S.W.COLE
ENGINEERING, INC.

# GEOTECHNICAL DESIGN REPORT

20-1403

November 8, 2021

## Geotechnical Engineering Services

WIN 021876.00
Route 117 over Nezinscot River
Hall Bridge #3287
Buckfield, Maine

Prepared For:
Maine Department of Transportation
Attention: Laura Krusinski, P.E.
State House Station 16
Augusta, ME 04333-0016


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Dear Laura:

In accordance with our Proposal, dated February 1, 2021, and project specific Assignment Letter #2, dated February 3, 2021, we have completed geotechnical services for the subject project. The purpose of our services was to review the provided subsurface information, laboratory testing and progress plans in order to provide geotechnical parameters and recommendations for foundations and earthwork associated with the proposed construction.

The services provided by S. W. Cole Engineering, Inc. (S.W.COLE) were conducted in accordance with our Multi-PIN Agreement with the Maine Department of Transportation (MaineDOT), No. 20200623000000000765, dated June 22, 2020. The contents herein are subject to the limitations set forth in Appendix A.

## 1.0 INTRODUCTION

### 1.1 Site Conditions

The site is Hall Bridge (MaineDOT Bridge #3287) carrying Route 117 (Turner Street) over the Nezinscot River in Buckfield, Maine. The site location is shown on the "Site Location Map" attached in Appendix B. We understand the existing crossing was originally constructed in 1936 and consists of a 3-span, ±147-foot-long structure supported by concrete abutments and piers. The interior piers are reportedly founded on bedrock. Historic plans do not indicate what the abutments are founded on.

### 1.2 Proposed Construction

Based on the information provided by MaineDOT, we understand the existing bridge will be replaced with a new 150-foot single-span, integral abutment bridge supported on steel H-piles that are driven to end-bearing on bedrock or rock-socketed into bedrock. We understand the preferred replacement structure will be constructed on the existing alignment and the vertical grade will be raised about 1 foot on the west abutment (Abutment No. 1) and about 3 feet at the east abutment (Abutment No. 2). We understand the bridge will be widened about 8 feet (out-to-out). We understand 1.75H:1V riprap slopes will wrap around and in front of the abutments matching into 2H:1V approach side slopes.

## 2.0 EXPLORATIONS AND TESTING

### 2.1 Explorations

Four test borings were made at the site for the proposed replacement structure. Test borings BB-BNR-101 and -102 were made on August 9, 2017, and test borings BB-BNR-201 and -202 were made between May 9 and 15, 2019 by the MaineDOT Drill Crew using a trailer-mounted CME 45C drill rig. The exploration locations were selected, established, and logged in the field by MaineDOT. The "as-drilled" exploration locations, as provided by MaineDOT, are shown on the "Boring Location Plan" attached in Appendix B. Logs of these test borings, as provided by MaineDOT, and a Key to Soil and Rock Descriptions and Terms used on the logs are attached as Appendix C.

### 2.2 Testing

The test borings were drilled using a combination of solid-stem auger, cased wash boring, and NQ2 rock core drilling techniques. The soils were sampled at approximate 5-foot intervals using a split-spoon sampler and Standard Penetration Testing (SPT) methods using a calibrated automatic hammer. Upon encountering refusal, each boring was advanced about 9 to 10 feet into bedrock using NQ2 rock coring.

The MaineDOT drill rig was equipped with an automatic hammer to drive the split-spoon sampler. The hammer was calibrated per ASTM D4633-10 "Standard Test Method for Energy Measurement for Dynamic Penetrometers." Corrected N-values discussed in this report were computed by applying the corresponding average energy transfer factor of 0.854 for the 2017 explorations and 0.928 for the 2019 explorations to the raw field N-values. The hammer efficiency factors (0.854 and 0.928), uncorrected SPT blow counts, uncorrected and corrected SPT N-values and rock core intervals and Rock Quality Designation (RQD) are shown on the boring logs provided in Appendix C.

Laboratory testing was performed on disturbed SPT samples obtained during the explorations. Laboratory testing was performed by the MaineDOT Materials Testing and Exploration Central Laboratory in Bangor, Maine, following applicable American Association of State Highway and Transportation Officials (AASHTO) testing procedures. Laboratory testing included twelve natural water content tests and twelve grain size analyses (two with hydrometer and ten without hydrometer) and one Atterberg Limit test. Moisture contents are shown on the boring logs in Appendix C. A summary and results of the laboratory testing are provided in Appendix D.

## 3.0 SUBSURFACE CONDITIONS

### 3.1 Surficial and Bedrock Geology

According to the Maine Geological Survey's (MGS's) mapping of the Buckfield Quadrangle, Maine (Open-File Map 08-68)[1], surficial geologic units within the site vicinity consist of Stream Alluvium (sand, gravel and silt, organics), Glaciomarine fan and Marine regressive deposits (sand and gravel) and Glaciomarine sediments (sand, gravel, and clay-silt). The surficial geologic units encountered were generally consistent with the mapped geology; however, the explorations also encountered Fill soils from previous site development.

According to the MGS Bedrock Geologic Map of Maine Bedrock[2], bedrock in the site vicinity is mapped as Sangerville Formation, Anasagunticook Member consisting of graywacke metasandstone. The observed bedrock is generally consistent with the mapped bedrock geology.

### 3.2 Soil and Bedrock

Subsurface conditions at the project site were explored by drilling 4 test borings. Borings BB-BNR-101 and BB-BNR-102 were drilled behind the existing west and east abutments, respectively. Borings BB-BNR-201 and BB-BNR-202 were drilled through the existing bridge deck in front of the existing west and east abutments, respectively.

The test borings encountered a soils profile generally consisting of fill overlying marine deposits overlying bedrock. The principal strata encountered in the explorations are summarized below. An Interpretive Subsurface Profile is attached in Appendix B. Refer to the boring logs in Appendix C for more detailed descriptions of the subsurface findings at the exploration locations.

Surficial: Test borings BB-BNR-101 and BB-BNR-102, made within the roadway of State Route 117 encountered an 8- and 6-inch-thick layer of pavement, respectively. Test borings BB-BNR-201 and BB-BNR-202, made through the bridge deck within the existing abutment slopes encountered a surficial layer of gravel and rock.

Fill: Below the pavement or gravel and rock fill, granular fill was encountered in each boring extending to depths of about 3.5 to 28 feet below ground surface (bgs), corresponding to Elevation (El.) 313.9 to 303.7 feet. Where sampled, the fill generally consisted of:

- Light brown to brown, SAND, some silt, little to trace gravel.
- Light brown, SAND, some silt, trace gravel, trace organics/roots.
- Light brown, Gravelly SAND, trace silt.
- Light brown, GRAVEL, little sand.

[1] Weddle, Thomas K., and Duchette, Jonathan W., 2008, Surficial geology of the Buckfield quadrangle, Maine: Maine Geological Survey, Open-File Map 08-68, map, scale 1:24,000.
[2] Pankiwskyj, Kost A., 1978, Reconnaissance bedrock geology of the Buckfield [15-minute] quadrangle, Maine: Maine Geological Survey, Open-File Map 78-18, map, scale 1:62,500.

The fill was generally very loose to dense with SPT $N_{60}$ values ranging from 4 to 39 blows per foot (bpf).

Marine Deposit: Below the fill, marine deposits were observed to depths of 14.8 to 31.2 feet, corresponding to El. 302.6 to 296.1 feet. The deposit generally consisted of:

- Brown, SAND, some to little silt, little to trace gravel.
- Brown, wet, SAND, little gravel, trace silt.
- Grey-brown, Silty SAND, some gravel.
- Grey, SILT, little clay, little sand.
- Dark grey, SILT, little sand, trace gravel, trace clay.

The granular portion of the deposit was generally loose to very dense with SPT $N_{60}$ values of 6 to 65 bpf, where sampled. The cohesive portion was generally soft to hard with SPT $N_{60}$ values of 3 bpf to refusal (greater than 50 blows per 6-inch drive), where sampled.

Bedrock: Bedrock was encountered and sampled each boring. A 2-foot-thick weathered zone was observed at BB-BNR-201. The top of intact bedrock varied from about 14.8 to 31.8 feet bgs (El. 302.6 to 295.2 feet). The bedrock generally consisted of grey, hard, fresh metasandstone of the Sangerville Formation (Anasagunticook Member). Joints were generally along bedding planes, low to moderately dipping, and tight to open.

The following table summarizes the approximate depths to bedrock, corresponding top of bedrock elevations and Rock Quality Designation (RQD) where encountered.

| Boring Number (Substructure) | Approximate Depth to Bedrock (feet) | Approximate Bedrock Elevation (feet) | RQD (RMQ) |
|---|---|---|---|
| BB-BNR-101 (Abutment No. 1) | 31.2 | 300.5 | R1: 85% (Good)<br>R2: 93% (Excellent) |
| BB-BNR-201 (Abutment No. 1) | 24.5 (Weathered)<br>26.5 | 297.2 (Weathered)<br>295.2 | R1: 53% (Fair)<br>R2: 62% (Fair) |
| BB-BNR-102 (Abutment No. 2) | 30.8 | 296.1 | R1: 78% (Good)<br>R2: 67% (Fair) |
| BB-BNR-202 (Abutment No. 2) | 14.8 | 302.6 | R1:75% (Good)<br>R2: 19% (Poor) |

RQD values for the bedrock cores generally ranged from 19 to 93 percent corresponding to a Rock Quality of poor to excellent. The average RQD for the bedrock was about 66% corresponding to an average Rock Quality of fair. Detailed descriptions of the rock core and RQD values for each core run are shown on the exploration logs in Appendix C. Rock core photographs are shown in Appendix C.

## 3.3 Groundwater

The water level was measured in boring BB-BNR-101 at a depth of about 14 feet bgs. Wet soils were noted the remaining borings at depths of 5 to 20 feet. It should be noted that water was introduced during drilling; therefore, water levels indicated may not represent stabilized ground water conditions. Long term groundwater information is not available. It should be anticipated that groundwater levels will fluctuate seasonally, particularly in response to periods of snowmelt and precipitation, changes in site use and the water level of Nezinscot River.

## 4.0 GEOTECHNICAL EVALUATIONS

S.W.COLE conducted geotechnical engineering evaluations in accordance with 2020 AASHTO LRFD Bridge Design Specifications, 9th Edition (LRFD) and the MaineDOT Bridge Design Guide, 2003 Edition with revisions through June 2018 (MaineDOT BDG). Geotechnical engineering calculations and reference documents used to support the recommendations within this report are provided in Appendix E.

### 4.1 Abutment Stability

The replacement bridge is proposed to be constructed on the existing horizontal alignment however the vertical grade will be raised about 1 foot at Abutment No. 1 and about 3 feet at Abutment No. 2. The approach embankments will be widened on both sides to allow for an increase from the current 24-foot width to the proposed 32-foot width with typical side slopes of approximately 2H:1V or flatter requiring tapered sliver fills. A steeper slope of approximately 1.75H:1V or flatter is proposed in front of the abutments. The embankments will be constructed per MaineDOT Standard Specifications and Standard Details using engineered fill placed over the existing embankment/side slopes following grubbing.

S.W.COLE interpreted the generalized soil profile at each abutment. The following strength parameters were developed for each soil unit using the corrected SPT N-values and soil types encountered in the borings.

| Soil Type | Unit Weight (pcf) | Friction Angle | Cohesion (psf) |
|---|---|---|---|
| Fill | 125 | 30 | 0 |
| Marine Deposit | 122 | 30 | 0 |

S.W.COLE completed longitudinal stability analyses to assess the factors of safety against rotational instability of the proposed slope modifications. We used the computer software Slide2, developed by RocScience, based on the Morgenstern-Price method.

Longitudinal analyses were conducted through the abutments to determine the factor of safety against rotational failure. Results of the analyses indicate a minimum calculated factor of safety of 2.3 for Abutment 1 and 2.6 for Abutment 2. Therefore, the global stability is considered acceptable in the longitudinal direction.

### 4.2 Foundation Options and Discussion

Based on the Preliminary Design Report (PDR), we understand a pile-supported Integral Abutment Bridge (IAB) is the preferred replacement structure and driven piles are the preferred foundation option. The following sections provide geotechnical design considerations and recommendations for an H-pile supported IAB.

## 4.3 Integral Abutment H-Piles

The site is underlain by fill overlying marine deposits and relatively shallow bedrock. We understand Abutments No. 1 (west) and No. 2 (east) will be integral abutments founded on a single row of steel HP14x117 H-piles. The piles will be end bearing on or within bedrock and driven to the required resistance. H-piles shall be 50 ksi, Grade A572 steel with Rock Injector HP-80500 pile points to help reduce damage to the piles during driving, improve penetration, and improve friction at the pile tip to support a pinned pile tip assumption.

Based on the subsurface findings, the bedrock surface appears to slope downward from south to north at the abutments with about 5 to 7 feet of surface relief between boring locations. Based on the depth bedrock was encountered at the borings we estimate the following pile lengths:

| Location | Approx. Bottom of Proposed Abutment | Approx. Top of Competent Bedrock | Estimated Pile Length (feet) |
|---|---|---|---|
| | Elevation (feet) | | |
| Abutment No. 1 BB-BNR-101 & BB-BNR-201 | 318.8 | 295.2 to 300.5 | 19 to 24 |
| Abutment No. 2 BB-BNR-102 & BB-BNR-202 | 316.7 | 296.1 to 302.6 | 14 to 21 |

The estimated pile lengths do not consider pile damage, additional footage (5 feet, typical) of pile required for dynamic testing instrumentation (per ASTM D4945), additional pile length needed to accommodate leads and driving equipment, or additional pile length needed for embedment in the abutment or pile cap.

### 4.3.1 Strength Limit State Design

Design of pile foundations bearing on or within bedrock at the strength limit state shall consider.

- Compressive axial geotechnical resistance of individual piles bearing on bedrock.
- Drivability resistance of individual piles driven to bedrock.
- Structural resistance of individual piles in axial compression.
- Structural resistance of individual piles in combined axial loading and flexure.

Pile groups should be designed to resist all lateral earth loads, vehicular loads, dead and live loads, and lateral forces transferred through the abutments. The pile group resistance after scour due to the design flood shall provide adequate foundation resistance using the resistance factors given in this section.

Per LRFD Article 6.5.4.2, at the strength limit state, the axial resistance factor $\phi_c$ = 0.50, for severe driving conditions shall be applied to the structural compressive resistance of the pile. The H-piles will be subjected to lateral loading; therefore, the piles shall be evaluated for resistance against combined axial compression and flexure in accordance with LRFD Articles 6.9.2.2 and 6.15.2.

Per LRFD Article 6.5.4.2, at the strength limit state, the axial resistance factor $\phi_c$ = 0.70 and the flexural resistance factor $\phi_f$ = 1.0 shall be applied to the combined axial and flexural resistance of the pile in the interaction equation (LRFD Eq. 6.9.2.2-1 or -2).

Abutment H-piles should be analyzed for determination of unbraced lengths and fixity using LPile® 2016 (LPile) software. The calculated unbraced lengths should be used to analyze the piles in combined axial compression and flexure resistance provided in LRFD Articles 6.9.2.2 and 6.15.2.

Structural Resistance. The nominal axial compressive structural resistance ($P_n$) for piles loaded in compression shall be as specified in LRFD Article 6.9.4.1. The nominal axial structural compressive resistance ($P_n$) subject to the combined axial compression and flexure shall be evaluated based on unbraced lengths (l) and effective length factors (K) as determined from LPile once structural loads are available. The nominal axial structural resistance should be evaluated based on combined axial compression and flexure.

Preliminary estimates of the structural axial resistance for selected H-pile sections were calculated using a resistance factor, $\phi_c$ = 0.50, for severe driving conditions. The unbraced pile lengths (l) and effective length factors (K) in these evaluations have been assumed. It is the responsibility of the structural engineer to calculate the nominal axial structural compressive resistance ($P_n$) based on unbraced lengths (l) and effective length factors (K) determined from LPile.

Geotechnical Resistance. The nominal axial geotechnical resistance in the strength limit state were calculated using the guidance in LRFD Article 10.7.3.2.3 which states the nominal bearing resistance of piles driven to point bearing on hard rock shall not exceed the structural pile resistances obtained from LRFD Article 6.9.4.1 with a resistance factor $\phi_c$ = 0.50 for severe driving conditions. For non-displacement piles driven to end bearing on or within bedrock, it is our experience that this is generally not the controlling resistance.

Drivability Analyses. Drivability analyses were performed to determine the pile resistance that might be achieved considering available diesel hammers. The maximum driving stresses in the pile, assuming the use of 50 ksi steel, shall be less than 45 ksi, but for this project pile stresses were capped at 40 ksi to reduce the potential for piles walking out of position during hard driving. The drivability resistances were calculated using the resistance factor, $\varphi_{dyn}$, of 0.65, for a single pile in axial compression when a dynamic test is performed as specified in LRFD Table 10.5.5.2.3-1.

A summary of the calculated factored axial compressive structural, geotechnical, and drivability resistances of selected H-piles for the strength limit states are provided in the following table.

| Factored Axial Pile Resistances at Strength Limit States | | | | |
|---|---|---|---|---|
| Pile Section | Factored Axial Pile Resistance (kips) | | | |
| | Structural Resistance $\phi_c = 0.5$ | Controlling Geotechnical Resistance $\phi = 0.5$ | Drivability Resistance $\phi_{dyn} = 0.65$ | Controlling Axial Pile Resistance |
| HP 14x117 | 860 | 860 | 412 | 412 |

**Notes**: Due to sloping bedrock, drivability resistance based on driving stresses limited to 40 ksi or less to reduce potential for pile walking and over-stressing the pile section.

LRFD Article 10.7.3.2.3 states the nominal axial compressive resistance of piles driven to hard rock is typically controlled by the structural resistance with a resistance factor for severe driving conditions applied. However, the estimated factored axial pile resistance from the drivability analyses for the H-pile sections are less than the controlling factored axial structural resistance per LRFD Article 10.7.3.2.3 therefore, drivability controls. The maximum applied factored axial pile load for the strength limit states should not exceed the controlling factored pile resistance shown in above table.

#### 4.3.2 Service and Extreme Limit State Design

The design of H-piles at the service limit state shall consider tolerable transverse and longitudinal movement of piles and pile group movement considering changes in soil conditions due to scour based on the design flood ($Q_{100}$). For the service limit state, resistance factors of $\varphi = 1.0$ should be used in accordance with LRFD Article 10.5.5.1. The exception is the overall global stability of the foundation which should be investigated at the Service I load combination and a resistance factor, $\varphi$, of 0.65.

Extreme limit state design shall include pile axial compressive resistance, overall global stability of the pile group, pile failure by uplift in tension, and structural failure. The extreme event load combinations are those related to seismic forces, ice loads, debris loads, and hydraulic events. Extreme limit state design shall also check that the nominal pile foundation resistance remaining after scour due to the check flood ($Q_{500}$) can support the extreme limit state loads. Resistance factors for extreme limit states, per LRFD Article 10.5.5.3, shall be taken as $\varphi = 1.0$ except for uplift of piles, for which the resistance factor, $\varphi_{up}$, shall be 0.80 or less per LRFD Article 10.5.5.3.2.

The nominal axial geotechnical pile resistance at the service and extreme limit state was calculated using the guidance in LRFD Article 10.7.3.2.3. A summary of the calculated factored axial structural, geotechnical, and drivability resistances of selected H-piles for the extreme and service limit states are provided in the following table.

| Factored Axial Pile Resistances at Service and Extreme Limit States | | | | |
|---|---|---|---|---|
| Pile Section | Factored Axial Pile Resistance (kips) | | | |
| | Structural Resistance $\phi_c$ = 1.0 | Controlling Geotechnical Resistance $\phi$ = 1.0 | Drivability Resistance $\phi_{dyn}$ = 1.0 | Controlling Axial Pile Resistance |
| HP 14x117 | 1,720 | 1,720 | 634 | 634 |

**Notes**: Due to sloping bedrock, drivability resistance based on driving stresses limited to 40 ksi or less to reduce potential for pile walking and over-stressing the pile section.

LRFD Article 10.7.3.2.3 states that the nominal axial compressive resistance of piles driven to hard rock is typically controlled by the structural resistance with a resistance factor for severe driving conditions applied. However, the estimated factored axial pile resistances from the drivability analyses for the H-pile sections are less than the controlling factored axial structural resistance per LRFD Article 10.7.3.2.3 and the nominal structural resistances. The maximum applied factored axial pile load for the extreme and service limit states should not exceed the controlling factored pile resistance shown in above table.

### 4.3.3 Downdrag

We anticipate settlement will occur during construction with negligible long-term settlement. Therefore, downdrag is not considered to be an issue.

### 4.3.4 Lateral Pile Resistance

In accordance with LRFD Article 6.15.1, the structural analysis of pile groups subjected to lateral loads shall include consideration of soil-structure interaction effects as specified in LRFD Article 10.7.3.9. Assumptions regarding a fixed or pinned condition at the pile tip should be also confirmed with soil-structure interaction analyses.

A series of lateral pile resistance analyses were performed to evaluate pile behavior using LPile® 2016 (LPile) software with pile head deflections and axial loads supplied by the structural engineer. The analyses indicate the pile lengths when driven to bedrock have up to 0.1 inches of translation at the pile tip however, when modelled with a 0.2-foot penetration into bedrock the translation at the pile tip is less than 0.01 inches. The designer should utilize the results of the LPile analyses to recalculate axial compressive structural pile resistances based on unbraced pile segments and K-factors and verify pile bending stresses do not exceed allowable stresses.

Geotechnical parameters for generation of soil-resistance (p-y) curves in lateral pile analyses using LPile® software are shown in the following Table. In general, the model developed emulates the soil at the site by using the soil layers, appropriate pile material properties, section parameters, and pile-head boundary conditions for the pile section being analyzed.

| Recommended LPILE® Soil Parameters | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Elevation Range[1,2] (Depth Range) | | Soil Layer[2] (Soil Model) | $K_{static}$ | Soil Parameters | | | | |
| Top | Bottom | | (pci) | Effective Unit Wt. γ', (pcf) | Cohesion c, (psf) | $e_{50}$ | Friction Angle ϕ', (deg) |
| **Abutment 1 (Boring BB-BNR-101)** | | | | | | | | |
| 318.9 (0) | 312.7 (6.2) | medium dense Sand Fill (Sand-Reese) | 60 | 62.6 | - | - | 30 |
| 312.7 (6.2) | 301.7 (17.2) | loose Marine Deposit (Sand-Reese) | 20 | 59.6 | - | - | 30 |
| 301.7 (17.2) | 300.5 (18.4) | hard Marine Deposit (Sand-Reese) | 125 | 67.6 | - | - | 38 |
| 300.5 (18.4) | 300.3 (18.6) | Strong Rock (Vuggy Limestone) | - | 107.6 | $Q_u$ = 5,000 psi | - | - |
| **Abutment 2 (Boring BB-BNR-202)** | | | | | | | | |
| 316.7 (0) | 313.9 (2.8) | medium dense Sand Fill (Sand-Reese) | 60 | 62.6 | - | - | 30 |
| 313.9 (2.8) | 303.4 (13.3) | loose Marine Deposit (Sand-Reese) | 20 | 59.6 | - | - | 30 |
| 303.4 (13.3) | 302.6 (14.1) | hard Marine Deposit (Sand-Reese) | 125 | 67.6 | - | - | 38 |
| 302.6 (14.1) | 302.4 (14.3) | Strong Rock (Vuggy Limestone) | - | 107.6 | Qu = 5,000 psi | - | - |

**Notes**: 1. Bottom of Abutment 1 pile cap at El 318.9 feet.
2. Bottom of Abutment 2 pile cap at El 316.7 feet.
3. Groundwater at El.319.7 feet corresponding to $Q_{50}$.

### 4.3.5 Driven Pile Resistance and Pile Quality Control

The contract documents shall require the contractor to perform a wave equation analysis for the proposed pile-hammer system and conduct dynamic pile load tests with signal matching. The first pile driven at each abutment should be dynamically tested to confirm nominal pile resistance and verify the stopping criteria developed by the contractor in the wave equation analysis. Minimum 24-hour restrike tests will be required and should be noted on the plans. Additional dynamic tests may be required as part of the pile field quality control program if:

- Pile behavior that varies radically between adjacent piles.
- Pile behavior indicates pile refusal on a boulder or in a cobble layer above bedrock.
- Pile tip is not firmly embedded in bedrock.
- Pile tip “walks” out of position and is out of tolerance.

Piles should be driven to an acceptable penetration resistance based on the results of a wave equation analysis provided by the contractor and as approved by the design team. Pile load testing should be completed by PDA testing with signal matching including one pile at each abutment. Driving stresses in the pile determined in the drivability analysis and confirmed by PDA testing shall be less than 45 ksi, in accordance with LRFD Article 10.7.8. However; due to sloping bedrock the driving stresses shall be limited to 40 ksi to reduce potential for pile walking. The pile hammer should be selected such that the required pile resistance when the penetration resistance for the final 3 to 6 inches is between 3 to 12 blows per inch (bpi). If an abrupt increase in driving resistance is encountered, the driving may be terminated when the penetration is less than 0.5-inch in 10 consecutive blows. Termination criteria shall be confirmed and evaluated for the selected pile hammer.

## 4.4 Integral Abutment Design

Integral abutment sections shall be designed for all relevant strength, service, and extreme limit states and load combinations specified in LRFD Articles 3.4.1 and 11.5.5. Stub abutments shall be designed to resist all lateral earth loads, vehicular loads, dead and live loads, and lateral forces transferred through the integral superstructure. The design of the integral abutment at the strength limit state shall consider reinforced-concrete structural design. Strength limit state design shall also consider changes in foundation conditions and foundation resistance after scour due to the design ($Q_{100}$) flood.

A resistance factor (φ) of 1.0 shall be used to assess abutment design at the service limit state, including: settlement, excessive horizontal movement, and movement resulting after scour due to the design ($Q_{100}$) flood. The overall stability of the foundation should be investigated at the Service I Load Combination and a resistance factor, φ, of 0.65.

Extreme limit state design of integral abutment supported on H-piles shall include pile structural resistance, pile geotechnical resistance, pile resistance in combined axial and flexure, and overall stability. Resistance factors for extreme limit state shall be taken as 1.0. Extreme limit state design shall also check that the nominal foundation resistance remaining after scour due to the check ($Q_{500}$) flood can support the extreme limit state loads with a resistance factor of 1.0.

Design may assume Soil Type 4 (MaineDOT Bridge Design Guide (BDG) Section 3.6.1) for abutment backfill material soil properties. The backfill properties are as follows:

- Angle of internal friction (ϕ) of 32 degrees.
- Total unit weight (γ) of 125 pcf.
- Soil-concrete interface friction angle (δ) of 20 degrees.

Integral abutments shall be designed to withstand a lateral earth load equal to the passive pressure state. AASHTO LRFD Article C3.11.5.4 suggests full passive pressure is mobilized when the ratio of lateral abutment movement to abutment height (y/H) is 0.05H in loose cohesionless soils (sands) and less than 0.05H in dense cohesionless soils. Additionally, Federal Highway Authority (FHWA) NHI-06-089 Figure 10-4, indicates mobilization of full passive pressure in dense cohesionless soils occurs at a y/H ratio of 0.02H.

Considering the above information, the structural designer should estimate the abutment rotation and then select a passive pressure coefficient, $K_p$, in accordance with Figure 3.10.8-1 of the Massachusetts Department of Transportation (MassDOT) Bridge Design Manual.

Additional lateral earth pressure due to live load surcharge is required per Section 3.6.8 of the MaineDOT BDG for abutments if an approach slab is not specified. When a structural approach slab is specified, reduction, not elimination, of the surcharge load is permitted per LRFD Article 3.11.6.5. The live load surcharge may be estimated as a uniform horizontal earth pressure due to an equivalent height of soil ($h_{eq}$) based on LRFD Table 3.11.6.4-1.

The abutment design shall include a drainage system behind the abutment to mitigate excessive hydrostatic pressures. Drainage behind the structure shall be in accordance with MaineDOT BDG Section 5.4.2.13.

Backfill within 10 feet of the abutments and side slope fill shall conform to MaineDOT Specification 703.19 "Granular Borrow for Underwater Backfill."

Slopes in front of the pile supported integral abutments should be protected with riprap and erosion control geotextile. The riprap protected slopes shall not exceed 1.75:1(H:V) in accordance with MaineDOT Standard Detail 610(03). The 1.75H:1V riprap slopes shall "toe-in" at least 2 feet.

## 4.5 Seismic Design Considerations

Seismic site class was evaluated in accordance with LRFD Article 3.10.3.1 Method B (average N-value method). AASHTO allows for an N-value of 100 to be used for bedrock in the upper 100 feet of the soil profile. Based on the subsurface information and an N-value of 100 for the bedrock, the average N-value fell between 15 and 50 bpf corresponding to an AASHTO Site Class D as defined in LRFD Table 3.10.3.1-1.

The United States Geological Survey (USGS) Seismic Design Parameters program (Version 2.1) was used to obtain the seismic design parameters for the site. Based on the assigned site class (AASHTO Site Class D) and site coordinates, the software provides the recommended AASHTO Response Spectrum for a 7 percent probability of exceedance in 75 years (1,000-year return period). The results for the project site are summarized below and program output are provided in Appendix E.

| RECOMMENDED SEISMIC DESIGN PARAMETERS[1] | |
|---|---|
| Site Class | D |
| PGA | 0.090 g |
| $S_s$ | 0.180 g |
| $S_1$ | 0.048 g |
| $F_{pga}$ | 1.6 |
| $F_a$ | 1.6 |
| $F_v$ | 2.4 |
| $A_s$ | 0.14 g |
| $S_{DS}$ | 0.29 g |
| $S_{D1}$ | 0.12 g |
| Seismic Zone (based on $S_{D1}$)[2] | Zone 1 |

NOTE: 1. Based on Site Coordinates: N44.285535, W70.352425
2. Seismic Zone from AASHTO Table 3.10.6-1

## 4.6 Recommendations for Scour Evaluation

Laboratory grain size analyses were performed on soil samples taken near the approximate streambed elevation (El. 300 to 303 feet) to generate parameters to be used in scour analyses. Results of the grain size analyses tests are included in Appendix D and summarized in the following table:

| Boring No. | Sample No. | Depth (ft) | Elevation (ft) | Estimated $D_{95}$ (mm) | Estimated $D_{50}$ (mm) |
|---|---|---|---|---|---|
| BB-BNR-101 | 6D/B | 30.8 | 300.9 | 13 | 0.06 |
| BB-BNR-102 | 5D | 25.0 | 301.9 | 0.2 | 0.03 |
| BB-BNR-201 | 4D | 20.0 | 301.7 | 42 | 0.40 |

Design at the strength limit state should consider loss of lateral and vertical support due to scour. Design at the extreme limit state should check that the nominal foundation resistance due to the check flood ($Q_{500}$) event is no less than the extreme limit state loads. At the service limit state, the design shall limit movements and ensure overall stability considering scour at the design load.

For scour protection of the pile-supported abutments, the bridge and abutment slopes will be armored with riprap. It is our understanding the existing abutments will remain at or below the streambed to provide additional protection to the new abutments. In accordance with MaineDOT BDG Section 2.3.11.3, the top of the riprap shall be located at the $Q_{50}$ elevation. It is our understanding that new riprap slopes in front of the new abutments will be keyed-in behind the existing abutments that remain at or below the streambed. The toe of the new riprap slopes outside of the existing abutments that remain should be keyed into the existing soils at least 2 feet.

Riprap shall conform to MaineDOT Standard Specification 703.26 “Plain and Hand Laid Riprap” and should be placed at a maximum slope of 1.75H:1V. The riprap section shall be underlain by a 1-foot-thick layer of MaineDOT Standard Specification 703.19 “Granular Borrow Material for Underwater Backfill” and a Class 1 nonwoven erosion control geotextile per MaineDOT Standard Specification 722.03.

## 4.7 Construction Considerations

Construction of the abutments will require pile driving. The new integral abutments will be constructed in front of (Abutment No. 1) and behind (Abutment No. 2) the existing abutments. The pile lengths at both abutments will be short and, therefore, scour protection will be critical. Since the proposed bridge design will rely on the riprap slopes to provide scour protection for the integral abutment piles, slope construction and riprap placement are of critical importance. Care should be taken in construction of the riprap slopes to assure that they are constructed in accordance with Sections 710 and 703 of the MaineDOT Standard Specifications, MaineDOT Standard Details, and the Project Plans.

Cobbles were encountered within the existing fill at the site. There is potential for these obstructions to impede the driving of H-piles to bedrock for abutment foundations. Obstructions may be cleared by conventional excavation methods, pre-augering, pre-drilling or spudding.

Alternative methods to clear obstructions may be used as approved by the Resident. Care should be taken to drive H-piles within allowable tolerances without damaging the H-piles.

Construction of the new abutments will require soil excavation and partial or full removal of the existing structure. Construction activities may require cofferdams and/or temporary earth support systems. The removal of the existing structure may require the replacement of excavated soils with compacted granular fill prior to pile driving. In some locations the native soils may be saturated and significant water seepage may be encountered during construction. There may be localized sloughing and surface instability in some soil slopes. The Contractor should control groundwater, surface water infiltration and soil erosion during construction.

Using the excavated native soils as structural backfill should not be permitted. The native soils may only be used as common borrow in accordance with Section 203 and 703 of the MaineDOT Standard Specifications. The Contractor will have to excavate the existing subbase and subgrade fill soils in the bridge approaches. These materials should not be used to re-base the new bridge approaches.

Excavated subbase sand and gravel may be used as fill below subgrade level in fill areas provided all other requirements of Section 203 and 703 of the MaineDOT Standard Specifications are met.

**5.0 CLOSURE**

It has been a pleasure to be of assistance to you with this phase of your project. We look forward to working with you during the construction phase of the project.

Sincerely,

**S. W. Cole Engineering, Inc.**

Digitally signed by Michael St.Pierre, P.E.
Date: 2021.11.08 15:10:48 -05'00'

STATE OF MAINE
MICHAEL A. ST. PIERRE
No. 12519
LICENSED
PROFESSIONAL ENGINEER

Michael A. St. Pierre, P.E.
Senior Geotechnical Engineer

Robert E. Chaput, Jr., P.E.
Principal Geotechnical Engineer

MAS:prw-rec

**APPENDIX A**
**Limitations**

This report has been prepared for the exclusive use of Maine Department of Transportation for specific application to the Hall Bridge #3287 over Nezinscot River (WIN 021876.00) on Route 117 in Buckfield, Maine. S. W. Cole Engineering, Inc. (S.W.COLE) has endeavored to conduct our services in accordance with generally accepted soil and foundation engineering practices. No warranty, expressed or implied, is made.

The soil profiles described in the report are intended to convey general trends in subsurface conditions. The boundaries between strata are approximate and are based upon interpretation of exploration data and samples.

