USDA
United States Department of Agriculture

Natural Resources Conservation Service

National Design, Construction, and Soil Mechanics Center

501 W. Felix, Bldg. 23
Fort Worth, Texas 76115

Phone: 817.509.3204

Subject: ENG - Soil Mechanics Report
Plum Creek # 12
Hays County, Texas

Date: MAY 27 2015

To: John Mueller, P.E.
State Conservation Engineer
NRCS, Temple, TX

File Code: 210-22
Job No: 7562

INTRODUCTION

Plum Creek # 12 is an existing embankment dam located in Hays County, Texas. Seven boreholes (Number 207 through 213) were advanced to depths ranging from 5.0 to 17.5 feet along the northwest, inside edge of the auxiliary spillway.

Nine Shelby tubes of undisturbed field samples were delivered from five of the boreholes to the Fort Worth Soil Mechanics Laboratory (SML) for testing. Requested testing included: index, dry unit weight, and unconfined compressive strength. The purpose of this report is to provide the results of the unconfined compressive strength testing (q_u) which will be utilized to determine the headcut erodibility index (Kh).

INTERPRETATION AND DISCUSSION OF DATA

Index Tests and Water Content

Index testing was completed on thirteen soil samples and the majority classified as fat clay (CH) according to the Unified Soil Classification System (USCS). Three of the soil samples from shallow depths in the boreholes classified as elastic silt (MH; F15-314 / 207.1), gravelly elastic silt (MH; F15-316 / 208.1), and sandy elastic silt with gravel (MH; F15-317 / 208.2). One sample classified as lean clay (CL; F15-325 / 210.2) and one sample classified as clayey gravel with sand (GC; F15-318 / 208.3). The Liquid Limit (LL) values varied from 38 to 65 and Plasticity Index (PI) values ranged from 18 to 34.

Index properties of the samples are shown in Attachment 1 on form SCS-ENG-354.

Dispersion Tests

Double Hydrometer and Crumb tests were performed on all of the soil samples. Double Hydrometer test results less than about 60 indicate that dispersion is not a problem, and this was the case for all of the soil samples tested. Crumb test results of 1 indicate that dispersion is not

present or is minimal, but results of 3 or 4 are positive indicators that clays are dispersive. The testing of soil samples from this area of the project site did not indicate that these samples have dispersive clay characteristics.

Unconfined Compressive Strength (q_u) Tests

The Unconfined Compressive Strength of Cohesive Soil test (ASTM D2166) was performed on eight soil samples at the Lincoln Soil Mechanics Laboratory in Nebraska. The samples were sheared at or below their natural moisture content and associated saturation level. The saturation level of the samples ranged from 74.3 % to 99.7 %. However, the majority of the samples had a saturation level of 88 % or more. The sample with the lowest saturation level was from a depth of less than four feet.

All eight of soil samples were sheared at their extruded diameter (+2.7 inch diameter), and were in compliance with the ASTM D2166's height-to-diameter ratio.

A summary of the peak compressive stresses is provided below and the full test reports are provided as Attachment 2.

Lab Sample No.	Field Sample No.	Depth (ft)	Natural Moisture Content (%)	Percent Saturation (%)	q_u (psf)
315	207.2	5.0 - 7.5	15.3	92.3	11,830*
319	208.4	10.0 - 11.5	18.3	94.0	8,130
320	208.5	15.0 - 17.5	17.9	90.8	4,165
321	209.1	2.5 - 4.0	20.1	74.3	7,585
323	209.3	10.0 - 12.5	19.5	99.7	10,135
324	210.1	2.5 - 5.0	23.7	88.7	5,830
325	210.2	10.0 - 12.5	19.7	96.5	9,285
326	211.1	7.5 - 10.0	19.3	95.8	8,970

Note: * The load cell maxed out before this sample failed

CONCLUSIONS AND RECOMMENDATIONS

The following are conclusions regarding the results of the testing:

1) The results of the unconfined compressive strength tests ranged from 4,165 to 11,830 psf.

2) The recorded q_u values are peak stresses.

3) Consideration should be given to whether the unconfined compressive strength of the sample is appropriate for calculation of the headcut erodibility index (K_h) considering the soil in the spillway will fail in shear, when it experiences water flow.

4) The majority of the soil samples were fat clay (CH). However, BH 208 (the upper 10ft) classified as MH / GC and as the hatched area shows on the borehole location map (Figure 1) this may have been fill material during construction. The strength increased with depth in BH 209 and BH 210, but this was not the case at BH 208. Because of this anomaly at BH 208 extra analysis should be taken in developing the Kh for the entire auxiliary spillway and a determination of whether this borehole along with the elastic silt identified in BH 207 represents an area that should be treated with caution. Furthermore, this could be a significant anomaly within the auxiliary spillway and a critical parameter that requires added attention, engineering judgement, and sensitivity analysis.

