Geotechnical Engineering Report

Pilgrim Monument

Provincetown, Massachusetts

October 19, 2015

Project No. J1155151

Prepared for:
Coastal Engineering Company, Inc.
Orleans, Massachusetts

Prepared by:
Terracon Consultants, Inc.
Manchester, New Hampshire

October 19, 2015

Coastal Engineering Company, Inc.
250 Cranberry Highway
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Attn: Mr. John Bologna, P.E.
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Re: Geotechnical Engineering Report
Pilgrim Monument
Provincetown, Massachusetts
Terracon Project No: J1155151

Dear Mr. Bologna:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above-referenced project. Services were performed in general accordance with our proposal dated August 4, 2015. This geotechnical engineering report presents the results of the subsurface exploration coordinated and monitored by Coastal Engineering Company and provides laboratory data and geotechnical recommendations related to soil strength parameters, global slope stability, and criteria for design of proposed retaining walls by others.

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

Sincerely,
Terracon Consultants, Inc.

Anant S. Panwalker, PE
Geotechnical Project Manager

Lawrence S. Bryer, PE
Principal

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1.0 EXECUTIVE SUMMARY

A geotechnical exploration has been performed for the existing and proposed soil slope at the Pilgrim Monument in Provincetown, Massachusetts. Terracon's geotechnical scope of services included reviewing two test boring logs and samples prepared by Coastal Engineering along the top and bottom of an existing soil slope. Based on the information obtained from the borings, the slope soils are suitable for supporting the proposed walkway grading and retaining walls. The following geotechnical considerations were identified:

- Soil conditions generally consist of 2 to 4 feet of silty (loamy) sand over stratified drift comprised of poorly graded sand. Sand was encountered to 65 feet deep (approximately El 21 feet) at the top of the slope and to at least El -18 at the bottom of the slope, however the deposit contained more gravel at about El -14 feet. The stratified drift is generally loose to very loose relative density. Groundwater was noted at El 3 feet at the toe of the slope.

- The proposed retaining walls supporting the walkway cut into the slope may bear on a minimum 8-inch, thick layer of compacted structural fill or crushed stone (leveling course) placed above the natural sand proofrolled and compacted as discussed herein. Assuming proper site and subgrade preparation, total and differential settlement should be within tolerable limits.

- Retaining wall options include mechanically stabilized earth walls, soil nailed walls with or without aesthetic facades, or conventional concrete cantilevered walls. We also considered stone filled basket type gravity walls, however the aesthetics may not be favorable.

- The current and final soil slope satisfies a factor of safety of at least 1.3 for static loading and 1.1 for seismic loading conditions. The temporary condition, where an open excavation is necessary to construct the retaining wall, has a factor of safety slightly below 1.3 for static. The permanent condition assumes that wall systems need to reinforce/improve soils 8 to 10 feet behind the wall.

- Earthwork on the project should be observed and evaluated for conformance of recommendations provided herein. The evaluation of earthwork should include observation and testing of compacted fill, wall installation, and other geotechnical conditions exposed during construction.

The geotechnical executive summary should be used in conjunction with the entire report for design and/or construction purposes. It should be recognized that specific details are not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The **General Comments** section should be read for an understanding of the report limitations.

GEOTECHNICAL ENGINEERING REPORT
PILGRIM MONUMENT
PROVINCETOWN, MASSACHUSETTS

Terracon Project No. J1155151
October 19, 2015

1.0 INTRODUCTION

This report presents the results of our geotechnical engineering services performed for the proposed walkway and retaining walls associated with the site development along the slope below the Pilgrim Monument in Provincetown, Massachusetts.

The purpose of our services is to provide information, design parameters, and geotechnical engineering recommendations related to:

- Subsurface soil conditions
- Earthwork construction
- Soil strength parameters for wall design
- Slope stability for temporary and permanent conditions
- Stabilization of cut soil slopes
- Foundations for a potential elevated walkway

Our geotechnical engineering scope of services included reviewing subsurface information from two test borings, monitored by Coastal Engineering, at the top and bottom of the existing slope. Borings, designated SPT-1 and SPT-2, were advanced to depths of 25 and 65 feet below the existing ground surface, respectively. A Site Location Map and Boring Location Plan are included in Appendix A as Exhibits A-1 and A-2. Test boring logs, prepared by Coastal Engineering, are included in Appendix A.

2.0 PROJECT INFORMATION

2.1 Site and Project Description

The project is located on a slope at the southeast side of the Pilgrim Monument, along Bradford Street in Provincetown, Massachusetts. The base of the granite block tower is 27 feet by 27 feet. The foundation consists of granite blocks bearing 10.5 feet below the promenade level. The top of the foundation extends downward at an incline of 2H:1V creating a base area of 69 feet by 69 feet. The edge of the foundation is located about 30 feet from the top of the slope. A ground level promenade also comprised of granite blocks surrounds the monument.

An approximate 250-ft. long walkway is planned to connect the monument with Bradford Street to the southeast. The grade change from the monument to Bradford Street is about 74 feet,

sloping from about elevation (El) 80 feet to El 6 feet from top to bottom, respectively. The slope between the monument and Bradford Street appears to be inclined at about 1.3 horizontal:1 vertical (1.3H:1V). Currently, the slope surface is lightly vegetated.

Cut and fill approximately 1 to 7 feet will be required along the walkway which mostly traverses the slope to achieve suitable grading. Retaining walls are being considered to avoid steepened slopes where cuts and fills are relatively high. The wall type will likely be a mechanically stabilized earth (MSE) retaining wall. An alternative approach for the walkway consisting of an elevated structure supported on piles such as drilled helical piers is also under consideration.

3.0 SUBSURFACE CONDITIONS

3.1 Typical Subsurface Profile

The USGS surficial geology map identifies the soils as glacially deposited stratified drift comprised mainly of sand but contains silt, clay and gravel. Based on the results of the borings, subsurface conditions can be generalized as follows:

Description	Approximate Depth to Bottom of Stratum (feet)	Material Encountered	Consistency/Density
Aeolian Deposit	2 to 4	Loamy poorly graded SAND, dark brown	Loose to Very Loose
Stratified Glacial Drift	>65	Poorly-graded SAND, light brown to gray brown (SP). (Note 1)	Loose to Medium Dense
Note 1: Poorly graded SAND, with gravel, brown (SP) observed below El -14 feet.			

Visual soil classifications and conditions encountered at each boring location are indicated on the individual boring logs. Stratification boundaries on the boring logs represent the approximate location of changes in soil types; in-situ, the transition between materials may be gradual. Details for each boring can be found on the boring logs in Appendix A.

3.2 Groundwater

Test borings were observed after completion for the presence and level of groundwater. Groundwater was not observed in SPT-2 which terminated at approximately El 21 feet. However, groundwater was observed within the depth of drilling in SPT-1 at a depth of 4 feet, corresponding to about El 3 feet. Groundwater level fluctuations occur due to tides and seasonal variations in the amount of rainfall and other factors not evident at the time the borings were performed.

3.3 Laboratory Test Results

Laboratory tests were conducted on selected samples of the stratified drift sand. Laboratory testing included grain size distribution and moisture-density testing (Modified Proctor), and direct shear testing. Laboratory testing was performed in general accordance with applicable ASTM Standards. Laboratory test results are discussed herein and presented in Appendix B.

The natural sand deposit consisted of medium to fine sand (SP, based on USCS) and contained only 1 to 2 percent fines (percent passing the No. 200 sieve). The average maximum dry density of the two sand samples was approximately 106 pounds per cubic foot (pcf) with an average optimum moisture content of 11.5 percent.

