

Geotechnical Engineering Report

National Cemetery Pavement Improvements

Near Muncie Road

Leavenworth, KS

September 24, 2013

Terracon Project No. 02135123

Prepared for:

FourFront Design

Rapid City, SD

Prepared by:

Terracon Consultants, Inc.

Lenexa, KS

Offices Nationwide
Employee-Owned

Established in 1965
terracon.com

Terracon

Geotechnical ■ Environmental ■ Construction Materials ■ Facilities

September 24, 2013



FourFront Design, Inc.
517 Seventh Street
Rapid City, SD 57701

Attn: Mr. Shane Matt
E: smatt@4front.biz

Re: Geotechnical Engineering Report
National Cemetery Pavement Improvements
Near Muncie Road
Leavenworth, KS
Terracon Project Number: 02135123

Dear Mr. Matt:

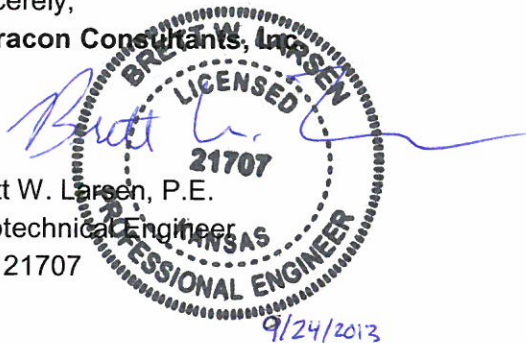
Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the planned pavement improvements at the Leavenworth National Cemetery. This study was performed in general accordance with our proposal number P02121031 dated November 28, 2012. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning proposed pavement improvements.

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.

Brett W. Larsen, P.E.
Geotechnical Engineer
KS: 21707



John A. Thomas, Jr., P.E.
Geotechnical Services Manager
KS: 20694

Enclosures
cc: 1 – Client (PDF)
1 – File

Geotechnical Engineering Report

National Cemetery Pavement Improvements ■ Leavenworth, KS

September 24, 2013 ■ Terracon Project No. 02135123



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**GEOTECHNICAL ENGINEERING REPORT
NATIONAL CEMETERY PAVEMENT IMPROVEMENTS
LEAVENWORTH, KS**

Terracon Project No. 02135123

September 24, 2013

1.0 INTRODUCTION

Terracon Consultants, Inc. (Terracon) has completed a subsurface exploration for the proposed pavement improvements to Fort Leavenworth National Cemetery. Twelve (12) borings were performed at this site to depths of approximately 6 feet. The boring location diagram and logs of the borings are included in Appendix A of this report.

The purpose of these services is to provide recommendations for development of pavement subgrades and opinions of minimum pavement thickness for the proposed pavements.

2.0 PROJECT INFORMATION

2.1 Project Description

Item	Description
Site layout	See Appendix A, Exhibit A-1: Site Location Plan and Appendix A, Exhibit A-2 and A-3: Boring Location Plan
Proposed Road Improvements	FourFront has recommended that portions of existing pavements be removed and replaced. Other planned improvements include isolated patch repairs, repairing existing curbs and inlets, replacing existing inlets with new ones, and building new curbs in some areas.
Grading	We understand that the proposed road alignment and profile will not be substantially altered.

2.2 Site Location and Description

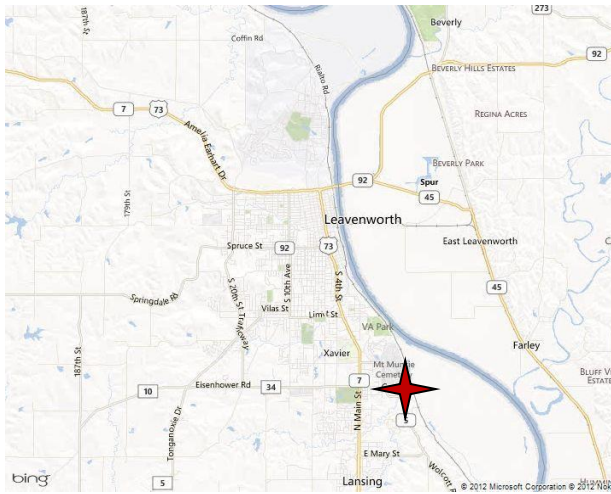


Figure 1. Site Locations



Figure 2. Aerial of Site

Item	Description
Location	The site is located off of Muncie Road in Leavenworth, KS, southeast of the VA hospital.
Existing conditions	The existing pavements are asphalt. Some existing sections have curb and gutter and some do not. FourFront has identified areas of pavement distress and have recommended that portions of the existing pavements be fully removed and replaced.

3.0 SUBSURFACE CONDITIONS

3.1 Typical Profile

In general, the borings encountered lean clay soils beneath the existing pavement section. At Borings B-4 and B-9, fill was encountered to the termination of the boring and a depth of 4 feet, respectively. The existing pavement sections observed at each boring location are noted on the logs, and summarized in the table below.

Boring No.	Asphalt Thickness (inches)	Gravel Thickness (inches)
B-1	6	1
B-2	5	3
B-3	8	3
B-4	3	5

Boring No.	Asphalt Thickness (inches)	Gravel Thickness (inches)
B-5	6	2
B-6	6	1
B-7	6	2
B-8	4	2
B-9	5	3
B-10	6	2
B-11	7	0
B-12	6	1

Subsurface conditions encountered at the boring locations are indicated on the attached 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.

3.2 Groundwater

The borings were observed while drilling and after completion for the presence of groundwater. Groundwater was not observed in the borings. Long term observations in piezometers or observation wells sealed from influence of surface water are often required to define groundwater levels.

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. Groundwater (perched) may be encountered during construction or at other times in the life of the pavements.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

Existing fill was encountered at each of the borings. Generally, the thickness of the fill was less than 6 inches, with the exception of Borings B-4 and B-9 where fills extended deeper. Pavements supported on fills that have not been placed and compacted with strict moisture and density control may not perform predictably; subsidence and pavement cracking could result. In our opinion, the extent and quality of existing fill subgrade should be evaluated further during the site grading phase once the existing asphalt is removed. Provided the existing fill soils will support proofrolling operations, the fill may remain in place.

Clay soils are not ideal for subgrade support of pavements because they tend to have moderate to high shrink-swell potential and low structural strength. However, if compacted to a relatively high degree, these subgrade soils can satisfactorily support pavements. Particular attention should be paid to utility trenches and new excavations crossing pavement subgrades.

