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FINAL GEOTECHNICAL DESIGN REPORT

U.S. ROUTE 1 VIADUCT BRIDGE REHABILITATION
MAINEDOT WIN 19273.00
BATH, MAINE

by Haley & Aldrich, Inc.
Portland, Maine

for Maine Department of Transportation
Augusta, Maine

File No. 40725-010
January 2016

Haley & Aldrich, Inc.
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24 January 2016
File No. 40725-010

Maine Department of Transportation
16 State House Station
Augusta, Maine 04333-0016

Attention: Ms. Laura Krusinski, P.E.
Senior Geotechnical Engineer

Subject: Final Geotechnical Design Report
U.S. Route 1 Viaduct Bridge Rehabilitation
MaineDOT WIN 19273.00
Bath, Maine

Ladies and Gentlemen:

We are pleased to submit herewith our report entitled, "Final Geotechnical Design Report, U.S. Route 1 Viaduct Bridge Rehabilitation, MaineDOT WIN 19273.00, Bath, Maine," prepared in accordance with our proposal, dated 30 July 2015 and executed by you on 8 August 2015 and with the provisions of our General Consultant Agreement (GCA) with the Maine Department of Transportation (MaineDOT), No. CT20110614000000006492.

This Final Geotechnical Design Report (GDR) presents the results of final design phase subsurface explorations, geotechnical evaluations and also provides geotechnical design recommendations that were completed and developed by Haley & Aldrich, Inc. (Haley & Aldrich) in support of Vanasse Hangen Brustlin, Inc.'s (VHBs) development and submission of the 100 percent plans, specifications and engineer's estimate (PSE) package to MaineDOT.

Please recall that Haley & Aldrich previously completed subsurface investigation and laboratory testing programs and geotechnical evaluations, which were summarized in our Preliminary and Supplemental Geotechnical Design Reports, dated 17 September 2013 and 5 September 2014, respectively.

Elevation Datum

Elevations referenced herein are in feet and reference the North American Vertical Datum of 1988 (NAVD 88).

Background

The existing viaduct bridge carries U.S. Route 1 traffic eastbound and westbound and serves as the west approach to the Sagadahoc Bridge over the Kennebec River in Bath, Maine as shown in Figure 1, Project Locus. The structure was originally constructed in 1957 and consists of an approximate 1,300-ft long, 34-ft wide (two travel lanes, one in each direction), 20-span structure supported on two abutments and 19 piers. Span lengths vary between approximately 60 and 76 ft. The foundation support type for the abutments and piers is variable and consists of one of the following:

- Cast-in-place (CIP) concrete spread footings bearing on bedrock (i.e., Abutment 1, Piers 1, 2, 4, 8, 9 and 13)
- CIP concrete spread footings constructed on seal concrete, bearing on bedrock (i.e., Piers 3 and 14)
- HP10x42 steel H-piles (i.e., Piers 5-7, 10-12, 15-19 and Abutment 2)

The viaduct bridge has been repaired/rehabilitated several times since its original construction in the late 1950s. The most recent rehabilitation occurred in 2006 and consisted of repairs to the concrete deck. In general, the structure has deteriorated over time due to continued and on-going leakage of expansion joints on diaphragms, bearings and beam seats.

As a result, several repair and replacement alternatives for the deteriorating viaduct bridge deck, superstructure and substructures were considered during the feasibility study stage of the project. It was determined that replacement of the superstructure and completing repairs or rehabilitating the pier caps/columns and substructures, if necessary, was the approach preferred by MaineDOT. Based on our recent discussions with VHB, we understand that the feasibility of alternative superstructure types and number of bridge deck segments to those investigated during the feasibility study stage of the project has been evaluated.

It is our understanding that MaineDOT plans to deliver the project using a modified version of the Construction Manager/General Contractor (CM/GC) methodology. The modified CM/GC delivery method involves the short-listing (pre-qualification) of multiple Contractors who will provide input to MaineDOT, VHB and Haley & Aldrich to consider during the final design and contract document preparation phase (Phase II) of the project.

Subsurface Exploration Programs

Multiple subsurface exploration programs have been completed to support the original design and construction of the existing viaduct bridge as well as the subject project. Preliminary and supplemental subsurface investigations, consisting of rod soundings and test borings, were completed in late 1956 and early 1957 by others (presumably MaineDOT) as part of the design and construction of the existing viaduct bridge. In addition, preliminary (March 2013), supplemental (March and April 2014) and final (September 2015) design phase subsurface exploration programs were completed under the direction of Haley & Aldrich in support of the subject project and generally consisted of test borings, test pits and non-destructive testing.

Please note that only the final design phase subsurface exploration program is discussed herein. Refer to the Preliminary and Supplemental Geotechnical Design Reports, dated 17 September 2013 and 5 September 2014, respectively, prepared by Haley & Aldrich, for additional details on the historic, preliminary and supplemental design phase subsurface exploration programs. The final design phase subsurface exploration program is discussed in the following section of this report.

FINAL DESIGN PHASE SUBSURFACE EXPLORATION PROGRAM

A final design phase subsurface exploration program was developed, coordinated and executed by Haley & Aldrich to provide sufficient subsurface information for use in the evaluation of foundations for three proposed mast arm overhead sign/traffic signals (mast arms) located at the northeast and northwest corners of the intersection of Washington and Commercial Streets.

A total of three test borings, designated BB-BROV-301 through BB-BROV-303, were drilled at or adjacent to each proposed mast arm. The proposed mast arm locations were laid out in the field by MaineDOT and test borings were located as close to the proposed locations as practicable as judged by Haley & Aldrich considering drill rig accessibility, the location of existing utilities and impacts to pedestrian and vehicular traffic prior to the start of drilling.

The test borings were drilled by New England Boring Contractors (NEBC) of Hermon, Maine and were monitored by a Haley & Aldrich engineer on 16 and 17 September 2015 using a truck-mounted Mobile Drill B-52 drill rig. Test borings were advanced to depths ranging from approximately 11 to 21 ft below existing ground surface (BGS) using 3.0 in. (NW-size) outside diameter (OD) steel casing.

Soil samples were generally collected continuously and/or at standard, 5-ft intervals, by driving a 1-3/8-in. ID split-spoon sampler with a 140-lb hammer dropped from a height of 30 in., as indicated on the test boring logs. The number of hammer blows required to advance the sampler through each 6 in. interval was recorded and is provided on the logs. The uncorrected SPT N-value (N-uncorrected) is defined as the total number of blows required to advance the sampler through the middle 12 in. of the 24-in. sampling interval. The drill rig was equipped with a standard rope and cathead and safety hammer per MaineDOT requirements. The energy-corrected SPT N-value (N_{60}) is equal to the uncorrected N-value multiplied by the hammer efficiency factor divided by 0.60 (i.e., 60 percent theoretical hammer efficiency).

Each test boring was advanced approximately 5 to 7 ft into bedrock using a 2.0-in. (NQ-size) ID diamond-tipped core barrel.

All soil and bedrock samples are available for review upon request. The available soil and bedrock samples are currently being stored at the Haley & Aldrich laboratory facility in Portland, Maine.

Generalized Subsurface Conditions

The subsurface conditions encountered in the final design phase test borings generally consisted of man-placed fill soils overlying naturally-deposited marine silt/clay, glacial till and bedrock. A brief description of each soil unit encountered, presented in order of increasing depth below ground surface, is summarized below. Detailed soil and bedrock descriptions are provided on the Haley & Aldrich test boring logs included in Appendix A. The soil descriptions provided on the test boring logs and summarized below do not represent actual field conditions other than at the specific test boring locations. The actual conditions may vary from those described and shown herein and may not become apparent until construction begins.

Please note that the information provided below is limited to the conditions encountered in the 2015 final design phase test borings completed under the direction of Haley & Aldrich. Refer to the Preliminary and Supplemental Geotechnical Design Reports, dated 17 September 2013 and 5 September 2014, respectively, prepared by Haley & Aldrich, for additional details on the subsurface conditions present along portions of the viaduct bridge alignment.

Mast Arm No.	Mast Arm Location (Sta, ft)	Test Boring No.	Generalized Subsurface Conditions
1	Sta 1394+65	BB-BROV-303	Fill (0.0'-5.0') - medium dense to very dense fine to medium SAND Weathered Bedrock (5.0'-5.6') – very dense fine to coarse SAND Bedrock (5.6'-10.6') – moderately hard to very hard, slightly to moderately weathered GNEISS (RQD = 27%)
2	Sta 1394+82	BB-BROV-302	Fill (0.0'-6.8') – medium dense SAND Weathered Bedrock (6.8'-7.1') – no sample obtained Bedrock (7.1'-14.4') – hard to very hard, fresh to slightly weathered GNEISS (79% < RQD < 91%)
3	Sta 1395+40	BB-BROV-301	Fill (0.0'-4.6') – loose, fine to medium SAND and poorly-graded GRAVEL to soft SILT Marine Deposit (4.6—15.7') – medium stiff to hard SILT Glacial Till (15.7'-16.1') – very dense sandy SILT Bedrock (16.1'-21.1') – hard, fresh to slightly weathered GNEISS (RQD not recorded)

Observation wells were not installed in any of the completed boreholes. As a result, long term static water levels at test boring locations were not determined. In general, collected soil samples were visually observed to be "dry" with the exception of the glacial till soils encountered in test boring BB-BROV-301, which were described as "moist". Please note that the visual observations made during drilling may have been affected by drilling means/methods and may not be representative of actual static water levels at the site.

In general, groundwater levels can be expected to fluctuate, subject to test boring drilling means/methods, seasonal variation, local soil conditions, topography and precipitation. Groundwater levels encountered during construction may differ from those observed in the test borings.

Geotechnical Evaluations and Design Recommendations

Geotechnical design recommendations for the subject project, as discussed and provided herein, were developed in accordance with the following documents:

- AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications, Seventh Edition, 2014 with Interim Revisions through 2015, referred to herein as AASHTO LRFD,
- MaineDOT Bridge Design Guide (BDG), August 2003, with Interim Revisions through August 2008, referred to herein as Bridge Design Guide.
- MaineDOT Standard Specifications, November 2014 Edition, referred to herein as Standard Specifications.

The recommendations provided herein are intended to be used to develop the Contract Documents (plans, specifications and special provisions). Where differences exist between information contained in the Preliminary, Supplemental and Final Geotechnical Design Reports and shown in the Contract Documents, the information shown in the Contract Documents shall take precedence.

Engineering calculations that support the recommendations outlined in this report are provided for reference Appendix B.

SEISMIC SITE CLASS AND DESIGN PARAMETERS

It is our understanding, based on email correspondence with you, that seismic site class and the corresponding horizontal response spectral acceleration coefficient at 1.0-second period modified by the site factor for long-period range of acceleration response spectrum (SD_1) will be used by VHB to determine pier column reinforcing requirements. In general, we understand that that more stringent pier column reinforcing is required for SD_1 greater than 0.10. If SD_1 is less than 0.10 then AASHTO LRFD Section 5.10.11.2 does not require the pier column to be modeled as having a plastic hinge, which would require additional reinforcement.

Considering how the seismic site class and associated seismic design parameters impact the pier column reinforcing requirements and due to the variable subsurface conditions that exist along the viaduct bridge alignment, Haley & Aldrich judged that each substructure should be evaluated independently and seismic site class and SD_1 be provided for each substructure.

Site class was determined at each substructure location in accordance with AASHTO LRFD Section 3.10.3.1 using Method B and/or Method C for cohesionless and cohesive soils, respectively, based on the subsurface conditions encountered in historic (1956 and 1957 explorations completed by MaineDOT) and recent (2013 and 2014 explorations completed by Haley & Aldrich) explorations . Seismic site class definitions at individual substructure locations are summarized below.

Substructure Locations	Seismic Site Class
Abutment 1, Pier Nos. 1-6, 8-9, 11 and 13-14	Site Class C
Pier No. 15	Site Class D
Pier Nos. 7, 10, 12, 16-19 and Abutment 2	Site Class E

Spectral accelerations were determined based on the geographic site location and the assignment of "Site Class C" using the United States Geological Survey (USGS) software application Seismic Design Parameters v. 2.0 provided the recommended AASHTO response spectra for a 7 percent probability of exceedance in 75 years (approx. 1,000-year return period). The values are summarized below.

Seismic Site Class	F_v	SD_1
C	1.70	0.07
D	2.40	0.10
E	3.50	0.15

In accordance with AASHTO LRFD Section 3.10.6, each substructure location should be considered to be in Seismic Performance Zone (SPZ) 1 based on the calculated value of SD_1 (≤ 0.15).

Please note that substructures consisting of spread footings bearing on bedrock or by spread footings constructed on seal concrete, bearing on bedrock were assumed to be no worse than Site Class C. Based on our discussions with you, we understand that there is no benefit if a substructure location was classified as Site Class A versus Site Class C since $SD1_1$ in both cases is less than 0.10. In reality, some substructures assigned with a Site Class C designation may actually be Site Class B or Site Class A.

REUSE OF EXISTING STEEL H-PILE SUPPORTED FOUNDATIONS

As discussed in previous sections of this report, Pier Nos. 5 through 7, 10 through 12, 15 through 19 and Abutment 2 are supported on HP10x42 steel H-piles. A preliminary evaluation of their reuse potential in supporting a rehabilitated/replacement superstructure was presented in the 5 September 2014 Supplemental Geotechnical Design Report.

Based on the available information, Haley & Aldrich judged that the existing piles are end bearing in/on bedrock and that subsequent pile evaluations should consider the structural resistance of the pile.

In addition, visual observations and measurements made by Haley & Aldrich on a limited number of piles at a limited number of substructure locations indicated that the observed piles appeared in good condition with no visible signs of corrosion. Although the subsurface soil and groundwater conditions were judged by Haley & Aldrich to be indicative of an environment with low corrosive potential, it is possible that the significant number of piles that were not observed may have experienced some degree of section loss due to corrosion. As a result, considering that the rehabilitated superstructure has a design life of at least 50 years (existing piles will have been in place for more than 100 years), Haley &

Aldrich recommended that the design axial compressive pile resistance of existing steel H-piles and other pile evaluations consider a 1/16-in. reduction in cross-sectional area to account for corrosion.

We understand that VHB has reviewed all the information provided in the Supplemental Geotechnical Design Report, has completed their own independent evaluations and has determined that the existing steel H-piles are suitable for reuse to support the rehabilitated superstructure.

REUSE OF EXISTING SPREAD FOOTING SUPPORTED FOUNDATIONS

As discussed in previous sections of this report, Abutment 1 and Pier Nos. 1 through 4, 8 through 9, 13, and 14 are supported on either CIP concrete spread footings bearing on bedrock or CIP concrete spread footings constructed on seal concrete, bearing on bedrock. We recommend that VHB evaluate their reuse potential considering, but not limited to, the information provided in the following sections of this report.

Bearing Resistance

Service I and Strength I Limit State bearing pressures at Pier 13 and Abutment I retaining walls were calculated by VHB and were provided to Haley & Aldrich on 31 August and 1 September 2015. It is our understanding that Pier 13 is the controlling location due to the largest loads (longest spans and tallest pier column height). Based on the Limit State bearing pressures provided by VHB, Haley & Aldrich judged that the Strength I load combination is controlling and therefore calculated nominal and factored Strength I Limit State bearing resistances for spread footings bearing on bedrock based on the bedrock conditions encountered in the recent (2013 and 2014) test borings and in accordance with the theoretical and semi-empirical procedures presented in AASHTO LRFD Sections 10.6.3.1.2 and 10.6.3.2.2, specifically the procedures outlined by Munfakh, et al. (2001) and Carter & Kulhawy (1988), and the corresponding resistance factors provided in AASHTO LRFD Table 10.5.5.2.2-1 (φ_b=0.45 for bedrock bearing material).

We recommend that VHB compare Strength I Limit State bearing pressures to a factored Strength I Limit State bearing resistances equal to 87 kips per square foot (ksf) to determine if the existing spread footings are adequate for reuse to support the rehabilitated superstructure.

Sliding Resistance

We recommend that sliding resistance be evaluated at the Strength and Extreme Event Limit States in accordance AASHTO LRFD Section 10.6.3.4 and BDG Section 5.3.8 with the resistance factors specified in AASHTO LRFD Table 10.5.5.2.2-1. Sliding resistance between the base of the existing CIP spread footings and bedrock bearing material be evaluated based on the following:

- A coefficient of sliding friction equal to 0.70 (interface friction angle, δ, of 35 degrees) and STR and EE limit state resistance factors equal to 0.8 and 1.0 for bedrock bearing material.

- In accordance with AASHTO LRFD Section 10.6.3.4 and BDG Section 5.3.8, thought should be given to the potential for soil adjacent to the foundations to be removed in the future when considering whether passive lateral earth pressure resistance should be included in the evaluation. If included to resist lateral loads, passive lateral earth pressure, "is commonly taken as 50 percent of the maximum passive resistance," (i.e., resistance factor equal to 0.50) in accordance with AASHTO LRFD and the BDG.

- Available factored sliding resistance in all cases should be equal to or greater than the factored loads.

Eccentricity

We recommend that eccentricity be evaluated in accordance with AASHTO LRFD Section 10.6.3.3 and 10.6.4.2. In general, the calculated eccentricities should be less than the limiting value equal to 0.45 x footing length/width for footings bearing on bedrock.

Settlement

Settlement was previously evaluated during the preliminary design phase, as summarized in the Supplemental Geotechnical Design Report. The results indicated a negligible amount (less than 0.1 in.) of vertical deformation could occur under Service I Limit State loading conditions.

MAST ARM FOUNDATIONS

Haley & Aldrich completed technical evaluations to determine foundation length requirements for three proposed mast arm overhead sign/traffic signals (mast arms) located at the northeast and northwest corners of the intersection of Washington and Commercial Streets. Technical evaluations to determine foundation length consisted of the following:

- Utilization of MaineDOT design charts included in the MaineDOT Standard Details and
- Lateral pile evaluations using LPile v. 2015.8.03

Each evaluation was completed using loading information that was developed by VHB and provided to Haley & Aldrich on 25 September 2015. The substructure loads provided by VHB were developed in accordance with the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals 6th Edition with 2015 Interim Revisions as well as the MaineDOT 2014 Standard Specifications. Unfactored, Group II loads provided by VHB for each proposed 36-in. diameter mast arm foundation are summarized below.

Mast Arm No.	Mast Arm Location (Sta, ft)	Unfactored Group II Loading			
		Axial Compression (kips)	Lateral (kips)	Moment (kip-ft)	Torsion (kip-ft)
1	Sta 1394+65	6	2	46	24
2	Sta 1394+82	6.5	3	60	45
3	Sta 1395+40	6	2	40	19

Lateral analyses of mast arm foundations that were completed to determine minimum foundation lengths considered factored loads and nominal resistances in accordance in accordance with AASHTO LRFD requirements assuming a single drilled shaft-type foundation. Although AASHTO LRFD assigns a resistance factor equal to 1.0 to the lateral geotechnical resistance when conducting lateral foundation evaluations for drilled shafts at the Strength and Extreme Event Limit States, the Federal Highway Administration (FHWA) recommends using a more conservative resistance factor equal to 0.67 in order to ensure geotechnical stability under lateral loading.

As a result, the loading information provided by VHB was multiplied by a load factor equal to 1.25 (AASHTO LRFD Tables 3.4.1-1 and 3.4.1-2) and 1.5 (1/0.67). Factored Group II loads are summarized below.

Mast Arm No.	Mast Arm Location (Sta, ft)	Factored Group II Loading			
		Axial Compression (kips)	Lateral (kips)	Moment (kip-ft)	Torsion (kip-ft)
1	Sta 1394+65	11.2	3.7	85.8	44.8
2	Sta 1394+82	12.1	5.6	111.9	84.0
3	Sta 1395+40	11.2	3.7	74.6	35.4

Technical evaluations completed using the factored loading summarized above are discussed in the following sections of this report.

MaineDOT Design Charts

The November 2014 edition of the MaineDOT Standard Details includes design charts for determining the minimum length of foundations for traffic signals, highway signing and lighting for various foundation diameters (2.5 to 5 ft) based on a range of applied loads (moment and torsion) and soil properties ($28° < \phi < 34°$ for a uniform granular soil profile; 400 psf < Su < 1,200 psf for a uniform cohesive soil profile). It should be noted that the design charts were developed for an assumed uniform soil profile consisting entirely of either granular (friction angle, ϕ) or cohesive (undrained shear strength, Su) soil.

Mast Arm 1 @ Sta 1394+65

Subsurface conditions encountered in test boring BB-BROV-303 generally consist of 5 ft of granular man-placed fill soil overlying bedrock. A range of friction angle values was assumed and minimum foundation lengths were estimated based on the factored loads summarized above. The minimum foundation lengths for Mast Arm 1, estimated from the MaineDOT design charts are summarized below.

Minimum Foundation Length (ft)			
Moment = 86 kip-ft		Torsion = 45 kip-ft	
ϕ = 28°	ϕ = 34°	ϕ = 28°	ϕ = 34°
12	11	14	10

The minimum foundation lengths summarized above, regardless of friction angle value, exceed the depth to bedrock BGS. When bedrock is present at a depth BGS that is less than minimum required foundation length the MaineDOT Standard Details suggest "pinning" the foundation to bedrock using dowel reinforcement, which consists of a series of ¾-in. diameter (No. 6 bars) that are drilled and grouted into bedrock as shown in Standard Detail 626(06).

Mast Arm 2 @ Sta 1394+82

Similar to test boring BB-BROV-303, test boring BB-BROV-302 consists of approximately 7 ft of granular man-placed fill soil overlying bedrock. A range of friction angle values was assumed and minimum foundation lengths were estimated based on the factored loads summarized above. The minimum foundation lengths for Mast Arm 2, estimated from the MaineDOT design charts are summarized below.

Minimum Foundation Length (ft)			
Moment = 112 kip-ft		Torsion = 84 kip-ft	
ϕ = 28°	ϕ = 34°	ϕ = 28°	ϕ = 34°
13	12	20	12

Similar to Mast Arm 1, the minimum foundation lengths for Mast Arm 2 summarized above, regardless of friction angle value, exceed the depth to bedrock BGS. As a result, the MaineDOT Standard Details suggest "pinning" the foundation to bedrock in accordance with Standard Detail 626(06).

Mast Arm 3 @ Sta 1395+40

The soil profile encountered in test boring BB-BROV-301 consists of approximately 4.5 ft of granular man-placed fill overlying approximately 11 ft of marine silt/clay and 0.5 ft of glacial till. Bedrock was encountered at a depth of approximately 16 ft BGS. Since a non-uniform soil profile is present, consisting of granular and cohesive soils overlying bedrock, a range of friction

angles and undrained shear strengths were used to estimate minimum foundation lengths assuming that a uniform soil profile was present.

Minimum Foundation Length (ft)							
Moment = 75 kip-ft				Torsion = 35 kip-ft			
ϕ = 28°	ϕ = 34°	Su = 400 psf	Su = 1,200 psf	ϕ = 28°	ϕ = 34°	Su = 400 psf	Su = 1,200 psf
12	11	16	11	12	10	18	10

Since the soil profile is predominantly cohesive and the undrained shear strength is likely in excess of 1,000 psf based on SPT N60 values greater than 15 bpf the minimum foundation length estimated from the MaineDOT design charts is likely to be 10 to 11 ft. Since bedrock was encountered below this depth, "pinning" the foundation to bedrock to achieve fixity is not required using this design methodology.

Lateral Shaft Evaluations

Lateral foundation analyses were performed using the computer program LPile v. 2015.8.03 (LPile) developed by Ensoft, Inc. LPile is a special purpose program that is capable of analyzing piles or drilled shafts under several types of pile/drilled shaft-head loading conditions using lateral load-transfer curves.

LPile files for each substructure were prepared by Haley & Aldrich, including factored loading data and drilled shaft geometry/properties. The files also included subsurface soil, rock and groundwater conditions based on the conditions encountered in the design phase test borings. Multiple iterations were completed at each mast arm location to determine the minimum shaft length required to resist the applied loads (axial compression, lateral, moment and torsion) and to achieve fixity at the shaft tip.

The program output was evaluated, summarized and discussed with MaineDOT and VHB prior to finalizing this report. The results of the lateral shaft evaluations at each mast arm location are summarized below.

Mast Arm No.	Mast Arm Location (Sta, ft)	Minimum Foundation Length (ft)
1	Sta 1394+65	7.0
2	Sta 1394+82	5.5
3	Sta 1395+40	16.0

Lateral shaft evaluations for mast arm nos. 1 and 2 indicated that "pinning" or socketing the foundations a minimum of 3 ft into bedrock in accordance with Standard Detail 626(06) is required to achieve fixity. Mast arm no. 3 does not require the foundation to be "pinned" or socketed to/into bedrock.

Recommended Foundation Length

Based on the results of the evaluations summarized herein, considering the minimum foundation lengths determined from both the MaineDOT Design Charts and lateral shaft evaluations, we recommend the following:

- Mast Arm No. 1 should have a minimum length equal to 7 ft and be "pinned" to bedrock in accordance with Standard Detail 626(06).
- Mast Arm No. 2 should have a minimum length equal to 5.5 ft and be "pinned" to bedrock in accordance with Standard Detail 626(06).
- Mast Arm No. 3 should have a minimum length equal to 16 ft. Pinning the foundation to bedrock is not required.