Direct shear tests were performed on the natural poorly graded sand deposit. Samples were compacted to a target density of 92 percent of the maximum dry density and were tested under a normal stress ranging from 1,000 to 3,000 pounds per square foot to represent in-place conditions. Direct shear test results are summarized as follows:

Sample	Compaction (% of max. dry density)	Maximum Dry Density (pcf)	Friction Angle (degrees)	Cohesion (psf)
SPT-1 (10 to15 feet deep)	92%	105.3	36.8	89
SPT-2 (10 to 15 feet deep)	92%	106.8	38.0	18

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Global Stability Analyses

Slope stability analyses were completed for two sections through the central area landing where the cut and fill is greatest. Temporary construction and permanent site grading were analyzed at the critical section for static loading. Seismic loading was also analyzed for the permanent site grading conditions. A surcharge pressure, estimated from the tower foundation plans and information in the Pilgrim Monument Structural Assessment Report, prepared by Coastal Engineering Company, was included in our analyses.

4.1.1 General

Based on available site drawings, a walkway will traverse across the existing slope requiring cut and fill to achieve proposed grading. At the central landing area near mid-slope, the project requires a maximum cut up to 6 feet into the slope and placing up to 6 feet of fill; both the cut and fill sides of the walkway will require retaining walls. Retaining walls will typically range in

height from 2 to 6 feet along the existing slope. The finish grading of the slope will remain consistent with the current slope incline.

Global stability analyses were performed to evaluate the stability of the overall site geometry, with particular attention to the stability of the maximum cut and fill section. Our stability analyses were performed using geometry developed from site contours depicted on the drawing entitled *"Site Plan, Provincetown Monument"* dated July 6, 2015 and prepared by Hawk Design, Inc of Sagamore, Massachusetts. In addition, groundwater conditions and soil strength parameters were estimated from test boring data and laboratory test results. The monument surcharge equal to 3,000 pounds per square foot (psf) was incorporated into the global stability analysis.

The existing conditions were modeled using the *SLIDE Version 5.0* computer program. The computer program analyzes the stability of a slope using a two-dimensional, limit-equilibrium method. Limit-equilibrium method of slices is used to compute the Factor of Safety (FS) against slope failure under normal and seismic loading conditions.

For the analyses, the phreatic groundwater surface was assumed at approximately El 3 feet based on observed groundwater levels in SPT-1. Since the test boring data, indicated very similar soils for the depth of the boreholes, the soil strength parameters for a single soil layer was modeled as presented in the table below.

Soil Layer	Friction Angle (degrees)	Cohesion (psf)	Moist Soil Unit Weight (pcf)	Saturated Soil Unit Weight (pcf)
Natural Sand	38	50	100	115

Seismic analyses were performed using a pseudo-static method with an earthquake coefficient for horizontal acceleration of 0.065 (peak ground acceleration), based on the Massachusetts Building Code, 8th Edition, and ASCE 7.

4.1.2 Findings & Recommendations

Based on ASSHTO guidelines, a recommended minimum FS against slope failure under normal loading conditions equal to 1.3 for non-critical slopes and 1.5 for critical slopes (potential loss of life) should be achieved when evaluating a slope using a circular arc method of analysis. Similarly, the minimum recommended FS under seismic loading conditions is 1.1.

Our global stability analyses indicated a primary mode of failure for the current slope configuration consisting of a circular failure surface extending from near the top of the slope to the toe of the natural earth slope. During the permanent, final cut/fill grading configuration, the mode of failure is similar to the existing condition, provided the retaining walls for the cut and fill sections have reinforced zones extending 8 to 10 feet behind the walls.

The worst case condition is during construction when the reinforcing for the retaining walls is not yet installed and temporary excavation slopes extend upward to meet existing slope grades. Our global stability analyses for the temporary excavation condition indicated a shallow circular failure surface extending from near the top of the temporary excavation slope (assumed no steeper than 1H:1V) to the toe of the temporary slope. However, considering the excavation is temporary a reduced factor of safety would be reasonable to assume.

Our analyses indicate the FS against slope failure under static (normal) and seismic loads for the conditions discussed above are as follow:

Condition	Estimated Factor of Safety	
	Static Loading	Seismic Loading
Existing Slope	1.39	1.22
Final Graded Slope w/Surcharge	1.36	1.19
Temporary Excavated Slope	1.26	NA

Notes
1: Factors of safety assume the reinforced zone for the retaining walls extend at least 8 to 10 feet behind the walls. Actual grid lengths will need to be reviewed when wall designs are submitted by the wall manufacturer.
2. The surcharge is the foundation load from the Pilgrim Monument bearing approximately 10.5 feet deep at the top of the slope.

The existing slope configuration as well as the final graded slope for the walkway, in our opinion cannot attain a minimum factor of safety of 1.5, but can achieve at least 1.3. In order to achieve a factor of safety equal to 1.5 or greater, the existing slope would either need to be flattened from top to bottom, stabilized with a berm at the slope toe, improved in-situ using ground anchors, stone columns, aggregate piers, or improved by reconstruction using geogrid reinforcement. The cost to increase the slope from a factor of safety of over 1.3 to at least 1.5 would be relatively expensive. It seems more prudent to work with the existing conditions and understand the risk, considering the performance of the slope over many years.

Based on our stability analyses results shown above, cutting into the slope, as proposed, reduces the overall global stability at the critical slope section (through the central landing area). In order to increase the factor of safety to near existing conditions, the backfill zone behind the retaining walls needs to be increased in strength. Wall types that favor soil strength improvement are mechanically stabilized earth walls or soil nailed walls. The advantages of either type are discussed herein.

Regardless of the wall type, we recommend reducing cutting into the slope to the extent practical in order to have less impact on global stability and reduce construction costs. The deeper the cut into the slope, the length of the reinforced zone increases; therefore the

temporary excavation height also increases. At the central mid-slope landing, we recommend maintaining the alignment of the back retaining wall with the upslope and downslope sections in order to reduce the cut height by 2 feet, which is significant.

4.2 Retaining Walls

As mentioned above, two retaining wall types are recommended for the graded walkway alternative. The wall types include a mechanically stabilized earth (MSE) wall, also known as a modular block wall, or a soil nailed wall.

MSE walls use well graded sand and gravel and geogrids to reinforce the backfill zone. The advantage of an MSE wall is its flexibility to tolerate differential movements without severely cracking. The MSE wall also improves the strength of the backfill zone thereby increasing global slope stability. MSE walls are well understood and can be installed by non-specialty contractors and are relatively low cost. Lastly, MSE walls provide an aesthetic appeal with wall panels available in various patterns, colors and textures. The disadvantage to MSE walls is the reinforced grid zone will be longer than the overall wall height due to the backslope and seismic requirements. The long grids therefore will require a temporary excavation slope likely 1H:1V or flatter chasing upward to meet the existing slope.

Soil nailed walls are constructed as the veritical excavation is advanced. Steel tendons (nails) are drilled and grouted into the cut slope at a design spacing to reinforce and increase the strength of the retained soil. The tendons are tensioned at the wall face with nut and head assembly followed by placement of wire mesh across the tendon heads and subsequently shotcreted for stabilization. The wall is constructed in lifts, working from the top down.

Similar to MSE walls, soil nailed walls improve the strength of the retained zone thereby increasing global slope stability The primary advantage of soil nailed walls is the significant reduction in excavation; no excavation is required behind the wall line. The disadvantage of soil nailed walls is aesthetics; the wall face will look like sprayed concrete. There are however various architectural texturing and coloring that could be added to the shotcrete, or wall panels could be installed in front of the shotcrete face. Either of the added aesthetic considerations will increase costs significantly.

We recommend obtaining design and construction costs for both MSE and soil nailed walls from installers for comparison. MSE walls should be designed and submitted by the wall manufacturer for internal stability; grid strength and lengths will need to be reviewed by Terracon to evaluate global stability. Soil nailed walls should be designed and submitted by a specialty contractor, with cost alternatives for improving the wall face aesthetics. Tendons will also need to reviewed by Terracon for global stability. Names of some MSE wall manufacturers or soil nail specialty contractors can be provided upon request.