Though our borings did not encounter exceedingly soft or wet soils, based on California Bearing Ratio tests on selected bulk samples, the surficial soils at the site have low strengths. Additionally, silty clay soils are susceptible to disturbance from construction activity, particularly if the soil has a high natural moisture content or is wetted by surface water or seepage. Heavy equipment traffic directly on wet silty soils should be avoided whenever possible. In our experience, silty soils subjected to heavy repetitive loads often become unstable and are subject to excessive rutting and pumping. These soils will provide poor subgrade support for pavements. Depending on the time of year and amount of precipitation, the exposed subgrade soils may not pass proofrolling. The project team should be prepared for subgrade repair measures if the soils are wet. Options such as chemical stabilization, removal and replacement, placement of surge stone, or placement of geotextiles are common for these soils.

4.2 Earthwork

4.2.1 Pavement Subgrade Preparation

Subgrade preparation for the pavement subgrades should include removing existing pavement materials. The extent, composition and condition of existing fill encountered beneath the pavements should be determined during the grading phase.

Following grading but before any fill is placed, the exposed subgrade soils should be thoroughly observed and proofrolled. Proof-rolling should be performed with a loaded, tandem-axle dump truck, or similar equipment with a gross weight of 15 tons. Soft, dry and low-density soil should be removed or compacted in place prior to placing new engineered fill.

The moisture content and density of the top 9 inches of the subgrade should be evaluated and the pavement subgrades proofrolled within 2 days prior to commencement of actual paving operations. Areas not in compliance with the required ranges of moisture or density should be moisture conditioned and recompact. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing and replacing the materials with properly compacted fills.

Proofrolling should be accomplished in the presence of a Terracon representative. Proofrolling is helpful in identifying the presence of soft or unsuitable soils at shallow depths. Soft unsuitable soils that cannot be satisfactorily improved by scarification and re-compaction should be removed.

Areas that appear severely desiccated following removal of existing pavements and undercutting may require further undercutting and moisture conditioning. If a significant precipitation event occurs after the evaluation or if the surface becomes disturbed, the subgrade should be reviewed by qualified personnel immediately prior to paving. The subgrade should be in its finished form at the time of the final review.

4.2.2 Material Requirements

Fill materials 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. A sample of each material type should be submitted to the geotechnical engineer for evaluation. Compacted engineered fill should meet the following material property requirements:

Location	USCS Classification	Comments
Locations where drainage is required	GW & GP	Clean gravel or crushed stone
Acceptable for placement as engineered fill beneath proposed pavements	CL & CH	Native clays at the site; and/or native clays treated with lime or fly-ash

4.2.3 Compaction Requirements

Item		Description
Fill Lift Thickness ¹		9-inches or less in loose thickness
Compaction Requirements		95% of the materials maximum standard Proctor dry density (ASTM D 698)
Moisture Content Clay Soil	LL<40	-2% to +2% of optimum moisture content value ²
	LL>40	0 to 4% above the optimum moisture content value ²
Moisture Content Granular Material		Workable moisture levels ³

1. We recommend that engineered fill be tested for moisture content and compaction during placement. Should the results of the 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.
2. As determined by the standard Proctor test. Treated Proctors will be required for treated soils.
3. Specifically, moisture levels should be maintained low enough to allow for satisfactory compaction to be achieved without the cohesionless fill material pumping when proofrolled.

4.2.4 Grading and Drainage

Final surrounding grades should be sloped where possible to provide positive surface drainage away from the prepared roadway areas. During construction, water that accumulates on completed subgrades should be promptly removed and the surface reconditioned where it has been disturbed. Softened soils should be removed if they cannot be scarified and recompacted in place.

4.2.5 Earthwork Construction Considerations

Utility trench excavations located within the pavement areas and/or in areas where subsequent surface settlement is not desirable, should be backfilled by placing fill in lifts and compacting each lift.

Upon completion of filling and grading, care should be taken to maintain the subgrade moisture content prior to placement of base course and pavements. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. If the subgrade should become frozen, desiccated, saturated, or disturbed, the affected material should be removed or these materials should be scarified, moisture conditioned, and recompact prior to floor slab and pavement construction.

Terracon should be retained during construction to observe site preparation activities, perform field density tests on each lift of fill, and perform other appropriate tests and observations during subgrade preparation, placement and compaction of fills and backfilling of excavations.

4.2.6 Borrow Material

Two (2) composite bulk samples were collected at the site. Bulk 1 was collected from Borings B-1 through B-4 from 1 to 5 feet below grade. Bulk 2 was collected from Borings B-9 through B-12 from 1 to 5 feet below grade. The material in this area generally seemed suitable for re-use, provided that unsuitable materials, such as wood or other debris, are removed. We recommend a volumetric modification factor (VMF) of 0.8 be considered for this material. A VMF of 0.8, means that 1 cubic foot of soil excavated from areas of the site will yield 0.8 cubic feet of compacted engineered fill. Borrow materials placed to construct subgrades for the proposed pavements should be compacted as recommended in **Section 4.2.3**.

4.3 Pavement Subgrade Improvement

The clay soils at the site are moisture sensitive and will be soft if saturated. Depending on the time of year, it may be difficult to moisture condition these materials so that they can pass a proof roll. If clay subgrades do not pass initial proofrolling and/or cannot be properly moisture conditioned, the contractor may consider chemical treatment of the existing clay soils. Treatment of clay soils can be achieved by addition of 15% Class C fly ash on a dry weight basis. Class C fly ash reacts quickly with water and so, for these reasons, Class C fly ash is normally applied in dry bulk form and mixed with the soil prior to adding water. This application procedure results in significant “dusting”. If dusting is a concern, subgrade stabilization can be accomplished using a lime slurry. The lime slurry mixture should be such that the amount of hydrated or quicklime lime is at least 5% based on the dry weight of soil being stabilized.

If proofrolling indicates that soft subgrade soils extend deeper in certain areas, other treatment options may be required, such as undercutting the poor soil and replacing with good soil, placing geotextile and gravel, or working surgestone (large pieces of rock generally 4 to 12

inches in size) into the subgrade soils. The conditions at the time of construction, the budget, availability of materials, and contractors experience will be considered to evaluate the options. As previously discussed, Terracon should be retained during construction to observe site preparation and proofrolling of pavement subgrades; and to assist the project team in determining suitable options to stabilize soft subgrades, where observed.

4.4 Estimates of Minimum Pavement Thickness

Based on information provided by the Veteran's Administration we understand:

- There are approximately 80,000 personal vehicles which visit the site annually
- About half of this volume occurs over Memorial Day weekend
- A variety of truck traffic occurs at the site; but a majority of truck traffic to the site accesses the cemetery from the VA Hospital, not off Muncie Road.

