



Geotechnical Engineering Report

Rumford-Mexico Red Bridge #2707

Rumford and Mexico, Maine

May 9, 2023

MaineDOT WIN 21700.01

Terracon Project No. J1215037

Prepared for:

TY Lin International

Falmouth, Maine

Prepared by:

Terracon Consultants, Inc.

Manchester, New Hampshire



May 9, 2023

TY Lin International
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Attn: Mr. Rick Hebert, Senior Associate
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Re: Geotechnical Engineering Report
Rumford-Mexico Red Bridge #2707
U.S. Route 2
Rumford and Mexico, Maine
MaineDOT WIN 21700.01
Terracon Project No. J1215037

Dear Mr. Hebert:

We have completed the Geotechnical Engineering services for the above referenced project. This study was performed in general accordance with Terracon Proposal No. PJ1215037 dated August 13, 2021. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

Marc A. Gullison, P.E. (NH)
Project Engineer

Michael A. Ciance, P.E.
Principal / Office Manager



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Note: This report was originally delivered in a web-based format. **Orange Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the **GeoReport** logo will bring you back to this page. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES
PHOTOGRAPHY LOG
SITE LOCATION AND BORING LOCATION PLAN
EXPLORATION RESULTS
SUPPORTING INFORMATION

Note: Refer to each individual Attachment for a listing of contents.

Geotechnical Engineering Report
Rumford-Mexico Red Bridge #2707
U.S. Route 2
Rumford and Mexico, Maine
Terracon Project No. J1215037
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INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed replacement of the Red Bridge (#2707) spanning U.S. Route 2 over the Swift River between Rumford and Mexico, Maine. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil and rock conditions
- Groundwater conditions
- Site preparation and earthwork
- Demolition considerations
- Excavation considerations
- Dewatering considerations
- Foundation design and construction
- Seismic site classification per AASHTO
- Lateral earth pressures
- Frost considerations

The geotechnical field Scope of Services for this project included the advancement of four test borings, designated BB-RSR-201 through BB-RSR-204, to depths ranging from approximately 21.8 to 42.5 feet below existing site grades. Terracon performed a preliminary field investigation in December 2016 that included two borings, designated BB-RSR-101 and BB-RSR-102, to depths ranging from approximately 41.0 to 51.0 feet below existing site grades.

Maps showing the site and boring locations are shown in the **Site Location** and **Boring Location Plan** sections, respectively. The boring logs and laboratory results are shown in the **Exploration Results** section.

SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
Location	The subject bridge is located where U.S. Route 2 crosses the Swift River, which separates the towns of Rumford and Mexico, Maine. The bridge is located at the approximate coordinates 44.5555° N, 70.5464° W. See Site Location .

Item	Description
Existing Improvements	The existing bridge is a two-span bridge with a concrete slab deck (asphalt surfaced) supported on two steel through girders with transverse beams and five longitudinal stringers. The total structure length is approximately 175 feet. The existing concrete abutments are supported on steel piles, while the concrete pier is supported on timber piles. The current bridge, constructed circa 1952, is predated by a steel through-truss bridge supported on split granite blocks and mortar abutments.
Current Ground Cover	Paved roadway.
Existing Topography (from Red Bridge over Swift River Plan Set)	The existing bridge deck is at approximate Elevation (El.) 442.6 feet. The Swift River generally flows from northwest to southeast; the streambed at the bridge crossing is at approximate El. 420 feet. Grades along the riverbanks vary but are generally steep.

We also collected photographs at the time of our field exploration program. Representative photos of the site and collected rock cores are provided in our [Photography Log](#).

PROJECT DESCRIPTION

Our initial understanding of the project was provided in our proposal and was discussed during project planning. Our final understanding of the project conditions is as follows:

Item	Description
Information Provided	TY Lin provided the following information: <ul style="list-style-type: none"> ■ Red Bridge over Swift River Plan Set, prepared by the TY Lin, last dated February 17, 2022 ■ RFP Scope and Deliverables for Phase 2 (Final Design Phase) Geotechnical Engineering Services
Project Description	The project includes the replacement of the existing two span bridge with a new single span bridge. Associated roadway improvements on both ends of the bridge are also planned, as well as a retaining wall and stairway access from the road to the ballpark on the southwest side of the bridge.
Proposed Structure	The proposed single span bridge will be approximately 155 feet long supported on full height abutments with deep foundations. Wingwalls are planned to be cast-in-place concrete butterfly walls cantilevered off the abutment pile caps (or with short pile cap extensions). A temporary bridge is also planned on the south side of the bridge for traffic during construction. We understand the design of the temporary bridge is the responsibility of the contractor and therefore not incorporated into this report.

Item	Description
Maximum Loads (provided by TY Lin)	Based on email correspondence with TY Lin, we understand the maximum factored pile load is 365 kips.
Grading/Slopes	The bridge deck will be constructed with a vertical curve, with approximately 2 feet of vertical relief across its length. Since the northeast abutment will be relocated towards the river, we anticipate up to 15 feet of fill will be required to develop final grade immediately behind the abutment. Final slope angles of as steep as 1.75H:1V (Horizontal:Vertical) are expected along riprap surface embankments.
Free-Standing Retaining Walls	Abutments and wingwalls are anticipated to act as retaining walls. Wall heights of up to approximately 15 feet are expected. The western approach retaining wall is anticipated to be up to 5 feet tall. Wingwalls are planned to be cast-in-place concrete butterfly walls cantilevered off the abutment pile caps (or with short pile cap extensions).

GEOTECHNICAL CHARACTERIZATION

Subsurface Conditions

Two borings (BB-RSR-101 and BB-RSR-102) were advanced through the roadway embankment behind the existing bridge abutments in December 2016. The fill thickness at these boring locations was approximately 11.8 to 13.0 feet thick and generally consisted of poorly graded sand. Four additional borings (BB-RSR-201 through BB-RSR-204) were performed at the base of the roadway embankment in April 2022 and generally encountered approximately 4 feet of existing fill consisting of silty sand.

The native soils beneath the fill were comprised of very loose to very dense silty sand to poorly-graded sand with varying amounts of silt and gravel. A thin mantle of glacial till was observed at boring BB-RSR-201 at approximately 20 feet below ground surface but was not observed at the other borings. The bedrock surface was observed at depths ranging between 21.8 feet and 49.0 feet. Rock core samples were collected from BB-RSR-102, 202, 203, and 204, and generally consisted of hard granite to moderately hard migmatite of an untitled Devonian Granite Formation. The Rock Quality Designation (RQD) generally varied from 61 to 96 percent, indicating a rock quality of fair to excellent for the sampled intervals. Groundwater was observed during drilling operations at depths between approximately 9 and 12 feet below existing ground surface on the west side of the bridge (BB-RSR-201 and BB-RSR-202), and 5 feet below existing ground surface on the east side of the bridge (BB-RSR-203 and BB-RSR-204).

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting, and our understanding of the project. This characterization forms the basis of our geotechnical calculations and evaluation of site preparation and foundation options. Conditions encountered at each exploration point are indicated on the individual logs, as shown in the **Exploration Results** section. As part of our analyses, we identified the following generalized subsurface profile.

Stratum Name	Approximate Depth to Bottom of Stratum (feet) ¹	General Description
Fill	4.0	Silty sand with varying amounts of gravel, grayish brown to olive brown
Alluvium	20.0 to 49.0	Silty sand to poorly graded sand with varying amounts of silt and gravel, olive brown, very loose to dense
Till ²	21.8	Silty sand with gravel, dark gray, medium dense
Bedrock	Not Applicable	Migmatite, dark gray to light gray, moderately hard, fresh and Granite, very light gray, hard, fresh to very slightly weathered

1. Depths in this table are generally taken from the bottom of the existing roadway embankment. Thicker fill should be expected along the embankments, as indicated on the preliminary boring logs from 2016.
2. Glacial till was observed at boring BB-RSR-201 near the proposed retaining wall located west of the bridge, but not at the other borings.

Groundwater Conditions

The borings were observed while drilling for the presence and level of groundwater. The water levels observed in the borings can be found on the boring logs in the **Exploration Results** section and are summarized in the following table.

Boring No. ¹	Planned Structure	Approximate Depth to Groundwater (feet) ²	Approximate Elevation of Groundwater (feet)
BB-RSR-101	Abutment No. 2 (roadway)	15.7	426.3
BB-RSR-102	Abutment No. 1 (roadway)	Not observed	
BB-RSR-201	New Retaining Wall	9.0	423.0
BB-RSR-202	Abutment No. 1 (downstream)	10.0	423.0
BB-RSR-203	Abutment No. 2 (upstream)	5.0	423.0
BB-RSR-204	Abutment No. 2 (downstream)	5.0	424.0

Boring No. ¹	Planned Structure	Approximate Depth to Groundwater (feet) ²	Approximate Elevation of Groundwater (feet)
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1. Groundwater depths for BB-RSR-101 and BB-RSR-102 were measured in December 2016. Groundwater depths for BB-RSR-201 through BB-RSR-204 were measured in April 2022.
2. Below ground surface.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff, and other factors not evident at the time the boring was performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

Corrosivity Testing

The following table lists the results of laboratory soluble sulfate, soluble chloride, electrical resistivity, and pH testing conducted on selected soil samples. The values may be used to estimate potential corrosive characteristics of the on-site soils with respect to contact with the various underground materials which will be used for project construction.

Boring	Sample Depth (feet)	Soil Description	Soluble Sulfate (ppm)	Soluble Chloride (ppm)	Electrical Resistivity (Ω-cm)	pH
BB-RSR-202	20 to 22	Sandy Silt	3	71	3,600	7.11
BB-RSR-204	15 to 17	Sand	2	20	50,000	6.90

Results of water-soluble sulfate testing indicate samples of the on-site soils tested have an exposure class of S0 when classified in accordance with Table 19.3.1.1 of the American Concrete Institute of Concrete (ACI) Design Manual. Concrete should be designed in accordance with the provisions of the ACI Design Manual, Section 318, Chapter 19.

These test results are provided to assist in determining the required type and degree of corrosion protection. Terracon recommends retaining an experienced corrosion engineer to design a suitable corrosion protection system for underground concrete and/or metal structures or components.

Rock Testing

The following table presents a summary of results from compressive strength and elastic modulus tests on selected rock core samples. The laboratory results are shown in the **Exploration Results** section.

Boring No.	Sample Depth (feet)	Unit Weight, γ (pcf)	Uniaxial Compressive Strength, q_u (psi)	Elastic Modulus, E (psi) ¹	Poisson's Ratio (dim) ¹
BB-RSR-102	37.0 to 37.4	162.0	25,522	7,090,000	0.230
BB-RSR-202	25.3 to 26.2	178.4	7,630	790,000	0.185
BB-RSR-203	23.7 to 24.5	182.1	15,789	1,289,000	0.046
BB-RSR-204	33.6 to 34.5	159.7	7,217	858,000	0.034

1. The Elastic Modulus and Poisson's Ratio values were calculated using the tangent to the stress-strain curves as shown on the laboratory results in the **Exploration Results** section. As a result, the Elastic Modulus and Poisson's Ratio values for these samples are uncharacteristically low compared to published values provided in AASHTO Tables C10.4.6.5-1 and C10.4.6.5-2.

GEOTECHNICAL OVERVIEW

The near surface soil could become unstable with typical earthwork and construction traffic, especially after precipitation events. Effective site drainage should be completed early in the construction sequence and maintained after construction to avoid potential issues. If possible, the grading should be performed during the warmer and drier times of the year (typically May to October). If grading is performed during the winter months (typically November to April), an increased risk for possible undercutting and replacement of unstable subgrade will persist. Additional site preparation recommendations, including subgrade improvement and fill placement, are provided in the **Earthwork** section.

The **Driven Piles** section addresses support of the bridge abutments on driven piles bearing on bedrock. The **Shallow Foundations** section addresses support of the western approach retaining wall bearing on a minimum 12 inches of compacted Structural Fill over proof-rolled native soil. The geotechnical recommendations presented herein were developed using the 2020 American Association of State Highway and Transportation Officials (AASHTO) LRFD Bridge Design Specification, 9th Edition, in conjunction with the 2003 MaineDOT Bridge Design Guide with Updates through 2018, and MaineDOT specifications.

The **General Comments** section provides an understanding of the report limitations.

EARTHWORK

Earthwork is anticipated to include demolition, removing existing pavements, clearing and grubbing, excavations, and fill placement. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality

criteria, as necessary, to render the site in the state considered in our geotechnical engineering evaluation for foundations.

Demolition

The proposed bridge will be constructed within the approximate footprint of the existing bridge. As part of construction, the existing bridge, abutments, sidewalks and utilities will need to be demolished. We recommend existing foundations, slabs, and utilities be removed from within the proposed foundation footprints and at least 5 feet beyond the outer edge of foundations.

For areas outside the proposed foundation footprints and foundation bearing zones, existing foundations, structures, and utilities should be removed where they conflict with proposed utilities, retaining walls, and pavements. In such cases, existing foundations, structures, and utilities should be removed to a depth of at least 2 feet below the affected utility or design pavement subgrade elevation.

Site Preparation

Existing vegetation and root mat should be stripped before placing new fill. Complete stripping of the topsoil should be performed in the proposed bridge and roadway alignment. Topsoil may be stockpiled for re-use on-site (if applicable) or properly disposed off-site.

Subgrade Preparation

Foundation and roadway subgrades should be proof-rolled with at least six passes in perpendicular directions using a minimum 10-ton vibratory roller in open areas; or a minimum 1-ton self-propelled vibratory roller or large vibratory plate compactor in trenches. The proof-rolling should be performed under the direction of the Geotechnical Engineer. Areas excessively deflecting under the proof-roll should be delineated and subsequently addressed by the Geotechnical Engineer. Soft or unstable areas should be over-excavated to more competent material and replaced with compacted Structural Fill or General Fill depending on the anticipated future use. Excessively wet or dry material should either be removed, or moisture conditioned and recompacted.

Fill Material Types

The following section presents material property requirements and suitable placement locations for various types of fill. Regardless of its source, compacted fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade.

Reuse of On-site Soil: Excavated on-site soil may be selectively reused as raise-in-grade fill (General Fill) within pavement and landscaping areas. Excavated on-site soil is not suitable for

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reuse as Structural Fill and should not be placed beneath settlement sensitive structures and within foundation bearing zones. Portions of the on-site soil have an elevated fines content and will be sensitive to moisture conditions (particularly during seasonally wet periods) and may not be suitable for reuse when above optimum moisture content. On-site soil may be used as General Fill provided it has the following properties:

- Free of deleterious materials
- A recommended maximum particle size equal to the lesser of 6 inches or 2/3 of the lift thickness
- A suitable moisture content allowing for effective compaction
- Compactive efforts yield a firm and stable surface

Imported Fill Materials: Imported fill materials should meet the material property requirements in the following table.

Fill Type	Maine Department of Transportation (MaineDOT) Item	Acceptable Location for Placement
General Fill	703.18 – Common Borrow	General raise-in-grade fill within pavement and landscaping areas. General Fill should not be placed beneath settlement sensitive structures and within foundation bearing zones.
Granular Backfill	703.19 – Granular Borrow for Underwater Backfill	Backfill for abutments and retaining walls.
Crushed Stone ¹	703.13 – Crushed Stone ¾-Inch	Backfill of underdrains and over wet subgrades as needed. Crushed Stone may be substituted for Structural Fill when approved by the Geotechnical Engineer.
Non-Frost Susceptible Fill ²	703.22 – Underdrain Backfill Material, Type B or 703.13 – Crushed Stone ¾-Inch	Below exterior slabs, sidewalks, pavements, or other ancillary structures where frost heave may be a concern.

1. Crushed Stone should be separated from soil subgrades, excavation sidewalls, and backfill using a non-woven geotextile (such as Mirafi 140N or similar).
2. Non-Frost Susceptible (NFS) Fill should contain less than 5 percent material passing No. 200 sieve size.

Fill Compaction Requirements

Fill materials should meet the following compaction requirements.

Item	Description
Maximum Lift Thickness	<p><i>Vibratory Rollers:</i> 12 inches or less in loose thickness</p> <p><i>Plate Compactors:</i> 6 inches or less in loose thickness when hand-guided equipment (i.e., jumping jack or plate compactor) is used</p>
Minimum Compaction Requirements ^{1, 2}	<p><i>General Fill:</i> At least 92% of the material's maximum dry density</p> <p><i>Structural Fill:</i> At least 95% of the material's maximum dry density</p> <p><i>Crushed Stone:</i> Compacted to a non-yielding state using at least six (6) passes of a vibratory roller or large vibratory plate compactor</p>
Water Content Range ¹	±3% of optimum water content

1. Maximum density and optimum water content as determined by the Modified Proctor test (ASTM D1557, Method C).
2. We recommend testing fill for moisture content and compaction during placement. If the results of in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested, as required, until the specified moisture and compaction requirements are achieved.

Utility Trench Backfill

Trench excavations should be made with sufficient working space to permit construction including backfill placement and compaction. Trenches should be backfilled with material that approximately matches the permeability characteristics of the surrounding soil. Fill placed as backfill for utilities located below settlement sensitive structures should consist of compacted Structural Fill or suitable bedding material as specified by the utility designer.

Grading and Drainage

All grades must provide effective drainage away from the bridge during and after construction and should be maintained throughout the life of the structure. Water retained next to bridge substructures can result in soil movements greater than those discussed in this report. Greater movements can result in unacceptable differential foundation movements and cracked walls.

Final grades should be verified to document effective drainage has been achieved upon completion of construction. Grades around the structure should also be periodically inspected and adjusted, as necessary, as part of the structure's maintenance program. Where paving or flatwork abuts the structure, a maintenance program should be established to effectively seal and maintain joints and prevent surface water infiltration.

Earthwork Construction Considerations

Shallow excavations for the proposed structure are anticipated to be accomplished with conventional construction equipment. Upon completion of filling and grading, care should be taken to maintain the subgrade water content prior to construction. Construction traffic over the completed subgrades should be avoided. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. Water collecting over or adjacent to construction areas should be removed. If the subgrade freezes, desiccates, saturates, or is disturbed, the affected material should be removed, or the materials should be scarified, moisture conditioned, and recompacted prior to construction.

The groundwater table will affect excavation efforts for the abutment structures. A temporary dewatering system will be necessary to achieve the recommended depth of excavation. Dewatering is a means and methods consideration for the contractor.

As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, "Excavations" and its appendices, and in accordance with any applicable local, and/or state regulations.

Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming responsibility for construction site safety, or the contractor's activities; such responsibility shall neither be implied nor inferred.

Construction Observation and Testing

The earthwork efforts should be monitored under the direction of the Geotechnical Engineer. Monitoring should include documentation of adequate removal of demolition debris, pavements, and unsuitable fill. Subgrade preparation should also be observed by the Geotechnical Engineer. If unanticipated conditions are encountered, the Geotechnical Engineer should be notified to evaluate the need for supplemental mitigation recommendations.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the continuity to maintain the Geotechnical Engineer's evaluation of subsurface conditions, including assessing variations and associated design changes. Each lift of compacted fill should be tested, evaluated, and reworked, as necessary, until approved by the Geotechnical Engineer prior to placement of additional lifts.

DRIVEN PILES

Axial Loading

Bridge abutments may be supported on end-bearing piles driven to bedrock, and as such, the drivability resistance of the pile will control pile design. The following table provides resistances for the anticipated HP pile section. Anticipated bedrock surface elevations are also provided for both abutments.

Pile Section	Anticipated Bedrock Elevation (feet) ¹		Factored Driving Resistance (kips) ²	Nominal Driving Resistance (kips) ³
	Abutment No. 1 (West)	Abutment No. 2 (East)		
HP 14x89	405.0 ±	397.0 ± to 406.0 ± (Dipping down from north to south)	365	562

1. Based on ground surface elevations interpolated from the “Red Bridge over Swift River” Plan Set, prepared by the TY Lin, last dated February 17, 2022. Actual embedded pile lengths should be based on load testing with pile dynamic analyzer measurements. The final tip elevations to obtain the design factored resistance should be based on the driving criteria established based upon the results of dynamic testing (ASTM D4945, Standard Test Method for High-Strain Dynamic Testing of Piles) performed using a Pile Driving Analyzer (PDA) system.
2. The factored driving resistance was limited to the maximum factored pile load of 365 kips (provided by TY Lin).
3. The nominal driving resistance was calculated using a resistance factor of 0.65 assuming dynamic testing (PDA) will be performed at the time of pile driving.

Driven piles should be spaced at least three pile diameters apart from each other (center-to-center). Pile caps should extend at least 72 inches below the lowest adjacent finished grade for frost protection. Riprap should not be considered as a contributing layer for frost protection.

Driven Pile Lateral Loading

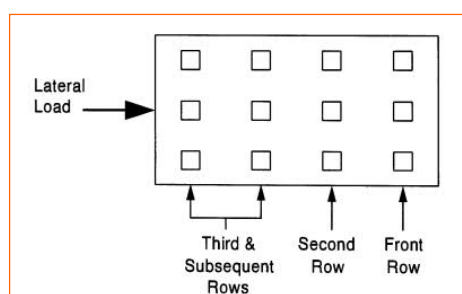
The parameters in the following table can be used in LPile software for analysis of the lateral capacity of driven piles. These parameters are based on correlations with SPT results, published values, and our experience with similar soil types.

Material	L Pile p-y Curve Model	Effective Unit Weight (pcf) ¹	Friction Angle (deg)	Uniaxial Compressive Strength (psi)	Poisson's Ratio	Geologic Strength Index, GSI	Intact Rock Modulus (psi)
Alluvium	Sand (Reese) ²	67.6	34	N/A	N/A	N/A	N/A
Bedrock	Massive Rock ³	102.6	N/A	7,000	0.18	80	800,000

- Parameters assume piles are fully submerged below the groundwater table.
- Use a default value for Soil Modulus, k.
- The Massive Rock model also requires the rock type and associated Hoek-Brown Material Index, designated as m_i . The rock type should be selected as migmatite with m_i equal to 29.

Lateral deflections of piles should be evaluated using an appropriate analysis method, and will depend upon the pile's dimensions, length, configuration, stiffness and "fixed head" or "free head" condition. We can provide additional analyses and estimates of lateral deflections for specific loading conditions upon request. The load-carrying capacity of piles may be increased by increasing the HP section and/or length.

Piles should be spaced at least three pile diameters apart (center-to-center) if they will be used to resist lateral loads. When piles are used in groups, the lateral capacities of the piles in the second, third, and subsequent rows of the group should be reduced as compared to the capacity of a single, independent pile. Guidance for applying p-multiplier factors to the p values in the p-y curves for each row of pile foundations within a pile group are as follows:



Pile Center-to-Center Spacing ¹	P-Multipliers, P_m ²		
	Front Row	Second Row	Third & Subsequent Rows
3B	0.8	0.4	0.3
5B	1.0	0.85	0.7

- Where B is the diameter of the pile.
- As shown in AASHTO Table 10.7.2.4-1.

Driving Resistance

Wave equation software (GRLWEAP 2010) was used to perform preliminary drivability analyses. The purpose of the analyses was to evaluate whether the proposed piles (specifically HP14x89) can be driven using typical construction equipment and techniques without over-stressing the piles. Our preliminary wave equation analyses were performed assuming a DELMAG 19-42 single-acting, diesel impact hammer with a ram weight of 4 kips and rated energy of 43.24 kip-feet. Analyses were performed using fuel setting 1. Due to the variable depths to bedrock at the site, four subsurface conditions were analyzed, specifically corresponding to borings BB-RSR-102, 202, 203, and 204. Final drivability analyses should be performed by the contractor based on the final pile design and the contractor's selected hammer. Acceptance of all equipment and procedures are subject to satisfactory field performance.

In accordance with AASHTO LRFD 10.7.8, the maximum permissible driving stress of driven steel piles should be less than 0.9 times the yield strength of the steel being used (i.e., for a yield strength of 50 ksi, the driving stress shall be less than 45 ksi). The preliminary wave equation analyses, assuming a DELMAG 19-42 hammer operating on fuel setting of 1, indicate the maximum compressive stress at the nominal capacity of 562 kips is below the allowable limit of 45 ksi. The analyses also indicate the number of hammer blows will be within 3 to 15 blows per inch (as required by Section 501.042 of the MaineDOT Standard Specifications) at the nominal driving capacity of 562 kips; however, piles should be driven to refusal and limited to about 5 blows per 1/4 inch upon encountering refusal conditions. Final driving criteria shall be determined from the Pile Driving Analyzer (PDA) test program. Results from the GRLWEAP analyses are provided in the **Supporting Information** section.

Driven Pile Construction Considerations

The contractor should select a driving hammer and cushion combination that can install the selected piling without overstressing the pile material. Drivability analyses should be performed by the contractor based on the final pile design and the contractor's selected hammer. Two wave equation analyses shall be performed at Abutment 1 (one each for both plumb and battered piles). Four wave equation analyses shall be performed at Abutment No. 2 (one each for both plumb and battered piles at both the upstream and downstream ends of Abutment 2).

The hammer should have a rated energy in foot-pounds at least equal to 15% of the design compressive load capacity in pounds. The contractor should submit the pile driving plan and the pile hammer-cushion combination to the engineer for evaluation of the driving stresses in advance of pile installation. Acceptance of all equipment and procedures are subject to satisfactory field performance.

While driving, a maximum of 5 blows per 1/4 inch is recommended to reduce the potential of pile damage. If practical refusal is experienced above the anticipated rock surface elevation, the pile

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may be on a boulder or other obstruction and a replacement pile should be driven. If this occurs, the situation should be evaluated by Terracon during the pile driving operations.

Piles will be driven to bedrock and should have high strength, cast steel pile tips to minimize damage to the pile tip. Rock injector pile tips (MaineDOT Item 501.903 Pile Tips – Rock Injector Point) are recommended for both plumb and battered piles due to the hardness of the rock and the sloping nature of the rock surface at the eastern abutment. Upon reaching bedrock, pile driving should be limited to about 5 blows per 1/4 inch of pile advancement. The contractor should be prepared to cut piles, as necessary.

Pile driving conditions, hammer efficiency, and stress on the pile while driving shall be evaluated during installation using a Pile Driving Analyzer (PDA). Dynamic pile testing should be conducted to verify nominal pile resistance at the end of drive (EOD). Case Pile Wave Analysis Program (CAPWAP) should also be performed to confirm the load-carrying capacities obtained from the PDA. The information can then be compared to driving data for the piles, to determine if amended criteria are warranted.

The contractor should perform a minimum of four dynamic load tests (two at each abutment) with restrike tests performed within a minimum of 24 hours. The first dynamic load test should be performed on the first vertical production pile driven at each abutment. The second dynamic load test should be performed on the first battered pile driven at each abutment, specifically at the opposite end of the abutment relative to the first dynamic load test.

A Terracon representative should observe pile driving operations. Each pile should be observed and checked for buckling, crimping and alignment in addition to recording penetration resistance, depth of embedment, and general pile driving operations.

Nearby structures and subsurface utilities should be observed prior to pile installation to document their conditions. Structures should also be observed during pile installation for indications of movement. If movement or cracking of the existing structures are observed, pile driving operations should be stopped, and the Geotechnical Engineer should be contacted for further evaluation. Vibration monitoring while pile driving should be considered. Although vibrations from pile driving may be below levels that will cause structural damage, they may be felt by occupants of nearby buildings. The potential impact of driving piles at this site should be considered when evaluating this alternative.

The pile driving process should be performed under the direction of the Geotechnical Engineer. The Geotechnical Engineer should document the pile installation process including soil/rock and groundwater conditions encountered, consistency with expected conditions, and details of the installed piles.

SHALLOW FOUNDATIONS

If the site has been prepared in accordance with the requirements noted in the **Earthwork** section, the following design parameters are applicable for shallow foundation support of the western approach retaining wall.

Design Parameters

Item	Description
Required Bearing Material ¹	Minimum 12 inches of MaineDOT Item 703.19 – Material for Underwater Backfill over proofrolled native inorganic sand
Bearing Resistance Factor, Φ_b	0.45 (AASHTO 10.5.5.2.2)
Nominal Sliding Resistance, R_r ²	0.62*V (kips) (AASHTO 10.6.3.4)
Sliding Resistance Factor, Φ_r	0.90 for precast concrete (AASHTO 10.5.5.2.2) 0.80 for cast-in-place concrete (AASHTO 10.5.5.2.2)
Moist Unit Weight, γ_m (Alluvium)	120 pounds per cubic foot
Minimum Embedment below Finished Grade ³	72 inches

1. Unsuitable or soft soils should be over-excavated and replaced per the recommendations presented in the **Earthwork** section.
2. The variable V stands for total vertical force, in kips. Nominal sliding resistance is for cast-in-place concrete against soil with an internal friction angle of 32°. Multiply cast-in-place value by 0.8 for precast concrete.
3. Embedment necessary to minimize the effects of frost and/or seasonal water content variations. For sloping ground, maintain depth below the lowest adjacent exterior grade within 5 horizontal feet of the structure.

Foundation excavations should be observed by the Geotechnical Engineer. If the encountered soil conditions differ significantly from those presented in this report, supplemental recommendations will be required. The Strength Case factored bearing resistance and Service Case bearing resistance for typical footing sizes are provided in the following table.

Limit State	Bearing Resistance (psf) by Foundation Width (feet) ¹				
	2.0	3.0	4.0	5.0	6.0
Strength Limit State Nominal Bearing Resistance	24,400	25,000	25,200	25,700	26,400
Service Limit State Factored Bearing Resistance 1 inch of Settlement	7,500	5,600	4,500	3,900	3,400

1. Bearing resistance values are for wall foundations up to 65 feet long.

Foundation Construction Considerations

As noted in the **Earthwork** section, the foundation excavations should be evaluated under the direction of the Geotechnical Engineer. The base of all foundation excavations should be free of water and loose soil prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Care should be taken to prevent wetting or drying of the bearing materials during construction. Excessively wet or dry material or any loose/disturbed material in the bottom of the foundation excavations should be removed/reconditioned before foundation concrete is placed.

If unsuitable material is encountered at the base of the planned footing excavation, the excavation should be extended deeper to suitable soils. The over-excavation should be backfilled up to the footing base elevation, with compacted Structural Fill placed, as recommended in the **Earthwork** section.

SEISMIC CONSIDERATIONS

The seismic design requirements are based on the AASHTO LRFD Bridge Design Specifications, 9th Edition, Section 3.10. The following table provides seismic design parameters:

Item	Value	Reference
Maximum Considered Earthquake Ground Motions¹		
Horizontal Peak Ground Acceleration, PGA	0.086g	AASHTO Figure 3.10.2.1-1
0.2 second Spectral Response Acceleration, S_s	0.177g	AASHTO Figure 3.10.2.1-2
1.0 second Spectral Response Acceleration, S₁	0.049g	AASHTO Figure 3.10.2.1-3
Site Class²	D	AASHTO 3.10.3.1

Item	Value	Reference
Site Factors		
PGA Site Factor, F_{pga}	1.6	AASHTO Table 3.10.3.2-1
S_s Site Factor, F_a	1.6	AASHTO Table 3.10.3.2-2
S_1 Site Factor, F_v	2.4	AASHTO Table 3.10.3.2-3
Design Response Spectrum		
0 second Design Response Acceleration, A_s	0.138g	AASHTO 3.10.4.2-2
0.2 second Design Response Acceleration, S_{DS}	0.283g	AASHTO 3.10.4.2-3
1.0 second Design Response Acceleration, S_{D1}	0.118g	AASHTO 3.10.4.2-6
Seismic Zone	1	AASHTO Table 3.10.6-1
Liquefaction Potential in Event of an Earthquake	Not susceptible ³	

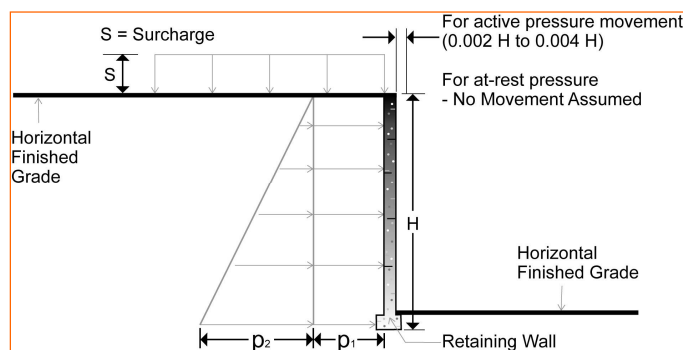
1. Maximum considered earthquake ground motions are mapped at 5% critical damping and 7% probability of exceedance in 75 years (AASHTO 3.10.2).
2. In general accordance with the AASHTO 3.10.3.1, Site Class is based on the average characteristics of the standard penetration resistance in the upper 100 feet of the subsurface profile. The borings extended to a maximum depth of 42.5 feet and were terminated on or in bedrock.
3. Based upon the soil composition, relative density, and groundwater conditions encountered in the test borings, it is our professional opinion the site is not susceptible to liquefaction during the design seismic event.