4.2.1 Lateral Earth Pressures

Based on the field explorations and laboratory test results presented above, and to account for potential variations with reusing the natural sand, we recommend neglecting cohesion and applying a 10 percent reduction in the friction angle determined by direct shear testing. In our opinion, the following soil strength parameters should be used for MSE or soil nailed retaining wall design purposes:

Sample	Anticipated In-Place Density (pcf)	Friction Angle (degrees)	Cohesion (psf)
Reinforced Zone (Processed Gravel)	130	36	0
Retained Soil (Natural Sand Backfill)	100	34	0
Note: MSE and soil nailed walls must consider the increase in active pressure from the retained zone due to a sloped backfill inclined at 1.3H:1V (38 degrees)			

The recommended design parameters above do not include a factor of safety and do not provide for hydrostatic pressure on the walls.

4.2.2 Foundation Design Criteria

Description	Value
Foundation Type	Conventional leveling pad
Bearing Material	Minimum 8-inch-thick layer of compacted crushed stone on proofrolled natural sand.
Net Allowable Bearing Pressure [1]	2,000 psf
Total Estimated Settlement [2]	<1 inch
Frost Depth	3 feet

1. The recommended net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the pad base elevation. Assumes unsuitable fill or loose soils, where present, will be replaced with compacted structural fill or crushed stone.
2. Foundation settlement will depend upon the variations within the subsurface soil profile, the structural loading conditions, the embedment depth of the wall, the thickness of compacted fill, and the quality of the earthwork operations.

The allowable foundation bearing pressures apply to dead loads plus design live load conditions. The design bearing pressure may be increased by one-third when considering total loads that include wind or seismic conditions.

4.2.3 Construction Considerations

As discussed above, the natural on-site soils are poorly graded and have a very low percentage of fines, therefore will be sensitive to drying and easily loosened by construction traffic. Care should be taken during construction to limit construction traffic to the extent practical.

Subgrades that become unstable will need to be undercut and replaced with compacted structural fill or crushed stone.

The individual contractor(s) is responsible for designing and constructing stable, temporary excavations, as required, to maintain stability of the excavation sides and the excavation bottom. Instability in the form of slope raveling, caving, and sloughing should be expected in all excavations and trenches that extend into the sand. Excavations should be sloped or shored in the interest of safety following local and federal regulations, including current OSHA excavation and trench safety standards. Temporary excavation slopes will need to be protected from raveling and drying. Temporary stabilization methods may include hydroseed and erosion control matting, or in severe conditions shotcrete applied protection.

Dewatering is not anticipated for construction of the retaining walls. Efforts should be made to prevent surface water runoff from collecting in excavations. Subgrade soils that become unstable should be replaced with compacted structural fill or crushed stone, as necessary.

Foundation excavations should be observed by the geotechnical engineer. If the soil conditions encountered differ significantly from those presented in this report, supplemental recommendations will be required.

4.3 Elevated Pile Supported Structures

We understand there may be an option to elevate the walkway and structurally support it on pile foundations. Considering the relatively light loads to be supported and the access restrictions of working on a relatively steep slope, we recommend the pile foundation system consist of helical piers. Foundation design recommendations for the proposed structures and related structural elements are presented in the following section.

4.3.1 Helical Pier Design Recommendations

Description	Value
Foundation Type	Helical piers on the order of 20 feet-deep, as determined by the installer
Bearing Material	Stratified glacial drift sand
Sand Angle of Internal Friction	34 degrees
Ultimate Load Capacity/Helix	15 to 20 kips (verified by load testing)
Typical Helix Diameter	8, 10, 12 and 14 inches

Helical piers consist of hollow steel rods (cylindrical or square cross section) with attached helical plates that are designed to reduce disturbance of the in-place soils. Helical piers are rotated into the natural sand deposit to achieve a predetermined torque in the bearing soils. Torque required to install the piers is measured and is used to evaluate the pier capacity. Helical piers are designed and installed by specialty design-build contractors; we can provide contact information upon request.

Helical piers for this site should bear within the native glacial drift deposit at a depth of at least 20 feet below ground surface; piers can be designed to accommodate the design loads by adjusting the diameter, number of helices, depth, helix diameter, or by providing multiple piers. The upper 3 feet of sand in the freeze thaw zone should be ignored when evaluating capacity. Actual pile capacity in the glacial drift sand should be verified by the pile installation contractor at the time of construction using a pile load test.

4.4 Seismic Considerations

Description	Value
Code Used	2009 International Building Code
Site Class [1]	D
Maximum Considered Earthquake Spectral Response Accelerations (Unadjusted for Site Class)	0.060g S_1 (1.0 second spectral response acceleration)
	0.177g S_S (0.2 second spectral response acceleration)
Liquefaction Potential in Event of an Earthquake	Does not appear to be susceptible

1. In general accordance with the *2009 International Building Code* (IBC), Site Class is based on the average characteristics of the upper 100 feet of the subsurface profile. The current scope did not include the required 100-foot soil profile determination. Borings extended to a maximum depth of 65 feet. This seismic site class definition considers that medium dense soil continues below the maximum depth of the borings.

4.5 Earthwork

The following presents recommendations for excavation, subgrade preparation, and placement of backfill for the project. The recommendations presented for design and construction of earth-supported elements are contingent upon the recommendations outlined in this section.

Earthwork on the project should be observed and evaluated by representatives of Terracon or other testing agency. The evaluation of earthwork should include observation and testing of engineered fill, review installation of MSE or soil nailed walls, wall foundation bearing soils and subgrade protection, and other geotechnical conditions exposed during the construction of the project.

4.5.1 Subgrade Preparation

Following stripping or surficial organic soils and excavation to rough grade, the natural sand subgrades should be proofrolled with at least six passes each way of a minimum 1-ton roller. Loose/unstable zones encountered during proofrolling should be overexcavated to competent material and replaced with compacted structural fill, as necessary. Once the subgrade is adequately compacted, crushed stone may be placed and compacted to achieve the minimum

8-inch thick leveling course. Crushed stone should be underlain with a geotextile separation fabric, such as Mirafi 140N or equivalent.

4.5.2 Fill Materials and Placement

Excavated on-site soils are anticipated to consist primarily of natural sand deposits. The on-site soils are poorly graded and contain little to no fines (material passing the No. 200 sieve). The sand will be sensitive to drying and compaction requirements will be difficult to achieve when too dry. Water may be needed to aid in proper compaction.

Due to the poorly graded composition of the natural sand, it is our opinion that excavated soils are not suitable for reuse as structural fill or as material within the reinforced zone of an MSE retaining wall. Excavated on-site soils may be selectively reused as common fill below pavement sections or in landscaped areas provided they can be adequately compacted.

Imported fill that meets the criteria defined below may be considered for its respective purpose. Fill should meet the following material property requirements:

Fill Type (1)	USCS Classification	Acceptable Location for Placement
Reinforced Zone	GW, SW, SP, GP	Within the reinforced zone for MSE walls. Gradation criteria to be determined based on wall designer.
Structural Fill	GW, GW-GM, SW, SW-SM, SP, GP (2)	General backfill in the retained earth zone, below pavements.
Common Fill	Varies (3)	Excavated inorganic soil may be reused as common fill for site grading as necessary.
Crushed Stone	GP	May be used on wet subgrades and as drainage fill. Should be uniform ¾-inch angular crushed stone.

1. Compacted fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used. Fill should not be placed on a frozen subgrade.
2. Imported structural fill should meet the following gradation:

Sieve Size	Percent Passing by Weight
4”	100
3”	70 – 100
2”	(100)*
¾”	45 – 95
No. 4	30 – 90
No. 10	25 – 80
No. 40	10 – 50
No. 200	0 – 10

* Maximum 2-inch particle size within 12 inches of the underside of footings or slabs

3. Common fill should have a maximum particle size of 6 inches and no more than 25 percent by weight passing the US No. 200 sieve.

