

SUBSURFACE EXPLORATION

City of Tulsa Maintenance Zoning Project Intersection
of E Admiral Place & N Quincy Ave Area Tulsa,
Oklahoma

PROJECT NO. 2030-0834



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February 4, 2021

Cowan Group Engineering
5416 South Yale, Suite 210
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Attn: Mr. Keith Duncan
Operations Manager

Re: Subsurface Exploration
City of Tulsa Maintenance Zoning Project Intersection
of E Admiral Place & N Quincy Ave Area Tulsa,
Oklahoma

Dear Mr. Duncan:

Standard Testing & Engineering, LLC (Standard Testing) is pleased to present the report covering the subsurface exploration for the subject project. This study was authorized by receipt of the signed "Agreement of Services" contract, dated December 29th, 2020.

Standard Testing conducted a geotechnical investigation at the site of the new City of Tulsa Maintenance Zoning Project in Tulsa, Oklahoma. This report contains the detailed results of the geotechnical investigation, including pavement recommendations, and construction considerations.

The subsurface soils consist of approximately 5 feet of clay with various amounts of sand and exhibit low to high plastic characteristics.

We trust that the results and recommendations contained herein will permit adequate economical design and construction of the proposed structure. Unless you specify otherwise, we will keep samples obtained from these cores in our Oklahoma City laboratory for the next thirty (30) days.

We appreciate the opportunity to assist on this project. Please call on us if we can be of further service.

Respectfully submitted,
STANDARD TESTING & ENGINEERING, LLC

Donovan Bradshaw, E.I.
Staff Geotechnical Engineer

Roy Khalife, P.E.
Geotechnical Engineer

Project No. 2030-0834
Account No. 0230COW01

SUBSURFACE EXPLORATION

City of Tulsa Maintenance Zoning Project
Intersection of E Admiral Place & N Quincy Road Area
Tulsa, Oklahoma

PROJECT NO. 2030-0834

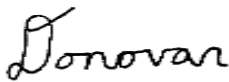
PREPARED FOR

Cowan Group Engineering
5416 South Yale, Suite 210
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PREPARED BY

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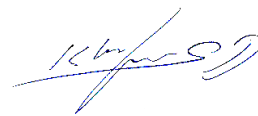
Prepared By:



Donovan Bradshaw, E.I.
Staff Geotechnical Engineer



Reviewed By:



Roy Khalife, P.E.
Geotechnical Engineer

I certify my e-signature for the study entitled "Subsurface Exploration."

Dated 2/4/2021

February 4, 2021

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Section 1 INTRODUCTION

1.1 Authorization

This report presents the results of a subsurface exploration performed by Standard Testing & Engineering, LLC (Standard Testing) in accordance with the proposal (P-20154) prepared for Mr. Robert Rose, dated July 16th, 2020, and identified as Standard Testing project number 2030-0834. This geotechnical study was authorized by receipt of the signed "Agreement of Services" contract, dated December 29th, 2020.

1.2 Purpose and Scope

A geotechnical investigation was performed for the purpose of (1) determining the subsurface conditions, (2) evaluating the plasticity characteristics of the soils, and (3) making recommendations concerning the earthwork, and pavement recommendations.

Eleven (11) exploratory cores (pavement cores C-1 thru C-11) were taken in the existing pavement, and the subgrade was sampled to a depth of 5 feet. The core depths and types of testing were performed according to the scope of work proposed by Standard Testing and accepted by Keith Duncan. Narrative descriptions of our findings and recommendations are contained in the body of this report. A site and coring location plan, the core logs, and a summary sheet of laboratory test results are included in the Appendices of this report.

1.3 Project Location and Description

It is understood that the City of Tulsa Maintenance Zoning Project is proposed to be constructed at Intersection of E Admiral Place & N Quincy Road Area in Tulsa, Oklahoma. This project consists of roadway improvements encompassing the following streets: E Admiral Place and N Quincy Ave and extending East to the intersection of E Admiral Place with N Utica Ave, also including sections of N Quincy Ave, N Rockford Ave, and N Trenton Ave.

If the project is not as described or has changed, Standard Testing must be notified in order to reevaluate the recommendations for the project.

Section 2**FIELD EXPLORATION****2.1 Drilling Information**

The field exploration work was performed between the 8th and 11th of January, 2020. Conditions at the site were investigated with eleven (11) cores at the locations indicated on the site and core location plan, included in Appendix "A." the subgrade underneath the cored pavement was sampled to a depth of 5 feet within the pavement footprint. For accurate sampling, cuttings were observed continuously during drilling with specific samples being taken at distinct lithologic changes. The equipment used, field tests performed, and soil samples taken are discussed below.

2.2 Equipment Used

Eleven (11) cores were drilled with a core drilling rig with a 4" diamond bit rotary core drill barrel , and the subgrade sampled with a truck-mounted CME-55 rotary drilling unit equipped with a 3.25" I.D. X 7.25" O.D. hollow stem augers (HSA).

2.3 Testing and Sampling Performed

In situ strength and consistency of the subgrade soils were evaluated using the Dynamic Cone Penetrometer (DCP) device in accordance with ASTM D6951 testing procedures to compute the California Bearing Ratio (CBR) value. Results are presented in Appendix "D."

Depths of individual grab samples and dynamic cone penetration tests are indicated on the coring logs included in Appendix "B." All samples were labeled and sealed in water tight, protective containers and returned to the laboratory for further evaluation and testing.

2.4 Subsurface Conditions

The subsurface material encountered under the existing pavement consist of clay with various amounts of sand, aggregate base, and chemically stabilized soils. Rock material was not encountered in the core locations.

2.5 Groundwater

During drilling and at completion of drilling operations, groundwater was NOT encountered at the core locations. However, due to the use of water to lubricate and cool core barrel, accurate water reading may not have been possible. Presence of water should be anticipated in any excavation. Water travelling through soil (subsurface water) is often unpredictable and may be present at shallow depths. Due to the seasonal changes in groundwater and the unpredictable nature of groundwater paths, groundwater levels will fluctuate. Therefore, it is necessary during construction to be observant for groundwater seepage in excavations in order to assess the

situation and make necessary changes. We cannot assume responsibility for difficulties experienced during construction or for future operational problems due to elevation or volume of water encountered.

Section 3**LABORATORY TESTING**

Laboratory testing was performed in order to determine the plasticity characteristics of the subsurface materials as well as confirm the soil classifications.

3.1 Tests Performed

- Moisture content tests were performed on split spoon and bag samples, in accordance with ASTM D2216, to determine the in-situ moisture conditions.
- Density tests were performed on intact split spoon samples in accordance with ASTM D7263 Method A.
- Atterberg limits tests were performed on split spoon and bag samples to determine the plasticity characteristics and swell potential of the soil. The tests were performed in accordance with ASTM D4318.
- Sieve analyses were performed on split spoon and bag samples, in accordance with ASTM D2487, for aid in soil classification. These soils were classified according to the Unified Soil Classification System (USCS) and the American Association of State Highway and Transportation Officials (AASHTO) soil classification system.
- Soluble sulfate content test was performed on a composite soil sample in accordance with OHDL-49. The test result is summarized under Laboratory Testing Results in Section 4 of this report.
- Standard Proctor test was conducted on a composite soil sample in accordance with AASHTO T99 testing procedures. The Standard Proctor test determines the relationship between moisture content and density at a specified compaction effort. The result of the standard proctor test is presented in Appendix "D."
- California Bearing Ratio (CBR) test was performed on a composite soil sample in accordance with ASTM D1883. Results are presented as the test load corresponding to a given penetration (e.g., 2.5mm) driven by a standard load, expressed as percent, where the standard load is based on a standard sample of crushed stone. The test result is presented in Appendix "D."

3.2 Laboratory Summary

General descriptions of the encountered soils together with visual and laboratory classifications and numerical values of the test results are on the coring logs included in Appendix "B." A "Summary of Test Results" is included in Appendix "D."

Section 4**ENGINEERING EVALUATION AND RECOMMENDATIONS****4.1 Soil Conditions**

The subsurface material encountered under the existing pavement consist of clay with various amounts of sand, aggregate base, and chemically stabilized soils. Rock material was not encountered in the core locations.

4.2 Laboratory Testing ResultsSoluble Sulfate Test Results

The soluble sulfate results are included in the following table:

Table 1: Soluble Sulfate Test Results

Cores No.	Sample I.D.	Depth (feet)	Sulfate Content (ppm)
C-1,2,3,4	Comp-1	0.0-5.0	212
C-6,7,8,9	Comp-2	0.0-5.0	960
C-5,10,11	Comp-3	0.0-5.0	66

The results of the sulfate content test indicate that Type I/II cement may be used for concrete and the sulfate levels are negligible in affecting lime stabilization of the soil. According to the National Lime Association's publication entitled "Technical Memorandum: Guidelines for Stabilization of Soils Containing Sulfates," which can be found on their website at "www.lime.org/documents/publications/free_downloads/technical-memorandum.pdf", If the total level of soluble sulfates is below 0.3%, or 3,000 parts per million (ppm), by weight of soil, then lime stabilization should not be of significant concern. The potential for a harmful reaction is low."

Standard Proctor Test Results

Standard proctor test was conducted on a composite soil sample in accordance with AASHTO T99 testing method. The result is presented in the following table and are also presented in the Appendix "D."

Table 2: Standard Proctor Test Results

Core No.	Sample I.D.	Depth (feet)	USCS	AASHTO	Maximum Dry Density (pcf)	Optimum Moisture (%)
C-1,2,3,4	Comp-1	0.0-5.0	CL	A-6(15)	110.8	15.1
C-6,7,8,9	Comp-2	0.0-5.0	CL	A-7-6(22)	111.7	16.0
C-5,10,11	Comp-3	0.0-5.0	CL	A-6(18)	108.9	16.0

California Bearing Ratio (CBR) Test Results

California bearing ratio (CBR) of laboratory-compacted soil was conducted on a composite soil sample in accordance with ASTM D1883 testing method. The results are presented in the following table and is also presented in Appendix “D.”

Table 3: California Bearing Ratio Test Results

Core No.	Sample I.D.	Depth (feet)	Soil Type	CBR
C-1,2,3,4	Comp-1	0.0-5.0	A-6(15)	3.1
C-6,7,8,9	Comp-2	0.0-5.0	A-7-6(22)	3.6
C-5,10,11	Comp-3	0.0-5.0	A-6(18)	3.0

4.3 Existing Pavement Conditions

Pavement Cores

Eleven (11) cores (C-1 through C-11) were drilled in the existing pavement for this project. The subgrade at those locations was sampled to a depth of five (5) feet below the existing surface. Pavement cores were collected at each of the core locations C-1 to C-11 and are summarized in the table below. A more detailed description and a photograph of the recovered cores are provided on the core logs in Appendix “B”.

Table 4: Pavement Coring Summary

Pavement Core	GPS Location	Core Thickness (in)	Aggregate Base (in)	Stabilized Subgrade
C-1	36 9.634'N 95 58.081'W	6.75	Not Encountered	Not Encountered
C-2	36 9.633'N 95 58.185'W	3.5	4.0	Not Encountered
C-3	36 9.636'N 95 58.287'W	4.0	4.0	Not Encountered
C-4	36 9.635'N 95 58.398'W	5.5	3.0	Not Encountered
C-5	36 9.592' N 95 58.418' W	3.25	4.0	Not Encountered
C-6	36° 9.600'N 95° 58.163'W	6.5	2.0	Not Encountered
C-7	36 9.687' N 95 58.160' W	7.5	Not Encountered	Not Encountered
C-8	36 9.762'N 95 58.165'W	7.5	Not Encountered	Encountered
C-9	36 9.805'N 95 58.160'W	7.0	Not Encountered	Not Encountered
C-10	36 9.592'N 95 58.293'W	7.5	3.0	Not Encountered
C-11	36 9.657'N 95 58.421'W	5.5	4.0	Not Encountered

Surface Distress Evaluation

The existing pavement distresses were visually inspected and evaluated in general accordance with FHWA “Distress Identification Manual for the LTPP, CH 1: Distresses for Pavements with Asphalt Concrete Surfaces”. Major cracking distresses present in asphalt pavement include, longitudinal, transverse, and fatigue cracking. Major distresses in the concrete pavement were joint cracking and patching. Photographic examples are collected in Appendix “E”

4.4 Pavement Recommendations

Subgrade Preparation

Prior to placement of fill or preparation of pavement subbase:

- The natural subgrade should be stripped of all topsoil or any other deleterious materials.
- Next, the subgrade should be proofrolled, including removing and replacing any soft material which exhibits permanent subgrade deformation exceeding 0.5 inch when traversed by a loaded truck with a rear axle load of approximately 17,000 lbs./axle.
- Once the subgrade has been satisfactorily proofrolled, the surface layer of the subgrade shall be scarified to a depth of 6 inches, then moisture condition the soil to within -2 to +2 percentage points of its optimum moisture and compact the soil to at least 95 percent of the standard Proctor (AASHTO T99) maximum dry density.
- If the aggregate base option was select for the design support under the pavement. The pavement section for this project should be placed on at least 6 inches of properly compacted ODOT non-recycled Type A aggregate base material over properly compacted subgrade soils. Prior to placing the Type A aggregate, the exposed subgrade should be visually observed and, depending on the condition of the subgrade, proofrolled. Unsuitable areas observed should be improved by compaction or by undercutting and placement of suitable compacted fill. Any imported fill material should be approved by Standard Testing prior to use. During this time, the moisture content of the exposed grade should be evaluated in all construction areas. Where moisture contents are outside the range recommended for controlled fill, the exposed grade should be scarified to a minimum depth of 6 inches, moisture conditioned to one percent below optimum to three percent above optimum, and recompacted to at least 95 percent of the material's maximum dry density as determined by AASHTO T99. The subgrade soils and aggregate base should be separated by a synthetic fabric separator such as US Fabrics US200 or equivalent in order to prevent the aggregate base from penetrating into the subgrade under traffic loads and to reduce the potential of rutting.
- We recommend that the prepared subgrade extend a minimum of 2-feet outside the pavements, where feasible. Standard Testing should be present during subgrade preparation to observe, document, and test compaction of the materials at the time of placement. Heavy, repetitive construction traffic should be controlled, especially during periods of wet weather, to minimize disturbance. Proofrolling operations should be observed and documented by Standard Testing.

- Any Inert fill materials should be placed in loose lifts of 8 inches or less. The soil should be compacted using equipment that is the appropriate type and properly sized for the job. Within small excavations, such as in utility trenches, or around manholes, vibrating plate compactors, walk behind rollers or jumping jacks can be used to achieve the specified compaction. Lift thicknesses should be reduced to 4 inches in small fill areas requiring small compaction equipment.

Inert Fill Requirements

Amount finer than 2-inch sieve	100%
Amount finer than No. 200 sieve	12% minimum and, if $PI \leq 7$, 60% maximum
Liquid Limit	40 maximum
Plasticity Index (PI)	Between 5 to 17

Pavement Sections

We estimate the CBR value of the near surface soils as 3.0 based on the paving cores. This would correspond to a modulus of subgrade reaction, k_s , of 70 pci, and a resilient modulus, M_r , of 4,000 psi.

Pavement sections were evaluated based on the AASHTO 1993 guidelines with the following assumptions. If traffic loads are different than used in the analysis, Standard Testing must be notified in order to reevaluate the recommendations.

- Design Period = 20 years
- Reliability Level = 85% (flexible and rigid)
- Initial Serviceability Index = 4.5 (flexible and rigid)
- Terminal Serviceability Index = 2.0 (flexible and rigid)
- Combined Standard Error (S_0) = 0.5 (flexible) and 0.4 (rigid)
- N Trenton etc. Section Full Depth ESAL Estimate: 500,000
- E Admiral Section Full Depth ESAL Estimate: 50,000

We recommend that the following pavement sections be used:

Table 5: New Pavement Sections (E Admiral Place)

Pavement Type	Thickness (inches)
<u>Flexible Pavement</u>	
Surface Course (S4)	2.0
Base Course (S3)	4.5
Aggregate Base (ODOT Type A)	6.0
Separator Fabric	-
<u>OR</u>	
Lime Stabilized Subgrade	8.0

*A full mix design will be required to estimate the amount of Lime required in the treated subgrade mixture.
 **If lime stabilization is selected, Standard Testing & Engineering must be retained to perform additional laboratory testing to determine if lime stabilization is compatible with subgrade soils due to the moderate levels of soluble sulfate content in the soil samples.