LATERAL EARTH PRESSURES

The following section presents lateral earth pressure parameters and recommendations for permanent earth retaining structures; they do not apply to design of temporary support-of-excavation structures or mechanically stabilized earth (MSE) retaining walls.

Design Parameters

Structures with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to the values indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown in the following diagram. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The “at-rest” condition assumes no wall movement and is commonly used for basement walls, loading dock walls, or other walls restrained at the top. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls (unless stated).



Lateral Earth Pressure Condition ¹	Lateral Earth Pressure Coefficient ²	Surcharge Pressure, p_1 (psf) ^{3, 4}	Effective Fluid Pressures (psf) ^{2, 4}	
			Unsaturated ⁵	Submerged ⁵
Active (K_a)	0.31	$(0.31)S$	$(40)H$	$(80)H$
At-Rest (K_o)	0.47	$(0.47)S$	$(55)H$	$(90)H$
Passive (K_p)	3.25	---	$(390)H$	$(250)H$

1. For active earth pressure, wall must rotate about base, with top lateral movements 0.002 H to 0.004 H, where H is wall height. For passive earth pressure, wall must move horizontally to mobilize resistance.
2. Backfill placed against structures should consist of compacted Structural Fill. A maximum unit weight of 120 pcf is assumed for the values in this table. For the earth pressure coefficients to be valid, the Structural Fill must extend out and up from the base of the wall at an angle of at least 45 and 60 degrees from vertical for the active and passive cases, respectively.
3. Uniform surcharge, where S is surcharge pressure.
4. Loading from heavy compaction equipment is not included.
5. To achieve "Unsaturated" conditions, follow guidelines in **Subsurface Drainage for Below-Grade Walls** below. "Submerged" conditions are recommended when drainage behind walls is not incorporated into the design.

Subsurface Drainage for Below-Grade Walls

A perforated rigid plastic drain line (HDPE or PVC) installed behind the base of walls that extends below adjacent grade is recommended to prevent hydrostatic loading on the walls. The invert of a drain line should be placed near foundation bearing level. The drain line should be sloped to provide positive gravity drainage to daylight or to a sump pit and pump. The drain line should be surrounded by clean, free-draining granular material having less than 5% passing the No. 200 sieve, such as Crushed Stone. The free-draining material should be encapsulated in a filter fabric. Wall backfill, consisting of compacted Structural Fill, should extend up to bottom of the pavement section to reduce infiltration of surface water into the drain system.

As an alternative to free-draining granular material, a prefabricated drainage structure may be used. A prefabricated drainage structure is a plastic drainage core or mesh which is covered with filter fabric to prevent soil intrusion and is fastened to the wall prior to placing backfill.

FROST CONSIDERATIONS

Abutments and Wingwalls

Bridge abutments, pile caps, and wingwalls should embed a minimum 72 inches below ground surface to minimize the effects of frost and/or seasonal water content variations. For sloping ground, maintain depth below the lowest adjacent exterior grade within 5 horizontal feet of the structure.

Exterior Slabs and Pavements

Placement of Non-Frost Susceptible (NFS) Fill beneath slabs on-grade, sidewalks, and/or pavements to a depth of 72 inches below final grades may not be feasible; however, the following recommendations are provided to help reduce potential frost heave for such structures:

- For slabs critical to the project, place a minimum 24-inch layer of NFS Fill as backfill beneath slabs, and within the slab bearing zone (defined as the area below 1H:1V lines extending downward and outward from slab edges).
- Place a non-woven geotextile over the excavation subgrade prior to placing NFS Fill to separate the NFS Fill from the subgrade and excavation side walls and reduce the potential for the migration of fines into the NFS Fill.
- Provide surface drainage away from structures and toward the site storm drainage system.
- Install drains below exterior slabs and pavements and connect them to the site storm drainage system (where applicable).
- Grade subgrades to allow potentially perched groundwater in overlying more permeable subgrades, such as sand or aggregate base, slope toward a site drainage system.
- Place a 3 horizontal to 1 vertical (3H:1V) transition zone between NFS Fill and other soils.

The previous recommendations would help reduce the effects of frost heave to tolerable magnitudes for most winters; however, a 72-inch-thick layer of NFS Fill should be used in design for extreme winter events when deeper frost penetration is expected. The NFS Fill thickness should be determined based the desired level of risk that the owner is willing to accept. As an alternative to extending NFS Fill to the full frost depth, consideration can be made to placing extruded polystyrene or cellular concrete under a buffer of at least 2 feet of NFS Fill.

GENERAL COMMENTS

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Natural variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction.

Geotechnical Engineering Report

Rumford-Mexico Red Bridge #2707 ■ Rumford and Mexico, Maine

May 9, 2023 ■ Terracon Project No. J1215037



Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence or collaboration through this system are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Boring No.	Boring Depth (feet)	Location
BB-RSR-101	51.0	Abutment No. 2 (roadway)
BB-RSR-102	41.0	Abutment No. 1 (roadway)
BB-RSR-201	21.8	New Retaining Wall
BB-RSR-202	34.5	Abutment No. 1 (downstream)
BB-RSR-203	32.4	Abutment No. 2 (upstream)
BB-RSR-204	42.5	Abutment No. 2 (downstream)

Boring Layout and Elevations: Unless otherwise noted, Terracon personnel provided the boring layout. Borings were located with swing-ties to two or three fixed objects/structures and approximate elevations were obtained by interpolation from the “Red Bridge over Swift River” Plan Set, prepared by the TY Lin, last dated February 17, 2022. If elevations and a more precise boring layout are desired, we recommend borings be surveyed following completion of fieldwork.

Subsurface Exploration Procedures: We advanced the borings with track- and truck-mounted rotary drill rigs using continuous flight augers and drive and wash methods, as necessary, depending on soil conditions. Four samples were obtained in the upper 10 feet of each boring and at intervals of 5 feet thereafter. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon was driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampler the last 12 inches of a normal 18-inch penetration was recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. Upon encountering bedrock conditions, 5 feet of rock coring (using NQ rock core barrel) at BB-RSR-102 and 10 feet of rock coring was performed at borings BB-RSR-202 through BB-RSR-204. We observed and recorded groundwater levels while drilling and sampling. For safety purposes, borings were backfilled with soil cuttings upon completion.

The sampling depths, penetration distances, and other sampling information was recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a Geotechnical Engineer. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials encountered while drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the Geotechnical Engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests to understand the engineering properties of the various soil and rock strata, as necessary, for this project. Procedural standards noted below are for reference to methodology in general. In some cases, variations to methods were applied because of local practice or professional judgment. Standards noted below include reference to other, related standards. Such references are not necessarily applicable to describe the specific test performed.

- ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D422 Standard Test Method for Particle-Size Analysis of Soils
- ASTM D7012 Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures
- ASTM G51 Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing
- ASTM C1580 Standard Test Method for Water-Soluble Sulfate in Soil
- ASTM D512 Standard Test Methods for Chloride Ion in Water
- ASTM G200 Standard Test Method for Measurement of Oxidation-Reduction Potential (ORP) of Soil
- ASTM G57 Standard Test Method for Measurement of Soil Resistivity Using the Wenner Four-Electrode Method

The laboratory testing program included examination of soil samples by an engineer. Based on the material's texture and plasticity, we described and classified the soil samples in accordance with the MaineDOT "Key to Soil and Rock Descriptions", as shown in the **Supporting Information** section.

PHOTOGRAPHY LOG

Site Photographs



Photograph 1: Existing ballpark access stairs (to be replaced with stairs and ramp)



Photograph 2: Existing ballpark structures to be demolished for bridge construction

Geotechnical Engineering Report

Rumford-Mexico Red Bridge #2707 ■ Rumford and Mexico, Maine

May 9, 2023 ■ Terracon Project No. J1215037



Photograph 3: Rumford side of the bridge, view from the south



Photograph 4: Mexico side of the bridge, view from the north

Rock Core Photographs

Row	Boring No.	Run	Depth (feet)	Recovery		RQD	
				(inches)	(%)	(inches)	(%)
1	BB-RSR-102	R1	36.0 to 41.0	40	66	37	61
2	Not Applicable						
3	Not Applicable						
4	Not Applicable						



Photograph 5: BB-RSR-102 (36.0 feet to 41.0 feet)

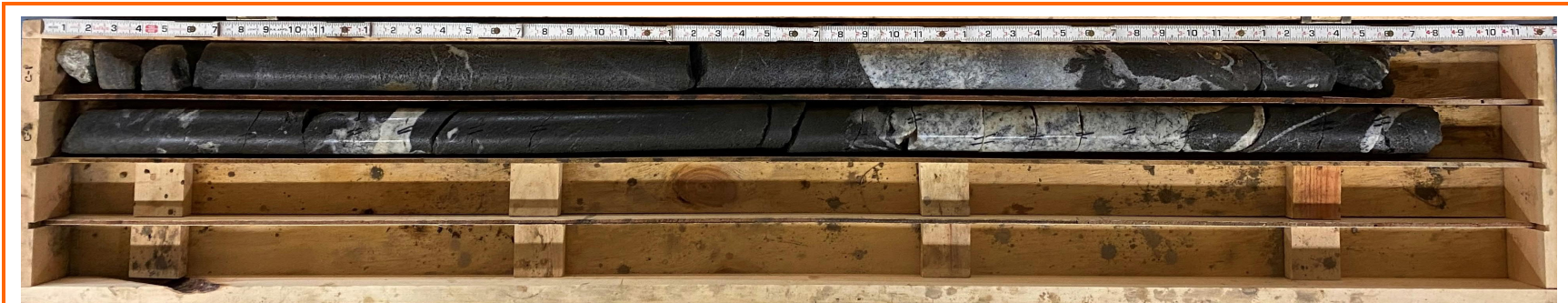
Geotechnical Engineering Report

Rumford-Mexico Red Bridge #2707 ■ Rumford and Mexico, Maine

May 9, 2023 ■ Terracon Project No. J1215037



Row	Boring No.	Run	Depth (feet)	Recovery		RQD	
				(inches)	(%)	(inches)	(%)
1	BB-RSR-202	R1	24.5 to 29.5	54	90	43	71
2	BB-RSR-202	R2	29.5 to 34.5	56	93	54	90
3	Not Applicable						
4	Not Applicable						



Photograph 6: BB-RSR-202 (24.5 feet to 34.5 feet)

Geotechnical Engineering Report

Rumford-Mexico Red Bridge #2707 ■ Rumford and Mexico, Maine

May 9, 2023 ■ Terracon Project No. J1215037



Row	Boring No.	Run	Depth (feet)	Recovery		RQD	
				(inches)	(%)	(inches)	(%)
1	BB-RSR-203	R1	22.4 to 27.4	59	98	58	96
2	BB-RSR-203	R2	27.4 to 32.4	55	91	55	91
3	BB-RSR-204	R1	32.5 to 37.5	60	100	50	83
4	BB-RSR-204	R2	37.5 to 42.5	59	98	58	96



Photograph 7: BB-RSR-203 (22.4 feet to 32.4 feet) and BB-RSR-204 (32.5 feet to 42.5 feet)

SITE LOCATION AND BORING LOCATION PLAN

Contents:

Site Location

Boring Location Plan

Interpretive Subsurface Profile

Note: All attachments are one page unless noted above.

SITE LOCATION

Rumford-Mexico Red Bridge #2707 ■ Rumford and Mexico, Maine
May 9, 2023 ■ Terracon Project No. J1215037

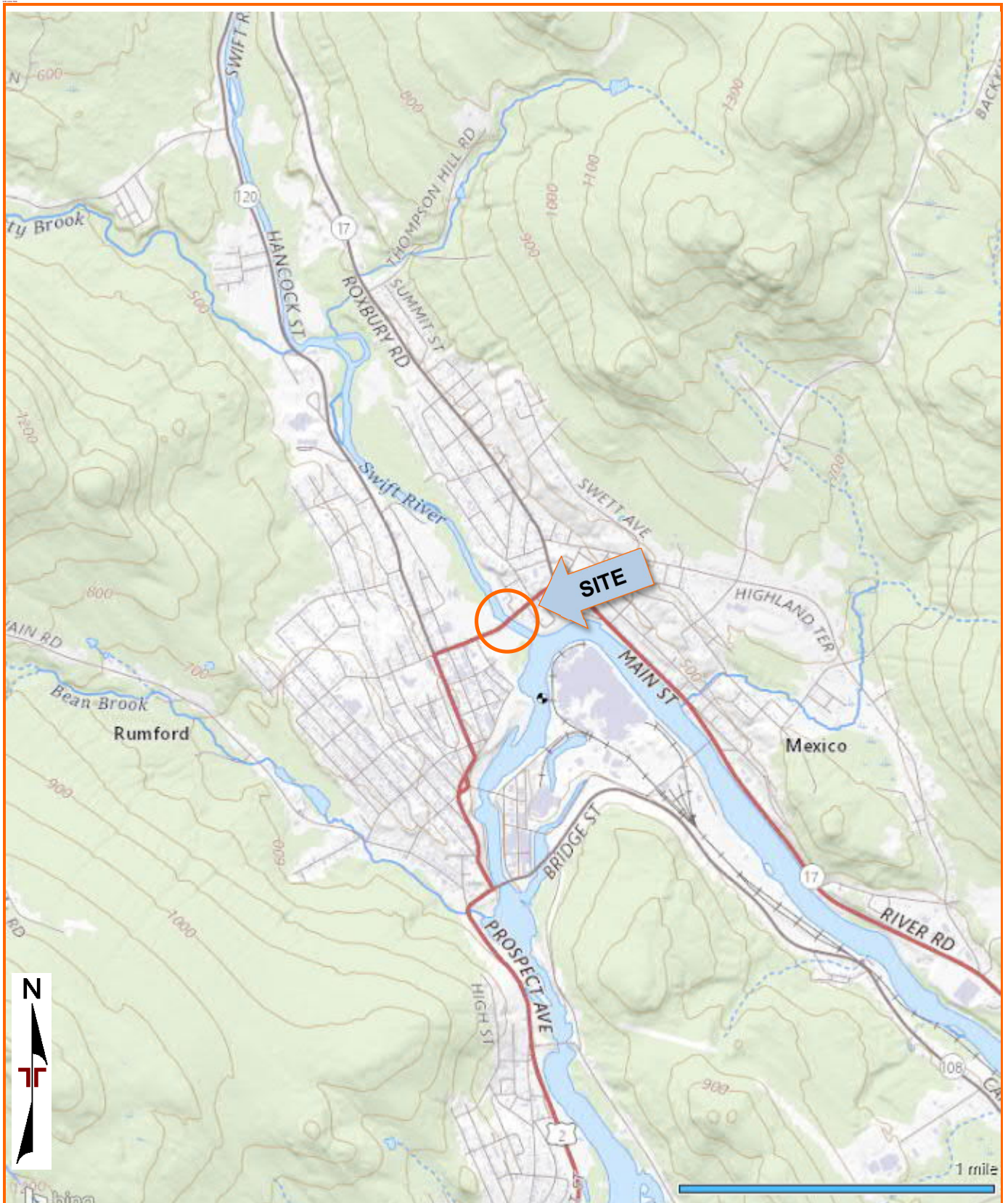


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

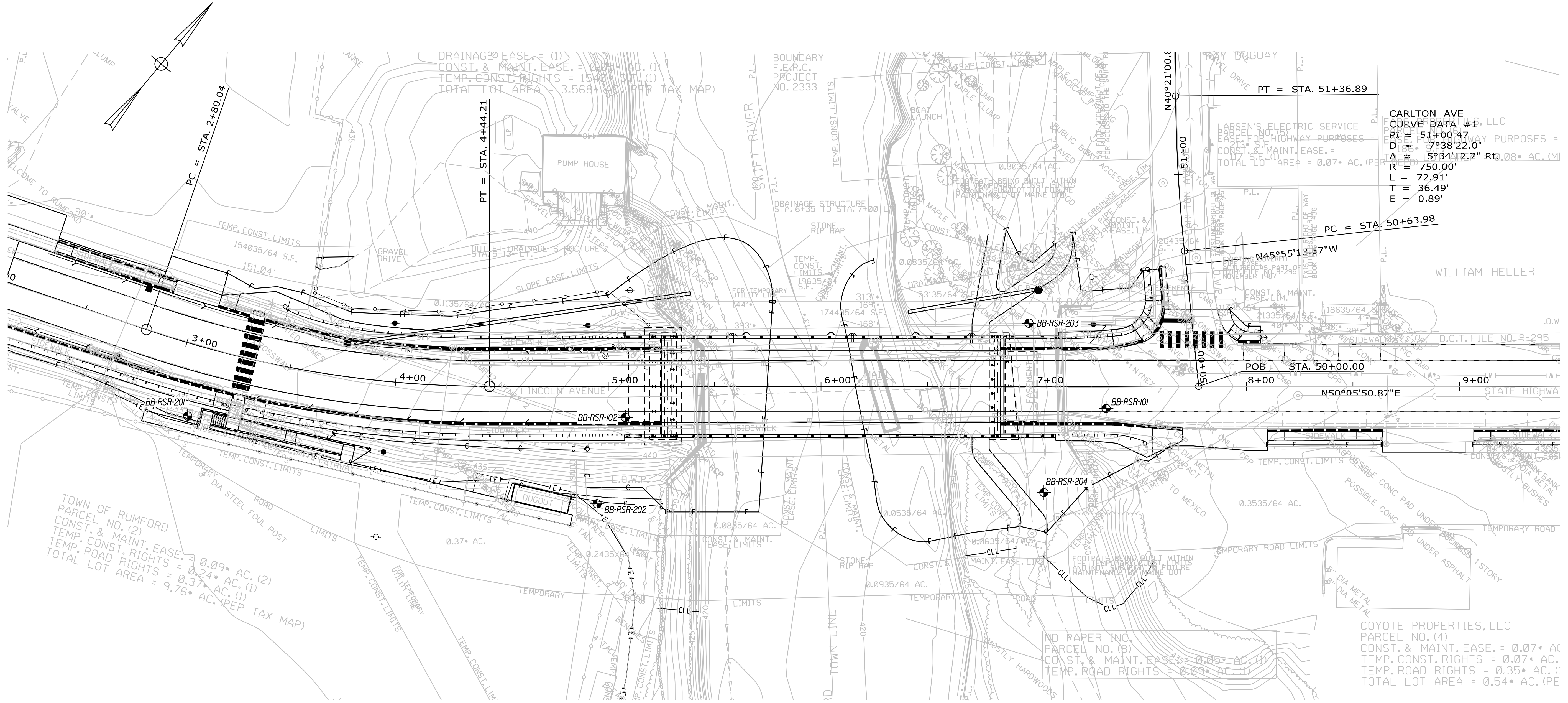
MAP COURTESY OF THE U.S. GEOLOGICAL SURVEY

Date: 4/25/2023

Username:

Division: HIGHWAY

Filename: ... \MSTA\... \Boring\ocPlan_01.dgn



NOTES:

1. Test borings BB-RSR-101 and BB-RSR-102 were advanced between December 19 and 21, 2016 under the direction of Terracon Consultants, Inc. (Terracon) with equipment owned and operated by Terracon. Test borings BB-RSR-201 through BB-RSR-204 were advanced between April 20 and 21, 2022 under the direction of Terracon with equipment owned and operated by Northern Test Boring of Gorham, Maine.
2. The test borings were located by handheld GPS, as well as by tape measurements referencing existing site features. The locations should be considered accurate to the degree implied by the method used.

LEGEND:



STATE OF MAINE DEPARTMENT OF TRANSPORTATION		STP-2170(000)		BRIDGE #2707		WIN 21700.01		BRIDGE PLANS	
RED BRIDGE OVER SWIFT RIVER		RUMFORD - MEXICO OXFORD COUNTY		BORING LOCATION PLAN		SHEET NUMBER		7	
PROJ. MANAGER	M. WIGHT	BY	M. DEVOID	DATE	7/2022	SIGNATURE	P.E. NUMBER	DATE	
DESIGN/DETAILED	TERRACON	CHECKED/REVIEWED	R. HEBERT	DESIGN/DETAILED	7/2022	REVISIONS 1			
				REVISIONS 2		REVISIONS 3			
				REVISIONS 4		FIELD CHANGES			

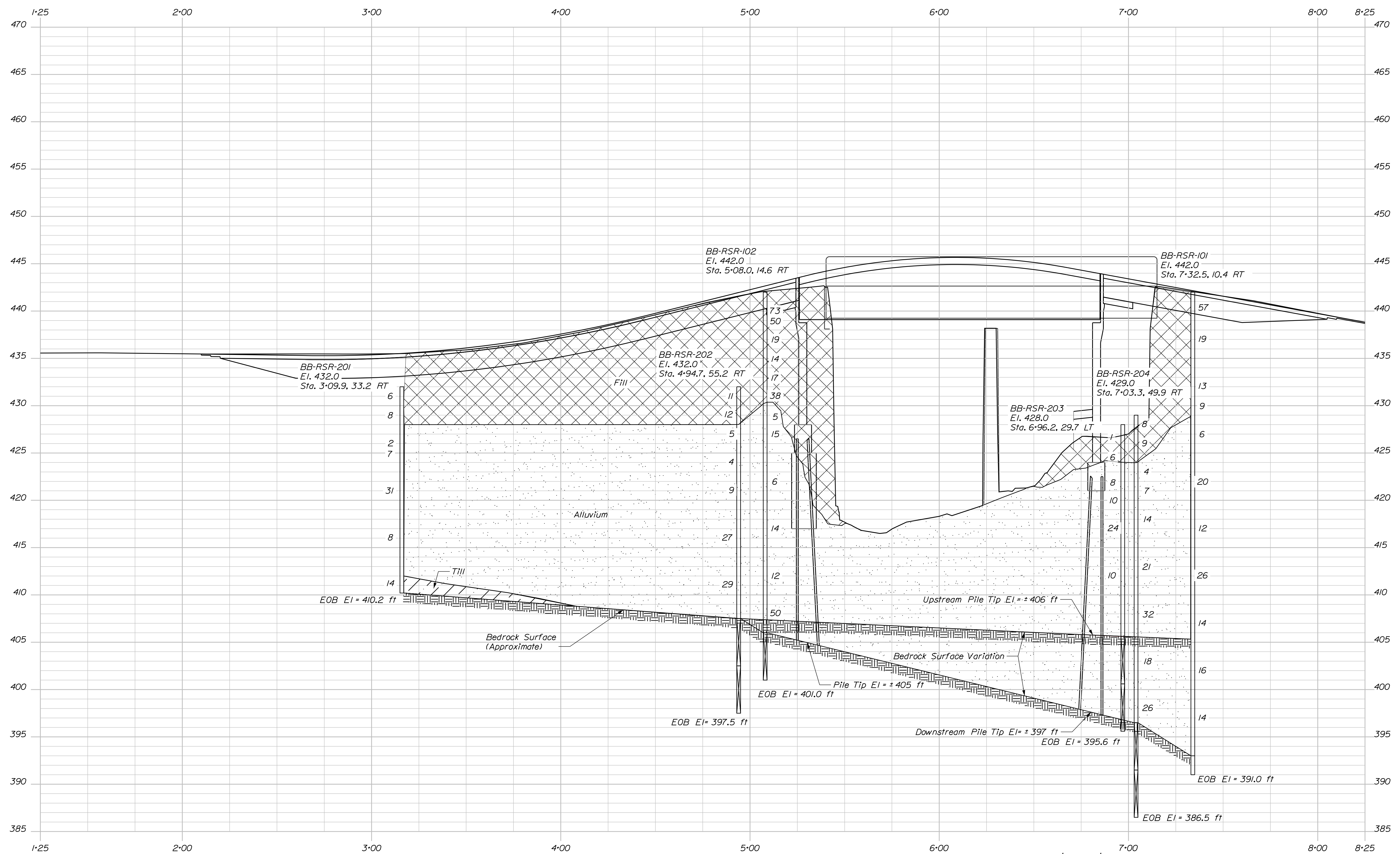


Date: 4/25/2023

Username:

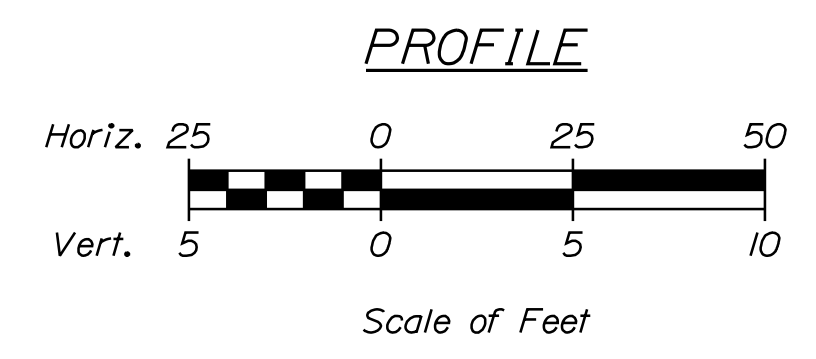
Division: HIGHWAY

Filename: ... \MSTA\... \SoilProfile_01.dgn



Notes:

1. Test borings BB-RSR-101 and BB-RSR-102 were advanced between December 19 and 21, 2016 under the direction of Terracon Consultants, Inc (Terracon) with equipment owned and operated by Terracon. Test borings BB-RSR-201 through BB-RSR-204 were advanced between April 20 and 21, 2022 under the direction of Terracon with equipment owned and operated by Northern Test Boring of Gorham, Maine.
2. The test borings were located by handheld GPS, as well as by tape measurement referencing existing site features. The locations should be considered accurate to the degree implied by the method used.
3. N-values are uncorrected and were measured using an 18-inch drop of a 140-pound automatic hammer.
4. Data concerning the various strata have been interpolated from test boring data. The stratigraphy between borings may vary from what is shown.



Legend:

- Fill
- Alluvium
- Till
- Bedrock
- BB-RSR-202
El. 432.0
Sta. 4+94.7, 55.2 RT
- Test boring designation
- SPT N-value
- Rock core
- End of boring elevation

STATE OF MAINE
 DEPARTMENT OF TRANSPORTATION
 STP-2170(000)
 BRIDGE #2707
 WIN
 21700.01
 BRIDGE PLANS

PROJ. MANAGER	M. WIGHT	BY	DATE
DESIGN-DETAILED	Terracon	M. David	7/2022
CHECKED-REVIEWED	Terracon	R. Hebert	7/2022
DESIGN-DETAILED			
REVISIONS 1			
REVISIONS 2			
REVISIONS 3			
REVISIONS 4			
FIELD CHANGES			

RED BRIDGE
 OVER SWIFT RIVER
 RUMFORD - MEXICO OXFORD COUNTY
 INTERPRETIVE SUBSURFACE
 PROFILE

SHEET NUMBER
 8
 OF 54



EXPLORATION RESULTS

Contents:

2022 Boring Logs (BB-RSR-201 through BB-RSR-204)

2016 Boring Logs (BB-RSR-101 through BB-RSR-102)

Grain Size Distribution (4 pages)

Uniaxial Compressive Strength of Rock (19 pages)

Corrosivity

Note: All attachments are one page unless noted above.

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	Project: Rumford-Mexico Red Bridge #2707 Location: Rumford and Mexico, Maine	Boring No.: <u>BB-RSR-201</u> WIN: <u>21700.01</u>
--	---	---

Driller: Northern Test Boring	Elevation (ft.): 432	Auger ID/OD: 2-1/4-inch ID SSA
Operator: Mike Nadeau	Datum: NAVD88 (See Remarks)	Sampler: 1-3/8-inch ID split spoon
Logged By: Vincent Mendoza	Rig Type: Diedrich D-50	Hammer Wt./Fall: 140 pounds / 30 inches
Date Start/Finish: 04/21/2022 - 04/21/2022	Drilling Method: SSA to 10 feet, then Rotary	Core Barrel: N/A
Boring Location: Sta. 3+09.9, 33.2RT	Casing ID/OD: 4-inch ID HW	Water Level*: 9 feet

Hammer Efficiency Factor: 0.928	Hammer Type: Automatic <input checked="" type="checkbox"/> Hydraulic <input type="checkbox"/> Rope & Cathead <input type="checkbox"/>	
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 Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
0	1D	24/8	0.00 - 2.00	2-2-4-5	6	9	SSA	428.0	Very dark grayish brown (2.5Y 3/2), moist, loose, SAND, some silt, trace gravel, trace roots, poorly-graded (Fill)		
	2D	24/3	2.00 - 4.00	4-4-4-4	8	12			Similar, medium dense (Fill)		
5	3D	24/19	5.00 - 7.00	1-1-1-4	2	3		425.0	Olive brown (2.5Y 4/3), wet, very loose, SAND, some silt, trace gravel, poorly-graded (Alluvium)	A-2-4 / SM WC=32.4%	
	4D	9/5	7.00 - 7.75	4-50/3"					Olive brown (2.5Y 4/3), wet, very dense, SAND, some gravel, little silt, poorly-graded (Alluvium)		
10	5D	24/12	10.00 - 12.00	10-17-14-11	31	48	82	417.0	Similar, saturated, dense (Alluvium)		
							87				
							100				
							42				
15	6D	24/12	15.00 - 17.00	20-11-7-8	18	28	60	412.0	Light olive brown (2.5Y 5/6), wet, very stiff, SILT, some sand, trace gravel, non-plastic (Alluvium)	A-4 / ML WC=29.8%	
							64				
							62				
							67				
20	7D	20/8	20.00 - 21.67	7-6-8-50/2"	14	22	RC	410.2	Dark gray (5Y 4/1), wet, medium dense, SAND, some gravel, some silt, poorly-graded (Till)		
							74				
25									Bottom of Exploration at 21.8 feet below ground surface. Boring Terminated on Probable Bedrock at 21.8 feet		

Remarks:
Boring location and elevation were interpolated from the "Red Bridge over Swift River Plan Set", prepared by the TY Lin International, last dated February 17, 2022.

Driller: Northern Test Boring	Elevation (ft.): 432	Auger ID/OD: 2-1/4-inch ID SSA
Operator: Mike Nadeau	Datum: NAVD88 (See Remarks)	Sampler: 1-3/8-inch ID split spoon
Logged By: Vincent Mendoza	Rig Type: Diedrich D-50	Hammer Wt./Fall: 140 pounds / 30 inches
Date Start/Finish: 04/21/2022 - 04/21/2022	Drilling Method: SSA to 10 feet, then Rotary	Core Barrel: 2-inch NQ
Boring Location: Sta. 4+94.7, 55.2RT	Casing ID/OD: 4-inch ID HW	Water Level*: 10 feet

Hammer Efficiency Factor: 0.928 **Hammer Type:** Automatic Hydraulic Rope & Cathead


Definitions: R = Rock Core Sample S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf) T_v = Pocket Torvane Shear Strength (psf)
 D = Split Spoon Sample SSA = Solid Stem Auger S_{u(lab)} = Lab Vane Undrained Shear Strength (psf) WC = Water Content, percent
 MD = Unsuccessful Split Spoon Sample Attempt HSA = Hollow Stem Auger q_p = Unconfined Compressive Strength (ksf) LL = Liquid Limit
 U = Thin Wall Tube Sample RC = Roller Cone N-uncorrected = Raw Field SPT N-value PL = Plastic Limit
 MU = Unsuccessful Thin Wall Tube Sample Attempt WOH = Weight of 140lb. Hammer Hammer Efficiency Factor = Rig Specific Annual Calibration Value PI = Plasticity Index
 V = Field Vane Shear Test, PP = Pocket Penetrometer WOR/C = Weight of Rods or Casing N₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency G = Grain Size Analysis
 MV = Unsuccessful Field Vane Shear Test Attempt WO1P = Weight of One Person N₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected C = Consolidation Test

Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
0	1D	24/16	0.00 - 2.00	1-3-4-4	7	11	SSA	432.0		5 inches of topsoil	
										Dark olive brown (2.5Y 3/3), moist, medium dense, SILTY SAND, little gravel, poorly-graded (Fill)	
	2D	24/8	2.00 - 4.00	2-4-8-7	12	19				Similar, medium dense, trace gravel (Fill)	
5								428.0			
	3D	24/24	5.00 - 7.00	2-2-3-3	5	8				Olive brown (2.5Y 4/3), moist, loose, SAND, some silt, poorly-graded (Alluvium)	
	4D	24/10	7.00 - 9.00	2-2-2-2	4	6		425.0		Olive brown (2.5Y 4/3), wet, loose, SAND, trace silt and gravel, poorly-graded (Alluvium)	A-3 / SP-SM WC=24.4%
10								422.0			
	5D	24/10	10.00 - 12.00	2-2-7-13	9	14				Olive brown (2.5Y 4/3), saturated, medium dense, SAND, little gravel, trace silt, well-graded (Alluvium)	A-1-b / SW-SM WC=16.5%
15								417.0			
	6D	24/4	15.00 - 17.00	28-18-9-8	27	42	62			Strong brown (7.5YR 5/8), saturated, dense, SAND, some gravel, trace silt, well-graded, oxidation (Alluvium)	A-1-b / SW-SM WC=12.4%
20								412.0			
	7D	24/11	20.00 - 22.00	9-8-21-18	29	45	60			Grayish brown (2.5Y 4/3), saturated, hard, SILT, some sand, trace gravel, non-plastic (Alluvium)	A-4 / ML WC=21.2%
25								407.5			
	R1	60/54	24.50 - 29.50	RQD = 71%			65				

Remarks:
 Boring location and elevation were interpolated from the "Red Bridge over Swift River Plan Set", prepared by the TY Lin International, last dated February 17, 2022.