Please recall that that each test boring was drilled as close to the proposed mast arm locations as practicable as judged by Haley & Aldrich considering drill rig accessibility, the location of existing utilities and impacts to pedestrian and vehicular traffic prior the start of drilling. As a result and given the erratic nature of the bedrock surface over short distances within the project limits, it is possible that the bedrock surface at the proposed mast arm locations may be higher or lower than that encountered in the test borings. We recommend that language to this affect be included in the Contract Documents and that adjustments to mast arm foundation lengths and modifications to the bedrock "pinning" detail (whether it is needed or not) may be necessary and require re-evaluation during construction.

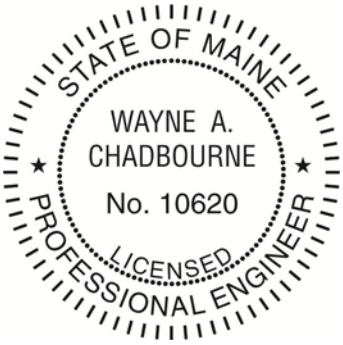
Closure

We appreciate the opportunity to provide geotechnical engineering services on this project. Please do not hesitate to call if you have any questions or comments.

Thank you for the opportunity to help support MaineDOT on this project. We look forward to providing continued assistance to you during subsequent phases of the project. Please contact us if you have any questions or comments on the information provided herein.

Sincerely yours,
HALEY & ALDRICH, INC.

Bryan C. Steinert, P.E.
Project Manager



Wayne A. Chadbourne, P.E.
Vice President

Enclosures:

- Figure 1 – Project Locus
- Figure 2 – Site and Subsurface Exploration Location Plan (1 of 2)
- Figure 3 – Site and Subsurface Exploration Location Plan (2 of 2)
- Figure 4 – Interpretive Subsurface Profile (1 of 2)
- Figure 5 – Interpretive Subsurface Profile (2 of 2)
- Appendix A – Test Boring Logs
- Appendix B - Calculations

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REFERENCES

1. Report entitled, "Supplemental Geotechnical Design Report, Route 1 Viaduct Bridge Rehabilitation, MaineDOT WIN 19273.00, Bath, Maine," prepared by Haley & Aldrich, Inc. for the Maine Department of Transportation, dated 5 September 2014.

2. Report entitled, "Preliminary Geotechnical Design Report, U.S. Route 1 Viaduct Bridge Rehabilitation, MaineDOT WIN 19273.00, Bath, Maine," prepared by Haley & Aldrich, Inc. for the Maine Department of Transportation, dated 17 September 2013.

3. Report entitled, "Supplemental Field and Laboratory Investigation, Bath/Woolwich Bridge, Bath and Woolwich, Maine," prepared by Haley & Aldrich, Inc. for the Maine Department of Transportation, dated 30 May 1997.

4. Report entitled, "Detailed Study in the Vicinity of the Abutment at Station 398+78, Carlton Bridge, Carlton, Maine," prepared by the Maine State Highway Commission, Soils Division, dated 8 May 1957.

5. Report entitled, "Subsurface Investigations For Carlton Bridge and West Approach in Bath, Maine," prepared by the Maine State Highway Commission, Soil Division, dated April 1957.

6. Drawings entitled, "Carlton Bridge Widening and West Approach between Bath and Woolwich, Sagadahoc County, Maine, Federal Aid Project No. U-026-1(8)," prepared by the State of Maine State Highway Commission, dated January 1957, Sheet Nos. 1, 10-14, 33-39 of 148.

MAP SOURCE: ESRI

SITE COORDINATES: 43°54'40"N, 69°49'5"W

HALEY ALDRICH

U.S. ROUTE 1 VIADUCT BRIDGE REHABILITATION
MAINEDOT WIN 19273.00
BATH, MAINE

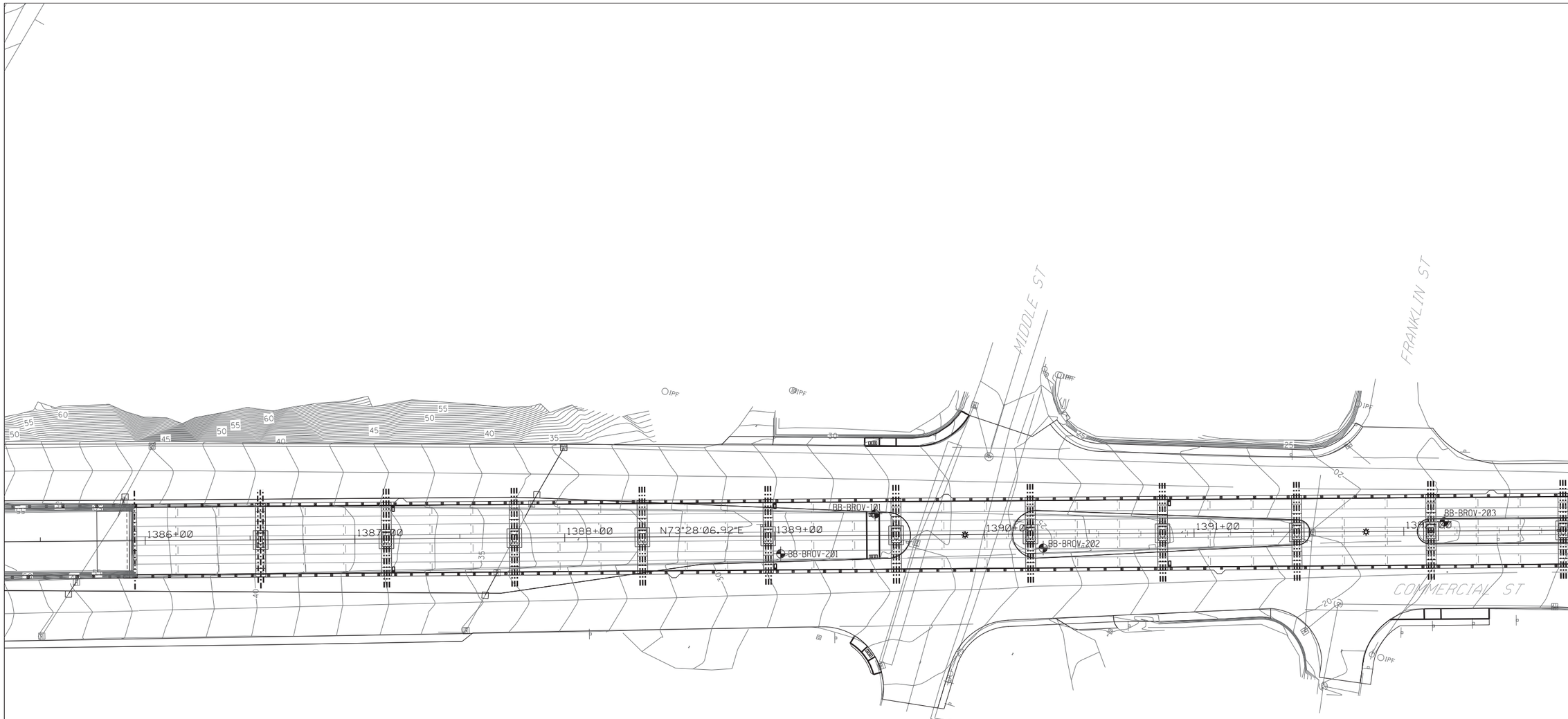
PROJECT LOCUS

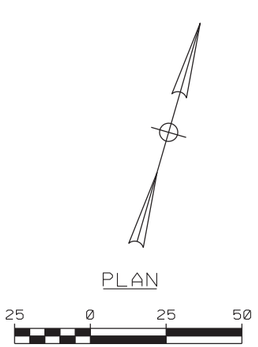
APPROXIMATE SCALE: 1 IN = 2000 FT
DECEMBER 2015

FIGURE 1

40725-010_1_LOCUS.PDF

Filename: $file$ Division: $wkgroup$ Username: $user$ Date:$date$





STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

19273.00

WIN
19273.00

BRIDGE NO. 3838

BRIDGE PLANS

STATE OF MAINE
BRYAN C. STEINERT
No. 12008
LICENSED
PROFESSIONAL ENGINEER

		BY	DATE
PROJ. MANAGER	J. KITTREDGE		
DESIGN-DETAILED	P. KOWALKE	PHK	10/15
CHECKED-REVIEWED	B. STEINERT	BCS	10/15
DESIGN2-DETAILED2	---	---	---
DESIGN3-DETAILED3	---	---	---
REVISIONS 1	---	---	---
REVISIONS 2	---	---	---
REVISIONS 3	---	---	---
REVISIONS 4	---	---	---
FIELD CHANGES	---	---	---

SIGNATURE

12008
P.E. NUMBER

11/30/2015
DATE

WEST APPROACH BRIDGE
MAINE OWNED RR & CITY STREETS
SAGADAHOC COUNTY

BORING LOCATION PLAN

HALEY ALDRICH

U.S. ROUTE 1 VIADUCT BRIDGE REHABILITATION
MAINEDOT WIN 19273.00
BATH, MAINE

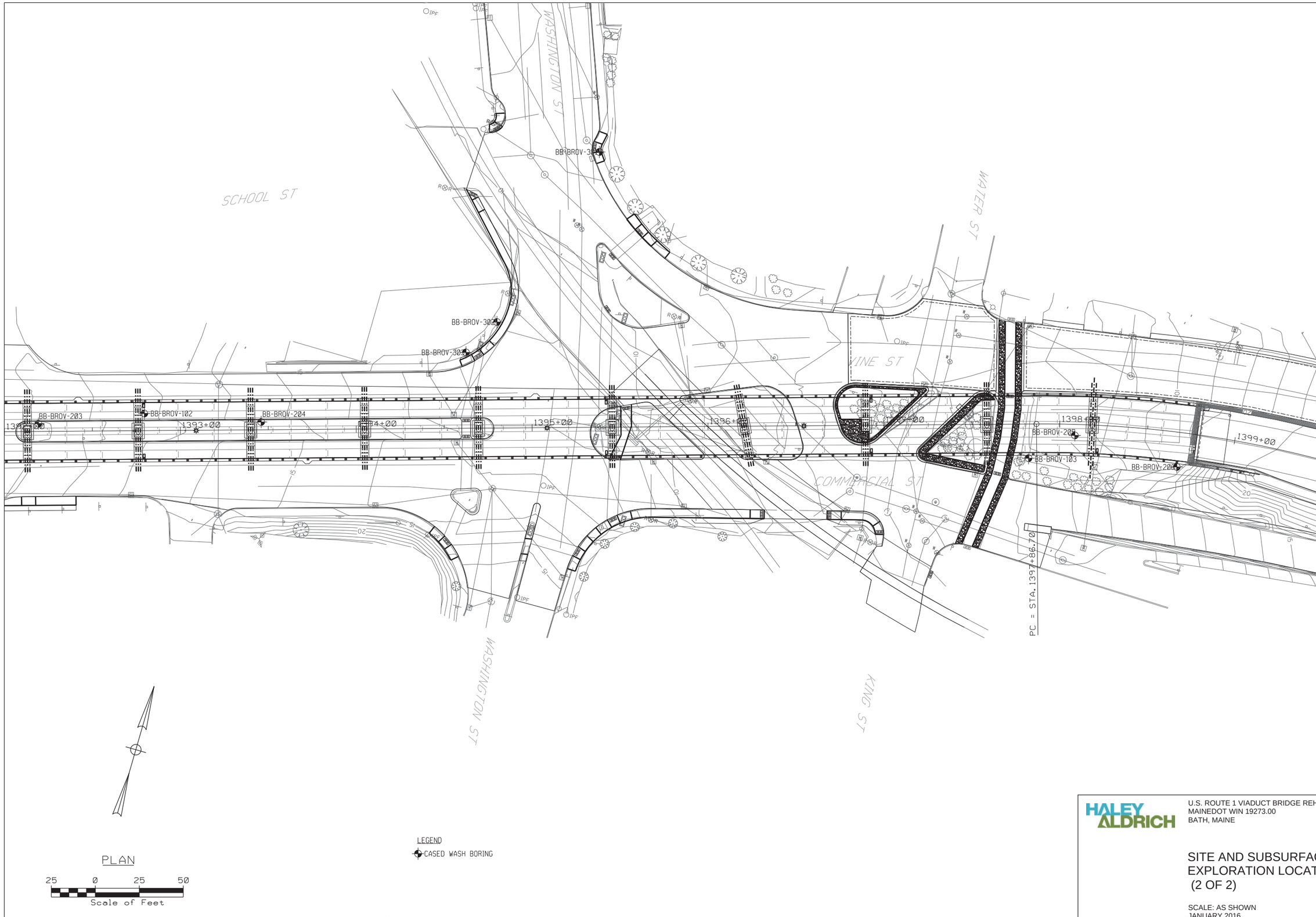
SITE AND SUBSURFACE
EXPLORATION LOCATION PLAN
(1 OF 2)

SCALE: AS SHOWN
JANUARY 2016

FIGURE 2

G:\PROJECTS\40725 - route 1 viaduct bath\010 - Final Design + CD Prep\Deliverables\Final G
bsteinert

Filename: $file$ Division: $wkgroup$ Username: $user$ Date:$date$



STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

19273.00

WIN 19273.00

BRIDGE NO. 3838

BRIDGE PLANS

STATE OF MAINE BRYAN C. STEINERT No. 12008 LICENSED PROFESSIONAL ENGINEER

PROJ. MANAGER	J. KITTREDGE	BY	DATE
DESIGN-DETAILED	P. KOWALKE	PHK	10/15
CHECKED-REVIEWED	B. STEINERT	BCS	10/15
DESIGN2-DETAILED2	---	---	---
DESIGN3-DETAILED3	---	---	---
REVISIONS 1	---	---	---
REVISIONS 2	---	---	---
REVISIONS 3	---	---	---
REVISIONS 4	---	---	---
FIELD CHANGES	---	---	---

SIGNATURE
12008
P.E. NUMBER
11/30/2015
DATE

WEST APPROACH BRIDGE
MAINE OWNED RR & CITY STREETS
SAGADAHOC COUNTY

BORING LOCATION PLAN

HALEY ALDRICH

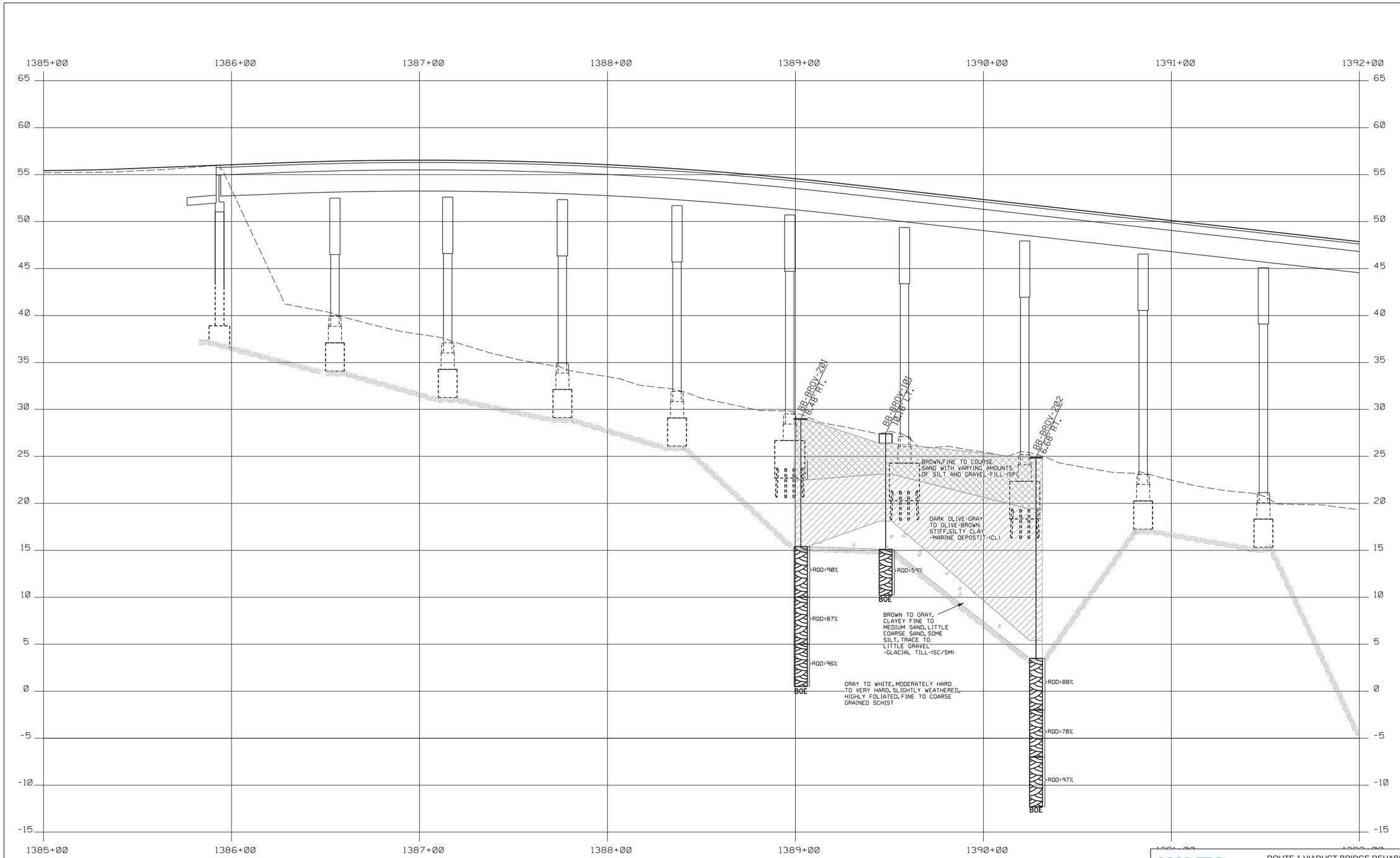
U.S. ROUTE 1 VIADUCT BRIDGE REHABILITATION
MAINEDOT WIN 19273.00
BATH, MAINE

SITE AND SUBSURFACE
EXPLORATION LOCATION PLAN
(2 OF 2)

SCALE: AS SHOWN
JANUARY 2016

FIGURE 3

G:\PROJECTS\40725 - route 1 viaduct bath\010 - Final Design + CD Prep\Deliverables\Final G
bsteinert



LEGEND

Boring No. / Offset

Pavement Thickness if applicable

Weathered ROCK

Strata Interface

Top of Bedrock

RQD= Rock Quality Designation for Rock Core Sample

BOE= Bottom Of Exploration

PROFILE

Horiz. 25 0 25 50

Vert. 5 0 5 10

Scale of Feet

NOTES:
1. TOP OF BEDROCK SURFACE SHOWN BASED
BETWEEN HISTORIC EXPLORATIONS COMPLETE
EXPLORATIONS COMPLETED UNDER THE DIREC
AND KNOWN EXISTING FOUNDATION BEARING

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

19273.00

WIN
19273.00

BRIDGE NO. 3838

BRIDGE PLANS

STATE OF MAINE
BRYAN C. STEINERT
No. 12008
LICENSED PROFESSIONAL ENGINEER

PROJ. MANAGER	J. KITTREDGE	BY	DATE
DESIGN-DETAILED	P. KOWALKE	PHK	10/15
CHECKED-REVIEWED	B. STEINERT	BCS	10/15
DESIGN2-DETAILED2	...	...	...
DESIGN3-DETAILED3	...	...	...
REVISIONS 1	...	...	...
REVISIONS 2	...	...	...
REVISIONS 3	...	...	...
REVISIONS 4	...	...	...
FIELD CHANGES	...	...	...

SIGNATURE

12008

P.E. NUMBER

12/07/2015

DATE

WEST APPROACH BRIDGE
MAINE OWNED RR & CITY STREETS
SAGADAHOC COUNTY

INTERPRETIVE SUBSURFACE PROFILE

HALEY ALDRICH

ROUTE 1 VIADUCT BRIDGE REHABILITATION
MAINEDOT WIN 19273.00
BATH, MAINE

INTERPRETIVE SUBSURFACE PROFILE (1 OF 2)

SCALE: AS SHOWN
JANUARY 2016

FIGURE 4

G:\PROJECTS\40725 - route 1 viaduct bath\010 - Final Design + CD Prep\Deliverables\Final G
bsteinert

Filename: $file$ Division: $wkgroup$ Username: $user$ Date:$date$

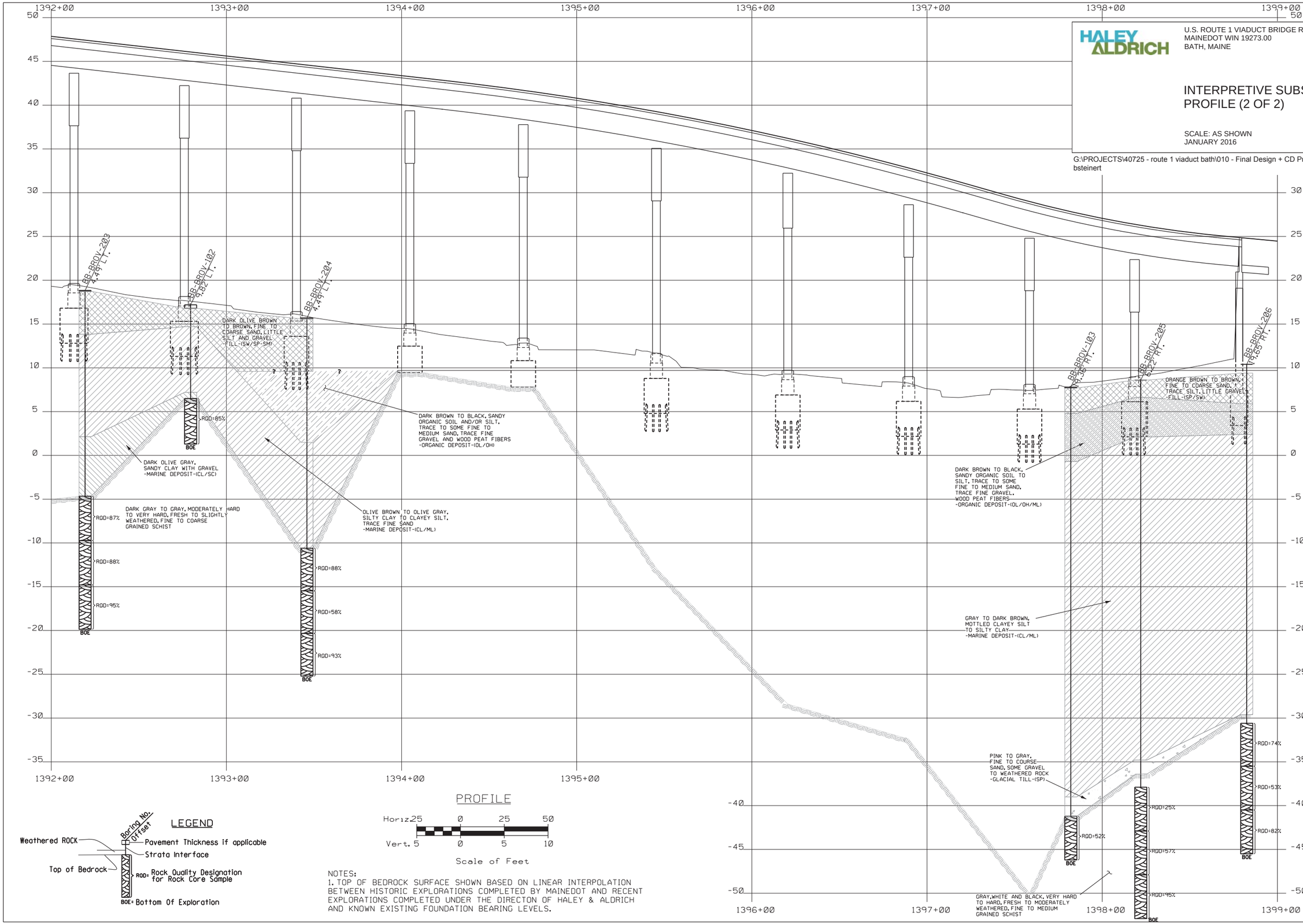
U.S. ROUTE 1 VIADUCT BRIDGE REHABILITATION
MAINEDOT WIN 19273.00
BATH, MAINE

INTERPRETIVE SUBSURFACE PROFILE (2 OF 2)

SCALE: AS SHOWN
JANUARY 2016

FIGURE 5

G:\PROJECTS\40725 - route 1 viaduct bath\010 - Final Design + CD Prep\Deliverables\Final G
bsteinert



NOTES:
1. TOP OF BEDROCK SURFACE SHOWN BASED ON LINEAR INTERPOLATION BETWEEN HISTORIC EXPLORATIONS COMPLETED BY MAINEDOT AND RECENT EXPLORATIONS COMPLETED UNDER THE DIRECTON OF HALEY & ALDRICH AND KNOWN EXISTING FOUNDATION BEARING LEVELS.

DEPARTMENT

BRIDGE NO.

