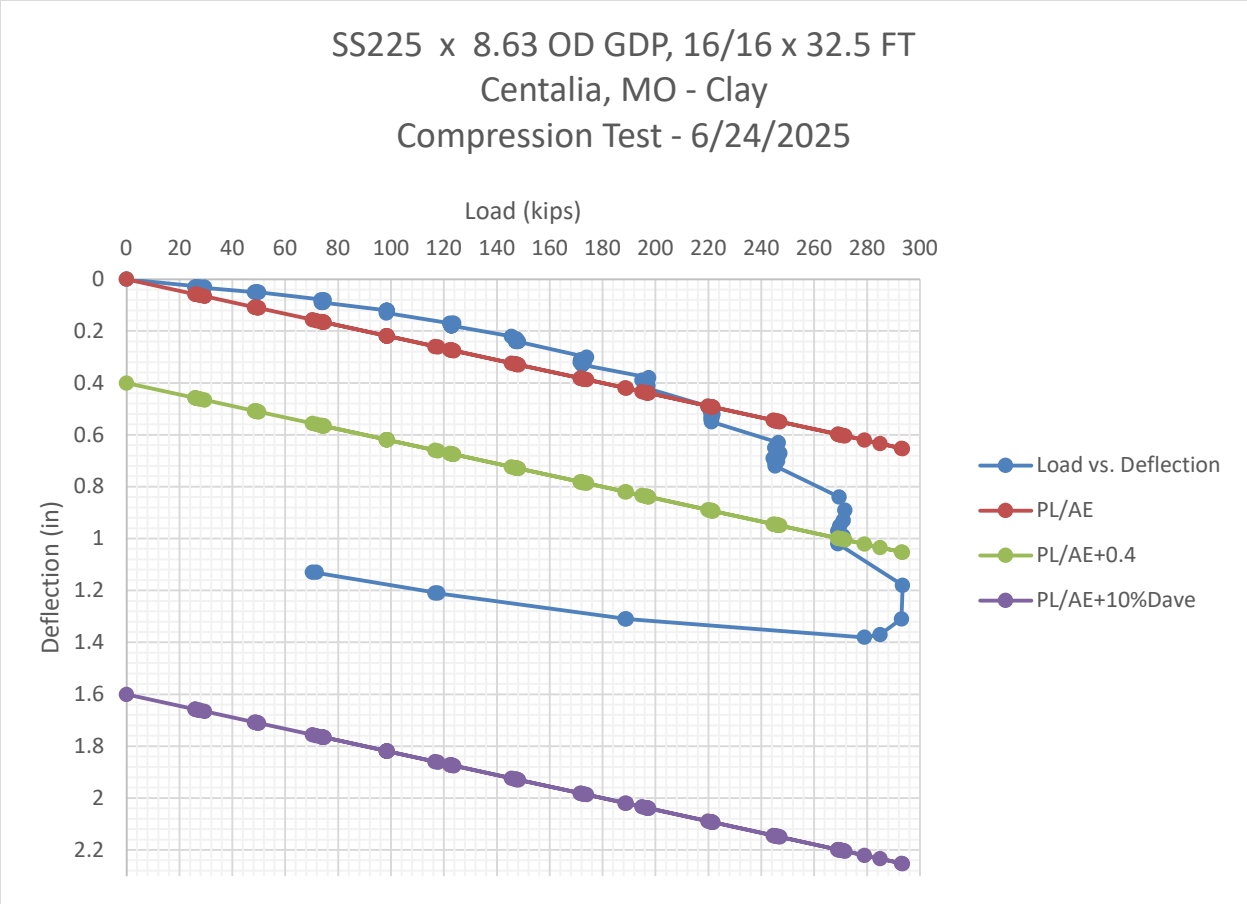


Figure C-6: Test Number 6

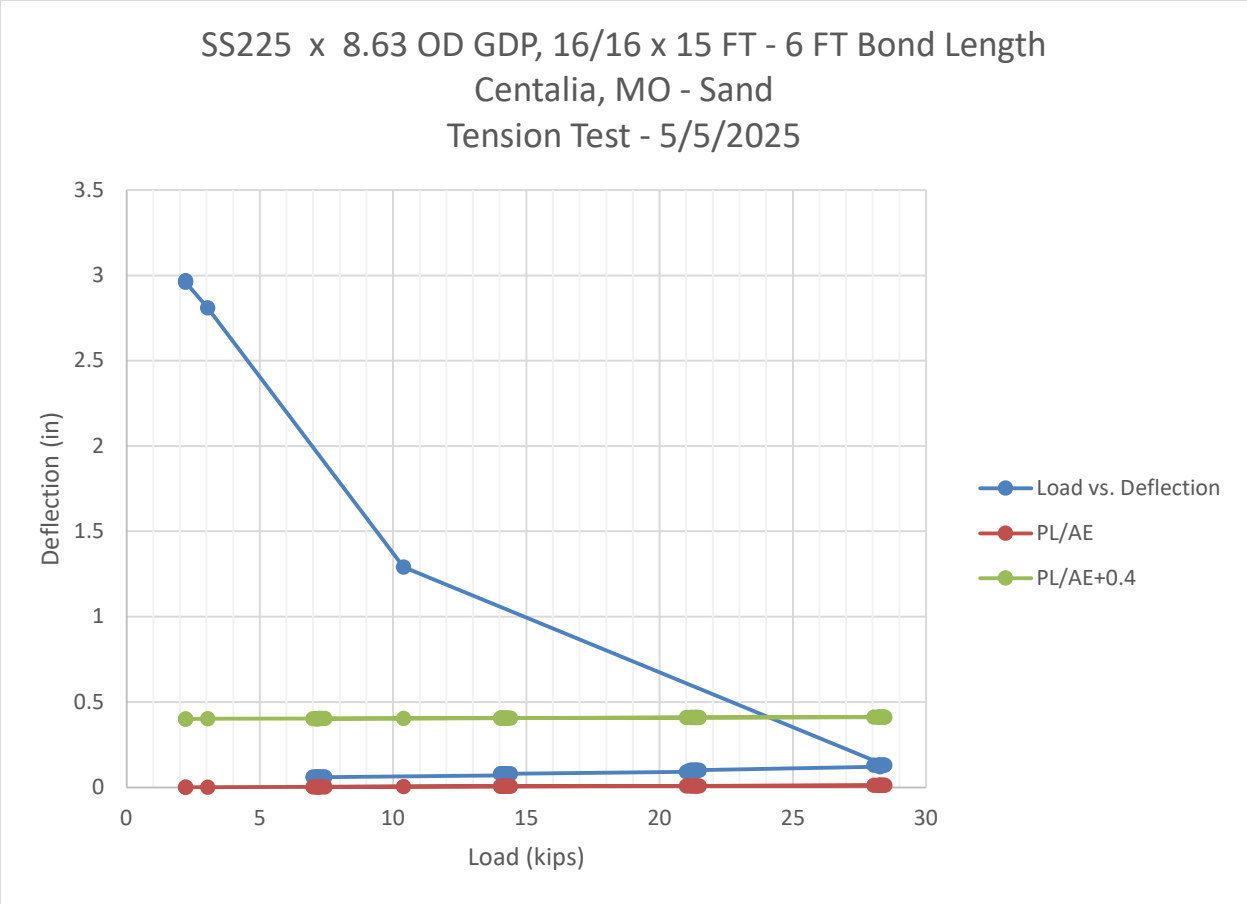