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS		Project: Rumford-Mexico Red Bridge #2707	Boring No.: BB-RSR-202
		Location: Rumford and Mexico, Maine	WIN: 21700.01
Driller: Northern Test Boring	Elevation (ft.): 432	Auger ID/OD: 2-1/4-inch ID SSA	
Operator: Mike Nadeau	Datum: NAVD88 (See Remarks)	Sampler: 1-3/8-inch ID split spoon	
Logged By: Vincent Mendoza	Rig Type: Diedrich D-50	Hammer Wt./Fall: 140 pounds / 30 inches	
Date Start/Finish: 04/21/2022 - 04/21/2022	Drilling Method: SSA to 10 feet, then Rotary	Core Barrel: 2-inch NQ	
Boring Location: Sta. 4+94.7, 55.2RT	Casing ID/OD: 4-inch ID HW	Water Level*: 10 feet	

Hammer Efficiency Factor: 0.928	Hammer Type: Automatic <input checked="" type="checkbox"/> Hydraulic <input type="checkbox"/> Rope & Cathead <input type="checkbox"/>
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 Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
25							NQ			Dark gray (N3), fine to medium-grained, MIGMATITE, moderately hard to hard, fresh, moderate dipping, moderately close spacing, open, untitled Devonian Granite Formation Core Rates (min/ft): 1.5-1.25-1.25-1.25-1 Rock Quality: Fair Light gray (N7) intrusion from 27.3 feet to 28.3 feet	q _p =7,630 psi E=790 ksi
30	R2	60/56	29.50 - 34.50	RQD = 90%				Similar to R1 Core Rates (min/ft): 1-2-1.25-1.75-1.5 Rock Quality: Good Light gray (N7) intrusion from 30.5 feet to 30.7 feet			
35								397.5		Light gray (N7) intrusion from 32.3 feet to 33.6 feet Bottom of Exploration at 34.5 feet below ground surface.	
40											
45											
50											

Remarks:
 Boring location and elevation were interpolated from the "Red Bridge over Swift River Plan Set", prepared by the TY Lin International, last dated February 17, 2022.

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	Project: Rumford-Mexico Red Bridge #2707 Location: Rumford and Mexico, Maine	Boring No.: <u>BB-RSR-203</u> WIN: <u>21700.01</u>
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Driller: Northern Test Boring	Elevation (ft.): 428	Auger ID/OD: 2-1/4-inch ID SSA
Operator: Mike Nadeau	Datum: NAVD88 (See Remarks)	Sampler: 1-3/8-inch ID split spoon
Logged By: Vincent Mendoza	Rig Type: Diedrich D-50	Hammer Wt./Fall: 140 pounds / 30 inches
Date Start/Finish: 04/20/2022 - 04/20/2022	Drilling Method: SSA to 5 feet, then Rotary	Core Barrel: 2-inch NQ
Boring Location: Sta. 6+96.2, 29.7LT	Casing ID/OD: 4-inch ID HW	Water Level*: 5 feet

Hammer Efficiency Factor: 0.928	Hammer Type: Automatic <input checked="" type="checkbox"/> Hydraulic <input type="checkbox"/> Rope & Cathead <input type="checkbox"/>	
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 Information								Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows					
0	1D	24/10	0.00 - 2.00	3-6-5-5	11	17	SSA			Dark olive brown (2.5Y 3/3), damp, medium dense, SAND, some silt, trace gravel, poorly-graded (Fill)	A-1-b / SP WC=17.2%	
										Similar, moist, loose (Fill)		
	2D	24/7	2.00 - 4.00	2-3-3-3	6	9						
5	3D	24/2	5.00 - 7.00	1-3-5-5	8	12			424.0	Moist, GRAVEL, some sand, limited recovery (Alluvium)		
	4D	24/14	7.00 - 9.00	3-4-6-6	10	15	30		421.0	Olive brown (2.5Y 4/3), saturated, medium dense, SAND, some gravel, trace silt, poorly-graded (Alluvium)		
							43					
							31					
10	5D	24/3	10.00 - 12.00	7-9-15-17	24	37	22		418.0	Similar, dense (Alluvium)	10.0	
							46					
							47					
							52					
							38					
15	6D	24/0	15.00 - 17.00	4-5-5-7	10	15	30			No recovery in sampler		
							40					
							70					
							65					
							70					
20	7D	24/9	20.00 - 22.00	10-17-15-15	32	49	80		408.0	Olive brown (2.5Y 4/3), saturated, dense, GRAVELLY SAND, trace silt, poorly-graded (Alluvium)	20.0	
							115					
	R1	60/59	22.40 - 27.40	RQD = 96%			80		405.6	Grayish black (N2), fine to medium-grained, MIGMATITE, moderately hard to hard, fresh, moderate dipping, moderately close to wide spacing, open, untitled Devonian Granite Formation	22.4	
							NQ			Core Rates (min/ft): 1.5-1.25-1.25-1-1		
25										Rock Quality: Excellent	q _p =15,789 psi E=1,289 ksi	

Remarks:
Boring location and elevation were interpolated from the "Red Bridge over Swift River Plan Set", prepared by the TY Lin International, last dated February 17, 2022.

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS		Project: Rumford-Mexico Red Bridge #2707	Boring No.: BB-RSR-203
		Location: Rumford and Mexico, Maine	WIN: 21700.01
Driller: Northern Test Boring	Elevation (ft.): 428	Auger ID/OD: 2-1/4-inch ID SSA	
Operator: Mike Nadeau	Datum: NAVD88 (See Remarks)	Sampler: 1-3/8-inch ID split spoon	
Logged By: Vincent Mendoza	Rig Type: Diedrich D-50	Hammer Wt./Fall: 140 pounds / 30 inches	
Date Start/Finish: 04/20/2022 - 04/20/2022	Drilling Method: SSA to 5 feet, then Rotary	Core Barrel: 2-inch NQ	
Boring Location: Sta. 6+96.2, 29.7LT	Casing ID/OD: 4-inch ID HW	Water Level*: 5 feet	

Hammer Efficiency Factor: 0.928 **Hammer Type:** Automatic Hydraulic Rope & Cathead

Definitions: R = Rock Core Sample S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf) T_v = Pocket Torvane Shear Strength (psf)
 D = Split Spoon Sample SSA = Solid Stem Auger S_{u(lab)} = Lab Vane Undrained Shear Strength (psf) WC = Water Content, percent
 MD = Unsuccessful Split Spoon Sample Attempt HSA = Hollow Stem Auger q_p = Unconfined Compressive Strength (ksf) LL = Liquid Limit
 U = Thin Wall Tube Sample RC = Roller Cone N-uncorrected = Raw Field SPT N-value PL = Plastic Limit
 MU = Unsuccessful Thin Wall Tube Sample Attempt WOH = Weight of 140 lb. Hammer Hammer Efficiency Factor = Rig Specific Annual Calibration Value PI = Plasticity Index
 V = Field Vane Shear Test, PP = Pocket Penetrometer WOR/C = Weight of Rods or Casing N₆₀ = SPT N-uncorrected Corrected for Hammer Efficiency G = Grain Size Analysis
 MV = Unsuccessful Field Vane Shear Test Attempt WO1P = Weight of One Person N₆₀ = (Hammer Efficiency Factor/60%)*N-uncorrected C = Consolidation Test

Depth (ft.)	Sample Information								Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows					
25									[Hatched Pattern]	Similar to R1 Core Rates (min/ft): 1-1.25-1-1.25-1.25 Rock Quality: Excellent Light greenish gray (5G 4/1) intrusion from 27.9 feet to 28.6 feet Several light gray (N7) intrusions from 28.6 feet to 29.2 feet		
	R2	60/55	27.40 - 32.40	RQD = 91%								
30								395.6	[Hatched Pattern]	Pinkish gray (5YR 8/1) and light greenish gray (5G 4/1) intrusions from 30.6 feet to 31.4 feet Bottom of Exploration at 32.4 feet below ground surface.		
35												
40												
45												
50												

Remarks:
 Boring location and elevation were interpolated from the "Red Bridge over Swift River Plan Set", prepared by the TY Lin International, last dated February 17, 2022.

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	Project: Rumford-Mexico Red Bridge #2707 Location: Rumford and Mexico, Maine	Boring No.: BB-RSR-204 WIN: 21700.01
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Driller: Northern Test Boring	Elevation (ft.): 429	Auger ID/OD: 2-1/4-inch ID SSA
Operator: Mike Nadeau	Datum: NAVD88 (See Remarks)	Sampler: 1-3/8-inch ID split spoon
Logged By: Vincent Mendoza	Rig Type: Diedrich D-50	Hammer Wt./Fall: 140 pounds / 30 inches
Date Start/Finish: 04/20/2022 - 04/21/2022	Drilling Method: SSA to 10 feet, then Rotary	Core Barrel: 2-inch NQ
Boring Location: Sta. 7+03.3, 49.9RT	Casing ID/OD: 4-inch ID HW	Water Level*: 5 feet

Hammer Efficiency Factor: 0.928	Hammer Type: Automatic <input checked="" type="checkbox"/> Hydraulic <input type="checkbox"/> Rope & Cathead <input type="checkbox"/>	
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 Information								Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows					
0	1D	24/17	0.00 - 2.00	2-3-5-7	8	12	SSA		425.0	Dark olive brown (2.5Y 3/3), damp, medium dense, SAND, some silt, trace gravel, trace glass, poorly-graded (Fill)		
	2D	24/14	2.00 - 4.00	5-4-5-10	9	14				Similar, moist, trace roots (Fill)		
5	3D	24/18	5.00 - 7.00	3-2-2-2	4	6			422.0	Dark olive brown (2.5Y 3/3), moist, loose, SAND, some silt, trace gravel, trace roots, poorly-graded (Alluvium)	A-2-4 / SM WC=32.4%	
	4D	24/12	7.00 - 9.00	3-3-4-14	7	11				Dark olive brown (2.5Y 3/3), wet, medium dense, SAND, little gravel, trace silt, poorly-graded (Alluvium)	A-3 / SP-SM WC=25.2%	
10	5D	24/0	10.00 - 12.00	7-9-5-7	14	22	50		409.0	No recovery in sampler		
							36					
							33					
							53					
							52					
15	6D	24/20	15.00 - 17.00	5-9-12-23	21	32	42			Similar, dense, some gravel (Alluvium)	A-1-b / SP WC=12.5%	
							70					
							158					
							145					
							140					
20	7D	24/5	20.00 - 22.00	23-16-16-22	32	49	74			Similar, well-graded (Alluvium)	A-1-b / SW-SM WC=13.0%	
							90					
							90					
							100					
25							92					

Remarks:
Boring location and elevation were interpolated from the "Red Bridge over Swift River Plan Set", prepared by the TY Lin International, last dated February 17, 2022.

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS		Project: Rumford-Mexico Red Bridge #2707	Boring No.: BB-RSR-204
		Location: Rumford and Mexico, Maine	WIN: 21700.01
Driller: Northern Test Boring	Elevation (ft.): 429	Auger ID/OD: 2-1/4-inch ID SSA	
Operator: Mike Nadeau	Datum: NAVD88 (See Remarks)	Sampler: 1-3/8-inch ID split spoon	
Logged By: Vincent Mendoza	Rig Type: Diedrich D-50	Hammer Wt./Fall: 140 pounds / 30 inches	
Date Start/Finish: 04/20/2022 - 04/21/2022	Drilling Method: SSA to 10 feet, then Rotary	Core Barrel: 2-inch NQ	
Boring Location: Sta. 7+03.3, 49.9RT	Casing ID/OD: 4-inch ID HW	Water Level*: 5 feet	

Hammer Efficiency Factor: 0.928	Hammer Type: Automatic <input checked="" type="checkbox"/> Hydraulic <input type="checkbox"/> Rope & Cathead <input type="checkbox"/>
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 Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
25	8D	24/5	25.00 - 27.00	13-10-8-10	18	28	84	404.0		Similar, medium dense, some gravel and/or cobble fragments (Alluvium)	q _p =7.217 psi E=858 ksi
							95	399.0		Olive brown (2.5Y 4/4), wet, dense, SAND, some silt and weathered rock fragments, poorly-graded (Alluvium)	
							102				
							96				
							154	396.5		Very light gray (N7) to grayish black (N2), fine to medium-grained, MIGMATITE, moderately hard to hard, fresh, steep, moderately close spacing, open, untitled Devonian Granite Formation Core Rates (min/ft): 2-2-2-1-1 Rock Quality: Good	
30	9D	21/4	30.00 - 31.75	12-11-15-50/3"	26	40	94				
							92	386.5		Similar to R1, very light gray (N7) and grayish black (N2) folds from 37.5 feet to 42.5 feet Core Rates (min/ft): 1.5-1.5-1.25-1.25 1.25 Rock Quality: Excellent	
	R1	60/60	32.50 - 37.50	RQD = 83%			95 NQ				
								42.5		Bottom of Exploration at 42.5 feet below ground surface.	
								386.5		Similar to R1, very light gray (N7) and grayish black (N2) folds from 37.5 feet to 42.5 feet Core Rates (min/ft): 1.5-1.5-1.25-1.25 1.25 Rock Quality: Excellent	
	R2	60/59	37.50 - 42.50	RQD = 96%							
35								386.5		Bottom of Exploration at 42.5 feet below ground surface.	
								386.5		Bottom of Exploration at 42.5 feet below ground surface.	
								386.5		Bottom of Exploration at 42.5 feet below ground surface.	
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								386.5		Bottom of Exploration at 42.5 feet below ground surface.	
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								386.5		Bottom of Exploration at 42.5 feet below ground surface.	

Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS		Project: Rumford-Mexico Red Bridge #2707	Boring No.: BB-RSR-101
		Location: Rumford and Mexico, Maine	WIN: 21700.01
Driller: Terracon Consultants, Inc.	Elevation (ft.): 442	Auger ID/OD: N/A	
Operator: Sam Shaw	Datum: NAVD88 (See Remarks)	Sampler: 1-3/8-inch ID split spoon	
Logged By: Jordan Tate	Rig Type: CME-75 Truck	Hammer Wt./Fall: 140 pounds / 30 inches	
Date Start/Finish: 12/21/2016 - 12/22/2016	Drilling Method: Rotary	Core Barrel: N/A	
Boring Location: Sta. 7+32.5, 10.4RT	Casing ID/OD: 4-inch ID / 3-inch ID	Water Level*: 15.7 feet	

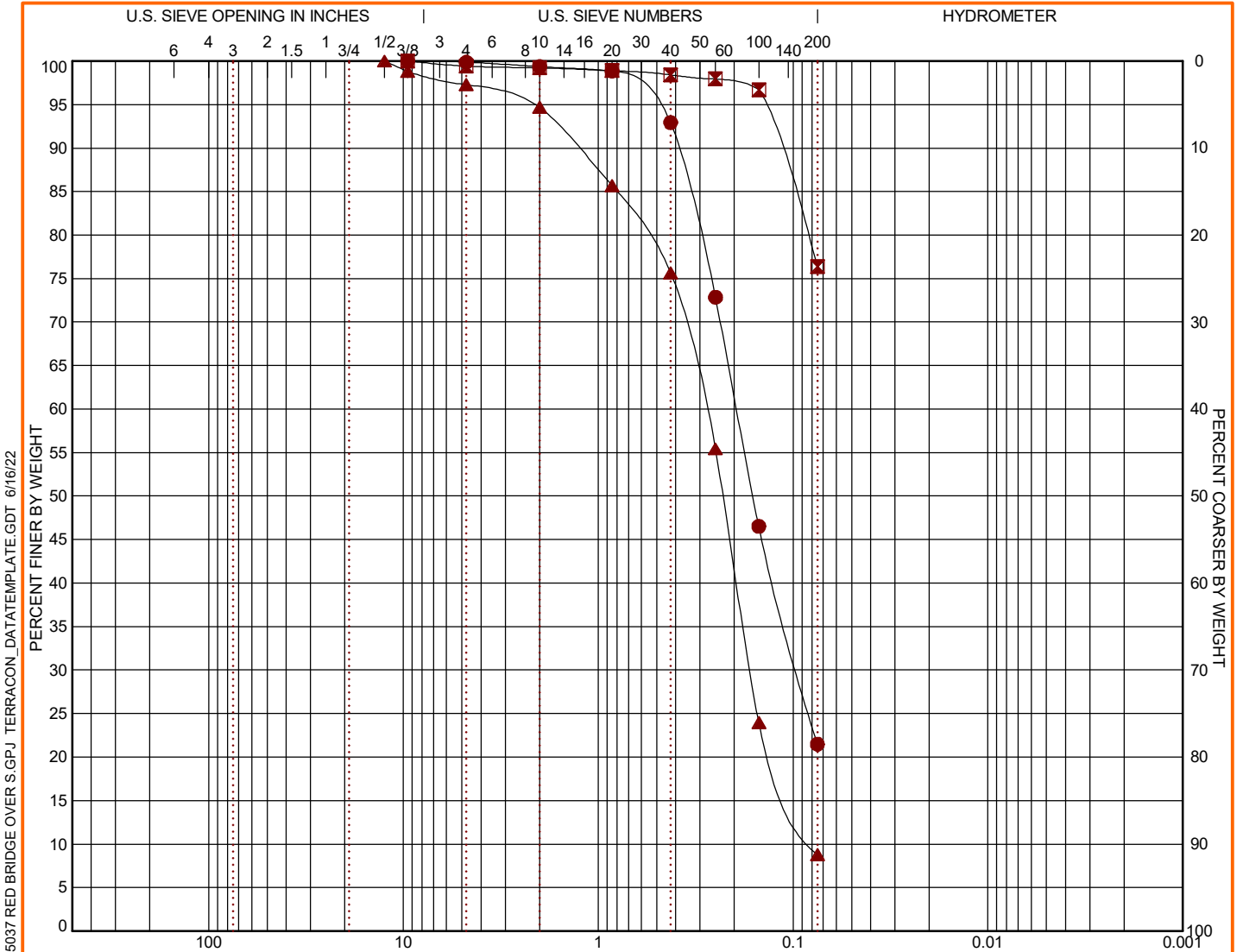
Hammer Efficiency Factor: 0.886	Hammer Type: Automatic <input checked="" type="checkbox"/> Hydraulic <input type="checkbox"/> Rope & Cathead <input type="checkbox"/>
Definitions: D = Split Spoon Sample MD = Unsuccessful Split Spoon Sample Attempt U = Thin Wall Tube Sample MU = Unsuccessful Thin Wall 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 Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N ₆₀	Casing Blows				
25							59		Similar, wet, dense, layered (Alluvium)		
							103				
							106				
							149				
30	8D	24/11	29.00 - 31.00	11-14-12-8	26	38	111				
							105				
							97				
							100				
							105				
35	9D	24/8	34.00 - 36.00	6-7-7-8	14	21	139				
							108				
							121				
							137				
							60				
40	10D	24/6	39.00 - 41.00	7-7-9-10	16	24	55				
							88				
							94				
							141				
45	11D	24/8	44.00 - 46.00	6-7-7-11	14	21	71				
							77				
							127				
							RC				
50							393.0		Roller bit resistance on probable bedrock at 49 feet, roller bit to 51		
							49.0				

Remarks:
 Boring performed as part of preliminary subsurface investigation in 2016. Boring location and elevation have been updated based on interpolation from the "Red Bridge over Swift River Plan Set", prepared by the TY Lin International, last dated February 17, 2022.

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 J1215037 RED BRIDGE OVER S.GPJ TERRACON_DATATEMPLATE.GDT 6/16/22

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
● BB-RSR-201	5 - 7	0.0	0.1	78.4		21.5		SM
☒ BB-RSR-201	15 - 17	0.0	0.6	23.1		76.4		ML
▲ BB-RSR-202	7 - 9	0.0	2.7	88.5		8.8		SP-SM

GRAIN SIZE			
	●	☒	▲
D ₆₀	0.195		0.282
D ₃₀	0.095		0.165
D ₁₀			0.079
COEFFICIENTS			
	●	☒	▲
C _c			1.22
C _u			3.55

●		☒		▲	
Sieve	% Finer	Sieve	% Finer	Sieve	% Finer
3/8"	100.0	3/8"	100.0	1/2"	100.0
#4	99.87	#4	99.41	3/8"	98.82
#10	99.36	#10	99.22	#4	97.28
#20	98.86	#20	98.9	#10	94.68
#40	92.93	#40	98.41	#20	85.69
#60	72.85	#60	97.95	#40	75.67
#100	46.52	#100	96.69	#60	55.43
#200	21.48	#200	76.36	#100	23.98
				#200	8.78

SOIL DESCRIPTION	
●	A-2-4 / Silty Sand (SM)
☒	A-4 / Silt with Sand (ML)
▲	A-3 / Poorly Graded Sand with Silt (SP-SM)
REMARKS	
●	
☒	
▲	

PROJECT: Rumford-Mexico Red Bridge #2707

SITE: U.S. Route 2
Rumford, ME



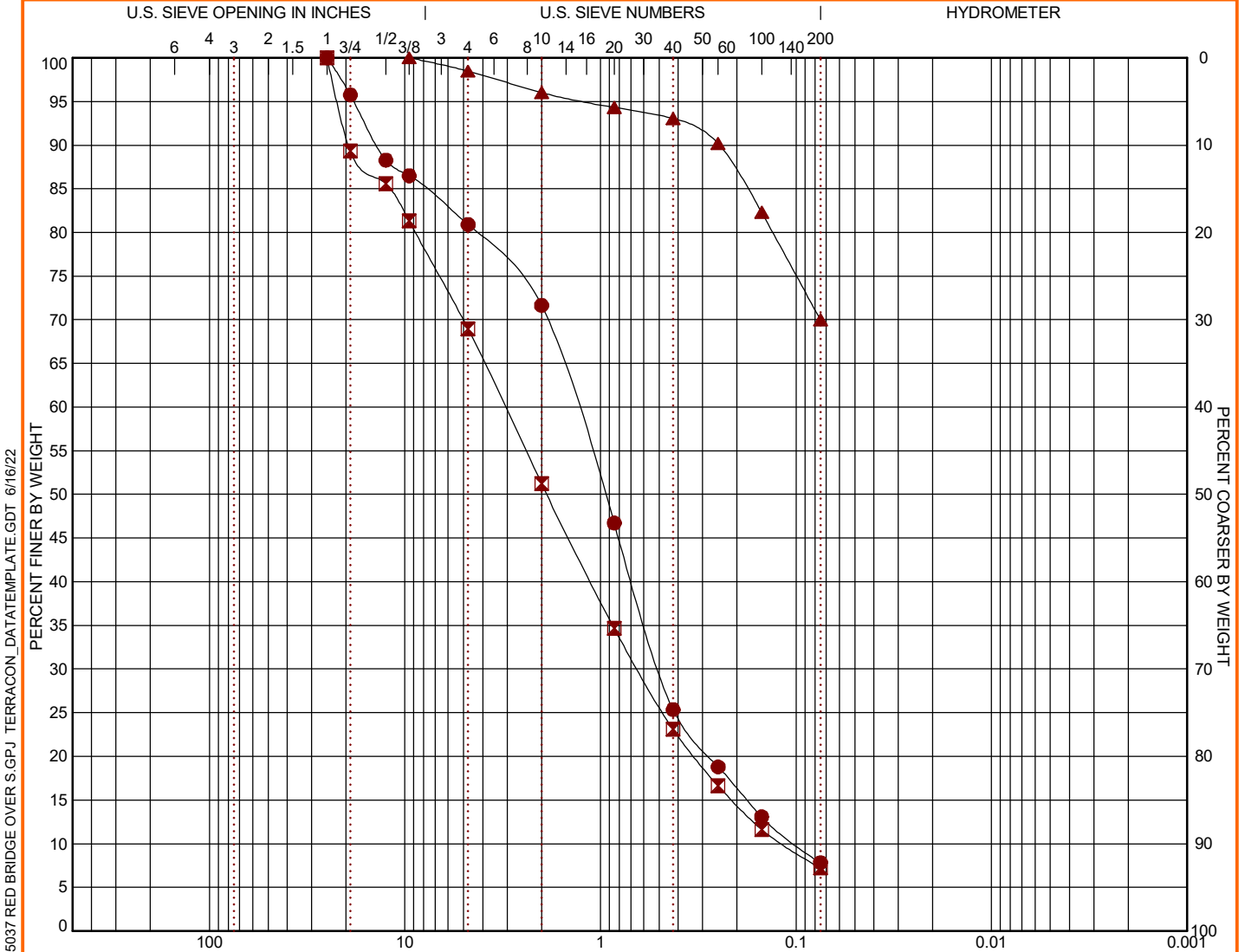
77 Sundial Ave, Ste 401W
Manchester, NH

PROJECT NUMBER: J1215037

CLIENT: TY Lin International
Falmouth, ME

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
● BB-RSR-202	10 - 12	0.0	19.1	73.1		7.8		SW-SM
☒ BB-RSR-202	15 - 17	0.0	31.0	61.7		7.2		SW-SM
▲ BB-RSR-202	20 - 22	0.0	1.5	28.5		70.0		ML

GRAIN SIZE			
	●	☒	▲
D ₆₀	1.341	3.068	
D ₃₀	0.494	0.643	
D ₁₀	0.1	0.116	

COEFFICIENTS			
	●	☒	▲
C _c	1.82	1.16	
C _u	13.41	26.45	

●		☒		▲	
Sieve	% Finer	Sieve	% Finer	Sieve	% Finer
1"	100.0	1"	100.0	3/8"	100.0
3/4"	95.75	3/4"	89.3	#4	98.48
1/2"	88.28	1/2"	85.6	#10	96.02
3/8"	86.5	3/8"	81.33	#20	94.32
#4	80.91	#4	68.97	#40	93.06
#10	71.65	#10	51.22	#60	90.18
#20	46.72	#20	34.66	#100	82.34
#40	25.35	#40	23.08	#200	69.99
#60	18.79	#60	16.62		
#100	13.08	#100	11.63		
#200	7.82	#200	7.24		

SOIL DESCRIPTION	
●	A-1-b / Well Graded Sand with Silt and Gravel (SW-SM)
☒	A-1-b / Well Graded Sand with Silt and Gravel (SW-SM)
▲	A-4 / Sandy Silt (ML)
REMARKS	
●	
☒	
▲	

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 J1215037 RED BRIDGE OVER S.G.P.J TERRACON_DATATEMPLATE.GDT 6/16/22

PROJECT: Rumford-Mexico Red Bridge #2707

SITE: U.S. Route 2
Rumford, ME



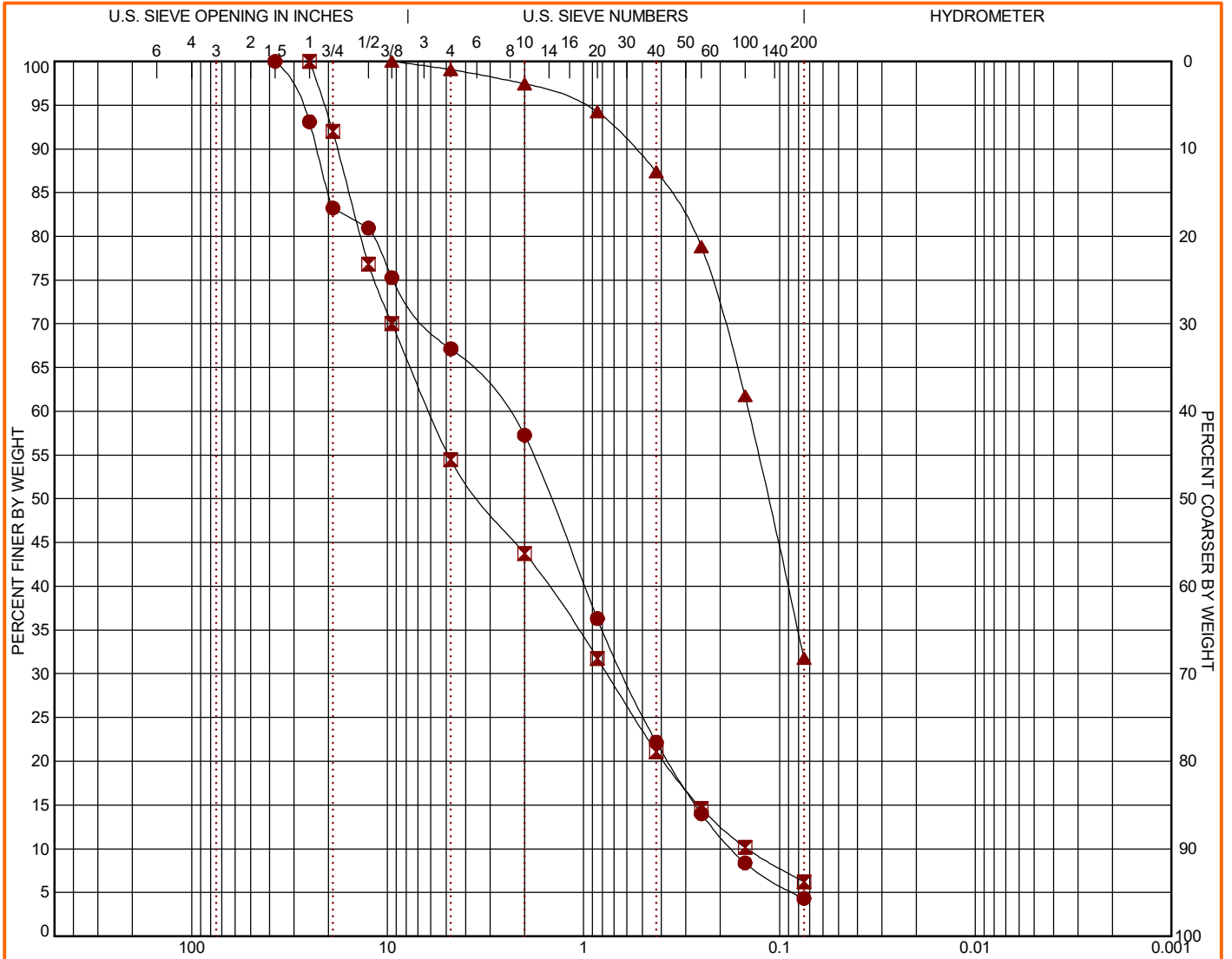
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Manchester, NH

PROJECT NUMBER: J1215037

CLIENT: TY Lin International
Falmouth, ME

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
● BB-RSR-203	7 - 9	0.0	32.9	62.8		4.3		SP
☒ BB-RSR-203	20 - 22	0.0	45.5	48.2		6.2		SP-SM
▲ BB-RSR-204	5 - 7	0.0	0.9	67.3		31.8		SM

GRAIN SIZE			
	●	☒	▲
D ₆₀	2.54	6.077	0.144
D ₃₀	0.624	0.757	
D ₁₀	0.174	0.145	

COEFFICIENTS			
	●	☒	▲
C _c	0.88	0.65	
C _u	14.62	41.77	

●		☒		▲	
Sieve	% Finer	Sieve	% Finer	Sieve	% Finer
1 1/2"	100.0	1"	100.0	3/8"	100.0
1"	93.1	3/4"	91.98	#4	99.05
3/4"	83.24	1/2"	76.82	#10	97.44
1/2"	80.94	3/8"	70.05	#20	94.23
3/8"	75.28	#4	54.46	#40	87.38
#4	67.15	#10	43.77	#60	78.83
#10	57.27	#20	31.78	#100	61.77
#20	36.31	#40	21.11	#200	31.78
#40	22.18	#60	14.58		
#60	14.0	#100	10.17		
#100	8.39	#200	6.23		
#200	4.32				