4.5.3 Compaction Requirements

The recommended compaction and moisture criteria for engineered fill materials follow:

ITEM	DESCRIPTION
Fill Lift Thickness	8 inches or less in loose thickness
Compaction Requirements [1]	95% maximum Modified Proctor dry density (ASTM D1557, Method C)
Moisture Content – Granular Material	Workable moisture levels

1. We recommend testing structural fill for moisture content and compaction during placement. If in-place density test results 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.

5.0 GENERAL COMMENTS

Terracon should be retained to review final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project.

The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include either specifically or by implication an 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.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

APPENDIX A
FIELD EXPLORATIONS

SCALE 1:25 000

1 1/2 0 1MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

N

QUADRANGLE LOCATION

SOURCE:
USGS PROVINCETOWN, MA
1972

Project Mngr: LJD	Project No. J1155151	Terracon	SITE LOCATION MAP
Drawn By: MCR	Scale: AS SHOWN		PILGRIM MONUMENT PROVINCETOWN, MASSACHUSETTS
Checked By: LJD	File No. J1155151.dwg		EXHIBIT
Approved By: LJD	Date: October 2015	77 Sundial Avenue, Suite 401W Manchester, NH 03103 PH. (603)647-9700 Fax. (603)647-4432	A-1

NOTES:

1. THIS EXHIBIT WAS PREPARED FROM A EXISTING SITE PLAN, DATED 7-6-15, PREPARED BY HAWK DESIGN, INC.

2. TEST BORINGS SHOWN WERE ADVANCED ON SEPTEMBER 9, 2015 UNDER THE DIRECTION OF COASTAL ENGINEERING COMPANY, INC. WITH EQUIPMENT OWNED AND OPERATED BY DESMOND WELL DRILLERS OF ORLEANS, MA.

3. REPORTEDLY, THE TEST BORINGS WERE LOCATED BY TAPING FROM EXISTING SITE FEATURES. THE LOCATIONS SHOULD BE CONSIDERED ACCURATE TO THE DEGREE IMPLIED BY THE METHOD USED.

4. USE OF THIS EXHIBIT IS LIMITED TO THE APPROXIMATE LOCATION OF THE TEST BORINGS AND OTHER PERTINENT SITE FEATURES. OTHER USE OF THIS EXHIBIT WITHOUT PERMISSION FROM TERRACON IS PROHIBITED.

LEGEND

SPT-1 APPROXIMATE TEST BORING LOCATION

20 0 20 40

GRAPHIC SCALE IN FEET

Prepared For:	Project Mngr: LJD Drawn By: MCR Checked By: LJD Approved By: LJD	Project No. J1155151 Scale: As shown File No. J1155151.dwg Date: October 2015	Terracon 77 Sundial Avenue, Suite 401W Manchester, NH 03103 PH. (603)647-9700 Fax. (603)647-4432	BORING LOCATION PLAN PILGRIM MONUMENT PROVINCETOWN, MASSACHUSETTS	EXHIBIT A-2

FIELD EXPLORATION DESCRIPTION

Two test borings (SPT-1 and SPT-2) were drilled at the site on September 9, 2015. Borings were drilled to depths of approximately 25 and 65 feet below the ground surface at the approximate locations shown on the attached Boring Location Plan (Exhibit A- 2).

Test borings were advanced by Desmond Well Drilling, Inc. of Orleans, Massachusetts using an all-terrain-vehicle-mounted drill rig and 2¼-inch inside diameter hollow stem augers. Borings were located in the field by tape measurement existing site features. The accuracy of boring locations should only be assumed to the level implied by the method used.

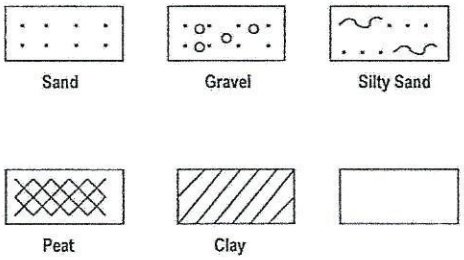
Soil samples were obtained at the ground surface followed by 5-foot intervals thereafter using a standard 2-inch-outside-diameter split-barrel sampler. Standard Penetration Tests were performed in general accordance with industry standards. Density of soil samples are based on N-values, which are determined by adding the number of hammer blows required to drive the sampler from 6 to 18 inches.

Visual classification of soils, by a Coastal Engineering field representative, is shown on test boring logs included in Appendix A. Ground surface elevations at exploration locations were estimated from contours illustrated on the *Site Plan* dated July 6, 2015 prepared by Hawk Design, Inc. of Sagamore, MA.

Groundwater conditions were measured in each boring at the time of drilling.

COASTAL ENGINEERING COMPANY, INC.
260 Cranberry Highway, Orleans, MA 02653
508.255.6511 ■ Fax 508.255.6700 ■ coastalengineeringcompany.com

LITHOLOGIC BOREHOLE LOG



Job #:	C14394.00
Job Name:	Cape Cod Pilgrim Memorial Assoc. Provincetown, MA
Test Hole #	SPT-1
Date:	9/9/15
Witness:	Todd Palmatier, Hydrogeologist
Drilling Contractor:	Desmond Well Drillers
Sampling Method:	HSA w/split spoon sampler
Surface Elevation:	7.0±
Sheet 1 of 3	

			Standard Penetration						
Lithology	Depth	Type of Sample	Depth	Strokes	"N" Value Blow / ft.	% of Recovery		Well Specifications Comments	Descriptions of Lithology and Remarks
		SS	0-2	1-1-3-2	4	90			SAND – dk brn, vfn-med, dry, loamy.
	5	SS	2-4	1-2-1-1	3	90	5		SAND – dk brn –gray brn, med-cse, sl. silty, moist.
		A	4-7			100			
	10	SS	7-9	1-4-4-4	8	50	10		SAND – graybrn, med-vcse, clean, mod. well srtd.
		A	9-12			100			
	15	SS	12-14	2-2-5-6	7	50	15		SAND – lt.gray brn, med-v.cse, clean, mod. well srtd.
		A	14-17			100			
	20	SS	17-19	3-5-10-12	15	70	20		SAND – brn, fn-vcse, clean.
		A	19-23			100			
	25	SS	23-25	8-12-11-14	23	70	25		SAND – brn, med to vcse, w/ abundant gravel, clean, poorly srtd.
	30						30		
	35						35		
	40						40		
	45						45		

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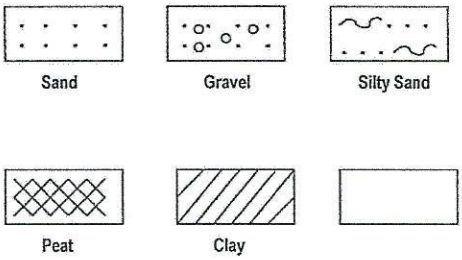
LITHOLOGIC BOREHOLE LOG



Job #:	C14394.00
Job Name:	Cape Cod Pilgrim Memorial Assoc. Provincetown, MA
Test Hole #	SPT-2
Date:	9/9/15
Witness:	Todd Palmatier, Hydrogeologist
Drilling Contractor:	Desmond Well Drillers
Sampling Method:	HSA w/split spoon sampler
Surface Elevation:	86±