The analyses performed during this investigation and recommendations presented in this report are based in part upon the data obtained from subsurface explorations made at the site. Variations in subsurface conditions may occur between explorations and may not become evident until construction. If variations in subsurface conditions become evident after submission of this report, it will be necessary to evaluate their nature and to review the recommendations of this report.

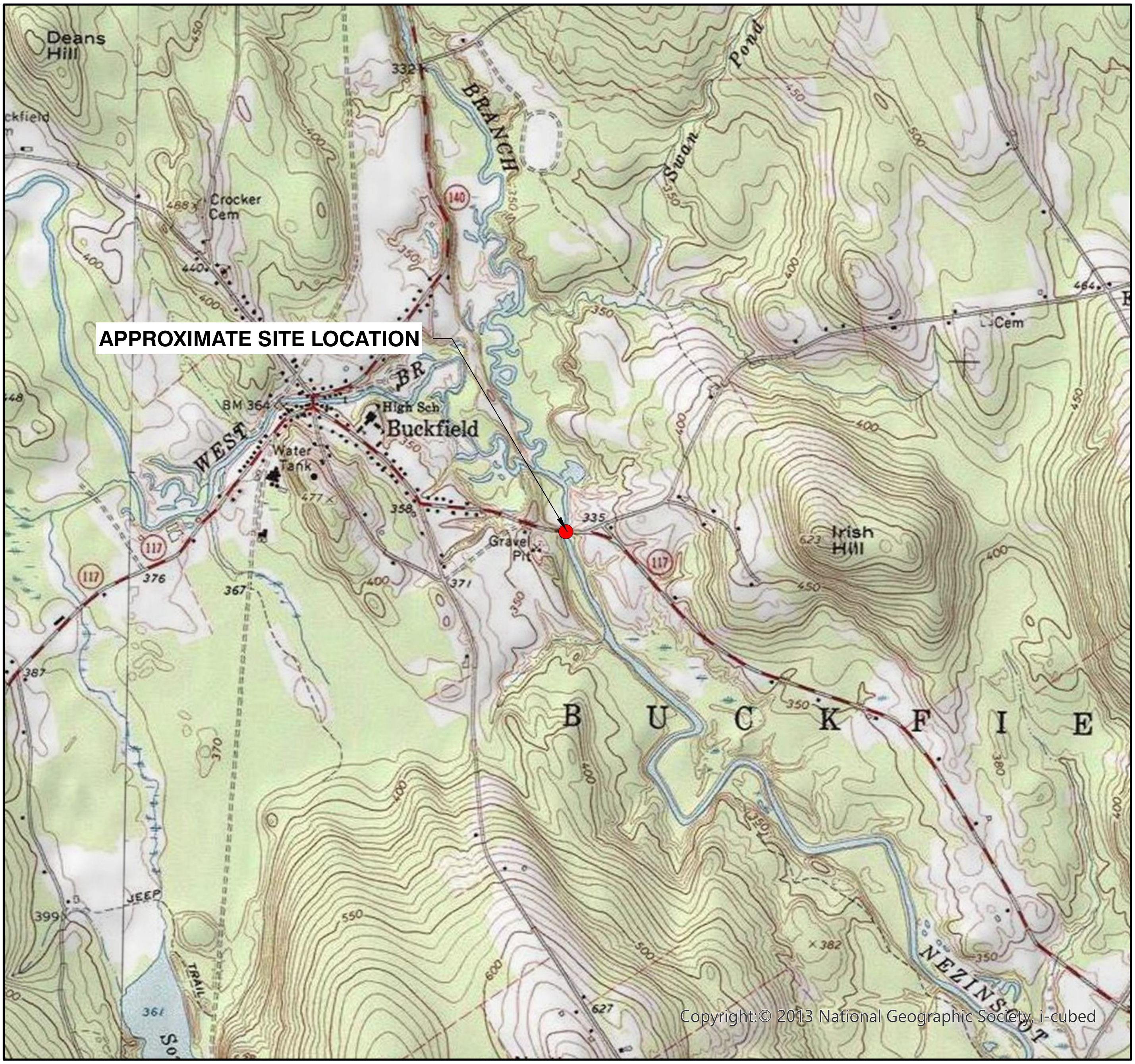
Observations have been made during exploration work to assess site groundwater levels. Fluctuations in water levels will occur due to variations in rainfall, temperature, and other factors.

S.W.COLE's scope of services has not included the investigation, detection, or prevention of any Biological Pollutants at the project site or in any existing or proposed structure at the site. The term "Biological Pollutants" includes, but is not limited to, molds, fungi, spores, bacteria, and viruses, and the byproducts of any such biological organisms.

Recommendations contained in this report are based substantially upon information provided by others regarding the proposed project. In the event that any changes are made in the design, nature, or location of the proposed project, S.W.COLE should review such changes as they relate to analyses associated with this report. Recommendations contained in this report shall not be considered valid unless the changes are reviewed by S.W.COLE.

**APPENDIX B**

**Figures**




2,000 0 2,000 4,000

Scale in Feet

S.W.COLE ENGINEERING, INC.

MAINEDOT

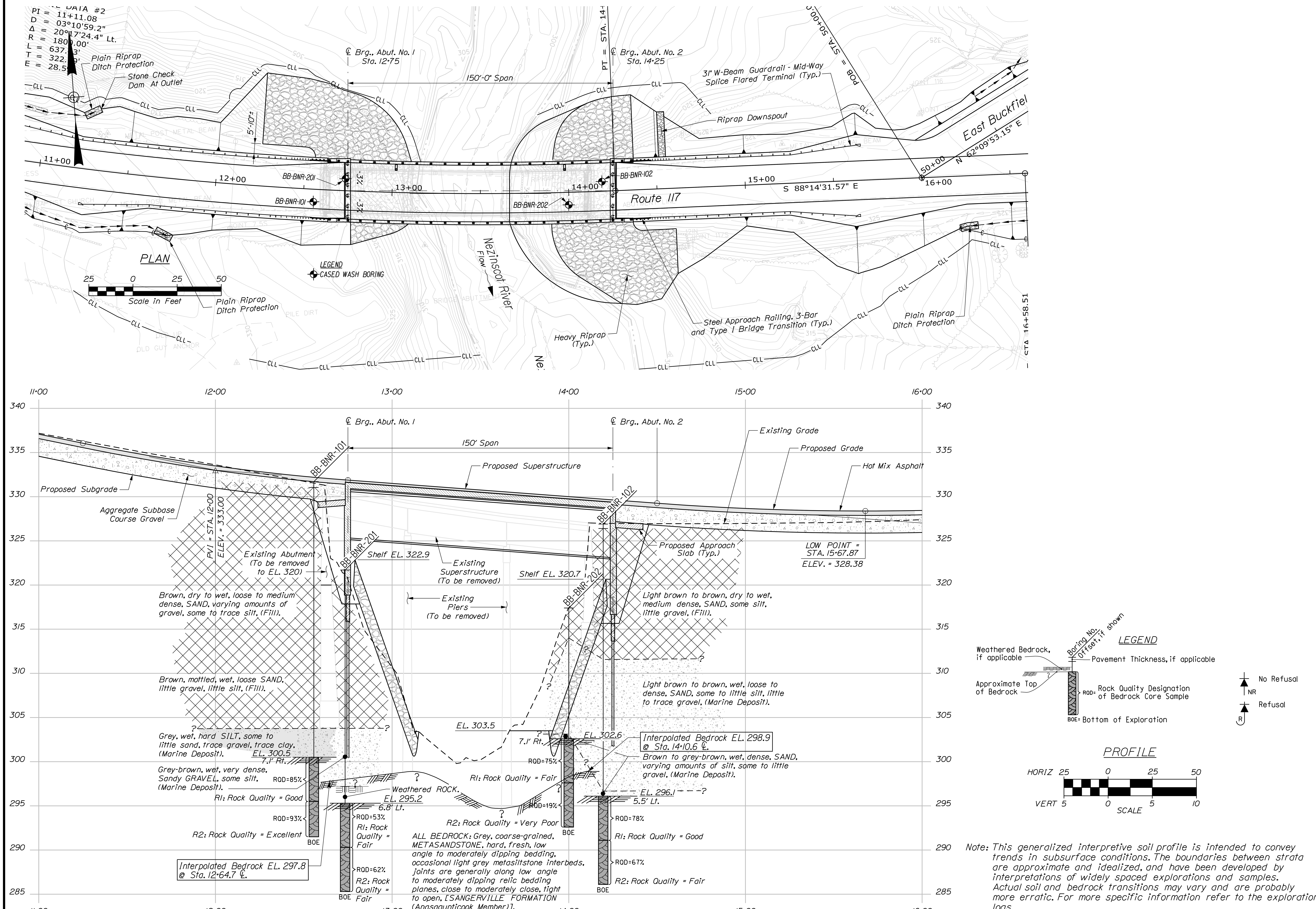
## SITE LOCATION MAP

ROUTE 117 OVER NEXINSCOT RIVER
HALL BRIDGE #3287 REPLACEMENT
BUCKFIELD, MAINE
WIN 021876.00

| | | | |
|---|---|---|---|
| Job No. | 20-1403-021876 | Scale | 1" = 2000' |
| Date: | 10/29/2021 | Sheet | 1 |

**NOTE:**
SITE LOCATION MAP PREPARED FROM ESRI ArcGIS ONLINE AND DATA PARTNERS INCLUDING USGS AND © 2007 NATIONAL GEOGRAPHIC SOCIETY.

R:\2020\20-1403\ArcProject\20-1403.aprx, 10/29/2021 2:24 PM, 1:24,000,




Note: This generalized interpretive soil profile is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and have been developed by interpretations of widely spaced explorations and samples. Actual soil and bedrock transitions may vary and are probably more erratic. For more specific information refer to the exploration logs.

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

021876.00

BRIDGE PLANS

WIN 21876.00

BRIDGE NO. 3287

| | BY | DATE |
|---|---|---|
| PROJ. MANAGER | | |
| DESIGN-DETAILED | | |
| CHECKED-REVIEWED | | |
| DESIGN2-DETAILED2 | M.ST.PIERRE | |
| DESIGN3-DETAILED3 | T.WHITE | OCT 2021 |
| REVISIONS 1 | | |
| REVISIONS 2 | | |
| REVISIONS 3 | | |
| REVISIONS 4 | | |
| FIELD CHANGES | | |

SIGNATURE

P.E. NUMBER

DATE

HALL BRIDGE
NEZINSCOT RIVER
BUCKFIELD OXFORD COUNTY

# BORING LOCATION PLAN & INTERPRETIVE SUBSURFACE PROFILE

SHEET NUMBER

2

OF 3

# APPENDIX C

## Boring Logs,
## Key to Soil and Rock Descriptions and Terms &
## Rock Core Photos

# Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

**Project:** Hall Bridge #3287 carries Route 117 over Nezinscot River.
**Location:** Buckfield, Maine

**Boring No.:** BB-BNR-101

**WIN:** 21876.00

| | | | | | |
|---|---|---|---|---|---|
| **Driller:** | MaineDOT | **Elevation (ft.)** | 331.7 | **Auger ID/OD:** | 5" Soild Stem |
| **Operator:** | Travis/James | **Datum:** | NAVD88 | **Sampler:** | Standard Split Spoon |
| **Logged By:** | B. Slaven | **Rig Type:** | CME 45C | **Hammer Wt./Fall:** | 140#/30" |
| **Date Start/Finish:** | 8/9/2017-8/9/2017 | **Drilling Method:** | Cased Wash Boring | **Core Barrel:** | NQ-2" |
| **Boring Location:** | 12+55.7, 7.1 ft Rt. | **Casing ID/OD:** | NW | **Water Level*:** | 14.0 ft bgs |
| **Hammer Efficiency Factor:** | 0.854 | **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 = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field 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/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_u$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
$q_p$ = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
$N_{60}$ = SPT N-uncorrected Corrected for Hammer Efficiency
$N_{60}$ = (Hammer Efficiency Factor/60%)*N-uncorrected
$T_v$ = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

| 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 | | | | | | | SSA | 331.0 | | 8" HMA. 0.7 | |
| 5 | 1D | 24/17 | 5.00 - 7.00 | 2/2/1/1 | 3 | 4 | | | | Light brown, dry, very loose, medium to fine SAND, some silt, trace gravel, (Fill). | G#270341 A-2-4, SM WC=9.9% |
| 10 | 2D | 24/6 | 10.30 - 12.30 | 8/11/8/5 | 19 | 27 | DROVE CASE | | | Light brown, dry, medium dense, Gravelly SAND, trace silt, (Fill). Set in NW Casing and drove to 15.0 ft bgs. | G#270342 A-1-b, SW-SM WC=9.4% |
| 15 | 3D | 24/3 | 15.00 - 17.00 | 4/4/5/12 | 9 | 13 | 16 | | | Light brown, wet, medium dense, GRAVEL, little coarse sand, (Fill). | |
| | | | | | | | 38 | | | | |
| | | | | | | | 27 | | | | |
| | | | | | | | 108 | | | | |
| | 4D/AB | 24/10 | 19.00 - 21.00 | 9/5/2/3 | 7 | 10 | 30 | | | 4D/A (19.0-20.9 ft bgs) Light brown, wet, loose, SAND, some silt, trace gravel, (Fill). | G#270343 A-2-4, SM WC=16.9% |
| 20 | | | | | | | 20 | | | | |
| | | | | | | | 18 | | | 4D/B (20.9-21.0 ft bgs) Dark brown, wet, loose, fine SAND, little silt, trace gravel, (Fill). | |
| | | | | | | | 24 | | | | |
| | | | | | | | 25 | | | | |
| 25 | | | | | | | 28 | | | | |

**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:** Hall Bridge #3287 carries Route 117 over Nezinscot River.
**Location:** Buckfield, Maine

**Boring No.:** BB-BNR-101

**WIN:** 21876.00

| | | | | | |
|---|---|---|---|---|---|
| **Driller:** | MaineDOT | **Elevation (ft.)** | 331.7 | **Auger ID/OD:** | 5" Soild Stem |
| **Operator:** | Travis/James | **Datum:** | NAVD88 | **Sampler:** | Standard Split Spoon |
| **Logged By:** | B. Slaven | **Rig Type:** | CME 45C | **Hammer Wt./Fall:** | 140#/30" |
| **Date Start/Finish:** | 8/9/2017-8/9/2017 | **Drilling Method:** | Cased Wash Boring | **Core Barrel:** | NQ-2" |
| **Boring Location:** | 12+55.7, 7.1 ft Rt. | **Casing ID/OD:** | NW | **Water Level*:** | 14.0 ft bgs |
| **Hammer Efficiency Factor:** 0.854 | | **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 = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt

R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person

$S_u$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
$q_p$ = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
$N_{60}$ = SPT N-uncorrected Corrected for Hammer Efficiency
$N_{60}$ = (Hammer Efficiency Factor/60%)*N-uncorrected

$T_v$ = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

| 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. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 5D | 24/15 | 25.00 - 27.00 | 6/4/2/1 | 6 | 9 | 8 | | | Light and dark brown, mottled, wet, loose, SAND, little gravel, little silt, (Fill). | G#270344 A-1-b, SM WC=41.1% |
| | | | | | | | 10 | | | | |
| | | | | | | | 17 | 303.7 | | 28.0 | |
| | | | | | | | 24 | | | | |
| | | | | | | | 35 | | | | |
| 30 | 6D/AB | 13.2/11 | 30.00 - 31.10 | 8/7/50(1.2") | --- | | | | | Dark grey, wet, hard, SILT, some sand, trace gravel, trace clay, (Marine Deposit) | |
| | R1 | 60/53 | 31.20 - 36.20 | RQD = 85% | | | NQ-2 | 300.5 | | 31.2<br>Top of Bedrock at Elev. 300.5 ft.<br>R1: Bedrock: Grey, coarse-grained, METASANDSTONE, hard, fresh, thin moderate dipping light grey metasiltstone beds, occasional zones of grey and light grey, fine to medium grained, cross and convolute-laminated metasandstone, joints along relic bedding are low to moderately dipping, close to moderately close, tight to open.<br>[SANGERVILLE FORMATION (Anasagunticook Member)]<br>Rock Mass Quality = Good.<br>R1: Core Times (min:sec):<br>31.2-32.2 ft (2:46)<br>32.2-33.2 ft (2:26)<br>33.2-34.2 ft (2:19)<br>34.2-35.2 ft (2:49) water loss<br>35.2-36.2 ft (1:51) 88% Recovery | G#270345 A-4, CL WC=13.4% |
| 35 | | | | | | | | | | | |
| | R2 | 48/48 | 36.20 - 40.20 | RQD = 93% | | | | | | R2: Bedrock: Similar to R1.<br>Rock Mass Quality = Excellent.<br>R2: Core Times (min:sec)<br>36.2-37.2 ft (3:45)<br>37.2-38.2 ft (2:44)<br>38.2-39.2 ft (2:35)<br>39.2-40.2 ft (3:28) 100% Recovery<br>Core Blocked | |
| 40 | | | | | | | | 291.5 | | 40.2<br>**Bottom of Exploration at 40.2 feet below ground surface.** | |
| 45 | | | | | | | | | | | |
| 50 | | | | | | | | | | | |

**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:** Hall Bridge #3287 carries Route 117 over Nezinscot River.
**Location:** Buckfield, Maine

**Boring No.:** BB-BNR-102
**WIN:** 21876.00

| | | | | | |
|---|---|---|---|---|---|
| **Driller:** | MaineDOT | **Elevation (ft.)** | 326.9 | **Auger ID/OD:** | 5" Solid Stem |
| **Operator:** | Travis/James | **Datum:** | NAVD88 | **Sampler:** | Standard Split Spoon |
| **Logged By:** | B. Slaven | **Rig Type:** | CME 45C | **Hammer Wt./Fall:** | 140#/30" |
| **Date Start/Finish:** | 8/9/2017-8/9/2017 | **Drilling Method:** | Cased Wash Boring | **Core Barrel:** | NQ-2" |
| **Boring Location:** | 14+19, 5.5 ft Lt. | **Casing ID/OD:** | NW | **Water Level*:** | Caved at 8.6 ft bgs. |
| **Hammer Efficiency Factor:** | 0.854 | **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 = Field Vane Shear Test, PP = Pocket Penetrometer
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HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_u$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
$q_p$ = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
$N_{60}$ = SPT N-uncorrected Corrected for Hammer Efficiency
$N_{60}$ = (Hammer Efficiency Factor/60%)*N-uncorrected
$T_v$ = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

| 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 | | | | | | | SSA | 326.4 | | 6" HMA. 0.5 | |
| 5 | 1D | 24/15 | 5.00 - 7.00 | 4/8/6/4 | 14 | 20 | | | | Light brown, medium dense, medium to fine SAND, some silt, little gravel, (Fill). | |
| 10 | 2D | 24/1 | 10.20 - 12.20 | 3/4/6/6 | 10 | 14 | | | | Brown, dry, medium dense, SAND, some silt, little gravel, (Fill). | |
| 15 | 3D | 24/16 | 15.00 - 17.00 | 2/2/2/2 | 4 | 6 | | 311.9 | | 15.0 Light brown, moist, loose, SAND, some silt, trace gravel, trace organics/ roots. (Marine Deposit).<br><br>Drove casing 20.0 ft bgs, and washed ahead. | G#270346<br>A-2-4, SM<br>WC=23.2% |
| | | | | | | | 12 | | | | |
| | | | | | | | 11 | | | | |
| | | | | | | | 28 | | | | |
| | | | | | | | 46 | | | | |
| 20 | 4D | 24/12 | 20.00 - 22.00 | 11/15/11/11 | 26 | 37 | 12 | | | Light brown, wet, medium dense, coarse to medium SAND, little gravel, trace silt, (Marine Deposit). | G#270347<br>A-1-b, SP-SM<br>WC=9.5% |
| | | | | | | | --- | | | | |
| | | | | | | | --- | | | | |
| | | | | | | | 41 | | | | |
| | | | | | | | 26 | | | | |
| 25 | | | | | | | | | | | |

**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:** Hall Bridge #3287 carries Route 117 over Nezinscot River.
**Location:** Buckfield, Maine

**Boring No.:** BB-BNR-102
**WIN:** 21876.00

| | | | | | |
|---|---|---|---|---|---|
| **Driller:** | MaineDOT | **Elevation (ft.)** | 326.9 | **Auger ID/OD:** | 5" Solid Stem |
| **Operator:** | Travis/James | **Datum:** | NAVD88 | **Sampler:** | Standard Split Spoon |
| **Logged By:** | B. Slaven | **Rig Type:** | CME 45C | **Hammer Wt./Fall:** | 140#/30" |
| **Date Start/Finish:** | 8/9/2017-8/9/2017 | **Drilling Method:** | Cased Wash Boring | **Core Barrel:** | NQ-2" |
| **Boring Location:** | 14+19, 5.5 ft Lt. | **Casing ID/OD:** | NW | **Water Level*:** | Caved at 8.6 ft bgs. |
| **Hammer Efficiency Factor:** | 0.854 | **Hammer Type:** | Automatic ☒ Hydraulic ☐ Rope & Cathead ☐ | | |

Definitions:
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MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
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MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_u$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
$q_p$ = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
$N_{60}$ = SPT N-uncorrected Corrected for Hammer Efficiency
$N_{60}$ = (Hammer Efficiency Factor/60%)*N-uncorrected
$T_v$ = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

| 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. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 5D | 24/22 | 25.00 - 27.00 | 3/1/1/1 | 2 | 3 | --- DROVE | | | Grey, wet, soft, SILT, little clay, little fine sand, (Marine Deposit). | G#270348 A-4, ML WC=30.7% LL=33 PL=30 PI=3 |
| 30 | 6D | 7.2/4 | 30.00 - 30.60 | 40/50(1.2") | --- | | NQ-2 | 296.1 | | Casing blows increase at 29.5 ft bgs. Grey-brown, wet, very dense, Silty fine SAND, some gravel, (Marine Deposit). 30.8 | |
| | R1 | 60/56 | 30.80 - 35.80 | RQD = 78% | | | | | | Top of Bedrock at Elev. 296.1 ft. R1: Bedrock: Grey, coarse grained, METASANDSTONE, hard, fresh, thin moderate dipping light grey metasiltstone beds, occasional zones of grey and light grey, fine to medium grained, cross and convolute-laminated metasandstone. Breaks along relic bedding are low to moderately dipping, close to moderately close, tight to open. [SANGERVILLE FORMATION (Anasagunticook Member)] Rock Mass Quality = Good. R1: Core Times (min:sec) 30.8-31.8 ft (1:33) 31.8-32.8 ft (1:21) 32.8-33.8 ft (1:39) 33.8-34.8 ft (1:36) 34.8-35.8 ft (1:39) 93% recovery | |
| 35 | R2 | 60/56 | 35.80 - 40.80 | RQD = 67% | | | | | | R2: Bedrock: Similar to R1. Rock Mass Quality = Fair. R2: Core Times (min:sec) 35.8-36.8 ft (1:07) 4" drop 36.1-36.5 ft bgs. 36.8-37.8 ft (2:04) 37.8-38.8 ft (2:09) 38.8-39.8 ft (2:26) 39.8-40.8 ft (2:30) 93% Recovery | |
| 40 | | | | | | | | 286.1 | | 40.8 **Bottom of Exploration at 40.8 feet below ground surface.** | |
| 45 | | | | | | | | | | | |
| 50 | | | | | | | | | | | |

**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:** Hall Bridge #3287 carries Route 117 over Nezinscot River.
**Location:** Buckfield, Maine

**Boring No.:** BB-BNR-201
**WIN:** 21876.00

| | | | | | |
|---|---|---|---|---|---|
| **Driller:** | MaineDOT | **Elevation (ft.)** | 321.7 | **Auger ID/OD:** | N/A |
| **Operator:** | Daggett/Niles | **Datum:** | NAVD88 | **Sampler:** | Standard Split Spoon |
| **Logged By:** | B. Wilder | **Rig Type:** | CME 45C | **Hammer Wt./Fall:** | 140#/30" |
| **Date Start/Finish:** | 5/9,15/2019 | **Drilling Method:** | Cased Wash Boring | **Core Barrel:** | NQ-2" |
| **Boring Location:** | 12+73.4, 6.8 ft Lt. | **Casing ID/OD:** | HW & NW | **Water Level*:** | None Observed |
| **Hammer Efficiency Factor:** 0.928 | | **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 = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field 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/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_u$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
$q_p$ = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
$N_{60}$ = SPT N-uncorrected Corrected for Hammer Efficiency
$N_{60}$ = (Hammer Efficiency Factor/60%)*N-uncorrected
$T_v$ = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

| 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 | | | | | | | SC | | | Gravel and Rock, (Fill).<br>SC = Spun HW Casing. | |
| 5 | 1D | 24/4 | 5.00 - 7.00 | 7/11/14/19 | 25 | 39 | | | | Brown, wet, dense, Gravelly fine to coarse SAND, with cobbles, (Fill). | |
| 10 | 2D | 24/16 | 10.50 - 12.50 | 4/10/14/12 | 24 | 37 | 24 | | | Cobble from 10.0-10.5 ft bgs.<br>Changed to NW Casing at 10.0 ft bgs.<br>Light brown, wet, dense, fine to coarse SAND, little gravel, little silt, (Fill). | |
| | | | | | | | 41 | | | | |
| | | | | | | | 47 | | | | |
| | | | | | | | 84 | | | | |
| | | | | | | | 58 | | | | |
| 15 | 3D | 24/18 | 15.00 - 17.00 | 2/3/3/4 | 6 | 9 | 6 | | | Light brown, wet, loose, fine to medium SAND, some silt, (Fill). | G#337176<br>A-2-4, SM<br>WC=34.6% |
| | | | | | | | 12 | | | | |
| | | | | | | | 26 | 303.7 | | 18.0 | |
| | | | | | | | 32 | | | | |
| | | | | | | | 40 | | | | |
| 20 | 4D | 24/16 | 20.00 - 22.00 | 60/20/22/17 | 42 | 65 | 25 | | | Grey-brown, wet, very dense, fine to coarse Sandy GRAVEL, some silt, (Marine Deposit). | G#337177<br>A-2-4, GM<br>WC=11.6% |
| | | | | | | | 19 | | | | |
| | | | | | | | 33 | | | | |
| | | | | | | | 29 | | | | |
| | | | | | | | 260 | 297.2 | | 24.5 | |
| 25 | | | | | | | | | | | |

**Remarks:**

10" Concrete Bridge Deck.
10.0 ft from Bridge Deck to Existing Grade.

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:** Hall Bridge #3287 carries Route 117 over Nezinscot River.
**Location:** Buckfield, Maine

**Boring No.:** BB-BNR-201
**WIN:** 21876.00

| | | | | | |
|---|---|---|---|---|---|
| **Driller:** | MaineDOT | **Elevation (ft.)** | 321.7 | **Auger ID/OD:** | N/A |
| **Operator:** | Daggett/Niles | **Datum:** | NAVD88 | **Sampler:** | Standard Split Spoon |
| **Logged By:** | B. Wilder | **Rig Type:** | CME 45C | **Hammer Wt./Fall:** | 140#/30" |
| **Date Start/Finish:** | 5/9,15/2019 | **Drilling Method:** | Cased Wash Boring | **Core Barrel:** | NQ-2" |
| **Boring Location:** | 12+73.4, 6.8 ft Lt. | **Casing ID/OD:** | HW & NW | **Water Level*:** | None Observed |
| **Hammer Efficiency Factor:** | 0.928 | **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 = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_u$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
$q_p$ = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
$N_{60}$ = SPT N-uncorrected Corrected for Hammer Efficiency
$N_{60}$ = (Hammer Efficiency Factor/60%)*N-uncorrected
$T_v$ = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

| 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. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | | | | | | | | | | Weathered ROCK. | |
| | R1 | 60/60 | 26.50 - 31.50 | RQD = 53% | | | NQ-2 | 295.2 | | 26.5 Top of Bedrock at Elev. 295.2 ft.<br>R1: Bedrock: Grey, coarse-grained, METASANDSTONE, hard, fresh, thin moderate dipping light grey metasiltstone beds, occasional zones of grey and light grey, fine to medium grained, cross and convolute-laminated metasandstone, joints along relic bedding are low to moderately dipping, close to moderately close, tight to open, [SANGERVILLE FORMATION (Anasagunticook Member)].<br>Rock Mass Quality = Fair<br>R1: Core Times (min:sec)<br>26.4-27.4 ft (1:08)<br>27.4-28.4 ft (1:15)<br>28.4-29.4 ft (1:12)<br>29.4-30.4 ft (1:03)<br>30.4-31.4 ft (1:04)<br>100% Recovery | |
| 30 | | | | | | | | | | | |
| | R2 | 60/55 | 31.40 - 36.40 | RQD = 62% | | | | | | R2: Bedrock:Similar to R1 except joints are moderately dipping (30-45 deg).<br>Rock Mass Quality = Fair<br>R2: Core Times (min:sec)<br>31.4-32.4 ft (1:19)<br>32.4-33.4 ft (2:00)<br>33.4-34.4 ft (1:46)<br>34.4-35.4 ft (2:00)<br>35.4-36.4 ft (2:08)<br>92% Recovery | |
| 35 | | | | | | | | 285.3 | | | |
| | | | | | | | | | | 36.4 **Bottom of Exploration at 36.4 feet below ground surface.** | |
| 40 | | | | | | | | | | | |
| 45 | | | | | | | | | | | |
| 50 | | | | | | | | | | | |

**Remarks:**

10" Concrete Bridge Deck.
10.0 ft from Bridge Deck to Existing Grade.

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:** Hall Bridge #3287 carries Route 117 over Nezinscot River.
**Location:** Buckfield, Maine

**Boring No.:** BB-BNR-202

**WIN:** 21876.00

| | | | | | |
|---|---|---|---|---|---|
| **Driller:** | MaineDOT | **Elevation (ft.)** | 317.4 | **Auger ID/OD:** | N/A |
| **Operator:** | Daggett/Niles | **Datum:** | NAVD88 | **Sampler:** | Standard Split Spoon |
| **Logged By:** | B. Wilder | **Rig Type:** | CME 45C | **Hammer Wt./Fall:** | 140#/30" |
| **Date Start/Finish:** | 5/15/2019; 10:00-15:30 | **Drilling Method:** | Cased Wash Boring | **Core Barrel:** | NQ-2" |
| **Boring Location:** | 13+99.8, 7.1 ft Rt. | **Casing ID/OD:** | HW & NW | **Water Level*:** | None Observed |
| **Hammer Efficiency Factor:** | 0.928 | **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 = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field 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/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_u$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
$q_p$ = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
$N_{60}$ = SPT N-uncorrected Corrected for Hammer Efficiency
$N_{60}$ = (Hammer Efficiency Factor/60%)*N-uncorrected
$T_v$ = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

| 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 | | | | | | | SC | | | Gravel and Rock, (Fill). SC = Spun HW Casing | |
| | | | | | | | | 313.9 | | 3.5 | |
| 5 | 1D | 24/14 | 5.00 - 7.00 | 3/4/3/5 | 7 | 11 | 15 | | | Brown, wet, medium dense, fine to coarse SAND, some silt, some gravel, (Marine Deposit). Changed to NW Casing at 5.0 ft bgs. | G#337178 A-4, SM WC=20.4% |
| | | | | | | | 38 | | | | |
| | | | | | | | 32 | | | | |
| | | | | | | | 36 | | | | |
| | 2D | 24/17 | 9.00 - 11.00 | 3/3/6/9 | 9 | 14 | 13 | | | Brown, wet, medium dense, fine to coarse SAND, little silt, trace gravel, (Marine Deposit). | G#337179 A-2-4, SM WC=20.1% |
| 10 | | | | | | | 22 | | | | |
| | | | | | | | 35 | | | | |
| | | | | | | | 52 | | | | |
| | | | | | | | 111 | | | | |
| | 3D | 6/3 | 14.00 - 14.50 | 55 | --- | | NQ-2 | | | Similar to above, except very dense. Roller Coned ahead to 14.8 ft bgs. | |
| 15 | R1 | 60/58 | 14.80 - 19.80 | RQD = 75% | | | | 302.6 | | 14.8 Top of Bedrock at Elev. 302.6 ft. R1: Bedrock: Grey, coarse-grained, METASANDSTONE, hard, fresh, thin moderate dipping light grey metasiltstone beds, occasional zones of grey and light grey, fine to medium grained, cross and convolute-laminated metasandstone, joints along relic bedding are low to moderately dipping, close to moderately close, tight to open, [SANGERVILLE FORMATION (Anasagunticook Member)]. Rock Mass Quality = Fair R1: Core Times (min:sec) 14.8-15.8 ft (1:44) 15.8-16.8 ft (1:46) 16.8-17.8 ft (1:45) 17.8-18.8 ft (2:02) 18.8-19.8 ft (2:11) 97% Recovery | |
| | R2 | 60/54 | 19.80 - 24.80 | RQD = 19% | | | | | | R2: Bedrock: Similar to R1 Rock Mass Quality = Very Poor R2: Core Times (min:sec) 19.8-20.8 ft (1:58) 20.8-21.8 ft (1:46) | |
| 20 | | | | | | | | | | | |
| 25 | | | | | | | | 292.6 | | | |

**Remarks:**

10" Concrete Bridge Deck.
11.2 ft from Bridge Deck to Existing Grade.

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<br>Soil/Rock Exploration Log<br>US CUSTOMARY UNITS | Project: Hall Bridge #3287 carries Route 117 over Nezinscot River.<br>Location: Buckfield, Maine | Boring No.: BB-BNR-202<br>WIN: 21876.00 |
|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| **Driller:** | MaineDOT | **Elevation (ft.)** | 317.4 | **Auger ID/OD:** | N/A |
| **Operator:** | Daggett/Niles | **Datum:** | NAVD88 | **Sampler:** | Standard Split Spoon |
| **Logged By:** | B. Wilder | **Rig Type:** | CME 45C | **Hammer Wt./Fall:** | 140#/30" |
| **Date Start/Finish:** | 5/15/2019; 10:00-15:30 | **Drilling Method:** | Cased Wash Boring | **Core Barrel:** | NQ-2" |
| **Boring Location:** | 13+99.8, 7.1 ft Rt. | **Casing ID/OD:** | HW & NW | **Water Level*:** | None Observed |
| **Hammer Efficiency Factor:** | 0.928 | **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 = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
$S_u$ = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
$q_p$ = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
$N_{60}$ = SPT N-uncorrected Corrected for Hammer Efficiency
$N_{60}$ = (Hammer Efficiency Factor/60%)*N-uncorrected
$T_v$ = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

| 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. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | | | | | | | | | | 21.8-22.8 ft (1:20)<br>22.8-23.8 ft (1:00) 2" drop<br>23.8-24.8 ft (2:06)<br>90% Recovery | |
| | | | | | | | | | | 24.8 | |
| | | | | | | | | | | **Bottom of Exploration at 24.8 feet below ground surface.** | |
| 30 | | | | | | | | | | | |
| 35 | | | | | | | | | | | |
| 40 | | | | | | | | | | | |
| 45 | | | | | | | | | | | |
| 50 | | | | | | | | | | | |

**Remarks:**

10" Concrete Bridge Deck.
11.2 ft from Bridge Deck to Existing Grade.