STATE OF MAINE — BRYAN C. STEINERT No. 12008 — LICENSED PROFESSIONAL ENGINEER

		BY	DATE
PROJ. MANAGER	J. KITTREDGE		
DESIGN-DETAILED	P. KOWALKE	PHK	10/15
CHECKED-REVIEWED	B. STEINERT	BCS	10/15
DESIGN2-DETAILED2	---	---	---
DESIGN3-DETAILED3	---	---	---
REVISIONS 1	---	---	---
REVISIONS 2	---	---	---
REVISIONS 3	---	---	---
REVISIONS 4	---	---	---
FIELD CHANGES	---	---	---

SIGNATURE
12008
P.E. NUMBER
12/07/2015
DATE

WEST APPROACH BRIDGE
MAINE OWNED RR & CITY STREETS
BATH SAGADAHOC COUNTY

INTERPRETIVE SUBSURFACE PROFILE

SHEET NUMBER
73
OF 145

Filename: $file$ Division: $wkgroup$ Username: $user$ Date:$date$

APPENDIX A

Test Boring Logs

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE-GRAINED SOILS (more than half of material is larger than No. 200 sieve size)	GRAVELS (more than half of coarse fraction is larger than No. 4 sieve size)	CLEAN GRAVELS (little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines
			GP	Poorly-graded gravels, gravel sand mixtures, little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS (more than half of coarse fraction is smaller than No. 4 sieve size)	CLEAN SANDS (little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines
			SP	Poorly-graded sands, gravelly sand, little or no fines.
		SANDS WITH FINES (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures.
FINE-GRAINED SOILS (more than half of material is smaller than No. 200 sieve size)	SILTS AND CLAYS (liquid limit less than 50)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity.
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
			OL	Organic silts and organic silty clays of low plasticity.
	SILTS AND CLAYS (liquid limit greater than 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
			CH	Inorganic clays of high plasticity, fat clays.
			OH	Organic clays of medium to high plasticity, organic silts
	HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.

Desired Soil Observations: (in this order)

Color (Munsell color chart)
Moisture (dry, damp, moist, wet, saturated)
Density/Consistency (from above right hand side)
Name (sand, silty sand, clay, etc., including portions - trace, little, etc.)
Gradation (well-graded, poorly-graded, uniform, etc.)
Plasticity (non-plastic, slightly plastic, moderately plastic, highly plastic)
Structure (layering, fractures, cracks, etc.)
Bonding (well, moderately, loosely, etc., if applicable)
Cementation (weak, moderate, or strong, if applicable, ASTM D 2488)
Geologic Origin (till, marine clay, alluvium, etc.)
Unified Soil Classification Designation
Groundwater level

TERMS DESCRIBING DENSITY/CONSISTENCY

Coarse-grained soils (more than half of material is larger than No. 200 sieve): Includes (1) clean gravels; (2) silty or clayey gravels; and (3) silty, clayey or gravelly sands. Consistency is rated according to standard penetration resistance.

Modified Burmister System

Descriptive Term	Portion of Total
trace	0% - 10%
little	11% - 20%
some	21% - 35%
adjective (e.g. sandy, clayey)	36% - 50%

Density of Cohesionless Soils	Standard Penetration Resistance N-Value (blows per foot)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

Fine-grained soils (more than half of material is smaller than No. 200 sieve): Includes (1) inorganic and organic silts and clays; (2) gravelly, sandy or silty clays; and (3) clayey silts. Consistency is rated according to shear strength as indicated.

Consistency of Cohesive soils	SPT N-Value blows per foot	Approximate Undrained Shear Strength (psf)	Field Guidelines
Very Soft	WOH, WOR, WOP, <2	0 - 250	Fist easily Penetrates
Soft	2 - 4	250 - 500	Thumb easily penetrates
Medium Stiff	5 - 8	500 - 1000	Thumb penetrates with moderate effort
Stiff	9 - 15	1000 - 2000	Indented by thumb with great effort
Very Stiff	16 - 30	2000 - 4000	Indented by thumbnai
Hard	>30	over 4000	Indented by thumbnail with difficulty

Rock Quality Designation (RQD):

$$RQD = \frac{\text{sum of the lengths of intact pieces of core* > 100 mm}}{\text{length of core advance}}$$

*Minimum NQ rock core (1.88 in. OD of core)

Correlation of RQD to Rock Mass Quality

Rock Mass Quality	RQD
Very Poor	<25%
Poor	26% - 50%
Fair	51% - 75%
Good	76% - 90%
Excellent	91% - 100%

Desired Rock Observations: (in this order)

Color (Munsell color chart)
Texture (aphanitic, fine-grained, etc.)
Lithology (igneous, sedimentary, metamorphic, etc.)
Hardness (very hard, hard, mod. hard, etc.)
Weathering (fresh, very slight, slight, moderate, mod. severe, severe, etc.)
Geologic discontinuities/jointing:
- -dip (horiz - 0-5, low angle - 5-35, mod. dipping - 35-55, steep - 55-85, vertical - 85-90)
- -spacing (very close - <5 cm, close - 5-30 cm, mod. close 30-100 cm, wide - 1-3 m, very wide >3 m)
- -tightness (tight, open or healed)
- -infilling (grain size, color, etc.)

Formation (Waterville, Ellsworth, Cape Elizabeth, etc.)
RQD and correlation to rock mass quality (very poor, poor, etc.)
ref: AASHTO Standard Specification for Highway Bridges 17th Ed. Table 4.4.8.1.2A
Recovery

Maine Department of Transportation
Geotechnical Section
Key to Soil and Rock Descriptions and Terms
Field Identification Information

Sample Container Labeling Requirements:

PIN	Blow Counts
Bridge Name / Town	Sample Recovery
Boring Number	Date
Sample Number	Personnel Initials
Sample Depth	

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Route 1 Viaduct Bridge Rehabilitation
Location: Bath, Maine

Boring No.: BB-BROV-301
PIN: 19273.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	9.0 (Est.)	**Auger ID/OD:**	--
Operator:	C. Dupuis	**Datum:**	NAVD 88	**Sampler:**	Split Spoon-1.375 in. ID
Logged By:	K. Russ	**Rig Type:**	Mobile B52	**Hammer Wt./Fall:**	NW-300#/24 in. SS-140#/30
Date Start/Finish:	9-17-15/9-17-15	**Drilling Method:**	NW Drive	**Core Barrel:**	NQ-2.0 in.
Boring Location:	See plan	**Casing ID/OD:**	NW-3.0 in. ID	**Water Level*:**	
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR = weight of rods
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)
0	1D	21.6/6	0.2 - 2.0	1/4/6/7	10	17	NW Drive	8.80
	2D	15/7	2.0 - 3.3	7/4/2/1	6	10		
	2DA	9/8	3.3 - 4.0					5.75
	3D	7.2/7	4.0 - 4.6	7/8/12/16	20	33		5.00
5	~~3DA~~	~~16.8/16~~	~~4.6 - 6.0~~					4.40
							36	
							37	
							36	
							36	
10	4D	24/21	10.0 - 12.0	4/6/7/8	15	25	47	
							53	
							50	
							55	
							55	
15	5D	10/10	15.0 - 15.8	5/10/50(1.0")	60	100	64	-6.70
	~~5DA~~	~~4/4~~	~~15.7 - 16.0~~					-7.10
	R1		16.1 - 21.1				NQ	
20								-12.10
25								
30								

Graphic Log

Visual Description and Remarks

-BITUMINOUS CONCRETE- — 0.2

Light brown, dry, loose, poorly-graded GRAVEL, little fine sand, trace medium and coarse sand -FILL-(GP)

Light brown, dry, loose, fine to medium SAND, little coarse sand, trace fine gravel
-FILL-(SW) — 3.3

Olive-brown, dry, soft, SILT (Likely reworked naturally-deposited soil)
-FILL-(ML) — 4.0

Brown, dry, loose, fine SAND, some medium sand, little coarse sand, little fine gravel, trace silt
-FILL-(SW) — 4.6

Olive-brown, dry, very stiff, SILT, trace fine sand
-MARINE DEPOSIT-(ML)

Olive-brown, dry, medium stiff, SILT
-MARINE DEPOSIT-(ML)

Olive-brown, dry, hard, SILT, trace fine sand
-MARINE DEPOSIT-(ML) — 15.7

Light brown to olive-brown, moist, very dense, sandy SILT, trace fine gravel, loosely bonded
-GLACIAL TILL-(ML) — 16.1

Top of Bedrock El.-7.1
White and gray, medium to fine-grained GNEISS. Hard, fresh to slightly weathered, joints low angle, very close to moderately close, few secondary vertical joints, tight to open.
Recovery=90%
Rock Mass Quality=Good
R1 Core Times (min:sec): 16.1-17.1' (1:00); 17.1-18.1' (1:30); 18.1-19.1' (1:30); 19.1-20.1' (1:30); 20.1-21.1' (1:30) — 21.1

Bottom of Exploration at 21.1 feet below ground surface.

Laboratory Testing Results/ AASHTO and Unified Class.

Remarks:

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Route 1 Viaduct Bridge Rehabilitation
Location: Bath, Maine

Boring No.: BB-BROV-302
PIN: 19273.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	11.0 (Est.)	**Auger ID/OD:**	--
Operator:	C. Dupuis	**Datum:**	NAVD 88	**Sampler:**	Split Spoon-1.375 in. ID
Logged By:	K. Russ	**Rig Type:**	Mobile B52	**Hammer Wt./Fall:**	NW-300#/24 in. SS-140#/30
Date Start/Finish:	9-16-15/9-17-15	**Drilling Method:**	NW Drive	**Core Barrel:**	NQ-2.0 in.
Boring Location:	See Plan	**Casing ID/OD:**	NW-3.0 in. ID	**Water Level*:**	
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
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MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR = weight of rods
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0	1D	24/7	0.0 - 2.0	1/7/12/7	19	32	NW Drive	10.40		Dark brown, damp, very loose, silty SAND, trace gravel -TOPSOIL-(SP) 0.6	
	2D	24/0	2.0 - 4.0	4/5/4/7	9	15				Note: No Recovery on sample, rock lodged in spoon tip.	
	3D	21/7	4.0 - 5.8	6/12/17/50(3.0")	29	48				Light brown, moist, medium dense, SAND, little gravel, trace silt -FILL-(SW) Note: Split-spoon refusal at 5.75 ft, probable bedrock. Advanced auger to refusal at 6.8 ft, set casing to 6.8 ft.	
5								4.20		6.8	
	R1	34.8/34	7.1 - 10.0	RQD = 79%			NQ	3.90		-WEATHERED BEDROCK- 7.1	
										Top of Bedrock El.3.9 Tan-white-gray, medium to fine-grained GNEISS. Horizontal to low angle foliation. Very hard to hard, fresh joints	
10	R2	53/52	10.0 - 14.4	RQD = 91%						Tan-white-gray, medium to fine-grained GNEISS with top 10 in. and lower 8 in. containing extremely close, extremely thin bands of biotite mica with horizontal to low angle quartz intrusions. Very hard to hard, fresh, joints low angle to moderately dipping, very close to close, rough, undulating, partly open to open. Recovery=98% Rock Mass Quality=Good R1 Core Times (min:sec): 7.1-8.1' (12:00); 8.1-9.1' (14:30); 9.1-10.0' (15:00)	
								-3.40		Tan-white-gray, medium to fine-grained GNEISS with top 10 in. and lower 8 in. containing extremely thin bands of biotite mica with quartz intrusion at extremely close. Horizontal or low angle. Granitic intrusion in between. Very hard to hard, fresh. Joints low angle to moderately dipping, very close to close, rough, undulating, partly open to open.	
15											
20										Gray-white-black, medium to fine-grained GNEISS, very hard to hard, slightly weathered to fresh, joints horizontal to low angle, very close to close, partly open to open, weathered joint surfaces. Foliation has high angle, no moderately dipping. Recovery=98% Rock Mass Quality=Excellent R2 Core Times (min:sec): 10.0-11.0' (11:30) 11.0-12.0' (15:30); 12.0-13.0' (17:00); 13.0-14.0' (15:00); 14.0-14.4' (7:00) 14.4	
25										**Bottom of Exploration at 14.4 feet below ground surface.**	
30											

Remarks:

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Route 1 Viaduct Bridge Rehabilitation
Location: Bath, Maine

Boring No.: BB-BROV-303
PIN: 19273.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	11.0 (Est.)	**Auger ID/OD:**	--
Operator:	C. Dupuis	**Datum:**	NAVD 88	**Sampler:**	Split Spoon-1.375 in. ID
Logged By:	K. Russ	**Rig Type:**	Mobile B52	**Hammer Wt./Fall:**	NW-300#/24 in. SS-140#/30
Date Start/Finish:	9-17-15/9-17-15	**Drilling Method:**	NW Drive	**Core Barrel:**	NQ-2.0 in.
Boring Location:	See Plan	**Casing ID/OD:**	NW-3.0 in. ID	**Water Level*:**	
Hammer Efficiency Factor:	0.6	**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

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RC = Roller Cone
WOH = weight of 140lb. hammer
WOR = weight of rods
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0	1D	6/6	0.0 - 0.5	1/6/9/11	15	25	NW Drive	10.50		Dark brown, dry, very soft, SILT, trace fine sand, contains organics -TOPSOIL-(OH)	
	~~1DA~~	~~18/8~~	~~0.5 - 2.0~~							0.5	
	2D	24/14	2.0 - 4.0	7/10/12/6	22	37				Brown, dry, medium dense, fine to medium, SAND, trace coarse sand, trace fine gravel -FILL-(SP)	
	3D	12/5	4.0 - 5.0	21/20/50(3.0")	70	117				Brown, dry, medium dense, fine to medium SAND, trace silt, trace coarse sand, little coarse gravel -FILL-(SP)	
5	3DA	3/3	5.0 - 5.3	RQD = 27%				6.00		Brown, dry, very dense, fine to medium SAND, trace coarse sand, trace gravel -FILL-(SP)	
	~~R1~~	~~60/48~~	~~5.6 - 10.6~~				NQ	5.40		5.0	
										Light brown, dry, very dense, fine to coarse SAND, some gravel, contains micaceous weathered rock -WEATHERED BEDROCK-(SW) Note: Containing micaceous weathered rock. Note: Auger refusal at 5.6 ft. Drove casing to 5.6 ft, advanced roller bit to 5.6 ft.	
10								0.40		5.6	
										Top of Bedrock El.5.4 Gray-black-white, fine to medium-grained GNEISS. Very hard to moderately hard, slight to moderately weathered. Joints low angle, very close to close, open, silt infilling on joint surfaces, weathered joint surfaces. Recovery=80% Rock Mass Quality=Poor R1 Core Times (min:sec): 5.6-6.6' (6:30); 6.6-7.6' (2:45); 7.6-8.6' (2:39); 8.6-9.6' (4:38); 9.6-10.6' (2:45)	
15										10.6	
										Bottom of Exploration at 10.6 feet below ground surface.	
20											
25											
30											

Remarks:

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

APPENDIX B

Calculations

HALEY & ALDRICH

CALCULATIONS

		File No.	40725-010
		Sheet	1 of 3
Client	Maine Department of Transportation	**Date**	9/1/2015
Project	Route 1 Viaduct Bridge Replacement - Bath, Maine	**Computed By**	BCS
Subject	Abutment/Pier Footing Bearing Resistance Evaluation	**Checked By**	JLL

OBJECTIVE:

Evaluate bearing resistance for existing bridge abutments/piers bearing on bedrock in accordance with AASHTO LRFD and the MaineDOT Bridge Design Guide (BDG). Compare recommendations to pier and retaining wall pressures calculated by VHB and provided to Haley & Aldrich in 8/31/15 (piers) and 9/1/15 (abutments/walls) emails.

REFERENCES:

1 AASHTO LRFD Bridge Design Specifications 7th Edition 2014 with Interim Revisions through 2015.
2 MaineDOT Bridge Design Guide 2003, with Interim Revisions through March 2014.
3 Report entitled, "Subsurface Investigations For Carlton Bridge and West Approach in Bath, Maine," prepared by the State Highway Commission Soils Division, dated April 1957.
4 Historic bridge plans entitled, "Carlton Bridge Widening and West Approach between Bath & Woolwich, Sagadahoc County, Maine," Sheet Nos. 36 through 39 of 148, prepared by the State Highway Commission Bridge Division, dated January 1957.
5 Preliminary and Supplemental Geotechnical Design Reports prepared by H&A dated 9/17/2013 and 9/5/2014, respectively.

SUMMARY OF EXISTING BRIDGE STRUCTURE:

Based on review of historic information provided by MaineDOT (references 3 and 4), the existing viaduct bridge is supported on two abutments and 19 piers. Select abutments/piers/retaining walls are supported on spread footings.

SUMMARY OF BEDROCK DATA:

BEDROCK CORE DATA: refer to test boring logs

Test Boring No.	Sample No.	Top Depth (ft, BGS)	Bottom Depth (ft, BGS)	Rock Core Length (ft)	Recovery		RQD	
					in.	%	in.	%
BB-BROV-101	R1	12.3	17.2	4.9	59	100%	35	59%
BB-BROV-102	R1	10.7	15.9	5.2	62	100%	53	85%
BB-BROV-103	R1	49.0	54.0	5.0	60	100%	31	52%
BB-BROV-201	R1	14.0	19.0	5.0	60	100%	54	90%
	R2	19.0	24.0	5.0	60	100%	52	87%
	R3	24.0	28.5	4.5	54	100%	52	96%
BB-BROV-202	R1	21.9	26.9	5.0	60	100%	53	88%
	R2	26.9	31.9	5.0	60	100%	47	78%
	R3	31.9	36.9	5.0	60	100%	58	97%
BB-BROV-203	R1	23.7	28.7	5.0	60	100%	52	87%
	R2	28.7	33.7	5.0	60	100%	53	88%
	R3	33.7	38.7	5.0	60	100%	57	95%
BB-BROV-204	R1	26.3	31.3	5.0	56	93%	49	88%
	R2	31.3	35.9	4.6	54	98%	31	58%
	R3	35.9	40.9	5.0	56	93%	52	93%
BB-BROV-205	R1	46.5	51.5	5.0	57	95%	14	25%
	R2	51.5	56.5	5.0	60	100%	34	57%
	R3	56.5	61.5	5.0	60	100%	57	95%
BB-BROV-206	R1	41.4	45.9	4.5	54	100%	40	74%
	R2	45.9	50.9	5.0	60	100%	32	53%
	R3	50.9	55.9	5.0	60	100%	49	82%
					Average =	99%		77%

BEARING RESISTANCE EVALUATION: (CONT.)

LABORATORY TEST DATA:

Test Boring No.	Sample No.	Top Depth (ft, BGS)	Bottom Depth (ft, BGS)	Peak Compressive Stress (psi)	Bulk Density (pcf)
BB-BROV-101	R1	14.6	15.0	2,321	174
BB-BROV-102	R1	14.0	14.4	1,522	173
			Average =	1,922	174

BEDROCK DESCRIPTION:

Moderately hard to very hard, fresh to slightly weathered, coarse to fine-grained chlorite/biotite/quartzite/pegmatite/ micaceous SCHIST. Primary joints dipping at low to high angles, very close to widely spaced, tight to open. Secondary joints dipping at moderate to high angles where present.

For additional details refer to test boring logs.

SERVICE LIMIT STATE:

Determine service limit state bearing resistance based on presumptive values provided in Table C10.6.2.6.1-1 (attached).

For foliated metamorphic rock (schist) values range from 60 to 80 kips per square foot (ksf).

For service limit state design use 60 ksf.

STRENGTH LIMIT STATE:

Calculate upper and lower bound nominal bearing resistance for spread footings bearing on bedrock in accordance with Section 10.8.3.5.4c.

Intact/Tightly Jointed Rock: upper bound value

qp = 2.5 x qu (Eqn. 10.8.3.5.4c-1)

Where: qu = unconfined compressive strengh of rock (ksf)

From above, 1.522 ksi < qu < 2.321 ksi…… say = 144 ksf (1 ksi; conservative)

qu = 144 ksf

qp = 360 ksf

Jointed Rock: lower bound solution

$qp = ((s)^{1/2} + (m(s)^{1/2} + s)^{1/2}) \times qu$ (Eqn. 10.8.3.5.4c-2)

Where: s,m = fractured rock mass parameters specified in Table 10.4.6.4-4.

parameters s and m are a function of rock quality as determined use the Rock Mass Rating (RMR) system.
Determine rock quality in accordance with Tables 10.4.6.4-1 and 10.4.6.4-2 (see attached spreadsheet summary).

BEARING RESISTANCE EVALUATION: (CONT.)

STRENGTH LIMIT STATE: (CONT.)

Jointed Rock: lower bound solution (cont.)

Average RMR from preliminary and supplemental test borings = 50 (see attachments)

For SCHIST and GNEISS bedrock assume Rock Types B and E, respectively. Say Rock Type B is predominant….

Calculate rock mass constants (m and s) directly from Eqns. 18 and 19 (Hoek and Brown, 1988)

m / mi = e^((RMR-100/14))…. m = mi x e^((RMR-100)/14)

s = e^((RMR-100)/6))

For Rock Type B and intact rock from Table 1 (Hoek and Brown, 1988)….. mi = 15

Calculate m for RMR = 50 (average)

m = 0.42

s = 0.000240

qp = $((s)^{1/2} + (m(s)^{1/2} + s)^{1/2}) \times qu$ (Eqn. 10.8.3.5.4c-2)

qp = 27 ksf

Based on review of rock core samples, rock more closely resembles "jointed rock" condition. However, the calculated nominal bearing resistance appears low based on experience.
Calculate average of "intact" and "jointed rock" values….

Calculate average nominal bearing resistance = 194 ksf

Resistance factor for bearing resistance of footings on rock, ϕ = 0.45

Calculate factored bearing resistance = 87 ksf **For strength limit state design use 87 ksf.**

EXTREME EVENT LIMIT STATE:

For extreme event limit state use 194 ksf

CONCLUSION:

Compare SER, STR and EE limit state bearing pressures to the values summarized herein to determine adequacy of existing spread footing foundations to support the rehabilitated superstructure.

Rock Mass Rating Field Data Sheet

AASHTO Geomechanics Classification of Rock Masses from Rock Core Recovery, for use with LRFD Design

Reference Elev. _____ X G/S ☐ Mudline

Project Datum NAVD 88

Core Barrel Type NQ Diam. 2

HALEY ALDRICH

Project Name Route 1 Viaduct Bridge Rehabilitation

Drilling Contractor Maine Test Borings/MaineDOT

Project Location Bath, Maine

Drill Rig Type Mobile Drill B-53 Truck & CME 45C Truck

File Number 40725-010

Client Maine Department of Transportation

Haley & Aldrich Rep. M. Snow/S. Shay

Date 9/1/2015

Boring Number	Core Run ID	Depth (ft) From	Depth (ft) To	Elev. (ft) From	Elev. (ft) To	Strength of Rock Mass: Rock Type	Strength of Rock Mass: Est. Strength	Strength of Rock Mass: RMR Rating	Recovery In.	Recovery %	RQD In.	RQD %	RQD RMR Rating	Joint Spacing 1° Set	Joint Spacing 2° Set	Joint Spacing RMR Rating	Joint Condition 1° Set	Joint Condition 2° Set	Joint Condition RMR Rating	Joint Condition Joint Adjust.	GW Rating	RMR Rating Sum
BB-BROV-101	R1	12.3	17.2			Schist	277	2	59	100%	34	58%	13	2-12		10			6	0	7	**38**
BB-BROV-102	R1	10.7	15.9			Gneiss	277	2	62	100%	53	85%	17	2-40		15			6	0	7	**47**
BB-BROV-103	R1	49.0	54.0			Schist	277	2	60	100%	31	52%	13	2-12		10			6	0	7	**38**
BB-BROV-201	R1	14.0	19.0			Schist	277	2	60	100%	54	90%	19	2-40		15			12	0	7	**55**
	R2	19.0	24.0			Schist	277	2	60	100	52	87%	17	12-40		20			20	0	7	**66**
	R3	24.0	28.5			Schist	277	2	54	100	52	96%	20	2-12		10			12	0	7	**51**
BB-BROV-202	R1	21.9	26.9			Schist	277	2	60	100	53	88%	17	12-40		20			20	0	7	**66**
	R2	26.9	31.9			Schist	277	2	60	100	47	78%	17	12-40		20			20	0	7	**66**
	R3	31.9	36.9			Schist	277	2	60	100	58	97%	20	12-40		20			20	0	7	**69**
BB-BROV-203	R1	23.7	28.7			Schist	277	2	60	100	52	87%	17	2-12		10			6	0	7	**42**

Strength of Intact Rock Mass

UCS Range of Values		RMR Rating
>4320 ksf	>30,000 psi	15
2160 - 4320 ksf	15,000 - 30,000 psi	12
1080 - 2160 ksf	7,500 - 15,000 psi	7
520 - 1080 ksf	3,611 - 7,500 psi	4
215 - 520 ksf	1,495 - 3,611 psi	2
70 - 215 ksf	486 - 1,495 psi	1
20 - 70 ksf	138 - 486 psi	0

Drill Core Quality from RQD

RQD	RMR Rating
100% - 90%	20
90% - 75%	17
75% - 50%	13
50% - 25%	8
<25%	3

Condition of Joints

	RMR Rating
1. ▪Very rough surfaces ▪Not continuous ▪No separation (tight) ▪Hard wall rock in joint	25
2. ▪Slightly rough surfaces ▪Opening/separation <0.05 in. ▪Hard joint wall rock	20
3. ▪Slighty rough surfaces ▪Opening/separation <0.05 in. ▪Soft joint wall rock	12
4. ▪Slickensided surfaces **or** ▪Gouge <0.2 in. thick **or** ▪Joints open 0.05 - 0.2 in. ▪Continuous joints	6
5. ▪Soft gouge >0.2 in. thick or ▪Joints open >0.2 in. ▪Continuous joints	0

General Groundwater Conditions

	RMR Rating
Completely dry	10
Moist only or interstitial water	7
Water under moderate pressure	4
Severe water flow/infiltration/problems	0

Approximate Rock Strength Field Guidelines

Extremely weak rock	36 - 145 psi	Indents by thumbnail (stiff fault gouge)
Very weak rock	145 - 725 psi	Crumbles under firm blow with pick point
Weak rock	725 - 3,625 psi	Shallow indentations with firm blow of pick
Medium strong rock	3,625 - 7,250 psi	Specimen fractured with single firm blow
Strong rock	7,250 - 14,500 psi	Specimen requires more than one blow to fracture
Very strong rock	14,500 - 36,250 psi	Specimen requires many blows to fracture
Extremely. strong rock	> 36,250 psi	Specimen can only be chipped with geological pick

Joint Spacing	RMR Rating
> 10 ft	30
3 ft - 10 ft	25
1 ft - 3 ft	20
2 in. - 1 ft	10
< 2 in.	5

Adjustment for Joint Orientation (foundations only)

	RMR Rating
Very Favorable	0
Favorable	-2
Fair	-7
Unfavorable	-15
Very Unfavorable	-25

Instructions:
1. Record data from individual rock core runs. Using RMR criteria, enter RMR Ratings for each evaluation category (Strength, RQD, Joints, groundwater, etc.).
2. Sum all RMR Ratings from shaded boxes into right hand column. Value should be between 0 - 100.