Table 6: New Pavement Sections (N Trenton Ave, N Quincy Ave, and N Rockford Ave)

Pavement Type	Thickness (inches)
<u>Flexible Pavement</u>	
Surface Course (S4)	2.0
Binder Course (S3)	2.5
Base Course (S3)	3.0
Aggregate Base (ODOT Type A)	6.0
Separator Fabric	-
<u>OR</u>	
Lime Stabilized Subgrade	8.0
<u>Rigid Pavement</u>	
Portland Cement Concrete	7.5
Aggregate Base (ODOT Type A)	6.0
Separator Fabric	-
<u>OR</u>	
Lime Stabilized Subgrade	8.0

*A full mix design will be required to estimate the amount of Lime required in the treated subgrade mixture.
 **If lime stabilization is selected, Standard Testing & Engineering must be retained to perform additional laboratory testing to determine if lime stabilization is compatible with subgrade soils due to the moderate levels of soluble sulfate content in the soil samples.

Pavement Sections were designed with City of Tulsa Standard thicknesses for Residential and Collector Streets as minimum thickness values.

Pavement Mill and Overlay

The existing pavement for the project sections are **NOT** good candidates for a mill and overlay. The poor subgrade conditions, the poor state of the existing pavement, and the variability in pavement structure and overall thickness all contribute to poor state of the roadway. Where milling and overlay would be possible, cracks may return and propagate through the new pavement a short time after construction.

Materials and Construction

All materials and construction for base should be in accordance with the Oklahoma Department of Transportation (ODOT), "2009 Standard Specifications for Highway Construction," and the latest Special Provisions adopted by ODOT to supplement the Standard Specifications. ODOT Type "A" aggregate base should be compacted to not less than 95 percent modified Proctor maximum dry density (ASTM D1557). Stabilized or compacted subgrade should be compacted to not less than 95% of the standard Proctor maximum dry density (AASHTO T99) within -2 to +2 percentage points of the corresponding optimum moisture content stabilized or compacted subgrade should extend the full width of the pavement section (i.e., including curb and gutter).

Concrete for paving should have a modulus of rupture, M_r , of at least 550 psi (compressive strength of approximately 3,500 psi or more), should be air entrained with 4 to 7 percent air, should have a cementitious materials content of at least 564 pcy, and should have a maximum water to cementitious materials ratio of 0.45. The concrete mix design submittal should adequately address the criteria of ACI 301, section 4, including documentation of strength test results. Control joints should be saw cut at least one-eighth (0.125) inch wide and one-quarter of pavement thickness deep as soon as possible after concrete reaches final set (i.e., approximately 8 to 12 hours after placing the concrete), cleaned by high pressure air jet, and sealed with a suitable pavement joint sealing material to prevent intrusion of surface water into the pavement base. Control joints should be spaced as indicated in the following table:

Table 7: Recommended Transverse Joint Spacings

Concrete Thickness (inches)	Maximum Joint Spacing (feet)
7.5	15.0

Section 5**BASIS FOR RECCOMENDATIONS****5.1 General Comments**

The recommendations and conclusions contained in this report are based on the cores drilled and tests performed. We would point out that there may be variations in material properties over the site and would caution that there may be unknown conditions in existence which differ seriously from those encountered by the test cores. Such conditions, if indeed they exist at all, cannot be, and have not been, accounted for in this report. Therefore, the descriptions, recommendations, and conclusions contained herein should be considered as generalized, applying only to the immediate vicinity of the cores.

5.2 Limitations

Since this report is being prepared in advance of much of the detailed design, the finalized soil and structure parameters (i.e., floor elevation, structural system and loading, vertical movement tolerance, etc.) may differ from the ones considered during the preparation of this report. If such a design variance is substantial, Standard Testing would request the opportunity to review the plans and specifications of the proposed facility for applicability to the soil conditions in this report, and assurance of consistency with its intent.

It is recommended that Standard Testing be retained for testing and observation during earthwork and foundation construction phases, to help determine that the design requirements are fulfilled.

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 practice.

APPENDIX A

Vicinity Map
Site and Coring Location Plan



**Approximate
Site Location**

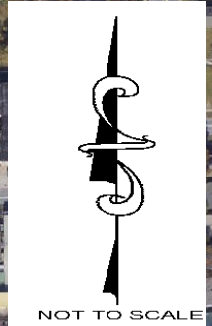
Vicinity Map

Project Name: City of Tulsa Maintenance Zone Exploration
 Project Location: Tulsa, OK
 Project No.: 2030-0834



LEGEND:

 **Approximate Boring Location**



Site and Boring Location Plan

Project Name: City of Tulsa Maintenance Zone Exploration
Project Location: Tulsa, OK
Project No.: 2030-0834



APPENDIX B

Core Logs

Definition of Descriptive Terms

Project Name:	City of Tulsa Maintenance Zone Exploration	GPS Location:	
City / Town:	Tulsa, Oklahoma	Latitude:	36 9.634'N
County:	Tulsa	Longitude:	95 58.081'W
Job Location:	E Admiral Place	Station Number:	
Core Number:	C-1	Lane Direction:	Westbound



CORE LAYER DATA (FROM TOP TO BOTTOM)

Layer	Layer Type	Thickness (in)	Layer Characteristics and Notes
1	Asphaltic Concrete	1.25	Small to Medium Aggregates, 1/2" Max Size Small Pores
2	Hot Sand	1.5	Separation at 2.5"
3	Portland Cement Concrete	4	Medium to Large Aggregates, 1" Max Size Bottom Up Crack up to 2.5", Disintegration at 4.5"

TOTAL CORE THICKNESS (in) 6.75

CORE DATA

Surface Material Type:	A.C.	<input checked="" type="checkbox"/>	P.C.C.	<input checked="" type="checkbox"/>	C.R.C.	<input type="checkbox"/>
Stripping or Separation in Asphalt:	Stripping	<input type="checkbox"/>	Separation	<input checked="" type="checkbox"/>	N/A	<input type="checkbox"/>
Honeycomb or "D" Cracking in PCC:	Honeycomb	<input type="checkbox"/>	"D" Cracking	<input type="checkbox"/>	N/A	<input type="checkbox"/>
Stabilized Subgrade Under Pavement:	Yes	<input type="checkbox"/>	No	<input checked="" type="checkbox"/>	Unknown	<input type="checkbox"/>
Reinforcing Fabric Present:	Yes	<input type="checkbox"/>	No	<input checked="" type="checkbox"/>		<input type="checkbox"/>

SUBGRADE INFORMATION *DCP results attached in appendix E

Layer	Layer Type	Depth (in)	LL, PL, PI	P#200 Sieve	AASHTO	USCS
4	Lean Clay W/ Silt	6.75-30.75	48,18,30	96.1%	A-7-6(31)	CL
5	Lean Clay	30.75-67.5				

WATER LEVEL OBSERVATIONS

	While Drilling	After Drilling
	None	None

Project Name:	City of Tulsa Maintenance Zone Exploration	GPS Location:	
City / Town:	Tulsa, Oklahoma	Latitude:	36 9.633'N
County:	Tulsa	Longitude:	95 58.185'W
Job Location:	E Admiral Place	Station Number:	
Core Number:	C-2	Lane Direction:	Eastbound



CORE LAYER DATA (FROM TOP TO BOTTOM)

Layer	Layer Type	Thickness (in)	Layer Characteristics and Notes
1	Asphaltic Concrete	2	Small to Medium Aggregates, 3/8" Max Size Small Pores, Top Down Crack Forming, Separation at 2"
2	Hot Sand	1.5	

TOTAL CORE THICKNESS (in) 3.5

CORE DATA

Surface Material Type:	A.C.	<input checked="" type="checkbox"/>	P.C.C.	<input type="checkbox"/>	C.R.C.	<input type="checkbox"/>
Stripping or Separation in Asphalt:	Stripping	<input type="checkbox"/>	Separation	<input checked="" type="checkbox"/>	N/A	<input type="checkbox"/>
Honeycomb or "D" Cracking in PCC:	Honeycomb	<input type="checkbox"/>	"D" Cracking	<input type="checkbox"/>	N/A	<input checked="" type="checkbox"/>
Stabilized Subgrade Under Pavement:	Yes	<input type="checkbox"/>	No	<input checked="" type="checkbox"/>	Unknown	<input type="checkbox"/>
Reinforcing Fabric Present:	Yes	<input type="checkbox"/>	No	<input checked="" type="checkbox"/>		

SUBGRADE INFORMATION *DCP results attached in appendix E

Layer	Layer Type	Depth (in)	LL, PL, PI	P#200 Sieve	AASHTO	USCS
3	Aggregate Base	3.5-7.5				
4	Lean Clay W/ Sand	7.5-31.5	33,19,14	83.6%	A-6(11)	CL

WATER LEVEL OBSERVATIONS

While Drilling	After Drilling
None	None

Project Name: City of Tulsa Maintenance Zone Exploration
City / Town: Tulsa, Oklahoma
County: Tulsa
Job Location: E Admiral Place
Core Number: C-3

GPS Location:
Latitude: 36 9.636'N
Longitude: 95 58.287'W
Station Number:
Lane Direction: Westbound



CORE LAYER DATA (FROM TOP TO BOTTOM)

Layer	Layer Type	Thickness (in)	Layer Characteristics and Notes
1	Asphaltic Concrete	2.5	Small to Medium Aggregates, 3/8" Max Size Small Pores
2	Hot Sand	1.5	

TOTAL CORE THICKNESS (in) 4

CORE DATA

Surface Material Type:	A.C.	<input checked="" type="checkbox"/>	P.C.C.	<input type="checkbox"/>	C.R.C.	<input type="checkbox"/>
Stripping or Separation in Asphalt:	Stripping	<input type="checkbox"/>	Separation	<input type="checkbox"/>	N/A	<input type="checkbox"/>
Honeycomb or "D" Cracking in PCC:	Honeycomb	<input type="checkbox"/>	"D" Cracking	<input type="checkbox"/>	N/A	<input checked="" type="checkbox"/>
Stabilized Subgrade Under Pavement:	Yes	<input type="checkbox"/>	No	<input checked="" type="checkbox"/>	Unknown	<input type="checkbox"/>
Reinforcing Fabric Present:	Yes	<input type="checkbox"/>	No	<input type="checkbox"/>		

SUBGRADE INFORMATION *DCP results attached in appendix E

Layer	Layer Type	Depth (in)	LL, PL, PI	P#200 Sieve	AASHTO	USCS
3	Aggregate Base	4-8				
4	Lean Clay	8-32.0	39,17,22	93.7%	A-6(21)	CL

WATER LEVEL OBSERVATIONS

While Drilling	After Drilling
None	None

Project Name:	City of Tulsa Maintenance Zone Exploration	GPS Location:	
City / Town:	Tulsa, Oklahoma	Latitude:	36 9.635'N
County:	Tulsa	Longitude:	95 58.398'W
Job Location:	E Admiral Place	Station Number:	
Core Number:	C-4	Lane Direction:	Eastbound



CORE LAYER DATA (FROM TOP TO BOTTOM)

Layer	Layer Type	Thickness (in)	Layer Characteristics and Notes
1	Asphaltic Concrete	2	Small to Medium Aggregates, 3/8" Max Size Small Pores
2	Asphaltic Concrete	0.75	Small Aggregates, <1/4" Max Size
3	Hot Sand	0.75	Separation at 3.75"
4	Portland Cement Concrete	2	Medium to Large Aggregates, 1.5" Max Size

TOTAL CORE THICKNESS (in) 5.5

CORE DATA

Surface Material Type:	A.C.	<input checked="" type="checkbox"/>	P.C.C.	<input checked="" type="checkbox"/>	C.R.C.	<input type="checkbox"/>
Stripping or Separation in Asphalt:	Stripping	<input type="checkbox"/>	Separation	<input checked="" type="checkbox"/>	N/A	<input type="checkbox"/>
Honeycomb or "D" Cracking in PCC:	Honeycomb	<input type="checkbox"/>	"D" Cracking	<input type="checkbox"/>	N/A	<input type="checkbox"/>
Stabilized Subgrade Under Pavement:	Yes	<input type="checkbox"/>	No	<input checked="" type="checkbox"/>	Unknown	<input type="checkbox"/>
Reinforcing Fabric Present:	Yes	<input type="checkbox"/>	No	<input checked="" type="checkbox"/>		<input type="checkbox"/>

SUBGRADE INFORMATION *DCP results attached in appendix E

Layer	Layer Type	Depth (in)	LL, PL, PI	P#200 Sieve	AASHTO	USCS
5	Aggregate Base	5.5-8.5				
6	Lean Clay	8.5-32.5				

WATER LEVEL OBSERVATIONS

While Drilling	After Drilling
None	None

Project Name: City of Tulsa Maintenance Zone Exploration
 City / Town: Tulsa, Oklahoma
 County: Tulsa
 Job Location: N Quincy Ave
 Core Number: C-5

GPS Location:
 Latitude: **36 9.592' N**
 Longitude: **95 58.418' W**
 Station Number:
 Lane Direction: Northbound



CORE LAYER DATA (FROM TOP TO BOTTOM)

Layer	Layer Type	Thickness (in)	Layer Characteristics and Notes
1	Asphaltic Concrete	2.25	Small to Medium Aggregates, 1/2" Max Size Small Pores, Cracking through core
2	Asphaltic Concrete	1	Small Aggregates, <1/4" Max Size

TOTAL CORE THICKNESS (in) 3.25

CORE DATA

Surface Material Type:	A.C.	<input checked="" type="checkbox"/>	P.C.C.	<input type="checkbox"/>	C.R.C.	<input type="checkbox"/>
Stripping or Separation in Asphalt:	Stripping	<input type="checkbox"/>	Separation	<input type="checkbox"/>	N/A	<input type="checkbox"/>
Honeycomb or "D" Cracking in PCC:	Honeycomb	<input type="checkbox"/>	"D" Cracking	<input type="checkbox"/>	N/A	<input checked="" type="checkbox"/>
Stabilized Subgrade Under Pavement:	Yes	<input type="checkbox"/>	No	<input checked="" type="checkbox"/>	Unknown	<input type="checkbox"/>
Reinforcing Fabric Present:	Yes	<input type="checkbox"/>	No	<input checked="" type="checkbox"/>		

SUBGRADE INFORMATION *DCP results attached in appendix E

Layer	Layer Type	Depth (in)	LL, PL, PI	P#200 Sieve	AASHTO	USCS
3	Aggregate Base	3.25-7.25				
4	Clay					

WATER LEVEL OBSERVATIONS

While Drilling: None
 After Drilling: None

Project Name:	City of Tulsa Maintenance Zone Exploration	GPS Location:	
City / Town:	Tulsa, Oklahoma	Latitude:	36 9.600'N
County:	Tulsa	Longitude:	95 58.163'W
Job Location:	N Trenton Ave	Station Number:	
Core Number:	C-6	Lane Direction:	Southbound



CORE LAYER DATA (FROM TOP TO BOTTOM)

Layer	Layer Type	Thickness (in)	Layer Characteristics and Notes
1	Asphaltic Concrete	1.75	Small to Medium Aggregates, 1/2" Max Size Very Small Pores to No Pores
2	Hot Sand	1.5	Separation at 3"
3	Portland Cement Concrete	3.25	Medium to Large Aggregates, 1" Max Size Cracking in Aggregates

TOTAL CORE THICKNESS (in) 6.5

CORE DATA

Surface Material Type:	A.C.	<input checked="" type="checkbox"/>	P.C.C.	<input checked="" type="checkbox"/>	C.R.C.	<input type="checkbox"/>
Stripping or Separation in Asphalt:	Stripping	<input type="checkbox"/>	Separation	<input checked="" type="checkbox"/>	N/A	<input type="checkbox"/>
Honeycomb or "D" Cracking in PCC:	Honeycomb	<input type="checkbox"/>	"D" Cracking	<input checked="" type="checkbox"/>	N/A	<input type="checkbox"/>
Stabilized Subgrade Under Pavement:	Yes	<input type="checkbox"/>	No	<input checked="" type="checkbox"/>	Unknown	<input type="checkbox"/>
Reinforcing Fabric Present:	Yes	<input type="checkbox"/>	No	<input checked="" type="checkbox"/>		

SUBGRADE INFORMATION *DCP results attached in appendix E

Layer	Layer Type	Depth (in)	LL, PL, PI	P#200 Sieve	AASHTO	USCS
4	Aggregate Base	6.5-8.5				
5	Fat Clay W/ Sand	8.5-68.5	57,17,40	81.4%	A-7-6(33)	CH