5) There was significantly more of a sand portion in the soil samples identified as elastic silt when compared to the soil samples classified as fat clay.

If you would like to discuss this report or if you need to request further testing, please contact me at (817) 509-3204.

Prepared by:

Steven Garner

STEVEN GARNER, P.E.
Civil Engineer
NRCS, Fort Worth, TX

Concurred by:

PHILLIP T. RIPPÉ, P.E
Head, Soil Mechanics Laboratory
NRCS, Fort Worth, TX

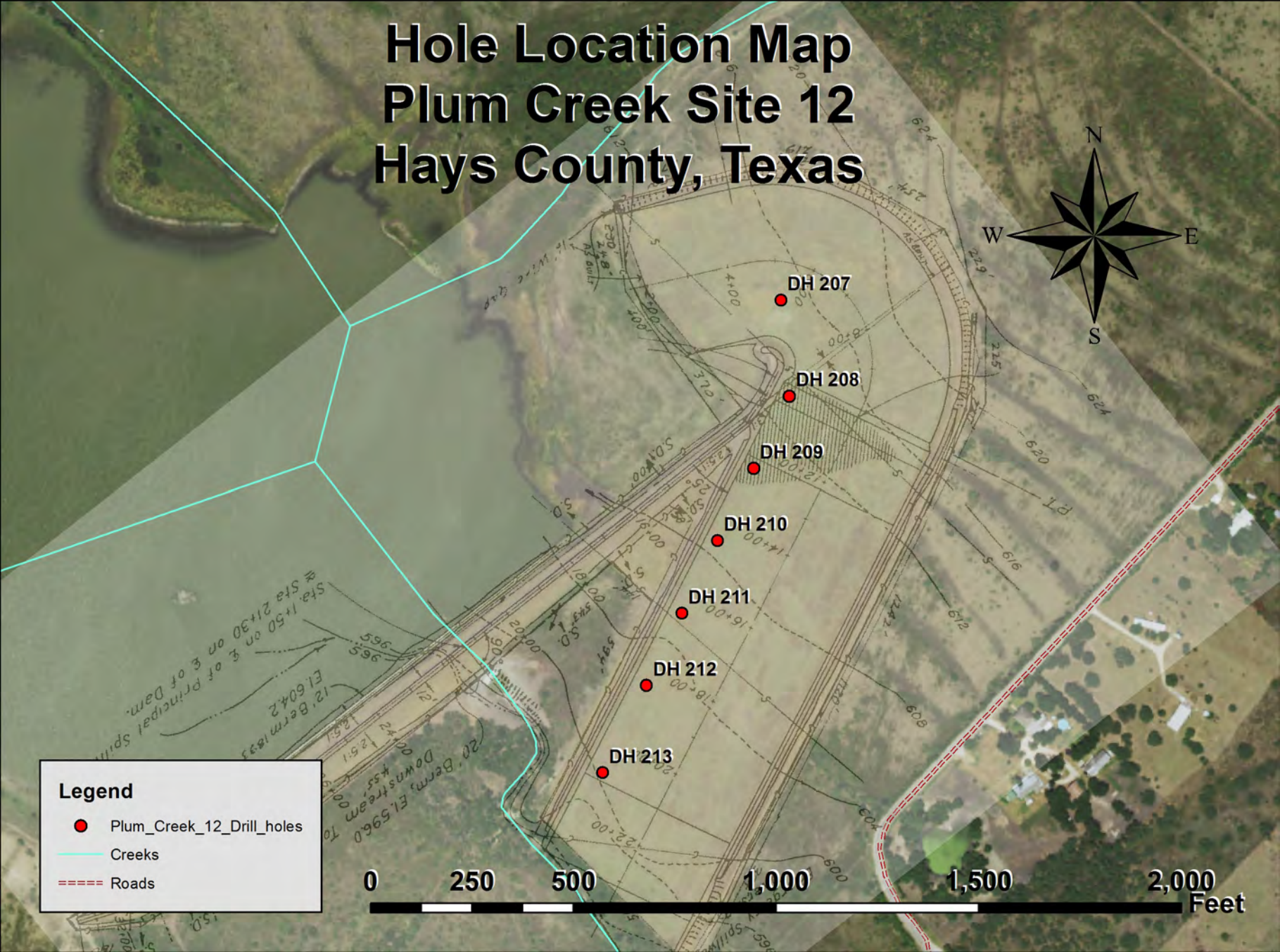
Figures:
1. Borehole Locations

Attachments:
1. Form SCS-ENG-354, Soil Mechanics Laboratory Test Data, 1 sheet
2. Unconfined Compression Test Report, 8 sheets

cc: (electronically distributed)
John Hebrik, State Design Engineer, NRCS, Temple, TX
Stephen Reinsch, Co-Director, NDCSMC, NRCS, Lincoln, NE
Noller Herbert, Director, CED, NRCS, Washington, DC