BORING NO:

Rock Mass Rating Field Data Sheet

AASHTO Geomechanics Classification of Rock Masses from Rock Core Recovery, for use with LRFD Design

Reference Elev. _____ X G/S ☐ Mudline

Core Barrel Type NQ Diam. 2

Project Datum NAVD 88

HALEY ALDRICH

Project Name Route 1 Viaduct Bridge Rehabilitation

Drilling Contractor Maine Test Borings/MaineDOT

Project Location Bath, Maine

Drill Rig Type Mobile Drill B-53 Truck & CME 45C Truck

File Number 40725-010

Client Maine Department of Transportation

Haley & Aldrich Rep. M. Snow/S. Shay

Date 9/1/2015

Boring Number	Core Run ID	Depth (ft) From	Depth (ft) To	Elev. (ft) From	Elev. (ft) To	Strength of Rock Mass: Rock Type	Strength of Rock Mass: Est. Strength	Strength of Rock Mass: RMR Rating	Recovery In.	Recovery %	RQD In.	RQD %	RQD RMR Rating	Joint Spacing 1° Set	Joint Spacing 2° Set	Joint Spacing RMR Rating	Joint Condition 1° Set	Joint Condition 2° Set	Joint Condition RMR Rating	Joint Adjust.	GW Rating	RMR Rating Sum
BB-BROV-203	R2	28.7	33.7			Schist	277	2	60	100%	53	88%	17	12-40		20			20	0	7	**66**
	R3	33.7	38.7			Schist	277	2	60	100%	57	95%	20	2-12		10			12	0	7	**51**
BB-BROV-204	R1	26.3	31.3			Schist	277	2	56	93%	49	82%	17	12-120		23			6	0	7	**55**
	R2	31.3	35.9			Schist	277	2	54	98%	31	56%	13	12-120		23			12	0	7	**57**
	R3	35.9	40.9			Schist	277	2	56	93%	52	87%	17	12-120		23			12	0	7	**61**
BB-BROV-205	R1	46.5	51.5			Schist	277	2	57	95%	14	23%	3	2		5			12	0	7	**29**
	R2	51.5	56.5			Schist	277	2	60	100%	34	57%	13	2-12		10			12	0	7	**44**
	R3	56.5	61.5			Schist	277	2	60	100%	57	95%	20	12-40		20			12	0	7	**61**
BB-BROV-206	R1	41.4	45.9			Schist	277	2	54	100%	40	74%	13	2-12		10			12	0	7	**44**
	R2	45.9	50.9			Schist	277	2	60	100%	32	53%	13	2-12		10			12	0	7	**44**

Strength of Intact Rock Mass

UCS Range of Values		RMR Rating
>4320 ksf	>30,000 psi	15
2160 - 4320 ksf	15,000 - 30,000 psi	12
1080 - 2160 ksf	7,500 - 15,000 psi	7
520 - 1080 ksf	3,611 - 7,500 psi	4
215 - 520 ksf	1,495 - 3,611 psi	2
70 - 215 ksf	486 - 1,495 psi	1
20 - 70 ksf	138 - 486 psi	0

Drill Core Quality from RQD

RQD	RMR Rating
100% - 90%	20
90% - 75%	17
75% - 50%	13
50% - 25%	8
<25%	3

Condition of Joints

	RMR Rating
1. ▪Very rough surfaces ▪Not continuous ▪No separation (tight) ▪Hard wall rock in joint	25
2. ▪Slightly rough surfaces ▪Opening/separation <0.05 in. ▪Hard joint wall rock	20
3. ▪Slighty rough surfaces ▪Opening/separation <0.05 in. ▪Soft joint wall rock	12
4. ▪Slickensided surfaces **or** ▪Gouge <0.2 in. thick **or** ▪Joints open 0.05 - 0.2 in. ▪Continuous joints	6
5. ▪Soft gouge >0.2 in. thick or ▪Joints open >0.2 in. ▪Continuous joints	0

General Groundwater Conditions

	RMR Rating
Completely dry	10
Moist only or interstitial water	7
Water under moderate pressure	4
Severe water flow/infiltration/problems	0

Approximate Rock Strength Field Guidelines

Extremely weak rock	36 - 145 psi	Indents by thumbnail (stiff fault gouge)
Very weak rock	145 - 725 psi	Crumbles under firm blow with pick point
Weak rock	725 - 3,625 psi	Shallow indentations with firm blow of pick
Medium strong rock	3,625 - 7,250 psi	Specimen fractured with single firm blow
Strong rock	7,250 - 14,500 psi	Specimen requires more than one blow to fracture
Very strong rock	14,500 - 36,250 psi	Specimen requires many blows to fracture
Extremely. strong rock	> 36,250 psi	Specimen can only be chipped with geological pick

Joint Spacing	RMR Rating
> 10 ft	30
3 ft - 10 ft	25
1 ft - 3 ft	20
2 in. - 1 ft	10
< 2 in.	5

Adjustment for Joint Orientation (foundations only)

	RMR Rating
Very Favorable	0
Favorable	-2
Fair	-7
Unfavorable	-15
Very Unfavorable	-25

Instructions:
1. Record data from individual rock core runs. Using RMR criteria, enter RMR Ratings for each evaluation category (Strength, RQD, Joints, groundwater, etc.).
2. Sum all RMR Ratings from shaded boxes into right hand column. Value should be between 0 - 100.

BORING NO:

Rock Mass Rating Field Data Sheet

AASHTO Geomechanics Classification of Rock Masses from Rock Core Recovery, for use with LRFD Design

Reference Elev. _____ X G/S ☐ Mudline

Core Barrel Type NQ Diam. 2

Project Datum NAVD 88

HALEY ALDRICH

Project Name Route 1 Viaduct Bridge Rehabilitation

Drilling Contractor Maine Test Borings/MaineDOT

Project Location Bath, Maine

Drill Rig Type Mobile Drill B-53 Truck & CME 45C Truck

File Number 40725-010

Client Maine Department of Transportation

Haley & Aldrich Rep. M. Snow/S. Shay

Date 9/1/2015

Boring Number		Depth (ft)		Elev. (ft)		Strength of Rock Mass			Recovery		RQD			Joint Spacing			Joint Condition				GW Rating	RMR Rating Sum
	Core Run ID	From	To	From	To	Rock Type	Est. Strength	RMR Rating	In.	%	In.	%	RMR Rating	1° Set	2° Set	RMR Rating	1° Set	2° Set	RMR Rating	Joint Adjust.		
BB-BROV-206	R3	50.9	55.9			Schist	277	2	60	100%	49	82%	17	12-40		20			6	0	7	**52**

Strength of Intact Rock Mass

UCS Range of Values		RMR Rating
>4320 ksf	>30,000 psi	15
2160 - 4320 ksf	15,000 - 30,000 psi	12
1080 - 2160 ksf	7,500 - 15,000 psi	7
520 - 1080 ksf	3,611 - 7,500 psi	4
215 - 520 ksf	1,495 - 3,611 psi	2
70 - 215 ksf	486 - 1,495 psi	1
20 - 70 ksf	138 - 486 psi	0

Drill Core Quality from RQD

RQD	RMR Rating
100% - 90%	20
90% - 75%	17
75% - 50%	13
50% - 25%	8
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Condition of Joints

	RMR Rating
1. ▪Very rough surfaces ▪Not continuous ▪No separation (tight) ▪Hard wall rock in joint	25
2. ▪Slightly rough surfaces ▪Opening/separation <0.05 in. ▪Hard joint wall rock	20
3. ▪Slighty rough surfaces ▪Opening/separation <0.05 in. ▪Soft joint wall rock	12
4. ▪Slickensided surfaces **or** ▪Gouge <0.2 in. thick **or** ▪Joints open 0.05 - 0.2 in. ▪Continuous joints	6
5. ▪Soft gouge >0.2 in. thick or ▪Joints open >0.2 in. ▪Continuous joints	0

General Groundwater Conditions

	RMR Rating
Completely dry	10
Moist only or interstitial water	7
Water under moderate pressure	4
Severe water flow/infiltration/problems	0

Approximate Rock Strength Field Guidelines

Extremely weak rock	36 - 145 psi	Indents by thumbnail (stiff fault gouge)
Very weak rock	145 - 725 psi	Crumbles under firm blow with pick point
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Extremely. strong rock	> 36,250 psi	Specimen can only be chipped with geological pick

Joint Spacing	RMR Rating
> 10 ft	30
3 ft - 10 ft	25
1 ft - 3 ft	20
2 in. - 1 ft	10
< 2 in.	5

Adjustment for Joint Orientation (foundations only)

	RMR Rating
Very Favorable	0
Favorable	-2
Fair	-7
Unfavorable	-15
Very Unfavorable	-25

Instructions:
1. Record data from individual rock core runs. Using RMR criteria, enter RMR Ratings for each evaluation category (Strength, RQD, Joints, groundwater, etc.).
2. Sum all RMR Ratings from shaded boxes into right hand column. Value should be between 0 - 100.

BORING NO:

HALEY ALDRICH

CALCULATIONS

Client	MAINEDOT
Project	ROUTE 1 VIADUCT BRIDGE REHABILITATION
Subject	MAST ARM OVERHEAD SIGN/TRAFFIC SIGNAL FOUNDATIONS

File No.	40725-010
Sheet	1 of 2
Date	11/2/2015
Computed By	BCS
Checked By	JLL

SUMMARIZE UNFACTORED LOADS PROVIDED BY VHB ON 9/24/15 ....

FND. NO.	TEST BORING	FOUNDATION LOADING AXIAL (KIP)	SHEAR (KIP)	MOMENT (K-FT)	TORSION (K-FT)
1	-302	6.5	3	60 112	45 84
2	-301	6 7.5	2 2.5	40 75	19 36
3	-303	6	2	46 86	24 45

FACTORED LOADS = (1/0.67)(1.25) = 1.87 MULTIPLIED BY UNFACTORED LOADS

ESTIMATE MINIMUM FOUNDATION LENGTHS BASED ON APPLIED BENDING MOMENTS AND TORSION AND ASSUMED BEST AND WORST CASE SOIL CONDITIONS (UNIFORM ALONG ENTIRE EMBEDDED FND. LENGTH) FOR EACH MAST ARM OVERHEAD SIGN/TRAFFIC SIGNAL USING DESIGN CHARTS INCLUDED IN MAINEDOT STANDARD DETAILS (NOV. 2014 EDITION).

FOUNDATION NO. 1: FND. DIAMETER = 36.0 IN. ; APPLICABLE TEST BORING = BB-BROV-302

MOMENT = 60 KIP-FT (112 SAY 110 KIP-FT)
TORSION = 45 KIP-FT (84 SAY 85 KIP-FT)
ASSUME GRANULAR SOIL ($\phi = 28°$ AND $\phi = 34°$)
ASSUME COHESIVE SOIL ($S_u = 400$ PSF AND $S_u = 1{,}200$ PSF)

BENDING MOMENT = 60 KIP-FT (112 SAY 110 KIP-FT)

ϕ = 28°	ϕ = 34°	S_u = 400 PSF	S_u = 1,200 PSF
13 FT 11 FT	12 FT 10 FT	18 FT 14 FT	12 FT 10 FT

TORSION = 45 KIP-FT (84 SAY 85 KIP-FT)

ϕ = 28°	ϕ = 34°	S_u = 400 PSF	S_u = 1,200 PSF
20 FT 14 FT	12 FT 10 FT	20 FT 20 FT	16 FT 11 FT

∴ SINCE TOP OF BEDROCK ENCOUNTERED IN BB-BROV-302 @ ~ 7 FT BGS (< MIN. REQ'D FND. LENGTH SUMMARIZED ABOVE), CONSTRUCT FOUNDATION NO. 1 IN ACCORDANCE WITH MAINEDOT STD. DETAIL 626 (06).

100% Post-consumer waste

HALEY ALDRICH

CALCULATIONS

Client	MAINEDOT	File No.	40725-010
Project	ROUTE 1 VIADUCT BRIDGE REHABILITATION	Sheet	2 of 2
Subject	MAST ARM OVERHEAD SIGN/TRAFFIC SIGNAL FOUNDATIONS	Date	11/2/2015
		Computed By	BCS
		Checked By	JLL

FOUNDATION NO. 2: FND. DIAMETER = 36.0 IN.; APPLICABLE TEST BORING BB-BROV-301

MOMENT = 40 KIP-FT (75 KIP-FT)
TORSION = 19 KIP-FT (SAY 20 KIP-FT) (36 SAY 35 KIP-FT)
ASSUME GRANULAR SOIL (ϕ = 28° AND ϕ = 34°)
ASSUME COHESIVE SOIL (S_u = 400 PSF AND S_u = 1,200 PSF)

BENDING MOMENT = 40 KIP-FT (75 KIP-FT)

ϕ = 28°	ϕ = 34°	S_u = 400 PSF	S_u = 1,200 PSF
12 FT	11 FT	16 FT	11 FT
10 FT	10 FT	12 FT	10 FT

∴ BASED ON SPT N60 VALUES IN MARINE CLAY (28, 15), APPROXIMATE 2,000 PSF < S_u < 4,000 PSF, ASSUME MARINE CLAY PRESENT ALONG ENTIRE EMBEDDED LENGTH.
SO... L = 11 FT (FACT. LOADS) FOR S_u = 1200 PSF (CHART MAX.)

TORSION = 19 KIP-FT (SAY 20 KIP-FT) (36 SAY 25 KIP-FT)

ϕ = 28°	ϕ = 34°	S_u = 400 PSF	S_u = 1,200 PSF
12 FT	10 FT	8 FT	11 FT
10 FT	10 FT	13 FT	10 FT

FOUNDATION NO. 3: FND. DIAMETER = 36.0 IN.; APPLICABLE TEST BORING BB-BROV-303

MOMENT = 46 KIP-FT (SAY 45 KIP-FT) (86 SAY 85 KIP-FT)
TORSION = 24 KIP-FT (SAY 25 KIP-FT) (45 KIP-FT)
ASSUME GRANULAR SOIL (ϕ = 28° AND ϕ = 34°)
ASSUME COHESIVE SOIL (S_u = 400 PSF AND S_u = 1,200 PSF)

BENDING MOMENT = 46 KIP-FT (SAY 45 KIP-FT) (86 SAY 85 KIP-FT)

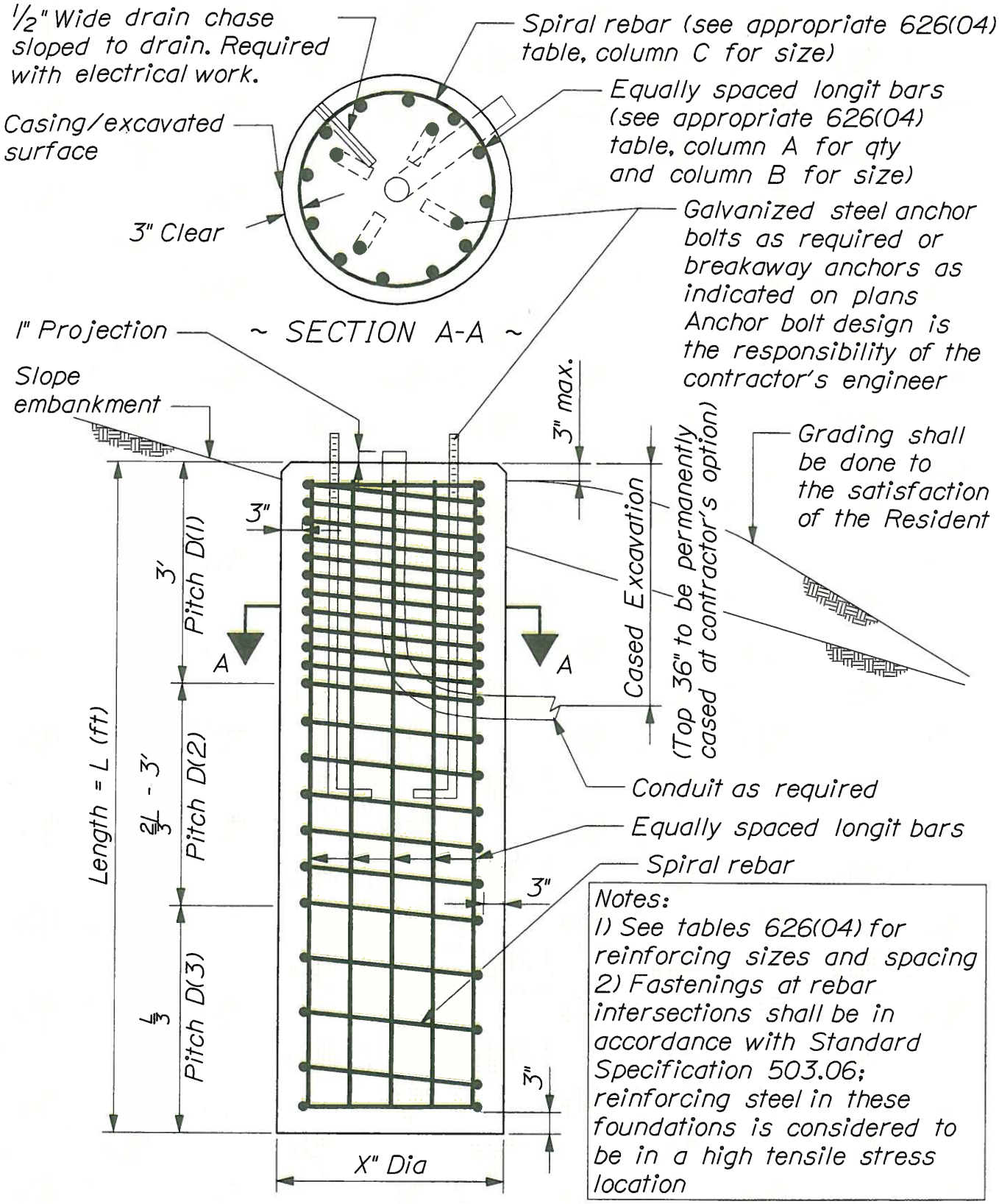
ϕ = 28°	ϕ = 34°	S_u = 400 PSF	S_u = 1,200 PSF
12 FT	11 FT	7 FT	12 FT
10 FT	10 FT	13 FT	10 FT

∴ SINCE TOP OF BEDROCK ENCOUNTERED IN BB-BROV-303 @ ~5.5 FT BGS (< MIN. REQ'D FND LENGTH), CONSTRUCT FND. NO. 3 IN ACCORDANCE WITH MAINEDOT STD. DETAIL 626(06).

TORSION = 24 KIP-FT (SAY 25 KIP-FT) (45 KIP-FT)

ϕ = 28°	ϕ = 34°	S_u = 400 PSF	S_u = 1,200 PSF
14 FT	10 FT	20 FT	11 FT
11 FT	10 FT	12 FT	10 FT

100% Post-consumer waste



Notes:
1) See tables 626(04) for reinforcing sizes and spacing
2) Fastenings at rebar intersections shall be in accordance with Standard Specification 503.06; reinforcing steel in these foundations is considered to be in a high tensile stress location

~ 30" to 60" DIA. FOUNDATION ~
ITEM NO. 626.331 and 626.332

FOUNDATIONS FOR TRAFFIC SIGNALS, HIGHWAY SIGNING AND LIGHTING

626(03)

Chart P28-1 - Foundation Length L (ft.) Based on Bending Moment (φ=28 deg)

BENDING MOMENT (kip-ft.)	FOUNDATION DIAMETER (inches) X					
	30	36	42	48	54	60
10	10					
20	10					
30	10					
40	10	10				
50	11	10	10			
60	11	11	10	10		
70	12	11	11	10	10	
80	12	12	11	11	10	10
90	12	12	11	11	11	10
100	13	12	12	11	11	11
110	13	13	12	12	11	11
120	14	13	12	12	12	11
130	14	13	13	12	12	11
140	14	13	13	12	12	12
150	15	14	13	13	12	12
160	15	14	13	13	12	12
170	15	14	14	13	13	12
180	15	15	14	13	13	12
190	16	15	14	14	13	13
200	16	15	14	14	13	13

Chart P28-2 - Foundation Length L (ft.) Based on Torsion (φ=28 deg)

TORSION (kip-ft.)	FOUNDATION DIAMETER (inches) X					
	30	36	42	48	54	60
10	10	10				
20	11	10	10			
30	13	11	10	10		
40	16	13	11	10	10	
50	18	15	12	11	10	10
60	20	16	14	12	11	10
70		17	15	13	11	10
80		19	16	14	12	11
90		20	17	15	13	12
100			18	15	14	12
110			19	16	14	13
120			20	17	15	13
130				18	16	14
140				19	16	15
150				19	17	15
160				20	18	16
170					19	16
180					19	17
190					20	17
200					20	18

Chart P28-3 - Summary of Reinforcing Steel (φ=28 deg) (for Charts P28-1 and P28-2)

Foundation Diameter X (ft)	Moment (kip-feet)	Torsion (kip-feet)	QTY Longit Bars A	Longit Bar Size B	Spiral Bar Size C	Spiral Spacing (0 to 3 ft) D1(in)	Spiral Spacing (3 ft to 2L/3 ft) D2 (in)	Spiral Spacing (2L/3 ft to tip) D3 (in)
2.5	$0 \le M \le 200$	$0 \le T \le 60$	12	#8	#5	4	12	12
3.0	$0 \le M \le 200$	$0 \le T \le 90$	15	#8	#5	4	12	12
3.5	$0 \le M \le 200$	$0 \le T \le 120$	18	#9	#5	4	12	12
4.0	$0 \le M \le 200$	$0 \le T \le 160$	21	#9	#5	4	12	12
4.5	$0 \le M \le 200$	$0 \le T \le 200$	24	#10	#5	4	12	12
5.0	$0 \le M \le 200$	$0 \le T \le 200$	27	#10	#5	4	12	12

Notes: Minimum clear cover to the reinforcing shall be 3 inches.
Spiral spacing shall be measured from the top of the foundation.

ITEM NOS. 626.331 AND 626.332 for SOILS WITH φ=28 deg.

Chart P30-1 - Foundation Length L (ft.) Based on Bending Moment (φ=30 deg)

BENDING MOMENT (kip-ft.)	FOUNDATION DIAMETER (inches) X					
	30	36	42	48	54	60
10						
20						
30						
40						
50	10					
60	11	10				
70	11	11	10			
80	12	11	11	10		
90	12	12	11	11	10	
100	13	12	11	11	11	10
110	13	12	12	11	11	11
120	13	13	12	12	11	11
130	14	13	12	12	12	11
140	14	13	13	12	12	11
150	14	13	13	12	12	12
160	14	14	13	13	12	12
170	15	14	13	13	12	12
180	15	14	14	13	13	12
190	15	14	14	13	13	12
200	16	15	14	13	13	13

Chart P30-2 - Foundation Length L (ft.) Based on Torsion (φ=30 deg)

TORSION (kip-ft.)	FOUNDATION DIAMETER (inches) X					
	30	36	42	48	54	60
10						
20	10					
30	11	10				
40	13	11				
50	14	12	10			
60	15	13	11			
70	17	14	12	10		
80	18	15	13	11	10	
90	20	16	13	12	11	
100		17	14	12	11	10
110		18	15	13	12	11
120		19	16	14	12	11
130		20	16	14	13	11
140			17	15	13	12
150			18	15	13	12
160			18	16	14	13
170			19	16	14	13
180			20	17	15	13
190			20	17	15	14
200				18	16	14

ITEM NOS. 626.331 AND 626.332 for SOILS WITH φ=30 deg.