SOIL DESCRIPTION	
●	A-1-b / Poorly Graded Sand with Gravel (SP)
☒	A-1-a / Poorly Graded Sand with Silt and Gravel (SP-SM)
▲	A-2-4 / Silty Sand (SM)

REMARKS	
●	
☒	
▲	

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 J1215037 RED BRIDGE OVER S.G.P.J TERRACON_DATATEMPLATE.GDT 6/16/22

PROJECT: Rumford-Mexico Red Bridge #2707

SITE: U.S. Route 2
Rumford, ME



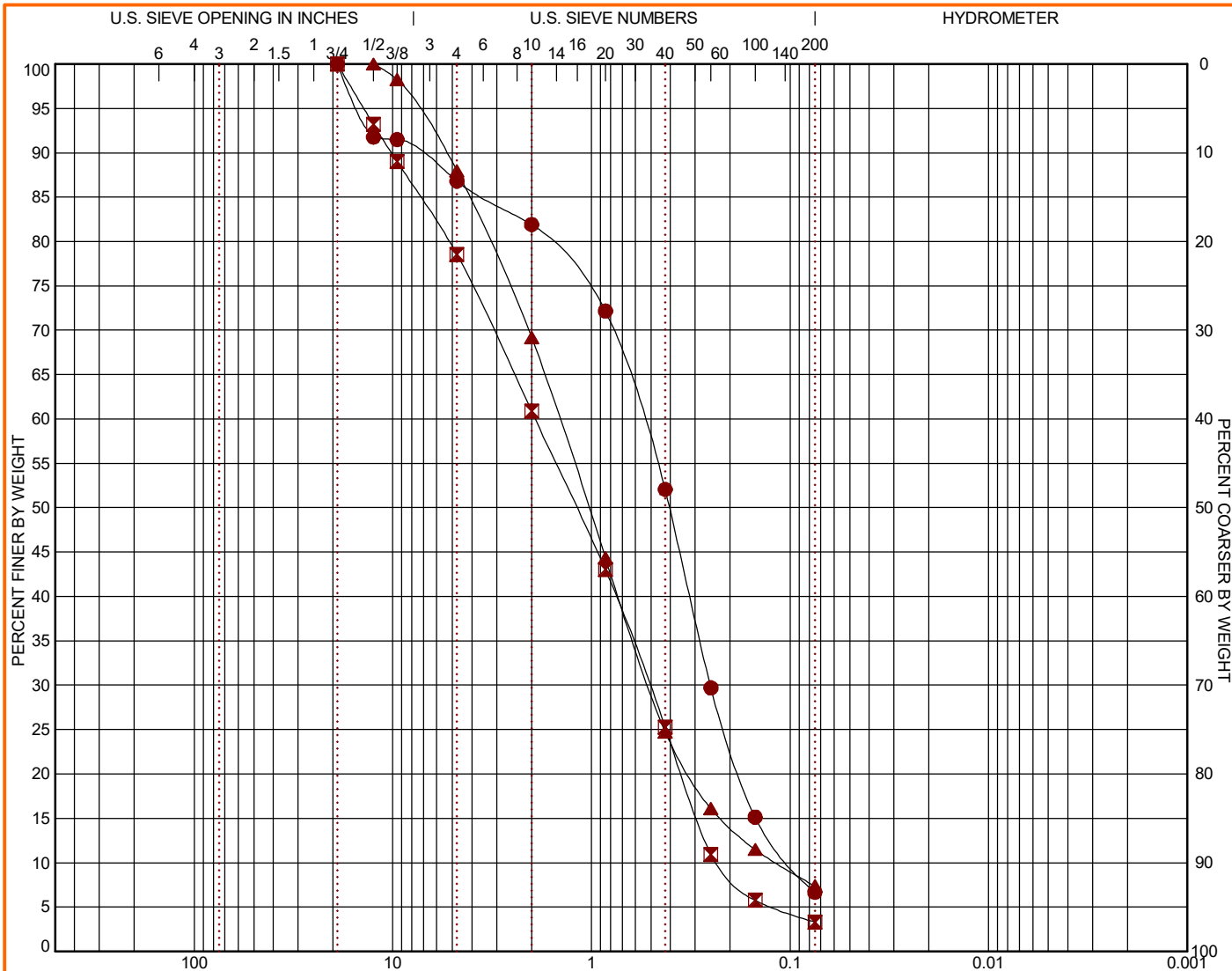
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Manchester, NH

PROJECT NUMBER: J1215037

CLIENT: TY Lin International
Falmouth, ME

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
● BB-RSR-204	7 - 9	0.0	13.2	80.2	6.7			SP-SM
☒ BB-RSR-204	15 - 17	0.0	21.4	75.3	3.3			SP
▲ BB-RSR-204	20 - 22	0.0	12.0	80.6	7.4			SW-SM

GRAIN SIZE			
	●	☒	▲
D ₆₀	0.559	1.919	1.457
D ₃₀	0.252	0.511	0.512
D ₁₀	0.099	0.228	0.117

COEFFICIENTS			
	●	☒	▲
C _c	1.15	0.60	1.54
C _u	5.67	8.41	12.49

●		☒		▲	
Sieve	% Finer	Sieve	% Finer	Sieve	% Finer
3/4"	100.0	3/4"	100.0	1/2"	100.0
1/2"	91.78	1/2"	93.19	3/8"	98.25
3/8"	91.48	3/8"	88.99	#4	87.97
#4	86.81	#4	78.56	#10	69.2
#10	81.91	#10	60.87	#20	44.37
#20	72.16	#20	43.03	#40	24.75
#40	52.06	#40	25.26	#60	16.08
#60	29.7	#60	10.93	#100	11.49
#100	15.13	#100	5.75	#200	7.38
#200	6.66	#200	3.3		

SOIL DESCRIPTION	
●	A-3 / Poorly Graded Sand with Silt (SP-SM)
☒	A-1-b / Poorly Graded Sand with Gravel (SP)
▲	A-1-b / Well Graded Sand with Silt (SW-SM)

REMARKS	
●	
☒	
▲	

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 J1215037 RED BRIDGE OVER S.GPJ TERRACON_DATATEMPLATE.GDT 6/16/22

PROJECT: Rumford-Mexico Red Bridge #2707

SITE: U.S. Route 2
Rumford, ME



77 Sundial Ave, Ste 401W
Manchester, NH

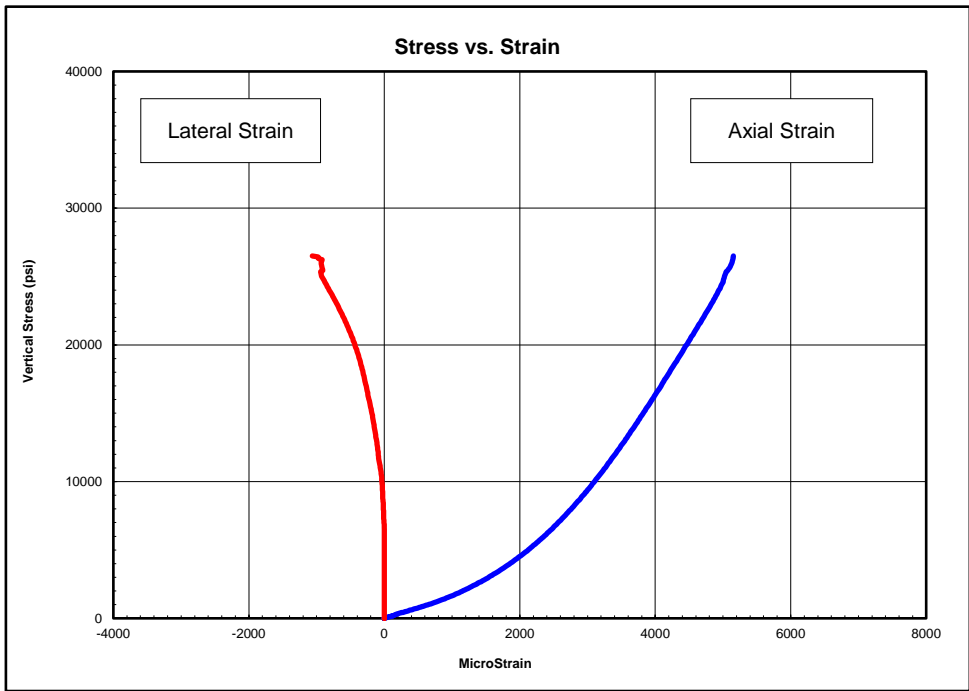
PROJECT NUMBER: J1215037

CLIENT: TY Lin International
Falmouth, ME



Client:	Maine DOT
Project Name:	Red Bridge
Project Location:	Rumford- Mexico, ME
GTX #:	305962
Test Date:	2/7/2017
Tested By:	trm/rlc
Checked By:	jsc
Boring ID:	BB-RSR-102
Sample ID:	R1-2
Depth, ft:	37.0-37.37
Sample Type:	rock core
Sample Description:	See photographs Intact material failure

**Compressive Strength and Elastic Moduli of Rock
by ASTM D7012 - Method D**



Peak Compressive Stress: 26,522 psi

Stress Range, psi	Young's Modulus, psi	Poisson's Ratio
2700-9700	4,340,000	0.02
9700-16800	7,090,000	0.23
16800-23900	8,080,000	---

Notes: Test specimen tested at the approximate as-received moisture content and at standard laboratory temperature. The axial load was applied continuously at a stress rate that produced failure in a test time between 2 and 15 minutes. Young's Modulus and Poisson's Ratio calculated using the tangent to the line in the stress range listed. Calculations assume samples are isotropic, which is not necessarily the case.



Client:	Maine DOT	Test Date:	2/4/2017
Project Name:	Red Bridge	Tested By:	trm/rlc
Project Location:	Rumford- Mexico, ME	Checked By:	jsc
GTX #:	305962		
Boring ID:	BB-RSR-102		
Sample ID:	R1-2		
Depth:	37.0-37.37 ft		
Visual Description:	See photographs		

UNIT WEIGHT DETERMINATION AND DIMENSIONAL AND SHAPE TOLERANCES OF ROCK CORE SPECIMENS BY ASTM D4543

BULK DENSITY				DEVIATION FROM STRAIGHTNESS (Procedure S1)			
	1	2	Average	Maximum gap between side of core and reference surface plate: Is the maximum gap \leq 0.02 in.? NO			
Specimen Length, in:	4.45	4.44	4.45	Maximum difference must be $<$ 0.020 in.			
Specimen Diameter, in:	1.98	1.98	1.98	Straightness Tolerance Met? NO			
Specimen Mass, g:	581.68						
Bulk Density, lb/ft ³ :	162						
Length to Diameter Ratio:	2.2	Minimum Diameter Tolerance Met? YES					
		Length to Diameter Ratio Tolerance Met? YES					

END FLATNESS AND PARALLELISM (Procedure FP1)															
END 1	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	-0.00070	-0.00060	-0.00050	-0.00040	-0.00030	-0.00020	-0.00010	0.00000	0.00000	0.00010	0.00020	0.00030	0.00030	0.00030	0.00030
Diameter 2, in (rotated 90°)	-0.00030	-0.00020	-0.00020	-0.00010	0.00000	0.00000	0.00000	0.00000	0.00000	-0.00010	-0.00020	-0.00030	-0.00020	-0.00010	-0.00010
	Difference between max and min readings, in: 0° = 0.00100 90° = 0.00030														
END 2	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	-0.00070	-0.00060	-0.00050	-0.00040	-0.00030	-0.00020	-0.00010	0.00000	0.00010	0.00020	0.00020	0.00030	0.00030	0.00030	0.00030
Diameter 2, in (rotated 90°)	-0.00030	-0.00020	-0.00010	-0.00010	-0.00010	0.00000	0.00000	0.00000	-0.00010	-0.00010	-0.00020	-0.00030	-0.00030	-0.00030	-0.00030
	Difference between max and min readings, in: 0° = 0.001 90° = 0.0003 Maximum difference must be $<$ 0.0020 in. Difference = \pm 0.00050														
	Flatness Tolerance Met? YES														

	<p>DIAMETER 1</p> <p>End 1: Slope of Best Fit Line: 0.00060 Angle of Best Fit Line: 0.03438</p> <p>End 2: Slope of Best Fit Line: 0.00062 Angle of Best Fit Line: 0.03552</p> <p>Maximum Angular Difference: 0.00115</p> <p align="center">Parallelism Tolerance Met? YES Spherically Seated</p> <hr/> <p>DIAMETER 2</p> <p>End 1: Slope of Best Fit Line: 0.00001 Angle of Best Fit Line: 0.00057</p> <p>End 2: Slope of Best Fit Line: 0.00007 Angle of Best Fit Line: 0.00401</p> <p>Maximum Angular Difference: 0.00344</p> <p align="center">Parallelism Tolerance Met? YES Spherically Seated</p>
--	---

PERPENDICULARITY (Procedure P1) (Calculated from End Flatness and Parallelism measurements above)						<i>Maximum angle of departure must be \leq 0.25°</i>
END 1	Difference, Maximum and Minimum (in.)	Diameter (in.)	Slope	Angle°	Perpendicularity Tolerance Met?	
Diameter 1, in	0.00100	1.978	0.00051	0.029	YES	
Diameter 2, in (rotated 90°)	0.00030	1.978	0.00015	0.009	YES	Perpendicularity Tolerance Met? YES
END 2						
Diameter 1, in	0.00100	1.978	0.00051	0.029	YES	
Diameter 2, in (rotated 90°)	0.00030	1.978	0.00015	0.009	YES	



Client:	Maine DOT
Project Name:	Red Bridge
Project Location:	Rumford- Mexico, ME
GTX #:	305962
Test Date:	2/7/2017
Tested By:	trm/rlc
Checked By:	jsc
Boring ID:	BB-RSR-102
Sample ID:	R1-2
Depth, ft:	37.0-37.37



After cutting and grinding



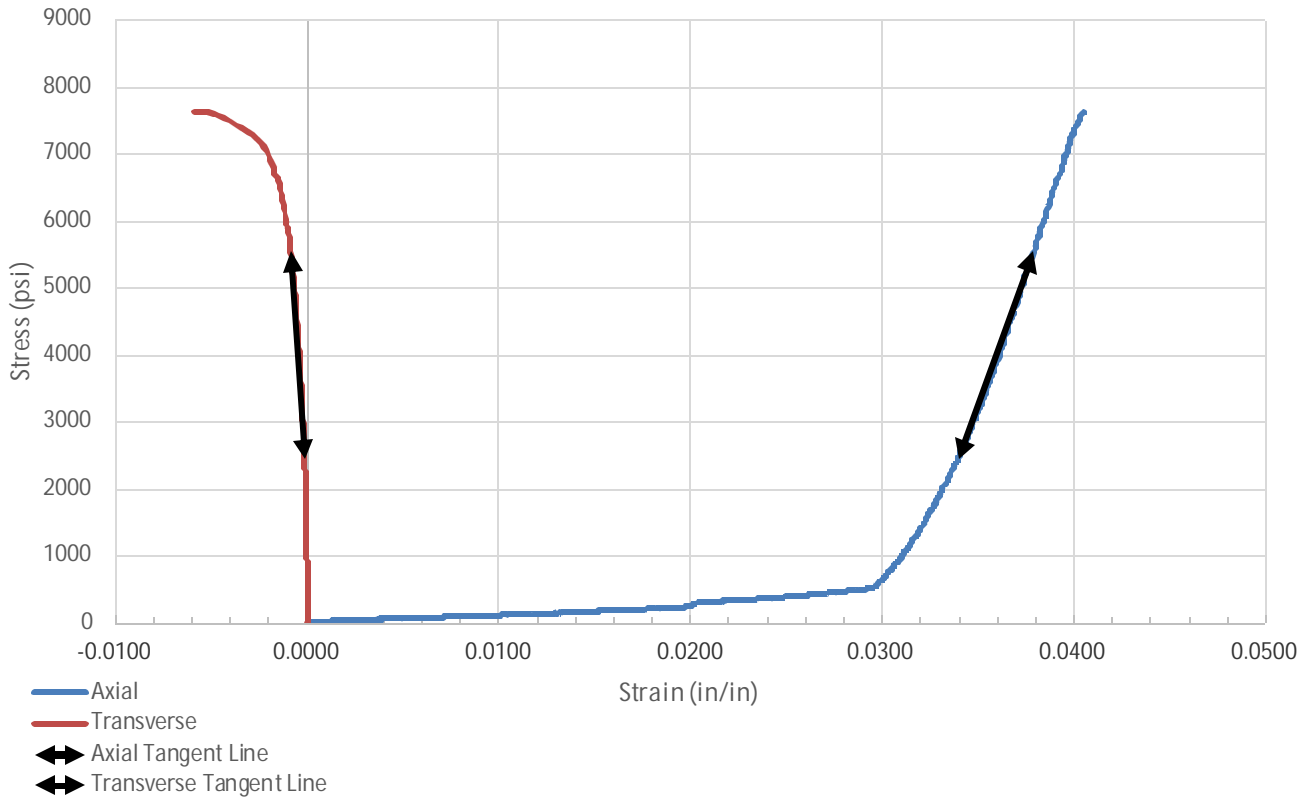
After break

Client
TY Lin International Falmouth, ME

Project
Rumford - Mexico Red Bridge #2707

Project No. J1215037

ASTM D7012 Stress/ Strain Curve



SAMPLE LOCATION

Site:	Rumford-Mexico Red Bridge #2707		
Rock Type:	Migmatite		
Boring:	BB-RSR-202	Depth (feet):	25.3-26.2

SPECIMEN INFORMATION

Moisture Content:	0.1%	Mass (g):	616.17
Length (in.):	4.23	Diameter (in.):	1.99
L/D Ratio:	2.1	Density (pcf):	178.419

TEST RESULTS

Failure Load (lbs):	23732
Failure Strain (%):	4.15
Unconfined Compressive Strength (psi):	7,630
Elastic Modulus, E, (ksi):	790
Poisson's Ratio, u:	0.185
Time of Failure (min):	03:10
Rate of Loading (psi/sec):	40.202

Client TY Lin International Falmouth, ME	Project Rumford - Mexico Red Bridge #2707
--	---

Project No. J1215037

ASTM D4543 Test Results:

<u>Parameter</u>	<u>Data</u>
Side Straightness:	0.0051
Perpendicularity Deviation:	
Diameter 1a:	0.0070
Diameter 1b:	0.0033
Diameter 2a:	0.0083
Diameter 2b:	0.0019
Max Deviation from Flatness:	0.0021
Parallelism Deviation:	
Diameter a:	0.02
Diameter b:	0.25

Equipment:

TICCS ID:	
Calipers:	W-54522
Scale:	B-38686
Dial Indicator:	W-71336
Compression (spherically seated):	Yes

Samples were prepared and tested in accordance with ASTM D4543 and D7012. Deviations, if any, are noted below:
Notes:

Per ASTM D4543, this specimen has not met the requirements for straightness, by exceeding 0.02 inches.
Per ASTM D4543, this specimen has not met the requirements for perpendicularity, by exceeding 0.250°.
Per ASTM D4543, this specimen has not met the requirements for flatness, by exceeding 0.001 inches.

According to ASTM D7012 Section 8.2.1, this specimen, although not meeting all requirements of ASTM D4543 is acceptable for testing. However, the results reported may differ from results obtained from a test specimen that meets the requirements of D4543.

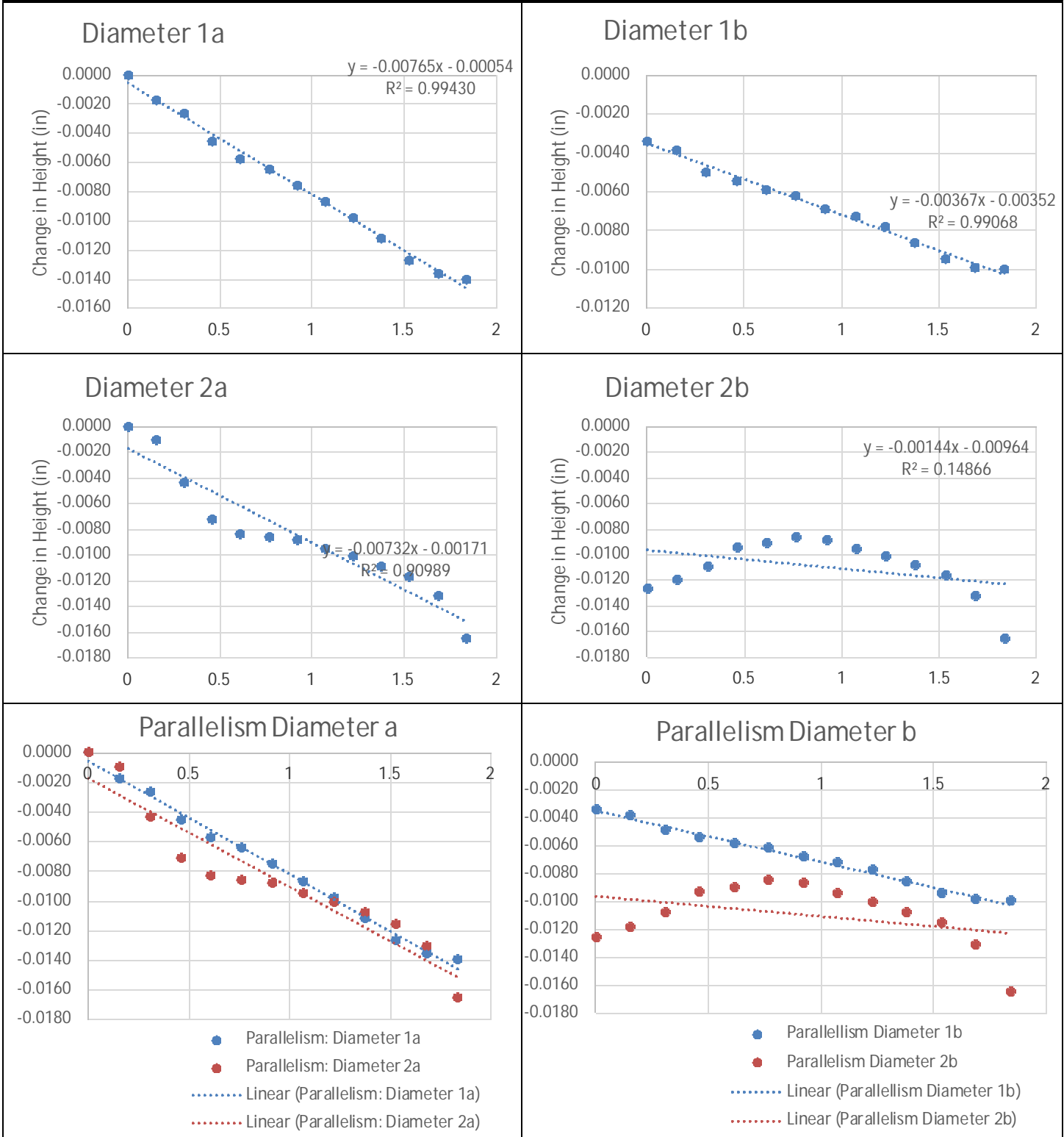
Client

TY Lin International Falmouth, ME

Project

Rumford - Mexico Red Bridge #2707

Project No. J1215037



Client

TY Lin International Falmouth, ME

Project

Rumford - Mexico Red Bridge #2707

Project No. J1215037

Tolerances Check
Side Straightness (Procedure S2):

 Maximum Gap \leq 0.020 in.

	Minimum Reading (in)	Maximum Reading (in)	Difference (in)
Δ 0°	0.0000	0.0041	0.0041
Δ 120°	0.0022	0.0042	0.0020
Δ 240°	-0.0008	0.0043	0.0051
Side Straightness Tolerance Met:	<u>Yes</u>		

End Flatness (Method FP2):

Distance (in):	0	0.1531	0.3062	0.4592	0.6123	0.7654	0.9185	1.0715	1.2246	1.3777	1.5308	1.6838	1.8369
Diameter 1a (in):	0.0000	-0.0018	-0.0027	-0.0045	-0.0057	-0.0065	-0.0076	-0.0087	-0.0098	-0.0112	-0.0127	-0.0136	-0.0140
Diameter 1b (in):	-0.0034	-0.0039	-0.0050	-0.0055	-0.0059	-0.0062	-0.0069	-0.0073	-0.0078	-0.0086	-0.0095	-0.0099	-0.0100

 Tolerance Met: Yes

Distance (in):	0	0.1531	0.3062	0.4592	0.6123	0.7654	0.9185	1.0715	1.2246	1.3777	1.5308	1.6838	1.8369
Diameter 2a (in):	0.0000	-0.0010	-0.0044	-0.0072	-0.0083	-0.0086	-0.0088	-0.0095	-0.0101	-0.0108	-0.0116	-0.0131	-0.0165
Diameter 2b (in):	-0.0126	-0.0119	-0.0109	-0.0094	-0.0090	-0.0086	-0.0088	-0.0095	-0.0101	-0.0108	-0.0116	-0.0131	-0.0165

 Tolerance Met: No
Parallelism (Method FP2):

Diameter 1a Angle of Best Fit (°):	-0.44	Diameter 1b Angle of Best Fit (°):	-0.21
Diameter 2a Angle of Best Fit (°):	-0.42	Diameter 2b Angle of Best Fit (°):	0.03
Maximum Angular Difference (°):	0.02	Maximum Angular Difference (°):	0.25
Parallelism Tolerance Met:	<u>Yes</u>	Parallelism Tolerance Met:	<u>Yes</u>

Perpendicularity (Procedure P1):

	Max Difference	Diameter (in)	Slope	Slope \leq 0.0043	Perpendicular Tolerance Met?
Diameter 1a	0.0140	1.99	0.0070	No	<u>No</u>
Diameter 1b	0.0066		0.0033	Yes	<u>Yes</u>
Diameter 2a	0.0165		0.0083	No	<u>No</u>
Diameter 2b	0.0037		0.0019	Yes	<u>Yes</u>

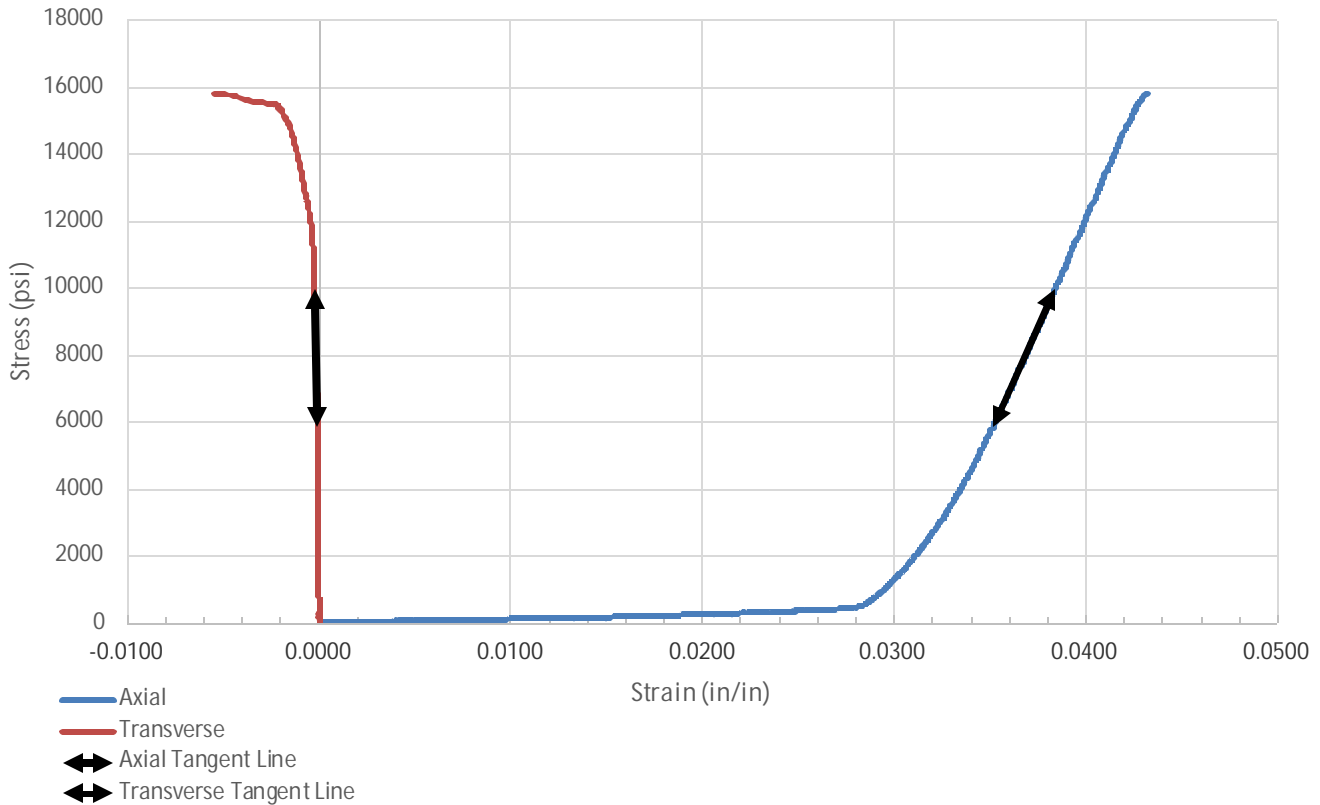
Technician for performed Sample Preparation: cs
 Technician for performing Sample Measurements: cs
 Technician for performing Compressive Strength: cs

Client
TY Lin International Falmouth, ME

Project
Rumford - Mexico Red Bridge #2707

Project No. J1215037

ASTM D7012 Stress/ Strain Curve



SAMPLE LOCATION

Site:	Rumford-Mexico Red Bridge #2707		
Rock Type:	Migmatite		
Boring:	BB-RSR-203	Depth (feet):	23.7-24.5

SPECIMEN INFORMATION

Moisture Content:	0.2%	Mass (g):	641.22
Length (in.):	4.27	Diameter (in.):	2.00
L/D Ratio:	2.1	Density (pcf):	182.099

TEST RESULTS

Failure Load (lbs):	49603
Failure Strain (%):	4.34
Unconfined Compressive Strength (psi):	15,789
Elastic Modulus, E, (ksi):	1289
Poisson's Ratio, u:	0.046
Time of Failure (min):	02:43
Rate of Loading (psi/sec):	96.747

Client TY Lin International Falmouth, ME	Project Rumford - Mexico Red Bridge #2707
--	---

Project No. J1215037

ASTM D4543 Test Results:

<u>Parameter</u>	<u>Data</u>
Side Straightness:	0.0029
Perpendicularity Deviation:	
Diameter 1a:	0.0080
Diameter 1b:	0.0080
Diameter 2a:	0.0138
Diameter 2b:	0.0059
Max Deviation from Flatness:	0.0066
Parallelism Deviation:	
Diameter a:	0.44
Diameter b:	0.63

Equipment:

	TICCS ID:
Calipers:	W-54522
Scale:	B-38686
Dial Indicator:	W-71336
Compression (spherically seated):	Yes

Samples were prepared and tested in accordance with ASTM D4543 and D7012. Deviations, if any, are noted below:
Notes:

- Per ASTM D4543, this specimen has not met the requirements for straightness, by exceeding 0.02 inches.
- Per ASTM D4543, this specimen has not met the requirements for perpendicularity, by exceeding 0.250°.
- Per ASTM D4543, this specimen has not met the requirements for flatness, by exceeding 0.001 inches.
- Per ASTM D4543, this specimen has not met the requirements for parallelism, by exceeding 0.25°.

According to ASTM D7012 Section 8.2.1, this specimen, although not meeting all requirements of ASTM D4543 is acceptable for testing. However, the results reported may differ from results obtained from a test specimen that meets the requirements of D4543.