Figure 1

Borehole Locations, 1 sheet


Hole Location Map
Plum Creek Site 12
Hays County, Texas
N
W
E
S
DH 207
DH 208
DH 209
DH 210
DH 211
DH 212
DH 213
Legend
Plum_Creek_12_Drill_holes
Creeks
Roads
0
250
500
1,000
1,500
2,000
Feet

Attachment 1

NRCS-ENG-354, Soil Mechanics Data, 1 sheet

NRCS-ENG-354
Rev. Feb 2006
File Code ENG-210-22

U.S. Department of Agriculture
Natural Resources Conservation Service

Soil Mechanics Laboratory Data

Sheet _1__ of _1__

Job No. **7562**

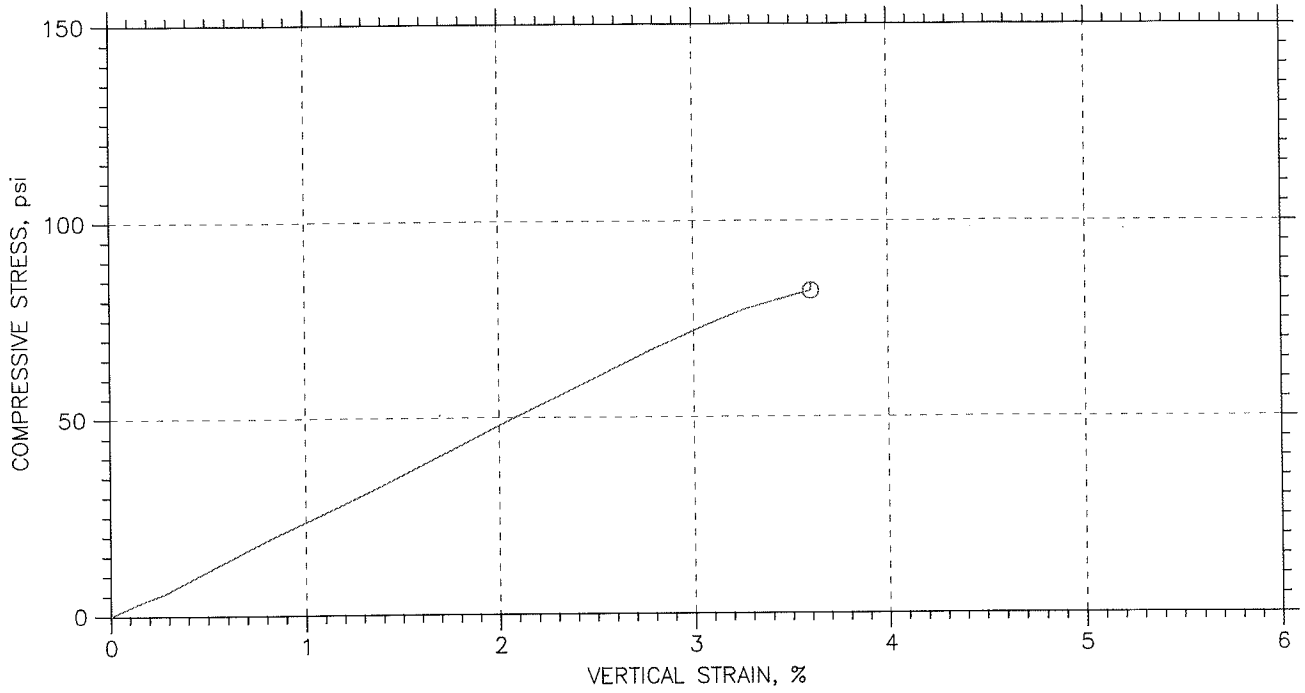
F14

8/20/14		TX Plum Creek Site # 12 7562 Hays Co.	WF-07		Mechanical Analysis Grain Size Distribution Expressed as Percent Finer by Dry Weight																Atterberg Limits								Dispersion				Moisture-Density ASTM D698					
					Fines					Sand						Gravel																					
Lab. Sample No.	Field Sample No.	Location and Description	Depth (ft)	Sample Type	0.002 mm	0.005 mm	0.02 mm	0.05 mm	#200 0.074 mm	#140 0.105 mm	#60 0.250 mm	#40 0.42 mm	#20 0.84 mm	#10 2.0 mm	#4 4.76 mm	3/8" 9.525 mm	1/2" 12.7 mm	3/4" 19.05 mm	1" 25.4 mm	1 1/2" 38.1 mm	3" 76.2 mm	L.L.	P.I.	Unified Classification	Soluble Salts %	Natural Moisture (%)	Natural Dry Unit Weight (gm/cm^3)	Percent Saturation	Double Hydrometer	Crumb Test 1 Hr	Crumb Test 4 Hr	Pinhole	Max γ_d (pcf)	w_0 %	G_S	G_M	% Absorp-tion	pH
314	207.1	Sta 5+00 CL AS 125 ft right	0.0 - 0.5	Small	48	62	74	86	89	90	93	94	94	95	98	98	98	100				65	29	MH	<.5	19.1			8	1	1				2.68			
315	207.2	Sta 5+00 CL AS 125 ft right	5.0 - 7.5	Undist.	47	72	91	96	99	-	-	-	-	100								51	30	CH	<.5	16.5			38	1	1				2.69			
316	208.1	Sta 11+25 CL AS 175 ft right	0.0 - 1.5	Undist.	35	44	57	68	70	71	72	73	73	75	83	84	84	89	92	100		61	28	MH	<.5	16.8			8	1	1				2.56			