Chart P30-3 - Summary of Reinforcing Steel (φ=30 deg) (for Charts P30-1 and P30-2)

Foundation Diameter X (feet)	Moment (kip-feet)	Torsion (kip-feet)	QTY Longit Bars A	Longit Bar Size B	Spiral Bar Size C	Spiral Spacing (0 to 3 ft) D1 (in)	Spiral Spacing (3 ft to 2L/3 ft) D2 (in)	Spiral Spacing (2L/3 ft to tip) D3 (in)
2.5	0 ≤ M ≤ 200	0 ≤ T ≤ 60	12	#8	#5	4	12	12
		60 < T ≤ 80	12	#8	#5	4	8	12
		80 < T ≤ 90	12	#8	#5	4	8	8
3.0	0 ≤ M ≤ 200	0 ≤ T ≤ 100	15	#8	#5	4	12	12
		100 < T ≤ 130	15	#8	#5	4	8	12
3.5	0 ≤ M ≤ 200	0 ≤ T ≤ 150	18	#9	#5	4	12	12
		150 < T ≤ 190	18	#9	#5	4	8	12
4.0	0 ≤ M ≤ 200	0 ≤ T ≤ 200	21	#9	#5	4	12	12
4.5	0 ≤ M ≤ 200	0 ≤ T ≤ 200	24	#10	#5	4	12	12
5.0	0 ≤ M ≤ 200	0 ≤ T ≤ 200	27	#10	#5	4	12	12

Notes: Minimum clear cover to the reinforcing shall be 3 inches.
Spiral spacing shall be measured from the top of the foundation.

ITEM NOS. 626.331 AND 626.332 for SOILS WITH φ=30 deg.

Chart P32-1 - Foundation Length L (ft.) Based on Bending Moment (φ=32 deg)

BENDING MOMENT (kip-ft.)	FOUNDATION DIAMETER (inches) X					
	30	36	42	48	54	60
10						
20						
30						
40						
50	10					
60	11	10				
70	11	11				
80	11	11	10			
90	12	11	11	10		
100	12	12	11	11	10	
110	12	12	11	11	11	10
120	13	12	12	11	11	11
130	13	12	12	11	11	11
140	13	13	12	12	11	11
150	14	13	12	12	12	11
160	14	13	13	12	12	11
170	14	13	13	12	12	12
180	14	14	13	13	12	12
190	15	14	13	13	12	12
200	15	14	13	13	12	12

Chart P32-2 - Foundation Length L (ft.) Based on Torsion (φ=32 deg)

TORSION (kip-ft.)	FOUNDATION DIAMETER (inches) X					
	30	36	42	48	54	60
10						
20						
30	10					
40	11					
50	12	10				
60	13	11				
70	14	12	10			
80	15	13	11			
90	16	13	12	10		
100	17	14	12	11		
110	19	15	13	11		
120	20	16	13	12	10	
130	20	16	14	12	11	
140		17	14	13	11	10
150		18	15	13	12	11
160		19	16	13	12	11
170		19	16	14	12	11
180		20	17	14	13	11
190			17	15	13	12
200			18	15	13	12

ITEM NOS. 626.331 AND 626.332 for SOILS WITH φ=32 deg.

Chart P32-3 - Summary of Reinforcing Steel (φ=32 deg) (for Charts P32-1 and P32-2)

Foundation Diameter X (feet)	Moment (kip-feet)	Torsion (kip-feet)	QTY Longit Bars A	Longit Bar Size B	Spiral Bar Size C	Spiral Spacing (0 to 3 ft) D1 (in)	Spiral Spacing (3 ft to 2L/3 ft) D2 (in)	Spiral Spacing (2L/3 ft to tip) D3 (in)
2.5	0 ≤ M ≤ 200	0 ≤ T ≤ 60	12	#8	#5	4	12	12
		60 < T ≤ 70	12	#8	#5	4	8	12
		70 < T ≤ 90	12	#8	#5	4	8	8
		90 < T ≤ 120	12	#8	#5	4	4	8
		120 < T ≤ 130	12	#8	#5	4	4	4
3.0	0 ≤ M ≤ 200	0 ≤ T ≤ 100	15	#8	#5	4	12	12
		100 < T ≤ 110	15	#8	#5	4	8	12
		110 < T ≤ 150	15	#8	#5	4	8	8
		150 < T ≤ 180	15	#8	#5	4	4	8
3.5	0 ≤ M ≤ 200	0 ≤ T ≤ 150	18	#9	#5	4	12	12
		150 < T ≤ 160	18	#9	#5	4	8	12
		160 < T ≤ 200	18	#9	#5	4	8	8
4.0	0 ≤ M ≤ 200	0 ≤ T ≤ 200	21	#9	#5	4	12	12
4.5	0 ≤ M ≤ 200	0 ≤ T ≤ 200	24	#10	#5	4	12	12
5.0	0 ≤ M ≤ 200	0 ≤ T ≤ 200	27	#10	#5	4	12	12

Notes: Minimum clear cover to the reinforcing shall be 3 inches.
Spiral spacing shall be measured from the top of the foundation.

ITEM NOS. 626.331 AND 626.332 for SOILS WITH φ=32 deg.

Chart P34-1 - Foundation Length L (ft.) Based on Bending Moment (φ=34 deg)

BENDING MOMENT (kip-ft.)	FOUNDATION DIAMETER (inches) X					
	30	36	42	48	54	60
10						
20						
30						
40						
50						
60	10					
70	11	10				
80	11	11	10			
90	12	11	11	10		
100	12	11	11	11		
110	12	12	11	11	10	
120	12	12	11	11	11	10
130	13	12	12	11	11	11
140	13	12	12	11	11	11
150	13	13	12	12	11	11
160	14	13	12	12	11	11
170	14	13	13	12	12	11
180	14	13	13	12	12	12
190	14	14	13	12	12	12
200	15	14	13	13	12	12

Chart P34-2 - Foundation Length L (ft.) Based on Torsion (φ=34 deg)

TORSION (kip-ft.)	FOUNDATION DIAMETER (inches) X					
	30	36	42	48	54	60
10						
20						
30						
40	10					
50	11					
60	12	10				
70	13	11				
80	13	11				
90	14	12	10			
100	15	13	11			
110	16	13	11			
120	17	14	12	10		
130	18	14	12	11		
140	18	15	13	11		
150	19	16	13	12	10	
160	20	16	14	12	11	
170		17	14	12	11	
180		17	15	13	11	
190		18	15	13	12	10
200		18	15	13	12	11

ITEM NOS. 626.331 AND 626.332 for SOILS WITH φ=34 deg.

Chart P34-3 - Summary of Reinforcing Steel (φ=34 deg) (for Charts P34-1 and P34-2)

Foundation Diameter X (feet)	Moment (kip-feet)	Torsion (kip-feet)	QTY Longit Bars A	Longit Bar Size B	Spiral Bar Size C	Spiral Spacing (0 to 3 ft) D1 (in)	Spiral Spacing (3 ft to 2L/3 ft) D2 (in)	Spiral Spacing (2L/3 ft to tip) D3 (in)
2.5	0 ≤ M ≤ 200	0 ≤ T ≤ 60	12	#8	#5	4	12	12
		60 < T ≤ 70	12	#8	#5	4	8	12
		70 < T ≤ 100	12	#8	#5	4	8	8
		100 < T ≤ 110	12	#8	#5	4	4	8
		110 < T ≤ 160	12	#8	#5	4	4	4
3.0	0 ≤ M ≤ 200	0 ≤ T ≤ 100	15	#8	#5	4	12	12
		100 < T ≤ 110	15	#8	#5	4	8	12
		110 < T ≤ 150	15	#8	#5	4	8	8
		150 < T ≤ 180	15	#8	#5	4	4	8
		180 < T ≤ 200	15	#8	#5	4	4	4
3.5	0 ≤ M ≤ 200	0 ≤ T ≤ 150	18	#9	#5	4	12	12
		150 < T ≤ 160	18	#9	#5	4	8	12
		160 < T ≤ 200	18	#9	#5	4	8	8
4.0	0 ≤ M ≤ 200	0 ≤ T ≤ 200	21	#9	#5	4	12	12
4.5	0 ≤ M ≤ 200	0 ≤ T ≤ 200	24	#10	#5	4	12	12
5.0	0 ≤ M ≤ 200	0 ≤ T ≤ 200	27	#10	#5	4	12	12

Notes: Minimum clear cover to the reinforcing shall be 3 inches.
Spiral spacing shall be measured from the top of the foundation.

ITEM NOS. 626.331 AND 626.332 for SOILS WITH φ=34 deg.

Chart S400-1 - Foundation Length L (ft.) Based on Bending Moment (Su=400 psf)

BENDING MOMENT (kip-ft.)	FOUNDATION DIAMETER (inches) X					
	30	36	42	48	54	60
10	10	10				
20	11	11	10	10	10	
30	12	12	11	11	11	10
40	13	12	12	12	11	11
50	14	14	13	13	12	12
60	15	14	14	13	13	13
70	16	15	15	14	14	13
80	17	16	15	15	14	14
90	18	17	16	15	15	14
100	19	18	17	16	15	15
110	20	18	17	16	16	15
120		19	18	17	16	16
130		20	18	17	17	16
140			19	18	17	17
150			20	18	18	17
160				19	18	18
170				20	19	18
180					19	19
190					20	19
200					20	19

Chart S400-2 - Foundation Length L (ft.) Based on Torsion (Su=400 psf)

TORSION (kip-ft.)	FOUNDATION DIAMETER (inches) X					
	30	36	42	48	54	60
10	11	10	10			
20	16	13	11	10		
30		16	13	11	10	10
40		20	16	13	12	11
50			18	15	13	12
60				17	15	13
70				19	17	14
80					18	16
90					20	17
100						18
110						20
120						
130						
140						
150						
160						
170						
180						
190						
200						

Chart S400-3 - Summary of Reinforcing Steel (Su=400 psf) (for Charts S400-1 and S400-2)

Foundation Diameter X (feet)	Moment (kip-feet)	Torsion (kip-feet)	QTY Longit Bars A	Longit Bar Size B	Spiral Bar Size C	Spiral Spacing (0 to 3 ft) D1 (in)	Spiral Spacing (3 ft to 2L/3 ft) D2 (in)	Spiral Spacing (2L/3 ft to tip) D3 (in)
2.5	$0 \le M \le 110$	$0 \le T \le 20$	12	#8	#5	4	12	12
3.0	$0 \le M \le 130$	$0 \le T \le 40$	15	#8	#5	4	12	12
3.5	$0 \le M \le 150$	$0 \le T \le 50$	18	#9	#5	4	12	12
4.0	$0 \le M \le 170$	$0 \le T \le 70$	21	#9	#5	4	12	12
4.5	$0 \le M \le 200$	$0 \le T \le 90$	24	#10	#5	4	12	12
5.0	$0 \le M \le 200$	$0 \le T \le 110$	27	#10	#5	4	12	12

Notes: Minimum clear cover to the reinforcing shall be 3 inches.
Spiral spacing shall be measured from the top of the foundation.

ITEM NOS. 626.331 AND 626.332 for SOILS WITH Su=400 psf

Chart S600-1 - Foundation Length L (ft.) Based on Bending Moment (Su=600 psf)

BENDING MOMENT (kip-ft.)	FOUNDATION DIAMETER (inches) X					
	30	36	42	48	54	60
10	10					
20	10					
30	11	10	10	10		
40	12	11	11	11	10	10
50	12	12	12	11	11	11
60	13	13	12	12	11	11
70	14	13	13	12	12	12
80	15	14	13	13	13	12
90	15	14	14	13	13	13
100	16	15	14	14	13	13
110	17	15	15	14	14	14
120	17	16	15	15	14	14
130	18	17	16	15	14	14
140	19	17	16	16	15	15
150	19	18	17	16	15	15
160	20	18	17	16	16	15
170	20	19	17	17	16	16
180		19	18	17	16	16
190		20	18	17	17	16
200		20	19	18	17	17

Chart S600-2 - Foundation Length L (ft.) Based on Torsion (Su=600 psf)

TORSION (kip-ft.)	FOUNDATION DIAMETER (inches) X					
	30	36	42	48	54	60
10	10					
20	12	10	10			
30	16	13	11	10		
40	19	15	12	11	10	
50		17	14	12	11	10
60		20	16	13	12	11
70			18	15	13	11
80			19	16	14	12
90				17	15	13
100				19	16	14
110				20	17	15
120					18	16
130					19	17
140					20	17
150						18
160						19
170						20
180						
190						
200						

Chart S600-3 - Summary of Reinforcing Steel (Su=600 psf) (for Charts S600-1 and S600-2)

Foundation Diameter X (feet)	Moment (kip-feet)	Torsion (kip-feet)	QTY Longit Bars A	Longit Bar Size B	Spiral Bar Size C	Spiral Spacing (0 to 3 ft) D1 (in)	Spiral Spacing (3 ft to 2L/3 ft) D2 (in)	Spiral Spacing (2L/3 ft to tip) D3 (in)
2.5	$0 \le M \le 170$	$0 \le T \le 40$	12	#8	#5	4	12	12
3.0	$0 \le M \le 200$	$0 \le T \le 60$	15	#8	#5	4	12	12
3.5	$0 \le M \le 200$	$0 \le T \le 80$	18	#9	#5	4	12	12
4.0	$0 \le M \le 200$	$0 \le T \le 110$	21	#9	#5	4	12	12
4.5	$0 \le M \le 200$	$0 \le T \le 140$	24	#10	#5	4	12	12
5.0	$0 \le M \le 200$	$0 \le T \le 170$	27	#10	#5	4	12	12

Notes: Minimum clear cover to the reinforcing shall be 3 inches.
Spiral spacing shall be measured from the top of the foundation.

ITEM NOS. 626.331 AND 626.332 for SOILS WITH Su=600 psf

Chart S800-1 - Foundation Length L (ft.) Based on Bending Moment (Su=800 psf)

BENDING MOMENT (kip-ft.)	FOUNDATION DIAMETER (inches) X					
	30	36	42	48	54	60
10						
20						
30	10					
40	11	10	10			
50	12	11	11	10	10	
60	12	12	11	11	11	10
70	13	12	12	11	11	11
80	13	13	12	12	12	11
90	14	13	13	12	12	12
100	14	14	13	13	12	12
110	15	14	13	13	13	12
120	15	14	14	13	13	13
130	16	15	14	14	13	13
140	16	15	15	14	14	13
150	17	16	15	14	14	14
160	17	16	15	15	14	14
170	18	16	16	15	15	14
180	18	17	16	15	15	14
190	19	17	16	16	15	15
200	20	18	17	16	15	15

Chart S800-2 - Foundation Length L (ft.) Based on Torsion (Su=800 psf)

TORSION (kip-ft.)	FOUNDATION DIAMETER (inches) X					
	30	36	42	48	54	60
10	10					
20	11	10				
30	13	12	10			
40	16	13	11			
50	18	15	12	10		
60		16	13	11	10	
70		18	15	12	11	10
80		20	16	13	12	11
90			17	14	13	11
100			18	15	13	12
110			20	16	14	13
120				17	15	13
130				18	16	14
140				19	17	14
150				20	17	15
160					18	16
170					19	16
180					20	17
190					20	18
200						18

Chart S800-3 - Summary of Reinforcing Steel (Su=800 psf) (for Charts S800-1 and S800-2)

Foundation Diameter X (feet)	Moment (kip-feet)	Torsion (kip-feet)	QTY Longit Bars A	Longit Bar Size B	Spiral Bar Size C	Spiral Spacing (0 to 3 ft) D1 (in)	Spiral Spacing (3 ft to 2L/3 ft) D2 (in)	Spiral Spacing (2L/3 ft to tip) D3 (in)
2.5	$0 \le M \le 200$	$0 \le T \le 50$	12	#8	#5	4	12	12
3.0	$0 \le M \le 200$	$0 \le T \le 80$	15	#8	#5	4	12	12
3.5	$0 \le M \le 200$	$0 \le T \le 110$	18	#9	#5	4	12	12
4.0	$0 \le M \le 200$	$0 \le T \le 150$	21	#9	#5	4	12	12
4.5	$0 \le M \le 200$	$0 \le T \le 190$	24	#10	#5	4	12	12
5.0	$0 \le M \le 200$	$0 \le T \le 200$	27	#10	#5	4	12	12

Notes: Minimum clear cover to the reinforcing shall be 3 inches.
Spiral spacing shall be measured from the top of the foundation.

ITEM NOS. 626.331 AND 626.332 for SOILS WITH Su=800 psf

Chart S1200-1 - Foundation Length L (ft.) Based on Bending Moment (Su=1,200 psf)

BENDING MOMENT (kip-ft.)	FOUNDATION DIAMETER (inches) X					
	30	36	42	48	54	60
10						
20						
30						
40						
50	10					
60	11	10	10			
70	11	11	11	10	10	
80	12	11	11	11	11	
90	12	12	11	11	11	10
100	13	12	12	11	11	11
110	13	12	12	12	11	11
120	13	13	12	12	12	11
130	14	13	13	12	12	12
140	14	13	13	12	12	12
150	14	14	13	13	12	12
160	15	14	13	13	13	13
170	15	14	14	13	13	13
180	15	14	14	13	13	13
190	16	15	14	14	13	13
200	16	15	14	14	13	13

Chart S1200-2 - Foundation Length L (ft.) Based on Torsion (Su=1,200 psf)

TORSION (kip-ft.)	FOUNDATION DIAMETER (inches) X					
	30	36	42	48	54	60
10						
20	10					
30	11					
40	12	10				
50	14	11	10			
60	16	13	11			
70	17	14	12	10		
80	19	15	12	11		
90		16	13	11	10	
100		17	14	12	11	
110		18	15	13	11	10
120		20	16	13	12	11
130			17	14	12	11
140			18	15	13	11
150			18	15	13	12
160			19	16	14	12
170			20	17	14	13
180				17	15	13
190				18	15	14
200				19	16	14

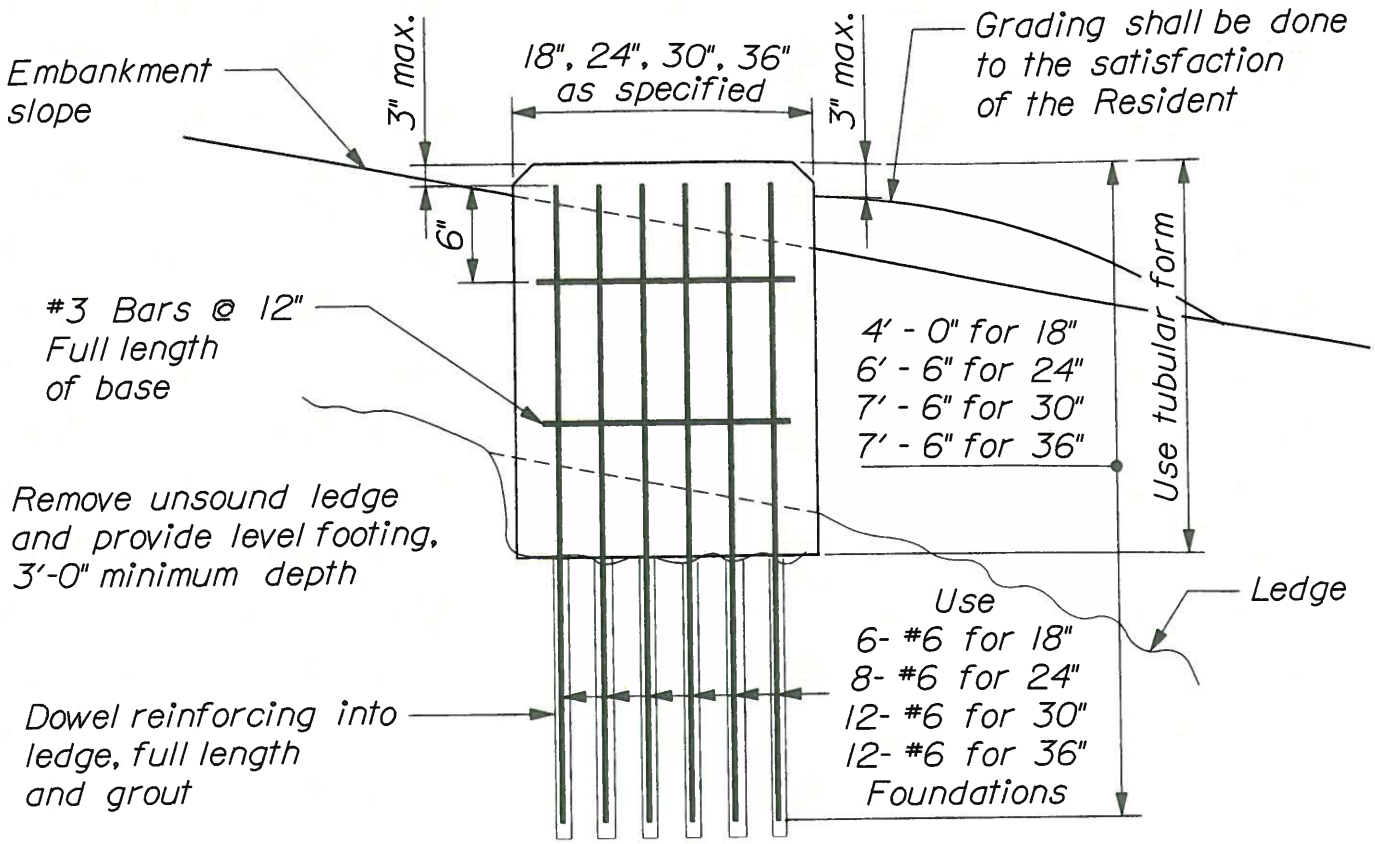
ITEM NOS. 626.331 AND 626.332 for SOILS WITH Su=1200 psf

Chart S1200-3 - Summary of Reinforcing Steel (Su=1,200 psf) (for Charts S1200-1 and S1200-2)

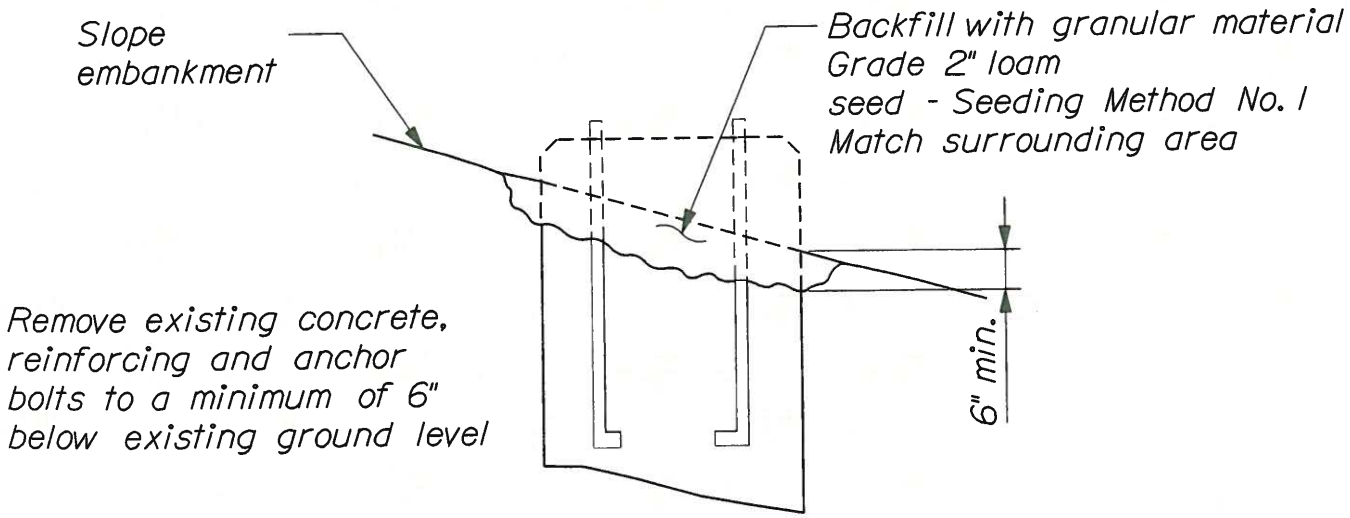
Foundation Diameter X (feet)	Moment (kip-feet)	Torsion (kip-feet)	QTY Longit Bars A	Longit Bar Size B	Spiral Bar Size C	Spiral Spacing (0 to 3 ft) D1 (in)	Spiral Spacing (3 ft to 2L/3 ft) D2 (in)	Spiral Spacing (2L/3 ft to tip) D3 (in)
2.5	0 ≤ M ≤ 200	0 ≤ T ≤ 60	12	#8	#5	4	12	12
		60 < T ≤ 80	12	#8	#5	4	8	12
3.0	0 ≤ M ≤ 200	0 ≤ T ≤ 100	15	#8	#5	4	12	12
		100 < T ≤ 120	15	#8	#5	4	8	12
3.5	0 ≤ M ≤ 200	0 ≤ T ≤ 140	18	#9	#5	4	12	12
		140 < T ≤ 170	18	#9	#5	4	8	12
4.0	0 ≤ M ≤ 200	0 ≤ T ≤ 200	21	#9	#5	4	12	12
4.5	0 ≤ M ≤ 200	0 ≤ T ≤ 200	24	#10	#5	4	12	12
5.0	0 ≤ M ≤ 200	0 ≤ T ≤ 200	27	#10	#5	4	12	12

Notes: Minimum clear cover to the reinforcing shall be 3 inches.
Spiral spacing shall be measured from the top of the foundation.

ITEM NOS. 626.331 AND 626.332 for SOILS WITH Su=1200 psf



~ 18, 24, 30,36 INCH FOUNDATIONS
WHERE SOLID ROCK IS ENCOUNTERED AT LESS THAN
THE REQUIRED DISTANCE BELOW GROUND LEVEL ~



~ REMOVAL OF CONCRETE FOUNDATIONS ~
ITEM NO. 626.36

FOUNDATIONS FOR TRAFFIC SIGNALS, HIGHWAY SIGNING AND LIGHTING

626(06)

HALEY ALDRICH	CALCULATIONS	File No.	40725-010
		Sheet	1 of 4
Client	Maine Department of Transportation	Date	08Oct2015
Project	Traffic Signal Preliminary foundation design	Computed by	JMK
Subject	Global Stability evaluation for foundation support	Checked by	BCS

Objective

-Determine the global stability requirement for bored concrete shafts.