Terracon utilized the limited information provided about site traffic volumes and types to develop minimum pavement sections for two traffic categories using the National Asphalt Pavement Association (NAPA) design methods. The pavement sections provided below represent our opinions of minimum thicknesses for a service life of 20 years and, as such, regular maintenance should be anticipated. Estimated numbers of service period ESALS are noted below for each design section.

Minimum Recommended ACC Pavement Section Thickness (inches)			
Traffic Area	Asphalt Surface	Asphalt Base	Total Thickness
Residential Streets with one truck per day or less (27,000 ESALS)	2.0	5.0	7.0
Collector Streets with up to 5 trucks per day (110,000 ESALS)	2.0	6.0	8.0

4.4.1 Pavement Drainage

Pavements should be sloped to provide rapid drainage of surface water. Water allowed to pond on or adjacent to the pavements could saturate the subgrade and contribute to premature pavement deterioration. In addition, the pavement subgrade should be graded to provide positive drainage within the granular base section.

4.4.2 Pavement Maintenance

The pavement sections provided in this report represent minimum recommended thicknesses and, as such, periodic maintenance should be anticipated. Therefore, preventive maintenance should be planned and provided for through an on-going pavement management program.

5.0 GENERAL COMMENTS

Terracon should be retained to review the 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, pavement 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 construction or 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 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.

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, either 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 EXPLORATION



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



Project Manager: BWL	Project No. 02135123	 <p>13910 West 96th Terrace Lenexa, Kansas 66215 PH. (913) 492-7777 FAX. (913) 492-7443</p>	SITE LOCATION PLAN	Exhibit
Drawn by: BWL	Scale: N.T.S.		NATIONAL CEMETERY PAVEMENT IMPROVEMENTS	A-1
Checked by: BWL	File Name: Boring Location (11x8.5).ppt		Near Muncie Road	
Approved by: BWL	Date: 7/23/2013		LEAVENWORTH, KS	

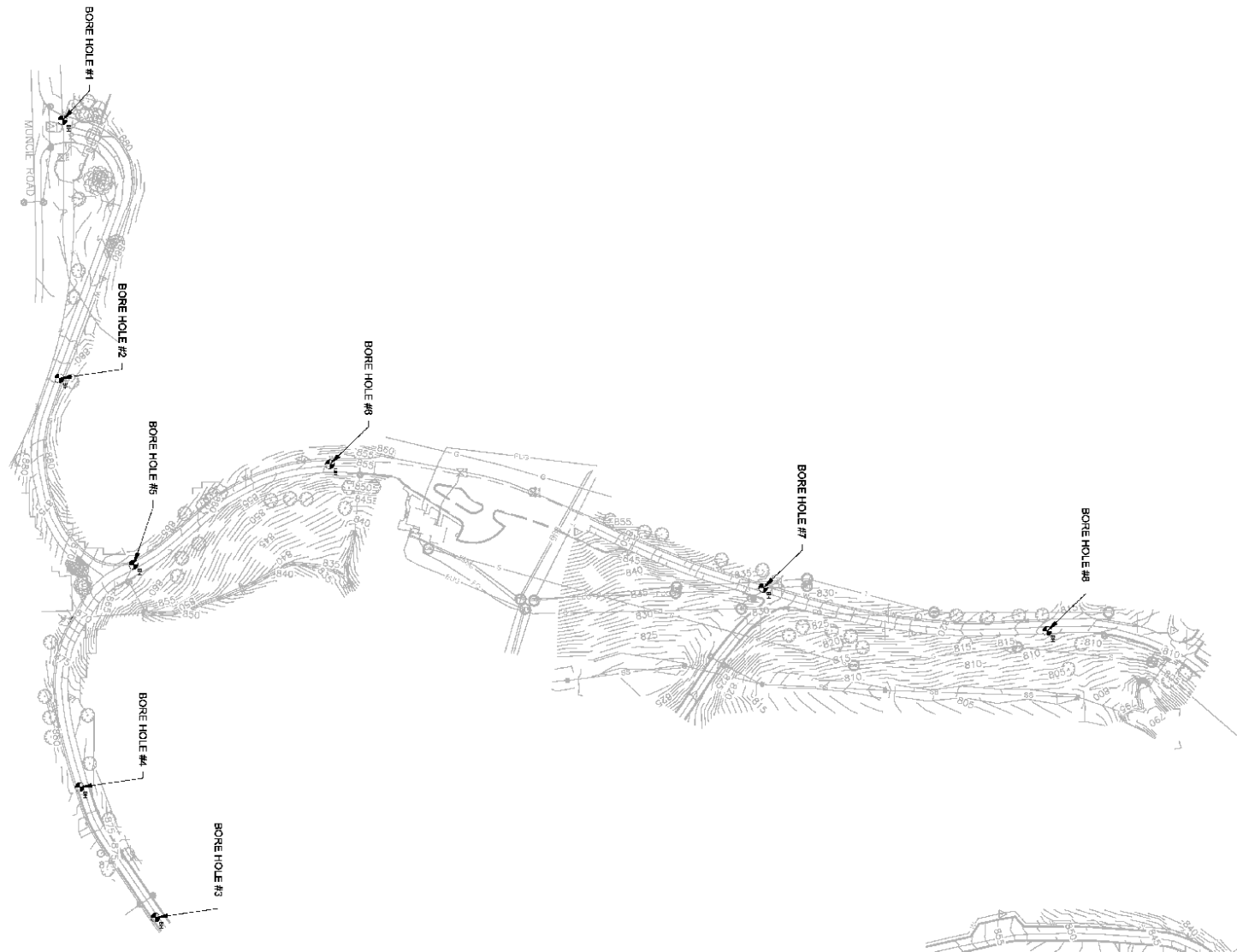


DIAGRAM IS FOR GENERAL LOCATION
ONLY, AND IS NOT INTENDED FOR
CONSTRUCTION PURPOSES

Project Manager:	BWL	Project No.	02135123
Drawn by:	BWL	Scale:	N.T.S.
Checked by:	BWL	File Name:	Boring Location (11x8.5).ppt
Approved by:	BWL	Date:	7/23/2013