317	208.2	Sta 11+25 CL AS 175 ft right	5.0 - 5.5	Small	34	43	55	68	69	69	69	70	72	74	85	95	100					59	28	MH	<.5	20.1			19	1	1				2.65			
318	208.3	Sta 11+25 CL AS 175 ft right	6 - 9	Small	9	13	18	21	21	21	23	25	28	32	50	70	80	93	98	100		38	18	GC	<.5	8.8			15	1	1				2.69			
319	208.4	Sta 11+25 CL AS 175 ft right	10.0 - 11.5	Undist.	48	71	90	97	100													56	32	CH	<.5	19.4			28	1	1				2.68			
320	208.5	Sta 11+25 CL AS 175 ft right	15.0 - 17.5	Undist.	47	66	85	96	98	-	-	-	-	100								53	31	CH	<.5	19.5			32	1	1				2.68			
321	209.1	Sta 13+25 CL AS 175 ft right	2.5 - 4.0	Undist.	48	60	78	91	94	-	-	-	-	100								58	28	CH	<.5	21.1			3	1	1				2.64			
322	209.2	Sta 13+25 CL AS 175 ft right	7.5 - 10.0	Small	51	73	86	97	99	-	-	-	-	100								53	32	CH	<.5	20.5			21	1	1				2.70			
323	209.3	Sta 13+25 CL AS 175 ft right	10.0 - 12.5	Undist.	47	66	85	94	96	-	-	-	-	100								53	32	CH	<.5	15.5			29	1	1				2.67			
324	210.1	Sta 15+25 CL AS 175 ft right	2.5 - 5.0	Undist.	47	59	78	94	96	-	-	-	-	100								60	34	CH	<.5	19.2			12	1	1				2.64			
325	210.2	Sta 15+25 CL AS 175 ft right	10.0 - 12.5	Undist.	40	58	78	91	96	-	-	-	-	100								47	26	CL	<.5	18.3			14	1	1				2.66			
326	211.1	Sta 17+25 CL AS 175 ft right	7.5 - 10.0	Undist.	43	62	75	94	96	-	-	-	-	100								50	28	CH	<.5	14.3			15	1	1				2.69			

Attachment 2

Unconfined Compression Test Report, 8 sheets

UNCONFINED COMPRESSION TEST REPORT



Symbol		⏲			
Test No.		1			
Initial	Diameter, in	2.734			
	Height, in	5.952			
	Water Content, %	15.31			
	Dry Density, pcf	116.1			
	Saturation, %	92.25			
	Void Ratio	0.447			
Unconfined Compressive Strength, psi		82.15			
Undrained Shear Strength, psi		41.07			
Time to Failure, min		3.6819			
Strain Rate, %/min		1			
Measured Specific Gravity		2.69			
Liquid Limit		---			
Plastic Limit		---			
Plasticity Index		---			
Failure Sketch					