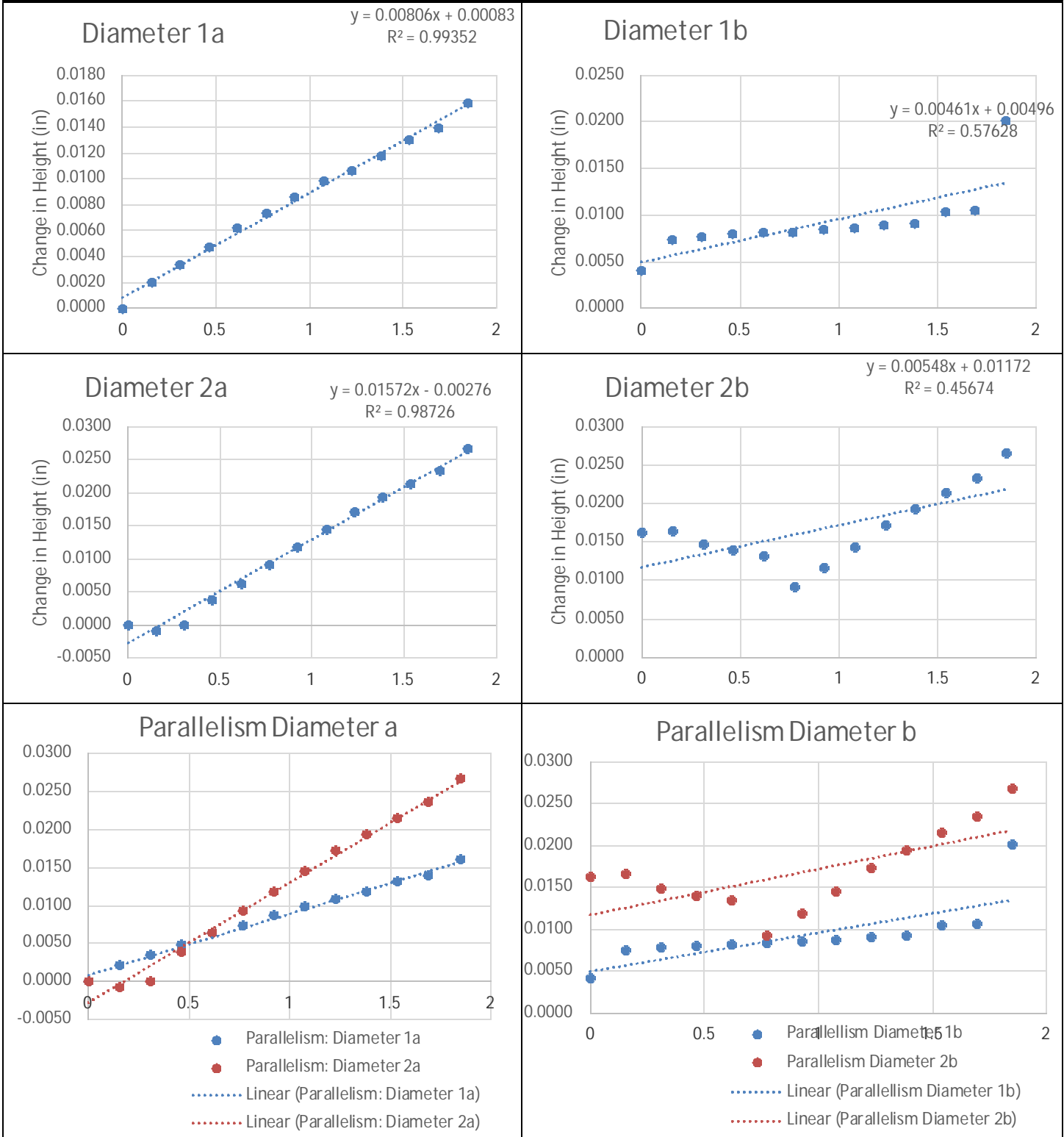
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Project

Rumford - Mexico Red Bridge #2707

Project No. J1215037



Client

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Project

Rumford - Mexico Red Bridge #2707

Project No. J1215037

Tolerances Check
Side Straightness (Procedure S2):

 Maximum Gap \leq 0.020 in.

	Minimum Reading (in)	Maximum Reading (in)	Difference (in)
Δ 0°	-0.0030	-0.0010	0.0020
Δ 120°	-0.0020	0.0009	0.0029
Δ 240°	-0.0012	-0.0001	0.0011
Side Straightness Tolerance Met:	<u>Yes</u>		

End Flatness (Method FP2):

Distance (in):	0	0.1538	0.3077	0.4615	0.6154	0.7692	0.9231	1.0769	1.2308	1.3846	1.5385	1.6923	1.8462
Diameter 1a (in):	0.0000	0.0020	0.0034	0.0048	0.0063	0.0074	0.0087	0.0099	0.0107	0.0118	0.0130	0.0139	0.0159
Diameter 1b (in):	0.0041	0.0074	0.0077	0.0080	0.0081	0.0082	0.0085	0.0087	0.0090	0.0092	0.0105	0.0106	0.0201

 Tolerance Met: No

Distance (in):	0	0.1538	0.3077	0.4615	0.6154	0.7692	0.9231	1.0769	1.2308	1.3846	1.5385	1.6923	1.8462
Diameter 2a (in):	0.0000	-0.0009	0.0000	0.0039	0.0064	0.0092	0.0118	0.0145	0.0172	0.0193	0.0214	0.0235	0.0267
Diameter 2b (in):	0.0162	0.0165	0.0147	0.0140	0.0133	0.0092	0.0118	0.0145	0.0172	0.0193	0.0214	0.0235	0.0267

 Tolerance Met: No
Parallelism (Method FP2):

Diameter 1a Angle of Best Fit (°):	0.46	Diameter 1b Angle of Best Fit (°):	0.26
Diameter 2a Angle of Best Fit (°):	0.90	Diameter 2b Angle of Best Fit (°):	-0.36
Maximum Angular Difference (°):	0.44	Maximum Angular Difference (°):	0.63
Parallelism Tolerance Met:	<u>No</u>	Parallelism Tolerance Met:	<u>No</u>

Perpendicularity (Procedure P1):

	Max Difference	Diameter (in)	Slope	Slope \leq 0.0043	Perpendicular Tolerance Met?
Diameter 1a	0.0159	2	0.0080	No	<u>No</u>
Diameter 1b	0.0161		0.0080	No	<u>No</u>
Diameter 2a	0.0275		0.0138	No	<u>No</u>
Diameter 2b	0.0118		0.0059	No	<u>No</u>

Technician for performed Sample Preparation: cs

Technician for performing Sample Measurements: cs

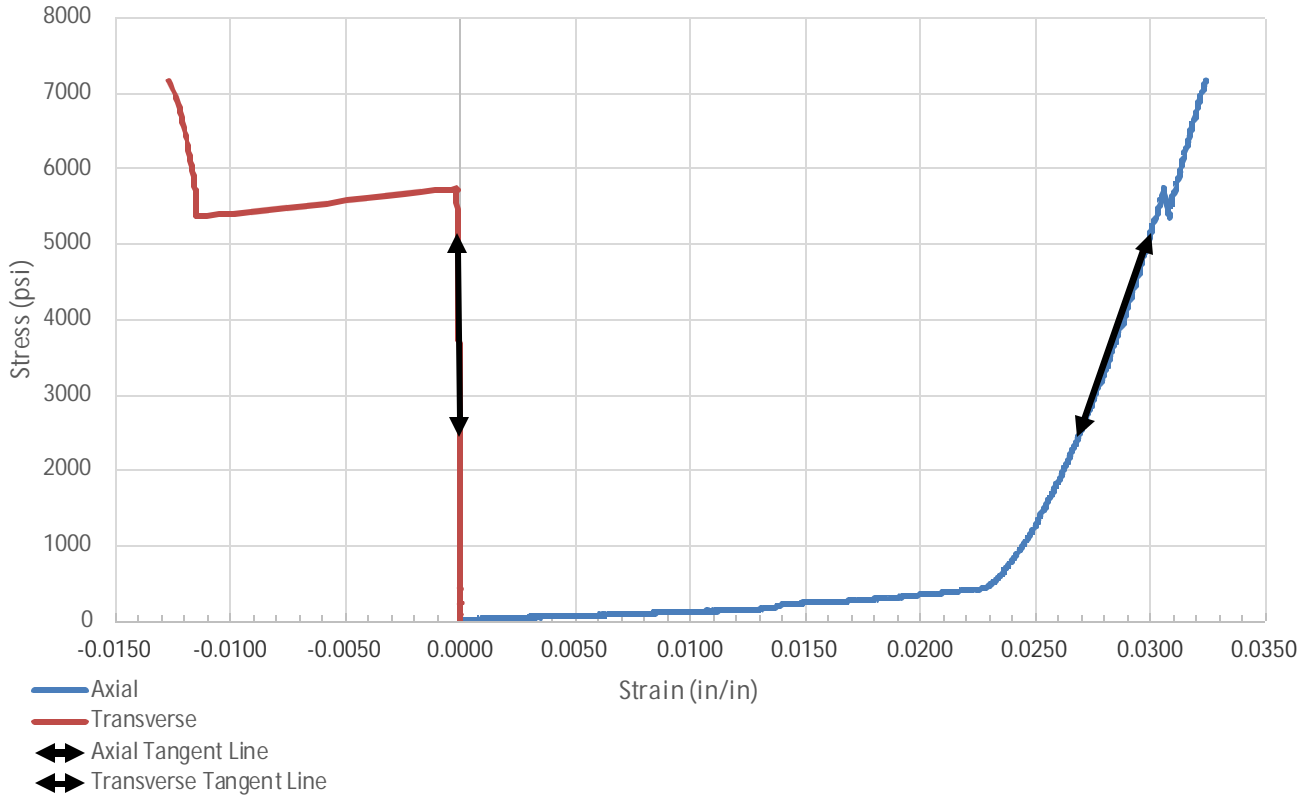
Technician for performing Compressive Strength: cs

Client
TY Lin International Falmouth, ME

Project
Rumford - Mexico Red Bridge #2707

Project No. J1215037

ASTM D7012 Stress/ Strain Curve



SAMPLE LOCATION

Site:	Rumford-Mexico Red Bridge #2707		
Rock Type:	Migmatite		
Boring:	BB-RSR-204	Depth (feet):	33.6-34.5

SPECIMEN INFORMATION

Moisture Content:	0.3%	Mass (g):	569.52
Length (in.):	4.325	Diameter (in.):	2.00
L/D Ratio:	2.2	Density (pcf):	159.680

TEST RESULTS

Failure Load (lbs):	22673
Failure Strain (%):	3.24
Unconfined Compressive Strength (psi):	7,217
Elastic Modulus, E, (ksi):	858
Poisson's Ratio, u:	0.034
Time of Failure (min):	03:49
Rate of Loading (psi/sec):	31.516

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Project

Rumford - Mexico Red Bridge #2707

Project No. J1215037

ASTM D4543 Test Results:

<u>Parameter</u>	<u>Data</u>
Side Straightness:	0.0030
Perpendicularity Deviation:	
Diameter 1a:	0.0199
Diameter 1b:	0.0139
Diameter 2a:	0.0121
Diameter 2b:	0.0198
Max Deviation from Flatness:	0.0144
Parallelism Deviation:	
Diameter a:	0.57
Diameter b:	1.80

Equipment:

	TICCS ID:
Calipers:	W-54522
Scale:	B-38686
Dial Indicator:	W-71336
Compression (spherically seated):	Yes

Samples were prepared and tested in accordance with ASTM D4543 and D7012. Deviations, if any, are noted below:
Notes:

Per ASTM D4543, this specimen has not met the requirements for straightness, by exceeding 0.02 inches.
Per ASTM D4543, this specimen has not met the requirements for perpendicularity, by exceeding 0.250°.
Per ASTM D4543, this specimen has not met the requirements for flatness, by exceeding 0.001 inches.

According to ASTM D7012 Section 8.2.1, this specimen, although not meeting all requirements of ASTM D4543 is acceptable for testing. However, the results reported may differ from results obtained from a test specimen that meets the requirements of D4543.

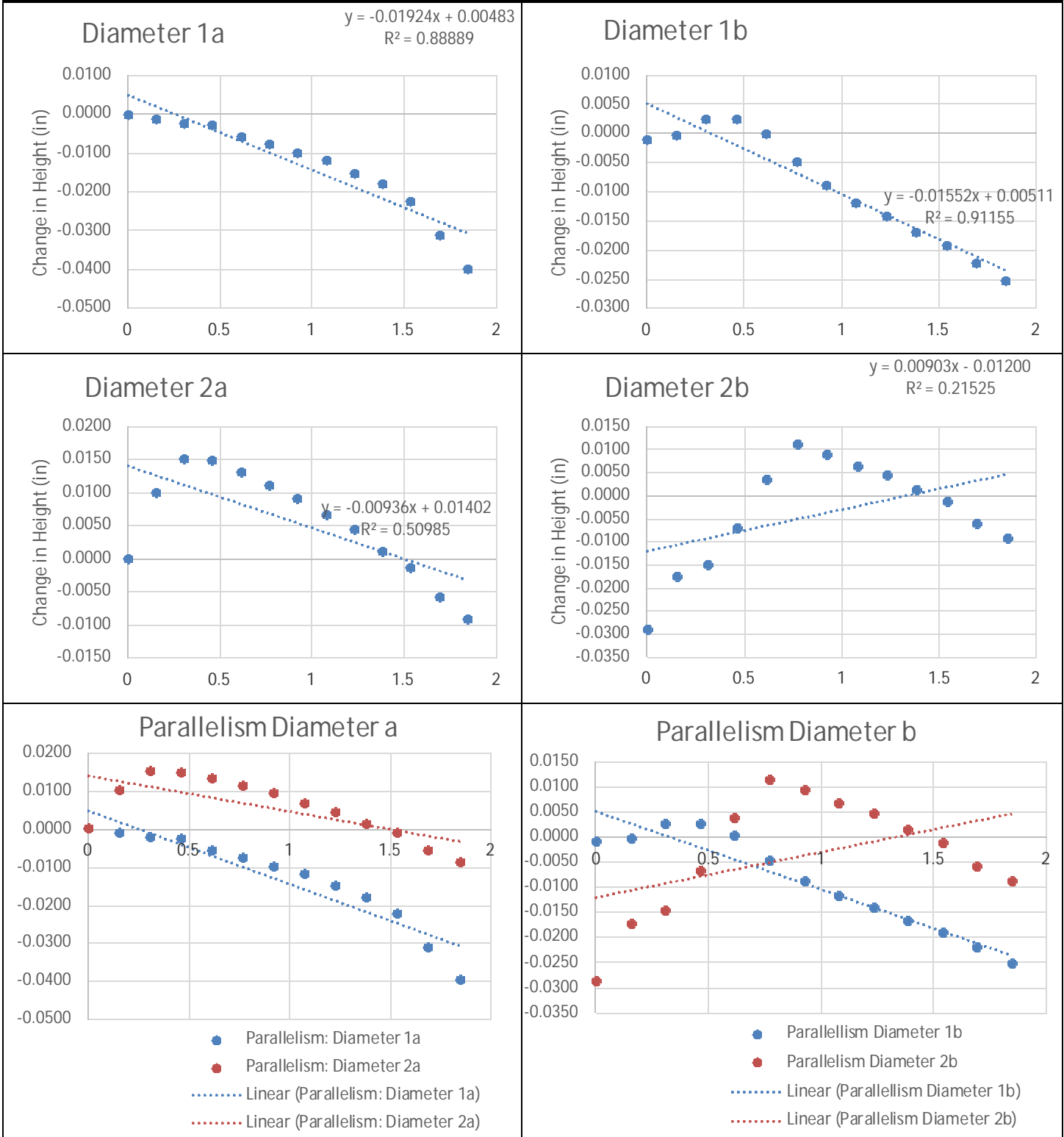
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Project

Rumford - Mexico Red Bridge #2707

Project No. J1215037



Client

TY Lin International Falmouth, ME

Project

Rumford - Mexico Red Bridge #2707

Project No. J1215037

Tolerances Check
Side Straightness (Procedure S2):

 Maximum Gap \leq 0.020 in.

	Minimum Reading (in)	Maximum Reading (in)	Difference (in)
Δ 0°	-0.0040	-0.0015	0.0025
Δ 120°	-0.0042	-0.0023	0.0019
Δ 240°	-0.0038	-0.0008	0.0030
Side Straightness Tolerance Met:	<u>Yes</u>		

End Flatness (Method FP2):

Distance (in):	0	0.1538	0.3077	0.4615	0.6154	0.7692	0.9231	1.0769	1.2308	1.3846	1.5385	1.6923	1.8462
Diameter 1a (in):	0.0000	-0.0012	-0.0024	-0.0028	-0.0057	-0.0076	-0.0098	-0.0119	-0.0151	-0.0181	-0.0225	-0.0313	-0.0399
Diameter 1b (in):	-0.0011	-0.0004	0.0025	0.0025	0.0001	-0.0050	-0.0089	-0.0119	-0.0142	-0.0170	-0.0192	-0.0222	-0.0253

 Tolerance Met: No

Distance (in):	0	0.1538	0.3077	0.4615	0.6154	0.7692	0.9231	1.0769	1.2308	1.3846	1.5385	1.6923	1.8462
Diameter 2a (in):	0.0000	0.0102	0.0152	0.0149	0.0132	0.0112	0.0092	0.0066	0.0045	0.0013	-0.0012	-0.0059	-0.0090
Diameter 2b (in):	-0.0288	-0.0175	-0.0148	-0.0069	0.0037	0.0112	0.0092	0.0066	0.0045	0.0013	-0.0012	-0.0059	-0.0090

 Tolerance Met: No
Parallelism (Method FP2):

Diameter 1a Angle of Best Fit (°):	-1.10	Diameter 1b Angle of Best Fit (°):	-0.89
Diameter 2a Angle of Best Fit (°):	-0.54	Diameter 2b Angle of Best Fit (°):	0.91
Maximum Angular Difference (°):	0.57	Maximum Angular Difference (°):	1.80
Parallelism Tolerance Met:	<u>No</u>	Parallelism Tolerance Met:	<u>No</u>

Perpendicularity (Procedure P1):

	Max Difference	Diameter (in)	Slope	Slope \leq 0.0043	Perpendicular Tolerance Met?
Diameter 1a	0.0399	2	0.0199	No	<u>No</u>
Diameter 1b	0.0278		0.0139	No	<u>No</u>
Diameter 2a	0.0242		0.0121	No	<u>No</u>
Diameter 2b	0.0397		0.0198	No	<u>No</u>

Technician for performed Sample Preparation: cs
 Technician for performing Sample Measurements: cs
 Technician for performing Compressive Strength: cs

15 Marway Cir Ste 2B
Rochester, NY 14624
(585) 247-3471



Client

TY Lin International
Falmouth, ME

Project

Rumford-Mexico Red Bridge #2707
J1215037

Date Received: 5/19/2022

Results from Corrosion Testing

Sample Location	BB-RSR-202	BB-RSR-204
Sample Depth (ft.)	20.0'	15.0'
pH Analysis, ASTM G 51	7.11	6.90
Water Soluble Sulfate (SO ₄), ASTM C 1580 (ppm)	3	2
Sulfides, AWWA 4500-S D, (mg/kg)	Nil	Nil
Chlorides, ASTM D 512, (ppm)	71	20
Red-Ox, ASTM G 200, (mV)	+480	+494
Total Salts, AWWA 2520 B, (mg/kg)	283	40
Resistivity (Saturated), ASTM G 57, (ohm-cm)	3600	50000

Analyzed By: ChrisAnne Ross
Field Geologist

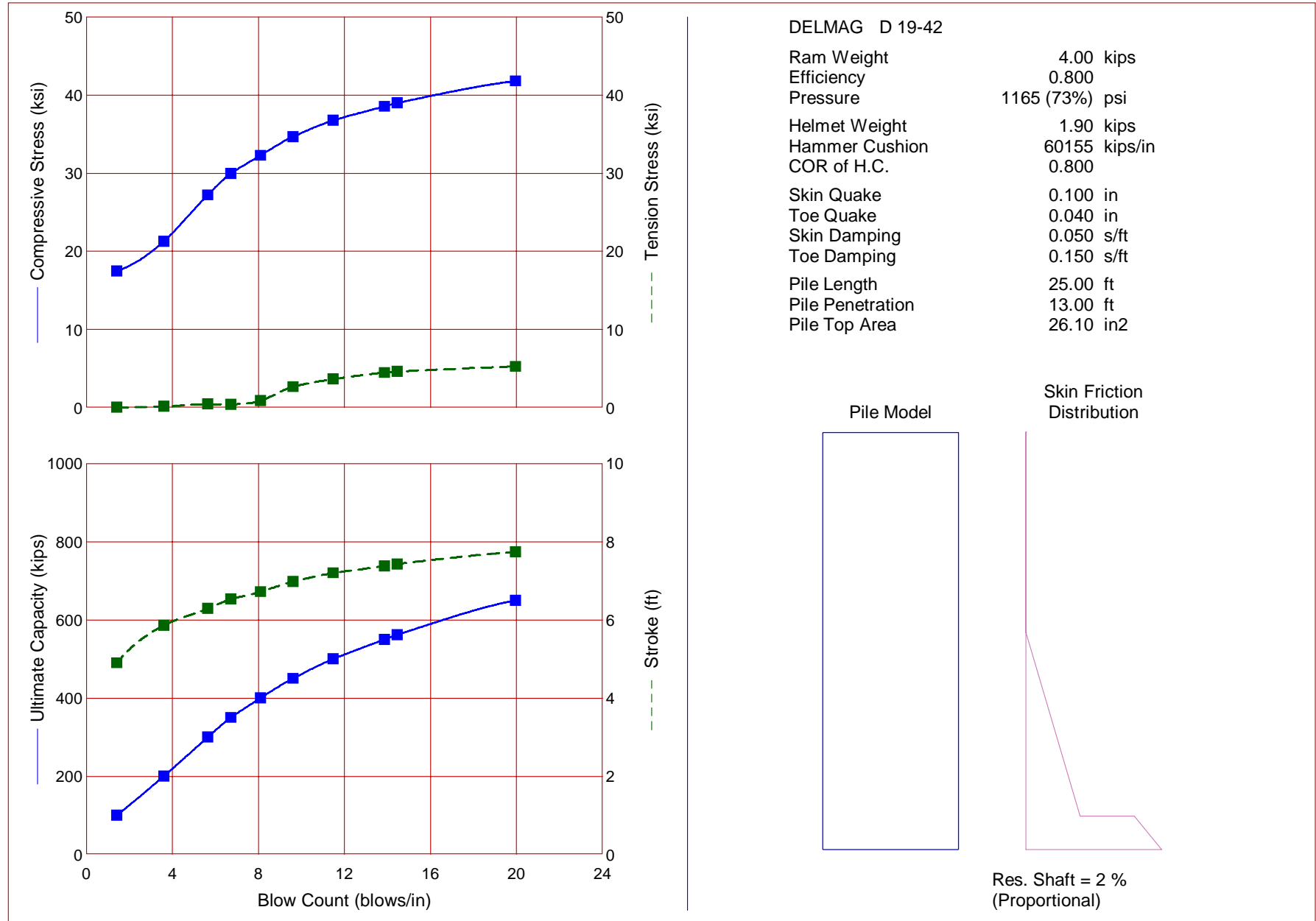
The tests were performed in general accordance with applicable ASTM and AWWA test methods. This report is exclusively for the use of the client indicated above and shall not be reproduced except in full without the written consent of our company. Test results transmitted herein are only applicable to the actual samples tested at the location(s) referenced and are not necessarily indicative of the properties of other apparently similar or identical materials.

SUPPORTING INFORMATION

Contents:

MaineDOT Key to Soil and Rock Descriptions and Terms
Preliminary WEAP Drivability Analyses (44 pages)
Calculations (16 pages)

Note: All attachments are one page unless noted above.



Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
100.0	17.49	0.07	1.4	4.90	11.08
200.0	21.26	0.17	3.6	5.86	10.08
300.0	27.21	0.47	5.7	6.29	10.18
350.0	29.95	0.44	6.7	6.53	10.45
400.0	32.26	0.90	8.1	6.72	10.61
450.0	34.65	2.69	9.6	6.98	11.07
500.0	36.74	3.67	11.5	7.20	11.54
550.0	38.54	4.50	13.9	7.38	11.91
562.0	38.97	4.62	14.5	7.43	12.01
650.0	41.79	5.27	20.0	7.74	12.69

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.
Copyright (c) 1998-2010, Pile Dynamics, Inc.

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

Input File: C:\USERS\SCCROWE\ONEDRIVE - TERRACON CONSULTANTS INC\DESKTOP\GRLWEAP
 DATA\RED BRIDGE, BB-RSR-102, HP14X89.GWW
 Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW
 Hammer File Version: 2003 (12/4/2018)

Input File Contents

```

Red Bridge, BB-RSR-102, HP14x89
OUT OSG HAM STR FUL PEL N SPL N-U P-D %SK ISM 0 PHI RSA ITR H-D MXT DEX
6 0 41 0 4 0 0 0 0 0 2 1 0 0 0 0 0 0 0.000
  Pile g Hammer g Toe Area Pile Size Pile Type
  32.170 32.170 32.600 14.690 H Pile
    W Cp A Cp E Cp T Cp CoR ROut StCp
    1.900 227.000 530.0 2.000 0.800 0.010 0.0
    A Cu E Cu T Cu CoR ROut StCu
    0.000 0.0 0.000 0.000 0.000 0.0
    LPle APle EPle WPle Peri CI CoR ROut
    25.000 26.10 30000.0 492.000 4.754 0 0.850 0.010
  FFatigue F0 0-Bottom
    0 0.000 0.000
  Manufac Hmr Name HmrType No Seg-s
  DELMAG D 19-42 1 5
    Ram Wt Ram L Ram Dia MaxStrk RtdStrk Efficcy
    4.00 129.10 12.60 11.86 10.81 0.80
    IB. Wt IB. L IB.Dia IB CoR IB RO
    0.75 25.30 12.60 0.900 0.010
  CompStrk A Chamber V Chamber C Delay C Duratn Exp Coeff VolCStart Vol CEnd
    16.65 124.70 157.70 0.0020 0.0020 1.250 0.00 0.00
    P atm P1 P2 P3 P4 P5
    14.70 1600.00 1440.00 1295.00 1165.00 0.00
  Stroke Effic. Pressure R-Weight T-Delay Exp-Coeff Eps-Str Total-AW
    10.8100 0.8000 1165.0000 0.0000 0.0000 0.0000 0.0100 0.0000
    Qs Qt Js Jt Qx Jx Rati Dept
    0.100 0.040 0.050 0.150 0.000 0.000 0.000 0.000
  Research Soil Model: Atoe, Plug, Gap, Q-fac
    0.000 0.000 0.000 0.000
  Research Soil Model: RD-skn: m, d, toe: m, d
    0.000 0.000 0.000 0.000
  Research Toe Plug: Res-int, Q-int, D-int, Res-plug, Q-plug, D-plug
    0.000 0.000 0.000 0.000 0.000 0.000
  Research Toe Plug: RD plug toe: m, d
    0.000 0.000
  Research Toe Plug: New Toe Plug Model is NOT applied
  Res. Distribution
    Dpth Rskn Dpth Dpth
    0.00 0.00 13.00 13.00 0.00 0.00 0.00 0.00 0.00 0.000
    11.00 0.20 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.000
    11.00 0.40 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.000
    13.00 0.50 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.000
    13.00 0.50 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.000
    20.00 0.84 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.000
    25.00 0.84 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.000
  Rult
  100.0 200.0 300.0 350.0 400.0 450.0 500.0 550.0 562.0 650.0
  
```

GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS
Version 2010
English Units

Red Bridge, BB-RSR-102, HP14x89

Hammer Model:	D 19-42		Made by:	DELMAG	
No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	0.800				
2	0.800	140046.6	1.000	0.0000	
3	0.800	140046.6	1.000	0.0000	
4	0.800	140046.6	1.000	0.0000	
5	0.800	140046.6	1.000	0.0000	
Imp Block	0.753	70735.6	0.900	0.0100	
Helmet	1.900	60155.0	0.800	0.0100	5.8
Combined Pile Top		20880.0			

HAMMER OPTIONS:

Hammer File ID No.	41	Hammer Type	OE Diesel
Stroke Option	FxdP-VarS	Stroke Convergence Crit.	0.010
Fuel Pump Setting	Max - 3		

HAMMER DATA:

Ram Weight	(kips)	4.00	Ram Length	(inch)	129.10
Maximum Stroke	(ft)	11.86			
Rated Stroke	(ft)	10.81	Efficiency		0.800
Maximum Pressure	(psi)	1600.00	Actual Pressure	(psi)	1165.00
Compression Exponent		1.350	Expansion Exponent		1.250
Ram Diameter	(inch)	12.60			
Combustion Delay	(s)	0.00200	Ignition Duration	(s)	0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION

Cross Sect. Area	(in2)	227.00
Elastic-Modulus	(ksi)	530.0
Thickness	(inch)	2.00
Coeff of Restitution		0.8
RoundOut	(ft)	0.0
Stiffness	(kips/in)	60155.0

PILE CUSHION

Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	0.00
Coeff of Restitution		0.0
RoundOut	(ft)	0.0
Stiffness	(kips/in)	0.0

PILE PROFILE:

Toe Area (in2) 32.600 Pile Type H Pile
 Pile Size (inch) 14.690

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	26.10	30000.	492.0	4.8	0	16807.	46.6
25.0	26.10	30000.	492.0	4.8	0	16807.	46.6

Wave Travel Time 2L/c (ms) 2.975

No.	Pile and Soil Model					Total Capacity Rut (kips)			100.0		
	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.279	20880	0.010	0.000	0.85	0.0	0.050	0.100	3.12	4.8	26.1
2	0.279	20880	0.000	0.000	1.00	0.0	0.050	0.100	6.25	4.8	26.1
4	0.279	20880	0.000	0.000	1.00	0.0	0.050	0.100	12.50	4.8	26.1
5	0.279	20880	0.000	0.000	1.00	0.1	0.050	0.100	15.62	4.8	26.1
6	0.279	20880	0.000	0.000	1.00	0.3	0.050	0.100	18.75	4.8	26.1
7	0.279	20880	0.000	0.000	1.00	0.5	0.050	0.100	21.88	4.8	26.1
8	0.279	20880	0.000	0.000	1.00	1.1	0.050	0.100	25.00	4.8	26.1
Toe						98.0	0.150	0.040			

2.229 kips total unreduced pile weight (g= 32.17 ft/s2)

2.229 kips total reduced pile weight (g= 32.17 ft/s2)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile		Pile Segments: Automatic	
No. of Slacks/Splices	0	Pile Damping (%)	1
Pile Penetration (ft)	13.00	Pile Damping Fact. (k/ft/s)	0.932
% Shaft Resistance	2		
Soil Damping Option	Smith		
Max No Analysis Iterations	0	Time Increment/Critical	160
Output Time Interval	1	Analysis Time-Input (ms)	0
Output Level: Variable vs Time			
Gravity Mass, Pile, Hammer:	32.170	32.170	32.170
Output Segment Generation:	Automatic		

Rut= 100.0, Rtoe = 98.0 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	448.6	0.00	17.19	8.60	0.770	11.08
2	-0.4	450.6	-0.02	17.26	8.59	0.767	11.08
3	-0.8	452.8	-0.03	17.35	8.58	0.763	11.09
4	-1.1	455.4	-0.04	17.45	8.59	0.759	11.09
5	-1.4	456.5	-0.05	17.49	8.93	0.756	11.10
6	-1.8	448.0	-0.07	17.17	10.47	0.752	11.08
7	-1.7	416.8	-0.07	15.97	11.65	0.747	11.06
8	-1.0	343.6	-0.04	13.17	12.42	0.743	11.03

(Eq) Strokes Analyzed and Last Return (ft):
10.81 4.28 5.04 4.90 4.92

Max. Combustion Pressure 1165.0 psi

Rut= 200.0, Rtoe= 196.0 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	532.3	0.00	20.40	10.31	0.381	10.08
2	0.0	534.8	0.00	20.49	10.30	0.372	10.03
3	-1.9	538.4	-0.07	20.63	10.30	0.364	9.97
4	-3.6	542.0	-0.14	20.77	10.30	0.355	9.91
5	-4.5	544.5	-0.17	20.86	10.38	0.346	9.85
6	-4.5	540.1	-0.17	20.69	10.63	0.337	9.77
7	-3.6	544.1	-0.14	20.85	10.22	0.328	9.68
8	-2.1	555.0	-0.08	21.26	11.05	0.318	9.59