Figure C-7: Test Number 7

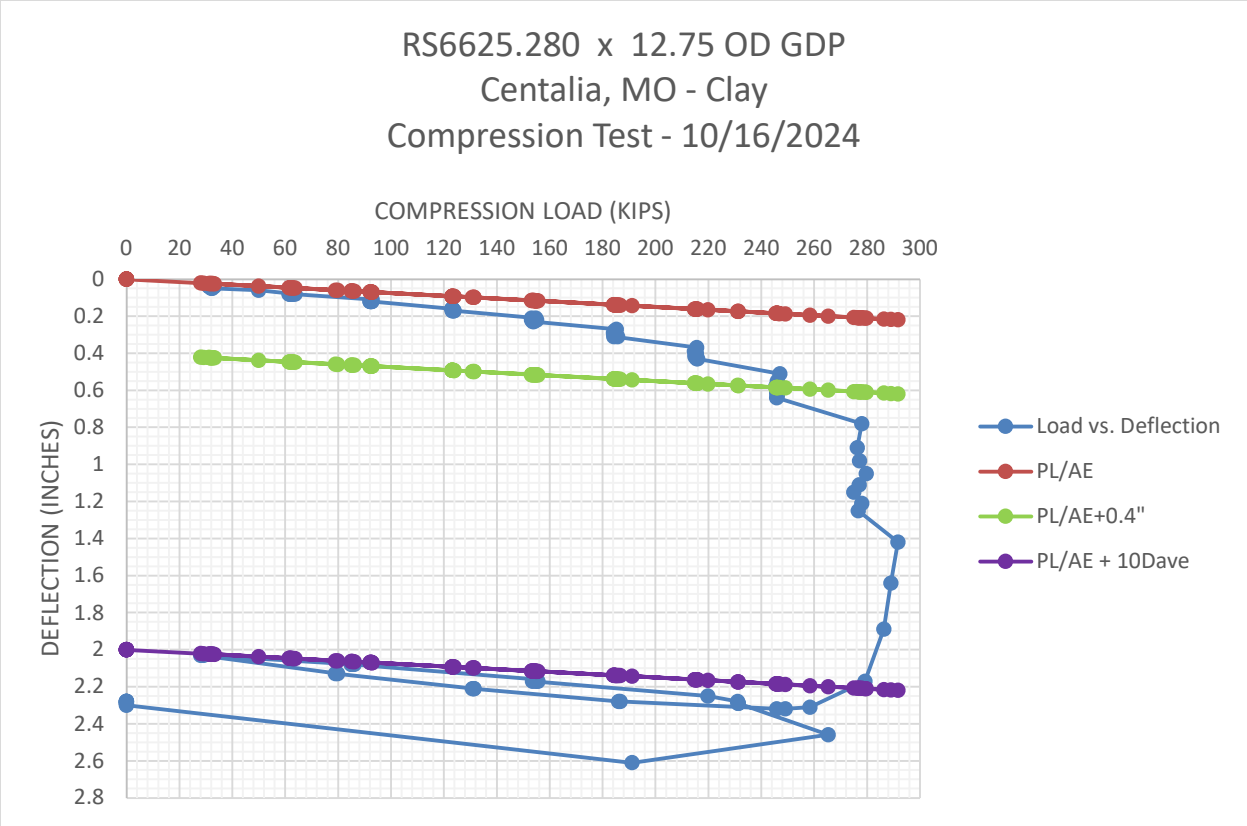


Figure C-8: Test Number 8