NRCS Natural Resources Conservation Service

Project: PLUM CREEK SITE #12

Location: TX

Project No.: 14-1221

Boring No.: 207.2

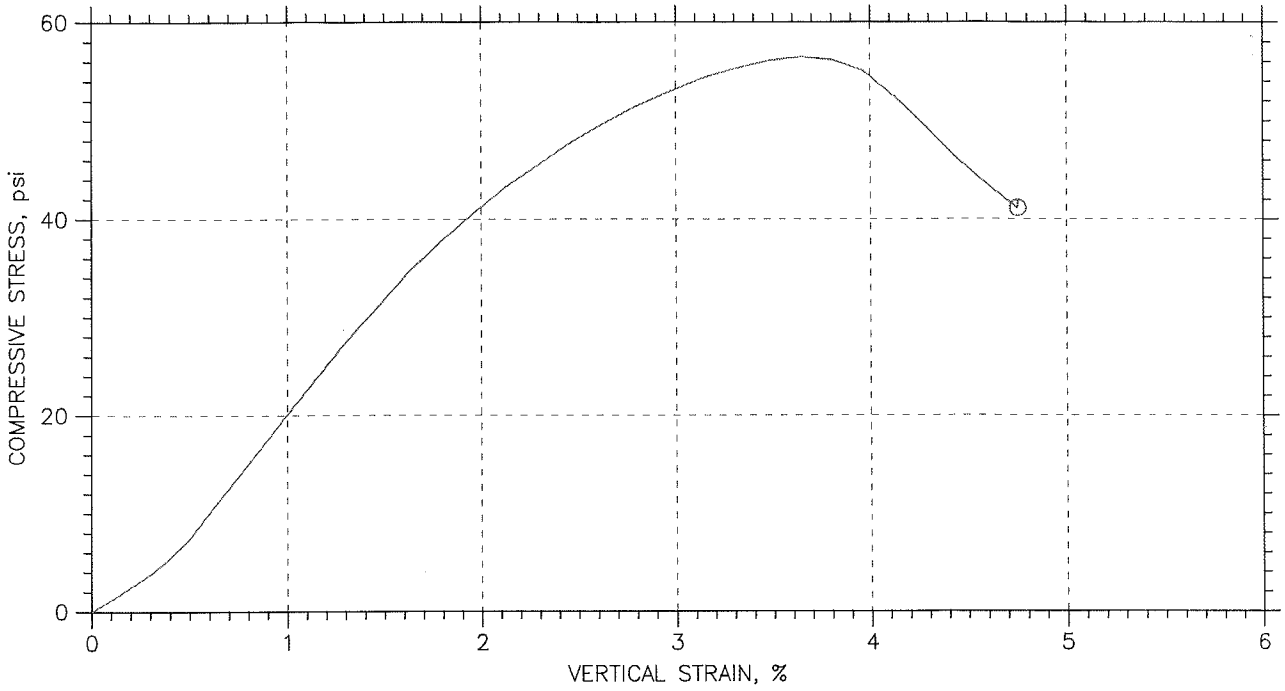
Sample Type: CORE

Description: ~5+00 cL AS 125' RIGHT, F14-315

Remarks: NOTE: LOAD CELL MAXED OUT BEFORE SAMPLE FAILED

Wed, 05-NOV-2014 09:07:05

UNCONFINED COMPRESSION TEST REPORT



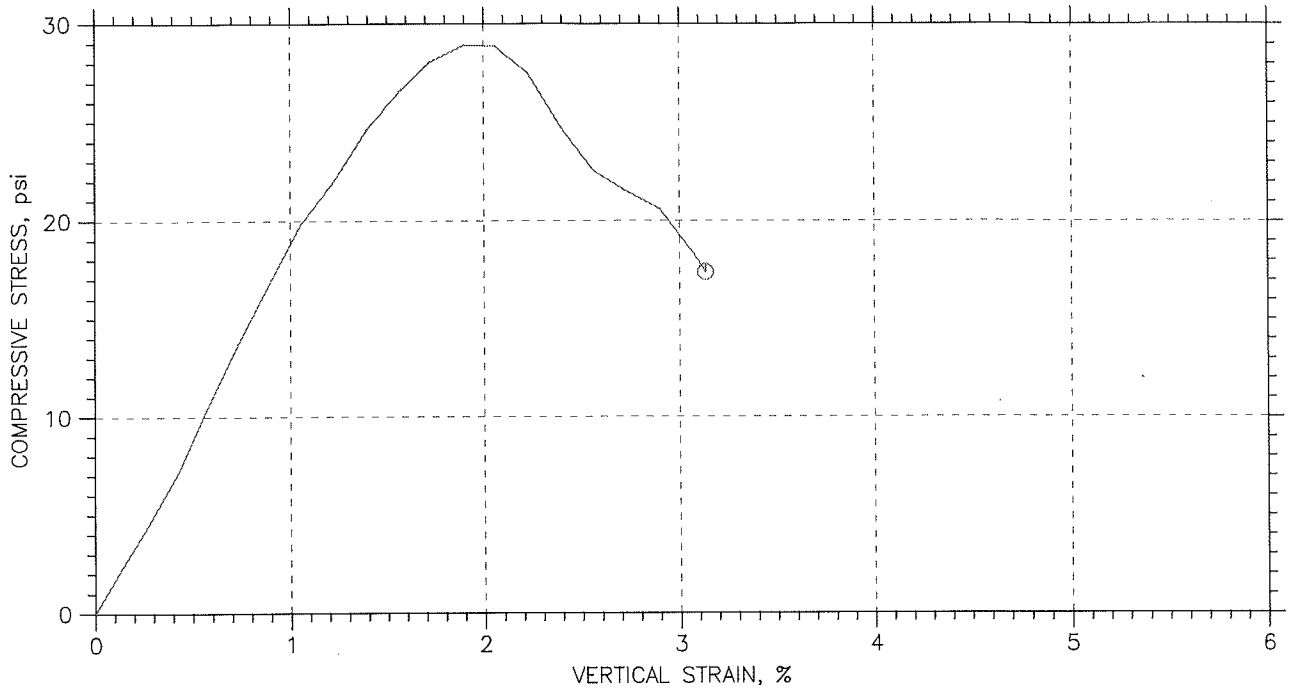
Symbol		⏲			
Test No.		1			
Initial	Diameter, in	2.754			
	Height, in	5.97			
	Water Content, %	18.29			
	Dry Density, pcf	109.9			
	Saturation, %	93.97			
	Void Ratio	0.522			
Unconfined Compressive Strength, psi		56.47			
Undrained Shear Strength, psi		28.24			
Time to Failure, min		3.6694			
Strain Rate, %/min		1			
Measured Specific Gravity		2.68			
Liquid Limit		---			
Plastic Limit		---			
Plasticity Index		---			
Failure Sketch					

NRCS Natural Resources Conservation Service

Project: PLUM CREEK SITE #12
Location: TX
Project No.: 14-1223
Boring No.: 208.4
Sample Type: CORE
Description: ~11+25 cL AS 175' RIGHT, F14-319
Remarks:

Wed, 05-NOV-2014 09:10:05

UNCONFINED COMPRESSION TEST REPORT



Symbol		⏲			
Test No.		1			
Initial	Diameter, in	2.771			
	Height, in	5.876			
	Water Content, %	17.88			
	Dry Density, pcf	109.5			
	Saturation, %	90.79			
	Void Ratio	0.528			
Unconfined Compressive Strength, psi		28.93			
Undrained Shear Strength, psi		14.47			
Time to Failure, min		2.0022			
Strain Rate, %/min		1			
Measured Specific Gravity		2.68			
Liquid Limit		---			
Plastic Limit		---			
Plasticity Index		---			
Failure Sketch					