Terracon
Consulting Engineers & Scientists

13910 West 96th Terrace Lenexa, Kansas 66215
PH. (913) 492-7777 FAX. (913) 492-7443

BORING LOCATION DIAGRAM

NATIONAL CEMETERY PAVEMENT IMPROVEMENTS
Near Muncie Road
LEAVENWORTH, KS

Exhibit

A-2

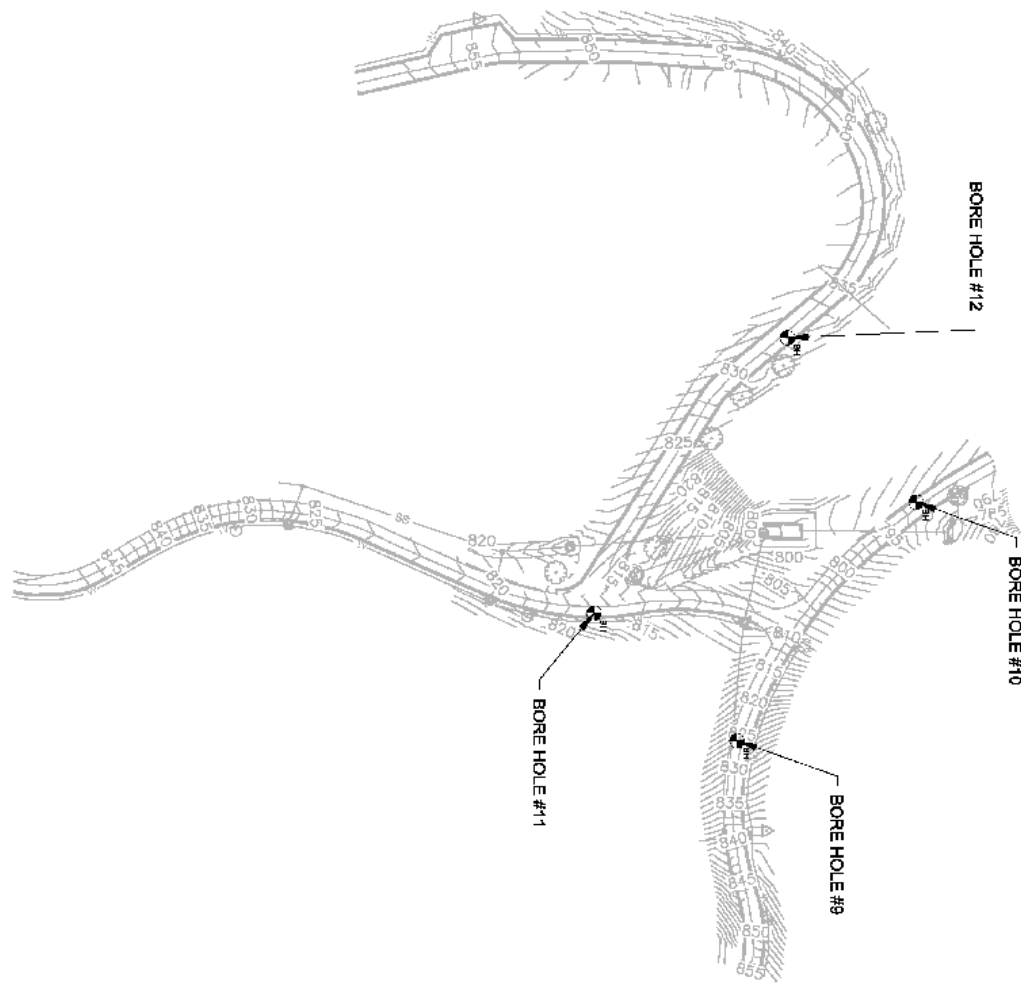



DIAGRAM IS FOR GENERAL LOCATION
ONLY, AND IS NOT INTENDED FOR
CONSTRUCTION PURPOSES

Project Manager: BWL	Project No. 02135123	 <p>13910 West 96th Terrace Lenexa, Kansas 66215 PH. (913) 492-7777 FAX. (913) 492-7443</p>	BORING LOCATION DIAGRAM	Exhibit
Drawn by: BWL	Scale: N.T.S.		NATIONAL CEMETERY PAVEMENT IMPROVEMENTS	A-3
Checked by: BWL	File Name: Boring Location (11x8.5).ppt		Near Muncie Road	
Approved by: BWL	Date: 7/23/2013		LEAVENWORTH, KS	

BORING LOG NO. B-1

Page 1 of 1

PROJECT: National Cemetary Pavement Improvements

CLIENT: FourFront Design
Rapid City, SD

SITE: Near Muncie Road
Leavenworth, KS

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)
	Approximate Surface Elev: 876.75 (Ft.) +/-									
	DEPTH ELEVATION (Ft.)									
	0.6 6" ASPHALT / 1" GRAVEL	876+/-								
	1.0 FILL - LEAN CLAY , brown	876+/-								
	LEAN CLAY (CL) , silty, brown, very stiff				5		+9000 (HP)		15	108
					7			4482	28	95
	6.0	871+/-								
	Boring Terminated at 6 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
0-6": Power Auger

See Exhibit A-16 for description of field procedures

Notes:

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

WATER LEVEL OBSERVATIONS

Terracon
13910 West 96th Terrace
Lenexa, Kansas

Boring Started: 6/25/2013

Boring Completed: 6/25/2013

Drill Rig: B-53

Driller: ZD

Project No.: 02135123

Exhibit: A-4

BORING LOG NO. B-2

Page 1 of 1

PROJECT: National Cemetary Pavement Improvements

CLIENT: FourFront Design
Rapid City, SD

SITE: Near Muncie Road
Leavenworth, KS

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)
	Approximate Surface Elev: 879.97 (Ft.) +/-									
	DEPTH ELEVATION (Ft.)									
	0.7 5" ASPHALT / 3" GRAVEL	879.5+/-								
	1.0 FILL - LEAN CLAY , brown	879+/-								
	LEAN CLAY (CL) , silty, brown, very stiff				11			3285	29	95
					18			2069	28	96
	6.0 Boring Terminated at 6 Feet	874+/-								

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
0-6": Power Auger

See Exhibit A-16 for description of field procedures

Notes:

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

WATER LEVEL OBSERVATIONS

Terracon
13910 West 96th Terrace
Lenexa, Kansas

Boring Started: 6/25/2013

Boring Completed: 6/25/2013

Drill Rig: B-53

Driller: ZD

Project No.: 02135123

Exhibit: A-5

BORING LOG NO. B-3

Page 1 of 1

PROJECT: National Cemetary Pavement Improvements

CLIENT: FourFront Design
Rapid City, SD

SITE: Near Muncie Road
Leavenworth, KS

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)
	Approximate Surface Elev: 874.16 (Ft.) +/-									
	DEPTH ELEVATION (Ft.)									
	8" ASPHALT / 3" GRAVEL									
	0.9 873.5+/-									
	1.0 FILL - LEAN CLAY , brown 873+/-									
	LEAN CLAY (CL) , silty, brown, very stiff				18		8500 (HP)		18	110
					16		5500 (HP)		25	99
	6.0 868+/-									
	Boring Terminated at 6 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
0-6": Power Auger