Sheet 2 of 3

Lithology	Depth	Type of Sample	Standard Penetration Depth	Strokes	"N" Value Blow / ft.	% of Recovery		Well Specifications Comments	Descriptions of Lithology and Remarks
		SS	0-2	1-1-1-1	2	70			SAND – dk brn – gray, fn-cse, loamy, poorly srtd.
	5	SS	2-4	1-1-1-1	2	70	5		SAND – gray brn, med-cse, clean, mod. well srtd.
		A	4-7			100			
	10	SS	7-9	1-2-1-1	3	80	10		SAND – brn, med—cse, clean.
		A	9-12			100			
	15	SS	12-14	1-1-2-2	4	80	15		SAND – lt-brn, fn-cse, clean, dry.
		A	14-17			100			
	20	SS	17-19	1-1-2-1	3	90	20		SAND – lt.brn, fn-cse, clean, dry.
		A	19-22			100			
	25	SS	22-24	1-1-2-2	3	90	25		SAND – lt.brn, fn-med, clean, mod.well srtd.
		A	24-27			100			
	30	SS	27-29	1-2-2-2	4	90	30		SAND - lt-brn, fn-med, sme cse, clean.
		A	29-32			100			
	35	SS	32-34	1-2-2-3	4	80	35		SAND – lt brn-buff, fn-med, clean, mod.well srtd.
		A	34-37			100			
	40	SS	37-39	2-2-1-3	3	90	40		SAND – lt brn-buff, med-cse, clean.
		A	39-42			100			

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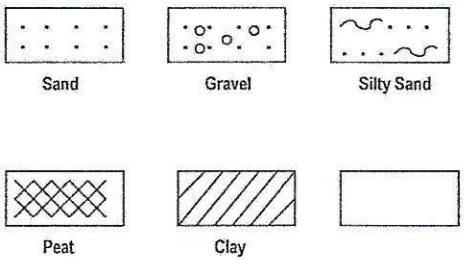
260 Cranberry Highway, Orleans, MA 02653
508.255.6511 ■ Fax 508.255.6700 ■ coastalengineeringcompany.com

LITHOLOGIC BOREHOLE LOG



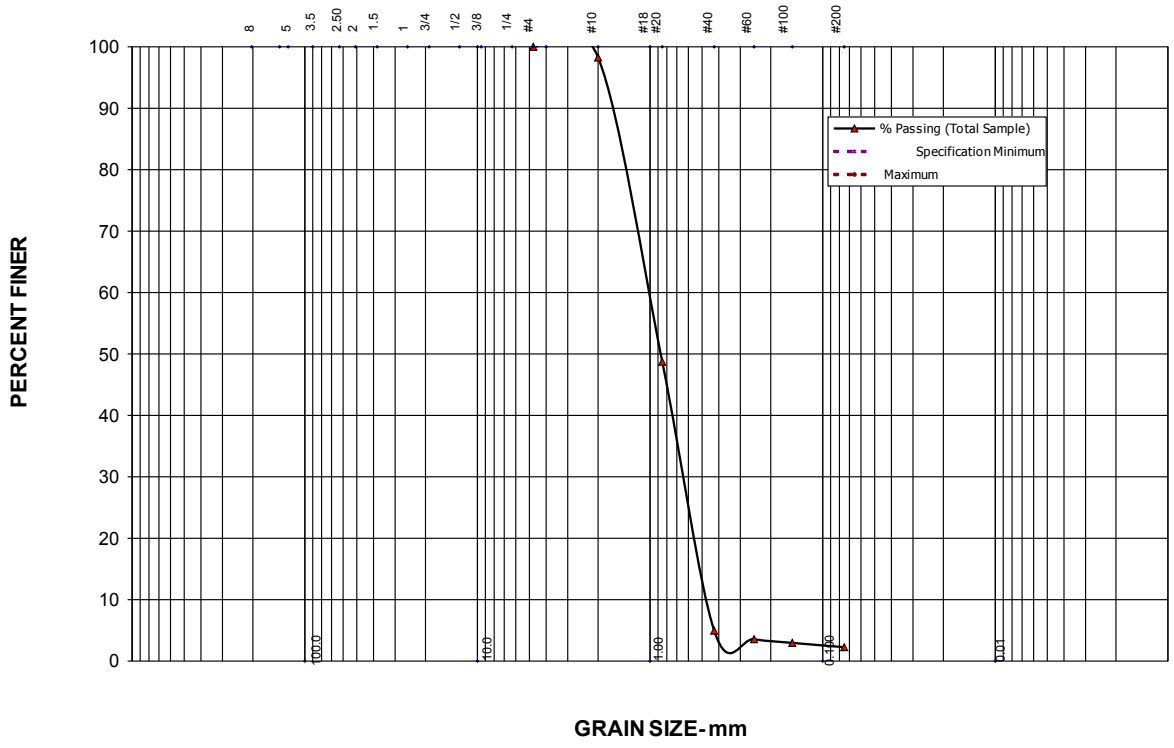
Job #:	C14394.00
Job Name:	Cape Cod Pilgrim Memorial Assoc. Provincetown, MA
Test Hole #	SPT-2
Date:	9/9/15
Witness:	Todd Palmatier, Hydrogeologist
Drilling Contractor:	Desmond Well Drillers
Sampling Method:	HSA w/split spoon sampler
Surface Elevation:	86±
Sheet 3 of 3	

			Standard Penetration						
Lithology	Depth	Type of Sample	Depth	Strokes	"N" Value Blow / ft.	% of Recovery		Well Specifications Comments	Descriptions of Lithology and Remarks
	45	SS	42-45	2-2-3-2	5	85	45		SAND – lt-brn – buff, med-cse, clean.
		A	45-47			100			
	50	SS	47-49	2-2-3-4	5	70	50		SAND – lt brn – buff, med-cse, clean, mod.well srtd.
		A	49-52			100			
	55	SS	52-55	1-3-3-5	6	80	55		SAND – lt-brn-buff, med-cse, clean.
		A	55-57			100			
	60	SS	57-59	2-3-4-6	7	80	60		SAND – lt.brn, med-cse, clean, well sorted.
		A	59-63			100			
		SS	63-65	2-4-4-5	8	80			SAND – lt.brn, med-cse, clean, well srtd.

APPENDIX B

LABORATORY TESTING

GRAIN SIZE DISTRIBUTION TEST REPORT
ASTM TEST METHODS: C136, C117, D2487



% Cobbles	% Gravel	Coarse	Medium	Fine	% Fines	
		52.4	44.8	2.8	Silt (>0.002mm)	Clay (<0.002mm)
0.0	0	% Sand		98	2.3	

USCS Classification: POORLY GRADED SAND, Brown (SP)

Sieve Size (mm)	U.S. Sieve Size (in.)	Cumulative Wt. Retained	% Passing (Total Sample)	% Passing (Sand Portion)	Specification Minimum	Maximum
200.0	8"					
152.4	6"					
101.0	4"					
76.2	3"					
50.0	2"					
37.5	1.5"					
25.0	1"					
19.0	3/4"					
12.5	1/2"					
9.5	3/8"					
6.3	1/4"					
4.75	#4	0	100	100		
2.00	#10	13.83	98			
0.85	#20	407.21	49			
0.425	#40	755.10	5			
0.250	#60	766.20	4			
0.150	#100	770.90	3			
0.075	#200	776.50	2.3	2.3		

Total Dry Wt. 9746.9395 g
Split Wt. 794.47 g

Project:	**Provincetown Monument**	Project No.:	**J1155151**	Date:	**9/23/2015**
City:	Provincetown, MA	Specification:	NA	Report No:	J1155151.0001
Source:	Test Boring by Coastal Engineering	Sampled from:	SPT-1; composite 10' to 15' BGS		

Terracon

http://www.terracon.com/

Remarks:

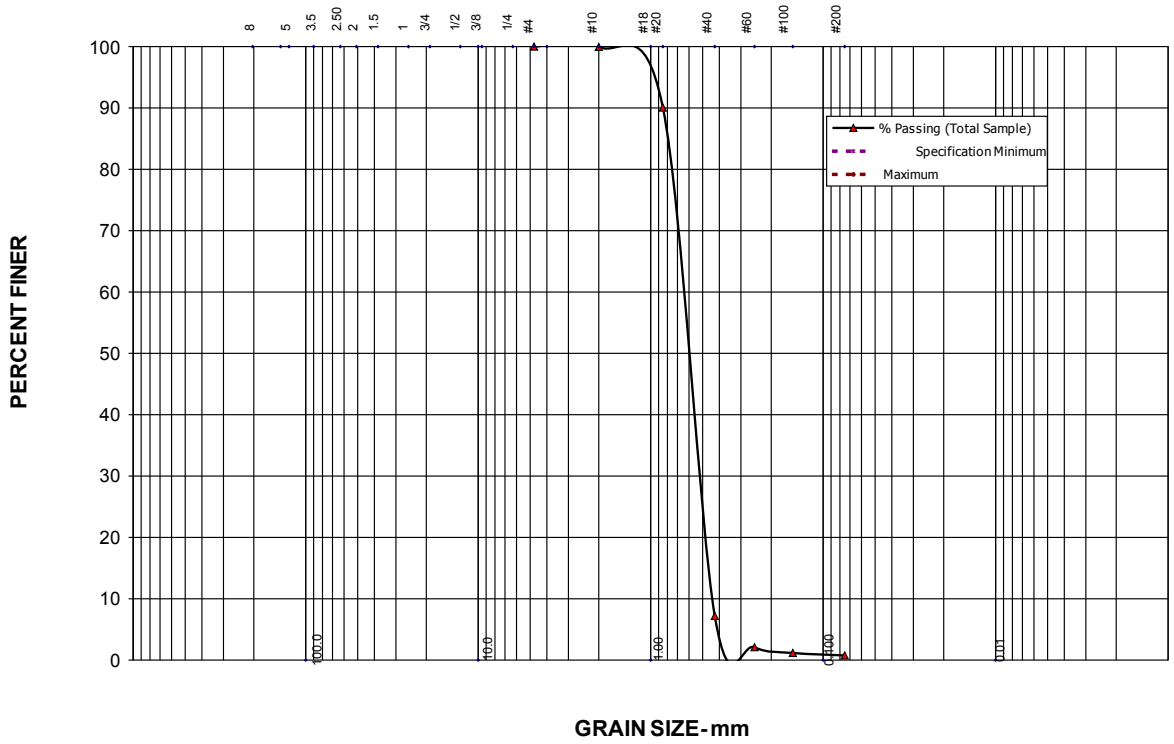
Cc= 0.8 Cu = 2.3

Tested By: D. Savage Date: 9/18/2015

Reviewed By: Date:

J1-C136, C117, D2487, 7-21-15, Rev 10

GRAIN SIZE DISTRIBUTION TEST REPORT
ASTM TEST METHODS: C136, C117, D2487



% Cobbles	% Gravel	Coarse	Medium	Fine	% Fines	
		10.0	83.5	6.5	Silt (>0.002mm)	Clay (<0.002mm)
0.0	0		% Sand	99	0.8	

USCS Classification: POORLY GRADED SAND, Light Brown (SP)

Sieve Size (mm)	U.S. Sieve Size (in.)	Cumulative Wt. Retained	% Passing (Total Sample)	% Passing (Sand Portion)	Specification Minimum	Maximum
200.0	8"					
152.4	6"					
101.0	4"					
76.2	3"					
50.0	2"					
37.5	1.5"					
25.0	1"					
19.0	3/4"					
12.5	1/2"					
9.5	3/8"					
6.3	1/4"					
4.75	#4	0	100	100		
2.00	#10	0.39	100			
0.85	#20	81.00	90			
0.425	#40	756.70	7			
0.250	#60	798.20	2			
0.150	#100	805.90	1			
0.075	#200	809.10	0.8	0.8		

Total Dry Wt. 8457.1201 g
Split Wt. 815.36 g

Project:	**Provincetown Monument**	Project No.:	**J1155151**	Date:	**9/23/2015**
City:	Provincetown, MA	Specification:	NA	Report No:	J1155151.0002
Source:	Test Boring by Coastal Engineering	Sampled from:	SPT-2; Composite 10' to 15' BGS		

Terracon

http://www.terracon.com/

Remarks:

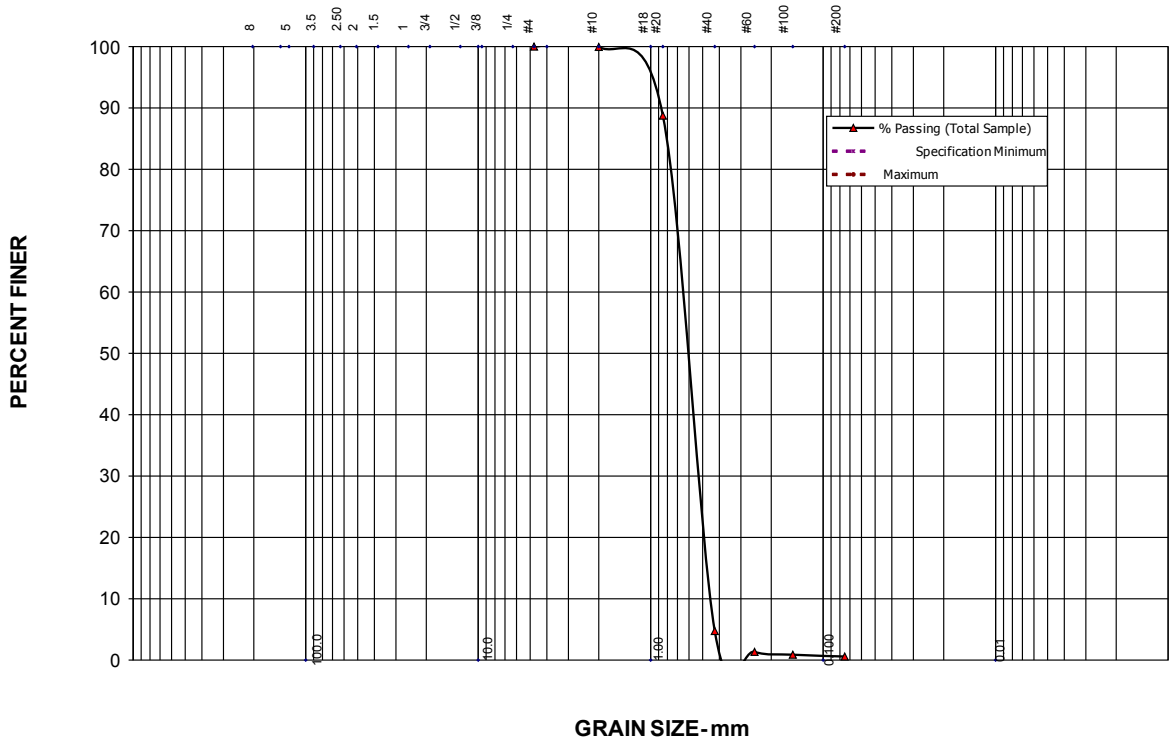
Cc= 1.0 Cu = 1.6

Tested By: D. Savage Date: 9/18/2015

Reviewed By: L. Dwyer Date: 9/25/2015

J1-C136, C117, D2487, 7-21-15, Rev 10

GRAIN SIZE DISTRIBUTION TEST REPORT
ASTM TEST METHODS: C136, C117, D2487



% Cobbles	% Gravel	Coarse	Medium	Fine	% Fines	
		11.3	84.5	4.2	Silt (>0.002mm)	Clay (<0.002mm)
0.0	0	% Sand		99	0.6	

USCS Classification: POORLY GRADED SAND, Light Brown (SP)

Sieve Size (mm)	U.S. Sieve Size (in.)	Cumulative Wt. Retained	% Passing (Total Sample)	% Passing (Sand Portion)	Specification Minimum	Maximum
200.0	8"					
152.4	6"					
101.0	4"					
76.2	3"					
50.0	2"					
37.5	1.5"					
25.0	1"					
19.0	3/4"					
12.5	1/2"					
9.5	3/8"					
6.3	1/4"					
4.75	#4	0	100	100		
2.00	#10	0.35	100			
0.85	#20	81.09	89			
0.425	#40	686.40	5			
0.250	#60	710.90	1			
0.150	#100	714.20	1			
0.075	#200	716.30	0.6	1		