(Eq) Strokes Analyzed and Last Return (ft):
10.81 5.69 5.86 5.85

Max. Combustion Pressure 1165.0 psi

Rut= 300.0, Rtoe= 294.0 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	566.3	0.00	21.70	10.99	0.316	10.18
2	-6.6	568.9	-0.25	21.80	10.98	0.302	10.01
3	-10.8	572.9	-0.41	21.95	10.99	0.288	9.85
4	-11.8	577.0	-0.45	22.11	10.98	0.274	9.68
5	-12.4	580.7	-0.47	22.25	11.03	0.260	9.50
6	-11.4	586.0	-0.44	22.45	11.08	0.246	9.32
7	-8.1	666.9	-0.31	25.55	10.05	0.232	9.12
8	-4.2	710.2	-0.16	27.21	9.03	0.218	8.95

(Eq) Strokes Analyzed and Last Return (ft):
10.81 6.29 6.26

Max. Combustion Pressure 1165.0 psi

Rut= 350.0, Rtoe = 343.0 kips, Time Inc. =0.072 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	584.2	0.00	22.38	11.37	0.309	10.45
2	-4.1	586.8	-0.16	22.48	11.35	0.291	10.19
3	-8.0	591.1	-0.31	22.65	11.37	0.274	9.94
4	-9.5	595.4	-0.36	22.81	11.36	0.257	9.69
5	-10.3	600.0	-0.40	22.99	11.39	0.241	9.44
6	-11.3	641.8	-0.43	24.59	11.34	0.224	9.17
7	-9.0	730.5	-0.35	27.99	10.09	0.207	8.90
8	-7.1	781.6	-0.27	29.94	8.24	0.190	8.64

(Eq) Strokes Analyzed and Last Return (ft):
10.81 6.53 6.47

Max. Combustion Pressure 1165.0 psi

Rut= 400.0, Rtoe= 392.0 kips, Time Inc. =0.066 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	597.5	0.00	22.89	11.64	0.304	10.61
2	-12.0	600.2	-0.46	23.00	11.63	0.282	10.20
3	-11.2	604.5	-0.43	23.16	11.64	0.262	9.85
4	-17.7	609.5	-0.68	23.35	11.65	0.243	9.52
5	-19.6	614.1	-0.75	23.53	11.66	0.223	9.19
6	-23.4	692.7	-0.90	26.54	11.53	0.204	8.85
7	-17.9	786.9	-0.69	30.15	10.07	0.184	8.48
8	-12.4	842.0	-0.47	32.26	7.47	0.165	8.14

(Eq) Strokes Analyzed and Last Return (ft):
10.81 6.82 6.72 6.71

Max. Combustion Pressure 1165.0 psi

Rut= 450.0, Rtoe= 441.0 kips, Time Inc. =0.062 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	633.7	0.00	24.28	12.02	0.306	11.07
2	-20.8	618.2	-0.80	23.69	12.02	0.285	10.68
3	-15.7	622.7	-0.60	23.86	12.03	0.262	10.24
4	-21.6	627.9	-0.83	24.06	12.04	0.237	9.65
5	-40.6	633.1	-1.56	24.26	12.04	0.212	9.10
6	-62.5	745.6	-2.40	28.57	11.83	0.190	8.67
7	-70.1	847.4	-2.69	32.47	10.16	0.168	8.21
8	-53.6	904.4	-2.06	34.65	6.89	0.145	7.76

(Eq) Strokes Analyzed and Last Return (ft):
10.81 7.08 6.98 6.98

Max. Combustion Pressure 1165.0 psi

Rut= 500.0, Rtoe = 490.0 kips, Time Inc. =0.057 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	702.9	0.00	26.93	12.33	0.310	11.54
2	-22.8	646.6	-0.88	24.77	12.32	0.289	11.14
3	-39.3	637.5	-1.50	24.42	12.34	0.265	10.67
4	-61.1	642.7	-2.34	24.63	12.35	0.238	10.03
5	-81.4	675.0	-3.12	25.86	12.35	0.206	9.12
6	-95.2	790.5	-3.65	30.29	12.08	0.178	8.41
7	-95.7	899.6	-3.67	34.47	10.19	0.154	7.87
8	-73.8	958.8	-2.83	36.74	6.30	0.128	7.30

(Eq) Strokes Analyzed and Last Return (ft):
 10.81 7.32 7.20 7.20

Max. Combustion Pressure 1165.0 psi

Rut= 550.0, Rtoe= 539.0 kips, Time Inc. =0.054 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	763.8	0.00	29.26	12.58	0.313	11.91
2	-15.3	699.2	-0.59	26.79	12.58	0.291	11.49
3	-50.9	684.1	-1.95	26.21	12.59	0.267	11.01
4	-92.9	655.1	-3.56	25.10	12.60	0.240	10.34
5	-117.4	713.5	-4.50	27.34	12.59	0.206	9.34
6	-115.9	830.6	-4.44	31.82	12.27	0.170	8.19
7	-114.2	944.0	-4.38	36.17	10.23	0.141	7.46
8	-80.5	1005.9	-3.08	38.54	5.72	0.113	6.77

(Eq) Strokes Analyzed and Last Return (ft):
 10.81 7.52 7.38 7.37

Max. Combustion Pressure 1165.0 psi

Rut= 562.0, Rtoe= 550.8 kips, Time Inc. =0.053 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	778.6	0.00	29.83	12.64	0.314	12.01
2	-15.2	712.2	-0.58	27.29	12.64	0.292	11.60
3	-52.6	695.9	-2.02	26.66	12.66	0.268	11.10
4	-97.6	658.3	-3.74	25.22	12.66	0.240	10.42
5	-120.6	722.8	-4.62	27.69	12.66	0.206	9.40
6	-118.3	839.3	-4.53	32.16	12.32	0.169	8.19
7	-117.6	953.7	-4.51	36.54	10.24	0.139	7.38
8	-82.2	1017.1	-3.15	38.97	5.58	0.110	6.67

(Eq) Strokes Analyzed and Last Return (ft):
 10.81 7.57 7.43 7.41

Max. Combustion Pressure 1165.0 psi

Rut= 650.0, Rtoe = 637.0 kips, Time Inc. =0.047 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	872.0	0.00	33.41	13.06	0.320	12.69
2	-36.4	796.9	-1.39	30.53	13.06	0.297	12.25
3	-57.4	774.6	-2.20	29.68	13.08	0.273	11.73
4	-104.1	718.9	-3.99	27.54	13.10	0.244	10.99
5	-118.1	783.1	-4.53	30.01	13.08	0.208	9.85
6	-130.5	900.6	-5.00	34.51	12.65	0.165	8.24
7	-137.5	1024.9	-5.27	39.27	10.31	0.125	6.84
8	-91.8	1090.7	-3.52	41.79	4.77	0.091	5.88

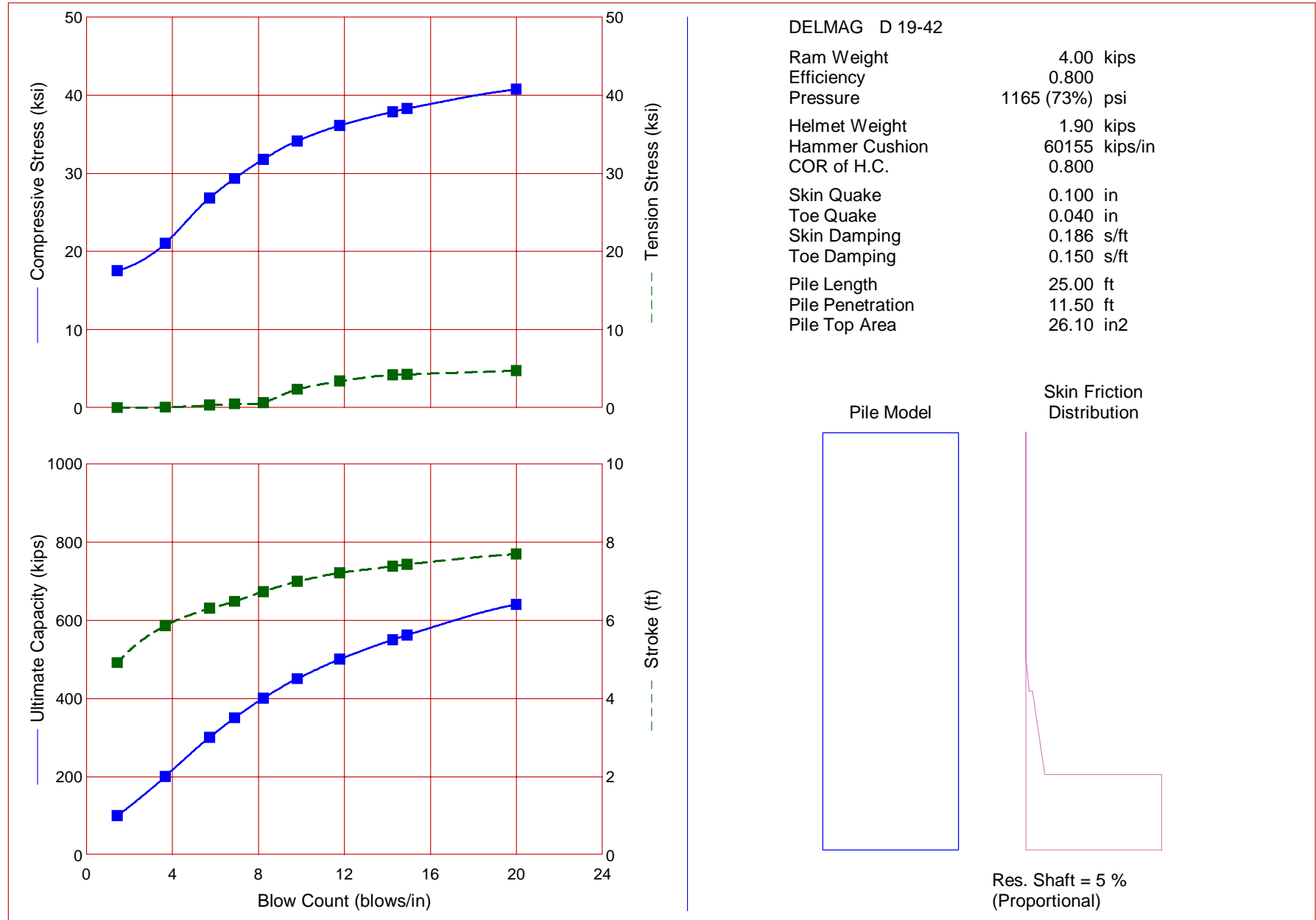
(Eq) Strokes Analyzed and Last Return (ft):
10.81 7.99 7.74 7.71

Max. Combustion Pressure 1165.0 psi

Red Bridge, BB-RSR-102, HP14x89
 Terracon

04/30/2023
 GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke down	(ft) up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
100.0	17.1	4.90	4.92	-0.07	6	49	17.49	5	3	11.1	52.9
200.0	43.3	5.86	5.85	-0.17	5	31	21.26	8	3	10.1	48.6
300.0	67.9	6.29	6.26	-0.47	5	12	27.21	8	3	10.2	47.0
350.0	80.7	6.53	6.47	-0.43	6	10	29.94	8	3	10.5	46.2
400.0	97.3	6.72	6.71	-0.90	6	14	32.26	8	3	10.6	45.6
450.0	115.4	6.98	6.98	-2.69	7	13	34.65	8	3	11.1	44.8
500.0	137.8	7.20	7.20	-3.67	7	13	36.74	8	3	11.5	44.1
550.0	166.4	7.38	7.37	-4.50	5	12	38.54	8	3	11.9	43.6
562.0	173.5	7.43	7.41	-4.62	5	12	38.97	8	3	12.0	43.5
650.0	239.5	7.74	7.71	-5.27	7	12	41.79	8	3	12.7	42.6



Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
100.0	17.54	0.04	1.4	4.91	11.08
200.0	21.01	0.08	3.7	5.86	10.04
300.0	26.81	0.34	5.7	6.30	10.19
350.0	29.32	0.51	6.9	6.48	10.34
400.0	31.76	0.68	8.2	6.73	10.63
450.0	34.12	2.37	9.8	6.99	11.08
500.0	36.10	3.42	11.8	7.21	11.54
550.0	37.85	4.23	14.3	7.38	11.90
562.0	38.26	4.29	14.9	7.43	12.00
640.0	40.72	4.74	20.0	7.69	12.59

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.
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ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

Input File: C:\USERS\SCCROWE\ONEDRIVE - TERRACON CONSULTANTS INC\DESKTOP\GRLWEAP
 DATA\RED BRIDGE, BB-RSR-202, HP14X89.GWW
 Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW
 Hammer File Version: 2003 (12/4/2018)

Input File Contents

Red Bridge, BB-RSR-202, HP14x89

OUT	OSG	HAM	STR	FUL	PEL	N	SPL	N-U	P-D	%SK	ISM	0	PHI	RSA	ITR	H-D	MXT	DEX
6	0	41	0	4	0	0	0	0	0	5	1	0	0	0	0	0	0	0.000

Pile g Hammer g Toe Area Pile Size Pile Type
 32.170 32.170 32.600 14.690 H Pile
 W Cp A Cp E Cp T Cp CoR ROut StCp
 1.900 227.000 530.0 2.000 0.800 0.010 0.0
 A Cu E Cu T Cu CoR ROut StCu
 0.000 0.0 0.000 0.000 0.000 0.0
 LPle APle EPle Wple Peri CI CoR ROut
 25.000 26.10 30000.0 492.000 4.754 0 0.850 0.010
 FFatigue F0 0-Bottom
 0 0.000 0.000

Manufac	Hmr	Name	HmrType	No	Seg-s
DELMAG	D	19-42	1	5	

Ram Wt Ram L Ram Dia MaxStrk RtdStrk Efficcy
 4.00 129.10 12.60 11.86 10.81 0.80
 IB. Wt IB. L IB.Dia IB CoR IB RO
 0.75 25.30 12.60 0.900 0.010
 CompStrk A Chamber V Chamber C Delay C Duratn Exp Coeff VolCStart Vol CEnd
 16.65 124.70 157.70 0.0020 0.0020 1.250 0.00 0.00
 P atm P1 P2 P3 P4 P5
 14.70 1600.00 1440.00 1295.00 1165.00 0.00
 Stroke Effic. Pressure R-Weight T-Delay Exp-Coeff Eps-Str Total-AW
 10.8100 0.8000 1165.0000 0.0000 0.0000 0.0000 0.0100 0.0000
 Qs Qt Js Jt Qx Jx Rati Dept
 0.100 0.040 0.186 0.150 0.000 0.000 0.000 0.000

Research Soil Model: Atoe, Plug, Gap, Q-fac
 0.000 0.000 0.000 0.000
 Research Soil Model: RD-skn: m, d, toe: m, d
 0.000 0.000 0.000 0.000
 Research Toe Plug: Res-int, Q-int, D-int, Res-plug, Q-plug, D-plug
 0.000 0.000 0.000 0.000 0.000 0.000
 Research Toe Plug: RD plug toe: m, d
 0.000 0.000
 Research Toe Plug: New Toe Plug Model is NOT applied

Res. Distribution

Dpth	Rskn	Dpth	Dpth	Dpth	Dpth	Dpth	Dpth	Dpth	Dpth
0.00	0.00	11.50	11.50	0.00	0.00	0.00	0.00	0.00	0.000
2.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
2.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
7.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
7.00	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
11.50	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
11.50	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
20.00	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
25.00	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000

Rult

100.0	200.0	300.0	350.0	400.0	450.0	500.0	550.0	562.0	640.0
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GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS
Version 2010
English Units

Red Bridge, BB-RSR-202, HP14x89

Hammer Model:	D 19-42		Made by:	DELMAG	
No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	0.800				
2	0.800	140046.6	1.000	0.0000	
3	0.800	140046.6	1.000	0.0000	
4	0.800	140046.6	1.000	0.0000	
5	0.800	140046.6	1.000	0.0000	
Imp Block	0.753	70735.6	0.900	0.0100	
Helmet	1.900	60155.0	0.800	0.0100	5.8
Combined Pile Top		20880.0			

HAMMER OPTIONS:

Hammer File ID No.	41	Hammer Type	OE Diesel
Stroke Option	FxdP-VarS	Stroke Convergence Crit.	0.010
Fuel Pump Setting	Max - 3		

HAMMER DATA:

Ram Weight	(kips)	4.00	Ram Length	(inch)	129.10
Maximum Stroke	(ft)	11.86			
Rated Stroke	(ft)	10.81	Efficiency		0.800
Maximum Pressure	(psi)	1600.00	Actual Pressure	(psi)	1165.00
Compression Exponent		1.350	Expansion Exponent		1.250
Ram Diameter	(inch)	12.60			
Combustion Delay	(s)	0.00200	Ignition Duration	(s)	0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION

Cross Sect. Area	(in2)	227.00
Elastic-Modulus	(ksi)	530.0
Thickness	(inch)	2.00
Coeff of Restitution		0.8
RoundOut	(ft)	0.0
Stiffness	(kips/in)	60155.0

PILE CUSHION

Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	0.00
Coeff of Restitution		0.0
RoundOut	(ft)	0.0
Stiffness	(kips/in)	0.0

PILE PROFILE:

Toe Area (in2) 32.600 Pile Type H Pile
Pile Size (inch) 14.690

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	26.10	30000.	492.0	4.8	0	16807.	46.6
25.0	26.10	30000.	492.0	4.8	0	16807.	46.6

Wave Travel Time 2L/c (ms) 2.975

No.	File and Soil Model					Total Capacity Rut (kips)			100.0		
	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.279	20880	0.010	0.000	0.85	0.0	0.186	0.100	3.12	4.8	26.1
2	0.279	20880	0.000	0.000	1.00	0.0	0.186	0.100	6.25	4.8	26.1
5	0.279	20880	0.000	0.000	1.00	0.0	0.186	0.100	15.62	4.8	26.1
6	0.279	20880	0.000	0.000	1.00	0.2	0.186	0.100	18.75	4.8	26.1
7	0.279	20880	0.000	0.000	1.00	1.6	0.186	0.100	21.88	4.8	26.1
8	0.279	20880	0.000	0.000	1.00	3.2	0.186	0.100	25.00	4.8	26.1
Toe						95.0	0.150	0.040			

2.229 kips total unreduced pile weight (g= 32.17 ft/s2)

2.229 kips total reduced pile weight (g= 32.17 ft/s2)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile		Pile Segments: Automatic	
No. of Slacks/Splices	0	Pile Damping (%)	1
Pile Penetration (ft)	11.50	Pile Damping Fact.(k/ft/s)	0.932
% Shaft Resistance	5		
Soil Damping Option	Smith		
Max No Analysis Iterations	0	Time Increment/Critical	160
Output Time Interval	1	Analysis Time-Input (ms)	0
Output Level: Variable vs Time			
Gravity Mass, Pile, Hammer:	32.170	32.170	32.170
Output Segment Generation: Automatic			

Rut= 100.0, Rtoe = 95.0 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	449.8	0.00	17.23	8.63	0.764	11.08
2	-0.3	451.8	-0.01	17.31	8.63	0.760	11.08
3	-0.6	454.2	-0.02	17.40	8.62	0.756	11.09
4	-0.8	456.5	-0.03	17.49	8.62	0.753	11.10
5	-0.8	457.8	-0.03	17.54	8.93	0.749	11.10
6	-0.9	449.5	-0.03	17.22	10.47	0.745	11.09
7	-0.7	418.8	-0.03	16.05	11.65	0.741	10.99
8	-0.3	341.5	-0.01	13.08	12.39	0.736	10.88

(Eq) Strokes Analyzed and Last Return (ft):
10.81 4.31 5.05 4.91 4.93

Max. Combustion Pressure 1165.0 psi

Rut= 200.0, Rtoe= 190.0 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	532.7	0.00	20.41	10.32	0.378	10.04
2	0.0	535.1	0.00	20.50	10.31	0.369	9.98
3	-0.4	538.0	-0.02	20.61	10.30	0.360	9.92
4	-1.7	542.2	-0.07	20.77	10.31	0.352	9.87
5	-2.2	544.8	-0.08	20.87	10.38	0.343	9.80
6	-1.7	540.2	-0.07	20.70	10.63	0.334	9.72
7	-1.1	545.7	-0.04	20.91	10.19	0.324	9.57
8	-0.5	548.3	-0.02	21.01	10.99	0.315	9.42

(Eq) Strokes Analyzed and Last Return (ft):
10.81 5.71 5.86 5.86

Max. Combustion Pressure 1165.0 psi

Rut= 300.0, Rtoe= 285.0 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	567.2	0.00	21.73	11.01	0.316	10.19
2	-4.7	569.7	-0.18	21.83	11.01	0.302	10.02
3	-7.8	573.4	-0.30	21.97	11.00	0.288	9.85
4	-8.8	578.1	-0.34	22.15	11.01	0.273	9.68
5	-8.3	581.4	-0.32	22.28	11.05	0.259	9.50
6	-6.6	588.0	-0.25	22.53	11.08	0.245	9.32
7	-5.9	667.0	-0.23	25.55	10.01	0.231	9.06
8	-3.5	699.8	-0.14	26.81	8.99	0.217	8.82

(Eq) Strokes Analyzed and Last Return (ft):
10.81 6.30 6.27

Max. Combustion Pressure 1165.0 psi

Rut= 350.0, Rtoe = 332.5 kips, Time Inc. =0.071 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	581.0	0.00	22.26	11.29	0.307	10.34
2	-3.7	583.5	-0.14	22.35	11.29	0.290	10.07
3	-6.5	587.3	-0.25	22.50	11.29	0.272	9.81
4	-8.0	592.2	-0.31	22.69	11.29	0.255	9.57
5	-11.2	596.3	-0.43	22.85	11.32	0.238	9.32
6	-13.2	640.6	-0.51	24.54	11.25	0.222	9.05
7	-11.3	727.9	-0.43	27.89	9.98	0.204	8.71
8	-6.9	765.3	-0.26	29.32	8.12	0.188	8.40

(Eq) Strokes Analyzed and Last Return (ft):
 10.81 6.55 6.48 6.48

Max. Combustion Pressure 1165.0 psi

Rut= 400.0, Rtoe= 380.0 kips, Time Inc. =0.066 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	598.1	0.00	22.92	11.65	0.304	10.63
2	-12.5	600.5	-0.48	23.01	11.64	0.282	10.22
3	-11.0	605.0	-0.42	23.18	11.65	0.262	9.86
4	-11.2	609.6	-0.43	23.35	11.66	0.243	9.53
5	-11.0	614.2	-0.42	23.53	11.67	0.223	9.20
6	-17.8	694.8	-0.68	26.62	11.53	0.204	8.86
7	-12.0	789.5	-0.46	30.25	10.01	0.184	8.43
8	-7.2	828.9	-0.27	31.76	7.46	0.164	8.03

(Eq) Strokes Analyzed and Last Return (ft):
 10.81 6.84 6.73 6.72

Max. Combustion Pressure 1165.0 psi

Rut= 450.0, Rtoe= 427.5 kips, Time Inc. =0.061 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	633.6	0.00	24.27	12.03	0.306	11.08
2	-18.0	618.7	-0.69	23.71	12.03	0.285	10.69
3	-16.0	623.2	-0.61	23.88	12.04	0.262	10.25
4	-22.3	628.3	-0.85	24.07	12.05	0.236	9.66
5	-39.8	633.6	-1.52	24.28	12.05	0.211	9.10
6	-57.7	747.6	-2.21	28.64	11.82	0.190	8.67
7	-62.0	847.8	-2.37	32.48	10.11	0.167	8.14
8	-47.5	890.4	-1.82	34.12	6.88	0.145	7.64

(Eq) Strokes Analyzed and Last Return (ft):
 10.81 7.10 6.99 6.98

Max. Combustion Pressure 1165.0 psi

Rut= 500.0, Rtoe = 475.0 kips, Time Inc. =0.057 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	700.4	0.00	26.83	12.34	0.310	11.54
2	-18.5	647.4	-0.71	24.80	12.33	0.288	11.13
3	-37.8	637.8	-1.45	24.44	12.34	0.265	10.66
4	-59.9	643.2	-2.30	24.64	12.36	0.238	10.03
5	-79.9	674.3	-3.06	25.83	12.35	0.206	9.11
6	-89.2	791.7	-3.42	30.33	12.04	0.177	8.40
7	-86.2	898.9	-3.30	34.44	10.14	0.153	7.79
8	-65.6	942.1	-2.52	36.10	6.27	0.128	7.17

(Eq) Strokes Analyzed and Last Return (ft):
 10.81 7.32 7.21 7.20

Max. Combustion Pressure 1165.0 psi

Rut= 550.0, Rtoe= 522.5 kips, Time Inc. =0.054 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	761.5	0.00	29.18	12.57	0.313	11.90
2	-16.0	699.6	-0.61	26.81	12.57	0.291	11.49
3	-49.4	683.7	-1.89	26.20	12.59	0.267	11.00
4	-89.1	655.0	-3.41	25.10	12.60	0.239	10.33
5	-110.5	712.5	-4.23	27.30	12.59	0.206	9.33
6	-105.1	830.2	-4.03	31.81	12.22	0.170	8.19
7	-103.2	942.9	-3.95	36.13	10.15	0.141	7.39
8	-73.4	987.8	-2.81	37.85	5.67	0.113	6.66

(Eq) Strokes Analyzed and Last Return (ft):
 10.81 7.51 7.38 7.37

Max. Combustion Pressure 1165.0 psi

Rut= 562.0, Rtoe= 533.9 kips, Time Inc. =0.053 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	774.6	0.00	29.68	12.63	0.314	12.00
2	-15.6	711.2	-0.60	27.25	12.63	0.292	11.58
3	-50.8	695.2	-1.94	26.64	12.65	0.268	11.08
4	-93.5	657.6	-3.58	25.19	12.66	0.240	10.40
5	-112.0	721.0	-4.29	27.62	12.64	0.206	9.38
6	-107.5	839.1	-4.12	32.15	12.28	0.169	8.19
7	-105.9	953.1	-4.06	36.52	10.16	0.138	7.30
8	-74.4	998.5	-2.85	38.26	5.54	0.110	6.54

(Eq) Strokes Analyzed and Last Return (ft):
 10.81 7.57 7.43 7.41

Max. Combustion Pressure 1165.0 psi

Rut= 640.0, Rtoe = 608.0 kips, Time Inc. =0.048 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	856.4	0.00	32.81	13.01	0.319	12.59
2	-29.8	785.5	-1.14	30.10	13.01	0.296	12.16
3	-51.7	763.8	-1.98	29.26	13.04	0.272	11.63
4	-95.3	710.3	-3.65	27.21	13.05	0.243	10.89
5	-108.6	774.3	-4.16	29.67	13.02	0.207	9.77
6	-117.7	893.7	-4.51	34.24	12.54	0.165	8.22
7	-123.7	1015.0	-4.74	38.89	10.18	0.126	6.82
8	-82.4	1062.7	-3.16	40.72	4.82	0.093	5.87

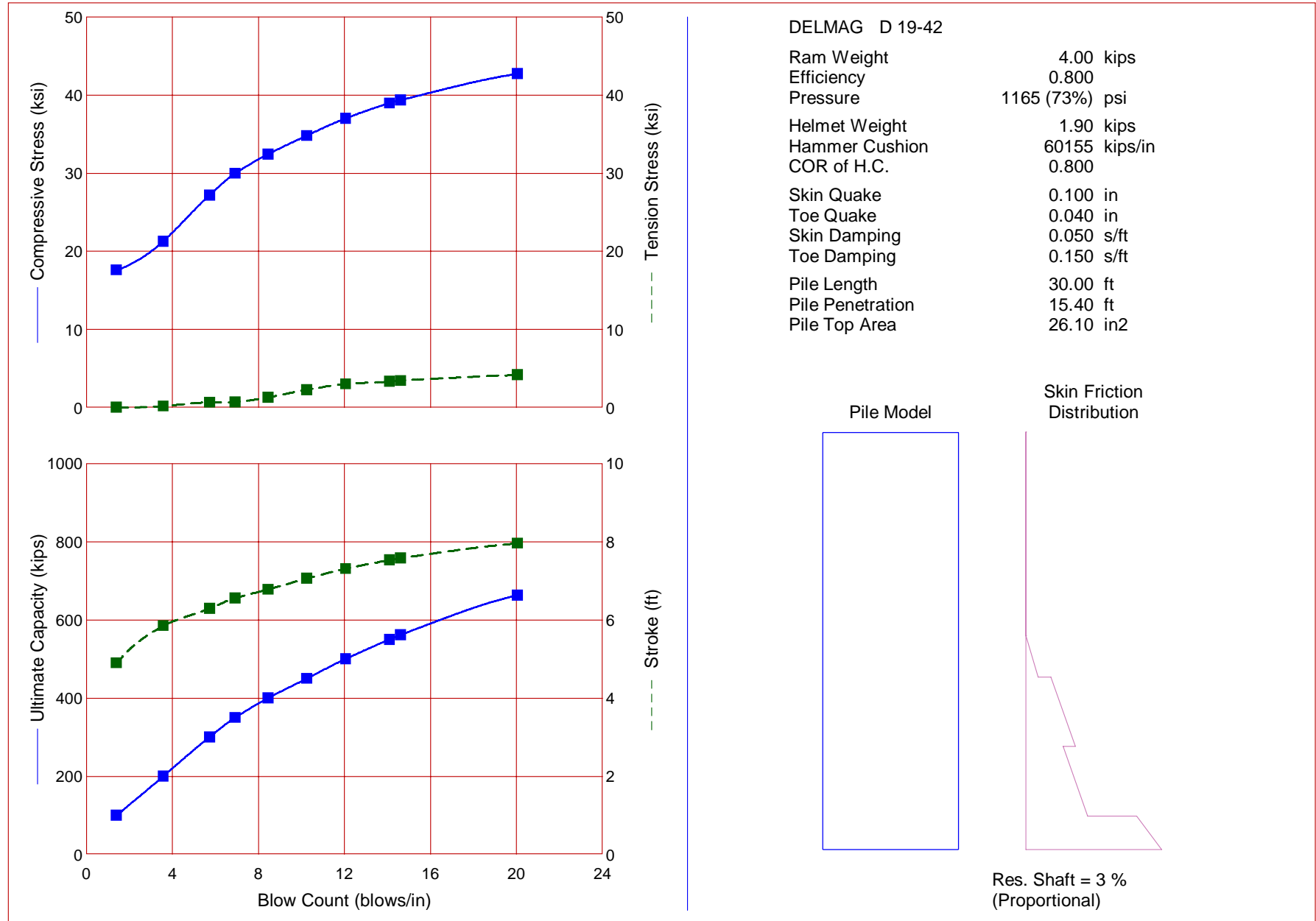
(Eq) Strokes Analyzed and Last Return (ft):
10.81 7.94 7.69 7.68

Max. Combustion Pressure 1165.0 psi

Red Bridge, BB-RSR-202, HP14x89
 Terracon

04/30/2023
 GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke down	(ft) up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
100.0	17.3	4.91	4.93	-0.03	6	49	17.54	5	3	11.1	52.9
200.0	44.1	5.86	5.86	-0.08	5	31	21.01	8	3	10.0	48.6
300.0	68.9	6.30	6.27	-0.34	4	28	26.81	8	3	10.2	47.0
350.0	82.9	6.48	6.48	-0.51	6	10	29.32	8	3	10.3	46.3
400.0	98.8	6.73	6.72	-0.68	6	14	31.76	8	3	10.6	45.5
450.0	117.8	6.99	6.98	-2.37	7	13	34.12	8	3	11.1	44.7
500.0	141.4	7.21	7.20	-3.42	6	12	36.10	8	3	11.5	44.1
550.0	171.0	7.38	7.37	-4.23	5	12	37.85	8	3	11.9	43.6
562.0	179.0	7.43	7.41	-4.29	5	12	38.26	8	3	12.0	43.5
640.0	239.9	7.69	7.68	-4.74	7	12	40.72	8	3	12.6	42.8



Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
100.0	17.62	0.05	1.4	4.90	11.05
200.0	21.28	0.21	3.6	5.85	10.19
300.0	27.18	0.70	5.7	6.29	10.31
350.0	29.97	0.73	6.9	6.56	10.69
400.0	32.41	1.32	8.4	6.78	11.19
450.0	34.80	2.30	10.3	7.06	11.78
500.0	37.00	3.04	12.1	7.31	12.37
550.0	38.95	3.35	14.1	7.53	12.85
562.0	39.35	3.46	14.6	7.58	12.97
663.0	42.70	4.20	20.0	7.96	13.85

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.
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ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

Input File: C:\USERS\SCCROWE\ONEDRIVE - TERRACON CONSULTANTS INC\DESKTOP\GRLWEAP
 DATA\RED BRIDGE, BB-RSR-203, HP14X89.GWW
 Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW
 Hammer File Version: 2003 (12/4/2018)