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.



**Boring No.:** BB-BNR-202

**MaineDOT**
**Hall Bridge #3287 carries Route 117 over Nezinscot River**
**Buckfield, ME**
*Rock Core Photographs*

| Boring No. | Run | Depth (ft) | Recovery (in) | Recovery (%) | RQD (in) | RQD (%) | Rock Type | Box Row |
|---|---|---|---|---|---|---|---|---|
| BB-BNR-102 | R1 | 30.8 – 35.8 | 56 | 93% | 47 | 78% | METASANDSTONE | 1 |
| BB-BNR-102 | R2 | 35.8 – 40.8 | 56 | 93% | 40 | 67% | METASANDSTONE | 2 |
| BB-BNR-101 | R1 | 31.2 – 36.2 | 53 | 88% | 51 | 85% | METASANDSTONE | 3 |
| BB-BNR-101 | R2 | 36.2 – 40.2 | 48 | 100% | 45 | 93% | METASANDSTONE | 4 |

**Notes:** 1. “Box row” indicates the section of the box where the core run is contained: 1 = top, 4 = bottom.
2. Transition between core runs is marked by wood separators.

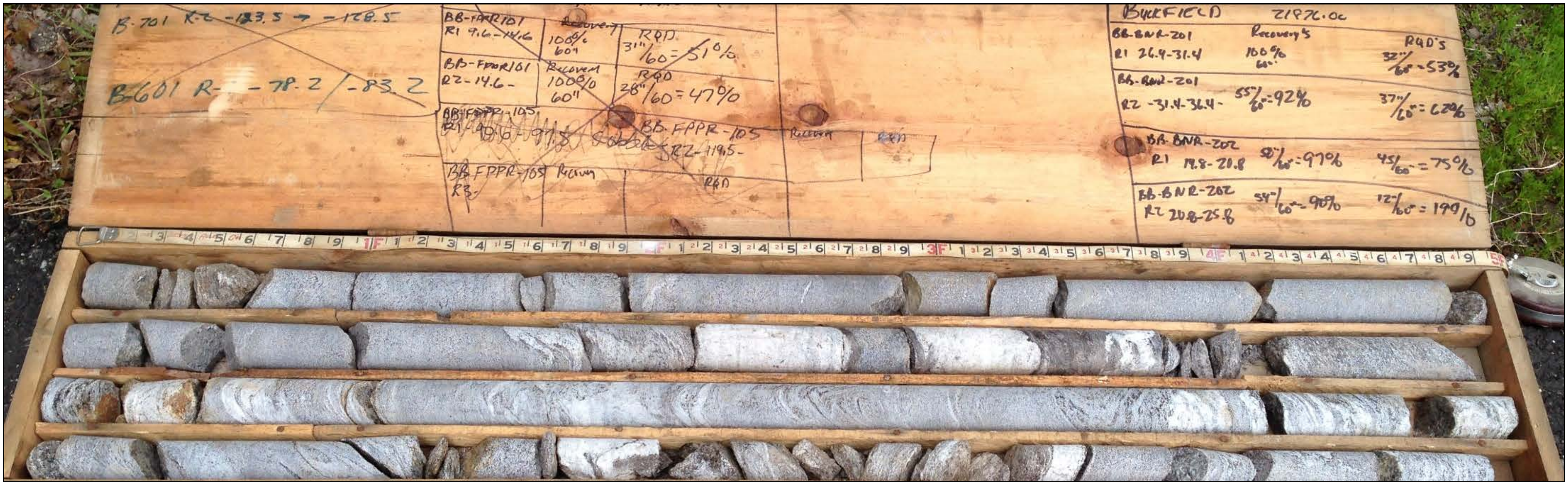
**MaineDOT**

**Hall Bridge #3287 carries Route 117 over Nezinscot River**

**Buckfield, ME**

*Rock Core Photographs*

| Boring No. | Run | Depth (ft) | Recovery (in) | Recovery (%) | RQD (in) | RQD (%) | Rock Type | Box Row |
|---|---|---|---|---|---|---|---|---|
| BB-BNR-201 | R1 | 26.4 – 31.4 | 60 | 100% | 32 | 53% | METASANDSTONE | 1 |
| BB-BNR-201 | R2 | 31.4 – 36.4 | 55 | 92% | 37 | 62% | METASANDSTONE | 2 |
| BB-BNR-202 | R1 | 14.8 – 19.8 | 58 | 97% | 45 | 75% | METASANDSTONE | 3 |
| BB-BNR-202 | R2 | 19.8 – 24.8 | 54 | 90% | 12 | 19% | METASANDSTONE | 4 |

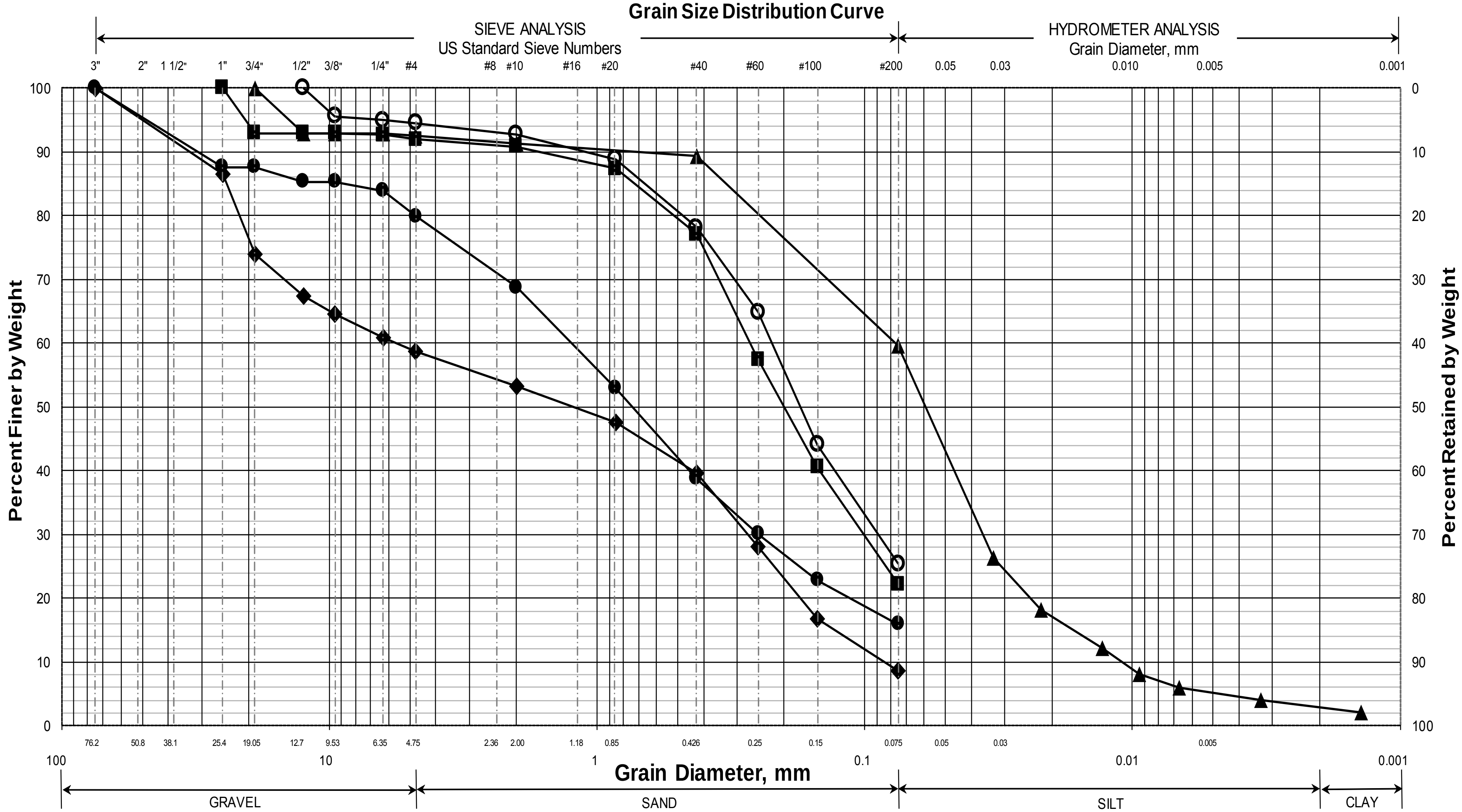



**Notes:** 1. "Box row" indicates the section of the box where the core run is contained: 1 = top, 4 = bottom.
2. Transition between core runs is marked by wood separators.

# APPENDIX D

## Laboratory Test Results

## Maine Department of Transportation
## Grain Size Distribution Curve



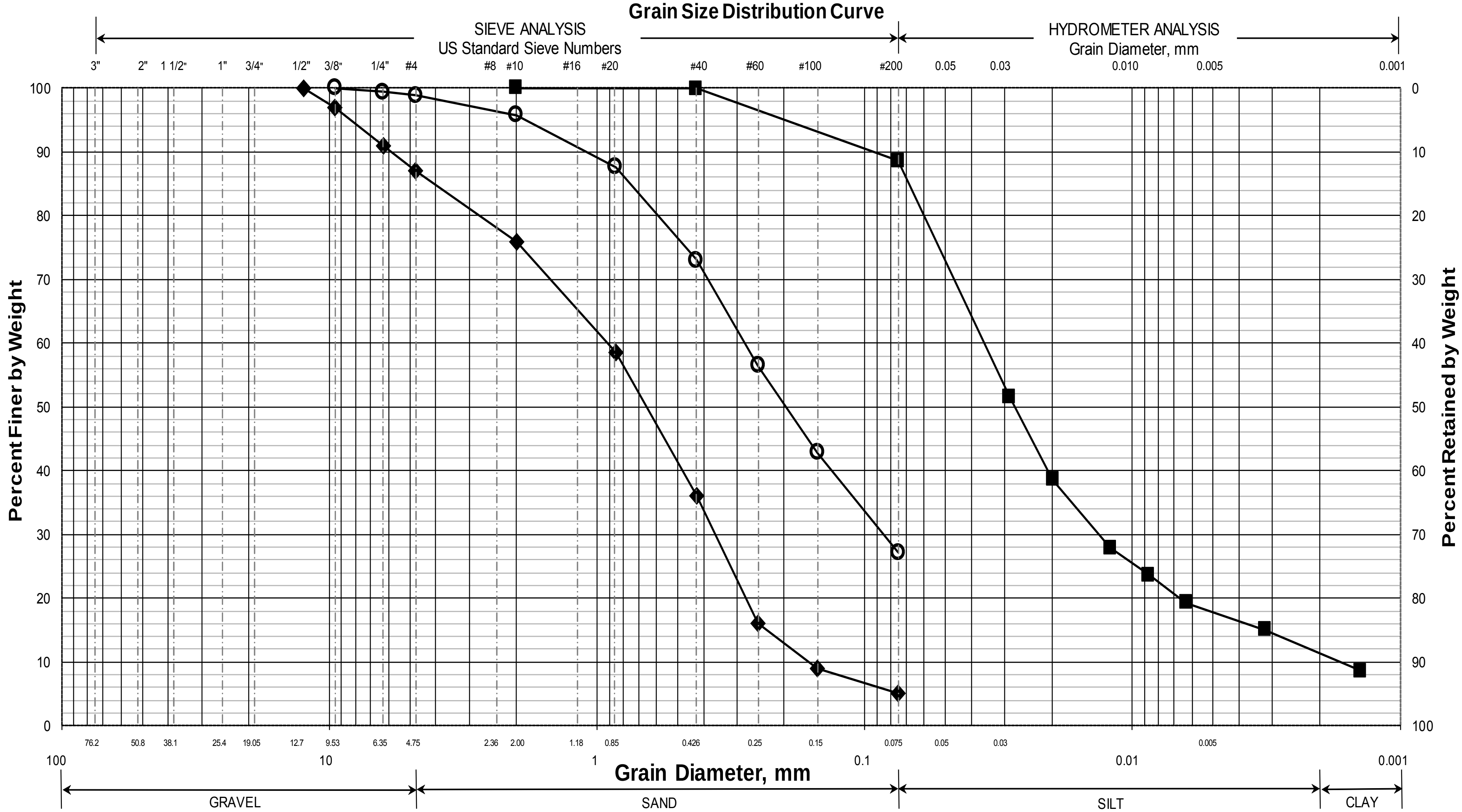

UNIFIED CLASSIFICATION

| | Boring/Sample No. | Station | Offset, ft | Depth, ft | Description | WC, % | LL | PL | PI |
|---|---|---|---|---|---|---|---|---|---|
| ○ | BB-BNR-101/1D | 12+55.7 | 7.1 RT | 5.0-7.0 | SAND, some silt, trace gravel. | 9.9 | | | |
| ◆ | BB-BNR-101/2D | 12+55.7 | 7.1 RT | 10.3-12.3 | Gravelly SAND, trace silt. | 9.4 | | | |
| ■ | BB-BNR-101/4D(A) | 12+55.7 | 7.1 RT | 19.0-20.9 | SAND, some silt, trace gravel. | 16.9 | | | |
| ● | BB-BNR-101/5D | 12+55.7 | 7.1 RT | 25.0-27.0 | SAND, little gravel, little silt. | 41.1 | | | |
| ▲ | BB-BNR-101/6D(B) | 12+55.7 | 7.1 RT | 30.8-31.1 | SILT, some sand, trace gravel, trace clay. | 13.4 | | | |
| × | | | | | | | | | |

| WIN | |
|---|---|
| 021876.00 | |
| Town | |
| Buckfield | |
| Reported by/Date | |
| WHITE, TERRY A | 3/26/2019 |

**SHEET 1**

# Maine Department of Transportation
## Grain Size Distribution Curve



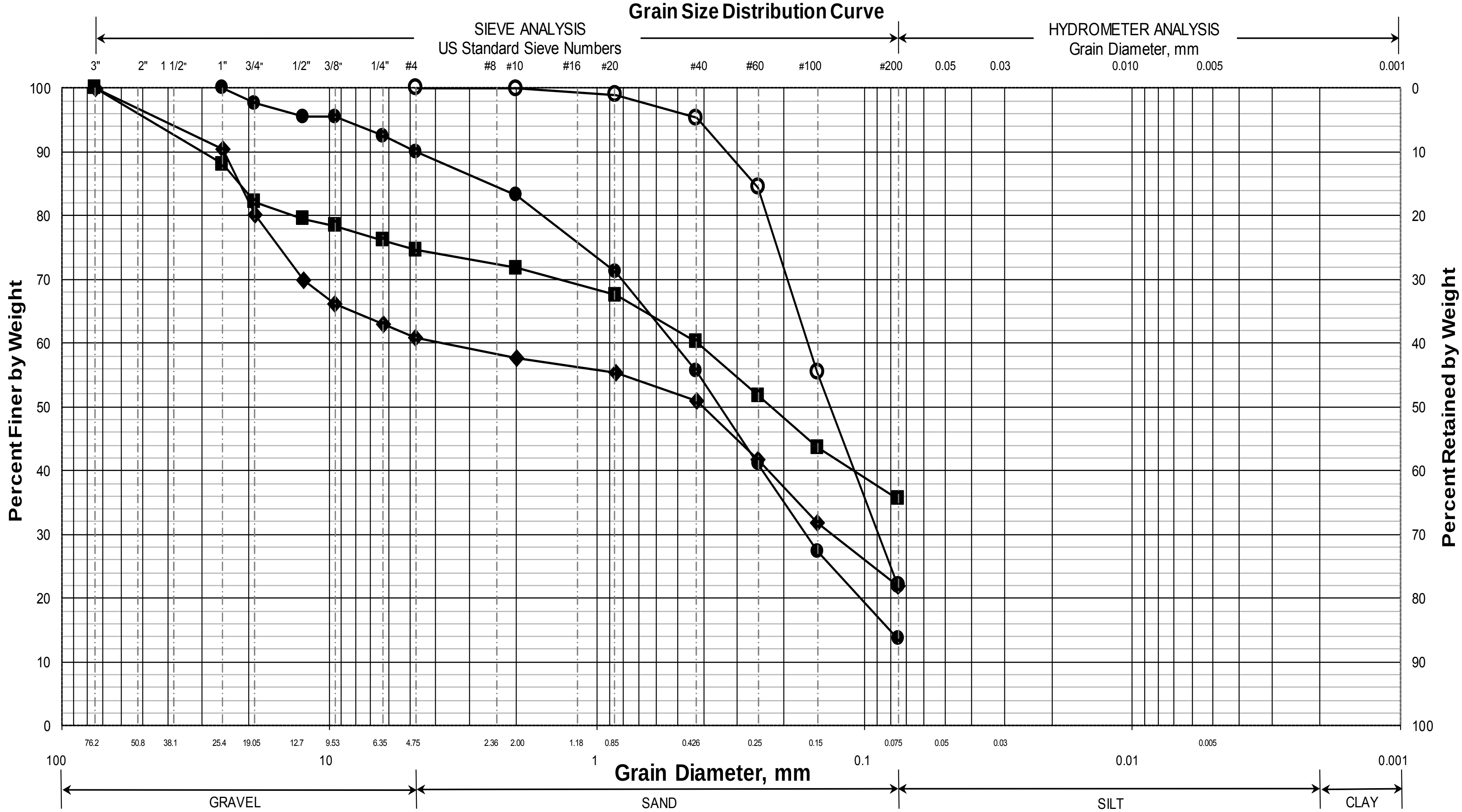

UNIFIED CLASSIFICATION

| | Boring/Sample No. | Station | Offset, ft | Depth, ft | Description | WC, % | LL | PL | PI |
|---|---|---|---|---|---|---|---|---|---|
| ○ | BB-BNR-102/3D | 14+19 | 5.5 LT | 15.0-17.0 | SAND, some silt, trace gravel. | 23.2 | | | |
| ◆ | BB-BNR-102/4D | 14+19 | 5.5 LT | 20.0-22.0 | SAND, little gravel, trace silt. | 9.5 | | | |
| ■ | BB-BNR-102/5D | 14+19 | 5.5 LT | 25.0-27.0 | SILT, little clay, little sand. | 30.7 | 33 | 30 | 3 |
| ● | | | | | | | | | |
| ▲ | | | | | | | | | |
| × | | | | | | | | | |

| WIN |
|---|
| 021876.00 |
| Town |
| Buckfield |
| Reported by/Date |
| WHITE, TERRY A 3/26/2019 |

**SHEET 2**

## Maine Department of Transportation
## Grain Size Distribution Curve




UNIFIED CLASSIFICATION

| | Boring/Sample No. | Station | Offset, ft | Depth, ft | Description | WC, % | LL | PL | PI |
|---|---|---|---|---|---|---|---|---|---|
| ○ | BB-BNR-201/3D | 12+73.4 | 6.8 LT | 15.0-17.0 | SAND, some silt. | 34.6 | | | |
| ◆ | BB-BNR-201/4D | 12+73.4 | 6.8 LT | 20.0-22.0 | Sandy GRAVEL, some silt. | 11.6 | | | |
| ■ | BB-BNR-202/1D | 13+99.8 | 7.1 RT | 5.0-7.0 | SAND, some silt, some gravel. | 20.4 | | | |
| ● | BB-BNR-202/2D | 13+99.8 | 7.1 RT | 9.0-11.0 | SAND, little silt, trace gravel. | 20.1 | | | |
| ▲ | | | | | | | | | |
| × | | | | | | | | | |

| WIN | |
|---|---|
| 021876.00 | |
| Town | |
| Buckfield | |
| Reported by/Date | |
| WHITE, TERRY A | 6/19/2019 |

**SHEET 3**

S.W.COLE ENGINEERING, INC.

# APPENDIX E

## Calculations

# SPT BLOW COUNT CONVERSION AND FRICTION ANGLE CORRELATION FOR GRANULAR SOILS

S.W.COLE ENGINEERING, INC.

**Project Name:** Hall Bridge #3287
**Project No.:** 20-1403
**Evaluated By/Date:** MAS / March 2021
**Reviewed By/Date:** TJB

85.4 Hammer Efficiency — *Ground Surface @ El 331.7 ft*
u = 12 Depth to Water — *Q50 @ El 319.7 ft*

**BORING** **BB-BNR-101**

| Soil Layer | Stratum | Sample No. | Top of Sample Depth (ft) | Field N-Value $N_m$ | Total Stress at Sample Depth (psf) | Effective Stress at Sample Depth (psf) | Correction Factors: Overburden Stress[1] $C_N$ | Hammer Efficiency $C_E$ | Borehole Diameter[2] $C_B$ | Rod Length[2] $C_R$ | Sampler[2] $C_S$ | $N_{60}$ | $(N1)_{60}$ | Friction Angle[3] (degrees) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Fill | 1D | 5 | 3 | 625 | 625 | 1.39 | 1.42 | 1.0 | 0.75 | 1.0 | 5 | 7 | 29 |
| 1 | Fill | 2D | 10 | 19 | 1250 | 1250 | 1.16 | 1.42 | 1.0 | 0.75 | 1.0 | 28 | 33 | 35 |
| 1 | Fill | 3D | 15 | 9 | 1875 | 1688 | 1.06 | 1.42 | 1.0 | 0.85 | 1.0 | 13 | 14 | 31 |
| 1 | Fill | 4D | 19 | 7 | 2375 | 1938 | 1.01 | 1.42 | 1.0 | 0.85 | 1.0 | 10 | 11 | 30 |
| 1 | Fill | 5D | 25 | 6 | 3125 | 2314 | 0.95 | 1.42 | 1.0 | 0.95 | 1.0 | 9 | 9 | 30 |
| 2 | Marine Deposit | 6D | 30 | 100 | 3765 | 2642 | 0.91 | 1.42 | 1.0 | 0.95 | 1.0 | 143 | 130 | 59 |

1. Determination of overburden stress correction factor (CN) based on Peck, Hanson and Thornburn (1974) and guidance from AASHTO LRFD Section 10.4.6.2.4 (AASHTO LRFD 8th Ed., 2017).
2. Determination of correction factors (CB, CR, CS) based on guidance from Seed et al. (1985) and Skempton (1986) as presented in Das (2014) Principles of Foundation Engineering, 8th Ed. Table 3.5.
3. Estimated friction angle based on guidance from Peck, Hanson and Thornburn (1974)
4. Refusal field N-values reported as 100 bpf.

# SPT BLOW COUNT CONVERSION AND FRICTION ANGLE CORRELATION FOR GRANULAR SOILS

S.W.COLE ENGINEERING, INC.

**Project Name:** Hall Bridge #3287
**Project No.:** 20-1403
**Evaluated By/Date:** MAS / March 2021
**Reviewed By/Date:** TJB

85.4 Hammer Efficiency — *Ground Surface @ El 326.9 ft*
u = 7.2 Depth to Water — *Q50 @ El 319.7 ft*

| | | **BORING** | | **BB-BNR-102** | | | Correction Factors | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soil Layer | Stratum | Sample No. | Top of Sample Depth (ft) | Field N-Value $N_m$ | Total Stress at Sample Depth (psf) | Effective Stress at Sample Depth (psf) | Overburden Stress[1] $C_N$ | Hammer Efficiency $C_E$ | Borehole Diameter[2] $C_B$ | Rod Length[2] $C_R$ | Sampler[2] $C_S$ | $N_{60}$ | $(N1)_{60}$ | Friction Angle[3] (degrees) |
| 1 | Fill | 1D | 5 | 14 | 625 | 625 | 1.39 | 1.42 | 1.0 | 0.75 | 1.0 | 20 | 28 | 33 |
| 1 | Fill | 2D | 10 | 10 | 1250 | 1075 | 1.21 | 1.42 | 1.0 | 0.75 | 1.0 | 15 | 19 | 31 |
| 2 | Marine Deposit | 3D | 15 | 4 | 1872 | 1385 | 1.12 | 1.42 | 1.0 | 0.85 | 1.0 | 6 | 7 | 29 |
| 2 | Marine Deposit | 4D | 19 | 26 | 2360 | 1624 | 1.07 | 1.42 | 1.0 | 0.85 | 1.0 | 38 | 41 | 38 |
| 2 | Marine Deposit | 5D | 25 | 2 | 3092 | 1981 | 1.00 | 1.42 | 1.0 | 0.95 | 1.0 | 3 | 4 | 28 |
| 2 | Marine Deposit | 6D | 30 | 100 | 3702 | 2279 | 0.96 | 1.42 | 1.0 | 0.95 | 1.0 | 143 | 138 | 59 |

1. Determination of overburden stress correction factor (CN) based on Peck, Hanson and Thornburn (1974) and guidance from AASHTO LRFD Section 10.4.6.2.4 (AASHTO LRFD 8th Ed., 2017).
2. Determination of correction factors (CB, CR, CS) based on guidance from Seed et al. (1985) and Skempton (1986) as presented in Das (2014) Principles of Foundation Engineering, 8th Ed. Table 3.5.
3. Estimated friction angle based on guidance from Peck, Hanson and Thornburn (1974)
4. Refusal field N-values reported as 100 bpf.

# SPT BLOW COUNT CONVERSION AND FRICTION ANGLE CORRELATION FOR GRANULAR SOILS

S.W.COLE ENGINEERING, INC.

**Project Name:** Hall Bridge #3287
**Project No.:** 20-1403
**Evaluated By/Date:** MAS / March 2021
**Reviewed By/Date:** TJB

92.8 Hammer Efficiency
u = 2 Depth to Water

*Ground Surface @ El 321.7 ft*
*Q50 @ El 319.7 ft*

| | | BORING | | BB-BNR-201 | | | Correction Factors | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soil Layer | Stratum | Sample No. | Top of Sample Depth (ft) | Field N-Value $N_m$ | Total Stress at Sample Depth (psf) | Effective Stress at Sample Depth (psf) | Overburden Stress[1] $C_N$ | Hammer Efficiency $C_E$ | Borehole Diameter[2] $C_B$ | Rod Length[2] $C_R$ | Sampler[2] $C_S$ | $N_{60}$ | $(N1)_{60}$ | Friction Angle[3] (degrees) |
| 1 | Fill | 1D | 5 | 25 | 625 | 438 | 1.51 | 1.55 | 1.0 | 0.75 | 1.0 | 39 | 59 | 38 |
| 1 | Fill | 2D | 10 | 24 | 1250 | 751 | 1.33 | 1.55 | 1.0 | 0.75 | 1.0 | 38 | 51 | 38 |
| 1 | Fill | 3D | 15 | 6 | 1875 | 1064 | 1.21 | 1.55 | 1.0 | 0.85 | 1.0 | 10 | 13 | 30 |
| 2 | Marine Deposit | 4D | 20 | 42 | 2491 | 1368 | 1.13 | 1.55 | 1.0 | 0.95 | 1.0 | 65 | 74 | 44 |

1. Determination of overburden stress correction factor (CN) based on Peck, Hanson and Thornburn (1974) and guidance from AASHTO LRFD Section 10.4.6.2.4 (AASHTO LRFD 8th Ed., 2017).
2. Determination of correction factors (CB, CR, CS) based on guidance from Seed et al. (1985) and Skempton (1986) as presented in Das (2014) Principles of Foundation Engineering, 8th Ed. Table 3.5.
3. Estimated friction angle based on guidance from Peck, Hanson and Thornburn (1974)
4. Refusal field N-values reported as 100 bpf.

# SPT BLOW COUNT CONVERSION AND FRICTION ANGLE CORRELATION FOR GRANULAR SOILS

S.W.COLE ENGINEERING, INC.

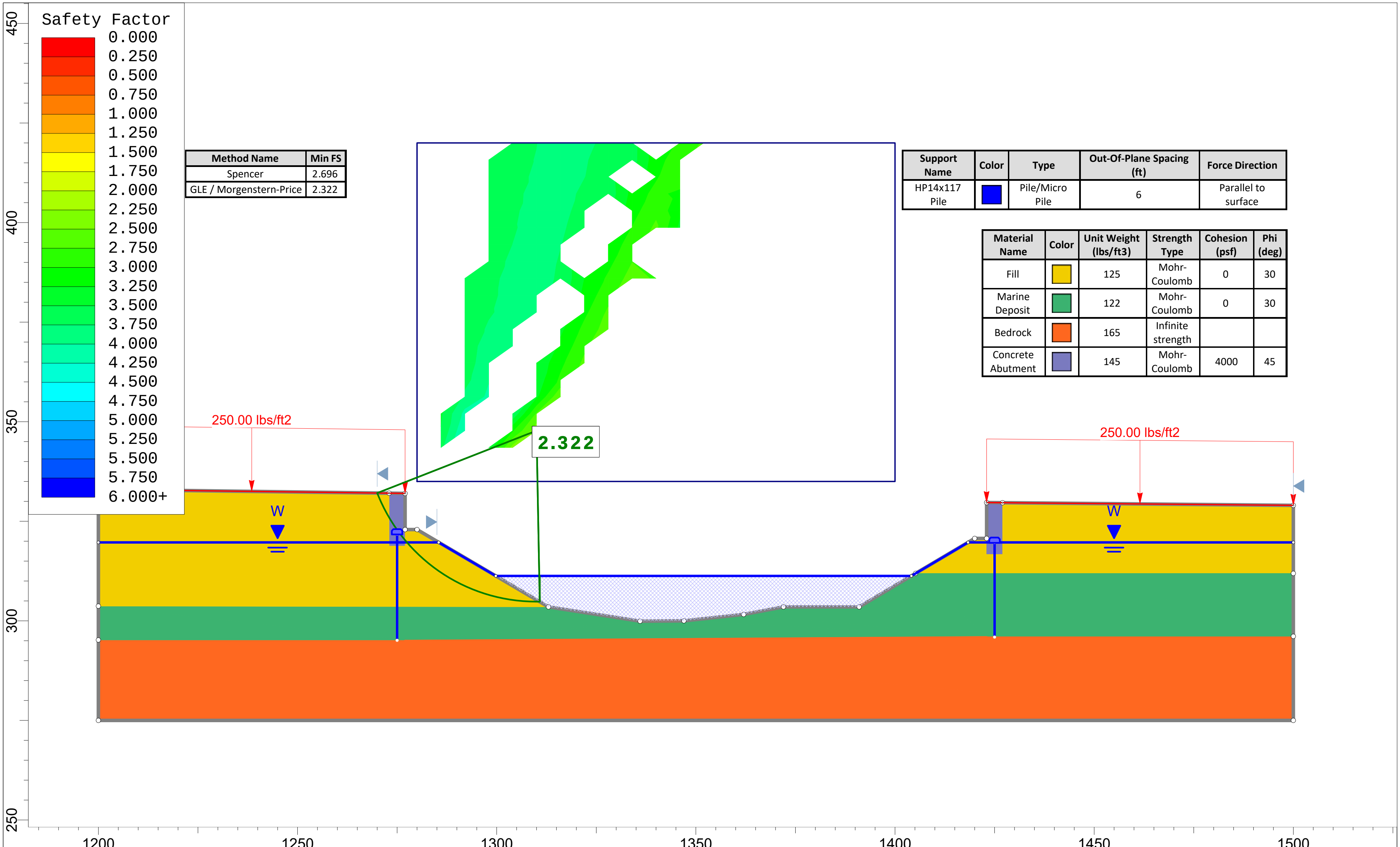
**Project Name:** Hall Bridge #3287
**Project No.:** 20-1403
**Evaluated By/Date:** MAS / March 2021
**Reviewed By/Date:** TJB

92.8 Hammer Efficiency
u = 0 Depth to Water

*Ground Surface @ El 317.4 ft*
*Q50 @ El 319.7 ft*

| | | **BORING** | | **BB-BNR-202** | | | Correction Factors | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soil Layer | Stratum | Sample No. | Top of Sample Depth (ft) | Field N-Value $N_m$ | Total Stress at Sample Depth (psf) | Effective Stress at Sample Depth (psf) | Overburden Stress[1] $C_N$ | Hammer Efficiency $C_E$ | Borehole Diameter[2] $C_B$ | Rod Length[2] $C_R$ | Sampler[2] $C_S$ | $N_{60}$ | $(N1)_{60}$ | Friction Angle[3] (degrees) |
| 2 | Marine Deposit | 1D | 5 | 7 | 619 | 307 | 1.63 | 1.55 | 1.0 | 0.75 | 1.0 | 11 | 18 | 30 |
| 2 | Marine Deposit | 2D | 10 | 9 | 1229 | 605 | 1.40 | 1.55 | 1.0 | 0.75 | 1.0 | 14 | 20 | 31 |
| 2 | Marine Deposit | 3D | 15 | 100 | 1882 | 946 | 1.25 | 1.55 | 1.0 | 0.85 | 1.0 | 155 | 195 | 61 |

1. Determination of overburden stress correction factor (CN) based on Peck, Hanson and Thornburn (1974) and guidance from AASHTO LRFD Section 10.4.6.2.4 (AASHTO LRFD 8th Ed., 2017).
2. Determination of correction factors (CB, CR, CS) based on guidance from Seed et al. (1985) and Skempton (1986) as presented in Das (2014) Principles of Foundation Engineering, 8th Ed. Table 3.5.
3. Estimated friction angle based on guidance from Peck, Hanson and Thornburn (1974)
4. Refusal field N-values reported as 100 bpf.




| Method Name | Min FS |
|---|---|
| Spencer | 2.696 |
| GLE / Morgenstern-Price | 2.322 |

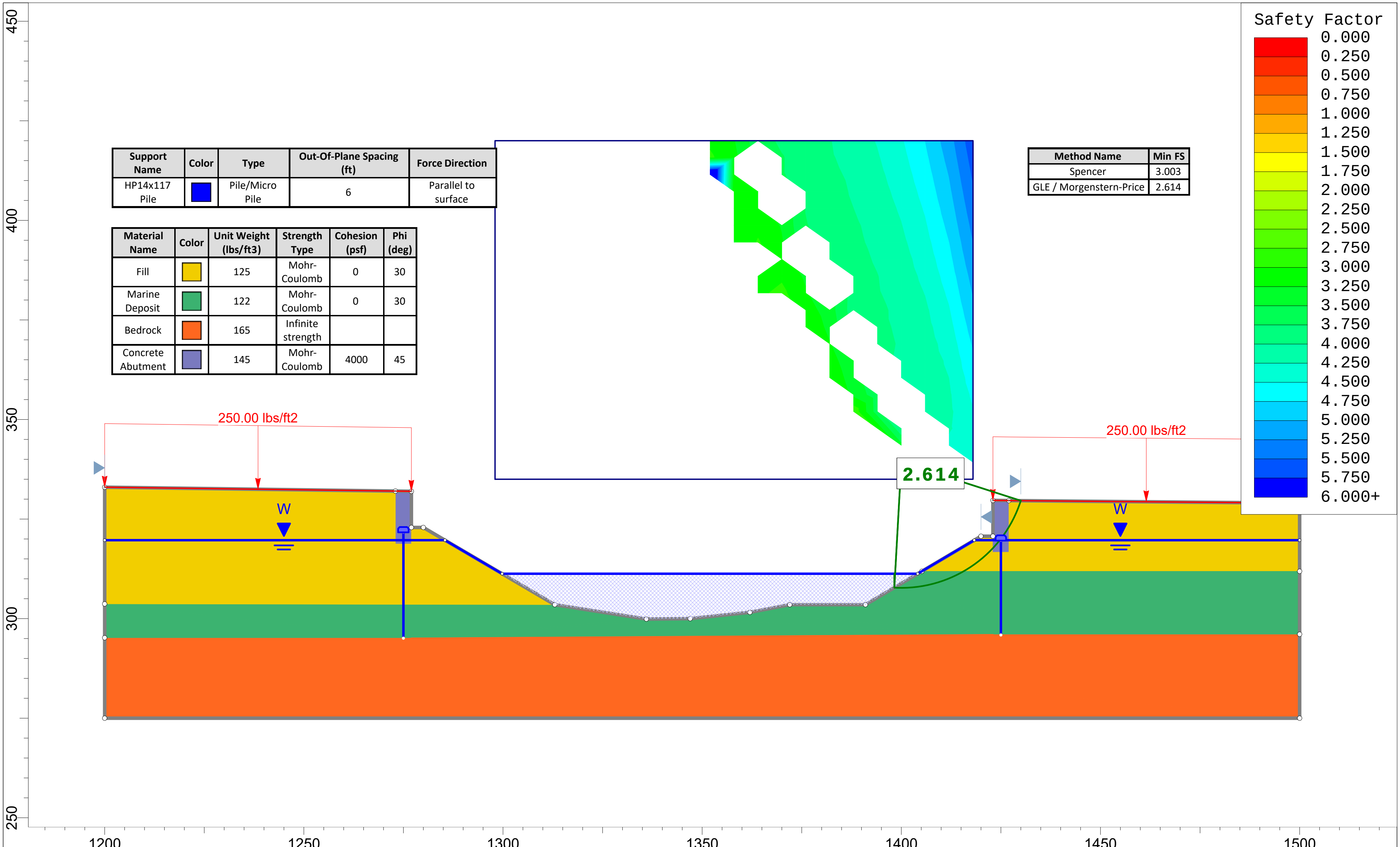
| Support Name | Color | Type | Out-Of-Plane Spacing (ft) | Force Direction |
|---|---|---|---|---|
| HP14x117 Pile | | Pile/Micro Pile | 6 | Parallel to surface |

| Material Name | Color | Unit Weight (lbs/ft3) | Strength Type | Cohesion (psf) | Phi (deg) |
|---|---|---|---|---|---|
| Fill | | 125 | Mohr-Coulomb | 0 | 30 |
| Marine Deposit | | 122 | Mohr-Coulomb | 0 | 30 |
| Bedrock | | 165 | Infinite strength | | |
| Concrete Abutment | | 145 | Mohr-Coulomb | 4000 | 45 |

S.W.COLE ENGINEERING, INC.