Total Dry Wt. 10331.605 g
Split Wt. 720.55 g

Project:	**Provincetown Monument**	Project No.:	**J1155151**	Date:	**9/23/2015**
City:	Provincetown, MA	Specification:	NA	Report No:	J1155151.0003
Source:	Test Boring by Coastal Engineering	Sampled from:	SPT-2; 45' to 65' BGS		

Terracon

http://www.terracon.com/

Remarks:

Cc= 1.0 Cu = 1.6

Tested By: D. Savage Date: 9/18/2015

Reviewed By: L. Dwyer Date: 9/25/2015

J1-C136, C117, D2487, 7-21-15, Rev 10

LABORATORY COMPACTION CHARACTERISTICS OF SOIL REPORT

Report Number: J1155151.0001
Service Date: 09/23/15
Report Date: 10/14/15

Terracon
77 Sundial Ave. Suite 401W
Manchester, NH 03103
603-647-9700

Client

Coastal Engineering Co., Inc.
Attn: John Bologna
260 Cranberry Highway
Orleans, MA 02653

Project

Provincetown Monument
1 High Pole Hill Road
Provincetown, MA

Project Number J1155151

Material Information

Source of Material: Test Boring by Coastal Engineering
Proposed Use: NA

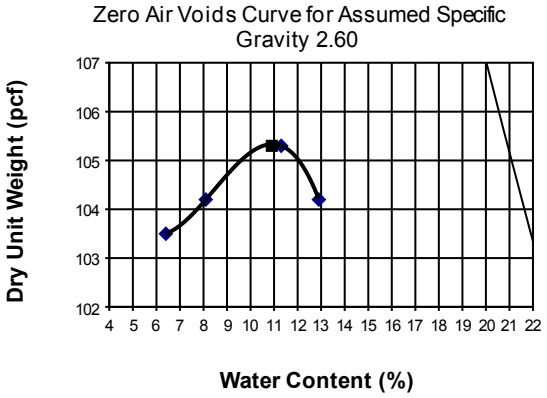
Sample Information

Sample Date:
Sampled By:
Sample Location: SPT-1; Composite 10' to 15' BGS
Sample Description: POORLY GRADED SAND, Brown (SP)

Laboratory Test Data

Test Procedure: ASTM D1557
Test Method: Method A
Sample Preparation: Wet
Rammer Type: Mechanical
Maximum Dry Unit Weight (pcf): 105.3
Optimum Water Content (%): 10.9

	Result	Specifications
Liquid Limit:		
Plastic Limit:		
Plasticity Index:		
In-Place Moisture (%):		
Passing #4 (%):	0.0	
Passing #200 (%):	2.3	
USCS:	SP	



Comments:

Services: Obtain a sample of soil from source. Return sample to laboratory for laboratory testing as requested.

Terracon Rep.: Daniel P. Savage
Reported To:
Contractor:
Report Distribution:
(1) Coastal Engineering Co., Inc., Emailed

Reviewed By: _____

Lawrence J. Dwyer
Project Manager

Test Methods: ASTM D1557, ASTM D2487

The tests were performed in general accordance with applicable ASTM, AASHTO, or DOT 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.

LABORATORY COMPACTION CHARACTERISTICS OF SOIL REPORT

Report Number: J1155151.0002
Service Date: 09/23/15
Report Date: 09/23/15

Terracon
77 Sundial Ave. Suite 401W
Manchester, NH 03103
603-647-9700

Client

Coastal Engineering Co., Inc.
Attn: John Bologna
260 Cranberry Highway
Orleans, MA 02653

Project

Provincetown Monument
1 High Pole Hill Road
Provincetown, MA

Project Number J1155151

Material Information

Source of Material: Test Boring by Coastal Engineering
Proposed Use:

Sample Information

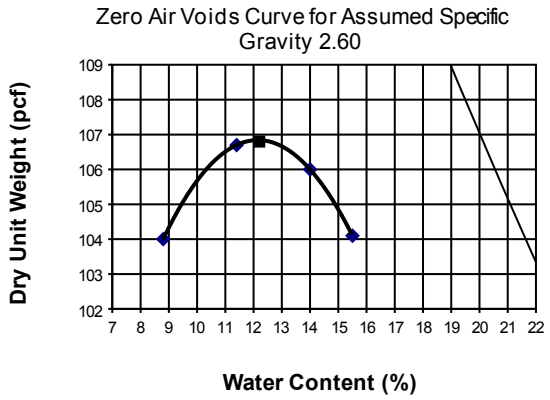
Sample Date:
Sampled By:
Sample Location: SPT-2; Composite 10' to 15' BGS

Sample Description: POORLY GRADED SAND, Light Brown (SP)

Laboratory Test Data

Test Procedure: ASTM D1557
Test Method: Method A
Sample Preparation: Wet
Rammer Type: Mechanical
Maximum Dry Unit Weight (pcf): **106.8**
Optimum Water Content (%): **12.2**

	Result	Specifications
Liquid Limit:		
Plastic Limit:		
Plasticity Index:		
In-Place Moisture (%):		
Passing #4 (%):	100.0	
Passing #200 (%):	0.8	
USCS:	SP	



Comments:

Services: Obtain a sample of soil from source. Return sample to laboratory for laboratory testing as requested.

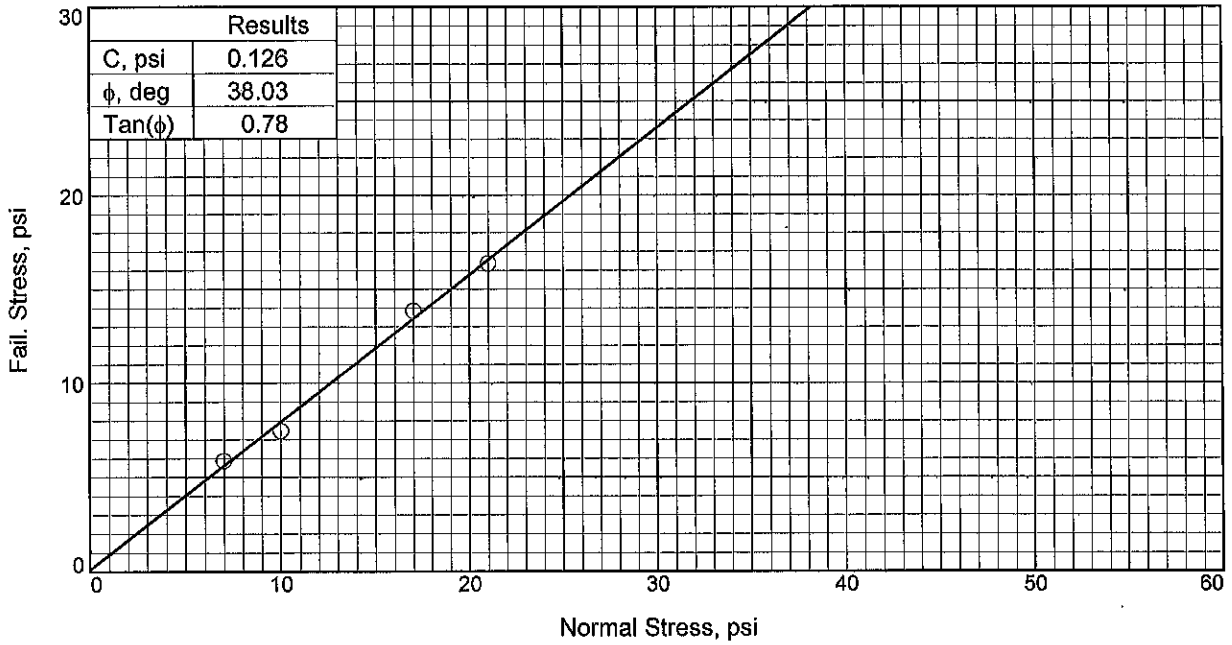
Terracon Rep.: Daniel P. Savage
Reported To:
Contractor:
Report Distribution:
(1) Coastal Engineering Co., Inc., Emailed