NRCS Natural Resources Conservation Service

Project: PLUM CREEK SITE #12

Location: TX

Project No.: 14-1224

Boring No.: 208.5

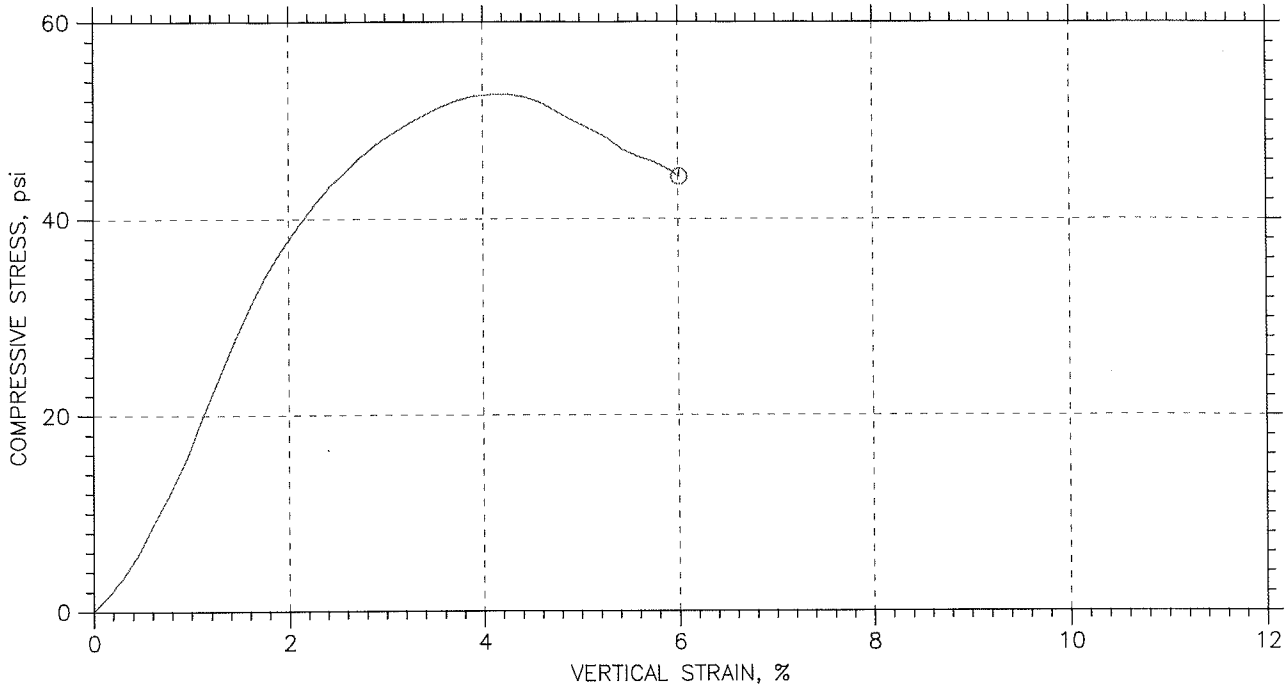
Sample Type: CORE

Description: ~11+25 cL AS 175' RIGHT, F14-320

Remarks:

Wed, 05-NOV-2014 10:28:57

UNCONFINED COMPRESSION TEST REPORT



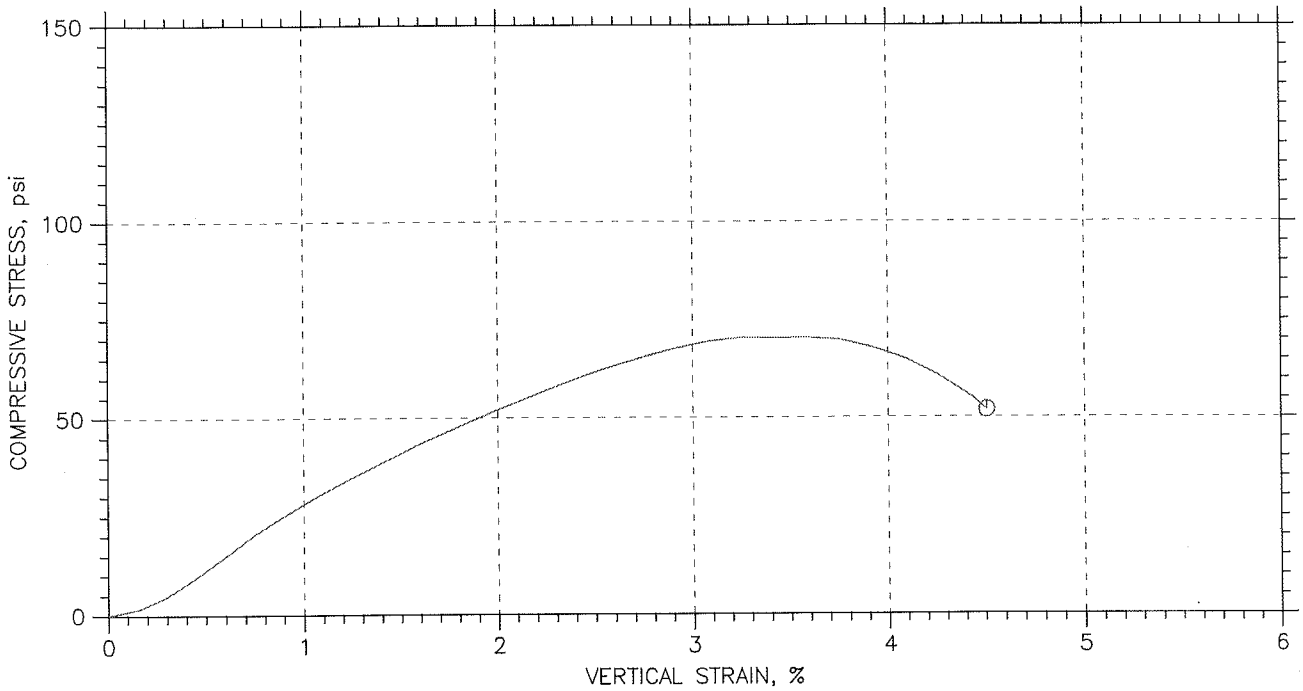
Symbol		⏲			
Test No.		1			
Initial	Diameter, in	2.724			
	Height, in	6.015			
	Water Content, %	20.09			
	Dry Density, pcf	96.18			
	Saturation, %	74.33			
	Void Ratio	0.714			
Unconfined Compressive Strength, psi		52.66			
Undrained Shear Strength, psi		26.33			
Time to Failure, min		4.3359			
Strain Rate, %/min		1			
Measured Specific Gravity		2.64			
Liquid Limit		---			
Plastic Limit		---			
Plasticity Index		---			
Failure Sketch					