Input File Contents

Red Bridge, BB-RSR-203, HP14x89

OUT	OSG	HAM	STR	FUL	PEL	N	SPL	N-U	P-D	%SK	ISM	0	PHI	RSA	ITR	H-D	MXT	DEX
6	0	41	0	4	0	0	0	0	0	3	1	0	0	0	0	0	0	0.000

Pile g Hammer g Toe Area Pile Size Pile Type
 32.170 32.170 32.600 14.690 H Pile
 W Cp A Cp E Cp T Cp CoR ROut StCp
 1.900 227.000 530.0 2.000 0.800 0.010 0.0
 A Cu E Cu T Cu CoR ROut StCu
 0.000 0.0 0.000 0.000 0.000 0.0
 LPle APle EPle WPle Peri CI CoR ROut
 30.000 26.10 30000.0 492.000 4.754 0 0.850 0.010
 FFatigue F0 0-Bottom
 0 0.000 0.000

Manufac	Hmr	Name	HmrType	No	Seg-s
DELMAG	D	19-42	1	5	

Ram Wt Ram L Ram Dia MaxStrk RtdStrk Efficcy
 4.00 129.10 12.60 11.86 10.81 0.80
 IB. Wt IB. L IB.Dia IB CoR IB RO
 0.75 25.30 12.60 0.900 0.010
 CompStrk A Chamber V Chamber C Delay C Duratn Exp Coeff VolCStart Vol CEnd
 16.65 124.70 157.70 0.0020 0.0020 1.250 0.00 0.00
 P atm P1 P2 P3 P4 P5
 14.70 1600.00 1440.00 1295.00 1165.00 0.00
 Stroke Effic. Pressure R-Weight T-Delay Exp-Coeff Eps-Str Total-AW
 10.8100 0.8000 1165.0000 0.0000 0.0000 0.0000 0.0100 0.0000
 Qs Qt Js Jt Qx Jx Rati Dept
 0.100 0.040 0.050 0.150 0.000 0.000 0.000 0.000

Research Soil Model: Atoe, Plug, Gap, Q-fac
 0.000 0.000 0.000 0.000
 Research Soil Model: RD-skn: m, d, toe: m, d
 0.000 0.000 0.000 0.000
 Research Toe Plug: Res-int, Q-int, D-int, Res-plug, Q-plug, D-plug
 0.000 0.000 0.000 0.000 0.000 0.000
 Research Toe Plug: RD plug toe: m, d
 0.000 0.000
 Research Toe Plug: New Toe Plug Model is NOT applied

Res. Distribution

Dpth	Rskn	Dpth	Dpth	Dpth	Dpth	Dpth	Dpth	Dpth	Dpth
0.00	0.00	15.40	15.40	0.00	0.00	0.00	0.00	0.00	0.000
3.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
3.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
8.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
8.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
13.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
13.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
15.40	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
15.40	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
20.00	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
30.00	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000

Rult

100.0	200.0	300.0	350.0	400.0	450.0	500.0	550.0	562.0	663.0
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GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS
Version 2010
English Units

Red Bridge, BB-RSR-203, HP14x89

Hammer Model:	D 19-42		Made by:	DELMAG	
No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	0.800				
2	0.800	140046.6	1.000	0.0000	
3	0.800	140046.6	1.000	0.0000	
4	0.800	140046.6	1.000	0.0000	
5	0.800	140046.6	1.000	0.0000	
Imp Block	0.753	70735.6	0.900	0.0100	
Helmet	1.900	60155.0	0.800	0.0100	5.8
Combined Pile Top		19575.0			

HAMMER OPTIONS:

Hammer File ID No.	41	Hammer Type	OE Diesel
Stroke Option	FxdP-VarS	Stroke Convergence Crit.	0.010
Fuel Pump Setting	Max - 3		

HAMMER DATA:

Ram Weight	(kips)	4.00	Ram Length	(inch)	129.10
Maximum Stroke	(ft)	11.86			
Rated Stroke	(ft)	10.81	Efficiency		0.800
Maximum Pressure	(psi)	1600.00	Actual Pressure	(psi)	1165.00
Compression Exponent		1.350	Expansion Exponent		1.250
Ram Diameter	(inch)	12.60			
Combustion Delay	(s)	0.00200	Ignition Duration	(s)	0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION

Cross Sect. Area	(in2)	227.00
Elastic-Modulus	(ksi)	530.0
Thickness	(inch)	2.00
Coeff of Restitution		0.8
RoundOut	(ft)	0.0
Stiffness	(kips/in)	60155.0

PILE CUSHION

Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	0.00
Coeff of Restitution		0.0
RoundOut	(ft)	0.0
Stiffness	(kips/in)	0.0

PILE PROFILE:

Toe Area (in2) 32.600 Pile Type H Pile
 Pile Size (inch) 14.690

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	26.10	30000.	492.0	4.8	0	16807.	46.6
30.0	26.10	30000.	492.0	4.8	0	16807.	46.6

Wave Travel Time 2L/c (ms) 3.570

No.	Pile and Soil Model					Total Capacity Rut (kips)			100.0		
	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.297	19575	0.010	0.000	0.85	0.0	0.050	0.100	3.33	4.8	26.1
2	0.297	19575	0.000	0.000	1.00	0.0	0.050	0.100	6.67	4.8	26.1
5	0.297	19575	0.000	0.000	1.00	0.0	0.050	0.100	16.67	4.8	26.1
6	0.297	19575	0.000	0.000	1.00	0.3	0.050	0.100	20.00	4.8	26.1
7	0.297	19575	0.000	0.000	1.00	0.6	0.050	0.100	23.33	4.8	26.1
8	0.297	19575	0.000	0.000	1.00	0.6	0.050	0.100	26.67	4.8	26.1
9	0.297	19575	0.000	0.000	1.00	1.4	0.050	0.100	30.00	4.8	26.1
Toe						97.0	0.150	0.040			

2.675 kips total unreduced pile weight (g= 32.17 ft/s2)

2.675 kips total reduced pile weight (g= 32.17 ft/s2)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile		Pile Segments: Automatic	
No. of Slacks/Splices	0	Pile Damping (%)	1
Pile Penetration (ft)	15.40	Pile Damping Fact. (k/ft/s)	0.932
% Shaft Resistance	3		
Soil Damping Option	Smith		
Max No Analysis Iterations	0	Time Increment/Critical	160
Output Time Interval	1	Analysis Time-Input (ms)	0
Output Level: Variable vs Time			
Gravity Mass, Pile, Hammer:	32.170	32.170	32.170
Output Segment Generation:	Automatic		

Rut= 100.0, Rtoe = 97.0 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	447.4	0.00	17.14	8.64	0.783	11.05
2	0.0	449.4	0.00	17.22	8.63	0.781	11.06
3	0.0	452.2	0.00	17.33	8.63	0.778	11.07
4	0.0	455.1	0.00	17.44	8.63	0.775	11.08
5	0.0	457.8	0.00	17.54	8.62	0.771	11.09
6	-0.3	459.8	-0.01	17.62	8.71	0.768	11.09
7	-1.2	453.1	-0.05	17.36	10.19	0.764	11.06
8	-1.3	424.2	-0.05	16.25	11.54	0.759	11.02
9	-0.6	348.2	-0.02	13.34	12.49	0.755	10.99

(Eq) Strokes Analyzed and Last Return (ft):
 10.81 4.28 5.04 4.90 4.93

Max. Combustion Pressure 1165.0 psi

Rut= 200.0, Rtoe= 194.0 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	529.8	0.00	20.30	10.33	0.398	10.19
2	-2.5	532.8	-0.10	20.41	10.34	0.388	10.12
3	-4.3	536.2	-0.17	20.54	10.34	0.378	10.05
4	-5.4	540.8	-0.21	20.72	10.35	0.369	9.99
5	-5.6	544.8	-0.21	20.88	10.35	0.359	9.92
6	-4.8	547.6	-0.19	20.98	10.39	0.350	9.84
7	-4.0	544.8	-0.15	20.87	10.58	0.340	9.75
8	-3.3	546.0	-0.13	20.92	10.20	0.331	9.64
9	-1.9	555.4	-0.07	21.28	11.11	0.321	9.55

(Eq) Strokes Analyzed and Last Return (ft):
 10.81 5.68 5.85 5.84

Max. Combustion Pressure 1165.0 psi

Rut= 300.0, Rtoe= 291.0 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	563.5	0.00	21.59	11.02	0.336	10.31
2	-2.1	566.5	-0.08	21.70	11.02	0.321	10.14
3	-7.0	571.4	-0.27	21.89	11.05	0.306	9.97
4	-14.6	575.7	-0.56	22.06	11.05	0.291	9.79
5	-18.3	580.7	-0.70	22.25	11.03	0.276	9.61
6	-17.7	585.0	-0.68	22.41	11.05	0.261	9.41
7	-15.8	584.0	-0.61	22.38	11.06	0.246	9.20
8	-11.0	654.1	-0.42	25.06	9.99	0.231	8.98
9	-5.2	709.4	-0.20	27.18	9.07	0.216	8.78

(Eq) Strokes Analyzed and Last Return (ft):
 10.81 6.29 6.28

Max. Combustion Pressure 1165.0 psi

Rut= 350.0, Rtoe = 339.5 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	584.0	0.00	22.38	11.46	0.331	10.69
2	-7.9	587.5	-0.30	22.51	11.47	0.312	10.40
3	-13.1	592.1	-0.50	22.68	11.49	0.293	10.12
4	-15.3	597.2	-0.59	22.88	11.48	0.275	9.86
5	-17.2	602.6	-0.66	23.09	11.49	0.257	9.60
6	-18.7	606.7	-0.72	23.25	11.49	0.239	9.32
7	-19.1	620.6	-0.73	23.78	11.43	0.222	9.03
8	-16.7	718.1	-0.64	27.51	10.13	0.204	8.74
9	-12.0	782.2	-0.46	29.97	8.35	0.186	8.47

(Eq) Strokes Analyzed and Last Return (ft):
10.81 6.56 6.52

Max. Combustion Pressure 1165.0 psi

Rut= 400.0, Rtoe= 388.0 kips, Time Inc. =0.071 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	599.6	0.00	22.97	11.79	0.335	11.19
2	-19.5	602.9	-0.75	23.10	11.80	0.314	10.85
3	-32.6	608.4	-1.25	23.31	11.82	0.292	10.43
4	-34.4	613.8	-1.32	23.52	11.84	0.268	9.98
5	-29.9	619.1	-1.15	23.72	11.83	0.243	9.45
6	-26.7	624.0	-1.02	23.91	11.82	0.220	9.03
7	-28.1	671.4	-1.08	25.72	11.66	0.200	8.67
8	-24.8	775.1	-0.95	29.70	10.14	0.181	8.32
9	-15.5	846.0	-0.60	32.41	7.65	0.160	7.96

(Eq) Strokes Analyzed and Last Return (ft):
10.81 6.87 6.78 6.78

Max. Combustion Pressure 1165.0 psi

Rut= 450.0, Rtoe= 436.5 kips, Time Inc. =0.066 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	618.0	0.00	23.68	12.18	0.340	11.78
2	-18.4	621.5	-0.71	23.81	12.20	0.319	11.42
3	-44.0	627.1	-1.69	24.03	12.23	0.296	10.97
4	-52.2	632.7	-2.00	24.24	12.24	0.272	10.50
5	-45.3	638.2	-1.74	24.45	12.24	0.245	9.93
6	-35.9	643.8	-1.37	24.67	12.22	0.214	9.12
7	-51.8	723.7	-1.98	27.73	11.99	0.186	8.45
8	-60.1	833.0	-2.30	31.91	10.24	0.162	7.95
9	-40.1	908.3	-1.53	34.80	7.08	0.139	7.52

(Eq) Strokes Analyzed and Last Return (ft):
10.81 7.17 7.06 7.06

Max. Combustion Pressure 1165.0 psi

Rut= 500.0, Rtoe = 485.0 kips, Time Inc. =0.061 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	644.5	0.00	24.69	12.55	0.346	12.37
2	-38.7	638.3	-1.48	24.46	12.57	0.324	11.98
3	-43.1	644.1	-1.65	24.68	12.61	0.300	11.51
4	-51.5	650.6	-1.97	24.93	12.62	0.275	11.02
5	-46.5	656.7	-1.78	25.16	12.62	0.248	10.40
6	-57.3	662.1	-2.20	25.37	12.59	0.215	9.48
7	-75.6	769.9	-2.90	29.50	12.30	0.181	8.50
8	-79.5	885.9	-3.05	33.94	10.36	0.151	7.71
9	-55.7	965.7	-2.13	37.00	6.51	0.125	7.15

(Eq) Strokes Analyzed and Last Return (ft):
10.81 7.47 7.31 7.29

Max. Combustion Pressure 1165.0 psi

Rut= 550.0, Rtoe= 533.5 kips, Time Inc. =0.057 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	707.7	0.00	27.12	12.83	0.351	12.85
2	-39.3	651.8	-1.51	24.97	12.86	0.328	12.44
3	-54.2	658.1	-2.08	25.21	12.89	0.303	11.95
4	-52.7	663.9	-2.02	25.44	12.92	0.278	11.44
5	-57.3	670.8	-2.20	25.70	12.92	0.250	10.78
6	-50.4	696.8	-1.93	26.70	12.88	0.216	9.78
7	-70.5	811.8	-2.70	31.10	12.54	0.177	8.50
8	-87.5	933.0	-3.35	35.75	10.42	0.142	7.47
9	-64.6	1016.6	-2.47	38.95	5.96	0.113	6.76

(Eq) Strokes Analyzed and Last Return (ft):
10.81 7.77 7.53 7.50

Max. Combustion Pressure 1165.0 psi

Rut= 562.0, Rtoe= 545.1 kips, Time Inc. =0.057 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	722.2	0.00	27.67	12.89	0.352	12.97
2	-39.9	655.1	-1.53	25.10	12.93	0.329	12.55
3	-55.9	661.1	-2.14	25.33	12.97	0.304	12.06
4	-52.3	667.8	-2.00	25.59	12.99	0.279	11.54
5	-60.5	674.0	-2.32	25.82	12.99	0.251	10.87
6	-52.3	705.9	-2.01	27.05	12.95	0.216	9.86
7	-71.9	820.8	-2.75	31.45	12.59	0.176	8.51
8	-90.4	943.5	-3.46	36.15	10.43	0.140	7.43
9	-66.8	1026.9	-2.56	39.35	5.82	0.110	6.67

(Eq) Strokes Analyzed and Last Return (ft):
10.81 7.84 7.58 7.55

Max. Combustion Pressure 1165.0 psi

Rut= 663.0, Rtoe = 643.1 kips, Time Inc. =0.050 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	829.6	0.00	31.79	13.41	0.360	13.85
2	-55.0	742.1	-2.11	28.43	13.46	0.336	13.39
3	-59.5	714.7	-2.28	27.38	13.50	0.311	12.87
4	-45.7	726.8	-1.75	27.85	13.53	0.285	12.32
5	-85.7	727.3	-3.28	27.87	13.53	0.255	11.58
6	-83.3	777.9	-3.19	29.81	13.47	0.218	10.44
7	-80.9	891.2	-3.10	34.15	13.00	0.173	8.70
8	-109.6	1024.0	-4.20	39.23	10.50	0.129	7.08
9	-89.8	1114.5	-3.44	42.70	4.83	0.092	5.92

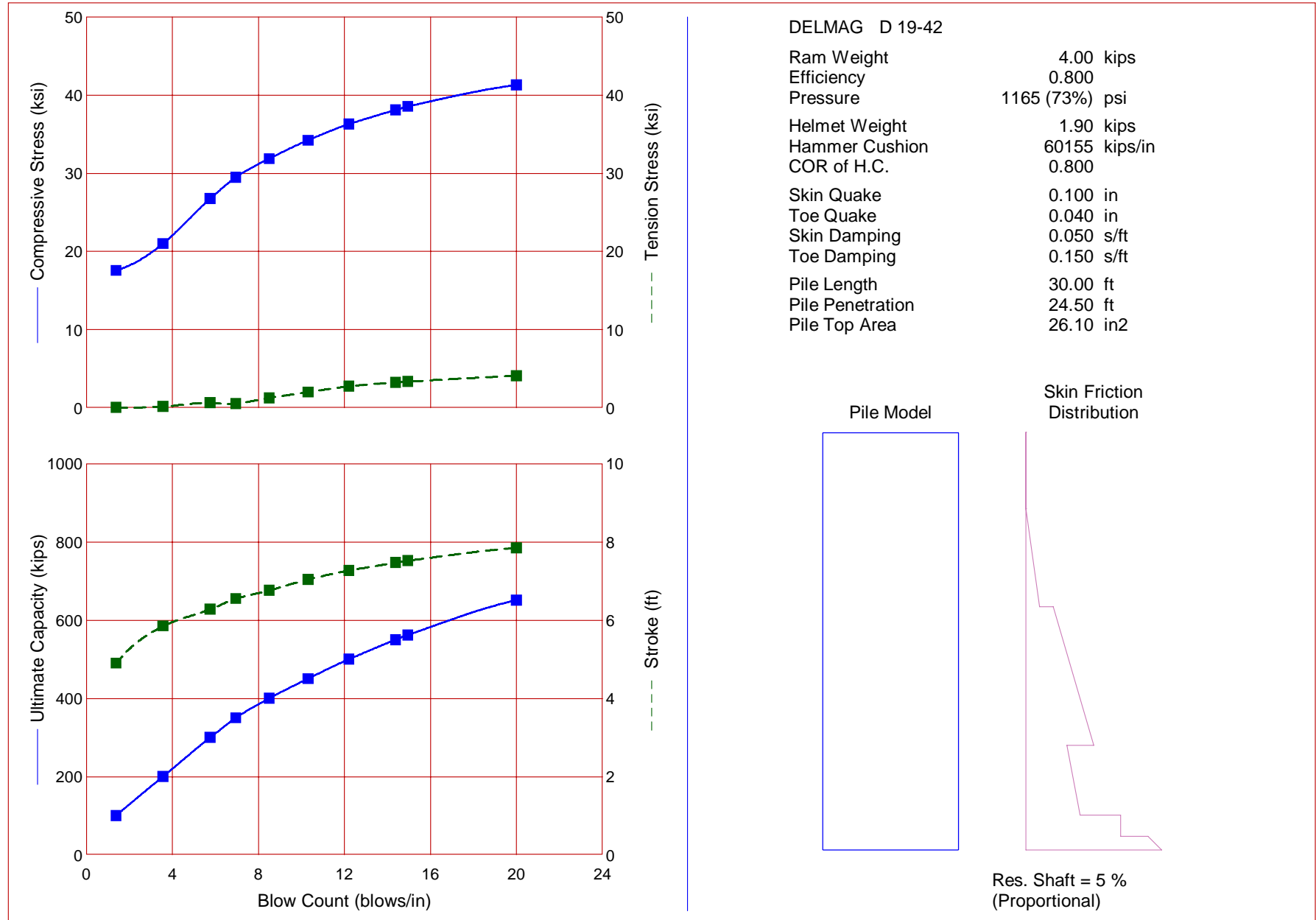
(Eq) Strokes Analyzed and Last Return (ft):
10.81 8.28 7.96 7.91

Max. Combustion Pressure 1165.0 psi

Red Bridge, BB-RSR-203, HP14x89
 Terracon

04/30/2023
 GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke down	(ft) up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
100.0	16.8	4.90	4.93	-0.05	8	50	17.62	6	3	11.0	52.9
200.0	43.0	5.85	5.84	-0.21	5	33	21.28	9	3	10.2	48.6
300.0	68.9	6.29	6.28	-0.70	5	13	27.18	9	3	10.3	47.0
350.0	83.1	6.56	6.52	-0.73	7	29	29.97	9	3	10.7	46.1
400.0	101.4	6.78	6.78	-1.32	4	13	32.41	9	3	11.2	45.3
450.0	123.1	7.06	7.06	-2.30	8	15	34.80	9	3	11.8	44.5
500.0	144.7	7.31	7.29	-3.05	8	14	37.00	9	3	12.4	43.8
550.0	169.2	7.53	7.50	-3.35	8	14	38.95	9	3	12.9	43.2
562.0	175.4	7.58	7.55	-3.46	8	14	39.35	9	3	13.0	43.1
663.0	240.5	7.96	7.91	-4.20	8	14	42.70	9	3	13.9	42.1



Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
100.0	17.56	0.05	1.4	4.90	11.06
200.0	20.99	0.19	3.6	5.85	10.20
300.0	26.74	0.64	5.8	6.28	10.29
350.0	29.47	0.54	7.0	6.55	10.66
400.0	31.85	1.28	8.5	6.76	11.15
450.0	34.19	2.01	10.3	7.04	11.76
500.0	36.27	2.76	12.2	7.27	12.30
550.0	38.09	3.27	14.4	7.47	12.74
562.0	38.52	3.36	14.9	7.52	12.84
651.0	41.29	4.10	20.0	7.85	13.58

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.
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ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

Input File: C:\USERS\SCCROWE\ONEDRIVE - TERRACON CONSULTANTS INC\DESKTOP\GRLWEAP
 DATA\RED BRIDGE, BB-RSR-204, HP14X89.GWW
 Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW
 Hammer File Version: 2003 (12/4/2018)

Input File Contents

Red Bridge, BB-RSR-204, HP14x89

OUT	OSG	HAM	STR	FUL	PEL	N	SPL	N-U	P-D	%SK	ISM	0	PHI	RSA	ITR	H-D	MXT	DEX
6	0	41	0	4	0	0	0	0	0	5	1	0	0	0	0	0	0	0.000

Pile g Hammer g Toe Area Pile Size Pile Type
 32.170 32.170 32.600 14.690 H Pile
 W Cp A Cp E Cp T Cp CoR ROut StCp
 1.900 227.000 530.0 2.000 0.800 0.010 0.0
 A Cu E Cu T Cu CoR ROut StCu
 0.000 0.0 0.000 0.000 0.000 0.0
 LPle APle EPle WPLE Peri CI CoR ROut
 30.000 26.10 30000.0 492.000 4.754 0 0.850 0.010
 FFatigue F0 0-Bottom
 0 0.000 0.000

Manufac	Hmr	Name	HmrType	No	Seg-s
DELMAG	D 19-42		1		5

Ram Wt Ram L Ram Dia MaxStrk RtdStrk Efficcy
 4.00 129.10 12.60 11.86 10.81 0.80
 IB. Wt IB. L IB.Dia IB CoR IB RO
 0.75 25.30 12.60 0.900 0.010
 CompStrk A Chamber V Chamber C Delay C Duratn Exp Coeff VolCStart Vol CEnd
 16.65 124.70 157.70 0.0020 0.0020 1.250 0.00 0.00
 P atm P1 P2 P3 P4 P5
 14.70 1600.00 1440.00 1295.00 1165.00 0.00
 Stroke Effic. Pressure R-Weight T-Delay Exp-Coeff Eps-Str Total-AW
 10.8100 0.8000 1165.0000 0.0000 0.0000 0.0000 0.0100 0.0000
 Qs Qt Js Jt Qx Jx Rati Dept
 0.100 0.040 0.050 0.150 0.000 0.000 0.000 0.000

Research Soil Model: Atoe, Plug, Gap, Q-fac
 0.000 0.000 0.000 0.000
 Research Soil Model: RD-skn: m, d, toe: m, d
 0.000 0.000 0.000 0.000
 Research Toe Plug: Res-int, Q-int, D-int, Res-plug, Q-plug, D-plug
 0.000 0.000 0.000 0.000 0.000 0.000
 Research Toe Plug: RD plug toe: m, d
 0.000 0.000
 Research Toe Plug: New Toe Plug Model is NOT applied

Res. Distribution

Dpth	Rskn	Dpth	Dpth	Dpth	Dpth	Dpth	Dpth	Dpth	Dpth
0.00	0.00	24.50	24.50	0.00	0.00	0.00	0.00	0.00	0.000
7.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
7.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
17.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
17.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
22.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
22.00	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
23.50	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
23.50	0.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
24.50	0.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
24.50	0.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
30.00	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000

Rult

100.0	200.0	300.0	350.0	400.0	450.0	500.0	550.0	562.0	651.0
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GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS
Version 2010
English Units

Red Bridge, BB-RSR-204, HP14x89

Hammer Model:	D 19-42		Made by:	DELMAG	
No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	0.800				
2	0.800	140046.6	1.000	0.0000	
3	0.800	140046.6	1.000	0.0000	
4	0.800	140046.6	1.000	0.0000	
5	0.800	140046.6	1.000	0.0000	
Imp Block	0.753	70735.6	0.900	0.0100	
Helmet	1.900	60155.0	0.800	0.0100	5.8
Combined Pile Top		19575.0			

HAMMER OPTIONS:

Hammer File ID No.	41	Hammer Type	OE Diesel
Stroke Option	FxdP-VarS	Stroke Convergence Crit.	0.010
Fuel Pump Setting	Max - 3		

HAMMER DATA:

Ram Weight	(kips)	4.00	Ram Length	(inch)	129.10
Maximum Stroke	(ft)	11.86			
Rated Stroke	(ft)	10.81	Efficiency		0.800
Maximum Pressure	(psi)	1600.00	Actual Pressure	(psi)	1165.00
Compression Exponent		1.350	Expansion Exponent		1.250
Ram Diameter	(inch)	12.60			
Combustion Delay	(s)	0.00200	Ignition Duration	(s)	0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION

Cross Sect. Area	(in2)	227.00
Elastic-Modulus	(ksi)	530.0
Thickness	(inch)	2.00
Coeff of Restitution		0.8
RoundOut	(ft)	0.0
Stiffness	(kips/in)	60155.0

PILE CUSHION

Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	0.00
Coeff of Restitution		0.0
RoundOut	(ft)	0.0
Stiffness	(kips/in)	0.0

PILE PROFILE:

Toe Area (in2) 32.600 Pile Type H Pile
 Pile Size (inch) 14.690

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	26.10	30000.	492.0	4.8	0	16807.	46.6
30.0	26.10	30000.	492.0	4.8	0	16807.	46.6

Wave Travel Time 2L/c (ms) 3.570

No.	Pile and Soil Model					Total Capacity Rut (kips)			100.0		
	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.297	19575	0.010	0.000	0.85	0.0	0.050	0.100	3.33	4.8	26.1
2	0.297	19575	0.000	0.000	1.00	0.0	0.050	0.100	6.67	4.8	26.1
3	0.297	19575	0.000	0.000	1.00	0.1	0.050	0.100	10.00	4.8	26.1
4	0.297	19575	0.000	0.000	1.00	0.3	0.050	0.100	13.33	4.8	26.1
5	0.297	19575	0.000	0.000	1.00	0.6	0.050	0.100	16.67	4.8	26.1
6	0.297	19575	0.000	0.000	1.00	0.8	0.050	0.100	20.00	4.8	26.1
7	0.297	19575	0.000	0.000	1.00	0.9	0.050	0.100	23.33	4.8	26.1
8	0.297	19575	0.000	0.000	1.00	0.8	0.050	0.100	26.67	4.8	26.1
9	0.297	19575	0.000	0.000	1.00	1.5	0.050	0.100	30.00	4.8	26.1
Toe						95.0	0.150	0.040			

2.675 kips total unreduced pile weight (g= 32.17 ft/s2)
 2.675 kips total reduced pile weight (g= 32.17 ft/s2)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile		Pile Segments: Automatic	
No. of Slacks/Splices	0	Pile Damping (%)	1
Pile Penetration (ft)	24.50	Pile Damping Fact.(k/ft/s)	0.932
% Shaft Resistance	5		
Soil Damping Option	Smith		
Max No Analysis Iterations	0	Time Increment/Critical	160
Output Time Interval	1	Analysis Time-Input (ms)	0
Output Level: Variable vs Time			
Gravity Mass, Pile, Hammer:	32.170	32.170	32.170
Output Segment Generation: Automatic			

Rut= 100.0, Rtoe = 95.0 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	446.9	0.00	17.12	8.63	0.788	11.06
2	0.0	448.7	0.00	17.19	8.62	0.785	11.07
3	0.0	451.7	0.00	17.31	8.62	0.782	11.07
4	0.0	454.4	0.00	17.41	8.61	0.779	11.07
5	0.0	457.1	0.00	17.51	8.60	0.776	11.05
6	0.0	458.4	0.00	17.56	8.68	0.772	11.01
7	-0.7	451.1	-0.03	17.28	10.22	0.769	10.95
8	-1.3	421.1	-0.05	16.13	11.57	0.764	10.89
9	-0.7	343.9	-0.03	13.18	12.52	0.760	10.85

(Eq) Strokes Analyzed and Last Return (ft):
10.81 4.27 5.04 4.90 4.92

Max. Combustion Pressure 1165.0 psi

Rut= 200.0, Rtoe= 190.0 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	530.0	0.00	20.31	10.33	0.399	10.20
2	-2.3	533.0	-0.09	20.42	10.34	0.389	10.14
3	-4.0	536.5	-0.15	20.55	10.34	0.379	10.06
4	-4.9	541.0	-0.19	20.73	10.33	0.370	9.98
5	-4.9	544.8	-0.19	20.87	10.32	0.361	9.89
6	-4.3	546.3	-0.17	20.93	10.35	0.351	9.78
7	-3.6	542.4	-0.14	20.78	10.55	0.342	9.66
8	-3.1	540.7	-0.12	20.72	10.21	0.332	9.54
9	-1.9	547.8	-0.07	20.99	11.17	0.323	9.45

(Eq) Strokes Analyzed and Last Return (ft):
10.81 5.67 5.85 5.84

Max. Combustion Pressure 1165.0 psi

Rut= 300.0, Rtoe= 285.0 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	563.0	0.00	21.57	11.00	0.334	10.29
2	-2.9	566.0	-0.11	21.69	11.00	0.320	10.12
3	-5.8	571.1	-0.22	21.88	11.02	0.305	9.95
4	-13.1	575.2	-0.50	22.04	11.00	0.290	9.75
5	-16.8	579.9	-0.64	22.22	10.97	0.276	9.54
6	-16.3	582.4	-0.62	22.32	10.98	0.261	9.32
7	-14.7	579.4	-0.56	22.20	10.99	0.246	9.08
8	-10.3	643.7	-0.40	24.66	9.96	0.231	8.85
9	-4.7	697.9	-0.18	26.74	9.11	0.216	8.66

(Eq) Strokes Analyzed and Last Return (ft):
10.81 6.28 6.27

Max. Combustion Pressure 1165.0 psi

Rut= 350.0, Rtoe = 332.5 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	583.4	0.00	22.35	11.44	0.329	10.66
2	-7.8	586.9	-0.30	22.49	11.45	0.310	10.38
3	-12.0	591.7	-0.46	22.67	11.46	0.292	10.11
4	-13.5	596.7	-0.52	22.86	11.44	0.275	9.83
5	-14.1	601.6	-0.54	23.05	11.42	0.257	9.53
6	-13.7	603.8	-0.52	23.14	11.40	0.239	9.22
7	-13.3	611.4	-0.51	23.43	11.34	0.221	8.91
8	-11.7	706.3	-0.45	27.06	10.10	0.204	8.61
9	-10.1	769.2	-0.39	29.47	8.39	0.187	8.34

(Eq) Strokes Analyzed and Last Return (ft):
10.81 6.55 6.50

Max. Combustion Pressure 1165.0 psi

Rut= 400.0, Rtoe= 380.0 kips, Time Inc. =0.072 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	598.7	0.00	22.94	11.76	0.333	11.15
2	-19.0	602.3	-0.73	23.08	11.78	0.313	10.82
3	-31.9	607.5	-1.22	23.28	11.79	0.290	10.38
4	-33.5	612.5	-1.28	23.47	11.78	0.266	9.91
5	-28.2	617.2	-1.08	23.65	11.73	0.241	9.35
6	-24.2	620.3	-0.93	23.77	11.70	0.219	8.91
7	-21.8	661.3	-0.84	25.34	11.58	0.200	8.53
8	-21.1	761.4	-0.81	29.17	10.12	0.180	8.18
9	-13.4	831.2	-0.51	31.85	7.67	0.160	7.83