See Exhibit A-16 for description of field procedures

Notes:

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

WATER LEVEL OBSERVATIONS

Terracon
13910 West 96th Terrace
Lenexa, Kansas

Boring Started: 6/25/2013

Boring Completed: 6/25/2013

Drill Rig: B-53

Driller: ZD

Project No.: 02135123

Exhibit: A-6

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 02135123.GPJ TERRACON2012.GDT 9/24/13

BORING LOG NO. B-4

Page 1 of 1

PROJECT: National Cemetary Pavement Improvements

CLIENT: FourFront Design
Rapid City, SD

SITE: Near Muncie Road
Leavenworth, KS

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)
	Approximate Surface Elev: 878.22 (Ft.) +/-									
	DEPTH ELEVATION (Ft.)									
	3" ASPHALT / 5" GRAVEL									
	0.7 877.5+/-									
	FILL - LEAN CLAY , trace gravel, brown, stiff to very stiff									
					11		5500 (HP)		23	102
					7			3648	26	98
		5								
	6.0 872+/-									
	Boring Terminated at 6 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
0-6": Power Auger

See Exhibit A-16 for description of field procedures

Notes:

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

WATER LEVEL OBSERVATIONS

Terracon
13910 West 96th Terrace
Lenexa, Kansas

Boring Started: 6/25/2013

Boring Completed: 6/25/2013

Drill Rig: B-53

Driller: ZD

Project No.: 02135123

Exhibit: A-7

BORING LOG NO. B-5

Page 1 of 1

PROJECT: National Cemetary Pavement Improvements

CLIENT: FourFront Design
Rapid City, SD

SITE: Near Muncie Road
Leavenworth, KS

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)
	Approximate Surface Elev: 864.82 (Ft.) +/-									
	DEPTH ELEVATION (Ft.)									
	0.7 6" ASPHALT / 2" GRAVEL 864+/-									
	1.0 FILL - LEAN CLAY , brown 864+/-									
	LEAN CLAY (CL) , silty, brown, very stiff									
					7		+9000 (HP)		20	108
					5		4000 (HP)		21	103
	6.0 Boring Terminated at 6 Feet 859+/-									

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
0-6": Power Auger

See Exhibit A-16 for description of field procedures

Notes:

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

WATER LEVEL OBSERVATIONS

Terracon
13910 West 96th Terrace
Lenexa, Kansas

Boring Started: 6/25/2013

Boring Completed: 6/25/2013

Drill Rig: B-53

Driller: ZD

Project No.: 02135123

Exhibit: A-8

BORING LOG NO. B-6

Page 1 of 1

PROJECT: National Cemetary Pavement Improvements

CLIENT: FourFront Design
Rapid City, SD

SITE: Near Muncie Road
Leavenworth, KS

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)
	Approximate Surface Elev: 855.14 (Ft.) +/-									
	DEPTH ELEVATION (Ft.)									
	0.6 6" ASPHALT / 1" GRAVEL	854.5+/-								
	1.0 FILL - LEAN CLAY , brown	854+/-								
	LEAN CLAY (CL) , silty, brown, very stiff to medium stiff				16		7500 (HP)		24	104
					6			1701	25	98
	6.0	849+/-								
	Boring Terminated at 6 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
0-6": Power Auger

See Exhibit A-16 for description of field procedures

Notes:

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

WATER LEVEL OBSERVATIONS

Terracon
13910 West 96th Terrace
Lenexa, Kansas

Boring Started: 6/25/2013

Boring Completed: 6/25/2013

Drill Rig: B-53

Driller: ZD

Project No.: 02135123

Exhibit: A-9

BORING LOG NO. B-7

Page 1 of 1

PROJECT: National Cemetary Pavement Improvements

CLIENT: FourFront Design
Rapid City, SD

SITE: Near Muncie Road
Leavenworth, KS

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)
	Approximate Surface Elev: 832.74 (Ft.) +/-									
	DEPTH ELEVATION (Ft.)									
	0.7 6" ASPHALT / 2" GRAVEL 832+/-									
	1.0 FILL - LEAN CLAY , brown 831.5+/-									
	LEAN CLAY (CL) , silty, brown, hard to very stiff									
					22		+9000 (HP)		21	107
					10		5500 (HP)		26	96
	6.0 826.5+/-									
	Boring Terminated at 6 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
0-6": Power Auger

See Exhibit A-16 for description of field procedures

Notes:

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

WATER LEVEL OBSERVATIONS

Terracon
13910 West 96th Terrace
Lenexa, Kansas

Boring Started: 6/25/2013

Boring Completed: 6/25/2013

Drill Rig: B-53

Driller: ZD

Project No.: 02135123

Exhibit: A-10

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 02135123.GPJ TERRACON2012.GDT 9/24/13

BORING LOG NO. B-8

Page 1 of 1

PROJECT: National Cemetary Pavement Improvements

CLIENT: FourFront Design
Rapid City, SD

SITE: Near Muncie Road
Leavenworth, KS

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)
	Approximate Surface Elev: 814.56 (Ft.) +/-									
	DEPTH ELEVATION (Ft.)									
	0.5 4" ASPHALT / 2" GRAVEL 814+/-									
	1.0 FILL - LEAN CLAY , brown 813.5+/-									
	LEAN CLAY (CL) , silty, brown, very stiff to stiff				8		7500 (HP)		23	105
					15			2686	24	101
	6.0 808.5+/-									
	Boring Terminated at 6 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
0-6": Power Auger

See Exhibit A-16 for description of field procedures

Notes:

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

WATER LEVEL OBSERVATIONS

Terracon
13910 West 96th Terrace
Lenexa, Kansas

Boring Started: 6/25/2013

Boring Completed: 6/25/2013

Drill Rig: B-53

Driller: ZD

Project No.: 02135123

Exhibit: A-11

BORING LOG NO. B-9

Page 1 of 1

PROJECT: National Cemetary Pavement Improvements

CLIENT: FourFront Design
Rapid City, SD

SITE: Near Muncie Road
Leavenworth, KS

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)
	Approximate Surface Elev: 826.18 (Ft.) +/-									
	DEPTH ELEVATION (Ft.)									
	5" ASPHALT / 3" GRAVEL									
	0.7 825.5+/-									
	FILL - LEAN CLAY , trace gravel, brown									
					12		5500 (HP)		24	102
	4.0 822+/-				5				14	
	LEAN CLAY (CL) , silty, brown									
	6.0 820+/-									
	Boring Terminated at 6 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
0-6": Power Auger

See Exhibit A-16 for description of field procedures

Notes:

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

WATER LEVEL OBSERVATIONS

Terracon
13910 West 96th Terrace
Lenexa, Kansas

Boring Started: 6/25/2013

Boring Completed: 6/25/2013

Drill Rig: B-53

Driller: ZD

Project No.: 02135123

Exhibit: A-12

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 02135123.GPJ TERRACON2012.GDT 9/24/13

BORING LOG NO. B-10

Page 1 of 1

PROJECT: National Cemetary Pavement Improvements

CLIENT: FourFront Design
Rapid City, SD

SITE: Near Muncie Road
Leavenworth, KS

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)
	Approximate Surface Elev: 793.32 (Ft.) +/-									
	DEPTH ELEVATION (Ft.)									
	0.7 6" ASPHALT / 2" GRAVEL	792.5+/-								
	1.0 FILL - LEAN CLAY , brown	792.5+/-								
	LEAN CLAY (CL) , silty, brown, very stiff				20		8000 (HP)		18	97
					8		8000 (HP)		11	116
	6.0 Boring Terminated at 6 Feet	787.5+/-								

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
0-6": Power Auger

See Exhibit A-16 for description of field procedures

Notes:

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

WATER LEVEL OBSERVATIONS

Terracon
13910 West 96th Terrace
Lenexa, Kansas

Boring Started: 6/25/2013

Boring Completed: 6/25/2013

Drill Rig: B-53

Driller: ZD

Project No.: 02135123

Exhibit: A-13

BORING LOG NO. B-11

Page 1 of 1

PROJECT: National Cemetary Pavement Improvements

CLIENT: FourFront Design
Rapid City, SD

SITE: Near Muncie Road
Leavenworth, KS

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)
	Approximate Surface Elev: 815.67 (Ft.) +/-									
	DEPTH ELEVATION (Ft.)									
	0.6 7" ASPHALT	815+/-								
	1.0 FILL - LEAN CLAY , brown	814.5+/-								
	LEAN CLAY (CL) , silty, brown, very stiff				9			4119	25	103
					12		6000 (HP)		15	112
	6.0	809.5+/-								
	Boring Terminated at 6 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
0-6": Power Auger

See Exhibit A-16 for description of field procedures

Notes:

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

WATER LEVEL OBSERVATIONS

Terracon
13910 West 96th Terrace
Lenexa, Kansas

Boring Started: 6/25/2013

Boring Completed: 6/25/2013

Drill Rig: B-53

Driller: ZD

Project No.: 02135123

Exhibit: A-14

BORING LOG NO. B-12

Page 1 of 1

PROJECT: National Cemetary Pavement Improvements

CLIENT: FourFront Design
Rapid City, SD

SITE: Near Muncie Road
Leavenworth, KS

GRAPHIC LOG	LOCATION See Exhibit A-2	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)
	Approximate Surface Elev: 832.07 (Ft.) +/-									
	DEPTH ELEVATION (Ft.)									
	0.6 6" ASPHALT / 1" GRAVEL	831.5+/-								
	1.0 FILL - LEAN CLAY , trace gravel, brown	831+/-								
	LEAN CLAY (CL) , silty, brown, hard to stiff				16		+9000 (HP)		22	108
					17			2215	23	97
	6.0	826+/-								
	Boring Terminated at 6 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
0-6": Power Auger

See Exhibit A-16 for description of field procedures

Notes:

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

WATER LEVEL OBSERVATIONS

Terracon
13910 West 96th Terrace
Lenexa, Kansas

Boring Started: 6/25/2013

Boring Completed: 6/25/2013

Drill Rig: B-53

Driller: ZD

Project No.: 02135123

Exhibit: A-15

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 02135123.GPJ TERRACON2012.GDT 9/24/13

Field Exploration Description

The proposed boring locations were laid out in the field by a Terracon representative. The as-staked boring locations were surveyed by FourFront and the ground surface elevations on the boring logs were provided. The locations and elevations of the borings should be considered accurate only to the degree implied by the means and methods used to define them.

The borings were drilled with a truck-mounted rotary drill rig using flight augers to advance the boreholes. Samples of the soil encountered in the borings were obtained using the thin-walled tube and split-barrel sampling procedures.

In the thin-walled tube sampling procedure, a 2-inch diameter, thin-walled, seamless steel tube with a sharp cutting edge is pushed hydraulically into the soil to obtain a relatively undisturbed sample. In the split-barrel sampling procedure, a standard 2-inch O.D. split barrel sampling spoon is driven into the ground by a 140 pound hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18 inch penetration is 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.

The samples were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further examination, testing, and classification. Information provided on the boring logs attached to this report includes soil descriptions, consistency evaluations, boring depths, sampling intervals, and groundwater conditions. The borings were backfilled with auger cuttings and the asphalt was patched prior to the drill crew leaving the site.

A field log of each boring was prepared by the drill crew. These logs included visual classifications of the materials encountered during drilling as well as the driller's interpretation of the subsurface conditions between samples. Final boring logs included with this report represent the engineer's interpretation of the field logs and include modifications based on laboratory observation and tests of the samples.

APPENDIX B
SUPPORTING INFORMATION

Geotechnical Engineering Report

National Cemetery Pavement Improvements ■ Leavenworth, KS

September 24, 2013 ■ Terracon Project No. 02135123



Laboratory Testing

Representative soil samples were tested in the laboratory to measure their natural water content, dry unit weight, unconfined compressive strength, and Atterberg limits. A calibrated hand penetrometer was also used to estimate the approximate unconfined compressive strength of some samples. The calibrated hand penetrometer has been correlated with unconfined compression tests. The test results are provided on the boring logs included in Appendix A.

Two (2) composite bulk samples were collected at the site. Bulk 1 was collected from Borings B-1 through B-4 from 1 to 5 feet below grade. Bulk 2 was collected from Borings B-9 through B-12 from 1 to 5 feet below grade. Standard Proctor and California Bearing Ratio (CBR) tests were performed on each bulk sample. These test results are provided in Appendix B.

Descriptive classifications of the soils indicated on the boring logs are in accordance with the enclosed General Notes and the Unified Soil Classification System. Also shown are estimated Unified Soil Classification Symbols. A brief description of this classification system is attached to this report. All classification was by visual manual procedures.

LABORATORY COMPACTION CHARACTERISTICS OF SOIL REPORT

Terracon

Report Number: 02135123.0001

Service Date: 06/28/13

Report Date: 07/08/13

13910 W. 96th Ter.

Lenexa, KS 66215

913-492-7777

Client

FourFront Design, Inc.