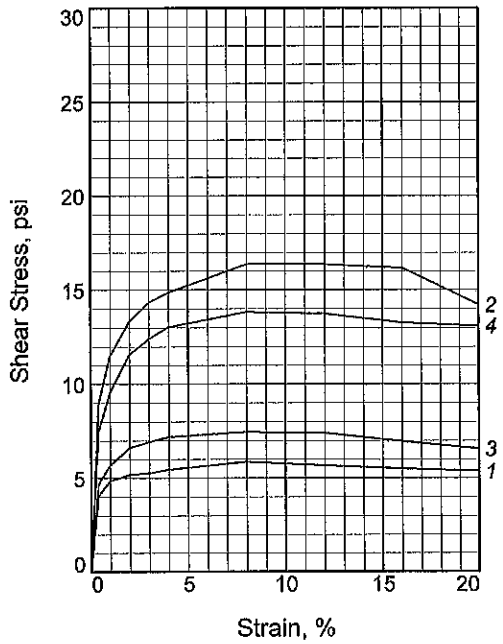
Reviewed By: _____

Lawrence J. Dwyer
Project Manager

Test Methods: ASTM D1557, ASTM D2487

The tests were performed in general accordance with applicable ASTM, AASHTO, or DOT 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.





Sample No.		1	2	3	4
Initial	Water Content, %	10.8	10.8	12.2	12.2
	Dry Density, pcf	96.9	96.9	98.2	98.2
	Saturation, %	40.4	40.4	47.1	47.1
	Void Ratio	0.7067	0.7067	0.6849	0.6849
	Diameter, in.	2.500	2.500	2.500	2.500
	Height, in.	1.100	1.100	1.100	1.100
At Test	Water Content, %	26.6	26.1	21.2	21.0
	Dry Density, pcf	97.0	97.9	98.4	98.7
	Saturation, %	100.0	100.0	82.4	82.4
	Void Ratio	0.7047	0.6904	0.6812	0.6762
	Diameter, in.	2.500	2.500	2.500	2.500
	Height, in.	1.099	1.090	1.098	1.094
Normal Stress, psi		7.000	21.000	10.000	17.000
Fail. Stress, psi		5.867	16.359	7.456	13.832
Strain, %		8.0	8.0	8.0	8.0
Ult. Stress, psi					
Strain, %					
Strain rate, in./min.		0.065	0.065	0.065	0.065

Sample Type: Remolded @92%, 10.9omc
Description: BROWN SAND

Assumed Specific Gravity= 2.65
Remarks:

Exhibit 8386 & 8387

Client: COASTAL ENGINEERING CO., INC

Project: PROVINCETOWN MONUMENT

Source of Sample: SPT-1 & SPT-2 **Depth:** 10-15'

Proj. No.: J1155151 **Date Sampled:** 10-8-15

DIRECT SHEAR TEST REPORT

Terracon, Inc.
Cincinnati, Ohio

Tested By: DR **Checked By:** GS

APPENDIX C

SUPPORTING DOCUMENTS

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SS:	Split Spoon – 1-$^{3}/_{8}$" I.D., 2" O.D., unless otherwise noted	HS:	Hollow Stem Auger
ST:	Thin-Walled Tube - 2" O.D., unless otherwise noted	PA:	Power Auger
RS:	Ring Sampler - 2.42" I.D., 3" O.D., unless otherwise noted	HA:	Hand Auger
DB:	Diamond Bit Coring - 4", N, B	RB:	Rock Bit
BS:	Bulk Sample or Auger Sample	WB:	Wash Boring or Mud Rotary

The number of blows required to advance a standard 2-inch O.D. split-spoon sampler (SS) the last 12 inches of the total 18-inch penetration with a 140-pound hammer falling 30 inches is considered the "Standard Penetration" or "N-value."

WATER LEVEL MEASUREMENT SYMBOLS:

WL:	Water Level	WS:	While Sampling	N/E:	Not Encountered
WCI:	Wet Cave in	WD:	While Drilling		
DCI:	Dry Cave in	BCR:	Before Casing Removal		
AB:	After Boring	ACR:	After Casing Removal		

DESCRIPTIVE SOIL CLASSIFICATION: Soils are generally categorized by Group Name with modifiers (Grain-size Distribution), Color, and Consistency. The order of the visual-manual classification is as follows:

1. Group Name
2. Modifiers (with, trace, or modified Group Name)
3. Color
4. Consistency (or Relative Density)

CONSISTENCY OF FINE-GRAINED SOILS

Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-value (SS) Blows/Ft.	Consistency
< 500	<2	Very Soft
500 – 1,000	2-3	Soft
1,001 – 2,000	4-6	Medium Stiff
2,001 – 4,000	7-12	Stiff
4,001 – 8,000	13-26	Very Stiff
8,000+	26+	Hard

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Standard Penetration or N-value (SS) Blows/Ft.	Ring Sampler (RS) Blows/Ft.	Relative Density
0 – 3	0-6	Very Loose
4 – 9	7-18	Loose
10 – 29	19-58	Medium Dense
30 – 49	59-98	Dense
50+	99+	Very Dense

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other Constituents	Percent of Dry Weight
Trace	< 15
With	15 – 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300mm)
Cobbles	12 in. to 3 in. (300mm to 75 mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm)
Silt or Clay	Passing #200 Sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other Constituents	Percent of Dry Weight
Trace	< 5
With	5 – 12
Modifiers	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1-10
Medium	11-30
High	30+

Exhibit C-1

Terracon

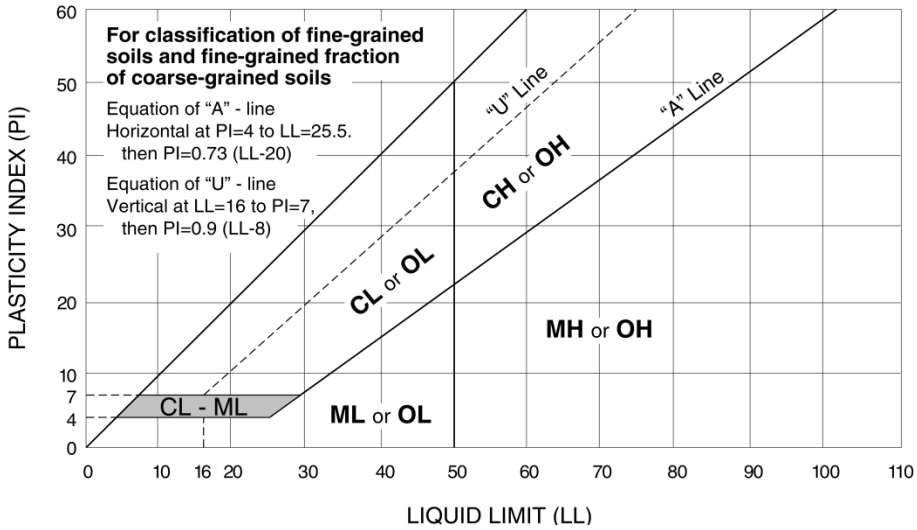
UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]		GW	Well-graded gravel [F]
			$Cu < 4$ and/or $1 > Cc > 3$ [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F,G, H]
			Fines classify as CL or CH		GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]		SW	Well-graded sand [I]
			$Cu < 6$ and/or $1 > Cc > 3$ [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G,H,I]
			Fines Classify as CL or CH		SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A" line [J]		CL	Lean clay [K,L,M]
			PI < 4 or plots below "A" line [J]		ML	Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K,L,M,N]
			Liquid limit - not dried			Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K,L,M]
			PI plots below "A" line		MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K,L,M,P]
			Liquid limit - not dried			Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.
[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.



Terracon

Exhibit C-2