Assumptions

- drilled shaft reinforcement embedded/anchored into bedrock can be simulated in Lpile by incorporating a 3ft rock socket into the model

-The shaft is modeled as a simple linear elastic beam, with the elastic modulus equal to that of concrete (about 4,000,000 psi) and the moment of inertia equal to that of the uncracked circular cross section ($I = \pi D^4/64$)

- A load factor recommended by FHWA (2010) higher than the 1.25 recommended by AASHTO was applied to the shear and moduli parameters

- It is assumed that the Foundation Loads provided by VHB on 09/24/2015 pertain the the loads acting on the top of the shaft

-Compressive strength of concrete is 4000 psi

References

1. AASHTO LRFD Bridge Design Specifications, 7th Edition, 2014
2. FHWA Drilled Shafts: Construction Procedures and LRFD Design Methods, FHWA-NHI-10-016, 2010

Calculations

Resistance Factors

AASHTO Section 10.5.5.2.3 - Resistance Factors for Driven Piles

FHWA Drilled Shaft Manual 10.4 - Resistance Factors for Drilled Shafts

The resistance factors presented in the FHWA (2010) manual for design of drilled shafts are those recommended by AASHTO . However the geotechnical lateral resistances by *p-y* pushover analysis for Strength Limit States used in the LPile analysis are different thanthe lateral resistance factors included in AASHTO Table 10.5.5.2.4.-1. The current AASHTO Specifications assign a resistance factor of 1.00 to the lateral (horizontal) geotechnical resistance for evaluation of strength and extreme event limit states. However, the FHWA (2010) recommends using resistance factors of 0.67 in order to ensure geotechnical stability of drilled shafts under lateral loading.

According to FHWA (2010) Strength at loads higher than the factored design load is necessary to ensure that a ductile lateral load response exists and that there is adequate reserve strength to accommodate site variability and other contingencies. This reserve strength is achieved by including a resistance factor less than one on the geotechnical strength for lateral resistance.

FHWA (2010) recommended that the pushover analysis model of the shaft should converge to a solution at loads that are at least 1/φ times the AASHTO factored design load for each strength limit state load case. Satisfactory convergence would be indicated by computed deflections that are no larger than 10% of the drilled shaft diameter.

LPILE Analysis

There are three Signal/Sign Foundation loads to be evaluationed for the preliminary design. The loads were provided by VHB on 09/24/2015

NAME	Location	Associated Boring	Axial (kip)	Shear (kip)	Moment (kip-ft)	Torsion (k-ft)
Foundation 1	Mast arm @ 1394+82	BB-BROV-302	6.5	3	60	45
Foundation 2	Mast arm @ 1395+40	BB-BROV-301	6	2	40	19
Foundation 3	Mast arm @ 1394+65	BB-BROV-303	6	2	46	24

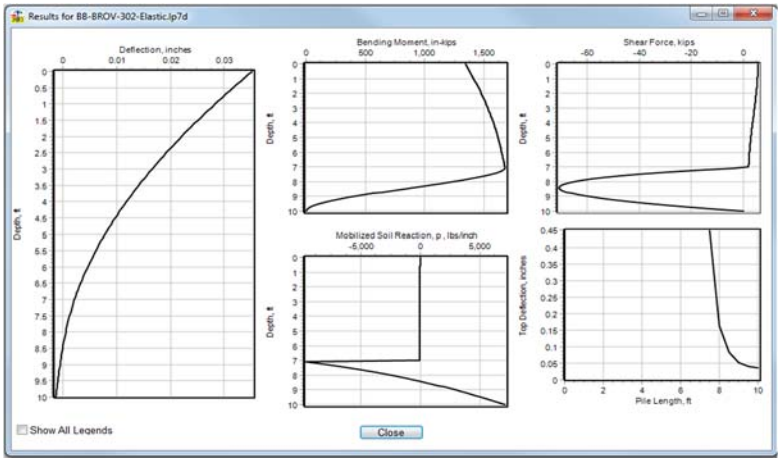
In order to comply with FHWA recommendations the following load factor was applied to the shear and moment portion of the foundation loads

$$\gamma_{FHWA} = \left(\frac{1}{0.67}\right) 1.25 = 1.87$$

Foundation 1 **FF-BROV-302**

Subsurface Profile Depth (ft)	Soil/Rock Type	Unit Wt (pcf)	Friction angle (degree)	Cohesion (psf)	ompressive Strength (psi)
0 to 7.1	Fill	115 to 120	32 to 34	---	---
7.1 to 50	Bedrock	140			5000

STATIC LOADING

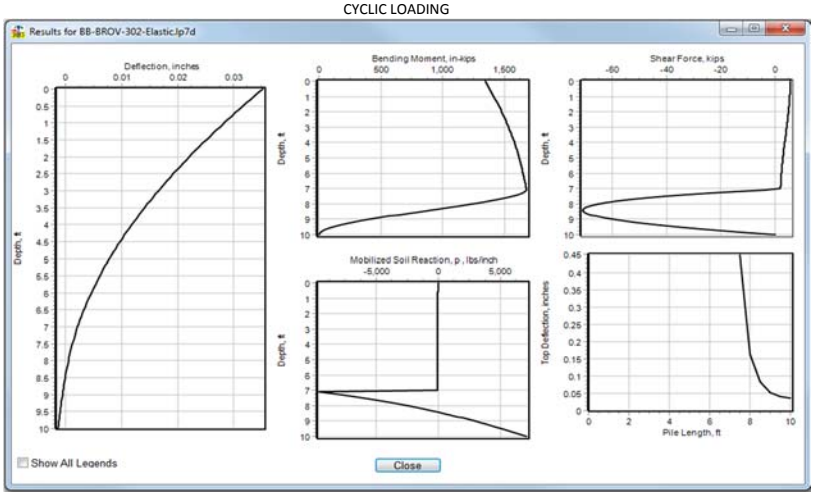


Length of Shaft 7 ft to top of bedrock.

NOTE: A 3ft rock socket was added to the Lpile model to simulate drilled shaft reinforcement embedded into bedrock

Foundation 1 **FF-BROV-302** **(Continued)**

CYCLIC LOADING



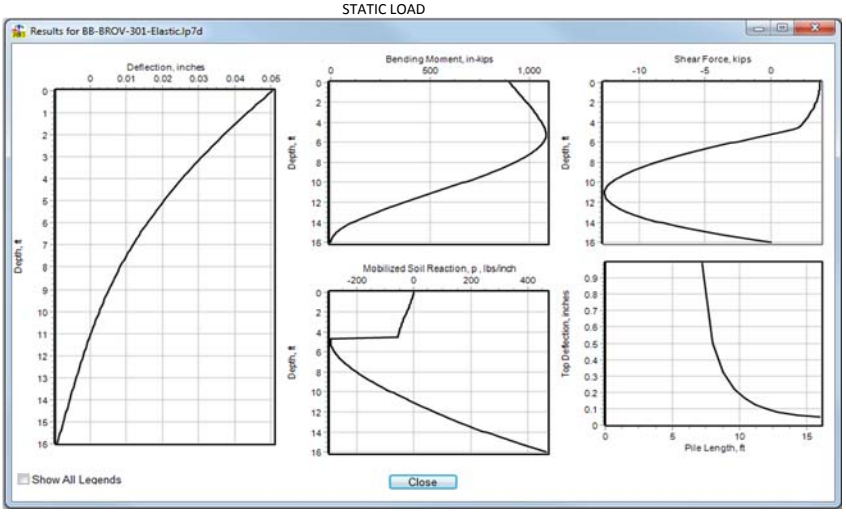
Shaft Diameter (in)	36	**Shaft Length(ft)**	7	Anchored into bedrock

Maximum Deflection (in)	**Maximum Shear** (kip)	**Maximum Moment** (kip-ft)	**Maximum Bending Stess** (psi)	**Maximum Shear Stress** (psi)
0.04	71	139	364	70

Foundation 2 **FF-BROV-301**

Subsurface Profile Depth (ft)	Soil/Rock Type	Unit Wt (pcf)	Friction angle (degree)	Cohesion (psf)	ompressive Strength (psi)
0 to 4.6	Fill	115	28 to 30	---	---
4.6 to 16.1	Silt	120 to 130	28	200 to 300	5000
16.1 to 50	Bedrock	145			5000

STATIC LOAD

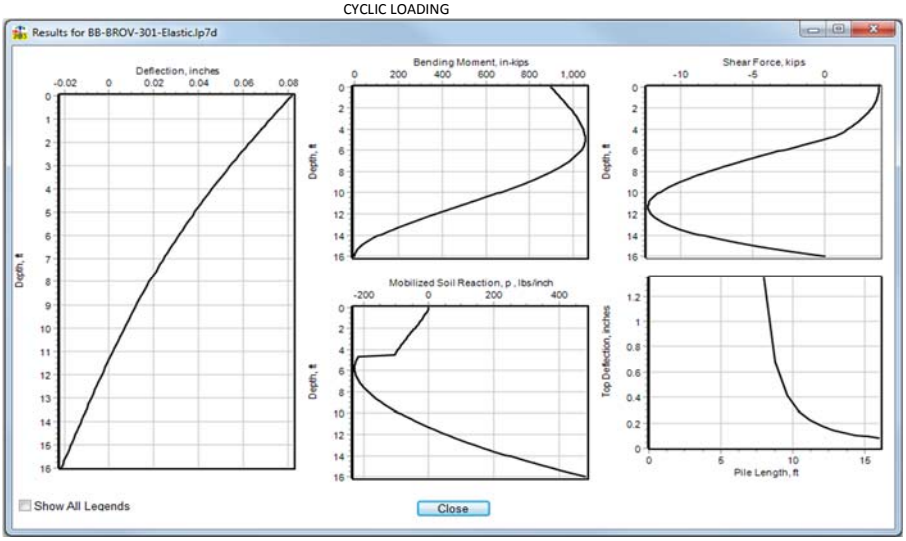


Length of Shaft 16 ft to top of bedrock.

NOTE: The graphs indicate that the shaft has attained fixity without the need to anchor into the bedrock

Foundation 2 **FF-BROV-301** **(Continued)**

CYCLIC LOADING



Shaft Diameter (in) 36 **Shaft Length(ft)** 16

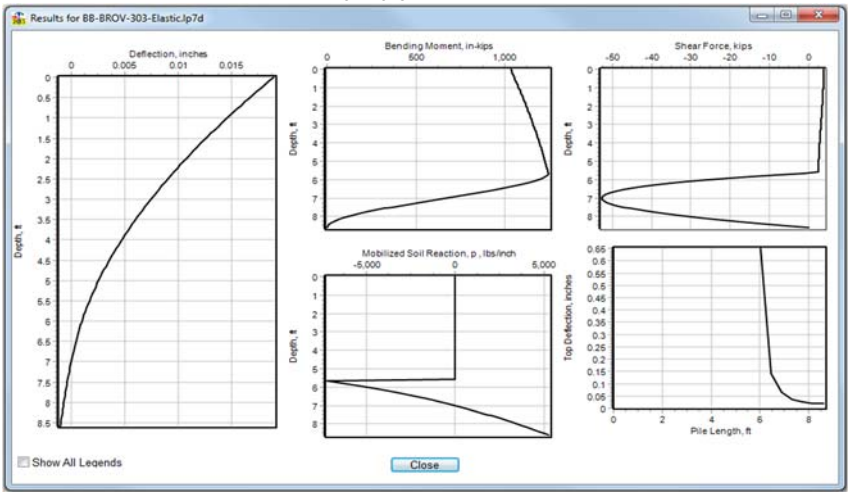
NOTE: The graphs indicate that the shaft has attained fixity without the need to anchor into the bedrock

Maximum Deflection (in)	**Maximum Shear** (kip)	**Maximum Moment** (kip-ft)	**Maximum Bending Stess** (psi)	**Maximum Shear Stress** (psi)
0.08	12	88	230	12

Foundation 3 **FF-BROV-303**

Subsurface Profile Depth (ft)	Soil/Rock Type	Unit Wt (pcf)	Friction angle (degree)	Cohesion (psf)	Compressive Strength (psi)
0 to 5.6	Fill	120 to 130	32 to 34	---	---
5.6 to 50	Bedrock	140			5000

STATIC LOAD

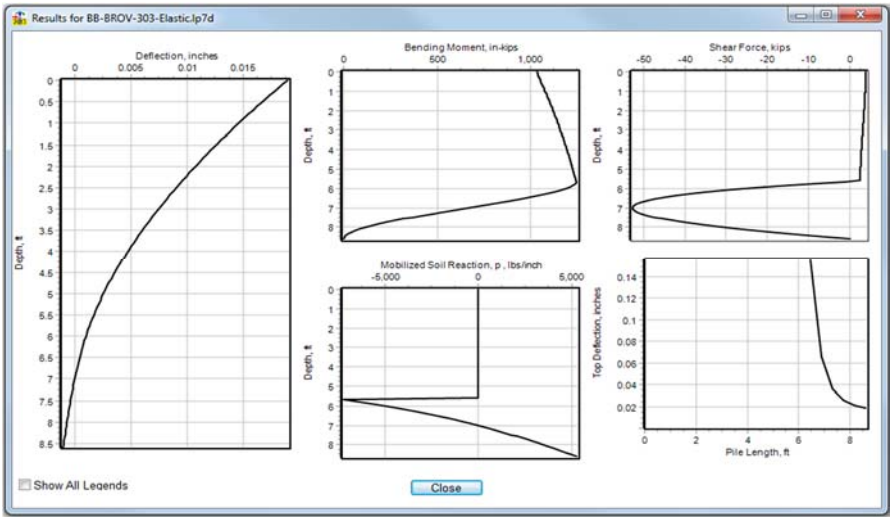


Length of Shaft 5.6 ft to top of bedrock.

NOTE: A 3ft rock socket was added to the Lpile model to simulate drilled shaft reinforcement embedded into bedrock

Foundation 3 **FF-BROV-303** **(Continued)**

CYCLIC LOADING



Shaft Diameter (in) 36 Shaft Length(ft) 5.6

NOTE: The graphs indicate that the shaft has attained fixity without the need to anchor into the bedrock

Maximum Deflection (in)	Maximum Shear (kip)	Maximum Moment (kip-ft)	Maximum Bending Stess (psi)	Maximum Shear Stress (psi)
0.02	53	104	272	52

==========

LPile Plus for Windows, Version 2013-07.007

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method

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Files Used for Analysis

Path to file locations: M:\2015\40725-010 Route 1 Viaduct Maine Traffic Signs\LPILE\
Name of input data file: BB-BROV-302-Elastic.lp7d
Name of output report file: BB-BROV-302-Elastic.lp7o
Name of plot output file: BB-BROV-302-Elastic.lp7p
Name of runtime messeage file: BB-BROV-302-Elastic.lp7r

Date and Time of Analysis

Date: October 9, 2015 Time: 13:50:13

Problem Title

Project Name: Route 1 Viaduct Bridge Rehabilitation Traffic Sign 1

Job Number:

Client:

Engineer: JMK

Description: Traffic Sign at 1394+82

Program Options and Settings

Engineering Units of Input Data and Computations:
- Engineering units are US Customary Units (pounds, feet, inches)

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	100

Loading Type and Number of Cycles of Loading:
- Cyclic loading specified
- Number of cycles of loading = 4636737291354636288

Computational Options:
- Use unfactored loads in computations (conventional analysis)
- Compute pile response under loading and nonlinear bending properties of pile (only if nonlinear pile properties are input)
- Use of p-y modification factors for p-y curves not selected
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:
- No p-y curves to be computed and reported for user-specified depths
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1

Pile Structural Properties and Geometry

Total number of pile sections = 1

Total length of pile = 10.00 ft

Depth of ground surface below top of pile = 0.00 ft

Pile diameter values used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile.

Point	Depth X ft	Pile Diameter in
1	0.00000	36.0000000
2	10.000000	36.0000000

Input Structural Properties:

Pile Section No. 1:

Section Type	=	Elastic Pile
Cross-sectional Shape	=	Circular
Section Length	=	10.00000 ft
Top Width	=	36.00000 in
Bottom Width	=	36.00000 in
Top Area	=	1017.87602 Sq. in
Bottom Area	=	1017.87602 Sq. in
Moment of Inertia at Top	=	82448. in^4
Moment of Inertia at Bottom	=	82448. in^4
Elastic Modulus	=	3604996. lbs/in^2

Ground Slope and Pile Batter Angles

Ground Slope Angle = 0.000 degrees
= 0.000 radians

```
Pile Batter Angle                                    =        0.000 degrees
                                                     =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 2 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer          =       0.0000 ft
   Distance from top of pile to bottom of layer       =      7.10000 ft
   Effective unit weight at top of layer              =    115.00000 pcf
   Effective unit weight at bottom of layer           =    120.00000 pcf
   Friction angle at top of layer                     =     32.00000 deg.
   Friction angle at bottom of layer                  =     34.00000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci

   NOTE: Internal default values for subgrade k will be computed for this soil layer.

Layer 2 is strong rock (vuggy limestone)

   Distance from top of pile to top of layer          =      7.10000 ft
   Distance from top of pile to bottom of layer       =     50.00000 ft
   Effective unit weight at top of layer              =    140.00000 pcf
   Effective unit weight at bottom of layer           =    140.00000 pcf
   Uniaxial compressive strength at top of layer      =   5000.00000 psi
   Uniaxial compressive strength at bottom of layer   =   5000.00000 psi


   (Depth of lowest soil layer extends   40.00 ft below pile tip)


**** Warning - Possible Input Data Error ****

Values entered for effective unit weights of soil were outside
the limits of 0.011574 pci (20 pcf) or 0.0810019 pci (140 pcf)
This data may be erroneous.  Please check your data.


--------------------------------------------------------------------------------
                           Summary of Soil Properties
--------------------------------------------------------------------------------
```

Layer Num.	Layer Soil Type (p-y Curve Criteria)	Layer Depth ft	Effective Unit Wt. pcf	Angle of Friction deg.	Uniaxial qu psi	kpy pci
1	Sand (Reese, et al.)	0.00	115.000	32.000	--	default
		7.100	120.000	34.000	--	default
2	Vuggy Limestone	7.100	140.000	--	5000.000	--
		50.000	140.000	--	5000.000	--

Loading Type

Cyclic loading criteria were used for computation of p-y curves for all analyses.

Number of cycles of loading = 100

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	1	V = 5610.00000 lbs	M = 1346400. in-lbs	6500.00000000	Yes

V = perpendicular shear force applied to pile head
M = bending moment applied to pile head
y = lateral deflection relative to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applie to pile head
Axial thrust is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness
---

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Moment-curvature properties were derived from elastic section properties

---
Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 5610.0 lbs
Applied moment at pile head = 1346400.0 in-lbs
Axial thrust load on pile head = 6500.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/in	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.0352	1346400.	5610.0000	-0.000604	300.3313	2.972E+11	0.000	0.000	0.000
0.10000	0.0345	1353137.	5608.8739	-0.000599	301.8020	2.972E+11	-1.8768	65.2581	0.000
0.200	0.0338	1359871.	5605.3399	-0.000593	303.2722	2.972E+11	-4.0133	142.5006	0.000
0.300	0.0331	1366599.	5599.0774	-0.000588	304.7411	2.972E+11	-6.4244	232.9978	0.000
0.400	0.0324	1373318.	5589.7477	-0.000582	306.2079	2.972E+11	-9.1251	338.1210	0.000
0.500	0.0317	1380023.	5576.9943	-0.000577	307.6719	2.972E+11	-12.1306	459.3502	0.000
0.600	0.0310	1386711.	5560.4421	-0.000571	309.1320	2.972E+11	-15.4563	598.2832	

0.000									
	0.700	0.0303	1393377.	5539.6979	-0.000565	310.5873	2.972E+11	-19.1175	756.6447
0.000									
	0.800	0.0296	1400015.	5514.3495	-0.000560	312.0366	2.972E+11	-23.1298	936.2974
0.000									
	0.900	0.0290	1406620.	5483.9756	-0.000554	313.4786	2.972E+11	-27.4935	1138.6132
0.000									
	1.000	0.0283	1413186.	5449.4611	-0.000548	314.9119	2.972E+11	-30.0306	1272.7407
0.000									
	1.100	0.0277	1419708.	5411.9649	-0.000543	316.3358	2.972E+11	-32.4631	1408.4017
0.000									
	1.200	0.0270	1426183.	5371.6124	-0.000537	317.7494	2.972E+11	-34.7910	1545.5989
0.000									
	1.300	0.0264	1432608.	5328.5292	-0.000531	319.1521	2.972E+11	-37.0143	1684.3354
0.000									
	1.400	0.0257	1438980.	5282.8407	-0.000525	320.5432	2.972E+11	-39.1331	1824.6139
0.000									
	1.500	0.0251	1445295.	5234.6725	-0.000520	321.9220	2.972E+11	-41.1473	1966.4372
0.000									
	1.600	0.0245	1451551.	5184.1497	-0.000514	323.2878	2.972E+11	-43.0573	2109.8084
0.000									
	1.700	0.0239	1457745.	5131.3975	-0.000508	324.6400	2.972E+11	-44.8631	2254.7301
0.000									
	1.800	0.0233	1463874.	5076.5406	-0.000502	325.9782	2.972E+11	-46.5651	2401.2053
0.000									
	1.900	0.0227	1469936.	5019.7033	-0.000496	327.3017	2.972E+11	-48.1637	2549.2368
0.000									
	2.000	0.0221	1475929.	4961.0096	-0.000490	328.6100	2.972E+11	-49.6592	2698.8275
0.000									
	2.100	0.0215	1481850.	4900.5827	-0.000484	329.9028	2.972E+11	-51.0522	2849.9802
0.000									
	2.200	0.0209	1487698.	4838.5456	-0.000478	331.1794	2.972E+11	-52.3431	3002.6978
0.000									
	2.300	0.0203	1493470.	4775.0201	-0.000472	332.4396	2.972E+11	-53.5326	3156.9831
0.000									
	2.400	0.0198	1499166.	4710.1278	-0.000466	333.6830	2.972E+11	-54.6214	3312.8391
0.000									
	2.500	0.0192	1504782.	4643.9889	-0.000460	334.9092	2.972E+11	-55.6101	3470.2685
0.000									
	2.600	0.0187	1510318.	4576.7230	-0.000454	336.1178	2.972E+11	-56.4996	3629.2743
0.000									
	2.700	0.0181	1515773.	4508.4488	-0.000448	337.3088	2.972E+11	-57.2908	3789.8592
0.000									
	2.800	0.0176	1521146.	4439.2835	-0.000442	338.4816	2.972E+11	-57.9846	3952.0262
0.000									
	2.900	0.0171	1526434.	4369.3437	-0.000436	339.6363	2.972E+11	-58.5819	4115.7781
0.000									
	3.000	0.0166	1531639.	4298.7442	-0.000429	340.7725	2.972E+11	-59.0838	4281.1177

0.000									
	3.100	0.0160	1536758.	4227.5990	-0.000423	341.8902	2.972E+11	-59.4916	4448.0479
0.000									
	3.200	0.0155	1541792.	4156.0203	-0.000417	342.9891	2.972E+11	-59.8063	4616.5716
0.000									
	3.300	0.0150	1546739.	4084.1190	-0.000411	344.0692	2.972E+11	-60.0292	4786.6916
0.000									
	3.400	0.0146	1551600.	4012.0045	-0.000404	345.1304	2.972E+11	-60.1616	4958.4108
0.000									
	3.500	0.0141	1556374.	3939.7845	-0.000398	346.1727	2.972E+11	-60.2050	5131.7321
0.000									
	3.600	0.0136	1561062.	3867.5650	-0.000392	347.1961	2.972E+11	-60.1609	5306.6582
0.000									
	3.700	0.0131	1565662.	3795.4501	-0.000386	348.2005	2.972E+11	-60.0306	5483.1921
0.000									
	3.800	0.0127	1570177.	3723.5422	-0.000379	349.1861	2.972E+11	-59.8159	5661.3366
0.000									
	3.900	0.0122	1574605.	3651.9416	-0.000373	350.1529	2.972E+11	-59.5184	5841.0946
0.000									
	4.000	0.0118	1578947.	3580.7466	-0.000367	351.1009	2.972E+11	-59.1399	6022.4689
0.000									
	4.100	0.0113	1583204.	3510.0535	-0.000360	352.0303	2.972E+11	-58.6820	6205.4624
0.000									
	4.200	0.0109	1587377.	3439.9562	-0.000354	352.9413	2.972E+11	-58.1468	6390.0779
0.000									
	4.300	0.0105	1591466.	3370.5464	-0.000347	353.8339	2.972E+11	-57.5362	6576.3183
0.000									
	4.400	0.0101	1595472.	3301.9134	-0.000341	354.7085	2.972E+11	-56.8521	6764.1865
0.000									
	4.500	0.009681	1599396.	3234.1443	-0.000334	355.5652	2.972E+11	-56.0966	6953.6853
0.000									
	4.600	0.009283	1603239.	3167.3231	-0.000328	356.4042	2.972E+11	-55.2719	7144.8176
0.000									
	4.700	0.008893	1607002.	3101.5319	-0.000322	357.2259	2.972E+11	-54.3802	7337.5862
0.000									
	4.800	0.008511	1610688.	3036.8495	-0.000315	358.0304	2.972E+11	-53.4238	7531.9940
0.000									
	4.900	0.008137	1614296.	2973.3522	-0.000309	358.8181	2.972E+11	-52.4050	7728.0438
0.000									
	5.000	0.007771	1617828.	2911.1134	-0.000302	359.5894	2.972E+11	-51.3263	7925.7386
0.000									
	5.100	0.007413	1621287.	2850.2036	-0.000295	360.3445	2.972E+11	-50.1901	8125.0811
0.000									
	5.200	0.007062	1624674.	2790.6901	-0.000289	361.0838	2.972E+11	-48.9990	8326.0742
0.000									
	5.300	0.006719	1627989.	2732.6373	-0.000282	361.8077	2.972E+11	-47.7557	8528.7208
0.000									
	5.400	0.006384	1631236.	2676.1063	-0.000276	362.5166	2.972E+11	-46.4628	8733.0237