Attn: Dirk Jablonksi

517 Seventh Street

Rapid City, SD 57701

Project

Ft. Leavenworth National Cemetery Pavements

Cemetery Rd

Ft. Leavenworth, KS

Project Number 02135123

Material Information

Source of Material:

Proposed Use:

Sample Information

Sample Date: 06/28/13

Sampled By:

Sample Location: Bulk #1

Sample Description: Lean Clay (CL), grayish brown

Laboratory Test Data

Test Procedure: ASTM D698

Test Method: Method A

Sample Preparation: Dry

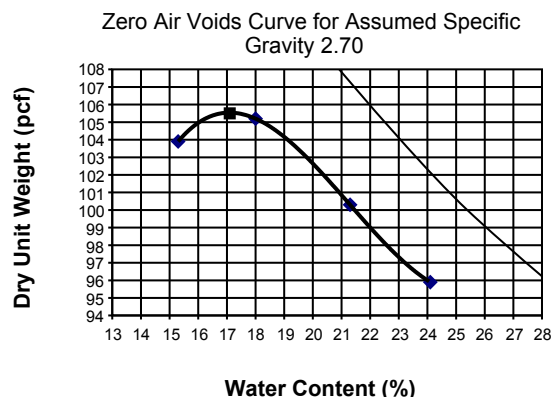
Rammer Type: Mechanical

Maximum Dry Unit Weight (pcf): 105.5

Optimum Water Content (%): 17.1

	Result	Specifications
Liquid Limit:	39	
Plastic Limit:	21	
Plasticity Index:	18	
In-Place Moisture (%):		

USCS:



Comments:

Services:

Terracon Rep.:

Reported To:

Contractor:

Report Distribution:

(1) FourFront Design, Inc., Emailed

Test Methods: ASTM D698

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.

California Bearing Ratio of Laboratory-Compacted Soils

Report Number: 02135123.0001
Service Date: 06/28/13
Report Date: 07/08/13
Task:

Terracon

13910 W. 96th Ter.
Lenexa, KS 66215
913-492-7777

Client

FourFront Design, Inc.
Attn: Dirk Jablonksi
517 Seventh Street
Rapid City, SD 57701

Project

Ft. Leavenworth National Cemetery Pavements
Cemetery Rd
Ft. Leavenworth, KS

Project No. 02135123

SAMPLE INFORMATION

Sample Number:		Proctor Method:	ASTM D698 - Method A
Boring Number:	Bulk #1	Maximum Dry Density (pcf):	105.5
Sample Location:		Optimum Moisture:	17.1
Depth:		Liquid Limit:	39
Material Description:	Lean Clay (CL), grayish brown	Plasticity Index:	18

CBR TEST DATA

CBR Value at 0.100 inch	2.2
CBR Value at 0.200 inch	2.2

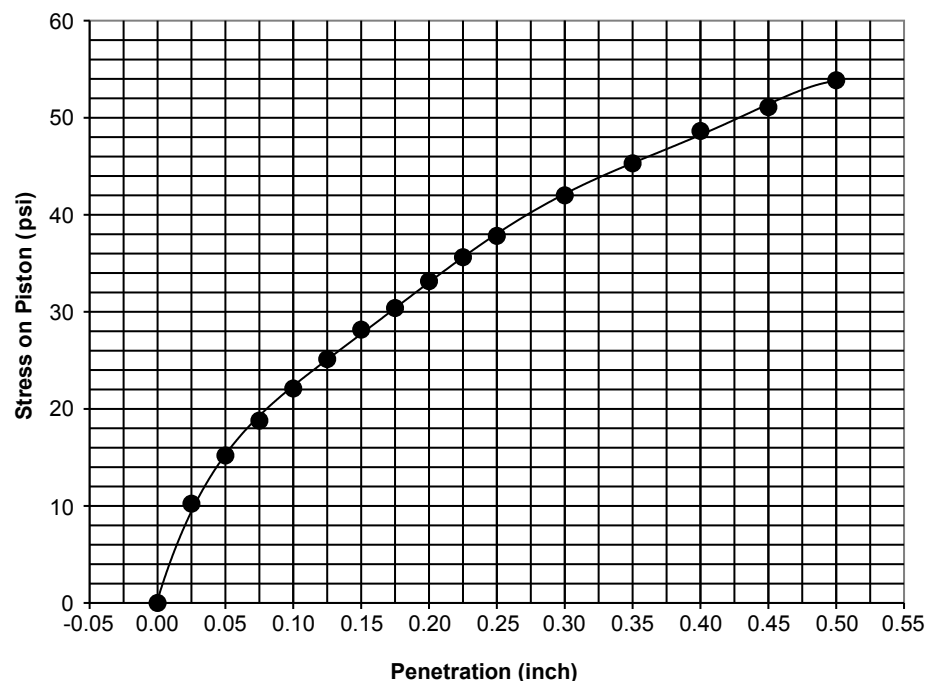
Surcharge Weight (lbs)	10
Soaking Condition	Soaked
Length of Soaking (hours)	96
Swell (%)	1.4

DENSITY DATA

Dry Density Before Soaking (pcf)	99.8
Compaction of Proctor (%)	94.6

MOISTURE DATA

Before Compaction (%)	16.8
After Compaction (%)	16.4
Top 1" After Soaking (%)	27.1
Average After Soaking (%)	23.5



Comments:

Test Methods: ASTM D1883

Services:

Terracon Rep:

Reported To:

Contractor:

Started:

Finished:

Lunch/Nonchargeable:

Report Distribution

(1) FourFront Design, Inc., Emailed

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

Terracon

Report Number: 02135123.0002

Service Date: 06/28/13

Report Date: 07/01/13

13910 W. 96th Ter.

Lenexa, KS 66215

913-492-7777

Client

FourFront Design, Inc.

Attn: Dirk Jablonksi

517 Seventh Street

Rapid City, SD 57701

Project

Ft. Leavenworth National Cemetery Pavements

Cemetery Rd

Ft. Leavenworth, KS

Project Number 02135123

Material Information

Source of Material:

Proposed Use:

Sample Information

Sample Date: 06/28/13

Sampled By:

Sample Location: Bulk #2

Sample Description: Lean Clay (CL), dark gray with yellowish gray

Laboratory Test Data

Test Procedure: ASTM D698

Test Method: Method A

Sample Preparation: Dry

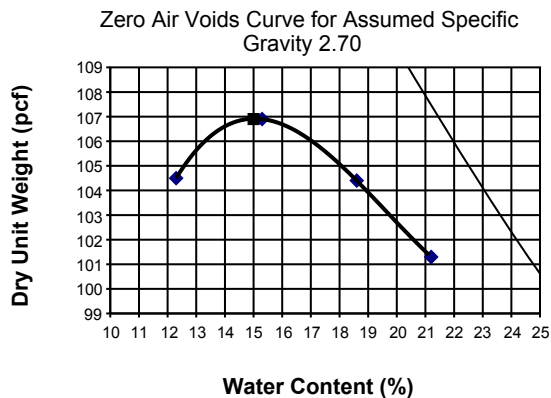
Rammer Type: Mechanical

Maximum Dry Unit Weight (pcf): 106.9

Optimum Water Content (%): 15.0

	Result	Specifications
Liquid Limit:	37	
Plastic Limit:	20	
Plasticity Index:	17	
In-Place Moisture (%):		

USCS:



Comments:

Services:

Terracon Rep.:

Reported To:

Contractor:

Report Distribution:

(1) FourFront Design, Inc., Emailed

Test Methods: ASTM D698

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.