SLIDEINTERPRET 9.012

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Project* | Hall Bridge #3287 Replacement over Nezinscot River - WIN 021876.00 | | | | | | |
| *Analysis Description* | Abutment No 1 (West Abutment) Longintudinal Stability - Drawdown | | | | | | |
| *Scale* | 1:400 | *Drawn By* | MAS | *Reviewed By* | PRW | *Date* | November 2021 |
| *Company* | S. W. Cole Engineering, Inc. | | | *File Name* | Hall Bridge - Longitudinal.slmd | | |




| Support Name | Color | Type | Out-Of-Plane Spacing (ft) | Force Direction |
|---|---|---|---|---|
| HP14x117 Pile | Blue | Pile/Micro Pile | 6 | Parallel to surface |

| Material Name | Color | Unit Weight (lbs/ft3) | Strength Type | Cohesion (psf) | Phi (deg) |
|---|---|---|---|---|---|
| Fill | Yellow | 125 | Mohr-Coulomb | 0 | 30 |
| Marine Deposit | Green | 122 | Mohr-Coulomb | 0 | 30 |
| Bedrock | Orange | 165 | Infinite strength | | |
| Concrete Abutment | Purple | 145 | Mohr-Coulomb | 4000 | 45 |

| Method Name | Min FS |
|---|---|
| Spencer | 3.003 |
| GLE / Morgenstern-Price | 2.614 |

S.W.COLE ENGINEERING, INC.

SLIDEINTERPRET 9.012

| | |
|---|---|
| *Project* | Hall Bridge #3287 Replacement over Nezinscot River - WIN 021876.00 |
| *Analysis Description* | Abutment No 2 (East Abutment) Longitudinal Stability - Drawdown |

| *Scale* | *Drawn By* | *Reviewed By* | *Date* |
|---|---|---|---|
| 1:400 | MAS | PRW | November 2021 |

| *Company* | *File Name* |
|---|---|
| S. W. Cole Engineering, Inc. | Hall Bridge - Longitudinal.slmd |

**Design of Bearing H-Piles**

Reference:

1. AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020. (LRFD)
2. AASHTO Standard Specifications for Highway Bridges 17th Edition, 2002. (AASHTO)

Bedrock Properties

| | | | |
|---|---|---|---|
| RQD: | BB-BNR-101 | R1, R2 = 85, 93% | Range: 19-93% |
| | BB-BNR-102 | R1, R2 = 78, 67% | Weighted Average: 66% |
| | BB-BNR-201 | R1, R2 = 53, 62% | |
| | BB-BNR-202 | R1, R2 = 75, 19% | |

Rock Type: META-SANDSTONE, hard, fresh, fine to medium-grained, generally low to moderately dipping (5 to 55 degrees), close to moderately close, tight to open joints

Friction Angle: $\phi$ = 27 to 34 degrees (LRFD Table C10.4.6.4-1)

Co = 9,700 - 25,000 psi (AASHTO Table 4.4.8.1.2B)

Pile Properties:

HP12x74 **NOTE: ALL MATRICES IN THIS ORDER**
HP12x84
HP14x89
HP14x117

$f_y := 50\ ksi$

$$A_s := \begin{bmatrix} 21.8 \\ 24.6 \\ 26.1 \\ 34.4 \end{bmatrix} \cdot in^2$$

$$d := \begin{bmatrix} 12.1 \\ 12.3 \\ 13.8 \\ 14.2 \end{bmatrix} \cdot in$$

$$b := \begin{bmatrix} 12.2 \\ 12.3 \\ 14.7 \\ 14.9 \end{bmatrix} \cdot in$$

$$A_p := \overrightarrow{(d \cdot b)} = \begin{bmatrix} 147.62 \\ 151.29 \\ 202.86 \\ 211.58 \end{bmatrix} in^2$$ Area of Perimeter

**Nominal and Factored Structural Compressive Resistance**

Find Nominal Axial Structural Resistance

$$P_o := f_y \cdot A_s = \begin{bmatrix} 1090 \\ 1230 \\ 1305 \\ 1720 \end{bmatrix} kip$$

Structural Resistance of unbraced segment

Assume 4 foot unbraced section due to scour

Determine elastic critical buckling resistance, Pe

$E_s := 29000\ ksi$

$K_{eff} := 2.0$ effective length factor / LRFD Table C4.6.2.5-1

$l_{unbraced} := 4\ ft$ unbraced length top of pile

$r_y := \begin{bmatrix} 2.92 \\ 2.94 \\ 3.53 \\ 3.59 \end{bmatrix} \cdot in$ radius of gyration, weak axis / LRFD Article C6.9.4.1.2

LRFD Eqn 6.9.4.1.2-1

$$P_e := \overrightarrow{\left( \frac{\pi^2 \cdot E_s}{\left( \frac{K_{eff} \cdot l_{unbraced}}{r_y} \right)^2} \cdot A_s \right)} = \begin{bmatrix} 5773 \\ 6604 \\ 10101 \\ 13769 \end{bmatrix} kip$$

LRFD Article 6.9.4.1.1

$$\frac{P_e}{P_o} = \begin{bmatrix} 5.296 \\ 5.369 \\ 7.74 \\ 8.005 \end{bmatrix}$$

$$P_n := \begin{array}{l} \text{if } \frac{P_e}{P_o} \ge 0.44 \\ \quad \overrightarrow{0.658^{\left(\frac{P_o}{P_e}\right)} \cdot P_o} \\ \text{if } \frac{P_e}{P_o} < 0.44 \\ \quad 0.877 \cdot P_e \end{array} = \begin{bmatrix} 1007 \\ 1138 \\ 1236 \\ 1632 \end{bmatrix} kip$$

Find Factored Axial Structural Resistance at Strength Limit State

$\phi_{cu} := 0.7$ For combined axial and flexural resistance of H piles
LRFD Article 6.5.4.2

$$P_r := \phi_{cu} \cdot P_n = \begin{bmatrix} 705 \\ 796 \\ 865 \\ 1143 \end{bmatrix} kip$$ LRFD Eqn 6.9.2.1-1

Find Factored Axial Structural Resistance at Strength Limit State

Structural Resistance of braced length

$l_{braced} := 0.1\ ft$

LRFD Eqn 6.9.4.1.2-1

$$P_e := \overrightarrow{\left(\frac{\pi^2 \cdot E_s}{\left(\frac{K_{eff} \cdot l_{braced}}{r_y}\right)^2} \cdot A_s\right)} = \begin{bmatrix} 9236288 \\ 10565864 \\ 16160886 \\ 22030411 \end{bmatrix} kip$$

LRFD Article 6.9.4.1.1

Check if Pe/Po >/= 0.44

$$\frac{P_e}{P_o} = \begin{bmatrix} 8473.659 \\ 8590.134 \\ 12383.821 \\ 12808.378 \end{bmatrix}$$

$$P_n := \begin{cases} \text{if } \frac{P_e}{P_o} \geq 0.44 & \overrightarrow{0.658^{\left(\frac{P_o}{P_e}\right)} \cdot P_o} \\ \text{if } \frac{P_e}{P_o} < 0.44 & 0.877 \cdot P_e \end{cases} = \begin{bmatrix} 1090 \\ 1230 \\ 1305 \\ 1720 \end{bmatrix} kip$$

Find Factored Axial Structural Resistance at Strength Limit State

$\phi_c := 0.5$ LRFD Article 6.5.4.2

$$P_r := \phi_c \cdot P_n = \begin{bmatrix} 545 \\ 615 \\ 652 \\ 860 \end{bmatrix} kip$$ LRFD Eqn 6.9.2.1-1

**Nominal and Factored Geotechnical Resistance**

LRFD Article 10.7.3.2.3 states "the nominal resistance of piles driven to point bearing on hard rock where pile penetration into the rock formation is minimal is controlled by the structural limit state. The nominal bearing resistance shall not exceed the values obtained from Article 6.9.4.1 with the resistance factor specified in Article 6.5.4.2 and Article 6.15 for severe driving conditions. A pile-driving acceptance criteria shall be developed that will prevent pile damage."

Nominal Structural Resistance

$$P_n = \begin{bmatrix} 1090 \\ 1230 \\ 1305 \\ 1720 \end{bmatrix} \boldsymbol{kip}$$

Find Factored Geotechnical Resistance at Strength, Service and Extreme Limit States

$\phi_c := 0.5$ LRFD 6.9.2.1-1 for Strength Limit State

$$P_r := \phi_c \cdot P_n = \begin{bmatrix} 545 \\ 615 \\ 652 \\ 860 \end{bmatrix} \boldsymbol{kip}$$

$\phi_{s\_ex} := 1.0$ LRFD 6.9.2.1-1 for the Services and Extreme Limit States

$$P_{r\_e} := \phi_{s\_ex} \cdot P_n = \begin{bmatrix} 1090 \\ 1230 \\ 1305 \\ 1720 \end{bmatrix} \boldsymbol{kip}$$

**Drivability Analysis**

From LRFD Article 10.7.8

For steel piles in compression or tension, limit driving stresses to 90% fy

$\phi_{da} := 1.0$ LRFD Table 10.5.5.2.3-1, Drivability Analysis, Steel Piles (See LRFD 6.5.4.2)

$\sigma_{da} := 0.9 \cdot f_y \cdot \phi_{da} = 45\ ksi$ LRFD Eqn 10.7.8.1

- Limit driving stresses to 45 ksi or less
- Per MaineDOT Standard Specifications Section 501, limit final pile set to 5-15 bpi with 6-10 bpi optimal

**Due to sloping bedrock, driving stresses limited to 40 ksi and final set to 12 bpi**

Find maximum resistance from drivability analysis:

$\phi_{dyn} := 0.65$ LRFD Table 10.5.5.2.3-1 Strength Limit State

$\phi_s := 1$ Service and Extreme Limit States

**GRLWeap Soil and Pile Model Assumptions**

Estimated pile lengths (bottom of pile cap to bedrock from explorations):

Abutment 1: 318.9ft - (300.5 to 295.2ft) = 18.4 to 23.7ft

Abutment 2: 316.7ft - (302.6 to 296.1ft) = 14.1 to 20.6ft

Assume contractor drives **25 (worst case) to 35 ft piles** to account for additional pile length for testing (5 ft), rock embedment (< 1 ft), pile cap embedment (3 ft) and cut off.

Delmag D19-42 Hammer was chosen as typical pile hammer capable of producing energy of about 42,000 ft-lbs. The following pile hammer and cushion parameters were used in the analysis:

Hammer parameters

| | | | | | |
|---|---|---|---|---|---|
| Efficiency | 0.8 | | | | |
| Pressure | 1600 | psi | Fixed | 100 | % |
| Stroke | 10.81 | ft | Fixed | | |

Cushion Information

| | Hammer | Pile | |
|---|---|---|---|
| Area | 227. | 0. | in^2 |
| Elastic Modulus | 530. | 0. | ksi |
| Thickness | 2. | 0. | in |
| C.O.R. | 0.8 | 0. | |
| Stiffness | 0. | 0. | kips/in |
| Helmet Weight | 1.9 | | kips |

From GRLWeap output:

$$R_{ndr} := \begin{bmatrix} 376 \\ 427 \\ 457 \\ 634 \end{bmatrix} kip$$

HP12x74
HP12x84
HP14x89
HP14x117

Strength Limit State

$$R_{fdr} := \overrightarrow{R_{ndr} \cdot \phi_{dyn}} = \begin{bmatrix} 244 \\ 278 \\ 297 \\ 412 \end{bmatrix} kip$$

Service and Extreme Limit States

$$R_{dr} := \overrightarrow{R_{ndr} \cdot \phi_s} = \begin{bmatrix} 376 \\ 427 \\ 457 \\ 634 \end{bmatrix} kip$$

**TABLE 4.4.8.1.2B Typical Range of Uniaxial Compressive Strength ($C_o$) as a Function of Rock Category and Rock Type**

| Rock Category | General Description | Rock Type | $C_o$[(1)] (ksf) | $C_o$[(1)] (psi) |
|---|---|---|---|---|
| A | Carbonate rocks with well-developed crystal cleavage | Dolostone | 700- 6,500 | 4,800-45,000 |
| | | Limestone | 500- 6,000 | 3,500-42,000 |
| | | Carbonatite | 800- 1,500 | 5,500-10,000 |
| | | Marble | 800- 5,000 | 5,500-35,000 |
| | | Tactite-Skam | 2,700- 7,000 | 19,000-49,000 |
| B | Lithified argillaceous rock | Argillite | 600- 3,000 | 4,200-21,000 |
| | | Claystone | 30- 170 | 200- 1,200 |
| | | Marlstone | 1,000- 4,000 | 7,600-28,000 |
| | | Phyllite | 500- 5,000 | 3,500-35,000 |
| | | Siltstone | 200- 2,500 | 1,400-17,000 |
| | | Shale[(2)] | 150- 740 | 1,000- 5,100 |
| | | Slate | 3,000- 4,400 | 21,000-30,000 |
| C | Arenaceous rocks with strong crystals and poor cleavage | Conglomerate | 700- 4,600 | 4,800-32,000 |
| | | Sandstone | 1,400- 3,600 | 9,700-25,000 |
| | | Quartzite | 1,300- 8,000 | 9,000-55,000 |
| D | Fine-grained igneous crystalline rock | Andesite | 2,100- 3,800 | 14,000-26,000 |
| | | Diabase | 450-12,000 | 3,100-83,000 |
| E | Coarse-grained igneous and metamorphic crystalline rock | Amphibolite | 2,500- 5,800 | 17,000-40,000 |
| | | Gabbro | 2,600- 6,500 | 18,000-45,000 |
| | | Gneiss | 500- 6,500 | 3,500-45,000 |
| | | Granite | 300- 7,000 | 2,100-49,000 |
| | | Quartzdiorite | 200- 2,100 | 1,400-14,000 |
| | | Quartzmonzonite | 2,700- 3,300 | 19,000-23,000 |
| | | Schist | 200- 3,000 | 1,400-21,000 |
| | | Syenite | 3,800- 9,000 | 26,000-62,000 |

(1) Range of Uniaxial Compressive Strength values reported by various investigations.
(2) Not including oil shale.

$$p = q_o(1 - \nu^2)BI_p/E_m, \text{ with } I_p = (L/B)^{1/2}/\beta_z \quad (4.4.8.2.2\text{-}2)$$

Values of $I_p$ may be computed using the $\beta_z$ values presented in Table 4.4.7.2.2B from Article 4.4.7.2.2 for rigid footings. Values of Poisson's ratio ($\nu$) for typical rock types are presented in Table 4.4.8.2.2A. Determination of the rock mass modulus ($E_m$) should be based on the results of in-situ and laboratory tests. Alternatively, values of $E_m$ may be estimated by multiplying the intact rock modulus ($E_o$) obtained from uniaxial compression tests by a reduction factor ($\alpha_E$) which accounts for frequency of discontinuities by the rock quality designation (RQD), using the following relationships (Gardner, 1987):

$$E_m = \alpha_E E_o \quad (4.4.8.2.2\text{-}3)$$

$$\alpha_E = 0.0231(RQD) - 1.32 \geq 0.15 \quad (4.4.8.2.2\text{-}4)$$

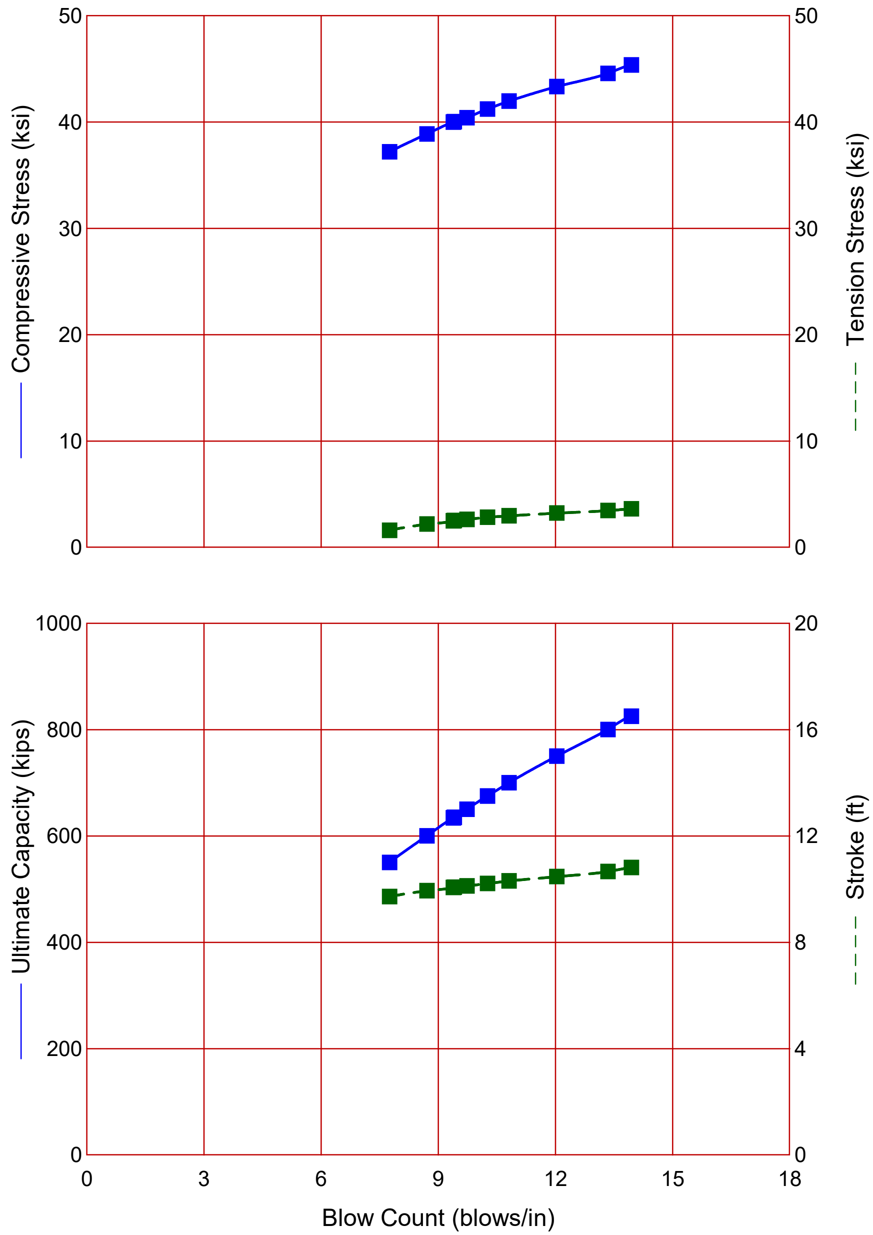
For preliminary design or when site-specific test data cannot be obtained, guidelines for estimating values of $E_o$ (such as presented in Table 4.4.8.2.2B or Figure 4.4.8.2.2A) may be used. For preliminary analyses or for final design when in-situ test results are not available, a value of $\alpha_E = 0.15$ should be used to estimate $E_m$.

#### *4.4.8.2.3 Tolerable Movement*

Refer to Article 4.4.7.2.3.

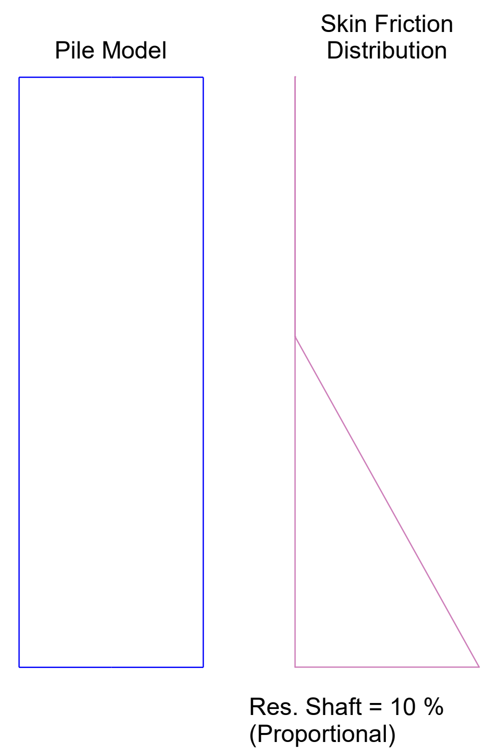
### 4.4.9 Overall Stability

The overall stability of footings, slopes, and foundation soil or rock shall be evaluated for footings located on




DELMAG D 19-42

| | | |
|---|---|---|
| Ram Weight | 4.00 | kips |
| Efficiency | 0.800 | |
| Pressure | 1600 (100%) | psi |
| Helmet Weight | 1.90 | kips |
| Hammer Cushion | 60155 | kips/in |
| COR of H.C. | 0.800 | |
| Skin Quake | 0.100 | in |
| Toe Quake | 0.040 | in |
| Skin Damping | 0.050 | s/ft |
| Toe Damping | 0.150 | s/ft |
| Pile Length | 25.00 | ft |
| Pile Penetration | 14.00 | ft |
| Pile Top Area | 34.40 | in2 |



| Ultimate Capacity kips | Maximum Compression Stress ksi | Maximum Tension Stress ksi | Blow Count blows/in | Stroke ft | Energy kips-ft |
|---|---|---|---|---|---|
| 550.0 | 37.18 | 1.61 | 7.8 | 9.72 | 17.77 |
| 600.0 | 38.86 | 2.19 | 8.7 | 9.94 | 18.24 |
| 634.0 | 39.99 | 2.50 | 9.4 | 10.06 | 18.48 |
| 635.0 | 40.02 | 2.52 | 9.4 | 10.07 | 18.48 |
| 650.0 | 40.39 | 2.63 | 9.7 | 10.12 | 18.58 |
| 675.0 | 41.21 | 2.83 | 10.3 | 10.21 | 18.78 |
| 700.0 | 41.96 | 2.97 | 10.8 | 10.31 | 18.99 |
| 750.0 | 43.32 | 3.22 | 12.0 | 10.47 | 19.37 |
| 800.0 | 44.55 | 3.46 | 13.3 | 10.66 | 19.78 |
| 825.0 | 45.36 | 3.62 | 13.9 | 10.81 | 20.11 |

Abutment No. 1
Piles driven to top of bedrock

================================================================================

LPile for Windows, Version 2016-09.010

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


================================================================================

This copy of LPile is being used by:

A
A

Serial Number of Security Device: 226662858

This copy of LPile is licensed for exclusive use by:

S.W. Cole Engineering, Inc., Som



--------------------------------------------------------------------------------
Files Used for Analysis
--------------------------------------------------------------------------------

Path to file locations:
\Users\mst.pierre\Desktop\LPile Output Files\20-1403-021876 Buckfield\Piles to Bedrock\

Name of input data file:
Abutment 1 HP14x117 - 18ft Pile.lp9d

Name of output report file:
Abutment 1 HP14x117 - 18ft Pile.lp9o

Name of plot output file:
Abutment 1 HP14x117 - 18ft Pile.lp9p

Name of runtime message file:
Abutment 1 HP14x117 - 18ft Pile.lp9r

--------------------------------------------------------------------------------
Date and Time of Analysis
--------------------------------------------------------------------------------

Date: October 27, 2021 Time: 13:19:35

--------------------------------------------------------------------------------
Problem Title
--------------------------------------------------------------------------------

Hall Bridge #3287 Replacement

WIN 021876

MaineDOT

MAS

Abutment No. 1 - HP14x117

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## Program Options and Settings

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Computational Options:
- Use unfactored loads in computations (conventional analysis)

Engineering Units Used for Data Input and Computations:
- US Customary System 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:
- Static loading specified

- Use of p-y modification factors for p-y curves not selected
- No distributed lateral loads are entered
- 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:
- Output files use decimal points to denote decimal symbols.
- 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
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

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## Pile Structural Properties and Geometry

---

Number of pile sections defined = 1
Total length of pile = 18.400 ft
Depth of ground surface below top of pile = 0.0000 ft

Pile diameters 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. A summary of values of pile diameter vs. depth follows.

| Point No. | Depth Below Pile Head feet | Pile Diameter inches |
|---|---|---|
| 1 | 0.000 | 14.0750 |
| 2 | 18.400 | 14.0750 |

### Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile
Cross-sectional Shape = Weak H-Pile
Length of section = 18.400000 ft
Flange Width = 14.775000 in
Section Depth = 14.075000 in
Flange Thickness = 0.680000 in
Web Thickness = 0.680000 in

```
   Section Area                                          =    28.740200 sq. in
   Moment of Inertia                                     =   365.877563 in^4
   Elastic Modulus                                       =    29000000. psi



--------------------------------------------------------------------------------
                       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          =     6.200000 ft
   Effective unit weight at top of layer                 =    62.600000 pcf
   Effective unit weight at bottom of layer              =    62.600000 pcf
   Friction angle at top of layer                        =    30.000000 deg.
   Friction angle at bottom of layer                     =    30.000000 deg.
   Subgrade k at top of layer                            =    60.000000 pci
   Subgrade k at bottom of layer                         =    60.000000 pci


Layer 2 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer             =     6.200000 ft
   Distance from top of pile to bottom of layer          =    17.200000 ft
   Effective unit weight at top of layer                 =    59.600000 pcf
   Effective unit weight at bottom of layer              =    59.600000 pcf
   Friction angle at top of layer                        =    30.000000 deg.
   Friction angle at bottom of layer                     =    30.000000 deg.
   Subgrade k at top of layer                            =    20.000000 pci
   Subgrade k at bottom of layer                         =    20.000000 pci


Layer 3 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer             =    17.200000 ft
   Distance from top of pile to bottom of layer          =    18.400000 ft
   Effective unit weight at top of layer                 =    67.600000 pcf
   Effective unit weight at bottom of layer              =    67.600000 pcf
   Friction angle at top of layer                        =    38.000000 deg.
   Friction angle at bottom of layer                     =    38.000000 deg.
   Subgrade k at top of layer                            =   125.000000 pci
   Subgrade k at bottom of layer                         =   125.000000 pci


 (Depth of the lowest soil layer extends 0.000 ft below the pile tip)



--------------------------------------------------------------------------------
                        Summary of Input Soil Properties
--------------------------------------------------------------------------------

Layer        Soil Type          Layer      Effective    Angle of
Layer          Name             Depth       Unit Wt.    Friction        kpy
 Num.     (p-y Curve Type)        ft          pcf         deg.          pci
-----   -------------------   ----------   ----------   ----------   ----------
  1            Sand               0.00      62.6000      30.0000      60.0000
```

| | | | | | |
|---|---|---|---|---|---|
| | (Reese, et al.) | 6.2000 | 62.6000 | 30.0000 | 60.0000 |
| 2 | Sand | 6.2000 | 59.6000 | 30.0000 | 20.0000 |
| | (Reese, et al.) | 17.2000 | 59.6000 | 30.0000 | 20.0000 |
| 3 | Sand | 17.2000 | 67.6000 | 38.0000 | 125.0000 |
| | (Reese, et al.) | 18.4000 | 67.6000 | 38.0000 | 125.0000 |

--------------------------------------------------------------------------------

## Static Loading Type

--------------------------------------------------------------------------------

Static loading criteria were used when computing p-y curves for all analyses.