0.000									
	5.500	0.006057	1634416.	2621.1547	-0.000269	363.2108	2.972E+11	-45.1231	8938.9858
0.000									
	5.600	0.005738	1637531.	2567.8372	-0.000263	363.8909	2.972E+11	-43.7395	9146.6100
0.000									
	5.700	0.005427	1640583.	2516.2046	-0.000256	364.5572	2.972E+11	-42.3149	9355.8991
0.000									
	5.800	0.005124	1643574.	2466.3043	-0.000249	365.2102	2.972E+11	-40.8522	9566.8559
0.000									
	5.900	0.004829	1646506.	2418.1803	-0.000243	365.8503	2.972E+11	-39.3545	9779.4833
0.000									
	6.000	0.004542	1649382.	2371.8725	-0.000236	366.4781	2.972E+11	-37.8250	9993.7843
0.000									
	6.100	0.004263	1652202.	2327.4174	-0.000229	367.0939	2.972E+11	-36.2669	10210.
0.000									
	6.200	0.003991	1654971.	2284.8472	-0.000223	367.6983	2.972E+11	-34.6834	10427.
0.000									
	6.300	0.003728	1657689.	2244.1905	-0.000216	368.2918	2.972E+11	-33.0778	10647.
0.000									
	6.400	0.003473	1660360.	2205.4717	-0.000209	368.8749	2.972E+11	-31.4536	10868.
0.000									
	6.500	0.003226	1662986.	2168.7109	-0.000203	369.4481	2.972E+11	-29.8143	11090.
0.000									
	6.600	0.002987	1665568.	2133.9242	-0.000196	370.0120	2.972E+11	-28.1635	11315.
0.000									
	6.700	0.002756	1668110.	2101.1232	-0.000189	370.5669	2.972E+11	-26.5047	11541.
0.000									
	6.800	0.002533	1670614.	2070.3154	-0.000182	371.1135	2.972E+11	-24.8417	11769.
0.000									
	6.900	0.002318	1673082.	2041.5033	-0.000176	371.6523	2.972E+11	-23.1783	11998.
0.000									
	7.000	0.002111	1675516.	2014.6854	-0.000169	372.1838	2.972E+11	-21.5183	12229.
0.000									
	7.100	0.001913	1677920.	-3736.8211	-0.000162	372.7085	2.972E+11	-9564.3259	6000000.
0.000									
	7.200	0.001722	1666551.	-14643.	-0.000155	370.2264	2.972E+11	-8612.0171	6000000.
0.000									
	7.300	0.001540	1642780.	-24430.	-0.000149	365.0368	2.972E+11	-7700.0791	6000000.
0.000									
	7.400	0.001366	1607921.	-33147.	-0.000142	357.4264	2.972E+11	-6827.9360	6000000.
0.000									
	7.500	0.001199	1563230.	-40840.	-0.000136	347.6695	2.972E+11	-5994.7433	6000000.
0.000									
	7.600	0.001040	1509907.	-47557.	-0.000130	336.0279	2.972E+11	-5199.4185	6000000.
0.000									
	7.700	0.000888	1449096.	-53341.	-0.000124	322.7518	2.972E+11	-4440.6698	6000000.
0.000									
	7.800	0.000743	1381890.	-58235.	-0.000118	308.0795	2.972E+11	-3717.0242	6000000.

0.000									
7.900	0.000605	1309332.	-62282.	-0.000112	292.2387	2.972E+11	-3026.8536	6000000.	
0.000									
8.000	0.000474	1232416.	-65519.	-0.000107	275.4463	2.972E+11	-2368.4005	6000000.	
0.000									
8.100	0.000348	1152089.	-67984.	-0.000102	257.9093	2.972E+11	-1739.8015	6000000.	
0.000									
8.200	0.000228	1069256.	-69711.	-9.796E-05	239.8254	2.972E+11	-1139.1108	6000000.	
0.000									
8.300	0.000113	984783.	-70733.	-9.381E-05	221.3833	2.972E+11	-564.3220	6000000.	
0.000									
8.400	2.678E-06	899498.	-71080.	-9.001E-05	202.7638	2.972E+11	-13.3886	6000000.	
0.000									
8.500	-0.000103	814193.	-70778.	-8.655E-05	184.1401	2.972E+11	515.7553	6000000.	
0.000									
8.600	-0.000205	729631.	-69854.	-8.343E-05	165.6785	2.972E+11	1025.1760	6000000.	
0.000									
8.700	-0.000303	646545.	-68329.	-8.065E-05	147.5392	2.972E+11	1516.9221	6000000.	
0.000									
8.800	-0.000399	565643.	-66223.	-7.821E-05	129.8768	2.972E+11	1993.0062	6000000.	
0.000									
8.900	-0.000491	487612.	-63554.	-7.608E-05	112.8410	2.972E+11	2455.3882	6000000.	
0.000									
9.000	-0.000581	413116.	-60337.	-7.426E-05	96.5771	2.972E+11	2905.9581	6000000.	
0.000									
9.100	-0.000669	342804.	-56585.	-7.274E-05	81.2267	2.972E+11	3346.5207	6000000.	
0.000									
9.200	-0.000756	277312.	-52310.	-7.148E-05	66.9284	2.972E+11	3778.7792	6000000.	
0.000									
9.300	-0.000841	217261.	-47520.	-7.048E-05	53.8181	2.972E+11	4204.3201	6000000.	
0.000									
9.400	-0.000925	163264.	-42223.	-6.972E-05	42.0296	2.972E+11	4624.5980	6000000.	
0.000									
9.500	-0.001008	115927.	-36424.	-6.915E-05	31.6949	2.972E+11	5040.9209	6000000.	
0.000									
9.600	-0.001091	75848.	-30126.	-6.877E-05	22.9450	2.972E+11	5454.4357	6000000.	
0.000									
9.700	-0.001173	43624.	-23334.	-6.852E-05	15.9099	2.972E+11	5866.1131	6000000.	
0.000									
9.800	-0.001255	19848.	-16048.	-6.840E-05	10.7190	2.972E+11	6276.7337	6000000.	
0.000									
9.900	-0.001337	5109.2275	-8270.2579	-6.835E-05	7.5013	2.972E+11	6686.8735	6000000.	
0.000									
10.000	-0.001419	0.000	0.000	-6.834E-05	6.3858	2.972E+11	7096.8896	3000000.	
0.000									

* The above values of total stress are combined axial and bending stresses.

Output Summary for Load Case No. 1:

```
Pile-head deflection            =      0.0352326 inches
Computed slope at pile head     =     -0.0006042 radians
Maximum bending moment          =       1677920. inch-lbs
Maximum shear force             =        -71080. lbs
Depth of maximum bending moment =      7.1000000 feet below pile head
Depth of maximum shear force    =      8.4000000 feet below pile head
Number of iterations            =              6
Number of zero deflection points =             1
```

Pile-head Deflection vs. Pile Length for Load Case 1

Boundary Condition Type 1, Shear and Moment

```
Shear      =           5610.  lb
Moment     =        1346400. in- lb
Axial Load =           6500.  lb
```

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
10.0000	0.0352326	1677920.	-71080.
9.5000	0.0407001	1648756.	-84828.
9.0000	0.0521810	1592755.	-102229.
8.5000	0.0866781	1535951.	-126383.
8.0000	0.1928012	1514382.	-153658.
7.5000	1.5966468	1483255.	-172979.

Summary of Pile Response(s)

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, lbs, and Load 2 = Moment, in-lbs
Load Type 2: Load 1 = Shear, lbs, and Load 2 = Slope, radians
Load Type 3: Load 1 = Shear, lbs, and Load 2 = Rotational Stiffness, in-lbs/radian

Load Type 4: Load 1 = Top Deflection, inches, and Load 2 = Moment, in-lbs
Load Type 5: Load 1 = Top Deflection, inches, and Load 2 = Slope, radians

Load Case No.	Load Type No.	Pile-head Condition 1 V(lbs) or y(inches)	Pile-head Condition 2 in-lb, rad., or in-lb/rad.	Axial Loading lbs	Pile-head Deflection inches	Maximum Moment in Pile in-lbs	Maximum Shear in Pile lbs	Pile-head Rotation radians
1	1	V = 5610.0000	M = 1346400.	6500.00000000	0.03523262	1677920.	-71080.	-0.00060416

The analysis ended normally.

==========

LPile Plus for Windows, Version 2013-07.007

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method

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Files Used for Analysis

Path to file locations: M:\2015\40725-010 Route 1 Viaduct Maine Traffic Signs\LPILE\
Name of input data file: BB-BROV-301-Elastic.lp7d
Name of output report file: BB-BROV-301-Elastic.lp7o
Name of plot output file: BB-BROV-301-Elastic.lp7p
Name of runtime messeage file: BB-BROV-301-Elastic.lp7r

Date and Time of Analysis

Date: October 9, 2015 Time: 13:48:32

Problem Title

Project Name: Maine Route 1 Viaduct BB-BROV-301

Job Number: 40725-010

Client: Maine DOT

Engineer: JMK

Description: Traffic Signal

Program Options and Settings

Engineering Units of Input Data and Computations:
- Engineering units are US Customary Units (pounds, feet, inches)

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	100

Loading Type and Number of Cycles of Loading:
- Cyclic loading specified
- Number of cycles of loading = 4636737291354636288

Computational Options:
- Use unfactored loads in computations (conventional analysis)
- Compute pile response under loading and nonlinear bending properties of pile (only if nonlinear pile properties are input)
- Use of p-y modification factors for p-y curves not selected
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:
- No p-y curves to be computed and reported for user-specified depths
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1

```
--------------------------------------------------------------------------------
                    Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Total number of pile sections                          =          1

Total length of pile                                   =      16.00 ft

Depth of ground surface below top of pile              =       0.00 ft

Pile diameter values used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile.

Point         Depth              Pile
                X              Diameter
                ft               in
-----       ---------        -----------
  1           0.00000         36.0000000
  2         16.000000         36.0000000


Input Structural Properties:
----------------------------

Pile Section No. 1:

   Section Type                                        =    Elastic Pile
   Cross-sectional Shape                               =        Circular
   Section Length                                      =     16.00000 ft
   Top Width                                           =     36.00000 in
   Bottom Width                                        =     36.00000 in
   Top Area                                            =   1017.87602 Sq. in
   Bottom Area                                         =   1017.87602 Sq. in
   Moment of Inertia at Top                            =       82448. in^4
   Moment of Inertia at Bottom                         =       82448. in^4
   Elastic Modulus                                     =     3604997. lbs/in^2


--------------------------------------------------------------------------------
                      Ground Slope and Pile Batter Angles
--------------------------------------------------------------------------------

Ground Slope Angle                                     =        0.000 degrees
                                                       =        0.000 radians
```

```
Pile Batter Angle                                    =        0.000 degrees
                                                     =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 3 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer         =       0.0000 ft
   Distance from top of pile to bottom of layer      =      4.60000 ft
   Effective unit weight at top of layer             =    115.00000 pcf
   Effective unit weight at bottom of layer          =    115.00000 pcf
   Friction angle at top of layer                    =     28.00000 deg.
   Friction angle at bottom of layer                 =     30.00000 deg.
   Subgrade k at top of layer                        =       0.0000 pci
   Subgrade k at bottom of layer                     =       0.0000 pci

   NOTE: Internal default values for subgrade k will be computed for this soil layer.

Layer 2 is cemented silt with cohesion and friction

   Distance from top of pile to top of layer         =      4.60000 ft
   Distance from top of pile to bottom of layer      =     16.10000 ft
   Effective unit weight at top of layer             =    120.00000 pcf
   Effective unit weight at bottom of layer          =    130.00000 pcf
   Undrained cohesion at top of layer                =    200.00000 psf
   Undrained cohesion at bottom of layer             =    300.00000 psf
   Friction angle at top of layer                    =     28.00000 deg.
   Friction angle at bottom of layer                 =     28.00000 deg.
   Epsilon-50 at top of layer                        =       0.0000
   Epsilon-50 at bottom of layer                     =       0.0000
   Subgrade k at top of layer                        =       0.0000 pci
   Subgrade k at bottom of layer                     =       0.0000 pci

   NOTE: Internal default values for Epsilon-50 will be computed for this soil layer.
   NOTE: Internal default values for subgrade k will be computed for this soil layer.

Layer 3 is strong rock (vuggy limestone)

   Distance from top of pile to top of layer         =     16.10000 ft
   Distance from top of pile to bottom of layer      =     50.00000 ft
   Effective unit weight at top of layer             =    145.00000 pcf
   Effective unit weight at bottom of layer          =    145.00000 pcf
```

Uniaxial compressive strength at top of layer = 5000.00000 psi
Uniaxial compressive strength at bottom of layer = 5000.00000 psi

(Depth of lowest soil layer extends 34.00 ft below pile tip)

**** Warning - Possible Input Data Error ****

Values entered for effective unit weights of soil were outside
the limits of 0.011574 pci (20 pcf) or 0.0810019 pci (140 pcf)
This data may be erroneous. Please check your data.

Summary of Soil Properties

Layer Num.	Soil Type (p-y Curve Criteria)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	Strain Factor Epsilon 50	kpy pci
1	Sand (Reese, et al.)	0.00	115.000	--	28.000	--	--	default
		4.600	115.000	--	30.000	--	--	default
2	Cemented Silt	4.600	120.000	200.000	28.000	--	default	default
		16.100	130.000	300.000	28.000	--	default	default
3	Vuggy Limestone	16.100	145.000	--	--	5000.000	--	--
		50.000	145.000	--	--	5000.000	--	--

Loading Type

Cyclic loading criteria were used for computation of p-y curves for all analyses.

Number of cycles of loading = 100

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	1	V = 3740.00000 lbs	M = 897600. in-lbs	6000.00000000	Yes

V = perpendicular shear force applied to pile head
M = bending moment applied to pile head
y = lateral deflection relative to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applie to pile head
Axial thrust is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Moment-curvature properties were derived from elastic section properties

---

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head	=	3740.0 lbs
Applied moment at pile head	=	897600.0 in-lbs
Axial thrust load on pile head	=	6000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/in	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.0818	897600.	3740.0000	-0.000824	201.8582	2.972E+11	0.000	0.000	0.000
0.160	0.0802	904790.	3737.5367	-0.000818	203.4280	2.972E+11	-2.5659	61.4025	0.000
0.320	0.0787	911971.	3729.9343	-0.000813	204.9957	2.972E+11	-5.3532	130.6534	0.000
0.480	0.0771	919132.	3716.7833	-0.000807	206.5591	2.972E+11	-8.3458	207.7973	0.000
0.640	0.0756	926262.	3697.7049	-0.000801	208.1157	2.972E+11	-11.5275	292.8790	0.000
0.800	0.0740	933350.	3672.3511	-0.000795	209.6631	2.972E+11	-14.8826	385.9429	0.000
0.960	0.0725	940382.	3640.4044	-0.000789	211.1984	2.972E+11	-18.3952	487.0337	0.000
1.120	0.0710	947347.	3601.5771	-0.000783	212.7190	2.972E+11	-22.0499	596.1961	0.000
1.280	0.0695	954230.	3555.6113	-0.000776	214.2217	2.972E+11	-25.8312	713.4745	0.000
1.440	0.0680	961018.	3502.2785	-0.000770	215.7037	2.972E+11	-29.7239	838.9138	0.000
1.600	0.0666	967697.	3441.3791	-0.000764	217.1617	2.972E+11	-33.7130	972.5583	0.000
1.760	0.0651	974251.	3372.7423	-0.000758	218.5926	2.972E+11	-37.7837	1114.4529	0.000
1.920	0.0636	980666.	3296.2256	-0.000751	219.9931	2.972E+11	-41.9213	1264.6420	0.000
2.080	0.0622	986926.	3211.7143	-0.000745	221.3598	2.972E+11	-46.1113	1423.1703	0.000
2.240	0.0608	993016.	3119.1213	-0.000739	222.6894	2.972E+11	-50.3397	1590.0824	0.000
2.400	0.0594	998920.	3018.3866	-0.000732	223.9784	2.972E+11	-54.5923	1765.4229	0.000
2.560	0.0580	1004623.	2909.4770	-0.000726	225.2235	2.972E+11	-58.8553	1949.2365	0.000
2.720	0.0566	1010109.	2792.3854	-0.000719	226.4212	2.972E+11	-63.1152	2141.5677	0.000
2.880	0.0552	1015363.	2667.1306	-0.000713	227.5681	2.972E+11	-67.3585	2342.4612	0.000
3.040	0.0538	1020367.	2533.7571	-0.000706	228.6608	2.972E+11	-71.5723	2551.9615	

0.000									
	3.200	0.0525	1025108.	2392.3338	-0.000700	229.6958	2.972E+11	-75.7435	2770.1134
0.000									
	3.360	0.0512	1029570.	2242.9548	-0.000693	230.6699	2.972E+11	-79.8597	2996.9613
0.000									
	3.520	0.0498	1033737.	2085.7376	-0.000686	231.5797	2.972E+11	-83.9082	3232.5500
0.000									
	3.680	0.0485	1037595.	1920.8238	-0.000680	232.4219	2.972E+11	-87.8770	3476.9240
0.000									
	3.840	0.0472	1041129.	1748.3778	-0.000673	233.1934	2.972E+11	-91.7542	3730.1279
0.000									
	4.000	0.0459	1044324.	1568.5867	-0.000666	233.8910	2.972E+11	-95.5281	3992.2064
0.000									
	4.160	0.0447	1047168.	1381.6599	-0.000659	234.5118	2.972E+11	-99.1873	4263.2041
0.000									
	4.320	0.0434	1049645.	1187.8283	-0.000653	235.0527	2.972E+11	-102.7206	4543.1655
0.000									
	4.480	0.0422	1051744.	987.3439	-0.000646	235.5109	2.972E+11	-106.1172	4832.1353
0.000									
	4.640	0.0409	1053451.	676.8459	-0.000639	235.8837	2.972E+11	-217.3182	10194.
0.000									
	4.800	0.0397	1054358.	256.6657	-0.000632	236.0815	2.972E+11	-220.3695	10655.
0.000									
	4.960	0.0385	1054452.	-168.8833	-0.000625	236.1020	2.972E+11	-222.9108	11116.
0.000									
	5.120	0.0373	1053724.	-598.8310	-0.000619	235.9431	2.972E+11	-224.9514	11576.
0.000									
	5.280	0.0361	1052166.	-1032.2249	-0.000612	235.6031	2.972E+11	-226.5007	12037.
0.000									
	5.440	0.0350	1049774.	-1468.1309	-0.000605	235.0808	2.972E+11	-227.5680	12498.
0.000									
	5.600	0.0338	1046543.	-1905.6323	-0.000598	234.3753	2.972E+11	-228.1626	12959.
0.000									
	5.760	0.0327	1042470.	-2343.8299	-0.000591	233.4862	2.972E+11	-228.2934	13420.
0.000									
	5.920	0.0315	1037556.	-2781.8423	-0.000585	232.4134	2.972E+11	-227.9695	13880.
0.000									
	6.080	0.0304	1031801.	-3218.8047	-0.000578	231.1570	2.972E+11	-227.1997	14341.
0.000									
	6.240	0.0293	1025209.	-3653.8694	-0.000571	229.7178	2.972E+11	-225.9928	14802.
0.000									
	6.400	0.0282	1017784.	-4086.2054	-0.000565	228.0967	2.972E+11	-224.3572	15263.
0.000									
	6.560	0.0271	1009531.	-4514.9978	-0.000558	226.2950	2.972E+11	-222.3015	15724.
0.000									
	6.720	0.0261	1000459.	-4939.4478	-0.000552	224.3144	2.972E+11	-219.8338	16184.
0.000									
	6.880	0.0250	990576.	-5358.7720	-0.000545	222.1568	2.972E+11	-216.9622	16645.

0.000									
	7.040	0.0240	979894.	-5772.2025	-0.000539	219.8246	2.972E+11	-213.6945	17106.
0.000									
	7.200	0.0230	968423.	-6178.9860	-0.000533	217.3204	2.972E+11	-210.0384	17567.
0.000									
	7.360	0.0219	956179.	-6578.3840	-0.000526	214.6471	2.972E+11	-206.0012	18028.
0.000									
	7.520	0.0209	943175.	-6969.6717	-0.000520	211.8081	2.972E+11	-201.5902	18488.
0.000									
	7.680	0.0199	929427.	-7352.1380	-0.000514	208.8068	2.972E+11	-196.8122	18949.
0.000									
	7.840	0.0190	914954.	-7725.0849	-0.000508	205.6470	2.972E+11	-191.6741	19410.
0.000									
	8.000	0.0180	899775.	-8087.8269	-0.000502	202.3330	2.972E+11	-186.1822	19871.
0.000									
	8.160	0.0170	883909.	-8439.6908	-0.000497	198.8691	2.972E+11	-180.3427	20332.
0.000									
	8.320	0.0161	867378.	-8780.0148	-0.000491	195.2601	2.972E+11	-174.1615	20792.
0.000									
	8.480	0.0151	850205.	-9108.1484	-0.000486	191.5109	2.972E+11	-167.6443	21253.
0.000									
	8.640	0.0142	832414.	-9423.4514	-0.000480	187.6268	2.972E+11	-160.7963	21714.
0.000									
	8.800	0.0133	814030.	-9725.2936	-0.000475	183.6132	2.972E+11	-153.6227	22175.
0.000									
	8.960	0.0124	795079.	-10013.	-0.000470	179.4760	2.972E+11	-146.1281	22636.
0.000									
	9.120	0.0115	775590.	-10286.	-0.000464	175.2212	2.972E+11	-138.3171	23096.
0.000									
	9.280	0.0106	755591.	-10544.	-0.000460	170.8550	2.972E+11	-130.1937	23557.
0.000									
	9.440	0.009734	735112.	-10786.	-0.000455	166.3840	2.972E+11	-121.7617	24018.
0.000									
	9.600	0.008865	714184.	-11011.	-0.000450	161.8151	2.972E+11	-113.0248	24479.
0.000									
	9.760	0.008005	692840.	-11219.	-0.000446	157.1551	2.972E+11	-103.9860	24940.
0.000									
	9.920	0.007154	671112.	-11410.	-0.000441	152.4115	2.972E+11	-94.6482	25400.
0.000									
	10.080	0.006312	649035.	-11583.	-0.000437	147.5916	2.972E+11	-85.0141	25861.
0.000									
	10.240	0.005477	626645.	-11736.	-0.000433	142.7034	2.972E+11	-75.0857	26322.
0.000									
	10.400	0.004650	603977.	-11871.	-0.000429	137.7547	2.972E+11	-64.8652	26783.
0.000									
	10.560	0.003831	581071.	-11985.	-0.000425	132.7538	2.972E+11	-54.3540	27244.
0.000									
	10.720	0.003018	557964.	-12079.	-0.000421	127.7091	2.972E+11	-43.5535	27704.