California Bearing Ratio of Laboratory-Compacted Soils

Report Number: 02135123.0002
Service Date: 06/28/13
Report Date: 07/01/13
Task:

Terracon

13910 W. 96th Ter.
Lenexa, KS 66215
913-492-7777

Client

FourFront Design, Inc.
Attn: Dirk Jablonksi
517 Seventh Street
Rapid City, SD 57701

Project

Ft. Leavenworth National Cemetery Pavements
Cemetery Rd
Ft. Leavenworth, KS

Project No. 02135123

SAMPLE INFORMATION

Sample Number:		Proctor Method:	ASTM D698 - Method A
Boring Number:	Bulk #2	Maximum Dry Density (pcf):	106.9
Sample Location:		Optimum Moisture:	15.0
Depth:		Liquid Limit:	37
Material Description:	Lean Clay(CL), dark gray with yellowish gray	Plasticity Index:	17

CBR TEST DATA

CBR Value at 0.100 inch	1.5
CBR Value at 0.200 inch	1.5

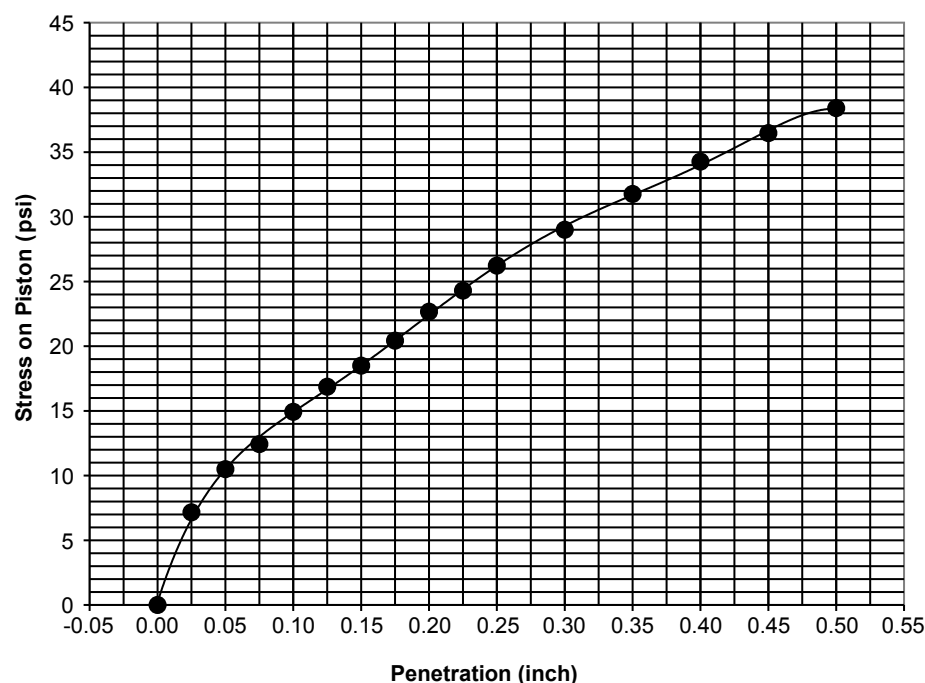
Surcharge Weight (lbs)	10
Soaking Condition	Soaked
Length of Soaking (hours)	96
Swell (%)	2.5

DENSITY DATA

Dry Density Before Soaking (pcf)	101.2
Compaction of Proctor (%)	94.6

MOISTURE DATA

Before Compaction (%)	14.9
After Compaction (%)	13.8
Top 1" After Soaking (%)	27.3
Average After Soaking (%)	23.7



Comments:

Test Methods: ASTM D1883

Services:

Terracon Rep:

Reported To:

Contractor:

Started:

Finished:

Lunch/Nonchargeable:

Report Distribution












(1) FourFront Design, Inc., Emailed

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.

APPENDIX C
SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING			WATER LEVEL		Water Initially Encountered	FIELD TESTS	(HP)	Hand Penetrometer	
	Auger	Split Spoon			Water Level After a Specified Period of Time		(T)	Torvane	
					Water Level After a Specified Period of Time		(b/f)	Standard Penetration Test (blows per foot)	
	Shelby Tube	Macro Core		Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.			(PID)	Photo-Ionization Detector	
							(OVA)	Organic Vapor Analyzer	
	Ring Sampler	Rock Core							
									
	Grab Sample	No Recovery							

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS	RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.			CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
	Descriptive Term (Density)	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.	Descriptive Term (Consistency)	Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-Value Blows/Ft.
	Very Loose	0 - 3	0 - 6	Very Soft	less than 500	0 - 1
	Loose	4 - 9	7 - 18	Soft	500 to 1,000	2 - 4
	Medium Dense	10 - 29	19 - 58	Medium-Stiff	1,000 to 2,000	4 - 8
	Dense	30 - 50	59 - 98	Stiff	2,000 to 4,000	8 - 15
	Very Dense	> 50	≥ 99	Very Stiff	4,000 to 8,000	15 - 30
				Hard	> 8,000	> 30

RELATIVE PROPORTIONS OF SAND AND GRAVEL

<u>Descriptive Term(s) of other constituents</u>	<u>Percent of Dry Weight</u>
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

<u>Major Component of Sample</u>	<u>Particle Size</u>
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
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

<u>Descriptive Term(s) of other constituents</u>	<u>Percent of Dry Weight</u>
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

<u>Term</u>	<u>Plasticity Index</u>
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

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 ≥ 4 and 1 ≤ Cc ≤ 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 ≥ 6 and 1 ≤ Cc ≤ 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-inch (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

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

^F If soil contains $\geq 15\%$ 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 $\geq 15\%$ 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 $\geq 30\%$ plus No. 200 predominantly sand, add "sandy" to group name.

^M If soil contains $\geq 30\%$ plus No. 200, predominantly gravel, add "gravelly" to group name.

^N $PI \geq 4$ 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.