--------------------------------------------------------------------------------

## 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 | 5 | y = 0.750000 in | S = 0.0000 in/in | 315000. | N.A. |

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force 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

--------------------------------------------------------------------------------

## Layering Correction Equivalent Depths of Soil & Rock Layers

--------------------------------------------------------------------------------

| Layer No. | Top of Layer Below Pile Head ft | Equivalent Top Depth Below Grnd Surf ft | Same Layer Type As Layer Above | Layer is Rock or is Below Rock Layer | F0 Integral for Layer lbs | F1 Integral for Layer lbs |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | N.A. | No | 0.00 | 13471. |
| 2 | 6.2000 | 6.2000 | Yes | No | 13471. | 187138. |
| 3 | 17.2000 | 17.2000 | Yes | No | 200610. | N.A. |

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

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

---

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head = 0.750000 inches
Rotation of pile head = 0.000E+00 radians
Axial load on pile head = 315000.0 lbs

| Depth X feet | Deflect. y inches | Bending Moment in-lbs | Shear Force lbs | Slope S radians | Total Stress psi* | Bending Stiffness in-lb^2 | Soil Res. p lb/inch | Soil Spr. Es*h lb/inch | Distrib. Lat. Load lb/inch |
|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 0.7505 | -2088806. | 32730. | 0.00 | 51138. | 1.06E+10 | 0.00 | 0.00 | 0.00 |
| 0.1840 | 0.7500 | -2016414. | 32707. | -4.27E-04 | 49745. | 1.06E+10 | -9.0851 | 26.7466 | 0.00 |
| 0.3680 | 0.7486 | -1943775. | 32676. | -8.39E-04 | 48348. | 1.06E+10 | -19.1994 | 56.6293 | 0.00 |
| 0.5520 | 0.7463 | -1870949. | 32622. | -0.00124 | 46947. | 1.06E+10 | -30.1205 | 89.1151 | 0.00 |
| 0.7360 | 0.7431 | -1797998. | 32543. | -0.00162 | 45544. | 1.06E+10 | -41.5371 | 123.4147 | 0.00 |
| 0.9200 | 0.7391 | -1724990. | 32438. | -0.00198 | 44140. | 1.06E+10 | -53.2263 | 158.9983 | 0.00 |
| 1.1040 | 0.7344 | -1651992. | 32308. | -0.00234 | 42736. | 1.06E+10 | -64.9671 | 195.3334 | 0.00 |
| 1.2880 | 0.7288 | -1579071. | 32151. | -0.00267 | 41333. | 1.06E+10 | -76.6718 | 232.2767 | 0.00 |
| 1.4720 | 0.7226 | -1506295. | 31969. | -0.00299 | 39933. | 1.06E+10 | -88.1284 | 269.2982 | 0.00 |
| 1.6560 | 0.7156 | -1433731. | 31763. | -0.00330 | 38537. | 1.06E+10 | -99.0434 | 305.5931 | 0.00 |
| 1.8400 | 0.7080 | -1361443. | 31532. | -0.00359 | 37147. | 1.06E+10 | -109.8083 | 342.4509 | 0.00 |
| 2.0240 | 0.6998 | -1289492. | 31278. | -0.00387 | 35763. | 1.06E+10 | -120.6926 | 380.8267 | 0.00 |
| 2.2080 | 0.6909 | -1217944. | 31000. | -0.00413 | 34387. | 1.06E+10 | -130.8475 | 418.1461 | 0.00 |
| 2.3920 | 0.6815 | -1146857. | 30700. | -0.00437 | 33020. | 1.06E+10 | -140.3220 | 454.6022 | 0.00 |
| 2.5760 | 0.6716 | -1076288. | 30380. | -0.00460 | 31662. | 1.06E+10 | -149.5313 | 491.5914 | 0.00 |
| 2.7600 | 0.6612 | -1006292. | 30041. | -0.00482 | 30316. | 1.06E+10 | -157.7197 | 526.6765 | 0.00 |
| 2.9440 | 0.6503 | -936920. | 29685. | -0.00502 | 28982. | 1.06E+10 | -164.9431 | 560.0081 | 0.00 |
| 3.1280 | 0.6390 | -868216. | 29310. | -0.00521 | 27660. | 1.06E+10 | -174.3658 | 602.4732 | 0.00 |
| 3.3120 | 0.6273 | -800237. | 28916. | -0.00538 | 26352. | 1.06E+10 | -183.0360 | 644.2302 | 0.00 |
| 3.4960 | 0.6153 | -733034. | 28503. | -0.00554 | 25060. | 1.06E+10 | -190.8456 | 684.8973 | 0.00 |
| 3.6800 | 0.6028 | -666656. | 28069. | -0.00569 | 23783. | 1.06E+10 | -202.5145 | 741.7336 | 0.00 |
| 3.8640 | 0.5901 | -601168. | 27608. | -0.00582 | 22523. | 1.06E+10 | -214.6803 | 803.2340 | 0.00 |
| 4.0480 | 0.5771 | -536640. | 27121. | -0.00594 | 21282. | 1.06E+10 | -226.6675 | 867.1748 | 0.00 |
| 4.2320 | 0.5639 | -473139. | 26608. | -0.00604 | 20061. | 1.06E+10 | -238.4253 | 933.5707 | 0.00 |
| 4.4160 | 0.5504 | -410733. | 26068. | -0.00614 | 18861. | 1.06E+10 | -249.9028 | 1002. | 0.00 |
| 4.6000 | 0.5368 | -349485. | 25504. | -0.00622 | 17682. | 1.06E+10 | -261.0492 | 1074. | 0.00 |
| 4.7840 | 0.5230 | -289459. | 24914. | -0.00628 | 16528. | 1.06E+10 | -273.3243 | 1154. | 0.00 |
| 4.9680 | 0.5091 | -230724. | 24298. | -0.00634 | 15398. | 1.06E+10 | -285.1455 | 1237. | 0.00 |
| 5.1520 | 0.4950 | -173346. | 23656. | -0.00638 | 14294. | 1.06E+10 | -296.5701 | 1323. | 0.00 |
| 5.3360 | 0.4809 | -117388. | 22989. | -0.00641 | 13218. | 1.06E+10 | -307.5487 | 1412. | 0.00 |
| 5.5200 | 0.4667 | -62913. | 22298. | -0.00643 | 12170. | 1.06E+10 | -318.0336 | 1505. | 0.00 |
| 5.7040 | 0.4525 | -9979. | 21585. | -0.00643 | 11152. | 1.06E+10 | -327.9791 | 1600. | 0.00 |
| 5.8880 | 0.4383 | 41357. | 20850. | -0.00643 | 11756. | 1.06E+10 | -337.5445 | 1700. | 0.00 |
| 6.0720 | 0.4241 | 91042. | 20093. | -0.00642 | 12711. | 1.06E+10 | -348.0210 | 1812. | 0.00 |
| 6.2560 | 0.4100 | 139017. | 19314. | -0.00639 | 13634. | 1.06E+10 | -357.9439 | 1928. | 0.00 |
| 6.4400 | 0.3959 | 185226. | 18513. | -0.00636 | 14523. | 1.06E+10 | -367.0993 | 2048. | 0.00 |
| 6.6240 | 0.3819 | 229619. | 17693. | -0.00632 | 15377. | 1.06E+10 | -375.8247 | 2173. | 0.00 |
| 6.8080 | 0.3680 | 272147. | 16854. | -0.00626 | 16195. | 1.06E+10 | -384.1089 | 2305. | 0.00 |
| 6.9920 | 0.3542 | 312762. | 15998. | -0.00620 | 16976. | 1.06E+10 | -391.9434 | 2443. | 0.00 |
| 7.1760 | 0.3406 | 351422. | 15124. | -0.00613 | 17720. | 1.06E+10 | -399.3223 | 2589. | 0.00 |
| 7.3600 | 0.3271 | 388084. | 14235. | -0.00606 | 18425. | 1.06E+10 | -406.2424 | 2742. | 0.00 |
| 7.5440 | 0.3138 | 422709. | 13330. | -0.00597 | 19091. | 1.06E+10 | -412.7029 | 2904. | 0.00 |
| 7.7280 | 0.3007 | 455261. | 12413. | -0.00588 | 19717. | 1.06E+10 | -418.7060 | 3074. | 0.00 |
| 7.9120 | 0.2879 | 485705. | 11482. | -0.00578 | 20303. | 1.06E+10 | -424.2559 | 3254. | 0.00 |
| 8.0960 | 0.2752 | 514011. | 10540. | -0.00568 | 20847. | 1.06E+10 | -429.3596 | 3445. | 0.00 |
| 8.2800 | 0.2628 | 540150. | 9586. | -0.00557 | 21350. | 1.06E+10 | -434.0263 | 3647. | 0.00 |
| 8.4640 | 0.2506 | 564094. | 8623. | -0.00546 | 21810. | 1.06E+10 | -438.2674 | 3862. | 0.00 |
| 8.6480 | 0.2387 | 585820. | 7651. | -0.00534 | 22228. | 1.06E+10 | -442.0965 | 4090. | 0.00 |
| 8.8320 | 0.2270 | 605306. | 6672. | -0.00521 | 22603. | 1.06E+10 | -445.4720 | 4333. | 0.00 |
| 9.0160 | 0.2157 | 622532. | 5685. | -0.00508 | 22934. | 1.06E+10 | -448.2021 | 4589. | 0.00 |
| 9.2000 | 0.2046 | 637483. | 4693. | -0.00495 | 23222. | 1.06E+10 | -450.2599 | 4860. | 0.00 |
| 9.3840 | 0.1938 | 650147. | 3714. | -0.00482 | 23466. | 1.06E+10 | -436.4312 | 4973. | 0.00 |
| 9.5680 | 0.1833 | 660589. | 2768. | -0.00468 | 23666. | 1.06E+10 | -420.8963 | 5070. | 0.00 |
| 9.7520 | 0.1731 | 668883. | 1856. | -0.00454 | 23826. | 1.06E+10 | -405.1451 | 5168. | 0.00 |
| 9.9360 | 0.1632 | 675106. | 978.7570 | -0.00440 | 23946. | 1.06E+10 | -389.2270 | 5265. | 0.00 |
| 10.1200 | 0.1537 | 679333. | 137.0491 | -0.00426 | 24027. | 1.06E+10 | -373.1896 | 5363. | 0.00 |
| 10.3040 | 0.1444 | 681642. | -669.1673 | -0.00412 | 24071. | 1.06E+10 | -357.0788 | 5460. | 0.00 |
| 10.4880 | 0.1354 | 682112. | -1440. | -0.00398 | 24080. | 1.06E+10 | -340.9387 | 5558. | 0.00 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 10.6720 | 0.1268 | 680821. | -2175. | -0.00384 | 24056. | 1.06E+10 | -324.8113 | 5655. | 0.00 |
| 10.8560 | 0.1185 | 677848. | -2874. | -0.00370 | 23998. | 1.06E+10 | -308.7365 | 5753. | 0.00 |
| 11.0400 | 0.1105 | 673271. | -3538. | -0.00356 | 23910. | 1.06E+10 | -292.7523 | 5850. | 0.00 |
| 11.2240 | 0.1028 | 667170. | -4167. | -0.00342 | 23793. | 1.06E+10 | -276.8941 | 5948. | 0.00 |
| 11.4080 | 0.09540 | 659623. | -4761. | -0.00328 | 23648. | 1.06E+10 | -261.1953 | 6045. | 0.00 |
| 11.5920 | 0.08831 | 650706. | -5321. | -0.00314 | 23476. | 1.06E+10 | -245.6869 | 6143. | 0.00 |
| 11.7760 | 0.08152 | 640498. | -5846. | -0.00301 | 23280. | 1.06E+10 | -230.3974 | 6240. | 0.00 |
| 11.9600 | 0.07503 | 629073. | -6338. | -0.00288 | 23060. | 1.06E+10 | -215.3529 | 6338. | 0.00 |
| 12.1440 | 0.06882 | 616508. | -6798. | -0.00275 | 22819. | 1.06E+10 | -200.5773 | 6435. | 0.00 |
| 12.3280 | 0.06290 | 602876. | -7225. | -0.00262 | 22556. | 1.06E+10 | -186.0916 | 6533. | 0.00 |
| 12.5120 | 0.05725 | 588249. | -7620. | -0.00250 | 22275. | 1.06E+10 | -171.9146 | 6630. | 0.00 |
| 12.6960 | 0.05187 | 572698. | -7984. | -0.00238 | 21976. | 1.06E+10 | -158.0626 | 6728. | 0.00 |
| 12.8800 | 0.04676 | 556295. | -8318. | -0.00226 | 21660. | 1.06E+10 | -144.5491 | 6825. | 0.00 |
| 13.0640 | 0.04190 | 539106. | -8623. | -0.00214 | 21330. | 1.06E+10 | -131.3856 | 6923. | 0.00 |
| 13.2480 | 0.03730 | 521198. | -8899. | -0.00203 | 20985. | 1.06E+10 | -118.5806 | 7020. | 0.00 |
| 13.4320 | 0.03293 | 502637. | -9147. | -0.00193 | 20628. | 1.06E+10 | -106.1406 | 7118. | 0.00 |
| 13.6160 | 0.02879 | 483486. | -9368. | -0.00182 | 20260. | 1.06E+10 | -94.0693 | 7215. | 0.00 |
| 13.8000 | 0.02487 | 463806. | -9563. | -0.00173 | 19881. | 1.06E+10 | -82.3682 | 7313. | 0.00 |
| 13.9840 | 0.02117 | 443658. | -9732. | -0.00163 | 19494. | 1.06E+10 | -71.0365 | 7410. | 0.00 |
| 14.1680 | 0.01767 | 423099. | -9877. | -0.00154 | 19098. | 1.06E+10 | -60.0707 | 7508. | 0.00 |
| 14.3520 | 0.01436 | 402185. | -9998. | -0.00146 | 18696. | 1.06E+10 | -49.4655 | 7605. | 0.00 |
| 14.5360 | 0.01124 | 380973. | -10096. | -0.00137 | 18288. | 1.06E+10 | -39.2131 | 7703. | 0.00 |
| 14.7200 | 0.00829 | 359514. | -10171. | -0.00130 | 17875. | 1.06E+10 | -29.3035 | 7800. | 0.00 |
| 14.9040 | 0.00551 | 337860. | -10225. | -0.00122 | 17459. | 1.06E+10 | -19.7246 | 7898. | 0.00 |
| 15.0880 | 0.00289 | 316061. | -10259. | -0.00116 | 17040. | 1.06E+10 | -10.4622 | 7995. | 0.00 |
| 15.2720 | 4.09E-04 | 294166. | -10272. | -0.00109 | 16618. | 1.06E+10 | -1.5003 | 8093. | 0.00 |
| 15.4560 | -0.00194 | 272220. | -10266. | -0.00103 | 16196. | 1.06E+10 | 7.1792 | 8190. | 0.00 |
| 15.6400 | -0.00416 | 250271. | -10241. | -9.79E-04 | 15774. | 1.06E+10 | 15.5964 | 8288. | 0.00 |
| 15.8240 | -0.00626 | 228361. | -10197. | -9.29E-04 | 15353. | 1.06E+10 | 23.7728 | 8385. | 0.00 |
| 16.0080 | -0.00826 | 206533. | -10136. | -8.84E-04 | 14933. | 1.06E+10 | 31.7320 | 8483. | 0.00 |
| 16.1920 | -0.01016 | 184831. | -10057. | -8.43E-04 | 14515. | 1.06E+10 | 39.4991 | 8580. | 0.00 |
| 16.3760 | -0.01198 | 163294. | -9962. | -8.07E-04 | 14101. | 1.06E+10 | 47.1006 | 8678. | 0.00 |
| 16.5600 | -0.01373 | 141964. | -9849. | -7.75E-04 | 13691. | 1.06E+10 | 54.5647 | 8775. | 0.00 |
| 16.7440 | -0.01541 | 120879. | -9721. | -7.48E-04 | 13285. | 1.06E+10 | 61.9207 | 8873. | 0.00 |
| 16.9280 | -0.01703 | 100078. | -9576. | -7.25E-04 | 12885. | 1.06E+10 | 69.1994 | 8970. | 0.00 |
| 17.1120 | -0.01861 | 79600. | -9415. | -7.06E-04 | 12491. | 1.06E+10 | 76.4327 | 9068. | 0.00 |
| 17.2960 | -0.02015 | 59483. | -8754. | -6.92E-04 | 12104. | 1.06E+10 | 522.8351 | 57284. | 0.00 |
| 17.4800 | -0.02167 | 41907. | -7549. | -6.81E-04 | 11766. | 1.06E+10 | 568.0999 | 57894. | 0.00 |
| 17.6640 | -0.02316 | 27094. | -6244. | -6.74E-04 | 11481. | 1.06E+10 | 613.6904 | 58503. | 0.00 |
| 17.8480 | -0.02464 | 15269. | -4839. | -6.70E-04 | 11254. | 1.06E+10 | 659.7727 | 59113. | 0.00 |
| 18.0320 | -0.02612 | 6659. | -3330. | -6.68E-04 | 11088. | 1.06E+10 | 706.4837 | 59722. | 0.00 |
| 18.2160 | -0.02759 | 1492. | -1718. | -6.67E-04 | 10989. | 1.06E+10 | 753.9255 | 60331. | 0.00 |
| 18.4000 | -0.02906 | 0.00 | 0.00 | -6.67E-04 | 10960. | 1.06E+10 | 802.1612 | 30470. | 0.00 |

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

Output Summary for Load Case No. 1:

```
Pile-head deflection            =     0.75047988 inches
Computed slope at pile head     =       0.000000 radians
Maximum bending moment          =      -2088806. inch-lbs
Maximum shear force             =         32730. lbs
Depth of maximum bending moment =       0.000000 feet below pile head
Depth of maximum shear force    =       0.000000 feet below pile head
Number of iterations            =              6
Number of zero deflection points =             1
```

--------------------------------------------------------------------------------

Summary of Pile-head Responses for Conventional Analyses

--------------------------------------------------------------------------------

Definitions of Pile-head Loading Conditions:

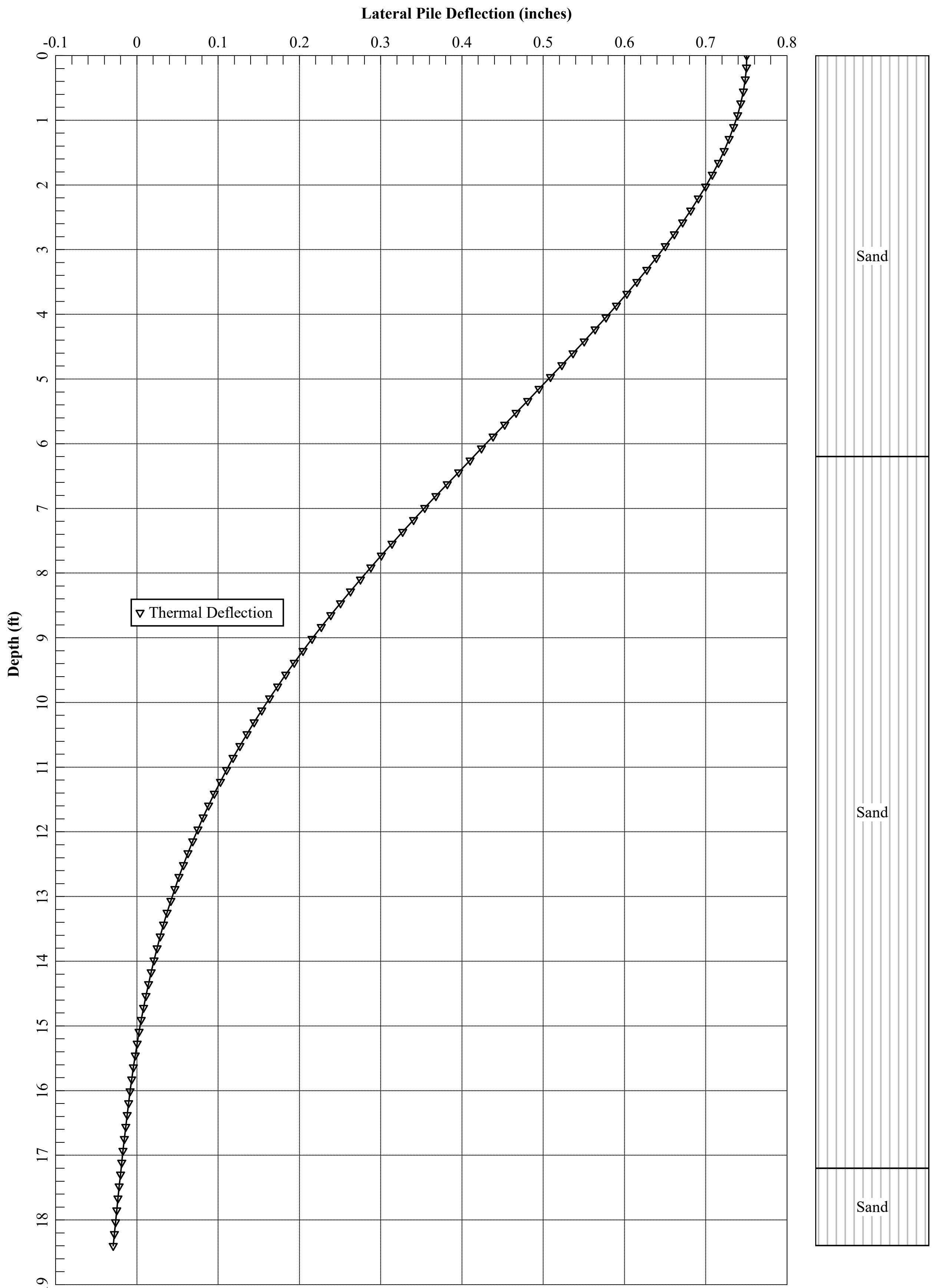
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Load Load Axial Pile-head Pile-head Max Shear Max Moment

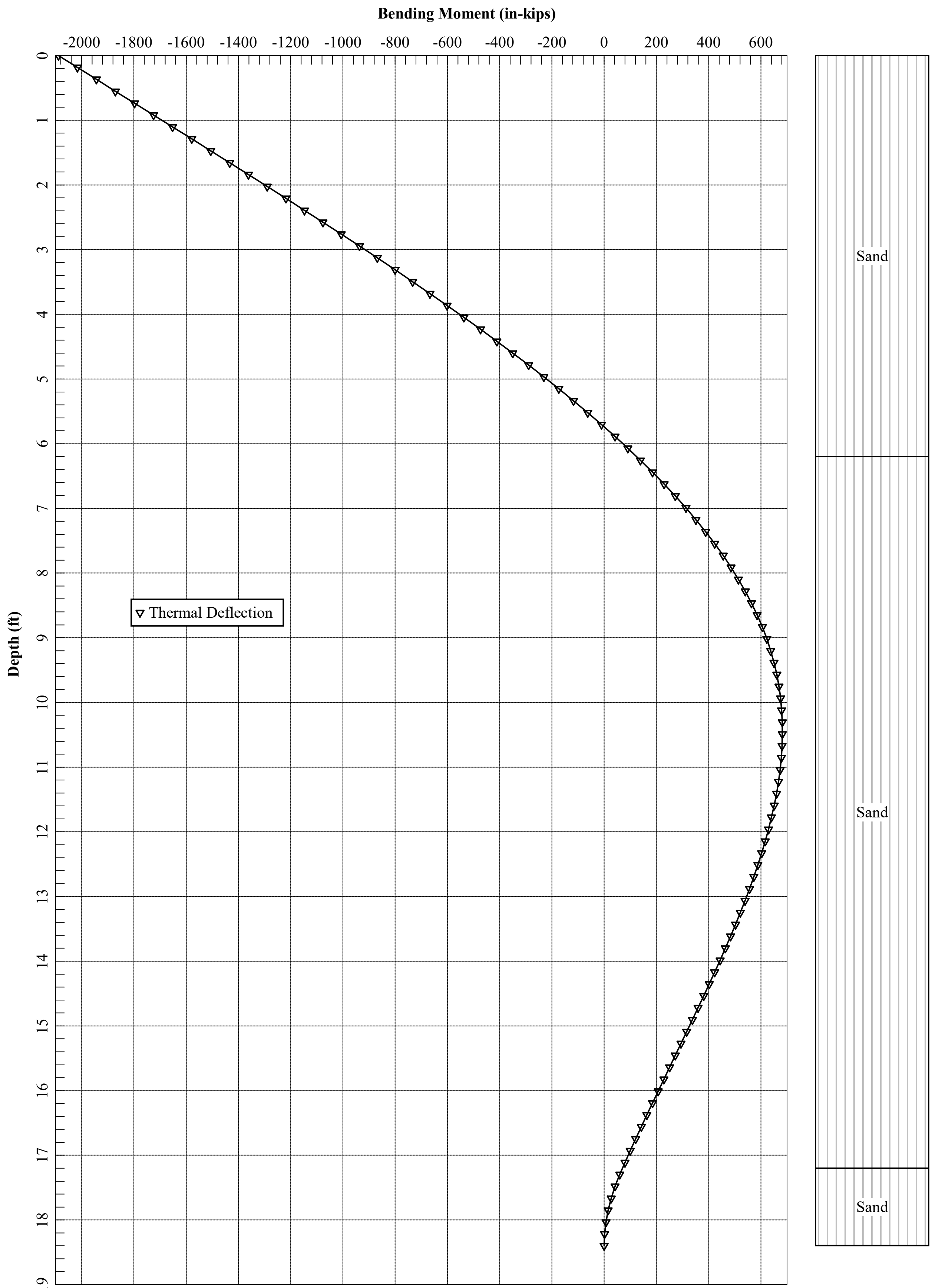
| Case No. | Type 1 | Pile-head Load 1 | Type 2 | Pile-head Load 2 | Loading lbs | Deflection inches | Rotation radians | in Pile lbs | in Pile in-lbs |
|---|---|---|---|---|---|---|---|---|---|
| 1 | y, in | 0.7500 | S, rad | 0.00 | 315000. | 0.7505 | 0.00 | 32730. | -2088806. |

Maximum pile-head deflection = 0.7504798797 inches
Maximum pile-head rotation = 0.0000000000 radians = 0.000000 deg.

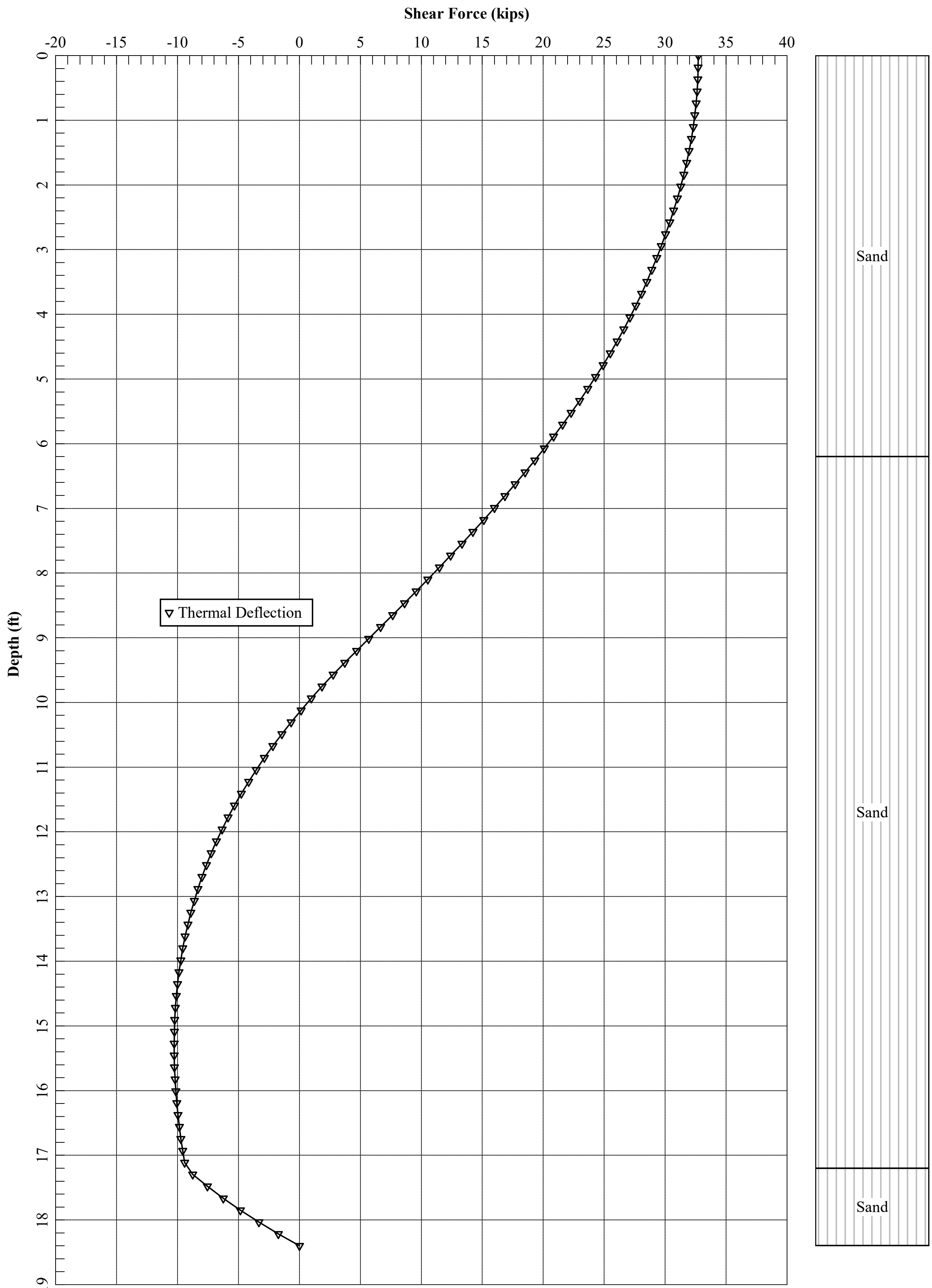
The analysis ended normally.



Lateral Pile Deflection (inches)
-0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
Thermal Deflection
Sand
Sand
Sand



Bending Moment (in-kips)
-2000
-1800
-1600
-1400
-1200
-1000
-800
-600
-400
-200
0
200
400
600
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
Thermal Deflection
Sand
Sand
Sand



Shear Force (kips)
-20
-15
-10
-5
0
5
10
15
20
25
30
35
40
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
Thermal Deflection
Sand
Sand
Sand

Abutment No. 2
Piles driven to top of bedrock

===============================================================================

LPile for Windows, Version 2016-09.010

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


===============================================================================

This copy of LPile is being used by:

A
A

Serial Number of Security Device: 226662858



-------------------------------------------------------------------------------
Files Used for Analysis
-------------------------------------------------------------------------------

Path to file locations:
\Users\mst.pierre\Desktop\LPile Output Files\20-1403-021876 Buckfield\Piles to Bedrock\

Name of input data file:
Abutment 2 HP14x117 - 14ft Pile.lp9d

Name of output report file:
Abutment 2 HP14x117 - 14ft Pile.lp9o

Name of plot output file:
Abutment 2 HP14x117 - 14ft Pile.lp9p

Name of runtime message file:
Abutment 2 HP14x117 - 14ft Pile.lp9r

-------------------------------------------------------------------------------
Date and Time of Analysis
-------------------------------------------------------------------------------

Date: November 2, 2021 Time: 14:43:23

-------------------------------------------------------------------------------
Problem Title
-------------------------------------------------------------------------------

Hall Bridge #3287 Replacement

WIN 021876

MaineDOT

MAS

Abutment No. 2 - HP14x117

---

## Program Options and Settings

---

Computational Options:
- Use unfactored loads in computations (conventional analysis)

Engineering Units Used for Data Input and Computations:
- US Customary System 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:
- Static loading specified

- Use of p-y modification factors for p-y curves not selected
- No distributed lateral loads are entered
- 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:
- Output files use decimal points to denote decimal symbols.
- 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
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

---

## Pile Structural Properties and Geometry

---

Number of pile sections defined = 1
Total length of pile = 14.100 ft
Depth of ground surface below top of pile = 0.0000 ft

Pile diameters 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. A summary of values of pile diameter vs. depth follows.

| Point No. | Depth Below Pile Head feet | Pile Diameter inches |
|---|---|---|
| 1 | 0.000 | 14.0750 |
| 2 | 14.100 | 14.0750 |

Input Structural Properties for Pile Sections:

---

Pile Section No. 1:

Section 1 is an elastic pile
Cross-sectional Shape = Weak H-Pile
Length of section = 14.100000 ft
Flange Width = 14.775000 in
Section Depth = 14.075000 in
Flange Thickness = 0.680000 in
Web Thickness = 0.680000 in

```
   Section Area                                          =    28.740200 sq. in
   Moment of Inertia                                     =   365.877563 in^4
   Elastic Modulus                                       =    29000000. psi
```

--------------------------------------------------------------------------------

Ground Slope and Pile Batter Angles

--------------------------------------------------------------------------------

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

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

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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          =     2.800000 ft
   Effective unit weight at top of layer                 =    62.600000 pcf
   Effective unit weight at bottom of layer              =    62.600000 pcf
   Friction angle at top of layer                        =    30.000000 deg.
   Friction angle at bottom of layer                     =    30.000000 deg.
   Subgrade k at top of layer                            =    60.000000 pci
   Subgrade k at bottom of layer                         =    60.000000 pci
```

Layer 2 is sand, p-y criteria by Reese et al., 1974

```
   Distance from top of pile to top of layer             =     2.800000 ft
   Distance from top of pile to bottom of layer          =    13.300000 ft
   Effective unit weight at top of layer                 =    59.600000 pcf
   Effective unit weight at bottom of layer              =    59.600000 pcf
   Friction angle at top of layer                        =    30.000000 deg.
   Friction angle at bottom of layer                     =    30.000000 deg.
   Subgrade k at top of layer                            =    20.000000 pci
   Subgrade k at bottom of layer                         =    20.000000 pci
```

Layer 3 is sand, p-y criteria by Reese et al., 1974