(Eq) Strokes Analyzed and Last Return (ft):
10.81 6.86 6.76 6.76

Max. Combustion Pressure 1165.0 psi

Rut= 450.0, Rtoe= 427.5 kips, Time Inc. =0.067 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	616.7	0.00	23.63	12.14	0.338	11.76
2	-18.0	620.7	-0.69	23.78	12.17	0.317	11.39
3	-43.1	626.2	-1.65	23.99	12.19	0.294	10.93
4	-50.6	631.9	-1.94	24.21	12.18	0.269	10.43
5	-42.6	637.0	-1.63	24.41	12.14	0.243	9.81
6	-31.4	640.1	-1.20	24.53	12.09	0.213	8.99
7	-46.3	711.8	-1.78	27.27	11.88	0.185	8.31
8	-52.5	817.5	-2.01	31.32	10.20	0.162	7.83
9	-32.8	892.4	-1.25	34.19	7.09	0.140	7.41

(Eq) Strokes Analyzed and Last Return (ft):
10.81 7.14 7.04 7.04

Max. Combustion Pressure 1165.0 psi

Rut= 500.0, Rtoe = 475.0 kips, Time Inc. =0.062 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	633.5	0.00	24.27	12.49	0.343	12.30
2	-38.0	636.4	-1.46	24.38	12.51	0.321	11.90
3	-42.9	642.6	-1.64	24.62	12.53	0.297	11.42
4	-53.1	648.6	-2.04	24.85	12.51	0.273	10.90
5	-48.5	653.5	-1.86	25.04	12.48	0.245	10.23
6	-57.2	656.7	-2.19	25.16	12.43	0.213	9.28
7	-72.2	756.6	-2.76	28.99	12.14	0.180	8.31
8	-71.9	868.4	-2.76	33.27	10.28	0.150	7.55
9	-44.9	946.6	-1.72	36.27	6.50	0.125	7.01

(Eq) Strokes Analyzed and Last Return (ft):
10.81 7.43 7.27 7.27

Max. Combustion Pressure 1165.0 psi

Rut= 550.0, Rtoe= 522.5 kips, Time Inc. =0.058 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	693.8	0.00	26.58	12.75	0.347	12.74
2	-38.1	649.0	-1.46	24.86	12.78	0.325	12.32
3	-54.0	655.4	-2.07	25.11	12.79	0.300	11.82
4	-52.7	661.1	-2.02	25.33	12.80	0.275	11.27
5	-59.0	667.1	-2.26	25.56	12.74	0.247	10.56
6	-52.1	684.3	-2.00	26.22	12.68	0.213	9.53
7	-69.9	795.0	-2.68	30.46	12.34	0.175	8.27
8	-85.3	912.9	-3.27	34.98	10.31	0.141	7.28
9	-62.4	994.1	-2.39	38.09	5.90	0.113	6.59

(Eq) Strokes Analyzed and Last Return (ft):
10.81 7.71 7.47 7.46

Max. Combustion Pressure 1165.0 psi

Rut= 562.0, Rtoe= 533.9 kips, Time Inc. =0.057 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	707.6	0.00	27.11	12.82	0.348	12.84
2	-38.8	652.1	-1.49	24.98	12.84	0.325	12.42
3	-55.1	658.4	-2.11	25.23	12.87	0.301	11.91
4	-51.5	664.8	-1.97	25.47	12.86	0.276	11.37
5	-62.1	670.0	-2.38	25.67	12.82	0.247	10.65
6	-54.3	693.8	-2.08	26.58	12.73	0.213	9.60
7	-71.7	804.4	-2.75	30.82	12.39	0.174	8.27
8	-87.8	922.3	-3.36	35.34	10.31	0.139	7.23
9	-65.1	1005.5	-2.50	38.53	5.79	0.110	6.50

(Eq) Strokes Analyzed and Last Return (ft):
10.81 7.78 7.52 7.50

Max. Combustion Pressure 1165.0 psi

Rut= 651.0, Rtoe = 618.5 kips, Time Inc. =0.051 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	800.0	0.00	30.65	13.25	0.355	13.58
2	-51.0	716.0	-1.95	27.43	13.29	0.331	13.12
3	-56.7	690.6	-2.17	26.46	13.31	0.306	12.58
4	-44.6	710.7	-1.71	27.23	13.30	0.280	12.01
5	-83.7	709.7	-3.21	27.19	13.25	0.250	11.22
6	-85.7	755.6	-3.28	28.95	13.15	0.214	10.05
7	-81.8	865.2	-3.14	33.15	12.70	0.170	8.36
8	-106.9	991.8	-4.10	38.00	10.37	0.129	6.87
9	-85.9	1077.7	-3.29	41.29	4.88	0.093	5.81

(Eq) Strokes Analyzed and Last Return (ft):
10.81 8.16 7.85 7.80

Max. Combustion Pressure 1165.0 psi

Red Bridge, BB-RSR-204, HP14x89
 Terracon

04/30/2023
 GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke down	(ft) up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
100.0	16.7	4.90	4.92	-0.05	8	50	17.56	6	3	11.1	52.9
200.0	42.9	5.85	5.84	-0.19	5	33	20.99	9	3	10.2	48.7
300.0	69.2	6.28	6.27	-0.64	5	13	26.74	9	3	10.3	47.0
350.0	83.5	6.55	6.50	-0.54	5	29	29.47	9	3	10.7	46.1
400.0	102.2	6.76	6.76	-1.28	4	13	31.85	9	3	11.1	45.4
450.0	123.8	7.04	7.04	-2.01	8	15	34.19	9	3	11.8	44.6
500.0	146.6	7.27	7.27	-2.76	7	14	36.27	9	3	12.3	43.9
550.0	172.6	7.47	7.46	-3.27	8	14	38.09	9	3	12.7	43.3
562.0	179.4	7.52	7.50	-3.36	8	14	38.53	9	3	12.8	43.2
651.0	240.1	7.85	7.80	-4.10	8	14	41.29	9	3	13.6	42.4

SOIL & ROCK PARAMETERS

Problem Statement

Determine the following parameters for site soils and rock:

- Soil – corrected N-values, γ_{sat} , γ_{dry} , Φ , c
- Rock – γ , q_u , E , Poisson's ratio, m_i , GSI
- Frost depth

Given

- Boring logs BB-RSR-201 through BB-RSR-204
- Uniaxial compressive strength and elastic modulus test results

References

1. An Introduction to Geotechnical Engineering, 2nd Ed.; Holtz, R., Kovacs, W., Sheahan, T., 2011
2. AASHTO LRFD Bridge Design Specification, 9th Ed., 2020
3. Quantification of the Geological Strength Index Chart, Hoek, E., Carter, T.G., Diederichs, M.S., 2013
4. 2003 MaineDOT Bridge Design Guide with Updates through 2018, prepared by Guertin Elkerton & Associates, 2003, revised 2018

Solution

Soil Properties:

Assumed Parameters:

Material	Saturated Unit Weight, γ_{sat} (pcf)	Dry Unit Weight, γ_{dry} (pcf)	Cohesion, c (psf)
Fill – Sand	130	120	0
Alluvium – Sand	130	120	0

1. Unit weights assumed from Table 2.2, Holtz et al, 2011.
2. Cohesion assumed to be zero for granular soils.

N-Value Correction Summary:

Material	Average $(N_1)_{60}$ by Boring Location				Total Average $(N_1)_{60}$
	BB-RSR-201	BB-RSR-202	BB-RSR-203	BB-RSR-204	
Fill – Sand	17	23	23	21	21
Alluvium – Sand	27	23	29	28	26

1. $(N_1)_{60}$ values are calculated accordance with AASHTO LRFD Section 10.4.6.2.4. See attached spreadsheet for calculations summarized in this table.

Geotechnical Engineering Report

Rumford-Mexico Bridge #2707 ■ Rumford and Mexico, Maine

May 9, 2023 ■ Terracon Project No. J1215037

Soil Properties (continued):*Friction Angle:*

Material	Average $(N_1)_{60}$	Interpolated Range of Φ	Friction Angle, Φ (degrees)
Fill – Sand	21	32 to 37	32
Alluvium – Sand	26	34 to 39	34

- Friction angles are based on $(N_1)_{60}$ using linear interpolation of friction angles in AASHTO LRFD Table 10.4.6.2.4-1.

Rock Properties:*Laboratory Test Results Summary:*

Boring	Depth Interval (feet)	Unit Weight, γ (pcf)	Uniaxial Compressive Strength, q_u (psi)	Elastic Modulus, E (ksi)	Poisson's Ratio (dim)
BB-RSR-102	37.0 to 37.4	162.0	26,522	7,090	0.23
BB-RSR-202	25.3 to 26.2	178.4	7,630	790	0.185
BB-RSR-203	23.7 to 24.5	182.1	15,789	1,289	0.046
BB-RSR-204	33.6 to 34.5	159.7	7,217	858	0.034

Based on the laboratory test results, the following parameters are assumed for analyses:

Material	Unit Weight, γ (pcf)	Uniaxial Compressive Strength, q_u (psi)	Elastic Modulus, E (ksi)	Poisson's Ratio (dim)
Migmatite	165	7,000	800	0.18

Determine m_i :

From AASHTO Table 10.4.6.4-1, the value of the constant m_i is 29 ± 3 (dimensionless) for migmatite.

Geotechnical Engineering Report

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Rock Properties (continued):*Determine GSI:*

Geological strength index (GSI) is interpreted from AASHTO Figure 10.4.6-1. To aid in determining GSI, refer to Hoek et al.'s 2013 publication *Quantification of the Geological Strength Index Chart*.

$$GSI = 1.5JCond_{89} + RQD/2$$

JCond₈₉ is the sum of discontinuity ratings of discontinuity length, separation, roughness, infilling, and weathering; as defined in Table 1 of the appendix to Hoek et al., 2013. The following ratings are used:

Discontinuity Length (persistence)	Separation (aperture)	Roughness	Infilling (gouge)	Weathering	JCond ₈₉
2	4	6	6	5	24

Rock Quality Designation (RQD) values are provided on the boring logs. The following table summarizes GSI calculations for each core interval.

Boring No.	Core Depth	RQD (%)	JCond ₈₉	GSI
BB-RSR-202	24.5 to 29.5	71	24	71.5
	29.5 to 34.5	90		81
BB-RSR-203	22.4 to 27.4	96		84
	27.4 to 32.4	91		81.5
BB-RSR-204	32.5 to 37.5	83		77.5
	37.5 to 42.5	96		84
Average				80

Geotechnical Engineering Report

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Frost Depth:

Frost penetration was determined in accordance with Section 5.2.1 of the 2003 MaineDOT Bridge Design Guide with Updates through 2018:

Step 1: From Figure 5-1, Design Freezing Index = 1,650 degree-days for Rumford, ME

Step 2: From laboratory results, soil water content of native soil in the depth range of 5 to 8 feet varied between 17.2% and 32.4% (average of 26.3%) and major constituent Sand

Step 3: From Table 5-1: Interpolated depth of frost penetration = 67.6 inches

Design Freezing Index (degree-days)	Frost Penetration (in) for Corresponding Water Content of Coarse-Grained Soil			
	10%	20%	26.3%	30%
1,600	84.8	70.2	66.6	60.3
1,650	86.2	71.3	67.6	61.3
1,700	87.5	72.4	68.6	62.2

To account for soil and water content variability, use 72 inches (6 feet) for frost penetration depth.

N-Value Corrections

PROJECT INFORMATION

Project Name: Rumford-Mexico Bridge #2707
 Project Number: J1215037
 Notes:
 Date: May 9, 2023

Denotes Input

Input and Subsurface Properties

Boring Information	
Boring Location	BB-RSR-201
Elevation of Ground Surface (ft)	432
Depth to Water (ft)	9
Hammer Efficiency	93%

Soil Strata				
Description	Top (ft)	Bottom (ft)	γ_{sat} (psf)	γ_{dry} (psf)
Fill - Sand	0	4	130	120
Alluvium - Sand	4	21.8	130	120

N-Values and Correction Information								Average $(N_1)_{60}$
Elevation (ft)	Depth (ft)	Raw N-Value	σ' (ksf)	N_{60}	C_N	$(N_1)_{60}$	Strata	
431	1	6	0.12	9	1.94	17	Fill	17
429	3	8	0.36	12	1.58	18		
426	6	2	0.72	3	1.34	4	Alluvium	27
424.6	7.4	50	0.89	77	1.27	98		
421	11	31	1.22	47	1.17	54		
416	16	18	1.55	27	1.09	29		
411	21	14	1.89	21	1.02	21		

Notes:

Average excludes sample at 7.4 feet because of sampler refusal
 AASHTO LRFD Bridge Design Specification, 9th Ed., 2020
 Section 10.4.6.2.4 - Drained Strength of Granular Soils

N-Value Corrections

PROJECT INFORMATION

Project Name: Rumford-Mexico Bridge #2707
 Project Number: J1215037
 Notes:
 Date: May 9, 2023

Denotes Input

Input and Subsurface Properties

Boring Information	
Boring Location	BB-RSR-202
Elevation of Ground Surface (ft)	432
Depth to Water (ft)	10
Hammer Efficiency	93%

Soil Strata				
Description	Top (ft)	Bottom (ft)	γ_{sat} (psf)	γ_{dry} (psf)
Fill - Sand	0	4	130	120
Alluvium - Sand	4	24.5	130	120

N-Values and Correction Information								Average $(N_1)_{60}$
Elevation (ft)	Depth (ft)	Raw N-Value	σ' (ksf)	N_{60}	C_N	$(N_1)_{60}$	Strata	
431	1	7	0.12	10	1.94	19	Fill	23
429	3	12	0.36	18	1.58	28		
426	6	5	0.72	7	1.34	9	Alluvium	23
424	8	4	0.96	6	1.25	7		
421	11	9	1.27	13	1.15	15		
416	16	27	1.61	41	1.08	44		
411	21	29	1.94	44	1.01	44		

Notes:

AASHTO LRFD Bridge Design Specification, 9th Ed., 2020
 Section 10.4.6.2.4 - Drained Strength of Granular Soils

N-Value Corrections

PROJECT INFORMATION

Project Name: Rumford-Mexico Bridge #2707
 Project Number: J1215037
 Notes:
 Date: May 9, 2023

Denotes Input

Input and Subsurface Properties

Boring Information	
Boring Location	BB-RSR-203
Elevation of Ground Surface (ft)	428
Depth to Water (ft)	5
Hammer Efficiency	93%

Soil Strata				
Description	Top (ft)	Bottom (ft)	γ_{sat} (psf)	γ_{dry} (psf)
Fill - Sand	0	4	130	120
Alluvium - Sand	4	22.4	130	120

N-Values and Correction Information								Average $(N_1)_{60}$
Elevation (ft)	Depth (ft)	Raw N-Value	σ' (ksf)	N_{60}	C_N	$(N_1)_{60}$	Strata	
427	1	11	0.12	17	1.94	33	Fill	23
425	3	6	0.36	9	1.58	14		
422	6	8	0.67	12	1.37	16	Alluvium	29
420	8	10	0.80	15	1.31	19		
417	11	24	1.01	37	1.23	45		
412	16	10	1.34	15	1.13	17		
407	21	32	1.68	49	1.06	51		

Notes:

AASHTO LRFD Bridge Design Specification, 9th Ed., 2020
 Section 10.4.6.2.4 - Drained Strength of Granular Soils

N-Value Corrections

PROJECT INFORMATION

Project Name: Rumford-Mexico Bridge #2707
 Project Number: J1215037
 Notes:
 Date: May 9, 2023

Denotes Input

Input and Subsurface Properties

Boring Information	
Boring Location	BB-RSR-204
Elevation of Ground Surface (ft)	429
Depth to Water (ft)	5
Hammer Efficiency	93%

Soil Strata				
Description	Top (ft)	Bottom (ft)	γ_{sat} (psf)	γ_{dry} (psf)
Fill - Sand	0	4	130	120
Alluvium - Sand	4	32.5	130	120

N-Values and Correction Information								Average $(N_1)_{60}$
Elevation (ft)	Depth (ft)	Raw N-Value	σ' (ksf)	N_{60}	C_N	$(N_1)_{60}$	Strata	
428	1	8	0.12	12	1.94	23	Fill	21
426	3	9	0.36	13	1.58	20		
423	6	4	0.67	6	1.37	8	Alluvium	28
421	8	7	0.80	10	1.31	13		
418	11	14	1.01	21	1.23	25		
413	16	21	1.34	32	1.13	36		
408	21	32	1.68	49	1.06	51		
403	26	18	2.02	27	1.00	26		
398	31	26	2.36	40	0.95	37		

Notes:

AASHTO LRFD Bridge Design Specification, 9th Ed., 2020
 Section 10.4.6.2.4 - Drained Strength of Granular Soils

Seismic Site Class Determination

PROJECT INFORMATION

Project Name: Rumford-Mexico Bridge #2707
 Project Number: J1215037
 Notes: Seismic Site Class using SPT N-values
 Date: May 9, 2023

Denotes Input

Input and Subsurface Properties

Boring Location BB-RSR-201

Layer Top	Layer Bottom	Layer Thickness, d _i	N-Value, N _i	d _i /N _i
ft	ft	-	-	-
0	2	2	9	0.22
2	5	3	12	0.25
5	7	2	3	0.67
7	10	3	77	0.04
10	15	5	47	0.11
15	20	5	27	0.19
20	21.8	1.8	21	0.09
21.8	100	78.2	100	0.78
Sum		100	Sum	2.34

Average N 42

Boring Location BB-RSR-202

Layer Top	Layer Bottom	Layer Thickness, d _i	N-Value, N _i	d _i /N _i
ft	ft	-	-	-
0	2	2	10	0.20
2	5	3	18	0.17
5	7	2	7	0.29
7	10	3	6	0.50
10	15	5	13	0.38
15	20	5	41	0.12
20	24.5	4.5	44	0.10
24.5	100	75.5	100	0.76
Sum		100	Sum	2.52

Average N 39

Site Average N	42.0
Seismic Site Class	D

Notes:
 Use N₆₀-values
 Do not exceed N=100
 Use N=100 for bedrock refusal
 Layer bottom taken to be top of subsequent SPT sample

Boring Location BB-RSR-203

Layer Top	Layer Bottom	Layer Thickness, d _i	N-Value, N _i	d _i /N _i
ft	ft	-	-	-
0	2	2	17	0.12
2	5	3	9	0.33
5	7	2	12	0.17
7	10	3	15	0.20
10	15	5	37	0.14
15	20	5	15	0.33
20	22.4	2.4	49	0.05
22.4	100	77.6	100	0.78
Sum		100	Sum	2.11

Average N 47

Boring Location BB-RSR-204

Layer Top	Layer Bottom	Layer Thickness, d _i	N-Value, N _i	d _i /N _i
ft	ft	-	-	-
0	2	2	12	0.17
2	5	3	13	0.23
5	7	2	6	0.33
7	10	3	10	0.30
10	15	5	21	0.24
15	20	5	32	0.16
20	25	5	49	0.10
25	30	5	27	0.19
30	32.5	2.5	40	0.06
32.5	100	67.5	100	0.68
Sum		100	Sum	2.45

Average N 40

Gross Bearing Capacity



PROJECT INFORMATION

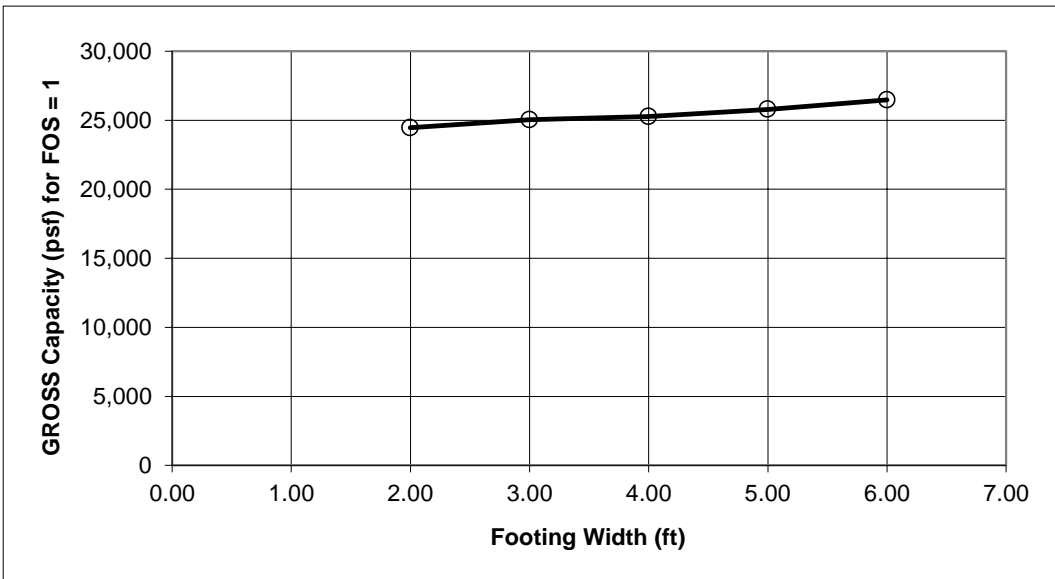
Project Name: Rumford-Mexico Bridge #2707
 Project Number: J1215037
 Notes: Horizontal ground surface
 Date: May 9, 2023

Soil Properties, Footing Dimensions, and Groundwater

Symbol	Value	Units	Definition
c	0	psf	Cohesion
ϕ	32	degrees	Drained Friction Angle
γ_{above}	120	pcf	Unit Weight of Soil above Footing
γ_{below}	120	pcf	Unit Weight of Soil below Footing
D_f	6	feet	Depth of Footing from Ground Surface
D_w	6	feet	Depth to Groundwater from Ground Surface
B_{min}	2	feet	Minimum Footing Width
B_{max}	6	feet	Maximum Footing Width
L	65	feet	Footing Length
FOS	1.0	none	Factor of Safety

Check if the soils above the footing are as competent as those below the footing.

Check if local or punching shear is possible. See Figure C10.6.3.1.2b-1 on the Instructions sheet.



Notes

- Calculations are based on Section 10.6.3.1.2 of AASHTO 2010 (Vesic factors).
- User can differentiate between soil unit weight above and below footing.
- Inclination factors are assumed to be 1.0. User must manually input overrides.
- Values for d_q are linearly interpolated based on D_f/B and ϕ (see Table 10.6.3.1.2a-4).
- See Calculation Sheet for a summary of all other variables.

Shallow Foundation Bearing Capacity (Gross)



PROJECT INFORMATION

Project Name:	Rumford-Mexico Bridge #2707
Project Number:	J1215037
Notes:	Horizontal ground surface
Date:	May 9, 2023

Governing Equations

$$q_u = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5\gamma B N_{\gamma m} C_{w\gamma}$$

$$N_{cm} = N_c s_c i_c$$

$$N_{qm} = N_q s_q d_q i_q$$

$$N_{\gamma m} = N_{\gamma} s_{\gamma} i_{\gamma}$$

See the instructions sheet for a definition of variables.

Parameter Values and Results of Equations for GROSS Capacity

Design phi = 32	Width = 2'	Width = 3'	Width = 4'	Width = 5'	Width = 6'
c	0	0	0	0	0
N _c	35.50	35.50	35.50	35.50	35.50
s _c	1.02	1.03	1.04	1.05	1.06
i _c	1.00	1.00	1.00	1.00	1.00
cN _c s _c i _c	0	0	0	0	0

γ _{above}	120	120	120	120	120
D _f	6.00	6.00	6.00	6.00	6.00
N _q	23.20	23.20	23.20	23.20	23.20
s _q	1.02	1.03	1.04	1.05	1.06
d _q	1.33	1.30	1.25	1.22	1.20
i _q	1.00	1.00	1.00	1.00	1.00
C _{wq}	1.00	1.00	1.00	1.00	1.00
γ _{above} D _f N _q s _q d _q i _q C _{wq}	22,661	22,367	21,715	21,398	21,247

γ _{below}	120	120	120	120	120
B	2.00	3.00	4.00	5.00	6.00
N _γ	30.20	30.20	30.20	30.20	30.20
s _γ	0.99	0.98	0.98	0.97	0.96
i _γ	1.00	1.00	1.00	1.00	1.00
C _{wγ}	0.50	0.50	0.50	0.50	0.50
0.5γ _{below} BN _γ s _γ i _γ C _{wγ}	1,794	2,664	3,552	4,394	5,219

Gross Bearing Capacity	Width = 2'	Width = 3'	Width = 4'	Width = 5'	Width = 6'
Ultimate (psf)	24,455	25,030	25,267	25,792	26,466
Gross Allowable (psf), FOS = 1	24,455	25,030	25,267	25,792	26,466

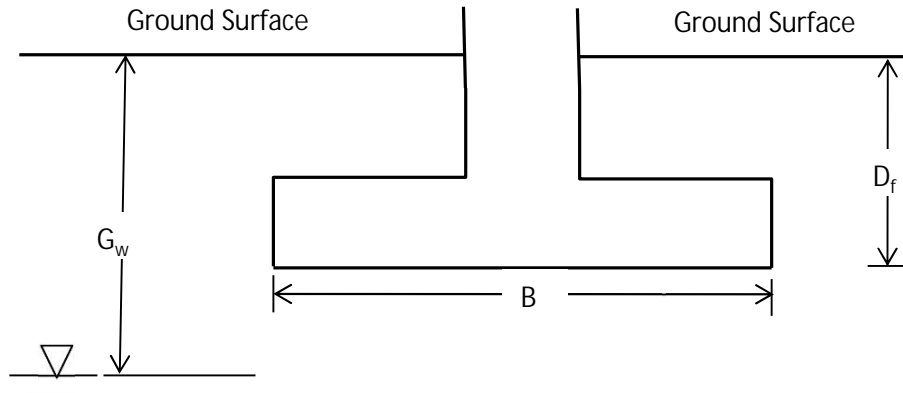
Shallow Foundation Settlement



PROJECT INFORMATION

Project	Rumford-Mexico Bridge #2707
Project No.	J1215037
Notes/Location	Rumford and Mexico, Maine
Date	5/9/2023

Definition of Footing Variables



Footing Input Parameters

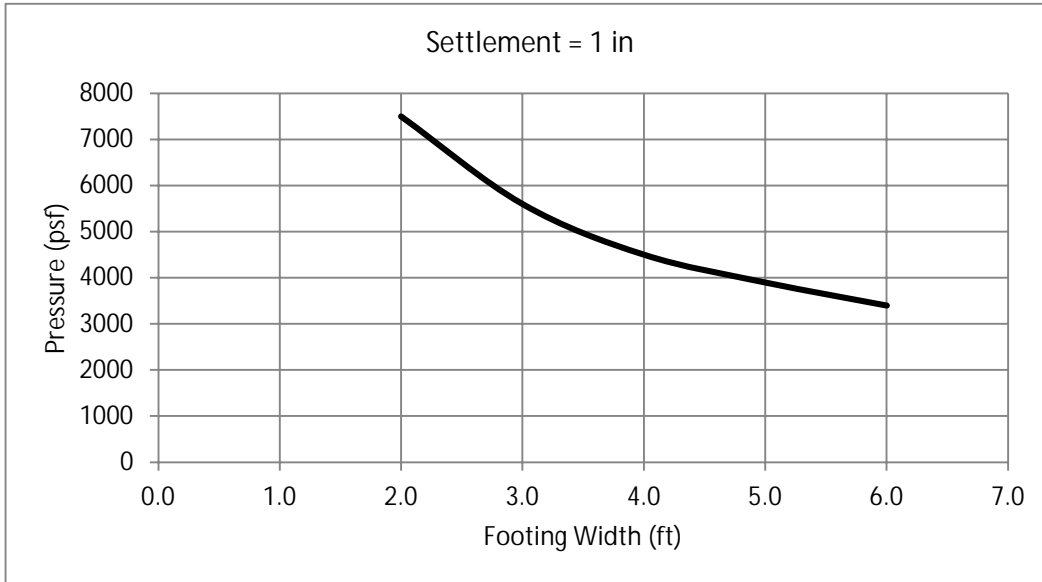
Symbol	Value	Units	Description
B_{min}	2.00	ft	Minimum Footing Width
B_{max}	6.00	ft	Maximum Footing Width
Footing length defined by:	<input checked="" type="radio"/> Fixed Footing Length <input type="radio"/> Fixed Length to Width (L/B) Ratio		
Length	65.00	ft	Fixed Footing Length
D_f	6.00	ft	Depth of Footing (from ground surface)
G_w	6.00	ft	Depth to Groundwater (from ground surface)
Selected Analysis Method:	Fixed Settlement ▼		
Settlement	1.00	in	Design settlement
Stress Distribution Method:	Boussinesq ▼		
Perform Analysis	Click to Perform Analysis		

Settlement Results



PROJECT INFORMATION

Project Rumford-Mexico Bridge #2707
Project No. J1215037
Notes/Location Rumford and Mexico, Maine
Date 5/9/2023



Boussinesq Stress Distribution Method

Dimensions, Pressure, and Settlement			
Width (ft)	Length (ft)	Pressure (psf)	Settlement (in)
2	65	7,500	1.0
3	65	5,600	1.0
4	65	4,500	1.0
5	65	3,900	1.0
6	65	3,400	1.0

Stress and Settlement Calculation Output



Project: Rumford-Mexico Bridge #2707
 Number: J1215037

Notes: Rumford and Mexico, Maine
 Date: 5/9/2023

Width (ft)	Length (ft)	Mid Point Depth (ft)	σ_o' (psf)	σ_p' (psf)	$\Delta\sigma'$ (psf)	σ_f' (psf)	Settlement (in)
2.0	65.0	1.00	120	120	0	120	0.0
2.0	65.0	3.00	360	360	0	360	0.0
2.0	65.0	6.50	749	749	7196	7945	0.4
2.0	65.0	11.00	1008	1008	1860	2868	0.3
2.0	65.0	17.50	1382	1382	822	2205	0.2
2.0	65.0	20.90	1578	1578	631	2210	0.1
Summary:					7500	Boussinesq	1.0

3.0	65.0	1.00	120	120	0	120	0.0
3.0	65.0	3.00	360	360	0	360	0.0
3.0	65.0	6.50	749	749	5522	6271	0.3
3.0	65.0	11.00	1008	1008	2020	3028	0.3
3.0	65.0	17.50	1382	1382	915	2298	0.3
3.0	65.0	20.90	1578	1578	704	2283	0.1
Summary:					5600	Boussinesq	1.0

4.0	65.0	1.00	120	120	0	120	0.0
4.0	65.0	3.00	360	360	0	360	0.0
4.0	65.0	6.50	749	749	4472	5221	0.3
4.0	65.0	11.00	1008	1008	2077	3085	0.4
4.0	65.0	17.50	1382	1382	972	2354	0.3
4.0	65.0	20.90	1578	1578	751	2329	0.1
Summary:					4500	Boussinesq	1.0

5.0	65.0	1.00	120	120	0	120	0.0
5.0	65.0	3.00	360	360	0	360	0.0
5.0	65.0	6.50	749	749	3887	4636	0.3
5.0	65.0	11.00	1008	1008	2144	3152	0.4
5.0	65.0	17.50	1382	1382	1042	2424	0.3
5.0	65.0	20.90	1578	1578	808	2386	0.1
Summary:					3900	Boussinesq	1.0

6.0	65.0	1.00	120	120	0	120	0.0
6.0	65.0	3.00	360	360	0	360	0.0
6.0	65.0	6.50	749	749	3394	4142	0.3
6.0	65.0	11.00	1008	1008	2124	3132	0.4
6.0	65.0	17.50	1382	1382	1076	2458	0.3
6.0	65.0	20.90	1578	1578	838	2417	0.1
Summary:					3400	Boussinesq	1.0

Lateral Earth Pressure



PROJECT INFORMATION

Project Name: Rumford-Mexico Bridge #2707
 Project Number: J1215037
 Notes:
 Date: May 9, 2023

Soil Information

Friction Angle, ϕ , (degrees) 32
 Effective Weight of Soil (pcf) 120
 Ground Inclination Uphill of Wall (degrees) 0
 Ground Inclination Downhill of Wall (degrees) 0

Rankine Lateral Earth Pressures

Active Pressure Coefficient (K_a) 0.31
 Active Pressure Equivalent Fluid (pcf) 37
 At Rest Pressure Coefficient (K_o) 0.47
 At Rest Pressure Equivalent Fluid (pcf) 56
 Passive Pressure Coefficient (K_p) 3.25
 Passive Pressure Equivalent Fluid (pcf) 391

Table C3.11.1-1—Approximate Values of Relative Movements Required to Reach Active or Passive Earth Pressure Conditions (Clough and Duncan, 1991)

Type of Backfill	Values of Δ/H	
	Active	Passive
Dense sand	0.001	0.01
Medium dense sand	0.002	0.02
Loose sand	0.004	0.04
Compacted silt	0.002	0.02
Compacted lean clay	0.010	0.05
Compacted fat clay	0.010	0.05