WATER LEVEL OBSERVATIONS

While Drilling	After Drilling
None	None

Project Name:	City of Tulsa Maintenance Zone Exploration	GPS Location:	
City / Town:	Tulsa, Oklahoma	Latitude:	36 9.687'N
County:	Tulsa	Longitude:	95 58.160'W
Job Location:	N Trenton Ave	Station Number:	
Core Number:	C-7	Lane Direction:	Northbound



CORE LAYER DATA (FROM TOP TO BOTTOM)

Layer	Layer Type	Thickness (in)	Layer Characteristics and Notes
1	Portland Cement Concrete	7.5	Medium to Large Aggregates, 0.75" Max Size Slightly Porous, Separation at 7.5"

TOTAL CORE THICKNESS (in) 7.5

CORE DATA

Surface Material Type:	A.C.	<input type="checkbox"/>	P.C.C.	<input checked="" type="checkbox"/>	C.R.C.	<input type="checkbox"/>
Stripping or Separation in Asphalt:	Stripping	<input type="checkbox"/>	Separation	<input type="checkbox"/>	N/A	<input checked="" type="checkbox"/>
Honeycomb or "D" Cracking in PCC:	Honeycomb	<input type="checkbox"/>	"D" Cracking	<input type="checkbox"/>	N/A	<input type="checkbox"/>
Stabilized Subgrade Under Pavement:	Yes	<input type="checkbox"/>	No	<input type="checkbox"/>	Unknown	<input checked="" type="checkbox"/>
Reinforcing Fabric Present:	Yes	<input type="checkbox"/>	No	<input checked="" type="checkbox"/>		

SUBGRADE INFORMATION *DCP results attached in appendix E

Layer	Layer Type	Depth (in)	LL, PL, PI	P#200 Sieve	AASHTO	USCS
2	Lean Clay	7.5-67.5	48,17,30	92.3%	A-7-6(30)	CL

WATER LEVEL OBSERVATIONS

While Drilling	After Drilling
None	None

Project Name: City of Tulsa Maintenance Zone Exploration
 City / Town: Tulsa, Oklahoma
 County: Tulsa
 Job Location: N Trenton Ave
 Core Number: C-8

GPS Location:
 Latitude: 36 9.762'N
 Longitude: 95 58.165'W
 Station Number:
 Lane Direction: Southbound



CORE LAYER DATA (FROM TOP TO BOTTOM)

Layer	Layer Type	Thickness (in)	Layer Characteristics and Notes
1	Asphaltic Concrete	1.25	Small to Medium Aggregates, 1/2" Max Size Small Pores, Separation at 1.25", Cracking to 1.25"
2	Portland Cement Concrete	6.25	Medium to Very Large Aggregates, 2" Max Size Cracking in Aggregate

TOTAL CORE THICKNESS (in) 7.5

CORE DATA

Surface Material Type:	A.C.	<input checked="" type="checkbox"/>	P.C.C.	<input checked="" type="checkbox"/>	C.R.C.	<input type="checkbox"/>
Stripping or Separation in Asphalt:	Stripping	<input type="checkbox"/>	Separation	<input checked="" type="checkbox"/>	N/A	<input type="checkbox"/>
Honeycomb or "D" Cracking in PCC:	Honeycomb	<input type="checkbox"/>	"D" Cracking	<input type="checkbox"/>	N/A	<input type="checkbox"/>
Stabilized Subgrade Under Pavement:	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>	Unknown	<input type="checkbox"/>
Reinforcing Fabric Present:	Yes	<input type="checkbox"/>	No	<input checked="" type="checkbox"/>		

SUBGRADE INFORMATION *DCP results attached in appendix E

Layer	Layer Type	Depth (in)	LL, PL, PI	P#200 Sieve	AASHTO	USCS
3	Fat Clay W/ Sand	7.5-31.5				
4	Fat Clay	31.5-67.5	50,20,30	95.5%	A-7-6(31)	CH

WATER LEVEL OBSERVATIONS

While Drilling: None
 After Drilling: None

Project Name:	City of Tulsa Maintenance Zone Exploration	GPS Location:	
City / Town:	Tulsa, Oklahoma	Latitude:	36 9.805'N
County:	Tulsa	Longitude:	95 58.160'W
Job Location:	N Trenton Ave	Station Number:	
Core Number:	C-9	Lane Direction:	Northbound



CORE LAYER DATA (FROM TOP TO BOTTOM)

Layer	Layer Type	Thickness (in)	Layer Characteristics and Notes
1	Asphaltic Concrete	0.5	Small Aggregates, 1/4" Max Size Small Pores
2	Portland Cement Concrete	6.5	Medium to Very Large Aggregates, 2" Max Size

TOTAL CORE THICKNESS (in) 7

CORE DATA

Surface Material Type:	A.C.	<input checked="" type="checkbox"/>	P.C.C.	<input checked="" type="checkbox"/>	C.R.C.	<input type="checkbox"/>
Stripping or Separation in Asphalt:	Stripping	<input type="checkbox"/>	Separation	<input type="checkbox"/>	N/A	<input type="checkbox"/>
Honeycomb or "D" Cracking in PCC:	Honeycomb	<input type="checkbox"/>	"D" Cracking	<input type="checkbox"/>	N/A	<input type="checkbox"/>
Stabilized Subgrade Under Pavement:	Yes	<input type="checkbox"/>	No	<input checked="" type="checkbox"/>	Unknown	<input type="checkbox"/>
Reinforcing Fabric Present:	Yes	<input type="checkbox"/>	No	<input checked="" type="checkbox"/>		

SUBGRADE INFORMATION *DCP results attached in appendix E

Layer	Layer Type	Depth (in)	LL, PL, PI	P#200 Sieve	AASHTO	USCS
3	Lean Clay w/ Silt	4-28				
4	Lean Clay	28-64	37,17,20	89.3%	A-6(17)	CL

WATER LEVEL OBSERVATIONS

While Drilling	After Drilling
None	None

Project Name:	City of Tulsa Maintenance Zone Exploration	GPS Location:	
City / Town:	Tulsa, Oklahoma	Latitude:	36 9.592'N
County:	Tulsa	Longitude:	95 58.293'W
Job Location:	N Rockford Ave	Station Number:	
Core Number:	C-10	Lane Direction:	Southbound



CORE LAYER DATA (FROM TOP TO BOTTOM)

Layer	Layer Type	Thickness (in)	Layer Characteristics and Notes
1	Asphaltic Concrete	1	Small to Medium Aggregates, 3/8" Max Size Small Pores
2	Asphaltic Concrete	1	Small Aggregates, <1/4" Max Size Separation at 2"
3	Asphaltic Concrete	1.5	Small to Medium Aggregates, 3/8" Max Size Erosion of layer at 2"
4	Portland Cement Concrete	4	Medium to Large Aggregates, 1.5" Max Size

TOTAL CORE THICKNESS (in) 7.5

CORE DATA

Surface Material Type:	A.C.	<input checked="" type="checkbox"/>	P.C.C.	<input checked="" type="checkbox"/>	C.R.C.	<input type="checkbox"/>
Stripping or Separation in Asphalt:	Stripping	<input type="checkbox"/>	Separation	<input checked="" type="checkbox"/>	N/A	<input type="checkbox"/>
Honeycomb or "D" Cracking in PCC:	Honeycomb	<input type="checkbox"/>	"D" Cracking	<input type="checkbox"/>	N/A	<input checked="" type="checkbox"/>
Stabilized Subgrade Under Pavement:	Yes	<input type="checkbox"/>	No	<input checked="" type="checkbox"/>	Unknown	<input type="checkbox"/>
Reinforcing Fabric Present:	Yes	<input type="checkbox"/>	No	<input checked="" type="checkbox"/>		

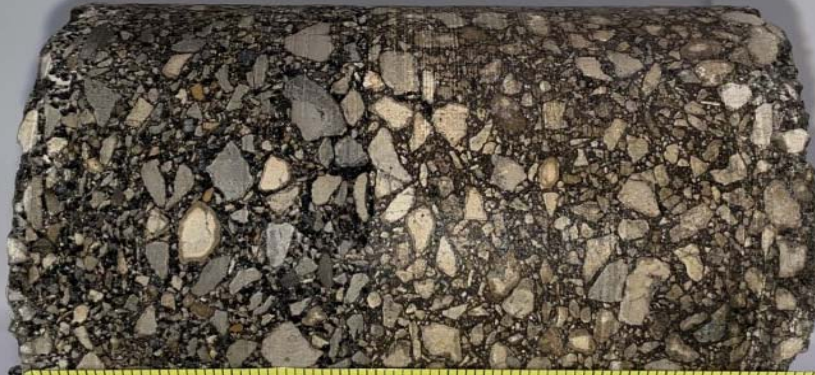
SUBGRADE INFORMATION *DCP results attached in appendix E

Layer	Layer Type	Depth (in)	LL, PL, PI	P#200 Sieve	AASHTO	USCS
5	Aggregate Base	7.5-10.5				
6	Lean Clay w/ Sand	10.5-34.5	42,16,26	86.1%	A-7-6(22)	CL

WATER LEVEL OBSERVATIONS

While Drilling	After Drilling
None	None

Project Name:	City of Tulsa Maintenance Zone Exploration	GPS Location:	
City / Town:	Tulsa, Oklahoma	Latitude:	36 9.657'N
County:	Tulsa	Longitude:	95 58.421'W
Job Location:	N Quincy Ave	Station Number:	
Core Number:	C-11	Lane Direction:	Southbound



CORE LAYER DATA (FROM TOP TO BOTTOM)

Layer	Layer Type	Thickness (in)	Layer Characteristics and Notes
1	Asphaltic Concrete	2.5	Medium to Small Aggregates, 1/2" Max Size Small Pores
2	Asphaltic Concrete	3	Medium to Small Aggregates, 1/4" Max Size No Pores, Separation at 5.5"

TOTAL CORE THICKNESS (in) 5.5

CORE DATA

Surface Material Type:	A.C.	<input checked="" type="checkbox"/>	P.C.C.	<input type="checkbox"/>	C.R.C.	<input type="checkbox"/>
Stripping or Separation in Asphalt:	Stripping	<input type="checkbox"/>	Separation	<input type="checkbox"/>	N/A	<input type="checkbox"/>
Honeycomb or "D" Cracking in PCC:	Honeycomb	<input type="checkbox"/>	"D" Cracking	<input type="checkbox"/>	N/A	<input checked="" type="checkbox"/>
Stabilized Subgrade Under Pavement:	Yes	<input type="checkbox"/>	No	<input checked="" type="checkbox"/>	Unknown	<input type="checkbox"/>
Reinforcing Fabric Present:	Yes	<input type="checkbox"/>	No	<input checked="" type="checkbox"/>		

SUBGRADE INFORMATION *DCP results attached in appendix E

Layer	Layer Type	Depth (in)	LL, PL, PI	P#200 Sieve	AASHTO	USCS
3	Lean Clay w/ Sand	5.5-18				
4	Lean Clay w/ Silt	18-36	37,17,20	91.4%	A-6(18)	CL

WATER LEVEL OBSERVATIONS

While Drilling	After Drilling
None	None

DEFINITION OF DESCRIPTIVE TERMS

Consistency of Cohesive Soils (at moisture content near plastic limit):

- Very Soft - Easily penetrated 4" to 6" by fist; tall core will sag under its own weight.
- Soft - Easily molded by fingers.
- Firm - Can be penetrated 2" to 3" by thumb with moderate effort, imprinted with fingers.
- Stiff - Readily indented by thumb but penetrated only with great effort.
- Very Stiff - Readily indented by thumbnail, imprinted very slightly with pressure from fingers.
- Hard - Indented with difficulty by thumbnail, cannot be imprinted with fingers.

Density of Cohesionless Soils:

- Very Loose - less than 4 SPT "N" value corrected for overburden.
- Loose - 5 to 10 SPT "N" value corrected for overburden.
- Medium Dense - 11 to 30 SPT "N" value corrected for overburden.
- Dense - 31 to 50 SPT "N" value corrected for overburden.
- Very Dense - 51 to 50/6" SPT "N" value corrected for overburden.
- Hard - less than 6" penetration in 50 SPT "N" blows corrected for overburden (cemented).

Hardness of Rock:

- Very Soft - can be scratched readily by fingernail
- Soft - can be grooved readily by knife or pick
- Medium - can be grooved 0.05" deep by firm pressure of knife
- Moderately Hard - can be scratched by knife
- Hard - can be scratched by knife or pick only with difficulty
- Very Hard - cannot be scratched by knife or sharp pick

Other Terms Descriptive of Consistency:

- Brittle - Ruptures with little deformation
- Friable - Crumbles or pulverizes easily.
- Elastic - Returns to original length after small deformation.
- Spongy - Is very porous, loose and elastic.
- Sticky - Adheres or sticks to tools or hands.

In-Situ Moisture Descriptions:

- Dry - powdery
- Slightly Moist - water not readily absorbed by paper
- Moist - water readily absorbed by paper
- Very Moist - water condenses on sample tray
- Wet - water drips from sample

Degree of Plasticity When Moist to Very Moist:

- Nonplastic - cannot be rolled into a ball
- Trace of Plasticity - can be rolled into a ball but not into a 1/8" thread
- Low Plasticity - barely holds its shape when rolled into a 1/8" thread
- Fairly Low Plasticity - 1/8" thread quickly ruptures when bent
- Medium Plasticity - 1/8" thread withstands considerable deformation without rupture.
- Fairly High Plasticity - difficult to rupture a 1/8" thread by bending.
- High Plasticity - can be kneaded without rupture; greasy texture.

Abbreviations:

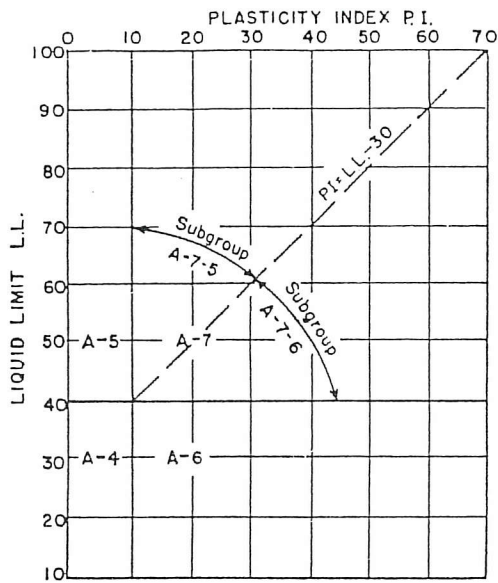
- | | | |
|----------------|---------------|--------------|
| V. - Very | Dk. - Dark | Blk. - Black |
| Tr. - Trace | Lt. - Light | Brn. - Brown |
| Fl. - Fairly | Med. - Medium | |
| Sl. - Slightly | | |

APPENDIX C

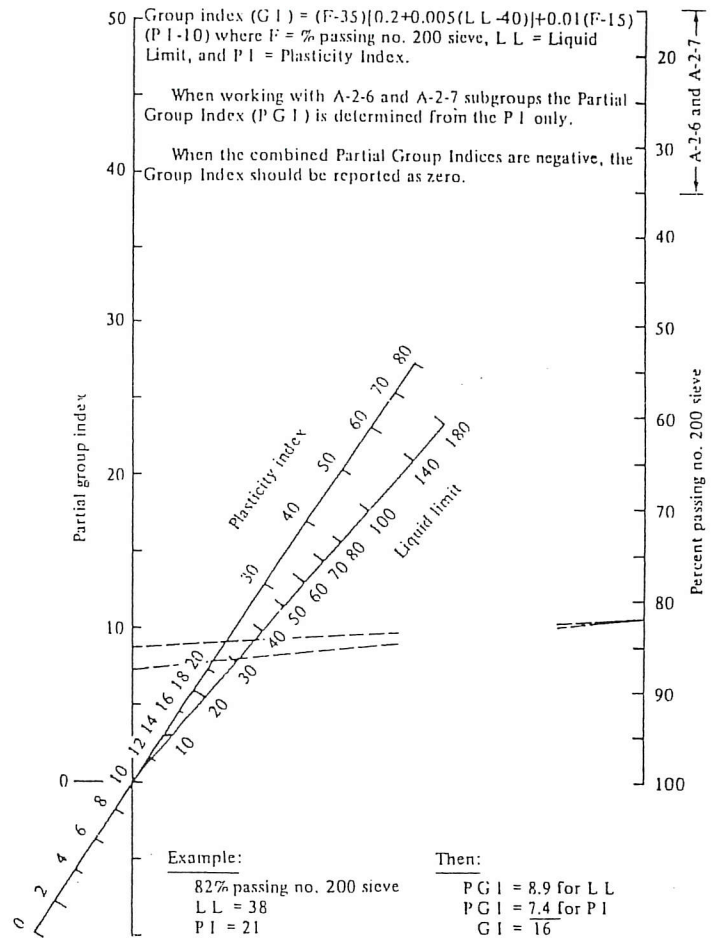
AASHTO Soil Classification System
Unified Soil Classification System

Soil Classification System — American Association of State Highway and Transportation Officials

The tables and charts given below are from AASHTO Designation: M 145-83, The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes. More detailed information as to the background and application of the system may be obtained from the report.