```
   Distance from top of pile to top of layer             =    13.300000 ft
   Distance from top of pile to bottom of layer          =    14.100000 ft
   Effective unit weight at top of layer                 =    67.600000 pcf
   Effective unit weight at bottom of layer              =    67.600000 pcf
   Friction angle at top of layer                        =    38.000000 deg.
   Friction angle at bottom of layer                     =    38.000000 deg.
   Subgrade k at top of layer                            =   125.000000 pci
   Subgrade k at bottom of layer                         =   125.000000 pci
```

(Depth of the lowest soil layer extends 0.000 ft below the pile tip)

--------------------------------------------------------------------------------

Summary of Input Soil Properties

--------------------------------------------------------------------------------

| Layer Layer Num. | Soil Type Name (p-y Curve Type) | Layer Depth ft | Effective Unit Wt. pcf | Angle of Friction deg. | kpy pci |
|---|---|---|---|---|---|
| 1 | Sand | 0.00 | 62.6000 | 30.0000 | 60.0000 |

| | | | | | |
|---|---|---|---|---|---|
| | (Reese, et al.) | 2.8000 | 62.6000 | 30.0000 | 60.0000 |
| 2 | Sand | 2.8000 | 59.6000 | 30.0000 | 20.0000 |
| | (Reese, et al.) | 13.3000 | 59.6000 | 30.0000 | 20.0000 |
| 3 | Sand | 13.3000 | 67.6000 | 38.0000 | 125.0000 |
| | (Reese, et al.) | 14.1000 | 67.6000 | 38.0000 | 125.0000 |

---------------------------------------------------------------------------------

## Static Loading Type

---------------------------------------------------------------------------------

Static loading criteria were used when computing p-y curves for all analyses.

---------------------------------------------------------------------------------

## 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 | 5 | y = 0.750000 in | S = 0.0000 in/in | 315000. | N.A. |

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with
specified shear loading (Load Types 1, 2, and 3).
Thrust force 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

---------------------------------------------------------------------------------

## Layering Correction Equivalent Depths of Soil & Rock Layers

---------------------------------------------------------------------------------

| Layer No. | Top of Layer Below Pile Head ft | Equivalent Top Depth Below Grnd Surf ft | Same Layer Type As Layer Above | Layer is Rock or is Below Rock Layer | F0 Integral for Layer lbs | F1 Integral for Layer lbs |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | N.A. | No | 0.00 | 2714. |
| 2 | 2.8000 | 2.8000 | Yes | No | 2714. | 94002. |
| 3 | 13.3000 | 13.3000 | Yes | No | 96716. | N.A. |

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals
for Layer n. Layering correction equivalent depths are computed only
for soil types with both shallow-depth and deep-depth expressions for
peak lateral load transfer. These soil types are soft and stiff clays,
non-liquefied sands, and cemented c-phi soil.

---

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

---

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head = 0.750000 inches
Rotation of pile head = 0.000E+00 radians
Axial load on pile head = 315000.0 lbs

| Depth X feet | Deflect. y inches | Bending Moment in-lbs | Shear Force lbs | Slope S radians | Total Stress psi* | Bending Stiffness in-lb^2 | Soil Res. p lb/inch | Soil Spr. Es*h lb/inch | Distrib. Lat. Load lb/inch |
|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 0.7503 | -1907528. | 28020. | 0.00 | 47651. | 1.06E+10 | 0.00 | 0.00 | 0.00 |
| 0.1410 | 0.7500 | -1860048. | 28008. | -3.00E-04 | 46737. | 1.06E+10 | -6.8616 | 15.4798 | 0.00 |
| 0.2820 | 0.7492 | -1812430. | 27990. | -5.93E-04 | 45822. | 1.06E+10 | -14.3581 | 32.4248 | 0.00 |
| 0.4230 | 0.7480 | -1764698. | 27959. | -8.78E-04 | 44903. | 1.06E+10 | -22.3894 | 50.6462 | 0.00 |
| 0.5640 | 0.7463 | -1716881. | 27914. | -0.00116 | 43984. | 1.06E+10 | -30.8554 | 69.9580 | 0.00 |
| 0.7050 | 0.7441 | -1669007. | 27854. | -0.00143 | 43063. | 1.06E+10 | -39.5895 | 90.0244 | 0.00 |
| 0.8460 | 0.7414 | -1621104. | 27779. | -0.00169 | 42141. | 1.06E+10 | -48.5057 | 110.6919 | 0.00 |
| 0.9870 | 0.7384 | -1573202. | 27690. | -0.00194 | 41220. | 1.06E+10 | -57.5078 | 131.7817 | 0.00 |
| 1.1280 | 0.7349 | -1525330. | 27585. | -0.00219 | 40299. | 1.06E+10 | -66.4900 | 153.0903 | 0.00 |
| 1.2690 | 0.7310 | -1477520. | 27465. | -0.00243 | 39380. | 1.06E+10 | -75.4668 | 174.6888 | 0.00 |
| 1.4100 | 0.7266 | -1429800. | 27330. | -0.00266 | 38462. | 1.06E+10 | -84.3174 | 196.3336 | 0.00 |
| 1.5510 | 0.7220 | -1382200. | 27180. | -0.00289 | 37546. | 1.06E+10 | -92.8940 | 217.7112 | 0.00 |
| 1.6920 | 0.7169 | -1334748. | 27016. | -0.00310 | 36634. | 1.06E+10 | -101.0965 | 238.6103 | 0.00 |
| 1.8330 | 0.7115 | -1287473. | 26837. | -0.00331 | 35724. | 1.06E+10 | -109.3822 | 260.1362 | 0.00 |
| 1.9740 | 0.7057 | -1240401. | 26645. | -0.00351 | 34819. | 1.06E+10 | -117.7996 | 282.4480 | 0.00 |
| 2.1150 | 0.6996 | -1193561. | 26439. | -0.00371 | 33918. | 1.06E+10 | -125.8170 | 304.3067 | 0.00 |
| 2.2560 | 0.6931 | -1146979. | 26220. | -0.00389 | 33022. | 1.06E+10 | -133.3545 | 325.5306 | 0.00 |
| 2.3970 | 0.6864 | -1100682. | 25988. | -0.00407 | 32131. | 1.06E+10 | -140.5842 | 346.5501 | 0.00 |
| 2.5380 | 0.6794 | -1054694. | 25744. | -0.00424 | 31247. | 1.06E+10 | -147.7076 | 367.8826 | 0.00 |
| 2.6790 | 0.6720 | -1009039. | 25489. | -0.00441 | 30369. | 1.06E+10 | -154.2508 | 388.3661 | 0.00 |
| 2.8200 | 0.6644 | -963740. | 25223. | -0.00457 | 29497. | 1.06E+10 | -160.0878 | 407.6705 | 0.00 |
| 2.9610 | 0.6566 | -918817. | 24947. | -0.00472 | 28633. | 1.06E+10 | -165.4100 | 426.2637 | 0.00 |
| 3.1020 | 0.6485 | -874290. | 24662. | -0.00486 | 27777. | 1.06E+10 | -172.2697 | 449.4896 | 0.00 |
| 3.2430 | 0.6401 | -830182. | 24365. | -0.00500 | 26928. | 1.06E+10 | -178.7019 | 472.3474 | 0.00 |
| 3.3840 | 0.6316 | -786514. | 24057. | -0.00512 | 26089. | 1.06E+10 | -184.6601 | 494.7149 | 0.00 |
| 3.5250 | 0.6228 | -743309. | 23740. | -0.00525 | 25257. | 1.06E+10 | -190.2704 | 516.9286 | 0.00 |
| 3.6660 | 0.6138 | -700585. | 23411. | -0.00536 | 24436. | 1.06E+10 | -199.3004 | 549.3802 | 0.00 |
| 3.8070 | 0.6046 | -658372. | 23066. | -0.00547 | 23624. | 1.06E+10 | -208.2539 | 582.7631 | 0.00 |
| 3.9480 | 0.5953 | -616699. | 22706. | -0.00557 | 22822. | 1.06E+10 | -217.1091 | 617.0786 | 0.00 |
| 4.0890 | 0.5858 | -575596. | 22331. | -0.00567 | 22032. | 1.06E+10 | -225.8442 | 652.3268 | 0.00 |
| 4.2300 | 0.5761 | -535090. | 21942. | -0.00575 | 21252. | 1.06E+10 | -234.4375 | 688.5075 | 0.00 |
| 4.3710 | 0.5663 | -495210. | 21538. | -0.00584 | 20485. | 1.06E+10 | -242.8671 | 725.6189 | 0.00 |
| 4.5120 | 0.5564 | -455983. | 21120. | -0.00591 | 19731. | 1.06E+10 | -251.1112 | 763.6581 | 0.00 |
| 4.6530 | 0.5463 | -417436. | 20689. | -0.00598 | 18989. | 1.06E+10 | -259.1481 | 802.6208 | 0.00 |
| 4.7940 | 0.5361 | -379595. | 20240. | -0.00605 | 18262. | 1.06E+10 | -270.6362 | 854.1150 | 0.00 |
| 4.9350 | 0.5258 | -342498. | 19772. | -0.00610 | 17548. | 1.06E+10 | -282.9224 | 910.3473 | 0.00 |
| 5.0760 | 0.5155 | -306181. | 19286. | -0.00616 | 16850. | 1.06E+10 | -291.8283 | 957.9005 | 0.00 |
| 5.2170 | 0.5050 | -270673. | 18785. | -0.00620 | 16167. | 1.06E+10 | -300.5003 | 1007. | 0.00 |
| 5.3580 | 0.4945 | -236003. | 18269. | -0.00624 | 15500. | 1.06E+10 | -308.9153 | 1057. | 0.00 |
| 5.4990 | 0.4839 | -202197. | 17740. | -0.00628 | 14849. | 1.06E+10 | -317.0507 | 1109. | 0.00 |
| 5.6400 | 0.4732 | -169281. | 17196. | -0.00631 | 14216. | 1.06E+10 | -324.8839 | 1162. | 0.00 |
| 5.7810 | 0.4626 | -137281. | 16640. | -0.00633 | 13601. | 1.06E+10 | -332.3929 | 1216. | 0.00 |
| 5.9220 | 0.4518 | -106221. | 16072. | -0.00635 | 13003. | 1.06E+10 | -340.0370 | 1273. | 0.00 |
| 6.0630 | 0.4411 | -76126. | 15489. | -0.00636 | 12425. | 1.06E+10 | -348.1127 | 1335. | 0.00 |
| 6.2040 | 0.4303 | -47021. | 14894. | -0.00637 | 11865. | 1.06E+10 | -355.9465 | 1400. | 0.00 |
| 6.3450 | 0.4195 | -18931. | 14285. | -0.00638 | 11324. | 1.06E+10 | -363.5263 | 1466. | 0.00 |
| 6.4860 | 0.4087 | 8121. | 13664. | -0.00638 | 11116. | 1.06E+10 | -370.8401 | 1535. | 0.00 |
| 6.6270 | 0.3979 | 34109. | 13030. | -0.00638 | 11616. | 1.06E+10 | -377.8768 | 1607. | 0.00 |
| 6.7680 | 0.3871 | 59013. | 12385. | -0.00637 | 12095. | 1.06E+10 | -384.6257 | 1681. | 0.00 |
| 6.9090 | 0.3763 | 82811. | 11729. | -0.00636 | 12553. | 1.06E+10 | -391.0767 | 1758. | 0.00 |
| 7.0500 | 0.3656 | 105483. | 11062. | -0.00634 | 12989. | 1.06E+10 | -397.2202 | 1838. | 0.00 |
| 7.1910 | 0.3549 | 127008. | 10385. | -0.00633 | 13403. | 1.06E+10 | -403.0472 | 1922. | 0.00 |
| 7.3320 | 0.3442 | 147368. | 9699. | -0.00630 | 13795. | 1.06E+10 | -408.5489 | 2008. | 0.00 |
| 7.4730 | 0.3335 | 166547. | 9003. | -0.00628 | 14164. | 1.06E+10 | -413.7175 | 2099. | 0.00 |
| 7.6140 | 0.3229 | 184526. | 8299. | -0.00625 | 14510. | 1.06E+10 | -418.5452 | 2193. | 0.00 |
| 7.7550 | 0.3124 | 201292. | 7587. | -0.00622 | 14832. | 1.06E+10 | -423.0248 | 2291. | 0.00 |
| 7.8960 | 0.3019 | 216830. | 6868. | -0.00619 | 15131. | 1.06E+10 | -427.1496 | 2394. | 0.00 |
| 8.0370 | 0.2915 | 231126. | 6142. | -0.00615 | 15406. | 1.06E+10 | -430.9131 | 2502. | 0.00 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 8.1780 | 0.2811 | 244169. | 5410. | -0.00611 | 15657. | 1.06E+10 | -434.3094 | 2614. | 0.00 |
| 8.3190 | 0.2708 | 255948. | 4672. | -0.00607 | 15883. | 1.06E+10 | -437.3327 | 2733. | 0.00 |
| 8.4600 | 0.2605 | 266453. | 3930. | -0.00603 | 16085. | 1.06E+10 | -439.9774 | 2857. | 0.00 |
| 8.6010 | 0.2504 | 275676. | 3184. | -0.00599 | 16263. | 1.06E+10 | -442.2384 | 2989. | 0.00 |
| 8.7420 | 0.2403 | 283610. | 2434. | -0.00594 | 16415. | 1.06E+10 | -444.1107 | 3127. | 0.00 |
| 8.8830 | 0.2303 | 290248. | 1681. | -0.00590 | 16543. | 1.06E+10 | -445.5708 | 3274. | 0.00 |
| 9.0240 | 0.2203 | 295585. | 926.5355 | -0.00585 | 16646. | 1.06E+10 | -446.4589 | 3429. | 0.00 |
| 9.1650 | 0.2105 | 299620. | 170.9112 | -0.00580 | 16723. | 1.06E+10 | -446.7140 | 3591. | 0.00 |
| 9.3060 | 0.2007 | 302350. | -584.5816 | -0.00576 | 16776. | 1.06E+10 | -446.3034 | 3763. | 0.00 |
| 9.4470 | 0.1910 | 303776. | -1328. | -0.00571 | 16803. | 1.06E+10 | -433.0166 | 3836. | 0.00 |
| 9.5880 | 0.1814 | 303937. | -2048. | -0.00566 | 16806. | 1.06E+10 | -417.3541 | 3893. | 0.00 |
| 9.7290 | 0.1718 | 302878. | -2740. | -0.00561 | 16786. | 1.06E+10 | -401.2324 | 3951. | 0.00 |
| 9.8700 | 0.1624 | 300644. | -3405. | -0.00556 | 16743. | 1.06E+10 | -384.6590 | 4008. | 0.00 |
| 10.0110 | 0.1530 | 297283. | -4042. | -0.00551 | 16678. | 1.06E+10 | -367.6408 | 4065. | 0.00 |
| 10.1520 | 0.1437 | 292845. | -4649. | -0.00547 | 16593. | 1.06E+10 | -350.1839 | 4123. | 0.00 |
| 10.2930 | 0.1345 | 287379. | -5226. | -0.00542 | 16488. | 1.06E+10 | -332.2935 | 4180. | 0.00 |
| 10.4340 | 0.1254 | 280937. | -5773. | -0.00538 | 16364. | 1.06E+10 | -313.9738 | 4237. | 0.00 |
| 10.5750 | 0.1163 | 273573. | -6289. | -0.00533 | 16222. | 1.06E+10 | -295.2284 | 4294. | 0.00 |
| 10.7160 | 0.1073 | 265340. | -6772. | -0.00529 | 16064. | 1.06E+10 | -276.0597 | 4352. | 0.00 |
| 10.8570 | 0.09843 | 256294. | -7222. | -0.00525 | 15890. | 1.06E+10 | -256.4696 | 4409. | 0.00 |
| 10.9980 | 0.08958 | 246492. | -7639. | -0.00521 | 15701. | 1.06E+10 | -236.4589 | 4466. | 0.00 |
| 11.1390 | 0.08081 | 235993. | -8022. | -0.00517 | 15499. | 1.06E+10 | -216.0274 | 4523. | 0.00 |
| 11.2800 | 0.07209 | 224854. | -8370. | -0.00513 | 15285. | 1.06E+10 | -195.1743 | 4581. | 0.00 |
| 11.4210 | 0.06344 | 213138. | -8682. | -0.00510 | 15060. | 1.06E+10 | -173.8978 | 4638. | 0.00 |
| 11.5620 | 0.05485 | 200906. | -8958. | -0.00506 | 14825. | 1.06E+10 | -152.1954 | 4695. | 0.00 |
| 11.7030 | 0.04631 | 188222. | -9197. | -0.00503 | 14581. | 1.06E+10 | -130.0634 | 4752. | 0.00 |
| 11.8440 | 0.03782 | 175149. | -9398. | -0.00500 | 14329. | 1.06E+10 | -107.4978 | 4810. | 0.00 |
| 11.9850 | 0.02937 | 161753. | -9560. | -0.00498 | 14072. | 1.06E+10 | -84.4936 | 4867. | 0.00 |
| 12.1260 | 0.02098 | 148101. | -9683. | -0.00495 | 13809. | 1.06E+10 | -61.0450 | 4924. | 0.00 |
| 12.2670 | 0.01262 | 134263. | -9767. | -0.00493 | 13543. | 1.06E+10 | -37.1456 | 4981. | 0.00 |
| 12.4080 | 0.00429 | 120306. | -9809. | -0.00491 | 13274. | 1.06E+10 | -12.7883 | 5039. | 0.00 |
| 12.5490 | -0.00400 | 106303. | -9809. | -0.00489 | 13005. | 1.06E+10 | 12.0344 | 5096. | 0.00 |
| 12.6900 | -0.01226 | 92325. | -9768. | -0.00488 | 12736. | 1.06E+10 | 37.3309 | 5153. | 0.00 |
| 12.8310 | -0.02049 | 78446. | -9683. | -0.00486 | 12469. | 1.06E+10 | 63.1098 | 5210. | 0.00 |
| 12.9720 | -0.02871 | 64741. | -9554. | -0.00485 | 12206. | 1.06E+10 | 89.3803 | 5268. | 0.00 |
| 13.1130 | -0.03691 | 51286. | -9380. | -0.00484 | 11947. | 1.06E+10 | 116.1519 | 5325. | 0.00 |
| 13.2540 | -0.04509 | 38160. | -9160. | -0.00483 | 11694. | 1.06E+10 | 143.4342 | 5382. | 0.00 |
| 13.3950 | -0.05327 | 25441. | -8386. | -0.00483 | 11450. | 1.06E+10 | 771.8009 | 24517. | 0.00 |
| 13.5360 | -0.06143 | 14930. | -7005. | -0.00483 | 11247. | 1.06E+10 | 859.8854 | 23683. | 0.00 |
| 13.6770 | -0.06960 | 6878. | -5476. | -0.00482 | 11093. | 1.06E+10 | 947.4448 | 23034. | 0.00 |
| 13.8180 | -0.07776 | 1539. | -3799. | -0.00482 | 10990. | 1.06E+10 | 1035. | 22520. | 0.00 |
| 13.9590 | -0.08592 | -837.4497 | -1974. | -0.00482 | 10976. | 1.06E+10 | 1123. | 22109. | 0.00 |
| 14.1000 | -0.09408 | 0.00 | 0.00 | -0.00482 | 10960. | 1.06E+10 | 1211. | 10889. | 0.00 |

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

Output Summary for Load Case No. 1:

Pile-head deflection = 0.75025734 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = -1907528. inch-lbs
Maximum shear force = 28020. lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 7
Number of zero deflection points = 1

--------------------------------------------------------------------------------
Summary of Pile-head Responses for Conventional Analyses
--------------------------------------------------------------------------------

Definitions of Pile-head Loading Conditions:

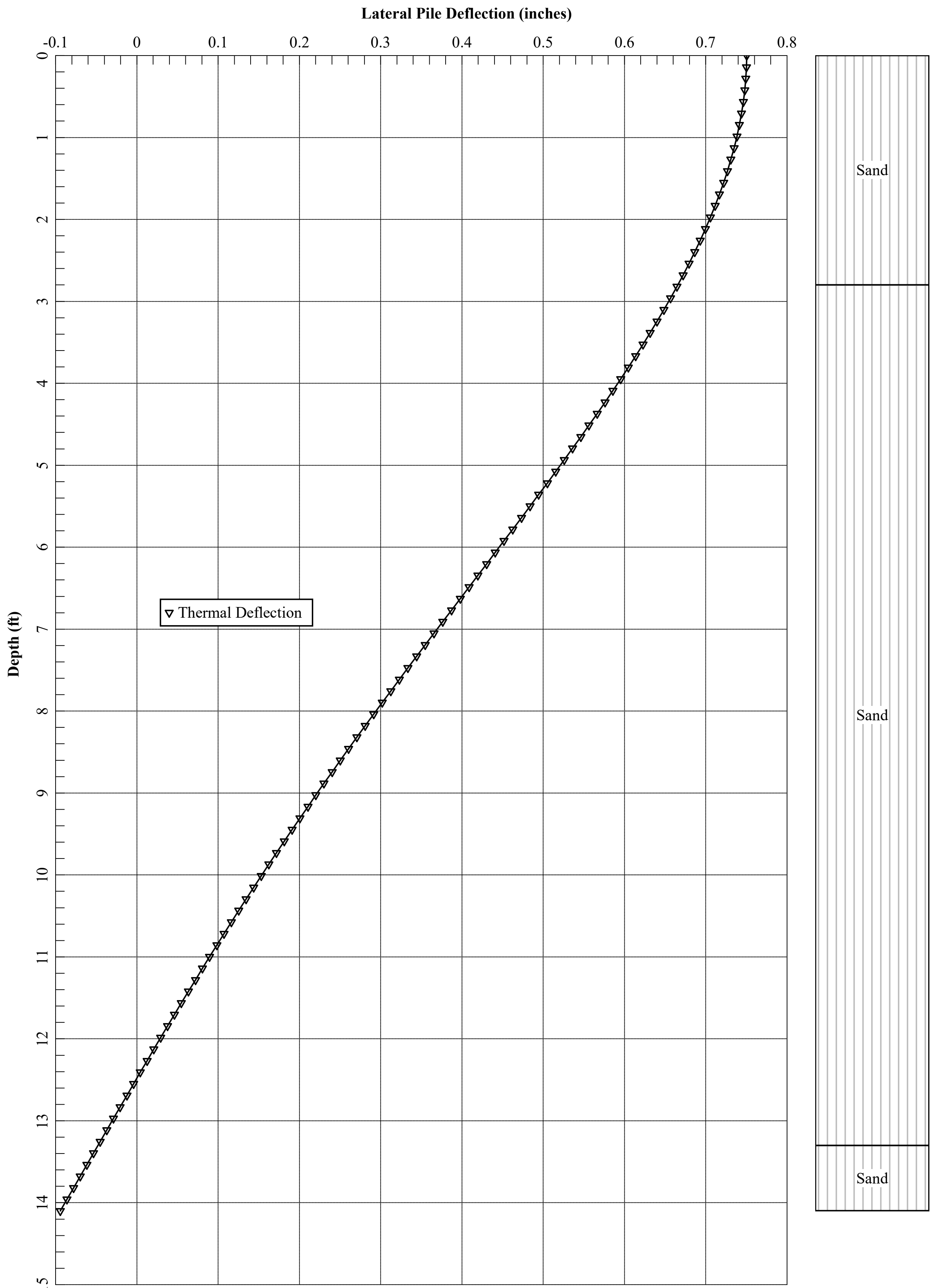
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Load Load Axial Pile-head Pile-head Max Shear Max Moment

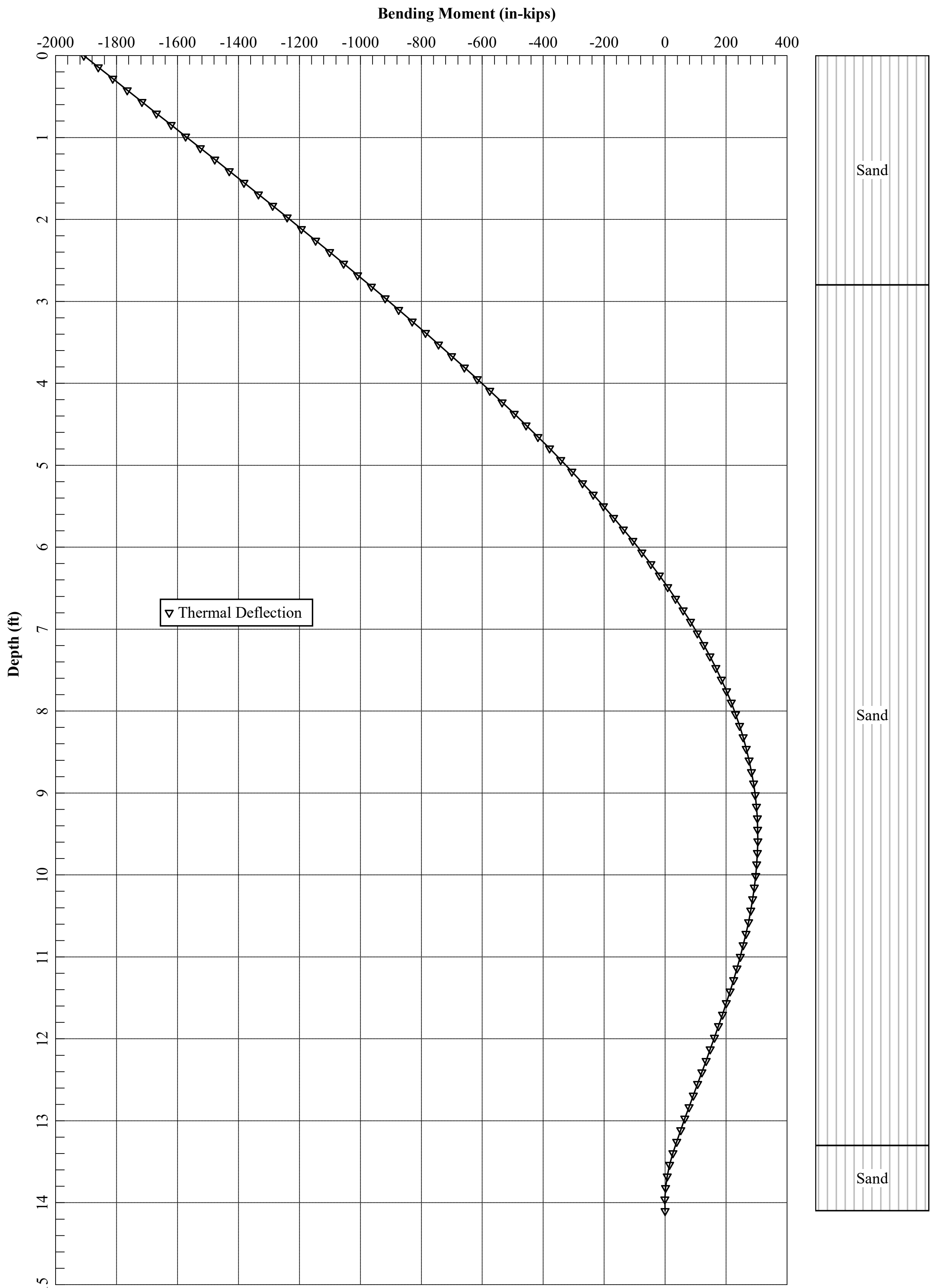
| Case No. | Type 1 | Pile-head Load 1 | Type 2 | Pile-head Load 2 | Loading lbs | Deflection inches | Rotation radians | in Pile lbs | in Pile in-lbs |
|---|---|---|---|---|---|---|---|---|---|
| 1 | y, in | 0.7500 | S, rad | 0.00 | 315000. | 0.7503 | 0.00 | 28020. | -1907528. |

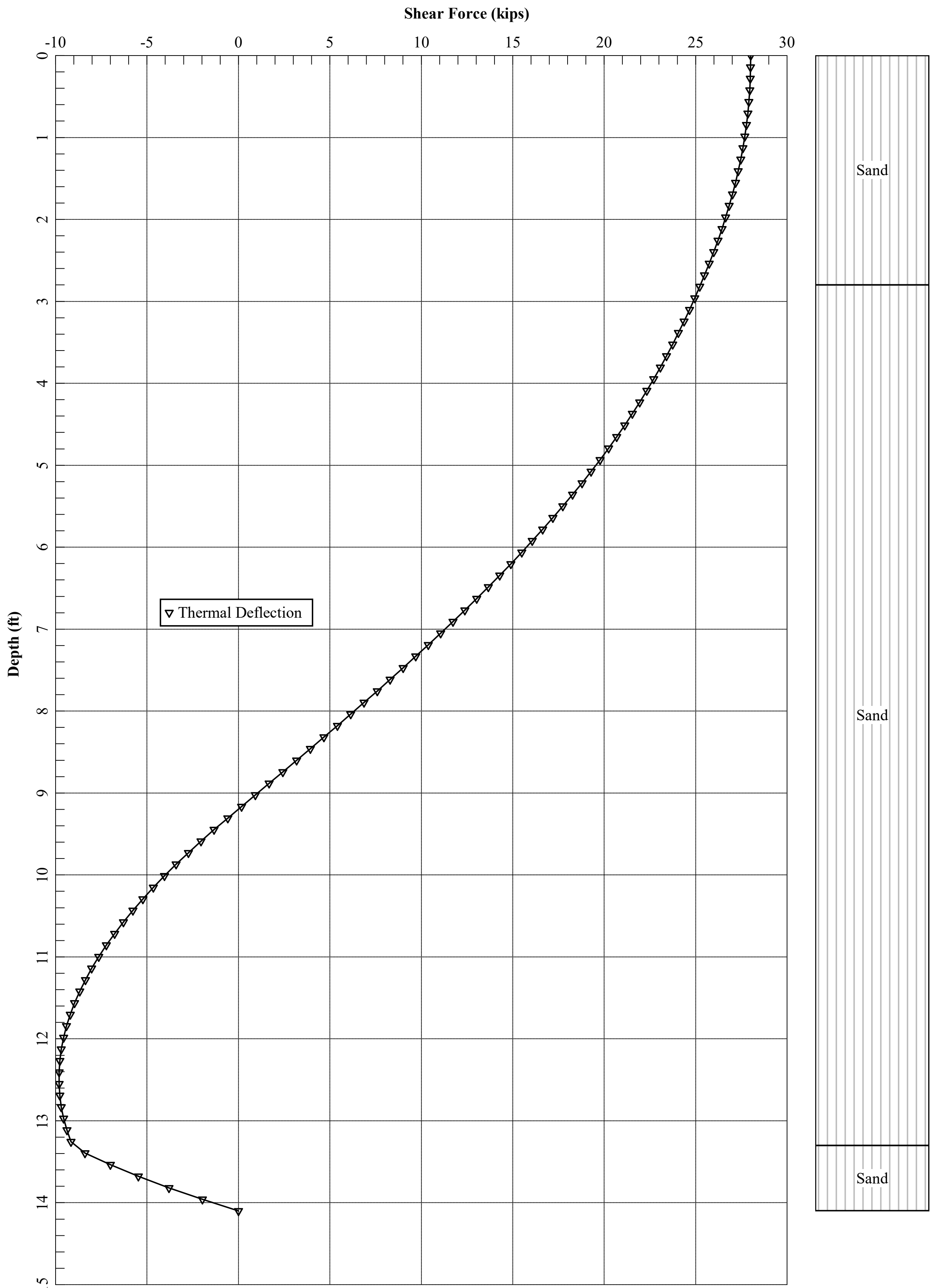
Maximum pile-head deflection = 0.7502573403 inches
Maximum pile-head rotation = 0.0000000000 radians = 0.000000 deg.

The analysis ended normally.



Lateral Pile Deflection (inches)
-0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Thermal Deflection
Sand
Sand
Sand


Bending Moment (in-kips)
-2000 -1800 -1600 -1400 -1200 -1000 -800 -600 -400 -200 0 200 400
Depth (ft)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Thermal Deflection
Sand
Sand
Sand



Shear Force (kips)
-10
-5
0
5
10
15
20
25
30
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Thermal Deflection
Sand
Sand
Sand

Abutment No. 1
Piles with 0.2-ft (2.4-in) embedment in bedrock

```
===============================================================================

                     LPile for Windows, Version 2016-09.010

                 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:
\Users\mst.pierre\Desktop\LPile Output Files\20-1403-021876 Buckfield\Pile with Rock Injector Tip\

Name of input data file:
Abutment 1 HP14x117 - Injector Tip.lp9d

Name of output report file:
Abutment 1 HP14x117 - Injector Tip.lp9o

Name of plot output file:
Abutment 1 HP14x117 - Injector Tip.lp9p

Name of runtime message file:
Abutment 1 HP14x117 - Injector Tip.lp9r


-------------------------------------------------------------------------------
                            Date and Time of Analysis
-------------------------------------------------------------------------------

               Date:  October 27, 2021           Time:  13:28:36


-------------------------------------------------------------------------------
                                 Problem Title
-------------------------------------------------------------------------------

Hall Bridge #3287 Replacement


WIN 021876


MaineDOT


MAS


Abutment No. 1 - HP14x117
```

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## Program Options and Settings

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Computational Options:
- Use unfactored loads in computations (conventional analysis)

Engineering Units Used for Data Input and Computations:
- US Customary System 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:
- Static loading specified

- Use of p-y modification factors for p-y curves not selected
- No distributed lateral loads are entered
- 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:
- Output files use decimal points to denote decimal symbols.
- 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
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

---

## Pile Structural Properties and Geometry

---

Number of pile sections defined = 1
Total length of pile = 18.600 ft
Depth of ground surface below top of pile = 0.0000 ft

Pile diameters 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. A summary of values of pile diameter vs. depth follows.

| Point No. | Depth Below Pile Head feet | Pile Diameter inches |
|---|---|---|
| 1 | 0.000 | 14.0750 |
| 2 | 18.600 | 14.0750 |

Input Structural Properties for Pile Sections:

---

Pile Section No. 1:

Section 1 is an elastic pile
Cross-sectional Shape = Weak H-Pile
Length of section = 18.600000 ft
Flange Width = 14.775000 in
Section Depth = 14.075000 in
Flange Thickness = 0.680000 in
Web Thickness = 0.680000 in

```
   Section Area                                         =    28.740200 sq. in
   Moment of Inertia                                    =   365.877563 in^4
   Elastic Modulus                                      =    29000000. psi



--------------------------------------------------------------------------------
                       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 4 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         =     6.200000 ft
   Effective unit weight at top of layer                =    62.600000 pcf
   Effective unit weight at bottom of layer             =    62.600000 pcf
   Friction angle at top of layer                       =    30.000000 deg.
   Friction angle at bottom of layer                    =    30.000000 deg.
   Subgrade k at top of layer                           =    60.000000 pci
   Subgrade k at bottom of layer                        =    60.000000 pci


Layer 2 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer            =     6.200000 ft
   Distance from top of pile to bottom of layer         =    17.200000 ft
   Effective unit weight at top of layer                =    59.600000 pcf
   Effective unit weight at bottom of layer             =    59.600000 pcf
   Friction angle at top of layer                       =    30.000000 deg.
   Friction angle at bottom of layer                    =    30.000000 deg.
   Subgrade k at top of layer                           =    20.000000 pci
   Subgrade k at bottom of layer                        =    20.000000 pci


Layer 3 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer            =    17.200000 ft
   Distance from top of pile to bottom of layer         =    18.400000 ft
   Effective unit weight at top of layer                =    67.600000 pcf
   Effective unit weight at bottom of layer             =    67.600000 pcf
   Friction angle at top of layer                       =    38.000000 deg.
   Friction angle at bottom of layer                    =    38.000000 deg.
   Subgrade k at top of layer                           =   125.000000 pci
   Subgrade k at bottom of layer                        =   125.000000 pci


Layer 4 is strong rock (vuggy limestone)

   Distance from top of pile to top of layer            =    18.400000 ft
   Distance from top of pile to bottom of layer         =    18.600000 ft
   Effective unit weight at top of layer                =   107.600000 pcf
   Effective unit weight at bottom of layer             =   107.600000 pcf
   Uniaxial compressive strength at top of layer        =        5000. psi
   Uniaxial compressive strength at bottom of layer     =        5000. psi