0.000									
	10.880	0.002213	534697.	-12152.	-0.000418	122.6294	2.972E+11	-32.4646	28165.
0.000									
	11.040	0.001414	511310.	-12204.	-0.000414	117.5235	2.972E+11	-21.0881	28626.
0.000									
	11.200	0.000622	487845.	-12233.	-0.000411	112.4006	2.972E+11	-9.4243	29087.
0.000									
	11.360	-0.000164	464345.	-12239.	-0.000408	107.2702	2.972E+11	2.5268	29548.
0.000									
	11.520	-0.000945	440855.	-12223.	-0.000405	102.1418	2.972E+11	14.7652	30008.
0.000									
	11.680	-0.001720	417419.	-12182.	-0.000402	97.0252	2.972E+11	27.2915	30469.
0.000									
	11.840	-0.002490	394083.	-12118.	-0.000400	91.9307	2.972E+11	40.1064	30930.
0.000									
	12.000	-0.003255	370895.	-12028.	-0.000397	86.8684	2.972E+11	53.2110	31391.
0.000									
	12.160	-0.004015	347904.	-11913.	-0.000395	81.8489	2.972E+11	66.6065	31852.
0.000									
	12.320	-0.004771	325158.	-11772.	-0.000393	76.8830	2.972E+11	80.2943	32312.
0.000									
	12.480	-0.005523	302708.	-11605.	-0.000391	71.9817	2.972E+11	94.2762	32773.
0.000									
	12.640	-0.006271	280606.	-11410.	-0.000389	67.1563	2.972E+11	108.5541	33234.
0.000									
	12.800	-0.007016	258903.	-11187.	-0.000387	62.4183	2.972E+11	123.1300	33695.
0.000									
	12.960	-0.007758	237655.	-10937.	-0.000385	57.7793	2.972E+11	138.0064	34156.
0.000									
	13.120	-0.008496	216915.	-10657.	-0.000384	53.2514	2.972E+11	153.1856	34616.
0.000									
	13.280	-0.009232	196740.	-10348.	-0.000383	48.8468	2.972E+11	168.6702	35077.
0.000									
	13.440	-0.009966	177187.	-10009.	-0.000381	44.5780	2.972E+11	184.4629	35538.
0.000									
	13.600	-0.0107	158314.	-9639.5660	-0.000380	40.4576	2.972E+11	200.5664	35999.
0.000									
	13.760	-0.0114	140180.	-9238.7178	-0.000379	36.4986	2.972E+11	216.9837	36460.
0.000									
	13.920	-0.0122	122846.	-8806.0444	-0.000379	32.7142	2.972E+11	233.7177	36920.
0.000									
	14.080	-0.0129	106373.	-8340.9350	-0.000378	29.1180	2.972E+11	250.7713	37381.
0.000									
	14.240	-0.0136	90825.	-7842.7731	-0.000377	25.7235	2.972E+11	268.1474	37842.
0.000									
	14.400	-0.0143	76266.	-7310.9367	-0.000377	22.5449	2.972E+11	285.8489	38303.
0.000									
	14.560	-0.0151	62760.	-6744.7983	-0.000376	19.5963	2.972E+11	303.8786	38764.

```
0.000
    14.720    -0.0158     50374. -6143.7250  -0.000376    16.8923  2.972E+11   322.2394     39224.
0.000
    14.880    -0.0165     39177. -5507.0788  -0.000376    14.4476  2.972E+11   340.9337     39685.
0.000
    15.040    -0.0172     29236. -4834.2168  -0.000375    12.2773  2.972E+11   359.9642     40146.
0.000
    15.200    -0.0179     20622. -4124.4916  -0.000375    10.3968  2.972E+11   379.3329     40607.
0.000
    15.360    -0.0187     13406. -3377.2517  -0.000375     8.8215  2.972E+11   399.0420     41068.
0.000
    15.520    -0.0194  7661.7956 -2591.8419  -0.000375     7.5673  2.972E+11   419.0932     41528.
0.000
    15.680    -0.0201  3462.2512 -1767.6041  -0.000375     6.6505  2.972E+11   439.4879     41989.
0.000
    15.840    -0.0208   882.8348  -903.8776  -0.000375     6.0874  2.972E+11   460.2272     42450.
0.000
    16.000    -0.0215      0.000      0.000  -0.000375     5.8946  2.972E+11   481.3119     21455.
0.000

* The above values of total stress are combined axial and bending stresses.


Output Summary for Load Case No. 1:

Pile-head deflection             =      0.0818108 inches
Computed slope at pile head      =     -0.0008243 radians
Maximum bending moment           =       1054452. inch-lbs
Maximum shear force              =        -12239. lbs
Depth of maximum bending moment  =      4.9600000 feet below pile head
Depth of maximum shear force     =     11.3600000 feet below pile head
Number of iterations             =              6
Number of zero deflection points =              1


--------------------------------------------------------------------------------
            Pile-head Deflection vs. Pile Length for Load Case 1
--------------------------------------------------------------------------------

Boundary Condition Type 1, Shear and Moment

Shear      =           3740.  lb
Moment     =         897600. in- lb
Axial Load =           6000.  lb


    Pile       Pile Head       Maximum       Maximum
```

Length feet	Deflection inches	Moment ln-lbs	Shear lbs
16.0000	0.0818108	1054452.	-12239.
15.2000	0.0919333	1047247.	-12980.
14.4000	0.1039382	1039445.	-13717.
13.6000	0.1210584	1029999.	-14578.
12.8000	0.1438002	1020356.	-15521.
12.0000	0.1767210	1010491.	-16632.
11.2000	0.2230462	1002433.	-17911.
10.4000	0.2936005	998108.	-19551.
9.6000	0.4146927	995198.	-21891.
8.8000	0.6799699	991365.	-25568.
8.0000	1.3461833	985799.	-31116.

Summary of Pile Response(s)

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, lbs, and Load 2 = Moment, in-lbs
Load Type 2: Load 1 = Shear, lbs, and Load 2 = Slope, radians
Load Type 3: Load 1 = Shear, lbs, and Load 2 = Rotational Stiffness, in-lbs/radian
Load Type 4: Load 1 = Top Deflection, inches, and Load 2 = Moment, in-lbs
Load Type 5: Load 1 = Top Deflection, inches, and Load 2 = Slope, radians

Load Case No.	Load Type No.	Pile-head Condition 1 V(lbs) or y(inches)	Pile-head Condition 2 in-lb, rad., or in-lb/rad.	Axial Loading lbs	Pile-head Deflection inches	Maximum Moment in Pile in-lbs	Maximum Shear in Pile lbs	Pile-head Rotation radians
1	1	V = 3740.0000	M = 897600.	6000.00000000	0.08181078	1054452.	-12239.	-0.00082431

The analysis ended normally.

==========

LPile Plus for Windows, Version 2013-07.007

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method

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Files Used for Analysis

Path to file locations: M:\2015\40725-010 Route 1 Viaduct Maine Traffic Signs\LPILE\
Name of input data file: BB-BROV-303-Elastic.lp7d
Name of output report file: BB-BROV-303-Elastic.lp7o
Name of plot output file: BB-BROV-303-Elastic.lp7p
Name of runtime messeage file: BB-BROV-303-Elastic.lp7r

Date and Time of Analysis

Date: October 9, 2015 Time: 13:51:09

Problem Title

Project Name: Traffic Signal Bath, Maine - BB-BROV-303

Job Number:

Client:

Engineer: JMK

Description: Traffic Signal at 1394+65

Program Options and Settings

Engineering Units of Input Data and Computations:
- Engineering units are US Customary Units (pounds, feet, inches)

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	100

Loading Type and Number of Cycles of Loading:
- Cyclic loading specified
- Number of cycles of loading = 4636737291354636288

Computational Options:
- Use unfactored loads in computations (conventional analysis)
- Compute pile response under loading and nonlinear bending properties of pile (only if nonlinear pile properties are input)
- Use of p-y modification factors for p-y curves not selected
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:
- No p-y curves to be computed and reported for user-specified depths
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1

```
--------------------------------------------------------------------------------
                    Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Total number of pile sections                          =          1

Total length of pile                                   =       8.60 ft

Depth of ground surface below top of pile              =       0.00 ft

Pile diameter values used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile.

Point         Depth              Pile
                X              Diameter
                ft               in
-----       ---------        -----------
  1           0.00000         36.0000000
  2          8.600000         36.0000000


Input Structural Properties:
----------------------------

Pile Section No. 1:

   Section Type                                        =    Elastic Pile
   Cross-sectional Shape                               =        Circular
   Section Length                                      =      8.60000 ft
   Top Width                                           =     36.00000 in
   Bottom Width                                        =     36.00000 in
   Top Area                                            =   1017.87602 Sq. in
   Bottom Area                                         =   1017.87602 Sq. in
   Moment of Inertia at Top                            =       82448. in^4
   Moment of Inertia at Bottom                         =       82448. in^4
   Elastic Modulus                                     =     3604996. lbs/in^2


--------------------------------------------------------------------------------
                      Ground Slope and Pile Batter Angles
--------------------------------------------------------------------------------

Ground Slope Angle                                     =        0.000 degrees
                                                       =        0.000 radians
```

```
Pile Batter Angle                                        =        0.000 degrees
                                                         =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 2 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer           =       0.0000 ft
   Distance from top of pile to bottom of layer        =      5.60000 ft
   Effective unit weight at top of layer               =    120.00000 pcf
   Effective unit weight at bottom of layer            =    130.00000 pcf
   Friction angle at top of layer                      =     32.00000 deg.
   Friction angle at bottom of layer                   =     34.00000 deg.
   Subgrade k at top of layer                          =       0.0000 pci
   Subgrade k at bottom of layer                       =       0.0000 pci

   NOTE: Internal default values for subgrade k will be computed for this soil layer.

Layer 2 is strong rock (vuggy limestone)

   Distance from top of pile to top of layer           =      5.60000 ft
   Distance from top of pile to bottom of layer        =     50.00000 ft
   Effective unit weight at top of layer               =    140.00000 pcf
   Effective unit weight at bottom of layer            =    140.00000 pcf
   Uniaxial compressive strength at top of layer       =   5000.00000 psi
   Uniaxial compressive strength at bottom of layer    =   5000.00000 psi


   (Depth of lowest soil layer extends   41.40 ft below pile tip)


**** Warning - Possible Input Data Error ****

Values entered for effective unit weights of soil were outside
the limits of 0.011574 pci (20 pcf) or 0.0810019 pci (140 pcf)
This data may be erroneous.  Please check your data.


--------------------------------------------------------------------------------
                            Summary of Soil Properties
--------------------------------------------------------------------------------
```

Layer Num.	Layer Soil Type (p-y Curve Criteria)	Layer Depth ft	Effective Unit Wt. pcf	Angle of Friction deg.	Uniaxial qu psi	kpy pci
1	Sand (Reese, et al.)	0.00	120.000	32.000	--	default
		5.600	130.000	34.000	--	default
2	Vuggy Limestone	5.600	140.000	--	5000.000	--
		50.000	140.000	--	5000.000	--

Loading Type

Cyclic loading criteria were used for computation of p-y curves for all analyses.

Number of cycles of loading = 100

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	1	V = 3760.00000 lbs	M = 1032240. in-lbs	6000.00000000	Yes

V = perpendicular shear force applied to pile head
M = bending moment applied to pile head
y = lateral deflection relative to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applie to pile head
Axial thrust is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness
---

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Moment-curvature properties were derived from elastic section properties

---
Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 3760.0 lbs
Applied moment at pile head = 1032240.0 in-lbs
Axial thrust load on pile head = 6000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/in	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.0189	1032240.	3760.0000	-0.000384	231.2528	2.972E+11	0.000	0.000	0.000
0.08600	0.0185	1036123.	3759.2970	-0.000380	232.1005	2.972E+11	-1.3624	75.9802	0.000
0.172	0.0181	1040004.	3757.0979	-0.000377	232.9478	2.972E+11	-2.8993	165.1768	0.000
0.258	0.0177	1043882.	3753.2178	-0.000373	233.7945	2.972E+11	-4.6203	268.9646	0.000
0.344	0.0173	1047755.	3747.6782	-0.000369	234.6400	2.972E+11	-6.1154	363.8619	0.000
0.430	0.0170	1051622.	3740.6386	-0.000366	235.4842	2.972E+11	-7.5273	457.8802	0.000
0.516	0.0166	1055480.	3732.1663	-0.000362	236.3266	2.972E+11	-8.8918	553.1246	

0.000									
	0.602	0.0162	1059329.	3722.3105	-0.000358	237.1669	2.972E+11	-10.2087	649.5977
0.000									
	0.688	0.0159	1063168.	3711.1203	-0.000355	238.0049	2.972E+11	-11.4778	747.3019
0.000									
	0.774	0.0155	1066994.	3698.6452	-0.000351	238.8402	2.972E+11	-12.6988	846.2399
0.000									
	0.860	0.0151	1070806.	3684.9348	-0.000347	239.6725	2.972E+11	-13.8716	946.4140
0.000									
	0.946	0.0148	1074604.	3670.0391	-0.000344	240.5016	2.972E+11	-14.9961	1047.8268
0.000									
	1.032	0.0144	1078385.	3654.0078	-0.000340	241.3272	2.972E+11	-16.0722	1150.4809
0.000									
	1.118	0.0141	1082150.	3636.8910	-0.000336	242.1490	2.972E+11	-17.0998	1254.3787
0.000									
	1.204	0.0137	1085896.	3618.7388	-0.000332	242.9669	2.972E+11	-18.0789	1359.5227
0.000									
	1.290	0.0134	1089623.	3599.6013	-0.000328	243.7806	2.972E+11	-19.0094	1465.9155
0.000									
	1.376	0.0130	1093330.	3579.5286	-0.000325	244.5898	2.972E+11	-19.8913	1573.5596
0.000									
	1.462	0.0127	1097015.	3558.5706	-0.000321	245.3944	2.972E+11	-20.7248	1682.4574
0.000									
	1.548	0.0124	1100678.	3536.7775	-0.000317	246.1942	2.972E+11	-21.5099	1792.6115
0.000									
	1.634	0.0121	1104319.	3514.1991	-0.000313	246.9890	2.972E+11	-22.2467	1904.0245
0.000									
	1.720	0.0117	1107936.	3490.8852	-0.000309	247.7786	2.972E+11	-22.9353	2016.6988
0.000									
	1.806	0.0114	1111528.	3466.8854	-0.000306	248.5629	2.972E+11	-23.5759	2130.6369
0.000									
	1.892	0.0111	1115095.	3442.2491	-0.000302	249.3417	2.972E+11	-24.1688	2245.8413
0.000									
	1.978	0.0108	1118636.	3417.0256	-0.000298	250.1148	2.972E+11	-24.7141	2362.3146
0.000									
	2.064	0.0105	1122151.	3391.2636	-0.000294	250.8822	2.972E+11	-25.2122	2480.0593
0.000									
	2.150	0.0102	1125640.	3365.0119	-0.000290	251.6438	2.972E+11	-25.6633	2599.0778
0.000									
	2.236	0.009893	1129100.	3338.3187	-0.000286	252.3993	2.972E+11	-26.0677	2719.3728
0.000									
	2.322	0.009599	1132533.	3311.2320	-0.000282	253.1488	2.972E+11	-26.4258	2840.9467
0.000									
	2.408	0.009310	1135938.	3283.7994	-0.000278	253.8922	2.972E+11	-26.7381	2963.8019
0.000									
	2.494	0.009025	1139315.	3256.0680	-0.000274	254.6293	2.972E+11	-27.0049	3087.9412
0.000									
	2.580	0.008744	1142662.	3228.0845	-0.000270	255.3601	2.972E+11	-27.2268	3213.3668

0.000									
	2.666	0.008467	1145981.	3199.8949	-0.000266	256.0846	2.972E+11	-27.4041	3340.0815
0.000									
	2.752	0.008194	1149270.	3171.5450	-0.000262	256.8028	2.972E+11	-27.5375	3468.0876
0.000									
	2.838	0.007926	1152530.	3143.0798	-0.000258	257.5145	2.972E+11	-27.6275	3597.3876
0.000									
	2.924	0.007661	1155761.	3114.5438	-0.000254	258.2198	2.972E+11	-27.6747	3727.9842
0.000									
	3.010	0.007401	1158962.	3085.9809	-0.000250	258.9186	2.972E+11	-27.6798	3859.8798
0.000									
	3.096	0.007144	1162133.	3057.4342	-0.000246	259.6110	2.972E+11	-27.6433	3993.0769
0.000									
	3.182	0.006892	1165275.	3028.9461	-0.000242	260.2970	2.972E+11	-27.5661	4127.5781
0.000									
	3.268	0.006644	1168388.	3000.5585	-0.000238	260.9765	2.972E+11	-27.4488	4263.3857
0.000									
	3.354	0.006401	1171471.	2972.3121	-0.000234	261.6497	2.972E+11	-27.2922	4400.5025
0.000									
	3.440	0.006161	1174526.	2944.2473	-0.000230	262.3165	2.972E+11	-27.0971	4538.9308
0.000									
	3.526	0.005926	1177551.	2916.4032	-0.000226	262.9771	2.972E+11	-26.8643	4678.6732
0.000									
	3.612	0.005694	1180548.	2888.8183	-0.000222	263.6313	2.972E+11	-26.5948	4819.7322
0.000									
	3.698	0.005468	1183516.	2861.5300	-0.000218	264.2794	2.972E+11	-26.2894	4962.1103
0.000									
	3.784	0.005245	1186457.	2834.5749	-0.000214	264.9213	2.972E+11	-25.9492	5105.8101
0.000									
	3.870	0.005027	1189370.	2807.9884	-0.000210	265.5573	2.972E+11	-25.5749	5250.8340
0.000									
	3.956	0.004812	1192255.	2781.8052	-0.000205	266.1872	2.972E+11	-25.1678	5397.1845
0.000									
	4.042	0.004602	1195114.	2756.0586	-0.000201	266.8113	2.972E+11	-24.7288	5544.8642
0.000									
	4.128	0.004397	1197946.	2730.7808	-0.000197	267.4297	2.972E+11	-24.2590	5693.8755
0.000									
	4.214	0.004196	1200753.	2706.0032	-0.000193	268.0424	2.972E+11	-23.7596	5844.2210
0.000									
	4.300	0.003999	1203534.	2681.7557	-0.000189	268.6496	2.972E+11	-23.2317	5995.9033
0.000									
	4.386	0.003806	1206290.	2658.0670	-0.000185	269.2513	2.972E+11	-22.6765	6148.9247
0.000									
	4.472	0.003618	1209022.	2634.9648	-0.000180	269.8478	2.972E+11	-22.0953	6303.2879
0.000									
	4.558	0.003434	1211731.	2612.4751	-0.000176	270.4392	2.972E+11	-21.4893	6458.9953
0.000									
	4.644	0.003254	1214417.	2590.6229	-0.000172	271.0255	2.972E+11	-20.8599	6616.0495

0.000									
	4.730	0.003078	1217080.	2569.4317	-0.000168	271.6070	2.972E+11	-20.2083	6774.4529
0.000									
	4.816	0.002907	1219722.	2548.9236	-0.000164	272.1838	2.972E+11	-19.5361	6934.2081
0.000									
	4.902	0.002741	1222343.	2529.1192	-0.000159	272.7560	2.972E+11	-18.8445	7095.3175
0.000									
	4.988	0.002579	1224944.	2510.0378	-0.000155	273.3238	2.972E+11	-18.1351	7257.7838
0.000									
	5.074	0.002421	1227526.	2491.6969	-0.000151	273.8875	2.972E+11	-17.4093	7421.6094
0.000									
	5.160	0.002267	1230089.	2474.1125	-0.000147	274.4470	2.972E+11	-16.6688	7586.7968
0.000									
	5.246	0.002118	1232634.	2457.2992	-0.000142	275.0027	2.972E+11	-15.9151	7753.3485
0.000									
	5.332	0.001974	1235162.	2441.2698	-0.000138	275.5547	2.972E+11	-15.1498	7921.2671
0.000									
	5.418	0.001834	1237675.	2426.0352	-0.000134	276.1032	2.972E+11	-14.3745	8090.5551
0.000									
	5.504	0.001698	1240171.	2411.6050	-0.000129	276.6483	2.972E+11	-13.5910	8261.2149
0.000									
	5.590	0.001566	1242654.	2397.9868	-0.000125	277.1902	2.972E+11	-12.8010	8433.2491
0.000									
	5.676	0.001440	1245122.	-1322.8795	-0.000121	277.7292	2.972E+11	-7198.1801	5160000.
0.000									
	5.762	0.001317	1239925.	-8435.6212	-0.000116	276.5944	2.972E+11	-6586.2030	5160000.
0.000									
	5.848	0.001199	1227713.	-14928.	-0.000112	273.9283	2.972E+11	-5996.4405	5160000.
0.000									
	5.934	0.001086	1209114.	-20824.	-0.000108	269.8679	2.972E+11	-5428.6739	5160000.
0.000									
	6.020	0.000977	1184734.	-26144.	-0.000104	264.5452	2.972E+11	-4882.5699	5160000.
0.000									
	6.106	0.000872	1155154.	-30912.	-9.972E-05	258.0873	2.972E+11	-4357.6919	5160000.
0.000									
	6.192	0.000771	1120933.	-35149.	-9.576E-05	250.6161	2.972E+11	-3853.5097	5160000.
0.000									
	6.278	0.000674	1082607.	-38876.	-9.194E-05	242.2489	2.972E+11	-3369.4104	5160000.
0.000									
	6.364	0.000581	1040693.	-42114.	-8.825E-05	233.0983	2.972E+11	-2904.7072	5160000.
0.000									
	6.450	0.000492	995686.	-44881.	-8.472E-05	223.2723	2.972E+11	-2458.6492	5160000.
0.000									
	6.536	0.000406	948060.	-47198.	-8.134E-05	212.8746	2.972E+11	-2030.4301	5160000.
0.000									
	6.622	0.000324	898271.	-49081.	-7.814E-05	202.0047	2.972E+11	-1619.1965	5160000.
0.000									
	6.708	0.000245	846758.	-50548.	-7.511E-05	190.7584	2.972E+11	-1224.0565	5160000.

0.000									
	6.794	0.000169	793941.	-51615.	-7.226E-05	179.2275	2.972E+11	-844.0872	5160000.
0.000									
	6.880	9.567E-05	740225.	-52297.	-6.960E-05	167.5003	2.972E+11	-478.3422	5160000.
0.000									
	6.966	2.517E-05	686000.	-52609.	-6.712E-05	155.6619	2.972E+11	-125.8592	5160000.
0.000									
	7.052	-4.287E-05	631641.	-52563.	-6.483E-05	143.7942	2.972E+11	214.3333	5160000.
0.000									
	7.138	-0.000109	577510.	-52173.	-6.273E-05	131.9764	2.972E+11	543.2092	5160000.
0.000									
	7.224	-0.000172	523958.	-51448.	-6.082E-05	120.2848	2.972E+11	861.7384	5160000.
0.000									
	7.310	-0.000234	471323.	-50399.	-5.909E-05	108.7936	2.972E+11	1170.8802	5160000.
0.000									
	7.396	-0.000294	419935.	-49035.	-5.755E-05	97.5747	2.972E+11	1471.5778	5160000.
0.000									
	7.482	-0.000353	370115.	-47365.	-5.617E-05	86.6979	2.972E+11	1764.7518	5160000.
0.000									
	7.568	-0.000410	322174.	-45396.	-5.497E-05	76.2315	2.972E+11	2051.2947	5160000.
0.000									
	7.654	-0.000466	276417.	-43134.	-5.393E-05	66.2420	2.972E+11	2332.0655	5160000.
0.000									
	7.740	-0.000522	233145.	-40585.	-5.305E-05	56.7947	2.972E+11	2607.8840	5160000.
0.000									
	7.826	-0.000576	192650.	-37754.	-5.231E-05	47.9538	2.972E+11	2879.5254	5160000.
0.000									
	7.912	-0.000630	155221.	-34644.	-5.171E-05	39.7825	2.972E+11	3147.7152	5160000.
0.000									
	7.998	-0.000683	121145.	-31258.	-5.123E-05	32.3430	2.972E+11	3413.1241	5160000.
0.000									
	8.084	-0.000735	90705.	-27600.	-5.086E-05	25.6972	2.972E+11	3676.3626	5160000.
0.000									
	8.170	-0.000788	64179.	-23671.	-5.059E-05	19.9062	2.972E+11	3937.9759	5160000.
0.000									
	8.256	-0.000840	41848.	-19473.	-5.040E-05	15.0308	2.972E+11	4198.4395	5160000.
0.000									
	8.342	-0.000892	23987.	-15006.	-5.029E-05	11.1316	2.972E+11	4458.1532	5160000.
0.000									
	8.428	-0.000943	10876.	-10272.	-5.023E-05	8.2690	2.972E+11	4717.4372	5160000.
0.000									
	8.514	-0.000995	2787.6907	-5269.4395	-5.021E-05	6.5032	2.972E+11	4976.5264	5160000.
0.000									
	8.600	-0.001047	0.000	0.000	-5.020E-05	5.8946	2.972E+11	5235.5656	2580000.
0.000									

* The above values of total stress are combined axial and bending stresses.

Output Summary for Load Case No. 1:

```
Pile-head deflection            =      0.0188991 inches
Computed slope at pile head     =     -0.0003838 radians
Maximum bending moment          =       1245122. inch-lbs
Maximum shear force             =        -52609. lbs
Depth of maximum bending moment =      5.6760000 feet below pile head
Depth of maximum shear force    =      6.9660000 feet below pile head
Number of iterations            =              6
Number of zero deflection points =             1
```

Pile-head Deflection vs. Pile Length for Load Case 1

Boundary Condition Type 1, Shear and Moment

```
Shear      =           3760.  lb
Moment     =        1032240. in- lb
Axial Load =           6000.  lb
```

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
8.6000	0.0188991	1245122.	-52609.
8.1700	0.0209069	1238286.	-60223.
7.7400	0.0260850	1223968.	-71950.
7.3100	0.0364712	1196216.	-86922.
6.8800	0.0662629	1146976.	-109832.
6.4500	0.1555840	1128687.	-141656.

Summary of Pile Response(s)

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, lbs, and Load 2 = Moment, in-lbs
Load Type 2: Load 1 = Shear, lbs, and Load 2 = Slope, radians
Load Type 3: Load 1 = Shear, lbs, and Load 2 = Rotational Stiffness, in-lbs/radian

Load Type 4: Load 1 = Top Deflection, inches, and Load 2 = Moment, in-lbs
Load Type 5: Load 1 = Top Deflection, inches, and Load 2 = Slope, radians

Load Case No.	Load Type No.	Pile-head Condition 1 V(lbs) or y(inches)	Pile-head Condition 2 in-lb, rad., or in-lb/rad.	Axial Loading lbs	Pile-head Deflection inches	Maximum Moment in Pile in-lbs	Maximum Shear in Pile lbs	Pile-head Rotation radians
1	1	V = 3760.0000	M = 1032240.	6000.00000000	0.01889914	1245122.	-52609.	-0.00038375

The analysis ended normally.