Liquid-limit and plasticity-index ranges for the A-4, A-5, A-6 and A-7 subgrade groups.



Group index chart

Classification of Soils and Soil-Aggregate Mixtures (with Suggested Subgroups)

General classification	Granular materials (35 per cent or less passing No. 200)						Silt-clay materials (More than 35 per cent passing No. 200)				
	A-1		A-3	A-2			A-4	A-5	A-6	A-7	
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7			A-7-5; A-7-6	
Sieve analysis: Per cent passing: No. 10 No. 40 No. 200	50 max. 30 max. 15 max.	— 50 max. 25 max.	— 51 min. 10 max.	— — 35 max.	— — 35 max.	— — 35 max.	— — 35 max.	— — 36 min.	— — 36 min.	— — 36 min.	— — 36 min.
Characteristics of fraction passing No. 40: Liquid limit Plasticity index	— 6 max.	— —	— NP	40 max. 10 max.	41 min. 10 max.	40 max. 11 min.	41 min. 11 min.	40 max. 10 max.	41 min. 10 max.	40 max. 11 min.	41 min. 11 min.*
Usual types of significant constituent materials	Stone fragments, gravel and sand		Fine sand	Silty or clayey gravel and sand			Silty soils	Clayey soils			
General rating as subgrade	Excellent to good						Fair to poor				

*P.I. of A-7-5 subgroup is equal to or less than L.L. minus 30. P.I. of A-7-6 subgroup is greater than L.L. minus 30

UNIFIED SOIL CLASSIFICATION (Including Identification and Description)								
Major Divisions		Group Symbols	Typical Names	Field Identification Procedures (Excluding particles larger than 3 inches and basing fractions on estimated weights)	Information Required for Describing Soils	Laboratory Classification Criteria		
1	2	3	4	5	6	7		
Coarse-grained Soils More than half of material is larger than No. 200 sieve size. The No. 200 sieve size is about the smallest particle visible to the naked eye.	Gravels More than half of coarse fraction is larger than No. 4 sieve size. (For visual classification, the 1/4-in size may be used as equivalent to the No. 4 sieve size)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics Give typical name; indicate approximate percentages of sand and gravel, maximum size, angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbol in parentheses. Example: Silty sand, gravelly; about 20% hard, angular gravel particles 1/2-in. maximum size; rounded and subangular sand grains coarse to fine; about 15% nonplastic fines with low dry strength, well compacted and moist in place; alluvial sand; (SM).	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 Not meeting all gradation requirements for GW Atterberg limits below "A" line or PI less than 4 Atterberg limits above "A" line or PI greater than 7 Above "A" Line with PI between 4 and 7 are <u>borderline</u> cases requiring use of dual symbols		
		GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.				
		GM	Silty gravels, gravel-sand-silt mixtures.	Nonplastic fines or fines with low plasticity (for identification procedures see ML below).				
		GC	Clayey gravels, gravel-sand-clay mixtures.	Plastic fines (for identification procedures see CL below).				
		SW	Well-graded sands, gravelly sands, little or no fines.	Wide range in grain size and substantial amounts of all intermediate particle sizes.				
		SP	Poorly-graded sands, gravelly sands, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.				
	Sands More than half of coarse fraction is smaller than No. 4 sieve size. (For visual classification, the 1/4-in size may be used as equivalent to the No. 4 sieve size)	Clean Sands (Little or no fines)	SM	Silty sands, sand-silt mixtures.	Nonplastic fines or fines with low plasticity (for identification procedures see ML below).	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 Not meeting all gradation requirements for SW Atterberg limits below "A" line or PI less than 4 Atterberg limits above "A" line or PI greater than 7 Limits plotting in hatched zone with PI between 4 and 7 are <u>borderline</u> cases requiring use of dual symbols		
			SC	Clayey sands, sand-clay mixtures.	Plastic fines (for identification procedures see CL below).			
		Sands with Fines (Appreciable amount of fines)						
Fine-grained Soils More than half of material is smaller than No. 200 sieve size. The No. 200 sieve size is about the smallest particle visible to the naked eye.	Sils and Clays Liquid limit less than 50	Identification Procedures On Fractions Smaller than No. 40 Sieve Sizes			Give typical name, indicate degree and character of plasticity, amount and maximum size of coarse grains, color in wet condition, odor if any, local or geologic name, and other pertinent descriptive information; and symbol in parentheses. For undisturbed soils add information on structure, stratification, consistency in undisturbed and remolded states, moisture and drainage conditions. Example: Clayey silt, brown, slightly plastic, small percentage of fine sand, numerous vertical root holes, firm and dry in place, loess, (ML).	Use grain-size curve in identifying the fractions as given under field identification Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse-grained soils are classified as follows: Less than 5% More than 12% 5% to 12%		
		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.	None to slight			Quick to slow	None
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	Medium to high			None to very slow	Medium
		OL	Organic silts and organic silty clays of low plasticity.	Slight to medium			Slow	Slight
		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	Slight to medium			Slow to none	Slight to Medium
		CH	Inorganic clays of high plasticity, fat clays.	High to very high			None	High
		OH	Organic clays of medium to high plasticity, organic silts.	Medium to high			None to very slow	Slight to medium
Highly Organic Soils	PI	Peat and other high organic soils.	Readily identified by color, odor, spongy feel and frequently by fibrous texture.					

Comparing Soils of Equal Liquid Limit Toughness and Dry Strength Index with Increasing Plasticity Index

PLASTICITY INDEX

LIQUID LIMIT PLASTICITY CHART

For laboratory classification of fine-grained soils

(1) **Boundary Classifications:** Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, well-graded gravel-sand mixture with clay binder. (2) All sieve sizes on this chart are U.S. Standard

FIELD IDENTIFICATION PROCEDURES FOR FINE-GRAINED SOILS OR FRACTIONS
 These procedures are to be performed on the minus No. 40 sieve size particles, approximately 1/64 in. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

Dilatancy (Reaction to shaking)
 After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky. Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat, which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and glass disappear from the surface, the pat stiffens, and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil. Very fine clean sands give the quickest and most distinct reactions whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour show a moderately quick reaction.

Dry Strength (Crushing Characteristics)
 After removing particles larger than No. 40 sieve size, mold a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun, or air drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity. High dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty, whereas a typical silt has the smooth feel of flour.

Toughness (Consistency near plastic limit)
 After removing particles larger than the No. 40 sieve size, a specimen of soil about one-half inch cube in size is molded to the consistency of putty. If too dry, water must be added and if sticky, specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eighth inch in diameter. The thread is then folded and rerolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached. After the thread crumbles, the pieces should be lumped together and slight kneading action continued until lump crumbles. The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line. Highly organic clays have a very weak and spongy feel at the plastic limit.

Adopted by Corps of Engineers and Bureau of Reclamation January 1952

APPENDIX D

Summary of Test Results



SUMMARY OF LABORATORY TEST RESULTS

Client: Cowan Group

Date: 1/28/2021

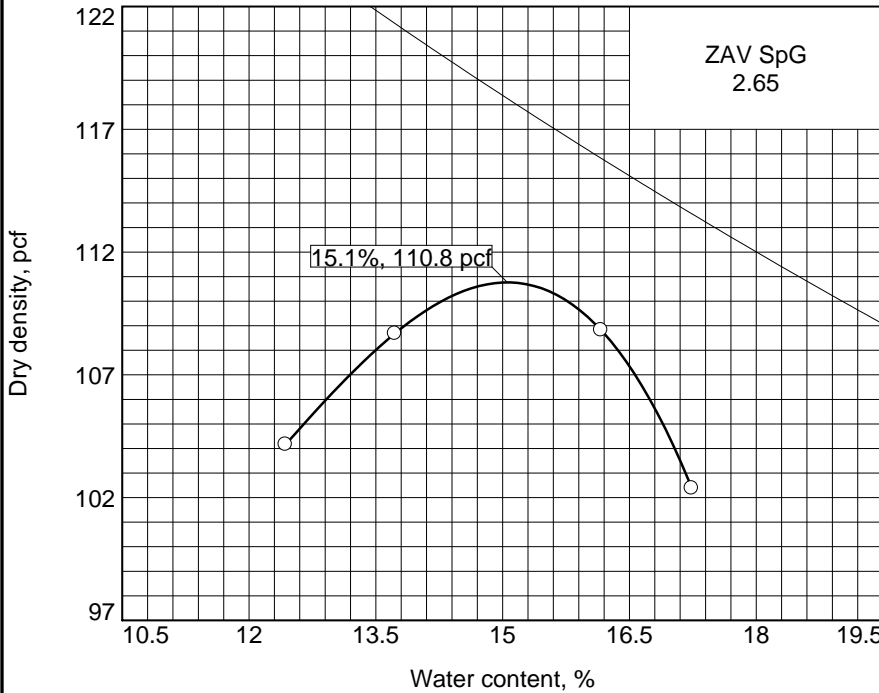
Project: City of Tulsa Maintenance Zone Project

Project No.: 2030-0834

Boring No.	Sample No.	Depth (ft)	Moisture Content (%)	Dry Density (pcf)	Atterberg Limits (% Moisture)			Sieve Analysis (% Passing)					Soil Classification		UCT	
					LL	PL	PI	#4	#10	#40	#100	#200	USCS	AASHTO	Stress (psf)	Strain (%)
C-1	A	0.0-2.0	21.2		48	18	30	100	100	99	98	96.1	CL	A-7-6(31)		
	B	2.0-5.0	21.0													
C-2	A	0.0-2.0	22.3		33	19	14	98	96	91	86	83.6	CL	A-6(11)		
	B	2.0-5.0	21.2													
C-3	A	0.0-2.0	21.1													
	B	2.0-5.0	21.7		39	17	22	100	99	99	97	93.7	CL	A-6(21)		
C-4	A	0.0-2.0	25.2													
	B	2.0-5.0	20.3		47	15	32	100	100	96	90	87.9	CL	A-7-6(29)		
C-5	A	0.0-2.0	25.1													
	B	2.0-5.0	22.9		33	21	12	98	95	91	87	83.6	CL	A-6(9)		
C-6	A	0.0-2.0	23.9													
	B	2.0-5.0	27.5		57	17	40	100	98	92	87	81.4	CH	A-7-6(33)		
C-7	A	0.0-2.0	27.1		48	17	31	100	99	98	97	92.3	CL	A-7-6(30)		
	B	2.0-5.0	24.1													
		5.0-6.5	22.4													
C-8	A	0.0-2.0	22.2													
	B	2.0-5.0	24.3		50	20	30	100	100	99	98	95.5	CH	A-7-6(31)		
C-9	A	0.0-2.0	19.6													
	B	2.0-5.0	21.0		37	17	20	100	100	99	94	89.3	CL	A-6(17)		

COMPACTION TEST REPORT

Curve No.



Test Specification:

ASTM D 698-12 Method A Standard

Hammer Wt.: 5.5 lb.

Hammer Drop: 12 in.

Number of Layers: three

Blows per Layer: 25

Mold Size: 0.03333 cu. ft.

Test Performed on Material

Passing #4 **Sieve**

Soil Data

NM 1.3 **Sp.G.** 2.65

LL 38 **PI** 21

%>#4 0.0 **%<#200** 78.5

USCS CL **AASHTO** A-6(15)

TESTING DATA

	1	2	3	4	5	6
WM + WS	5961.2	6059.3	6101.8	6005.4		
WM	4190.7	4190.7	4190.7	4190.7		
WW + T #1	496.1	473.0	506.8	510.8		
WD + T #1	448.6	424.1	445.6	446.9		
TARE #1	66.5	67.8	67.0	76.2		
WW + T #2						
WD + T #2						
TARE #2						
MOISTURE	12.4	13.7	16.2	17.2		
DRY DENSITY	104.2	108.7	108.8	102.4		

TEST RESULTS

Maximum dry density = 110.8 pcf

Optimum moisture = 15.1 %

Material Description

LEAN CLAY W/ SAND

Project No. 2030-0834 **Client:** Cowan Group

Project: City of Tulsa Maintenance Zone Project

Remarks:

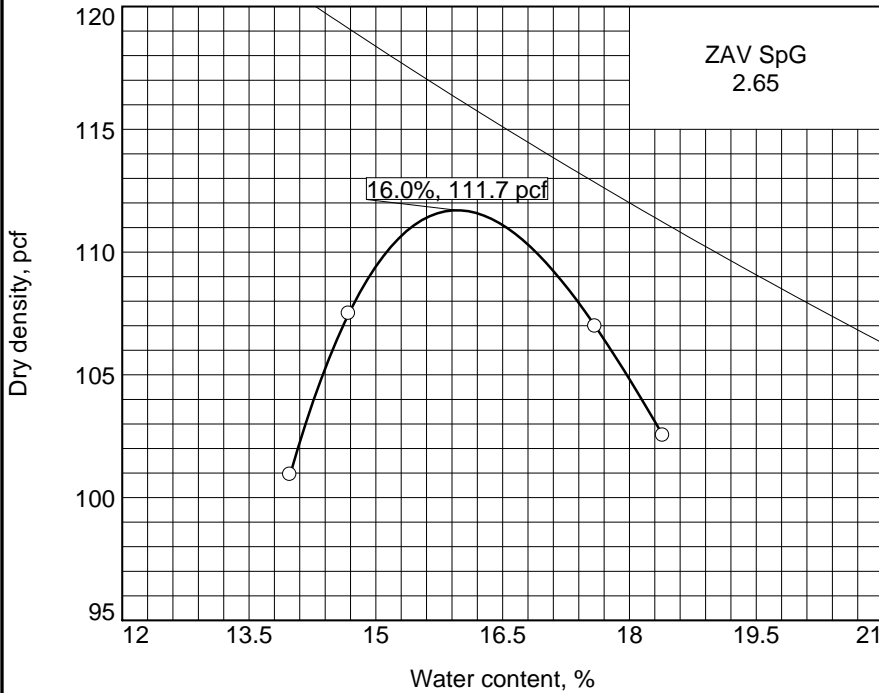
○ **Source of Sample:** Comp. 1 (C1,C2,C3,C4) **Depth:** 0.0-5.0



Figure

COMPACTION TEST REPORT

Curve No.



Test Specification:

ASTM D 698-12 Method A Standard

Hammer Wt.: 5.5 lb.

Hammer Drop: 12 in.

Number of Layers: three

Blows per Layer: 25

Mold Size: 0.03333 cu. ft.

Test Performed on Material

Passing #4 **Sieve**

Soil Data

NM 2.1 **Sp.G.** 2.65

LL 41 **PI** 24

%>#4 0.0 **%<#200** 90.9

USCS CL **AASHTO** A-7-6(22)

TESTING DATA

	1	2	3	4	5	6
WM + WS	5930.1	6054.4	6092.6	6025.9		
WM	4190.7	4190.7	4190.7	4190.7		
WW + T #1	436.1	536.2	553.1	547.1		
WD + T #1	392.1	476.2	480.2	474.1		
TARE #1	77.5	67.5	65.9	77.3		
WW + T #2						
WD + T #2						
TARE #2						
MOISTURE	14.0	14.7	17.6	18.4		
DRY DENSITY	100.9	107.5	107.0	102.5		

TEST RESULTS

Maximum dry density = 111.7 pcf

Optimum moisture = 16.0 %

Material Description

LEAN CLAY

Project No. 2030-0834 **Client:** Cowan Group

Project: City of Tulsa Maintenance Zone Project

Remarks:

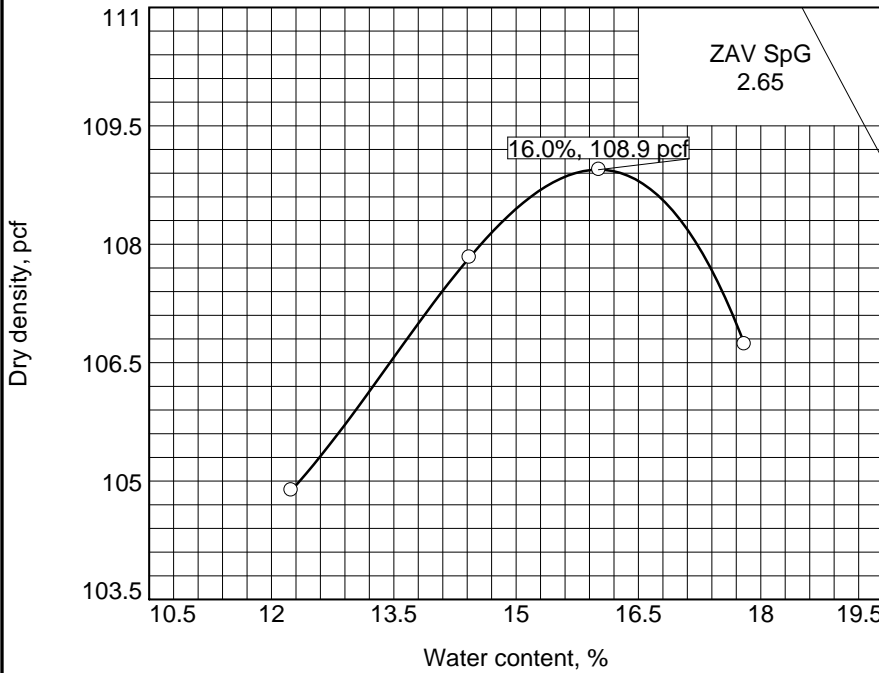
○ **Source of Sample:** Comp. 2 (C6,C7,C8,C9) **Depth:** 0.0-5.0



Figure

COMPACTION TEST REPORT

Curve No.