 (Depth of the lowest soil layer extends 0.000 ft below the pile tip)
```

--------------------------------------------------------------------------------

## Summary of Input Soil Properties

--------------------------------------------------------------------------------

| Layer Num. | Soil Type Name (p-y Curve Type) | Layer Depth ft | Effective Unit Wt. pcf | Angle of Friction deg. | Uniaxial qu psi | kpy pci |
|---|---|---|---|---|---|---|
| 1 | Sand | 0.00 | 62.6000 | 30.0000 | -- | 60.0000 |
| | (Reese, et al.) | 6.2000 | 62.6000 | 30.0000 | -- | 60.0000 |
| 2 | Sand | 6.2000 | 59.6000 | 30.0000 | -- | 20.0000 |
| | (Reese, et al.) | 17.2000 | 59.6000 | 30.0000 | -- | 20.0000 |
| 3 | Sand | 17.2000 | 67.6000 | 38.0000 | -- | 125.0000 |
| | (Reese, et al.) | 18.4000 | 67.6000 | 38.0000 | -- | 125.0000 |
| 4 | Strong Rock | 18.4000 | 107.6000 | -- | 5000. | -- |
| | (Vuggy Limestone) | 18.6000 | 107.6000 | -- | 5000. | -- |

--------------------------------------------------------------------------------

## Static Loading Type

--------------------------------------------------------------------------------

Static loading criteria were used when computing p-y curves for all analyses.

--------------------------------------------------------------------------------

## 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 | 5 | y = 0.750000 in | S = 0.0000 in/in | 315000. | N.A. |

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force 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

--------------------------------------------------------------------------------

## Layering Correction Equivalent Depths of Soil & Rock Layers

--------------------------------------------------------------------------------

| Layer No. | Top of Layer Below Pile Head ft | Equivalent Top Depth Below Grnd Surf ft | Same Layer Type As Layer Above | Layer is Rock or is Below Rock Layer | F0 Integral for Layer lbs | F1 Integral for Layer lbs |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | N.A. | No | 0.00 | 13471. |
| 2 | 6.2000 | 6.2000 | Yes | No | 13471. | 187138. |
| 3 | 17.2000 | 17.2000 | Yes | No | 200610. | 84165. |
| 4 | 18.4000 | 18.4000 | No | Yes | N.A. | N.A. |

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

---

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

---

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head = 0.750000 inches
Rotation of pile head = 0.000E+00 radians
Axial load on pile head = 315000.0 lbs

| Depth X feet | Deflect. y inches | Bending Moment in-lbs | Shear Force lbs | Slope S radians | Total Stress psi* | Bending Stiffness in-lb^2 | Soil Res. p lb/inch | Soil Spr. Es*h lb/inch | Distrib. Lat. Load lb/inch |
|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 0.7505 | -2112797. | 33164. | 0.00 | 51599. | 1.06E+10 | 0.00 | 0.00 | 0.00 |
| 0.1860 | 0.7500 | -2038647. | 33141. | -4.37E-04 | 50173. | 1.06E+10 | -9.1899 | 27.3492 | 0.00 |
| 0.3720 | 0.7485 | -1964240. | 33109. | -8.58E-04 | 48742. | 1.06E+10 | -19.4291 | 57.9332 | 0.00 |
| 0.5580 | 0.7462 | -1889640. | 33054. | -0.00126 | 47307. | 1.06E+10 | -30.4877 | 91.1968 | 0.00 |
| 0.7440 | 0.7429 | -1814913. | 32973. | -0.00165 | 45869. | 1.06E+10 | -42.0410 | 126.3083 | 0.00 |
| 0.9300 | 0.7388 | -1740126. | 32866. | -0.00203 | 44431. | 1.06E+10 | -53.8651 | 162.7341 | 0.00 |
| 1.1160 | 0.7339 | -1665351. | 32732. | -0.00238 | 42993. | 1.06E+10 | -65.7290 | 199.9109 | 0.00 |
| 1.3020 | 0.7281 | -1590656. | 32572. | -0.00273 | 41556. | 1.06E+10 | -77.5575 | 237.7378 | 0.00 |
| 1.4880 | 0.7217 | -1516113. | 32386. | -0.00305 | 40122. | 1.06E+10 | -89.1022 | 275.5708 | 0.00 |
| 1.6740 | 0.7145 | -1441789. | 32175. | -0.00337 | 38692. | 1.06E+10 | -100.0737 | 312.6099 | 0.00 |
| 1.8600 | 0.7067 | -1367751. | 31940. | -0.00366 | 37268. | 1.06E+10 | -111.0213 | 350.6601 | 0.00 |
| 2.0460 | 0.6982 | -1294064. | 31680. | -0.00394 | 35851. | 1.06E+10 | -121.9487 | 389.8589 | 0.00 |
| 2.2320 | 0.6891 | -1220792. | 31396. | -0.00421 | 34442. | 1.06E+10 | -132.1090 | 427.9174 | 0.00 |
| 2.4180 | 0.6794 | -1147999. | 31091. | -0.00445 | 33042. | 1.06E+10 | -141.6792 | 465.4500 | 0.00 |
| 2.6040 | 0.6692 | -1075741. | 30764. | -0.00469 | 31652. | 1.06E+10 | -150.8471 | 503.1307 | 0.00 |
| 2.7900 | 0.6585 | -1004075. | 30418. | -0.00491 | 30273. | 1.06E+10 | -158.9471 | 538.7750 | 0.00 |
| 2.9760 | 0.6473 | -933053. | 30055. | -0.00511 | 28907. | 1.06E+10 | -166.6311 | 574.5838 | 0.00 |
| 3.1620 | 0.6357 | -862724. | 29673. | -0.00530 | 27554. | 1.06E+10 | -176.0278 | 618.0873 | 0.00 |
| 3.3480 | 0.6236 | -793143. | 29270. | -0.00547 | 26216. | 1.06E+10 | -184.6351 | 660.8171 | 0.00 |
| 3.5340 | 0.6112 | -724365. | 28849. | -0.00563 | 24893. | 1.06E+10 | -192.7678 | 703.9247 | 0.00 |
| 3.7200 | 0.5985 | -656440. | 28405. | -0.00578 | 23587. | 1.06E+10 | -205.1718 | 765.1734 | 0.00 |
| 3.9060 | 0.5854 | -589440. | 27933. | -0.00591 | 22298. | 1.06E+10 | -217.4340 | 828.9830 | 0.00 |
| 4.0920 | 0.5721 | -523437. | 27434. | -0.00603 | 21028. | 1.06E+10 | -229.5019 | 895.3776 | 0.00 |
| 4.2780 | 0.5585 | -458499. | 26909. | -0.00613 | 19779. | 1.06E+10 | -241.3229 | 964.3778 | 0.00 |
| 4.4640 | 0.5447 | -394695. | 26357. | -0.00622 | 18552. | 1.06E+10 | -252.8445 | 1036. | 0.00 |
| 4.6500 | 0.5308 | -332093. | 25781. | -0.00630 | 17348. | 1.06E+10 | -264.0141 | 1110. | 0.00 |
| 4.8360 | 0.5166 | -270757. | 25178. | -0.00636 | 16168. | 1.06E+10 | -275.7387 | 1191. | 0.00 |
| 5.0220 | 0.5024 | -210755. | 24550. | -0.00641 | 15014. | 1.06E+10 | -287.4505 | 1277. | 0.00 |
| 5.2080 | 0.4880 | -152153. | 23896. | -0.00645 | 13887. | 1.06E+10 | -298.7320 | 1366. | 0.00 |
| 5.3940 | 0.4736 | -95018. | 23217. | -0.00647 | 12788. | 1.06E+10 | -309.5323 | 1459. | 0.00 |
| 5.5800 | 0.4591 | -39410. | 22514. | -0.00649 | 11718. | 1.06E+10 | -319.8030 | 1555. | 0.00 |
| 5.7660 | 0.4446 | 14610. | 21790. | -0.00649 | 11241. | 1.06E+10 | -329.4972 | 1654. | 0.00 |
| 5.9520 | 0.4301 | 66987. | 21043. | -0.00648 | 12249. | 1.06E+10 | -339.3537 | 1761. | 0.00 |
| 6.1380 | 0.4157 | 117663. | 20274. | -0.00646 | 13223. | 1.06E+10 | -349.6236 | 1877. | 0.00 |
| 6.3240 | 0.4013 | 166581. | 19484. | -0.00643 | 14164. | 1.06E+10 | -359.1319 | 1998. | 0.00 |
| 6.5100 | 0.3870 | 213684. | 18672. | -0.00639 | 15070. | 1.06E+10 | -368.0329 | 2123. | 0.00 |
| 6.6960 | 0.3728 | 258922. | 17841. | -0.00634 | 15941. | 1.06E+10 | -376.4832 | 2254. | 0.00 |
| 6.8820 | 0.3587 | 302246. | 16992. | -0.00628 | 16774. | 1.06E+10 | -384.4729 | 2393. | 0.00 |
| 7.0680 | 0.3447 | 343611. | 16125. | -0.00622 | 17569. | 1.06E+10 | -391.9949 | 2538. | 0.00 |
| 7.2540 | 0.3309 | 382971. | 15243. | -0.00614 | 18327. | 1.06E+10 | -399.0452 | 2692. | 0.00 |
| 7.4400 | 0.3173 | 420287. | 14345. | -0.00606 | 19044. | 1.06E+10 | -405.6227 | 2853. | 0.00 |
| 7.6260 | 0.3039 | 455520. | 13432. | -0.00596 | 19722. | 1.06E+10 | -411.7289 | 3024. | 0.00 |
| 7.8120 | 0.2907 | 488635. | 12507. | -0.00586 | 20359. | 1.06E+10 | -417.3682 | 3205. | 0.00 |
| 7.9980 | 0.2777 | 519598. | 11570. | -0.00576 | 20955. | 1.06E+10 | -422.5477 | 3396. | 0.00 |
| 8.1840 | 0.2650 | 548379. | 10621. | -0.00565 | 21508. | 1.06E+10 | -427.2773 | 3599. | 0.00 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 8.3700 | 0.2525 | 574951. | 9663. | -0.00553 | 22019. | 1.06E+10 | -431.5692 | 3815. | 0.00 |
| 8.5560 | 0.2403 | 599287. | 8695. | -0.00540 | 22487. | 1.06E+10 | -435.4381 | 4045. | 0.00 |
| 8.7420 | 0.2284 | 621365. | 7720. | -0.00528 | 22912. | 1.06E+10 | -438.8633 | 4289. | 0.00 |
| 8.9280 | 0.2167 | 641166. | 6737. | -0.00514 | 23293. | 1.06E+10 | -441.6459 | 4548. | 0.00 |
| 9.1140 | 0.2054 | 658671. | 5749. | -0.00501 | 23630. | 1.06E+10 | -443.7459 | 4822. | 0.00 |
| 9.3000 | 0.1944 | 673868. | 4769. | -0.00487 | 23922. | 1.06E+10 | -433.8787 | 4982. | 0.00 |
| 9.4860 | 0.1837 | 686804. | 3818. | -0.00472 | 24171. | 1.06E+10 | -418.1897 | 5081. | 0.00 |
| 9.6720 | 0.1733 | 697555. | 2903. | -0.00458 | 24377. | 1.06E+10 | -402.2937 | 5181. | 0.00 |
| 9.8580 | 0.1633 | 706199. | 2023. | -0.00443 | 24544. | 1.06E+10 | -386.2459 | 5281. | 0.00 |
| 10.0440 | 0.1535 | 712814. | 1179. | -0.00428 | 24671. | 1.06E+10 | -370.0998 | 5380. | 0.00 |
| 10.2300 | 0.1441 | 717480. | 370.7492 | -0.00413 | 24761. | 1.06E+10 | -353.9075 | 5480. | 0.00 |
| 10.4160 | 0.1351 | 720276. | -401.1062 | -0.00398 | 24814. | 1.06E+10 | -337.7193 | 5580. | 0.00 |
| 10.6020 | 0.1264 | 721284. | -1137. | -0.00383 | 24834. | 1.06E+10 | -321.5836 | 5679. | 0.00 |
| 10.7880 | 0.1180 | 720583. | -1837. | -0.00368 | 24820. | 1.06E+10 | -305.5470 | 5779. | 0.00 |
| 10.9740 | 0.1100 | 718253. | -2501. | -0.00352 | 24776. | 1.06E+10 | -289.6539 | 5879. | 0.00 |
| 11.1600 | 0.1023 | 714374. | -3130. | -0.00337 | 24701. | 1.06E+10 | -273.9468 | 5978. | 0.00 |
| 11.3460 | 0.09492 | 709024. | -3724. | -0.00322 | 24598. | 1.06E+10 | -258.4657 | 6078. | 0.00 |
| 11.5320 | 0.08789 | 702282. | -4284. | -0.00308 | 24468. | 1.06E+10 | -243.2488 | 6177. | 0.00 |
| 11.7180 | 0.08119 | 694225. | -4810. | -0.00293 | 24313. | 1.06E+10 | -228.3316 | 6277. | 0.00 |
| 11.9040 | 0.07482 | 684927. | -5304. | -0.00278 | 24135. | 1.06E+10 | -213.7476 | 6377. | 0.00 |
| 12.0900 | 0.06876 | 674463. | -5765. | -0.00264 | 23933. | 1.06E+10 | -199.5277 | 6476. | 0.00 |
| 12.2760 | 0.06303 | 662905. | -6195. | -0.00250 | 23711. | 1.06E+10 | -185.7004 | 6576. | 0.00 |
| 12.4620 | 0.05761 | 650324. | -6594. | -0.00236 | 23469. | 1.06E+10 | -172.2921 | 6676. | 0.00 |
| 12.6480 | 0.05249 | 636788. | -6964. | -0.00223 | 23209. | 1.06E+10 | -159.3264 | 6775. | 0.00 |
| 12.8340 | 0.04767 | 622365. | -7306. | -0.00209 | 22931. | 1.06E+10 | -146.8246 | 6875. | 0.00 |
| 13.0200 | 0.04314 | 607118. | -7620. | -0.00196 | 22638. | 1.06E+10 | -134.8056 | 6975. | 0.00 |
| 13.2060 | 0.03890 | 591110. | -7908. | -0.00184 | 22330. | 1.06E+10 | -123.2859 | 7074. | 0.00 |
| 13.3920 | 0.03493 | 574400. | -8171. | -0.00172 | 22009. | 1.06E+10 | -112.2795 | 7174. | 0.00 |
| 13.5780 | 0.03124 | 557046. | -8410. | -0.00160 | 21675. | 1.06E+10 | -101.7980 | 7273. | 0.00 |
| 13.7640 | 0.02781 | 539102. | -8626. | -0.00148 | 21330. | 1.06E+10 | -91.8505 | 7373. | 0.00 |
| 13.9500 | 0.02462 | 520621. | -8821. | -0.00137 | 20974. | 1.06E+10 | -82.4440 | 7473. | 0.00 |
| 14.1360 | 0.02169 | 501652. | -8995. | -0.00126 | 20609. | 1.06E+10 | -73.5829 | 7572. | 0.00 |
| 14.3220 | 0.01899 | 482243. | -9150. | -0.00116 | 20236. | 1.06E+10 | -65.2692 | 7672. | 0.00 |
| 14.5080 | 0.01651 | 462437. | -9287. | -0.00106 | 19855. | 1.06E+10 | -57.5028 | 7772. | 0.00 |
| 14.6940 | 0.01426 | 442276. | -9407. | -9.65E-04 | 19467. | 1.06E+10 | -50.2812 | 7871. | 0.00 |
| 14.8800 | 0.01221 | 421799. | -9512. | -8.74E-04 | 19073. | 1.06E+10 | -43.5998 | 7971. | 0.00 |
| 15.0660 | 0.01036 | 401043. | -9602. | -7.87E-04 | 18674. | 1.06E+10 | -37.4515 | 8071. | 0.00 |
| 15.2520 | 0.00869 | 380041. | -9680. | -7.05E-04 | 18270. | 1.06E+10 | -31.8272 | 8170. | 0.00 |
| 15.4380 | 0.00721 | 358824. | -9745. | -6.27E-04 | 17862. | 1.06E+10 | -26.7155 | 8270. | 0.00 |
| 15.6240 | 0.00589 | 337420. | -9800. | -5.54E-04 | 17450. | 1.06E+10 | -22.1031 | 8369. | 0.00 |
| 15.8100 | 0.00474 | 315857. | -9844. | -4.85E-04 | 17036. | 1.06E+10 | -17.9743 | 8469. | 0.00 |
| 15.9960 | 0.00373 | 294158. | -9880. | -4.21E-04 | 16618. | 1.06E+10 | -14.3115 | 8569. | 0.00 |
| 16.1820 | 0.00286 | 272344. | -9909. | -3.62E-04 | 16199. | 1.06E+10 | -11.0950 | 8668. | 0.00 |
| 16.3680 | 0.00211 | 250434. | -9930. | -3.07E-04 | 15777. | 1.06E+10 | -8.3031 | 8768. | 0.00 |
| 16.5540 | 0.00149 | 228446. | -9946. | -2.56E-04 | 15354. | 1.06E+10 | -5.9120 | 8868. | 0.00 |
| 16.7400 | 9.70E-04 | 206394. | -9957. | -2.11E-04 | 14930. | 1.06E+10 | -3.8959 | 8967. | 0.00 |
| 16.9260 | 5.48E-04 | 184293. | -9964. | -1.69E-04 | 14505. | 1.06E+10 | -2.2272 | 9067. | 0.00 |
| 17.1120 | 2.13E-04 | 162153. | -9967. | -1.33E-04 | 14079. | 1.06E+10 | -0.8763 | 9167. | 0.00 |
| 17.2980 | -4.54E-05 | 139985. | -9967. | -1.01E-04 | 13653. | 1.06E+10 | 1.1782 | 57914. | 0.00 |
| 17.4840 | -2.38E-04 | 117802. | -9959. | -7.41E-05 | 13226. | 1.06E+10 | 6.2537 | 58536. | 0.00 |
| 17.6700 | -3.76E-04 | 95633. | -9941. | -5.17E-05 | 12800. | 1.06E+10 | 9.9709 | 59159. | 0.00 |
| 17.8560 | -4.69E-04 | 73499. | -9916. | -3.39E-05 | 12374. | 1.06E+10 | 12.5624 | 59782. | 0.00 |
| 18.0420 | -5.27E-04 | 51417. | -9886. | -2.07E-05 | 11949. | 1.06E+10 | 14.2717 | 60405. | 0.00 |
| 18.2280 | -5.62E-04 | 29399. | -9853. | -1.22E-05 | 11526. | 1.06E+10 | 15.3535 | 61027. | 0.00 |
| 18.4140 | -5.82E-04 | 7452. | -6588. | -8.35E-06 | 11104. | 1.06E+10 | 2910. | 1.12E+07 | 0.00 |
| 18.6000 | -5.99E-04 | 0.00 | 0.00 | -7.56E-06 | 10960. | 1.06E+10 | 2994. | 5580000. | 0.00 |

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

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     0.75049600 inches
Computed slope at pile head      =       0.000000 radians
Maximum bending moment           =      -2112797. inch-lbs
Maximum shear force              =         33164. lbs
Depth of maximum bending moment  =       0.000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =              6
Number of zero deflection points =              1
```

--------------------------------------------------------------------------------

## Summary of Pile-head Responses for Conventional Analyses

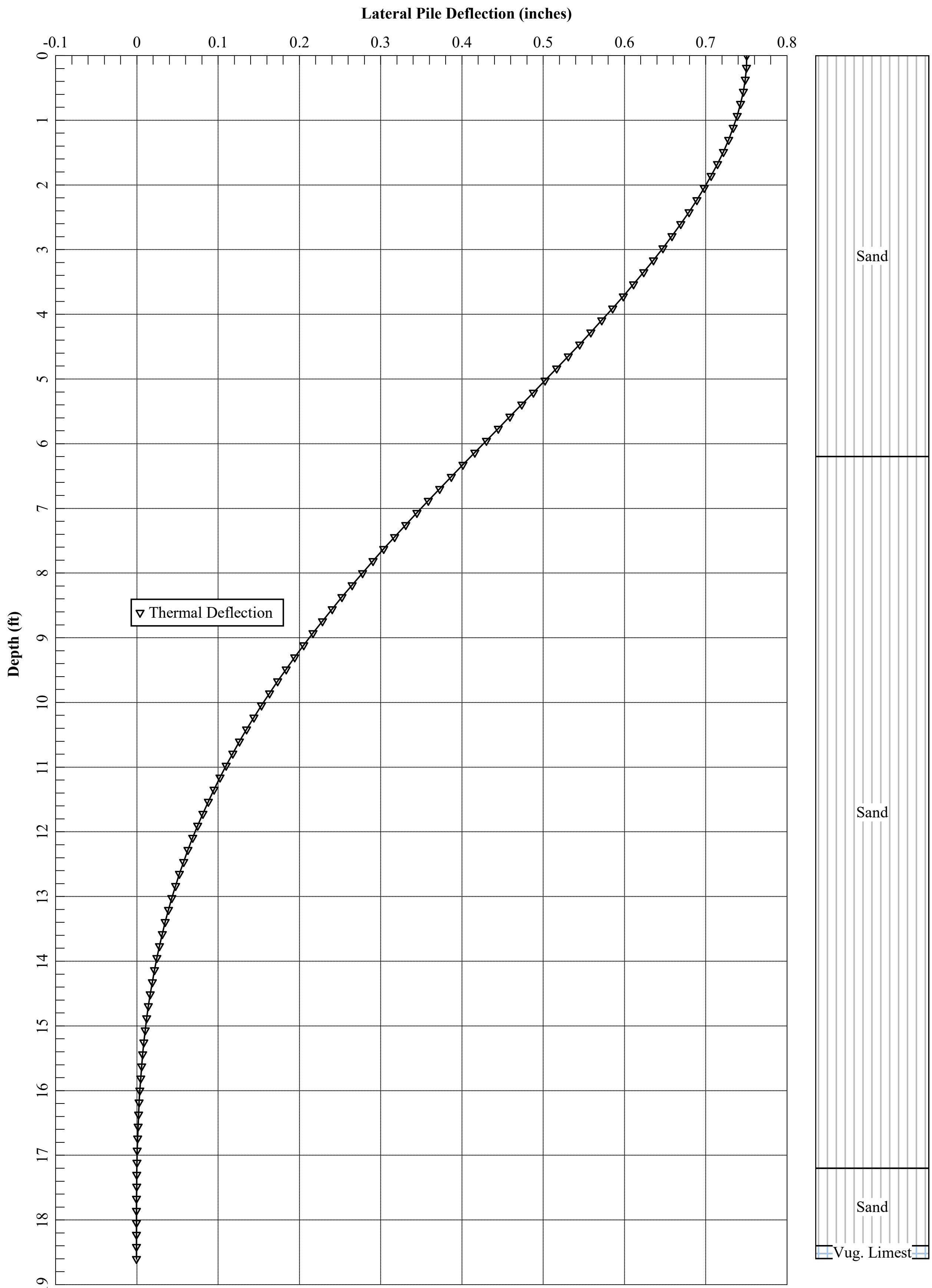
Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

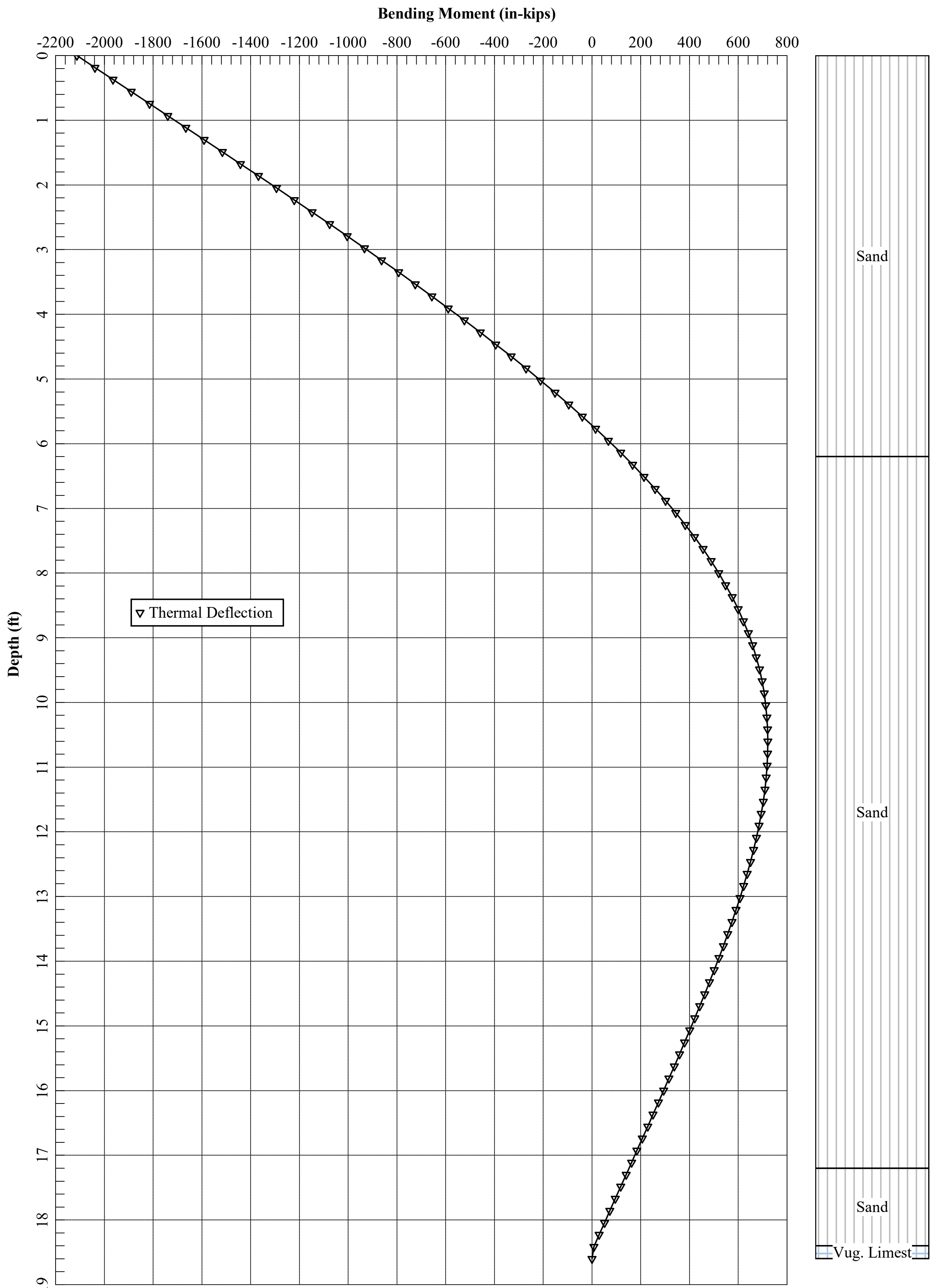
| Load Case No. | Load Type 1 | Pile-head Load 1 | Load Type 2 | Pile-head Load 2 | Axial Loading lbs | Pile-head Deflection inches | Pile-head Rotation radians | Max Shear in Pile lbs | Max Moment in Pile in-lbs |
|---|---|---|---|---|---|---|---|---|---|
| 1 | y, in | 0.7500 | S, rad | 0.00 | 315000. | 0.7505 | 0.00 | 33164. | -2112797. |

Maximum pile-head deflection = 0.7504960008 inches
Maximum pile-head rotation = 0.0000000000 radians = 0.000000 deg.

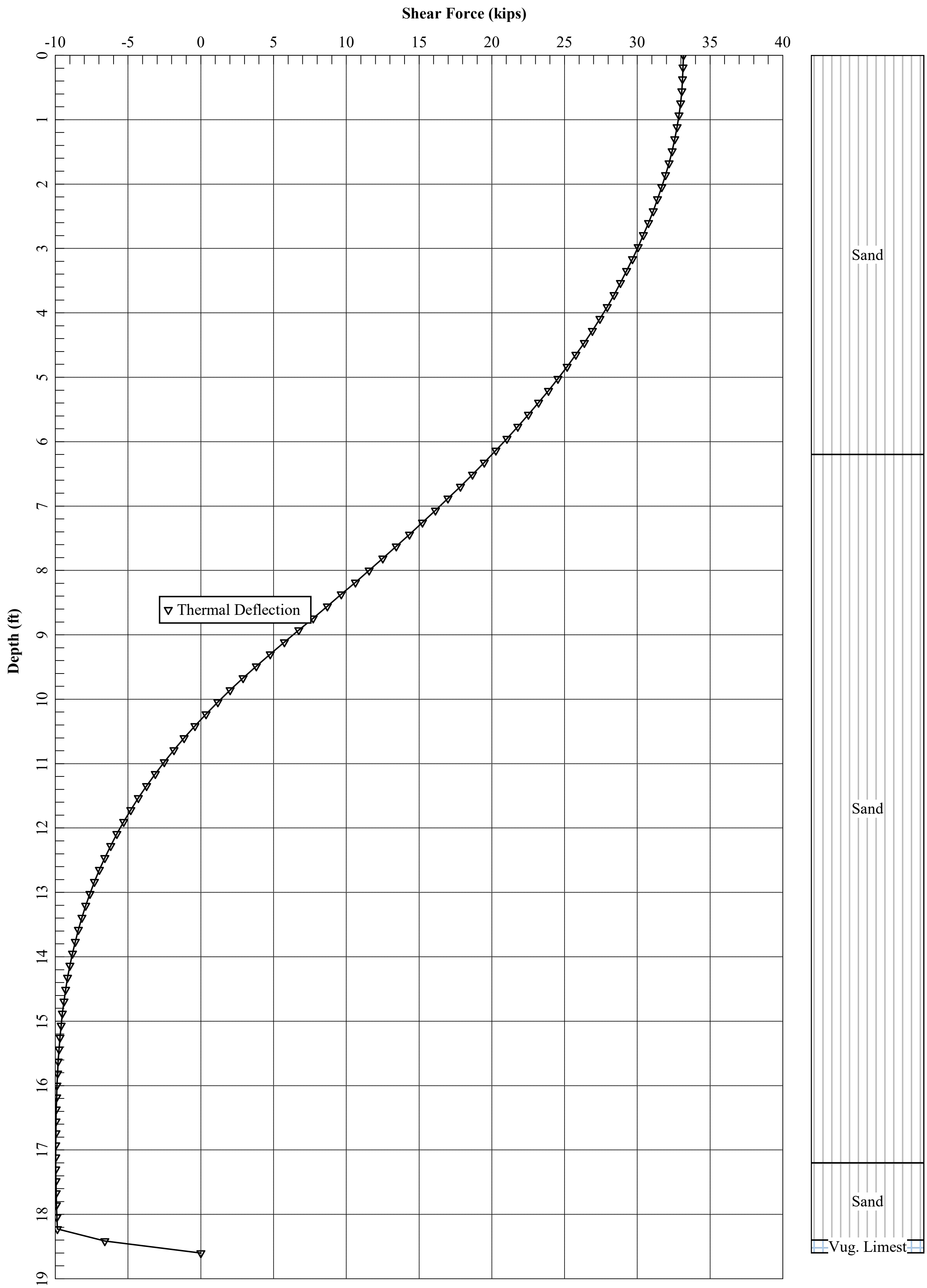
The analysis ended normally.



Lateral Pile Deflection (inches)
-0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
Thermal Deflection
Sand
Sand
Sand
Vug. Limest



Bending Moment (in-kips)
-2200
-2000
-1800
-1600
-1400
-1200
-1000
-800
-600
-400
-200
0
200
400
600
800
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
Thermal Deflection
Sand
Sand
Sand
Vug. Limest



Shear Force (kips)
-10
-5
0
5
10
15
20
25
30
35
40
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
Thermal Deflection
Sand
Sand
Sand
Vug. Limest

Abutment No. 2
Piles with 0.2-ft (2.4-in) embedment in bedrock

===============================================================================

LPile for Windows, Version 2016-09.010

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


===============================================================================

This copy of LPile is being used by:

A
A

Serial Number of Security Device: 226662858

This copy of LPile is licensed for exclusive use by:

S.W. Cole Engineering, Inc., Som



-------------------------------------------------------------------------------

Files Used for Analysis

-------------------------------------------------------------------------------

Path to file locations:
\Users\mst.pierre\Desktop\LPile Output Files\20-1403-021876 Buckfield\Pile with Rock Injector Tip\

Name of input data file:
Abutment 2 HP14x117 - Injector Tip.lp9d

Name of output report file:
Abutment 2 HP14x117 - Injector Tip.lp9o

Name of plot output file:
Abutment 2 HP14x117 - Injector Tip.lp9p

Name of runtime message file:
Abutment 2 HP14x117 - Injector Tip.lp9r

-------------------------------------------------------------------------------

Date and Time of Analysis

-------------------------------------------------------------------------------

Date: October 27, 2021 Time: 13:30:59

-------------------------------------------------------------------------------

Problem Title

-------------------------------------------------------------------------------

Hall Bridge #3287 Replacement

WIN 021876

MaineDOT

MAS

Abutment No. 2 - HP14x117

```
--------------------------------------------------------------------------------
                          Program Options and Settings
--------------------------------------------------------------------------------

Computational Options:
 - Use unfactored loads in computations (conventional analysis)
Engineering Units Used for Data Input and Computations:
 - US Customary System 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:
 - Static loading specified

 - Use of p-y modification factors for p-y curves not selected
 - No distributed lateral loads are entered
 - 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:
 - Output files use decimal points to denote decimal symbols.
 - 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
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats




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

Number of pile sections defined                        =           1
Total length of pile                                   =       14.300 ft
Depth of ground surface below top of pile              =       0.0000 ft

Pile diameters 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. A summary of values of pile diameter vs. depth follows.

            Depth Below          Pile
Point        Pile Head         Diameter
 No.           feet             inches
-----      -------------     -------------
  1            0.000           14.0750
  2           14.300           14.0750


Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is an elastic pile
   Cross-sectional Shape                               =   Weak H-Pile
   Length of section                                   =    14.300000 ft
   Flange Width                                        =    14.775000 in
   Section Depth                                       =    14.075000 in
   Flange Thickness                                    =     0.680000 in
   Web Thickness                                       =     0.680000 in
```

```
   Section Area                                         =    28.740200 sq. in
   Moment of Inertia                                    =   365.877563 in^4
   Elastic Modulus                                      =    29000000. psi



--------------------------------------------------------------------------------
                       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 4 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         =     2.800000 ft
   Effective unit weight at top of layer                =    62.600000 pcf
   Effective unit weight at bottom of layer             =    62.600000 pcf
   Friction angle at top of layer                       =    30.000000 deg.
   Friction angle at bottom of layer                    =    30.000000 deg.
   Subgrade k at top of layer                           =    60.000000 pci
   Subgrade k at bottom of layer                        =    60.000000 pci


Layer 2 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer            =     2.800000 ft
   Distance from top of pile to bottom of layer         =    13.300000 ft
   Effective unit weight at top of layer                =    59.600000 pcf
   Effective unit weight at bottom of layer             =    59.600000 pcf
   Friction angle at top of layer                       =    30.000000 deg.
   Friction angle at bottom of layer                    =    30.000000 deg.
   Subgrade k at top of layer                           =    20.000000 pci
   Subgrade k at bottom of layer                        =    20.000000 pci


Layer 3 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer            =    13.300000 ft
   Distance from top of pile to bottom of layer         =    14.100000 ft
   Effective unit weight at top of layer                =    67.600000 pcf
   Effective unit weight at bottom of layer             =    67.600000 pcf
   Friction angle at top of layer                       =    38.000000 deg.
   Friction angle at bottom of layer                    =    38.000000 deg.
   Subgrade k at top of layer                           =   125.000000 pci
   Subgrade k at bottom of layer                        =   125.000000 pci


Layer 4 is strong rock (vuggy limestone)

   Distance from top of pile to top of layer            =    14.100000 ft
   Distance from top of pile to bottom of layer         =    14.300000 ft
   Effective unit weight at top of layer                =   107.600000 pcf
   Effective unit weight at bottom of layer             =   107.600000 pcf
   Uniaxial compressive strength at top of layer        =        5000. psi
   Uniaxial compressive strength at bottom of layer     =        5000. psi


 (Depth of the lowest soil layer extends 0.000 ft below the pile tip)
```

---

## Summary of Input Soil Properties

---

| Layer Layer Num. | Soil Type Name (p-y Curve Type) | Layer Depth ft | Effective Unit Wt. pcf | Angle of Friction deg. | Uniaxial qu psi | kpy pci |
|---|---|---|---|---|---|---|
| 1 | Sand | 0.00 | 62.6000 | 30.0000 | -- | 60.0000 |
| | (Reese, et al.) | 2.8000 | 62.6000 | 30.0000 | -- | 60.0000 |
| 2 | Sand | 2.8000 | 59.6000 | 30.0000 | -- | 20.0000 |
| | (Reese, et al.) | 13.3000 | 59.6000 | 30.0000 | -- | 20.0000 |
| 3 | Sand | 13.3000 | 67.6000 | 38.0000 | -- | 125.0000 |
| | (Reese, et al.) | 14.1000 | 67.6000 | 38.0000 | -- | 125.0000 |
| 4 | Strong Rock | 14.1000 | 107.6000 | -- | 5000. | -- |
| | (Vuggy Limestone) | 14.3000 | 107.6000 | -- | 5000. | -- |

---

## Static Loading Type

---

Static loading criteria were used when computing p-y curves for all analyses.

---

## 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 | 5 | y = 0.750000 in | S = 0.0000 in/in | 315000. | N.A. |

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force 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

---

## Layering Correction Equivalent Depths of Soil & Rock Layers

---

| Layer No. | Top of Layer Below Pile Head ft | Equivalent Top Depth Below Grnd Surf ft | Same Layer Type As Layer Above | Layer is Rock or is Below Rock Layer | F0 Integral for Layer lbs | F1 Integral for Layer lbs |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | N.A. | No | 0.00 | 2714. |
| 2 | 2.8000 | 2.8000 | Yes | No | 2714. | 94002. |
| 3 | 13.3000 | 13.3000 | Yes | No | 96716. | 33604. |
| 4 | 14.1000 | 14.1000 | No | Yes | N.A. | N.A. |

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

---

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

---

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head = 0.750000 inches
Rotation of pile head = 0.000E+00 radians
Axial load on pile head = 315000.0 lbs

| Depth X feet | Deflect. y inches | Bending Moment in-lbs | Shear Force lbs | Slope S radians | Total Stress psi* | Bending Stiffness in-lb^2 | Soil Res. p lb/inch | Soil Spr. Es*h lb/inch | Distrib. Lat. Load lb/inch |
|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 0.7503 | -1954244. | 30226. | 0.00 | 48549. | 1.06E+10 | 0.00 | 0.00 | 0.00 |
| 0.1430 | 0.7500 | -1902304. | 30213. | -3.12E-04 | 47550. | 1.06E+10 | -6.9638 | 15.9331 | 0.00 |
| 0.2860 | 0.7492 | -1850218. | 30194. | -6.15E-04 | 46548. | 1.06E+10 | -14.5791 | 33.3925 | 0.00 |
| 0.4290 | 0.7479 | -1798013. | 30162. | -9.10E-04 | 45544. | 1.06E+10 | -22.7416 | 52.1796 | 0.00 |
| 0.5720 | 0.7461 | -1745717. | 30116. | -0.00120 | 44538. | 1.06E+10 | -31.3468 | 72.0985 | 0.00 |
| 0.7150 | 0.7438 | -1693362. | 30054. | -0.00147 | 43531. | 1.06E+10 | -40.2168 | 92.7854 | 0.00 |
| 0.8580 | 0.7410 | -1640977. | 29977. | -0.00174 | 42524. | 1.06E+10 | -49.2700 | 114.0967 | 0.00 |
| 1.0010 | 0.7378 | -1588593. | 29885. | -0.00201 | 41516. | 1.06E+10 | -58.4023 | 135.8353 | 0.00 |
| 1.1440 | 0.7341 | -1536243. | 29777. | -0.00226 | 40509. | 1.06E+10 | -67.5033 | 157.7860 | 0.00 |
| 1.2870 | 0.7300 | -1483957. | 29653. | -0.00250 | 39504. | 1.06E+10 | -76.6085 | 180.0719 | 0.00 |
| 1.4300 | 0.7255 | -1431767. | 29514. | -0.00274 | 38500. | 1.06E+10 | -85.5529 | 202.3437 | 0.00 |
| 1.5730 | 0.7206 | -1379704. | 29360. | -0.00297 | 37498. | 1.06E+10 | -94.2010 | 224.3118 | 0.00 |
| 1.7160 | 0.7154 | -1327797. | 29191. | -0.00318 | 36500. | 1.06E+10 | -102.4483 | 245.7510 | 0.00 |
| 1.8590 | 0.7097 | -1276076. | 29008. | -0.00340 | 35505. | 1.06E+10 | -110.9608 | 268.2893 | 0.00 |
| 2.0020 | 0.7037 | -1224571. | 28811. | -0.00360 | 34514. | 1.06E+10 | -119.4261 | 291.2208 | 0.00 |
| 2.1450 | 0.6974 | -1173310. | 28599. | -0.00379 | 33528. | 1.06E+10 | -127.4637 | 313.6478 | 0.00 |
| 2.2880 | 0.6907 | -1122321. | 28373. | -0.00398 | 32548. | 1.06E+10 | -134.9901 | 335.3749 | 0.00 |
| 2.4310 | 0.6837 | -1071632. | 28136. | -0.00415 | 31573. | 1.06E+10 | -142.3512 | 357.2739 | 0.00 |
| 2.5740 | 0.6764 | -1021269. | 27885. | -0.00432 | 30604. | 1.06E+10 | -149.4363 | 379.0912 | 0.00 |
| 2.7170 | 0.6689 | -971256. | 27623. | -0.00448 | 29642. | 1.06E+10 | -155.9058 | 399.9739 | 0.00 |
| 2.8600 | 0.6610 | -921618. | 27351. | -0.00464 | 28687. | 1.06E+10 | -161.5226 | 419.2924 | 0.00 |
| 3.0030 | 0.6530 | -872374. | 27069. | -0.00478 | 27740. | 1.06E+10 | -167.4954 | 440.1818 | 0.00 |
| 3.1460 | 0.6446 | -823548. | 26775. | -0.00492 | 26801. | 1.06E+10 | -174.3252 | 464.0495 | 0.00 |
| 3.2890 | 0.6361 | -775163. | 26471. | -0.00505 | 25870. | 1.06E+10 | -180.7002 | 487.4909 | 0.00 |
| 3.4320 | 0.6273 | -727242. | 26156. | -0.00517 | 24948. | 1.06E+10 | -186.5723 | 510.3710 | 0.00 |
| 3.5750 | 0.6183 | -679807. | 25829. | -0.00528 | 24036. | 1.06E+10 | -193.4802 | 536.9492 | 0.00 |
| 3.7180 | 0.6092 | -632882. | 25490. | -0.00539 | 23133. | 1.06E+10 | -202.6128 | 570.7518 | 0.00 |
| 3.8610 | 0.5998 | -586499. | 25134. | -0.00549 | 22241. | 1.06E+10 | -211.6584 | 605.5153 | 0.00 |
| 4.0040 | 0.5903 | -540687. | 24763. | -0.00558 | 21360. | 1.06E+10 | -220.5944 | 641.2364 | 0.00 |
| 4.1470 | 0.5807 | -495478. | 24377. | -0.00566 | 20491. | 1.06E+10 | -229.3979 | 677.9101 | 0.00 |
| 4.2900 | 0.5709 | -450901. | 23976. | -0.00574 | 19633. | 1.06E+10 | -238.0463 | 715.5295 | 0.00 |
| 4.4330 | 0.5610 | -406986. | 23560. | -0.00581 | 18788. | 1.06E+10 | -246.5168 | 754.0858 | 0.00 |
| 4.5760 | 0.5509 | -363761. | 23130. | -0.00587 | 17957. | 1.06E+10 | -254.7868 | 793.5673 | 0.00 |
| 4.7190 | 0.5408 | -321254. | 22685. | -0.00593 | 17139. | 1.06E+10 | -263.7901 | 836.9955 | 0.00 |
| 4.8620 | 0.5306 | -279496. | 22221. | -0.00598 | 16336. | 1.06E+10 | -276.9097 | 895.5413 | 0.00 |
| 5.0050 | 0.5203 | -238529. | 21737. | -0.00602 | 15548. | 1.06E+10 | -287.2065 | 947.2193 | 0.00 |
| 5.1480 | 0.5099 | -198387. | 21237. | -0.00605 | 14776. | 1.06E+10 | -296.2019 | 996.7338 | 0.00 |
| 5.2910 | 0.4995 | -159100. | 20721. | -0.00608 | 14020. | 1.06E+10 | -304.9648 | 1048. | 0.00 |
| 5.4340 | 0.4891 | -120697. | 20190. | -0.00611 | 13282. | 1.06E+10 | -313.4741 | 1100. | 0.00 |
| 5.5770 | 0.4786 | -83206. | 19645. | -0.00612 | 12561. | 1.06E+10 | -321.7090 | 1154. | 0.00 |
| 5.7200 | 0.4681 | -46656. | 19087. | -0.00613 | 11858. | 1.06E+10 | -329.6492 | 1209. | 0.00 |
| 5.8630 | 0.4575 | -11072. | 18514. | -0.00614 | 11173. | 1.06E+10 | -337.2752 | 1265. | 0.00 |
| 6.0060 | 0.4470 | 23520. | 17928. | -0.00614 | 11413. | 1.06E+10 | -345.7916 | 1327. | 0.00 |
| 6.1490 | 0.4365 | 57091. | 17328. | -0.00613 | 12058. | 1.06E+10 | -354.1149 | 1392. | 0.00 |
| 6.2920 | 0.4260 | 89615. | 16713. | -0.00612 | 12684. | 1.06E+10 | -362.2225 | 1459. | 0.00 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 6.4350 | 0.4155 | 121064. | 16085. | -0.00610 | 13289. | 1.06E+10 | -370.1056 | 1529. | 0.00 |
| 6.5780 | 0.4050 | 151413. | 15443. | -0.00608 | 13873. | 1.06E+10 | -377.7563 | 1600. | 0.00 |
| 6.7210 | 0.3946 | 180636. | 14789. | -0.00605 | 14435. | 1.06E+10 | -385.1674 | 1675. | 0.00 |
| 6.8640 | 0.3843 | 208709. | 14121. | -0.00602 | 14975. | 1.06E+10 | -392.3323 | 1752. | 0.00 |
| 7.0070 | 0.3740 | 235609. | 13442. | -0.00598 | 15492. | 1.06E+10 | -399.2456 | 1832. | 0.00 |
| 7.1500 | 0.3637 | 261312. | 12751. | -0.00594 | 15986. | 1.06E+10 | -405.9022 | 1915. | 0.00 |
| 7.2930 | 0.3536 | 285798. | 12049. | -0.00590 | 16457. | 1.06E+10 | -412.2980 | 2001. | 0.00 |
| 7.4360 | 0.3435 | 309044. | 11337. | -0.00585 | 16905. | 1.06E+10 | -418.4297 | 2090. | 0.00 |
| 7.5790 | 0.3335 | 331031. | 10614. | -0.00580 | 17328. | 1.06E+10 | -424.2946 | 2183. | 0.00 |
| 7.7220 | 0.3236 | 351740. | 9881. | -0.00574 | 17726. | 1.06E+10 | -429.8908 | 2280. | 0.00 |
| 7.8650 | 0.3138 | 371152. | 9138. | -0.00569 | 18099. | 1.06E+10 | -435.2169 | 2380. | 0.00 |
| 8.0080 | 0.3041 | 389250. | 8387. | -0.00562 | 18447. | 1.06E+10 | -440.2723 | 2485. | 0.00 |
| 8.1510 | 0.2945 | 406018. | 7628. | -0.00556 | 18770. | 1.06E+10 | -445.0569 | 2594. | 0.00 |
| 8.2940 | 0.2850 | 421440. | 6860. | -0.00549 | 19066. | 1.06E+10 | -449.5713 | 2707. | 0.00 |
| 8.4370 | 0.2756 | 435501. | 6085. | -0.00542 | 19337. | 1.06E+10 | -453.8165 | 2826. | 0.00 |
| 8.5800 | 0.2664 | 448187. | 5303. | -0.00535 | 19581. | 1.06E+10 | -457.7941 | 2949. | 0.00 |
| 8.7230 | 0.2572 | 459487. | 4514. | -0.00528 | 19798. | 1.06E+10 | -461.5062 | 3079. | 0.00 |
| 8.8660 | 0.2482 | 469387. | 3719. | -0.00520 | 19989. | 1.06E+10 | -464.9551 | 3214. | 0.00 |
| 9.0090 | 0.2394 | 477877. | 2919. | -0.00513 | 20152. | 1.06E+10 | -468.1435 | 3356. | 0.00 |
| 9.1520 | 0.2306 | 484947. | 2113. | -0.00505 | 20288. | 1.06E+10 | -471.0583 | 3505. | 0.00 |
| 9.2950 | 0.2220 | 490587. | 1302. | -0.00497 | 20396. | 1.06E+10 | -473.5802 | 3660. | 0.00 |
| 9.4380 | 0.2136 | 494790. | 487.7317 | -0.00489 | 20477. | 1.06E+10 | -475.6752 | 3822. | 0.00 |
| 9.5810 | 0.2053 | 497549. | -325.3419 | -0.00481 | 20530. | 1.06E+10 | -471.9630 | 3946. | 0.00 |
| 9.7240 | 0.1971 | 498874. | -1125. | -0.00473 | 20556. | 1.06E+10 | -459.9016 | 4005. | 0.00 |
| 9.8670 | 0.1890 | 498802. | -1904. | -0.00465 | 20555. | 1.06E+10 | -447.6062 | 4064. | 0.00 |
| 10.0100 | 0.1811 | 497368. | -2661. | -0.00457 | 20527. | 1.06E+10 | -435.0908 | 4123. | 0.00 |
| 10.1530 | 0.1733 | 494610. | -3397. | -0.00449 | 20474. | 1.06E+10 | -422.3689 | 4181. | 0.00 |
| 10.2960 | 0.1657 | 490564. | -4110. | -0.00441 | 20396. | 1.06E+10 | -409.4527 | 4240. | 0.00 |
| 10.4390 | 0.1582 | 485270. | -4802. | -0.00433 | 20294. | 1.06E+10 | -396.3536 | 4299. | 0.00 |
| 10.5820 | 0.1508 | 478766. | -5470. | -0.00425 | 20169. | 1.06E+10 | -383.0818 | 4358. | 0.00 |
| 10.7250 | 0.1436 | 471093. | -6116. | -0.00418 | 20022. | 1.06E+10 | -369.6466 | 4417. | 0.00 |
| 10.8680 | 0.1365 | 462290. | -6739. | -0.00410 | 19852. | 1.06E+10 | -356.0561 | 4476. | 0.00 |
| 11.0110 | 0.1295 | 452397. | -7338. | -0.00403 | 19662. | 1.06E+10 | -342.3173 | 4535. | 0.00 |
| 11.1540 | 0.1227 | 441458. | -7914. | -0.00395 | 19452. | 1.06E+10 | -328.4360 | 4594. | 0.00 |
| 11.2970 | 0.1160 | 429512. | -8465. | -0.00388 | 19222. | 1.06E+10 | -314.4170 | 4653. | 0.00 |
| 11.4400 | 0.1094 | 416604. | -8993. | -0.00382 | 18973. | 1.06E+10 | -300.2638 | 4711. | 0.00 |
| 11.5830 | 0.1029 | 402774. | -9496. | -0.00375 | 18707. | 1.06E+10 | -285.9786 | 4770. | 0.00 |
| 11.7260 | 0.09650 | 388067. | -9974. | -0.00368 | 18425. | 1.06E+10 | -271.5626 | 4829. | 0.00 |
| 11.8690 | 0.09023 | 372527. | -10427. | -0.00362 | 18126. | 1.06E+10 | -257.0157 | 4888. | 0.00 |
| 12.0120 | 0.08406 | 356198. | -10856. | -0.00356 | 17812. | 1.06E+10 | -242.3365 | 4947. | 0.00 |
| 12.1550 | 0.07799 | 339123. | -11259. | -0.00351 | 17483. | 1.06E+10 | -227.5224 | 5006. | 0.00 |
| 12.2980 | 0.07202 | 321349. | -11637. | -0.00345 | 17141. | 1.06E+10 | -212.5697 | 5065. | 0.00 |
| 12.4410 | 0.06614 | 302921. | -11988. | -0.00340 | 16787. | 1.06E+10 | -197.4732 | 5124. | 0.00 |
| 12.5840 | 0.06034 | 283885. | -12314. | -0.00336 | 16421. | 1.06E+10 | -182.2268 | 5183. | 0.00 |
| 12.7270 | 0.05462 | 264288. | -12614. | -0.00331 | 16044. | 1.06E+10 | -166.8230 | 5241. | 0.00 |
| 12.8700 | 0.04897 | 244176. | -12887. | -0.00327 | 15657. | 1.06E+10 | -151.2530 | 5300. | 0.00 |
| 13.0130 | 0.04339 | 223597. | -13133. | -0.00323 | 15261. | 1.06E+10 | -135.5070 | 5359. | 0.00 |
| 13.1560 | 0.03787 | 202600. | -13352. | -0.00320 | 14857. | 1.06E+10 | -119.5739 | 5418. | 0.00 |
| 13.2990 | 0.03241 | 181233. | -13543. | -0.00317 | 14446. | 1.06E+10 | -103.4415 | 5477. | 0.00 |
| 13.4420 | 0.02700 | 159546. | -14073. | -0.00314 | 14029. | 1.06E+10 | -514.2205 | 32684. | 0.00 |
| 13.5850 | 0.02163 | 136330. | -14892. | -0.00312 | 13583. | 1.06E+10 | -440.7780 | 34968. | 0.00 |
| 13.7280 | 0.01630 | 111805. | -15558. | -0.00310 | 13111. | 1.06E+10 | -335.6793 | 35336. | 0.00 |
| 13.8710 | 0.01100 | 86281. | -16043. | -0.00308 | 12620. | 1.06E+10 | -228.9400 | 35704. | 0.00 |
| 14.0140 | 0.00573 | 60076. | -16343. | -0.00307 | 12116. | 1.06E+10 | -120.4312 | 36072. | 0.00 |
| 14.1570 | 4.72E-04 | 33511. | -18469. | -0.00306 | 11605. | 1.06E+10 | -2358. | 8580000. | 0.00 |
| 14.3000 | -0.00478 | 0.00 | 0.00 | -0.00306 | 10960. | 1.06E+10 | 23883. | 4290000. | 0.00 |

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

Output Summary for Load Case No. 1:

```
Pile-head deflection            =     0.75027117 inches
Computed slope at pile head     =       0.000000 radians
Maximum bending moment          =      -1954244. inch-lbs
Maximum shear force             =         30226. lbs
Depth of maximum bending moment =       0.000000 feet below pile head
Depth of maximum shear force    =       0.000000 feet below pile head
Number of iterations            =              6
Number of zero deflection points =             1
```

--------------------------------------------------------------------------------

Summary of Pile-head Responses for Conventional Analyses

---

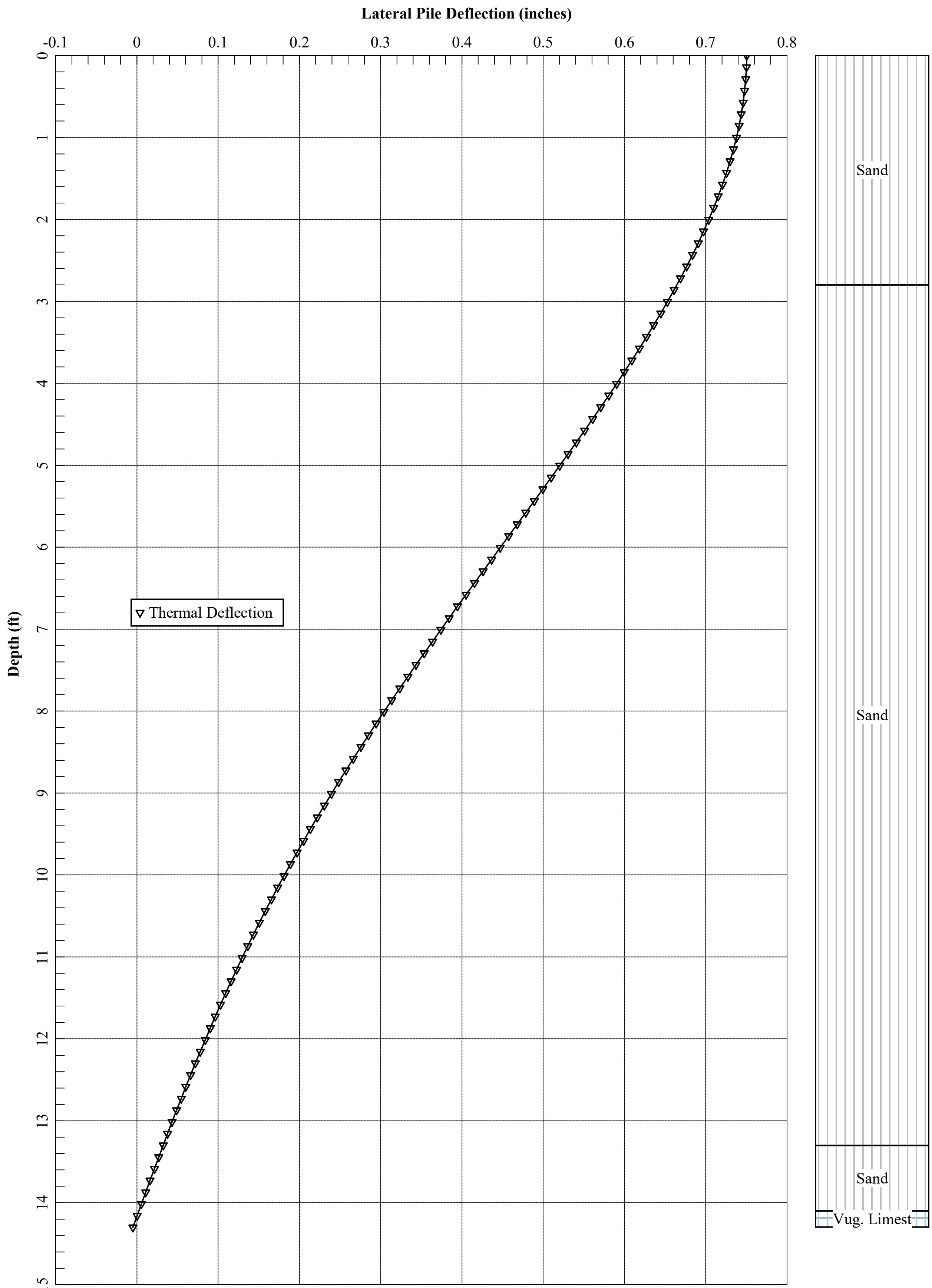
Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

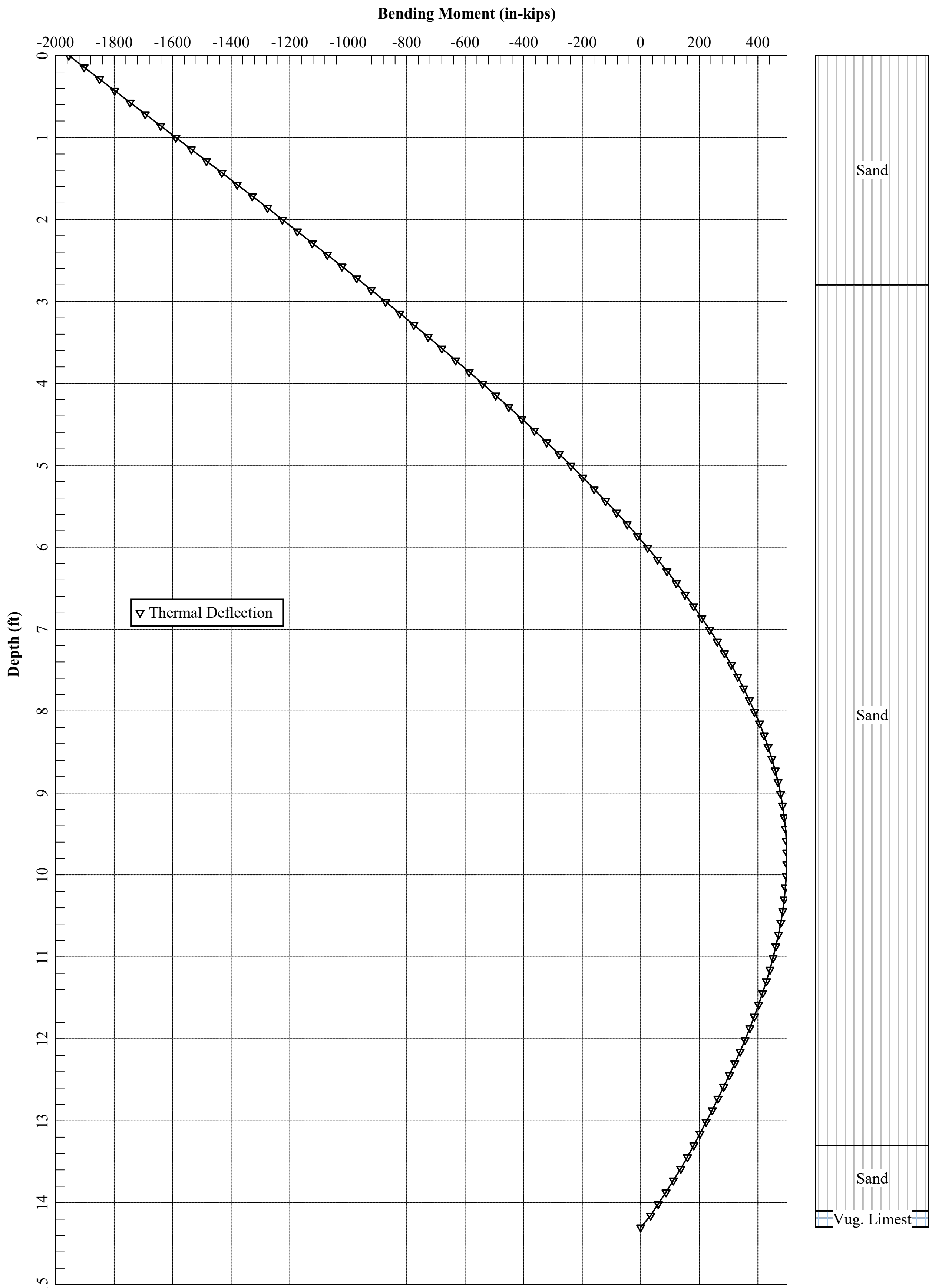
| Load Case No. | Load Type 1 | Pile-head Load 1 | Load Type 2 | Pile-head Load 2 | Axial Loading lbs | Pile-head Deflection inches | Pile-head Rotation radians | Max Shear in Pile lbs | Max Moment in Pile in-lbs |
|---|---|---|---|---|---|---|---|---|---|
| 1 | y, in | 0.7500 | S, rad | 0.00 | 315000. | 0.7503 | 0.00 | 30226. | -1954244. |

Maximum pile-head deflection = 0.7502711750 inches
Maximum pile-head rotation = 0.0000000000 radians = 0.000000 deg.

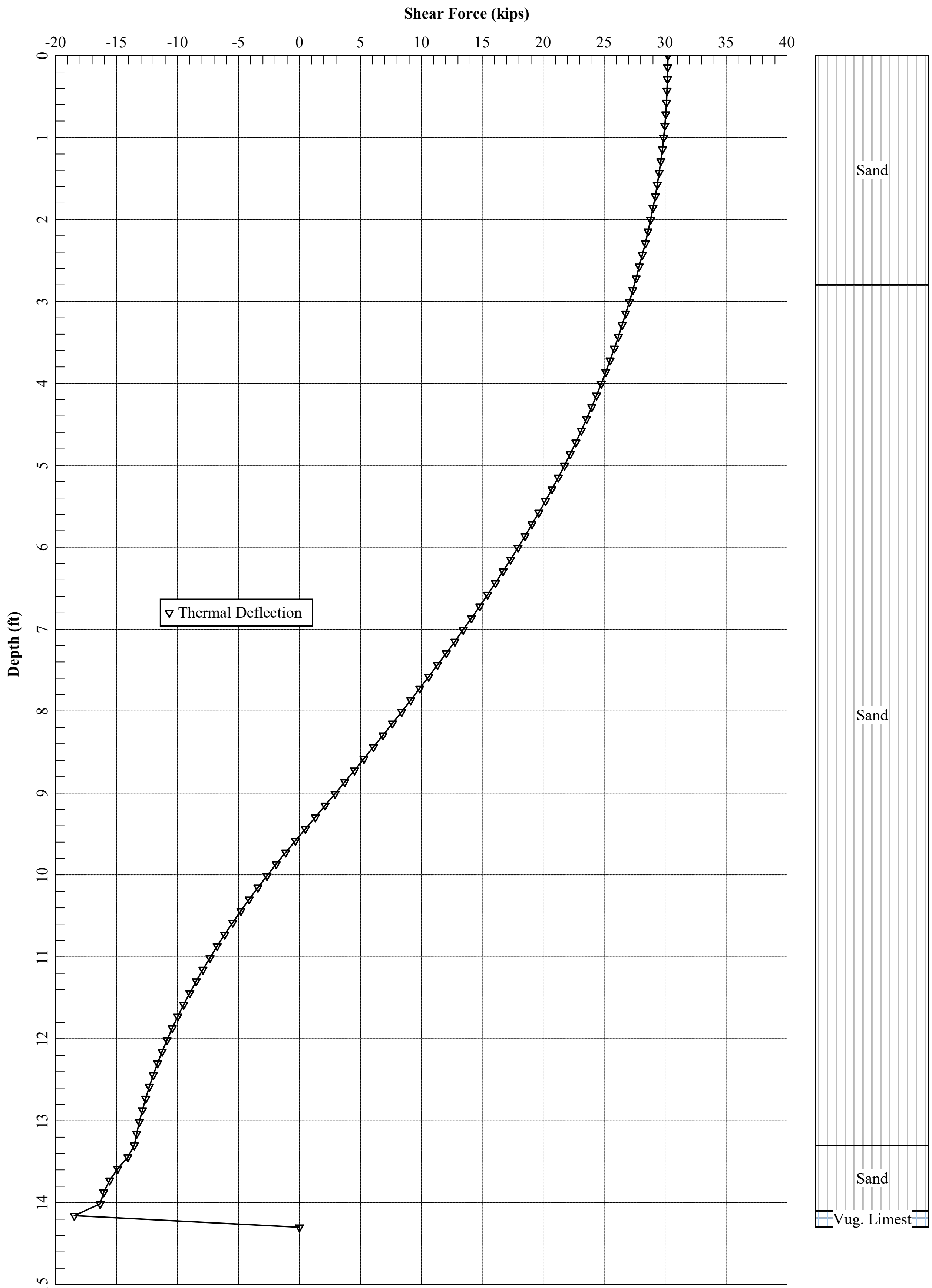
The analysis ended normally.



Lateral Pile Deflection (inches)
-0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Thermal Deflection
Sand
Sand
Sand
Vug. Limest



Bending Moment (in-kips)
-2000
-1800
-1600
-1400
-1200
-1000
-800
-600
-400
-200
0
200
400
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Thermal Deflection
Sand
Sand
Sand
Vug. Limest


Shear Force (kips)
-20
-15
-10
-5
0
5
10
15
20
25
30
35
40
Depth (ft)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Thermal Deflection
Sand
Sand
Sand
Vug. Limest

Hall Bridge #3287
Route 117 over Nezinscot River
Buckfield, Maine
WIN 021876.00

**Determine Seismic Site Classification per AASHTO LRFD Table C3.10.3.1-1 - Method B**

Data From BB-BNR-101

| Layer No. | Layer Description | Depth Range (ft) | | $N_{60}$ values recorded within layer | | | | | | | | Average $N_{60}$ value | Layer Thickness | $d_i/N_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Top | End | | | | | | | | | Ni | di | |
| 1 | Fill | 0 | 19 | 4 | 27 | 13 | | | | | | 14.7 | 19 | 1.30 |
| 2 | Marine Deposit | 19 | 31.2 | 10 | 9 | | | | | | | 9.5 | 12.2 | 1.28 |
| 4 | Bedrock | 31.2 | 100 | 100 | | | | | | | | 100.0 | 68.8 | 0.69 |
| | | | | | | | | | | | | **Σ =** | **100** | **3.27** |

**N_bar = di/di/Ni = 30.60**
**Site Class D**

Data From BB-BNR-102

| Layer No. | Layer Description | Depth Range (ft) | | $N_{60}$ values recorded within layer | | | | | | | | Average $N_{60}$ value | Layer Thickness | $d_i/N_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Top | End | | | | | | | | | Ni | di | |
| 1 | Fill | 0 | 15 | 20 | 14 | | | | | | | 17.0 | 15 | 0.88 |
| 2 | Marine Deposit | 15 | 30.8 | 6 | 37 | 3 | | | | | | 15.3 | 15.8 | 1.03 |
| 3 | Bedrock | 30.8 | 100 | 100 | | | | | | | | 100.0 | 69.2 | 0.69 |
| | | | | | | | | | | | | **Σ =** | **100** | **2.60** |

**N_bar = di/di/Ni = 38.39**
**Site Class D**

Data From BB-BNR-201

| Layer No. | Layer Description | Depth Range (ft) | | $N_{60}$ values recorded within layer | | | | | | | | Average $N_{60}$ value | Layer Thickness | $d_i/N_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Top | End | | | | | | | | | Ni | di | |
| 1 | Fill | 0 | 10.5 | 39 | 37 | | | | | | | 38.0 | 10.5 | 0.28 |
| 2 | Marine Deposit | 10.5 | 24.5 | 9 | 65 | | | | | | | 37.0 | 14 | 0.38 |
| 3 | Bedrock | 24.5 | 100 | 100 | | | | | | | | 100.0 | 75.5 | 0.76 |
| | | | | | | | | | | | | **Σ =** | **100** | **1.41** |

**N_bar = di/di/Ni = 70.94**
**Site Class C**

Data From BB-BNR-202

| Layer No. | Layer Description | Depth Range (ft) | | $N_{60}$ values recorded within layer | | | | | | | | Average $N_{60}$ value | Layer Thickness | $d_i/N_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Top | End | | | | | | | | | Ni | di | |
| 1 | Fill | 0 | 3.5 | 10 | | | | | | | | 10.0 | 3.5 | 0.35 |
| 2 | Marine Deposit | 3.5 | 14.8 | 11 | 14 | | | | | | | 12.5 | 11.3 | 0.90 |
| 4 | Bedrock | 14.8 | 100 | 100 | | | | | | | | 100.0 | 85.2 | 0.85 |
| | | | | | | | | | | | | **Σ =** | **100** | **2.11** |

**N_bar = di/di/Ni = 47.48**
**Site Class D**

**NOTES:**
1. Weight of rod (WOR) and weight of hammer (WOH) values taken as N=1
2. N60 values > 100 taken as N=100
3. N60 value for bedrock taken as N=100
4. N60 value for fill at BB-BNR-202 assumed as N=10 bpf.

Calculated by/Date: MAS - February 2021
Checked by: REC

Hall Bridge #3287

Conterminous 48 States
2007 AASHTO Bridge Design Guidelines
AASHTO Spectrum for 7% PE in 75 years
Latitude = 44.285535
Longitude = -070.352425
Site Class B
Data are based on a 0.05 deg grid spacing.

| Period (sec) | Sa (g) | |
|---|---|---|
| 0.0 | 0.090 | PGA - Site Class B |
| 0.2 | 0.180 | Ss - Site Class B |
| 1.0 | 0.048 | S1 - Site Class B |

Conterminous 48 States
2007 AASHTO Bridge Design Guidelines
Spectral Response Accelerations SDs and SD1
Latitude = 44.285535
Longitude = -070.352425
As = FpgaPGA, SDs = FaSs, and SD1 = FvS1
Site Class D - Fpga = 1.60, Fa = 1.60, Fv = 2.40
Data are based on a 0.05 deg grid spacing.

| Period (sec) | Sa (g) | |
|---|---|---|
| 0.0 | 0.144 | As - Site Class D |
| 0.2 | 0.288 | SDs - Site Class D |
| 1.0 | 0.115 | SD1 - Site Class D |

Conterminous 48 States
2007 AASHTO Bridge Design Guidelines
Design Response Spectra for Site Class D
Latitude = 44.285535
Longitude = -070.352425
As = FpgaPGA, SDs = FaSs, SD1 = FvS1
Site Class D - Fpga = 1.60, Fa = 1.60, Fv = 2.40
Data are based on a 0.05 deg grid spacing.

| Period (sec) | Sa (g) | Sd in. | |
|---|---|---|---|
| 0.000 | 0.144 | 0.000 | T = 0.0, Sa = As |
| 0.080 | 0.288 | 0.018 | |
| 0.200 | 0.288 | 0.113 | T = 0.2, Sa = SDs |
| 0.399 | 0.288 | 0.449 | T = Ts, Sa = SDs |
| 0.400 | 0.288 | 0.450 | |
| 0.600 | 0.192 | 0.675 | |
| 0.800 | 0.144 | 0.900 | |
| 1.000 | 0.115 | 1.125 | T = 1.0, Sa = SD1 |
| 1.200 | 0.096 | 1.350 | |
| 1.400 | 0.082 | 1.575 | |
| 1.600 | 0.072 | 1.800 | |
| 1.800 | 0.064 | 2.024 | |
| 2.000 | 0.058 | 2.249 | |
| 2.200 | 0.052 | 2.474 | |
| 2.400 | 0.048 | 2.699 | |
| 2.600 | 0.044 | 2.924 | |
| 2.800 | 0.041 | 3.149 | |
| 3.000 | 0.038 | 3.374 | |

| | | |
|---|---|---|
| 3.200 | 0.036 | 3.599 |
| 3.400 | 0.034 | 3.824 |
| 3.600 | 0.032 | 4.049 |
| 3.800 | 0.030 | 4.274 |
| 4.000 | 0.029 | 4.499 |