Test Specification:

ASTM D 698-12 Method A Standard

Hammer Wt.: 5.5 lb.

Hammer Drop: 12 in.

Number of Layers: three

Blows per Layer: 25

Mold Size: 0.03333 cu. ft.

Test Performed on Material

Passing #4 **Sieve**

Soil Data

NM 1.3 **Sp.G.** 2.65

LL 37 **PI** 21

%>#4 0.0 **%<#200** 87.2

USCS CL **AASHTO** A-6(18)

TESTING DATA

	1	2	3	4	5	6
WM + WS	6030.1	6115.8	6161.2	6151.2		
WM	4250.3	4250.3	4250.3	4250.3		
WW + T #1	341.9	406.5	400.1	356.2		
WD + T #1	311.9	364.9	354.3	312.5		
TARE #1	66.9	76.6	68.4	67.0		
WW + T #2						
WD + T #2						
TARE #2						
MOISTURE	12.2	14.4	16.0	17.8		
DRY DENSITY	104.9	107.8	108.9	106.7		

TEST RESULTS

Maximum dry density = 108.9 pcf

Optimum moisture = 16.0 %

Material Description

LEAN CLAY

Project No. 2030-0834 **Client:** Cowan Group

Project: City of Tulsa Maintenance Zone Project

Remarks:

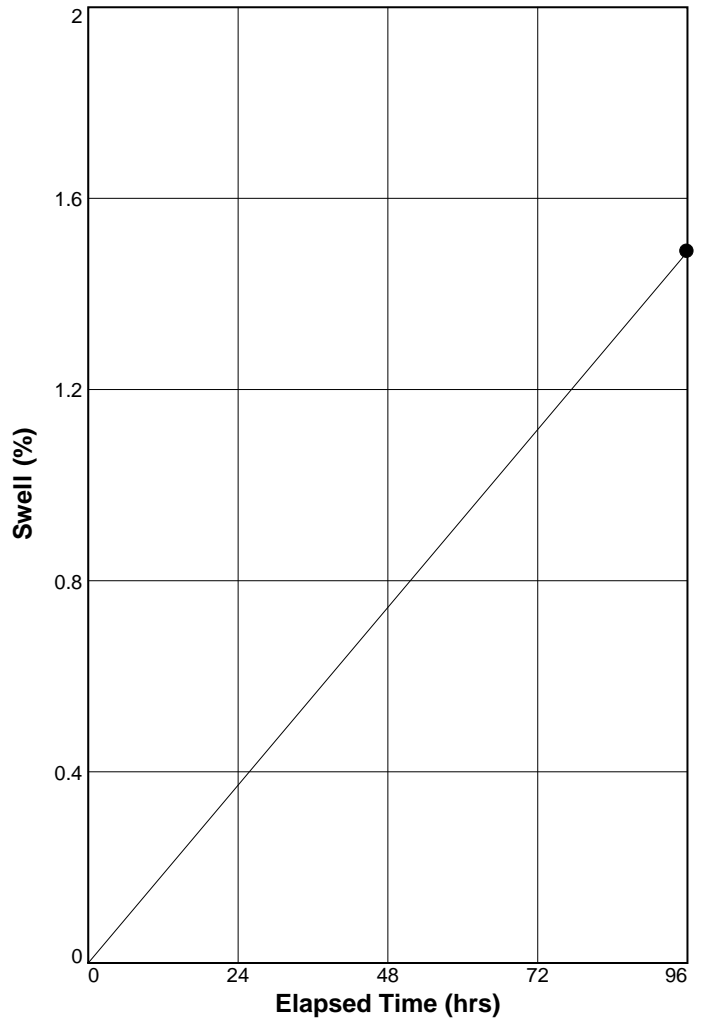
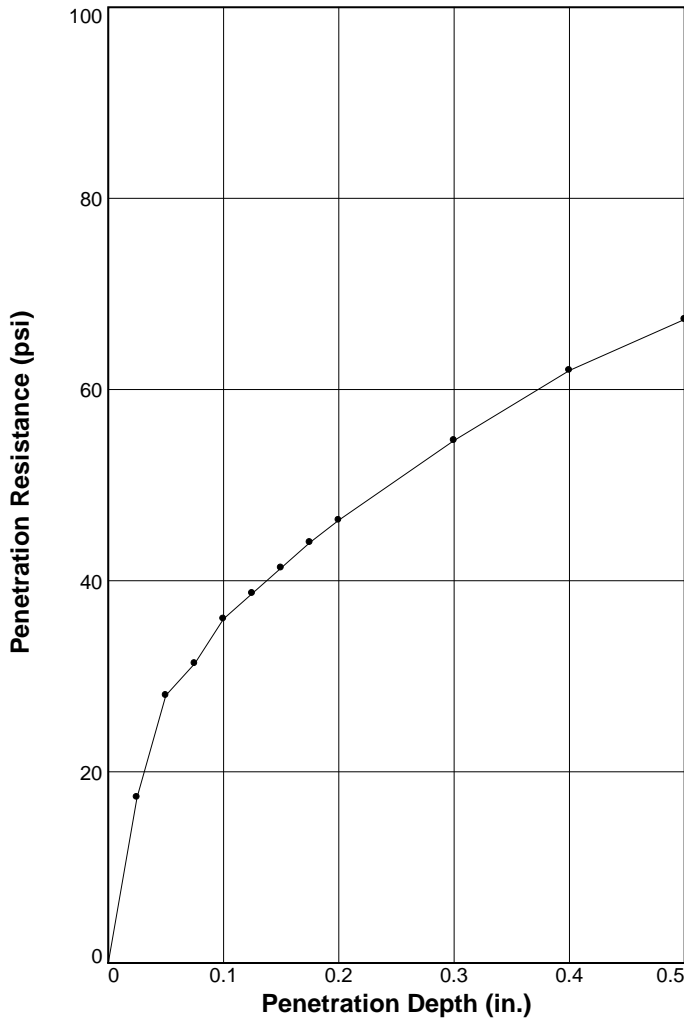
○ **Source of Sample:** Comp. 3 (C5,C10,C11) **Depth:** 0.0-5.0



Figure

BEARING RATIO TEST REPORT

ASTM D1883-14



	Molded			Soaked			CBR (%)		Linearity Correction (in.)	Surcharge (kgs.)	Max. Swell (%)
	Density (pcf)	Percent of Max. Dens.	Moisture (%)	Density (pcf)	Percent of Max. Dens.	Moisture (%)	0.10 in.	0.20 in.			
1 ○	80.5	72.1	13.2	79.3	71	26.2	3.6	3.1	0.000	4546.6	1.5
2 △											
3 □											

Material Description	USCS	Max. Dens. (pcf)	Optimum Moisture (%)	LL	PI
	LEAN CLAY	CL	111.7	16.0	41

Project No: 2030-0834
Project: City of Tulsa Maintenance Zone Project
Source of Sample: Comp. 2 (C6,C7,C8,C9) **Depth:** 0.0-5.0
Date: _____

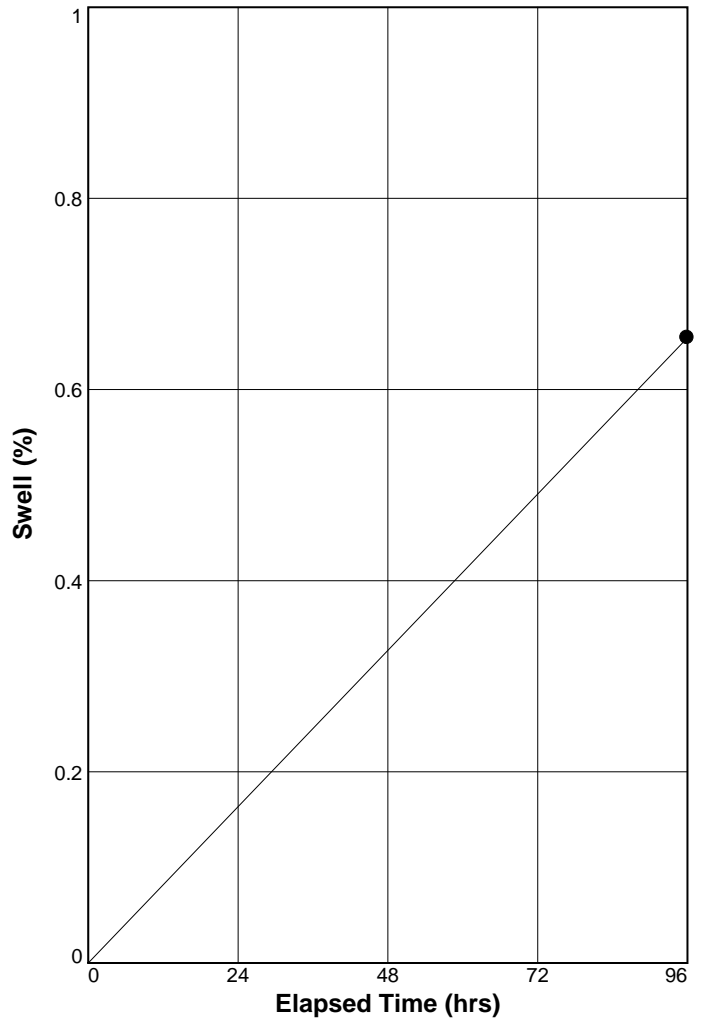
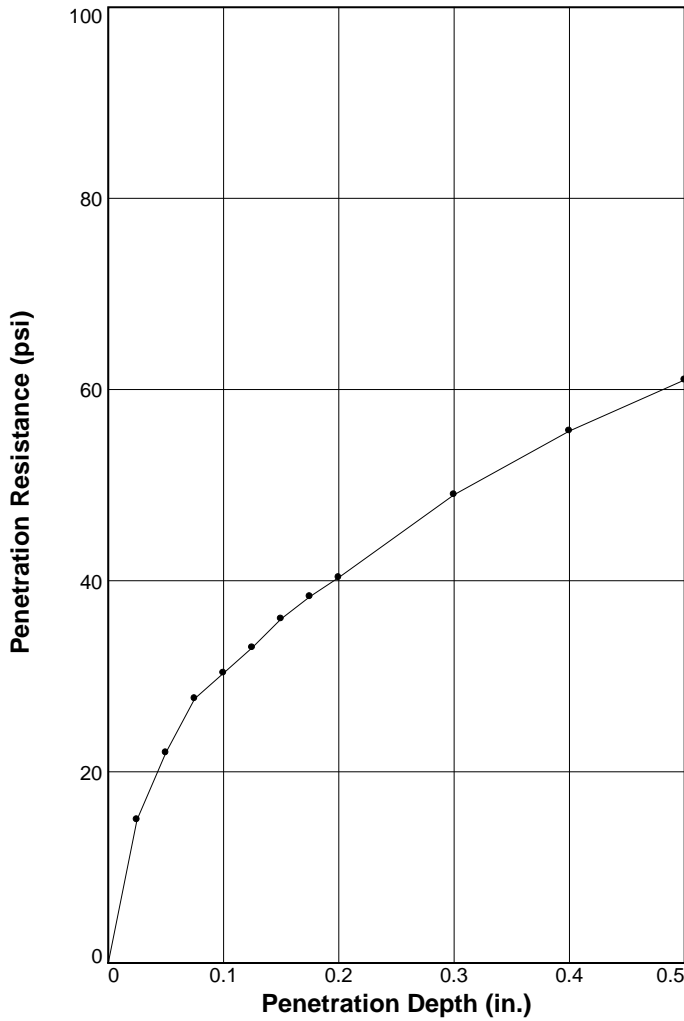
STANDARD TESTING
AND ENGINEERING COMPANY
Since 1951

Test Description/Remarks:

Figure _____

BEARING RATIO TEST REPORT

ASTM D1883-14



	Molded			Soaked			CBR (%)		Linearity Correction (in.)	Surcharge (kgs.)	Max. Swell (%)
	Density (pcf)	Percent of Max. Dens.	Moisture (%)	Density (pcf)	Percent of Max. Dens.	Moisture (%)	0.10 in.	0.20 in.			
1 ○	106.1	97.4	15.1	105.4	96.8	23.1	3.0	2.7	0.000	4534.4	0.7
2 △											
3 □											

Material Description	USCS	Max. Dens. (pcf)	Optimum Moisture (%)	LL	PI
	LEAN CLAY	CL	108.9	16.0	37

Project No: 2030-0834
Project: City of Tulsa Maintenance Zone Project
Source of Sample: Comp. 3 (C5,C10,C11) **Depth:** 0.0-5.0
Date:

Test Description/Remarks:

Figure _____



	<u>Area Offices</u>	
902 Trails West Loop	Enid, OK 73703	(580) 237-3130
202 SE "J" Ave.	Lawton, OK 73501	(580) 353-0872

Report On: Determining Soluble Sulfate Content in Soil

Lab No: 1570-1

Report No: 1570-1

File ID: 2030-0834

Acct ID: 0230COW01

Page 1 of 1

Client: Cowan Group Engineering
 Robert Rose
 7100 N Classen Blvd.
 Oklahoma City, OK 73116

Project: Subsurface Exploration
 City of Tulsa Maintenance Zone Project
 Tulsa, Oklahoma

Location: Comp 1: (0.0'-5.0')

Report Date: 01/28/2021

Sample Date: 01/28/2021

Sampled By:

Test Method: OHD L-49
 Material Represented: Native Soil

Mass of Air-Dried Sample Passing #10 Sieve (W_s): 5 g

Mass of Deionized Water Used in Slurry (W_w): 200 g

Average Colorimeter Reading (R): 5.3 ppm

Volume of Original Filtrate Used (V_f): N/A ml

Volume of Deionized Water Added to Filtrate (V_w): N/A ml

Colorimeter Reading on Diluted Filtrate (R_d): N/A ppm

$$C = [R * (W_w / W_s)] \text{ or } [R_d * (W_w / W_s) * (V_f + V_w) / V_f]$$

Sulfate Concentration in Air-Dry Soil, (C): 212 ppm

Test Methods: OHD L49

Orig: Cowan Group Engineering (Oklahoma City, OK)
 Attn: Robert Rose (1-cc copy)
 1-cc Laboratory

Respectfully Submitted,
 Standard Testing & Engineering Company

	<u>Area Offices</u>	
902 Trails West Loop	Enid, OK 73703	(580) 237-3130
202 SE "J" Ave.	Lawton, OK 73501	(580) 353-0872

Report On: Determining Soluble Sulfate Content in Soil

Lab No: 1570

Report No: 1570

File ID: 2030-0834

Acct ID: 0230COW01

Page 1 of 1

Client: Cowan Group Engineering
 Robert Rose
 7100 N Classen Blvd.
 Oklahoma City, OK 73116

Project: Subsurface Exploration
 City of Tulsa Maintenance Zone Project
 Tulsa, Oklahoma

Location: Comp 2: (0.0'-5.0')

Report Date: 01/28/2021

Sample Date: 01/28/2021

Sampled By:

Test Method: OHD L-49
 Material Represented: Native Soil

Mass of Air-Dried Sample Passing #10 Sieve (W_s): 5 g

Mass of Deionized Water Used in Slurry (W_w): 200 g

Average Colorimeter Reading (R): 24 ppm

Volume of Original Filtrate Used (V_f): N/A ml

Volume of Deionized Water Added to Filtrate (V_w): N/A ml

Colorimeter Reading on Diluted Filtrate (R_d): N/A ppm

$$C = [R * (W_w / W_s)] \text{ or } [R_d * (W_w / W_s) * (V_f + V_w) / V_f]$$

Sulfate Concentration in Air-Dry Soil, (C): 960 ppm

Test Methods: OHD L49

Orig: Cowan Group Engineering (Oklahoma City, OK)
 Attn: Robert Rose (1-cc copy)
 1-cc Laboratory

Respectfully Submitted,
 Standard Testing & Engineering Company

	<u>Area Offices</u>	
902 Trails West Loop	Enid, OK 73703	(580) 237-3130
202 SE "J" Ave.	Lawton, OK 73501	(580) 353-0872

Report On: Determining Soluble Sulfate Content in Soil

Lab No: 1570-2

Report No: 1570-2

File ID: 2030-0834

Acct ID: 0230COW01

Page 1 of 1

Client: Cowan Group Engineering
 Robert Rose
 7100 N Classen Blvd.
 Oklahoma City, OK 73116

Project: Subsurface Exploration
 City of Tulsa Maintenance Zone Project
 Tulsa, Oklahoma

Location: Comp 3: (0.0'-5.0')

Report Date: 01/28/2021

Sample Date: 01/28/2021

Sampled By:

Test Method: OHD L-49
 Material Represented: Native Soil

Mass of Air-Dried Sample Passing #10 Sieve (W_s): 5 g

Mass of Deionized Water Used in Slurry (W_w): 200 g

Average Colorimeter Reading (R): 1.66 ppm

Volume of Original Filtrate Used (V_f): N/A ml

Volume of Deionized Water Added to Filtrate (V_w): N/A ml

Colorimeter Reading on Diluted Filtrate (R_d): N/A ppm

$$C = [R * (W_w / W_s)] \text{ or } [R_d * (W_w / W_s) * (V_f + V_w) / V_f]$$

Sulfate Concentration in Air-Dry Soil, (C): 66 ppm

Test Methods: OHD L49

Orig: Cowan Group Engineering (Oklahoma City, OK)
 Attn: Robert Rose (1-cc copy)
 1-cc Laboratory

Respectfully Submitted,
 Standard Testing & Engineering Company

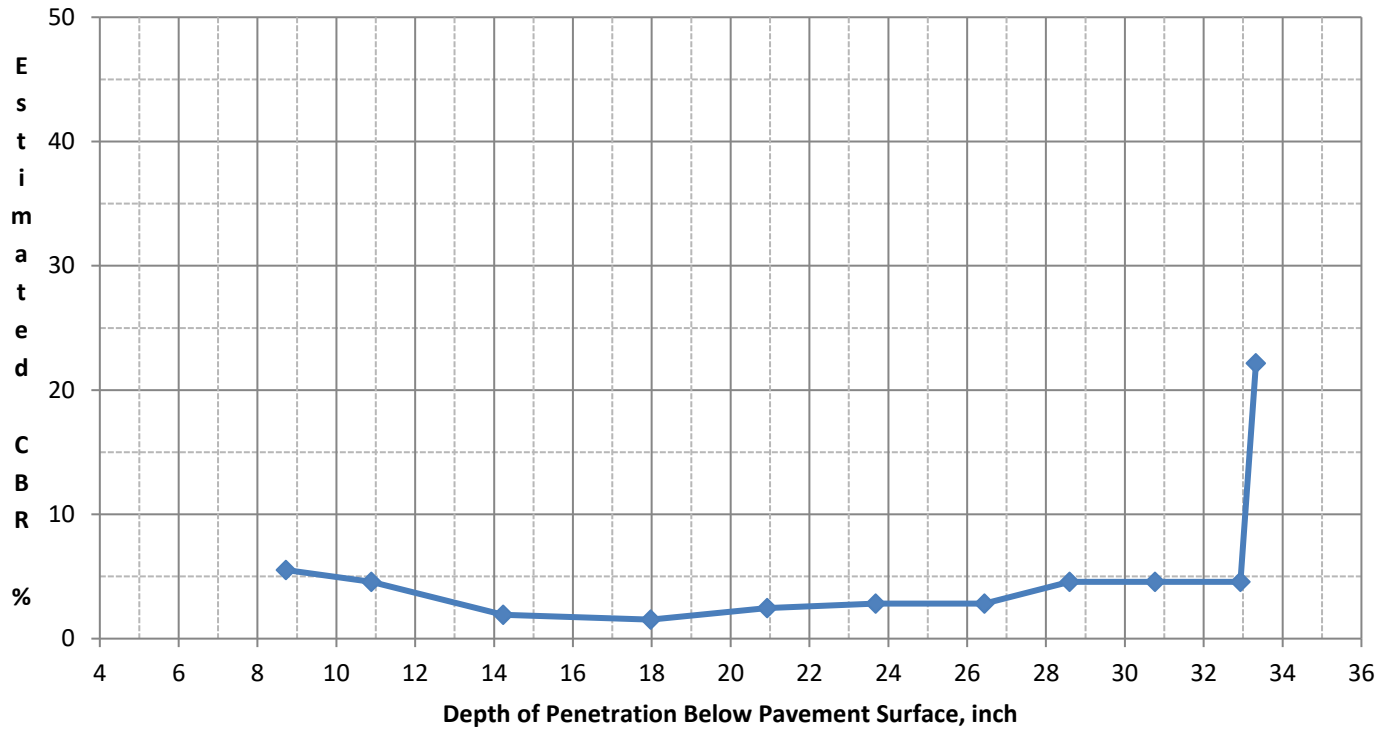
Test Location: C-1

Hammer Type: 1 (1 for 17.6 lbs. hammer or 2 for 10.1 lbs. hammer)

Reading cm	Total Penetration mm	Incremental Penetration mm	Blows	Estimated Soil Type USCS	Corrected DCP Index mm per blow	Estimated CBR
54.5	0			CL		
59.5	50	50	2	CL	25.0	6
65.0	105	55	2	CL	27.5	5
73.5	190	85	2	CL	42.5	2
83.0	285	95	2	CL	47.5	2
90.5	360	75	2	CL	37.5	2
97.5	430	70	2	CL	35.0	3
104.5	500	70	2	CL	35.0	3
110.0	555	55	2	CL	27.5	5
115.5	610	55	2	CL	27.5	5
121.0	665	55	2	CL	27.5	5
122.0	675	10	1	CL	10.0	22

Test Location: C-1

Estimated CBR versus Penetration Depth



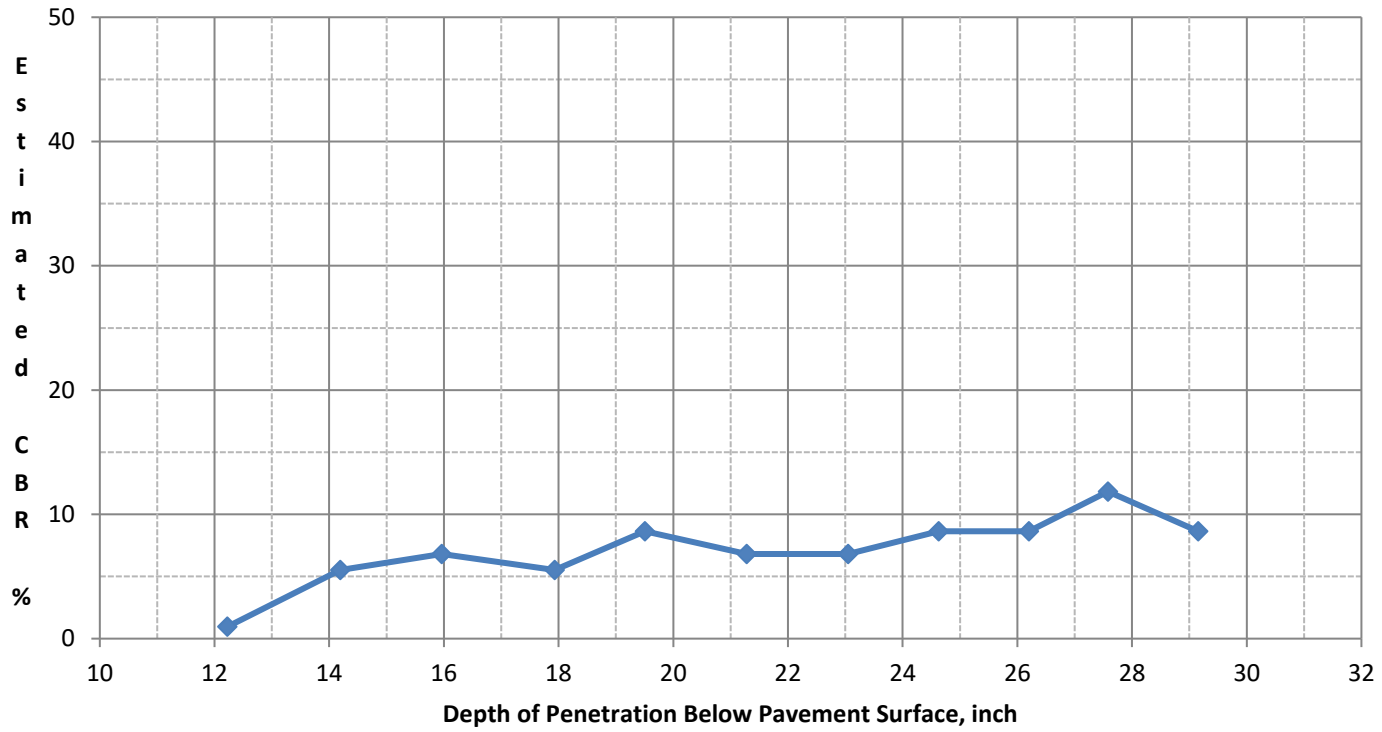
Test Location: C-2

Hammer Type: 1 (1 for 17.6 lbs. hammer or 2 for 10.1 lbs. hammer)

Reading cm	Total Penetration mm	Incremental Penetration mm	Blows	Estimated Soil Type USCS	Corrected DCP Index mm per blow	Estimated CBR
66.0	0			CL		
78.0	120	120	2	CL	60.0	1
83.0	170	50	2	CL	25.0	6
87.5	215	45	2	CL	22.5	7
92.5	265	50	2	CL	25.0	6
96.5	305	40	2	CL	20.0	9
101.0	350	45	2	CL	22.5	7
105.5	395	45	2	CL	22.5	7
109.5	435	40	2	CL	20.0	9
113.5	475	40	2	CL	20.0	9
117.0	510	35	2	CL	17.5	12
121.0	550	40	2	CL	20.0	9
122.0	560	10	2	CL	5.0	48

Test Location: C-2

Estimated CBR versus Penetration Depth



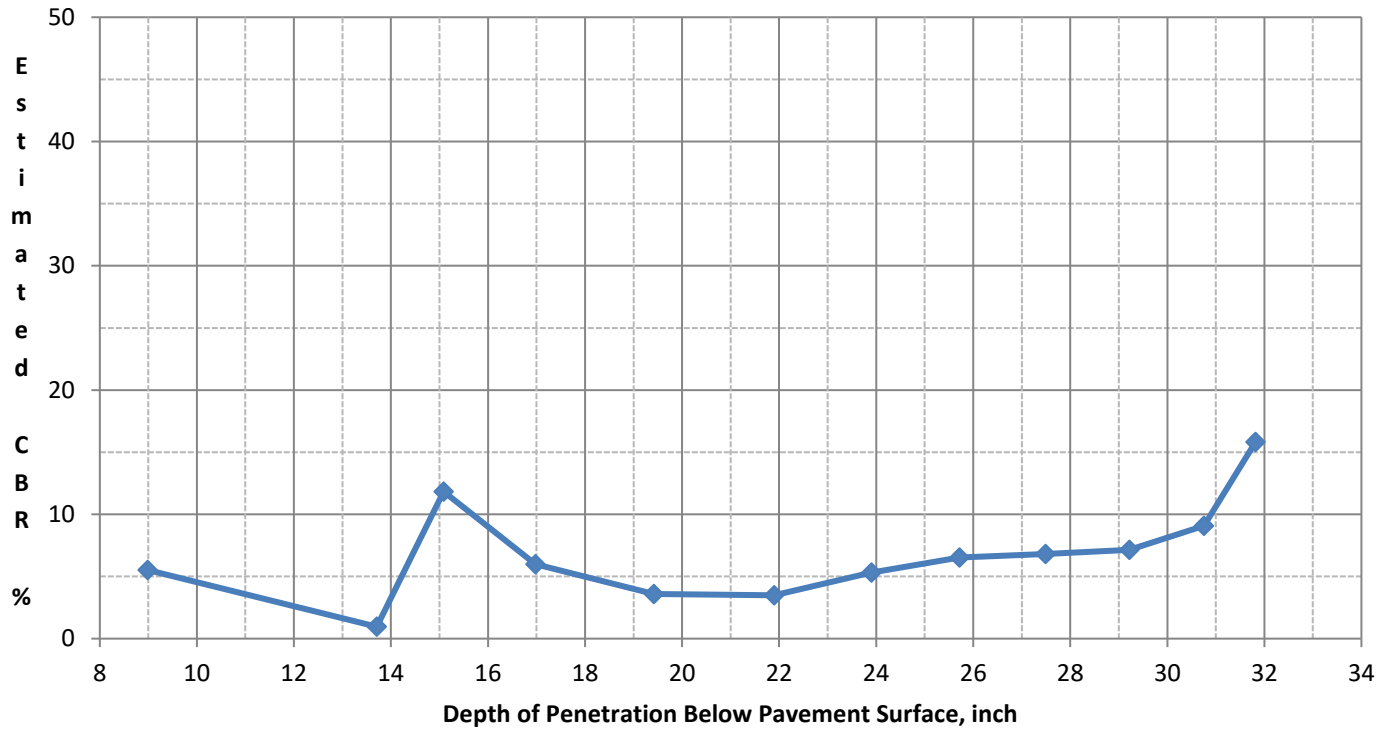
Test Location: C-3

Hammer Type: 1 (1 for 17.6 lbs. hammer or 2 for 10.1 lbs. hammer)

Reading cm	Total Penetration mm	Incremental Penetration mm	Blows	Estimated Soil Type USCS	Corrected DCP Index mm per blow	Estimated CBR
61.5	0			CL		
64.0	25	25	1	CL	25.0	6
76.0	145	120	2	CL	60.0	1
79.5	180	35	2	CL	17.5	12
84.3	228	48	2	CL	24.0	6
90.5	290	62	2	CL	31.0	4
96.8	353	63	2	CL	31.5	3
101.9	404	51	2	CL	25.5	5
106.5	450	46	2	CL	23.0	7
111.0	495	45	2	CL	22.5	7
115.4	539	44	2	CL	22.0	7
119.3	578	39	2	CL	19.5	9
122.0	605	27	2	CL	13.5	16

Test Locati C-3

Estimated CBR versus Penetration Depth



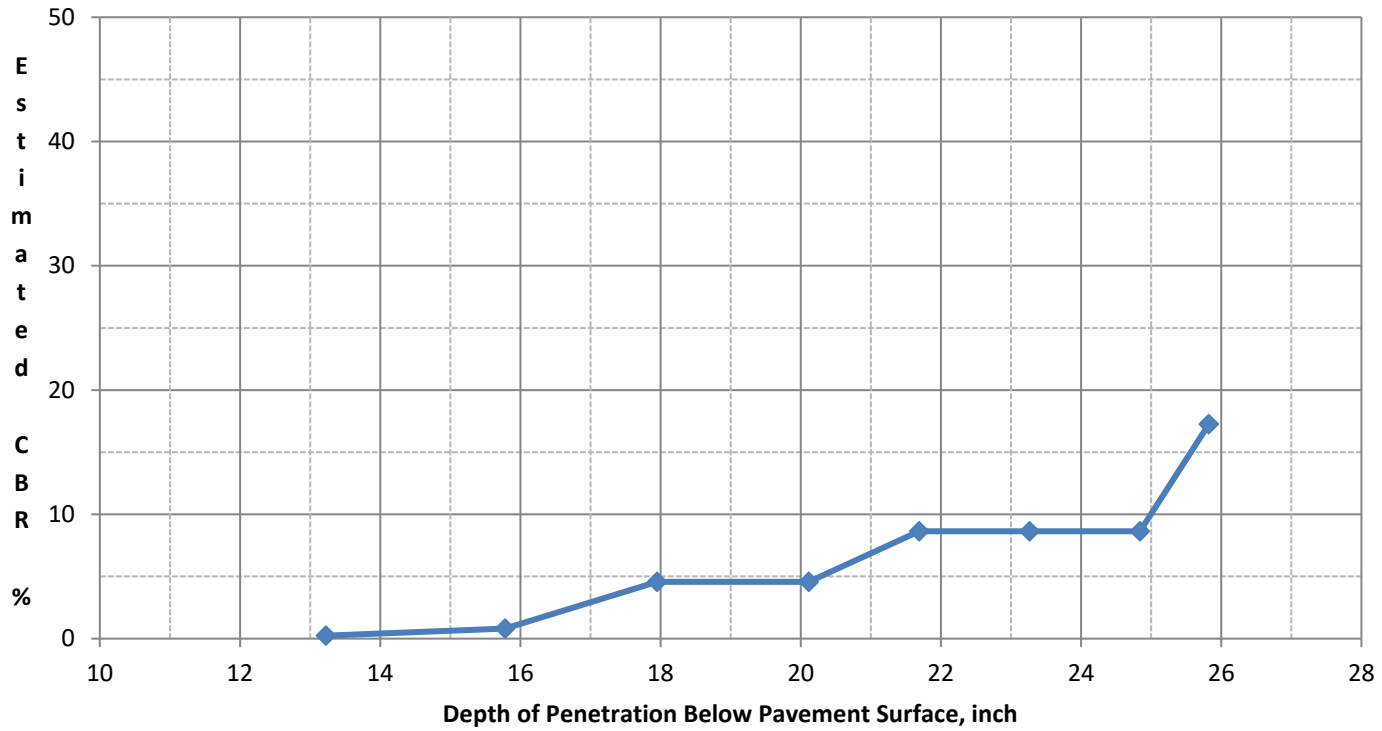
Test Location: C-4

Hammer Type: 1 (1 for 17.6 lbs. hammer or 2 for 10.1 lbs. hammer)

Reading cm	Total Penetration mm	Incremental Penetration mm	Blows	Estimated Soil Type USCS	Corrected DCP Index mm per blow	Estimated CBR
78.0	0			CL		
90.0	120	120	1	CL	120.0	0
96.5	185	65	1	CL	65.0	1
102.0	240	55	2	CL	27.5	5
107.5	295	55	2	CL	27.5	5
111.5	335	40	2	CL	20.0	9
115.5	375	40	2	CL	20.0	9
119.5	415	40	2	CL	20.0	9
122.0	440	25	2	CL	12.5	17

Test Locati C-4

Estimated CBR versus Penetration Depth



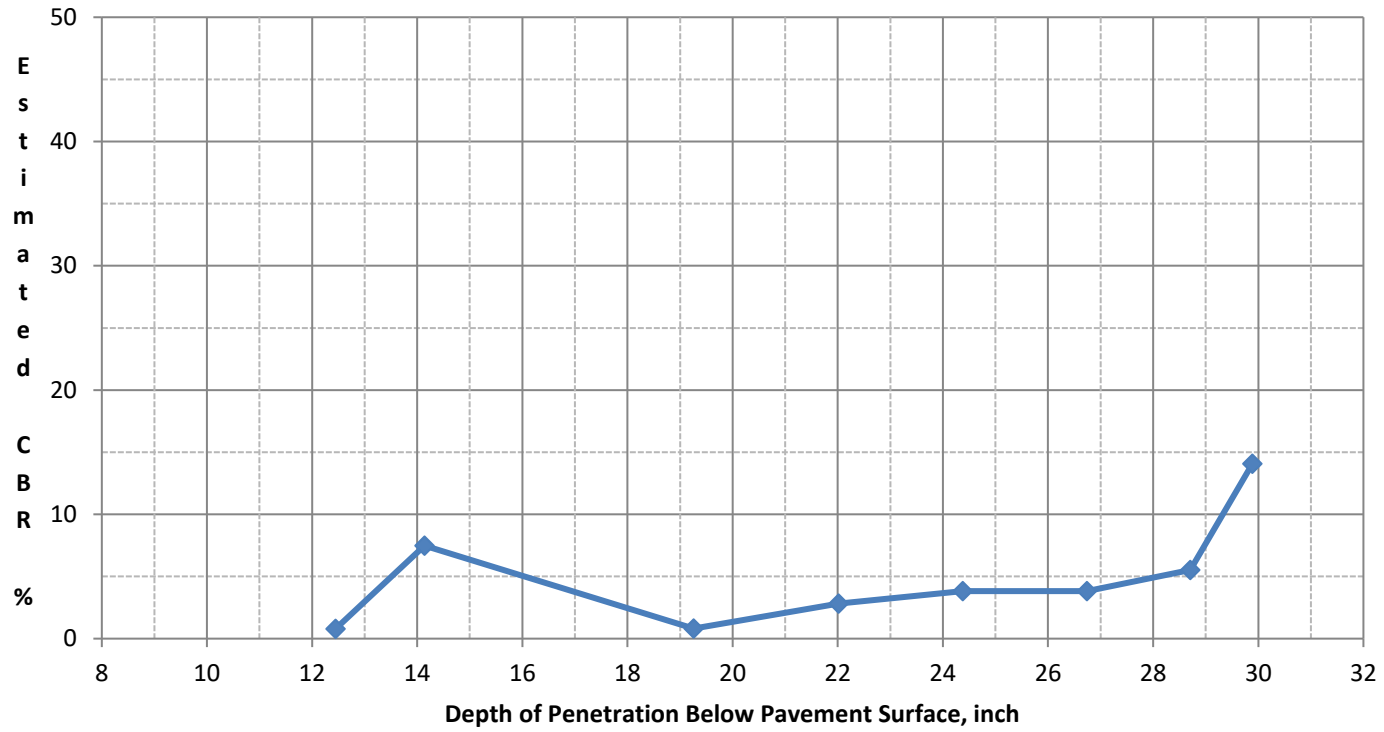
Test Location: C-5

Hammer Type: 1 (1 for 17.6 lbs. hammer or 2 for 10.1 lbs. hammer)

Reading cm	Total Penetration mm	Incremental Penetration mm	Blows	Estimated Soil Type USCS	Corrected DCP Index mm per blow	Estimated CBR
64.5	0			CL		
77.7	132	132	2	CL	66.0	1
82.0	175	43	2	CL	21.5	7
95.0	305	130	2	CL	65.0	1
102.0	375	70	2	CL	35.0	3
108.0	435	60	2	CL	30.0	4
114.0	495	60	2	CL	30.0	4
119.0	545	50	2	CL	25.0	6
122.0	605	27	2	CL	13.5	16

Test Locati C-5

Estimated CBR versus Penetration Depth



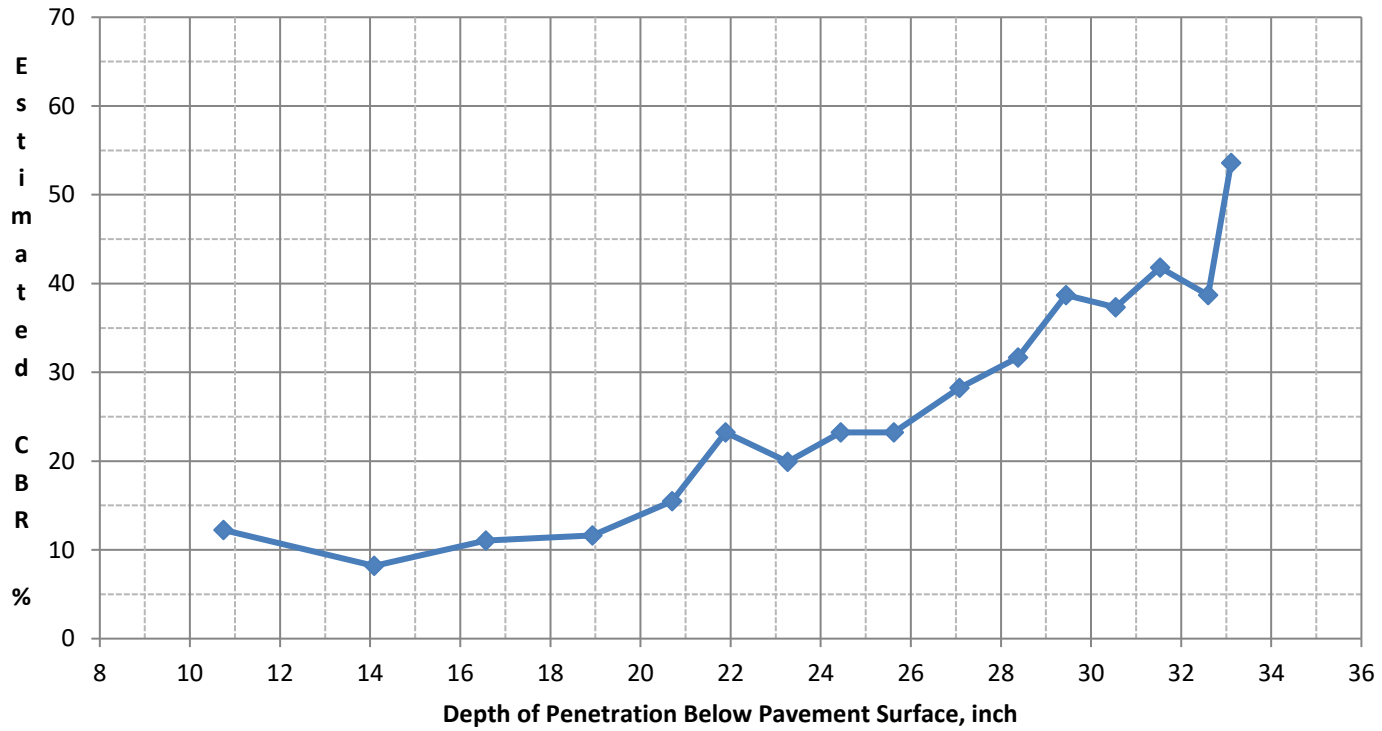
Test Location: C-6

Hammer Type: 1 (1 for 17.6 lbs. hammer or 2 for 10.1 lbs. hammer)

Reading cm	Total Penetration mm	Incremental Penetration mm	Blows	Estimated Soil Type USCS	Corrected DCP Index mm per blow	Estimated CBR
59.5	0			CH		
65.2	57	57	2	CH	28.5	12
73.7	142	85	2	CH	42.5	8
80.0	205	63	2	CH	31.5	11
86.0	265	60	2	CH	30.0	12
90.5	310	45	2	CH	22.5	15
93.5	340	30	2	CH	15.0	23
97.0	375	35	2	CH	17.5	20
100.0	405	30	2	CH	15.0	23
103.0	435	30	2	CH	15.0	23
106.7	472	37	3	CH	12.3	28
110.0	505	33	3	CH	11.0	32
112.7	532	27	3	CH	9.0	39
115.5	560	28	3	CH	9.3	37
118.0	585	25	3	CH	8.3	42
120.7	612	27	3	CH	9.0	39
122.0	625	13	2	CH	6.5	54

Test Location: C-6

Estimated CBR versus Penetration Depth



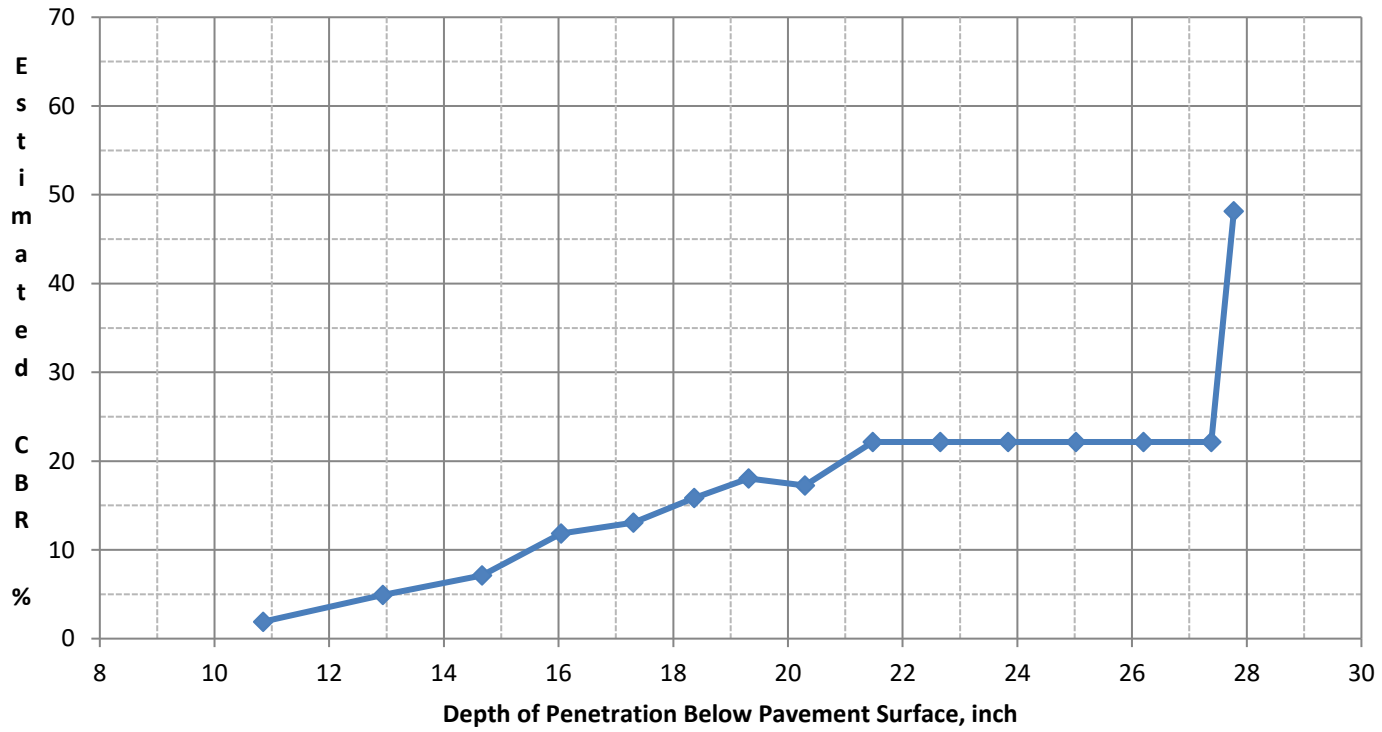
Test Location: C-7

Hammer Type: 1 (1 for 17.6 lbs. hammer or 2 for 10.1 lbs. hammer)

Reading cm	Total Penetration mm	Incremental Penetration mm	Blows	Estimated Soil Type USCS	Corrected DCP Index mm per blow	Estimated CBR
70.5	0			CL		
79.0	85	85	2	CL	42.5	2
84.3	138	53	2	CL	26.5	5
88.7	182	44	2	CL	22.0	7
92.2	217	35	2	CL	17.5	12
95.4	249	32	2	CL	16.0	13
98.1	276	27	2	CL	13.5	16
100.5	300	24	2	CL	12.0	18
103.0	325	25	2	CL	12.5	17
106.0	355	30	3	CL	10.0	22
109.0	385	30	3	CL	10.0	22
112.0	415	30	3	CL	10.0	22
115.0	445	30	3	CL	10.0	22
118.0	475	30	3	CL	10.0	22
121.0	505	30	3	CL	10.0	22
122.0	515	10	2	CL	5.0	48

Test Location: C-7

Estimated CBR versus Penetration Depth



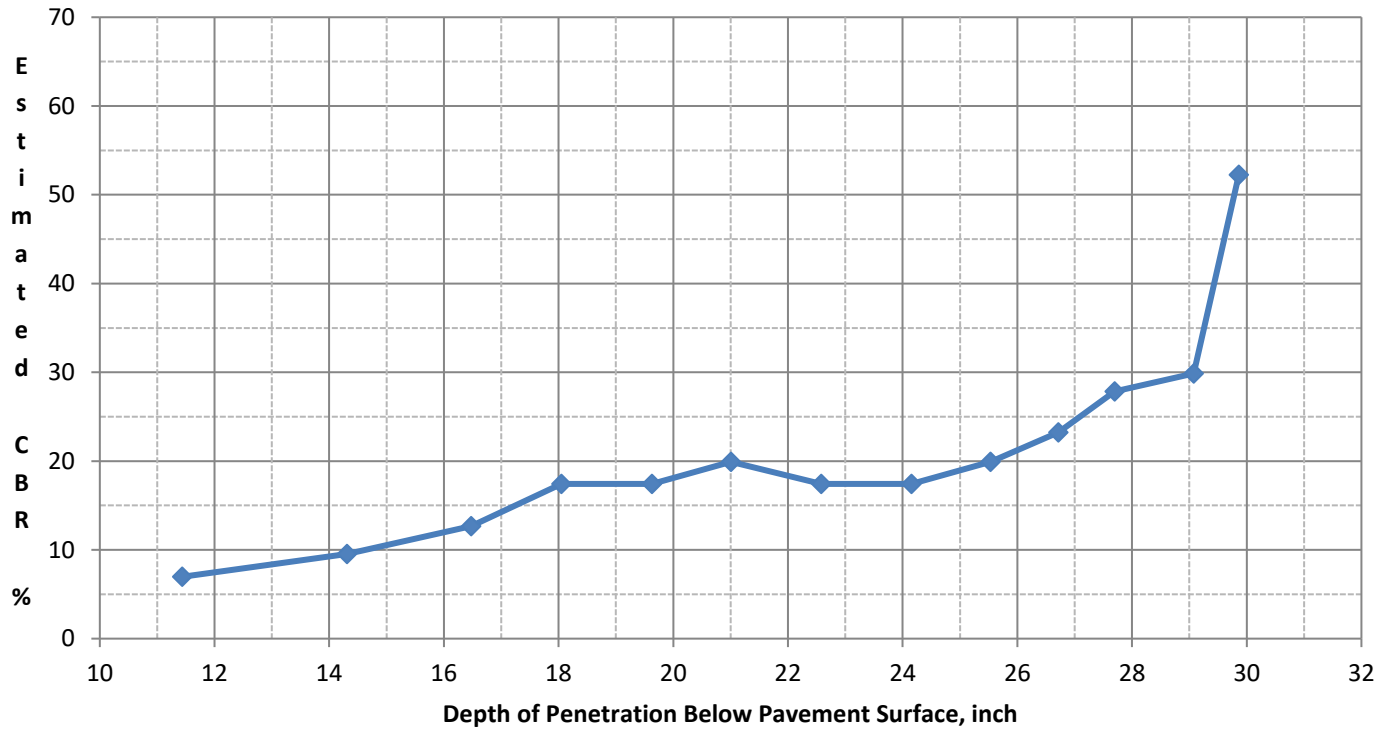
Test Location: C-8

Hammer Type: 1 (1 for 17.6 lbs. hammer or 2 for 10.1 lbs. hammer)

Reading cm	Total Penetration mm	Incremental Penetration mm	Blows	Estimated Soil Type USCS	Corrected DCP Index mm per blow	Estimated CBR
65.2	0			CH		
75.2	100	100	2	CH	50.0	7
82.5	173	73	2	CH	36.5	10
88.0	228	55	2	CH	27.5	13
92.0	268	40	2	CH	20.0	17
96.0	308	40	2	CH	20.0	17
99.5	343	35	2	CH	17.5	20
103.5	383	40	2	CH	20.0	17
107.5	423	40	2	CH	20.0	17
111.0	458	35	2	CH	17.5	20
114.0	488	30	2	CH	15.0	23
116.5	513	25	2	CH	12.5	28
120.0	548	35	3	CH	11.7	30
122.0	568	20	3	CH	6.7	52

Test Location: C-8

Estimated CBR versus Penetration Depth



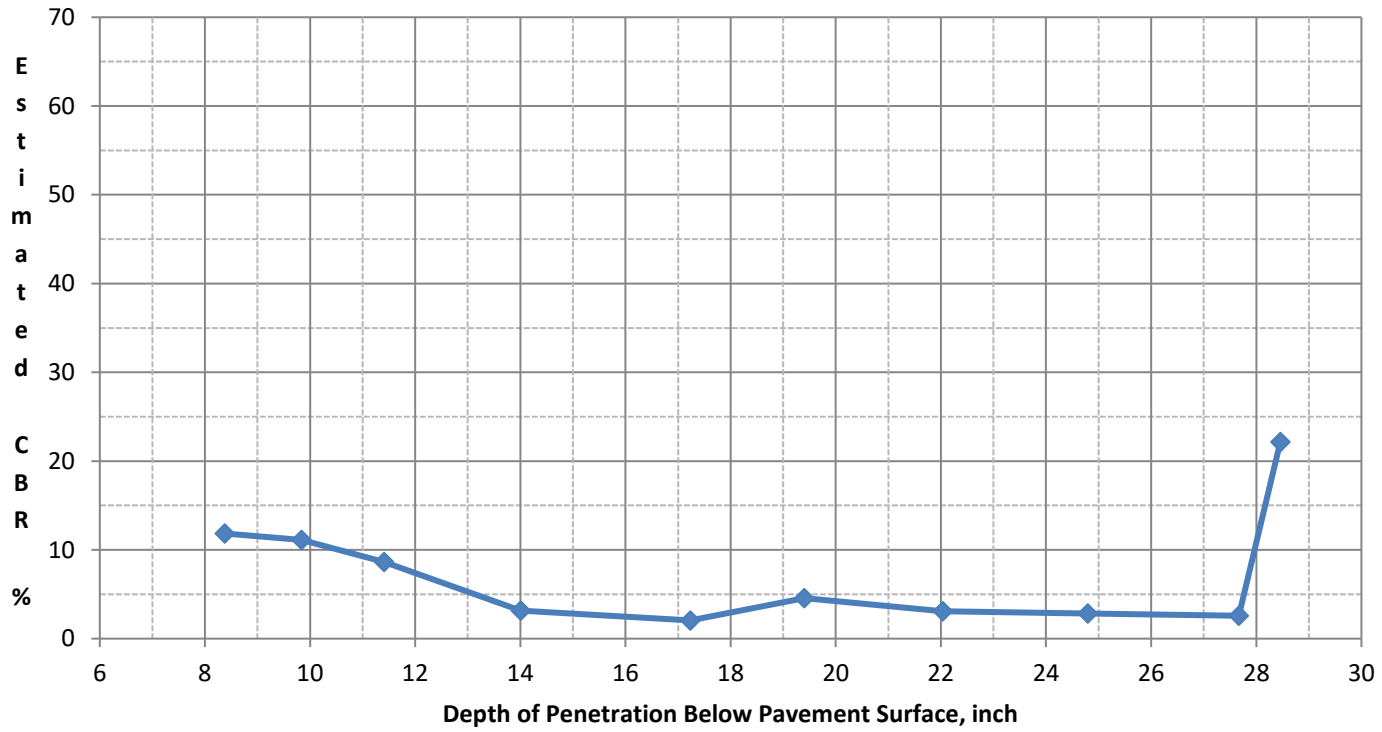
Test Location: C-9

Hammer Type: 1 (1 for 17.6 lbs. hammer or 2 for 10.1 lbs. hammer)

Reading cm	Total Penetration mm	Incremental Penetration mm	Blows	Estimated Soil Type USCS	Corrected DCP Index mm per blow	Estimated CBR
67.5	0			CL		
71.0	35	35	2	CL	17.5	12
74.7	72	37	2	CL	18.5	11
78.7	112	40	2	CL	20.0	9
85.3	178	66	2	CL	33.0	3
93.5	260	82	2	CL	41.0	2
99.0	315	55	2	CL	27.5	5
105.7	382	67	2	CL	33.5	3
112.7	452	70	2	CL	35.0	3
120.0	525	73	2	CL	36.5	3
122.0	545	20	2	CL	10.0	22

Test Location: C-9

Estimated CBR versus Penetration Depth



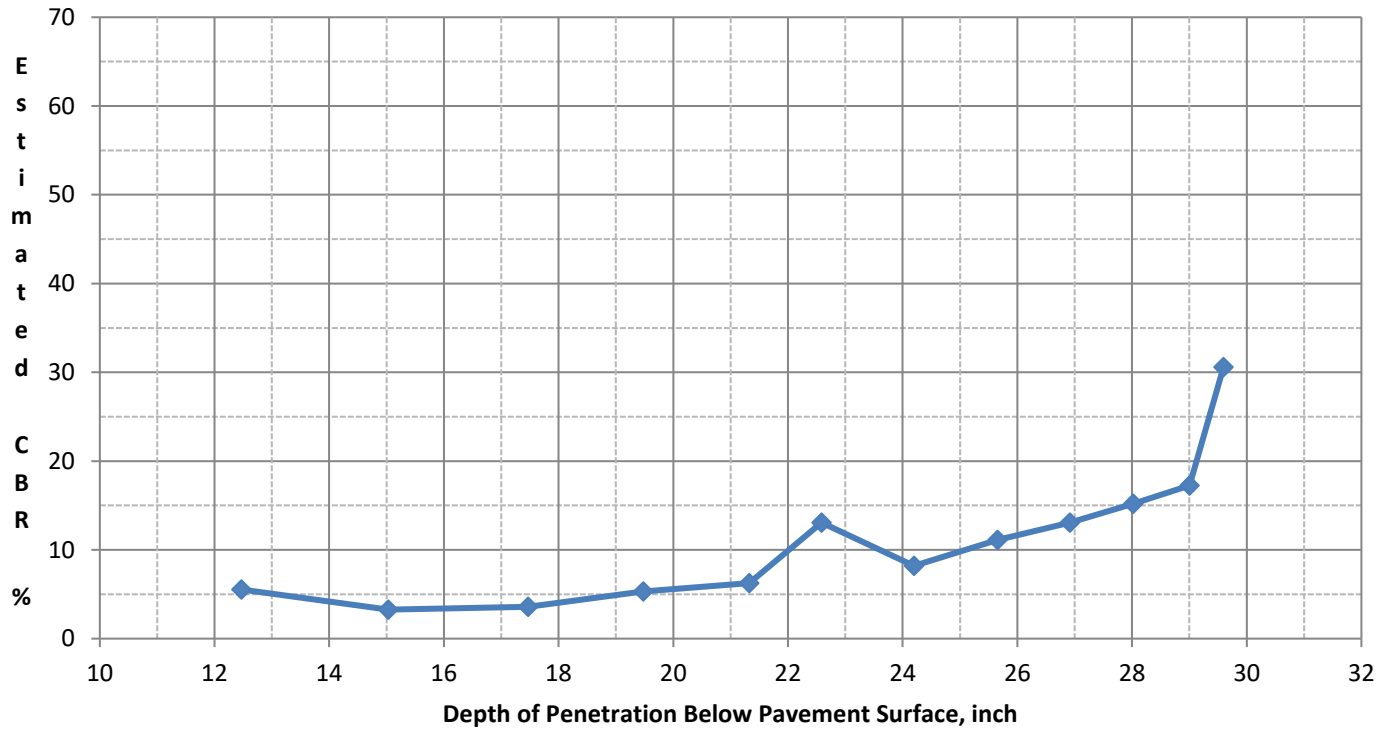
Test Location: C-10

Hammer Type: 1 (1 for 17.6 lbs. hammer or 2 for 10.1 lbs. hammer)

Reading cm	Total Penetration mm	Incremental Penetration mm	Blows	Estimated Soil Type USCS	Corrected DCP Index mm per blow	Estimated CBR
73.5	0			CL		
78.5	50	50	2	CL	25.0	6
85.0	115	65	2	CL	32.5	3
91.2	177	62	2	CL	31.0	4
96.3	228	51	2	CL	25.5	5
101.0	275	47	2	CL	23.5	6
104.2	307	32	2	CL	16.0	13
108.3	348	41	2	CL	20.5	8
112.0	385	37	2	CL	18.5	11
115.2	417	32	2	CL	16.0	13
118.0	445	28	2	CL	14.0	15
120.5	470	25	2	CL	12.5	17
122.0	485	15	2	CL	7.5	31

Test Location: C-10

Estimated CBR versus Penetration Depth



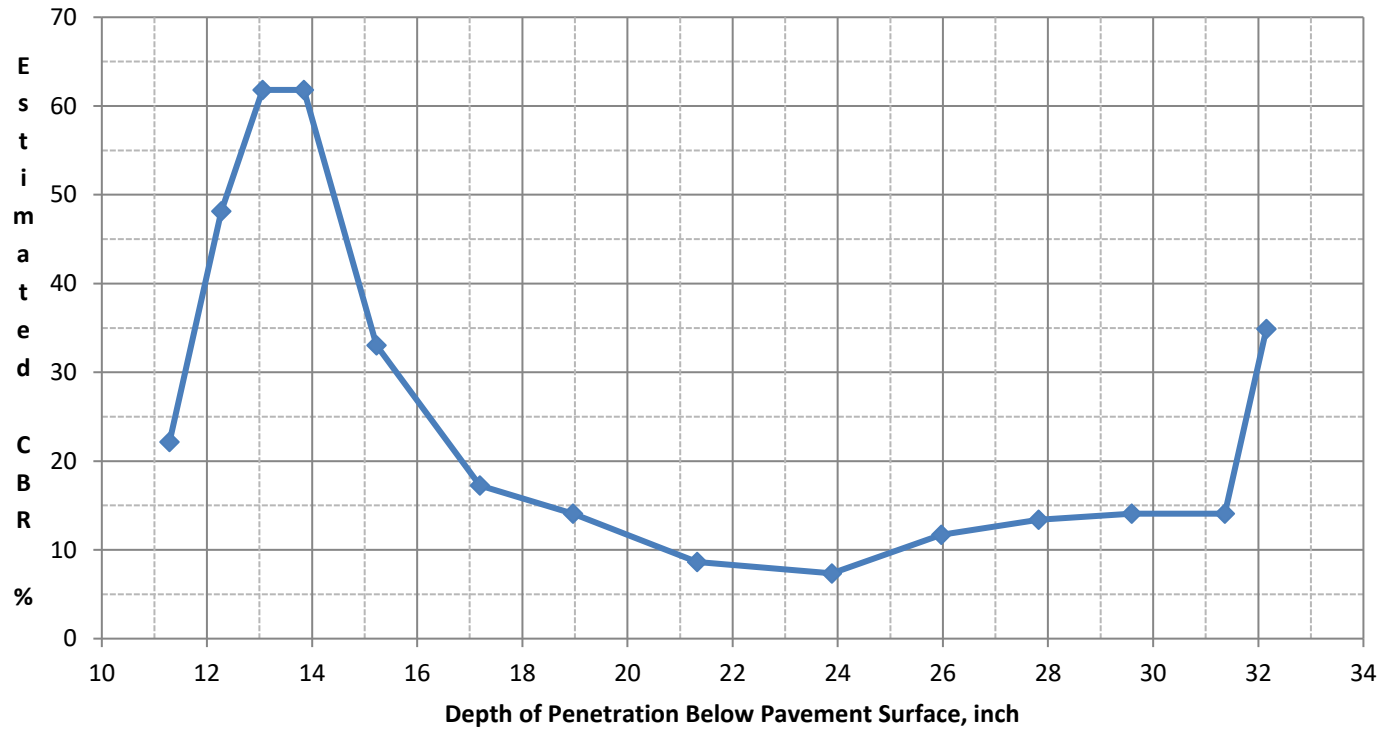
Test Location: C-11

Hammer Type: 1 (1 for 17.6 lbs. hammer or 2 for 10.1 lbs. hammer)

Reading cm	Total Penetration mm	Incremental Penetration mm	Blows	Estimated Soil Type USCS	Corrected DCP Index mm per blow	Estimated CBR
67.0	0			CL		
69.0	20	20	2	CL	10.0	22
71.5	45	25	5	CL	5.0	48
73.5	65	20	5	CL	4.0	62
75.5	85	20	5	CL	4.0	62
79.0	120	35	5	CL	7.0	33
84.0	170	50	4	CL	12.5	17
88.5	215	45	3	CL	15.0	14
94.5	275	60	3	CL	20.0	9
101.0	340	65	3	CL	21.7	7
106.3	393	53	3	CL	17.7	12
111.0	440	47	3	CL	15.7	13
115.5	485	45	3	CL	15.0	14
120.0	530	45	3	CL	15.0	14
122.0	550	20	3	CL	6.7	35

Test Location: C-11

Estimated CBR versus Penetration Depth



APPENDIX E

Summary of Test Results



Figure 1

Fatigue Cracking on E Admiral Place

Located Near C-3



Figure 2

Fatigue and Transverse Cracking on E Admiral Place

Located Near C-1



Figure 3

Transverse and Joint Cracking on N Trenton Ave

Located Near C-7



Figure 4

Transverse and Longitudinal Cracking on N Trenton Ave

Located Near C-8