NRCS Natural Resources Conservation Service

Project: PLUM CREEK SITE #12
Location: TX
Project No.: 14-1225
Boring No.: 209.1
Sample Type: CORE
Description: ~13+25 cL AS 175' RIGHT, F14-321
Remarks:

Wed, 05-NOV-2014 10:45:49

UNCONFINED COMPRESSION TEST REPORT

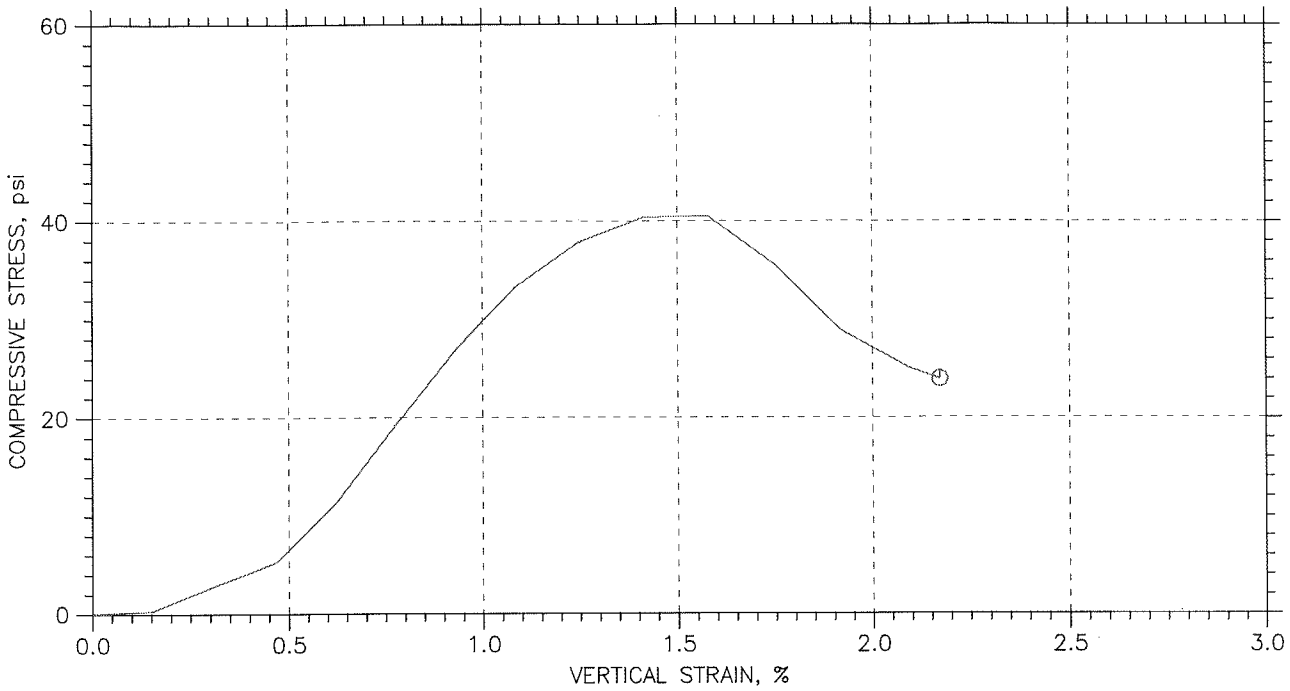


Symbol		⏲			
Test No.		1			
Initial	Diameter, in	2.769			
	Height, in	5.897			
	Water Content, %	19.51			
	Dry Density, pcf	109.5			
	Saturation, %	99.67			
	Void Ratio	0.523			
Unconfined Compressive Strength, psi		70.38			
Undrained Shear Strength, psi		35.19			
Time to Failure, min		3.6684			
Strain Rate, %/min		1			
Measured Specific Gravity		2.67			
Liquid Limit		---			
Plastic Limit		---			
Plasticity Index		---			
Failure Sketch					

NRCS Natural Resources Conservation Service

Project: PLUM CREEK SITE #12
Location: TX
Project No.: 14-1226
Boring No.: 209.3
Sample Type: CORE
Description: ~13+25 cL AS 175' RIGHT, F14-323
Remarks:

UNCONFINED COMPRESSION TEST REPORT

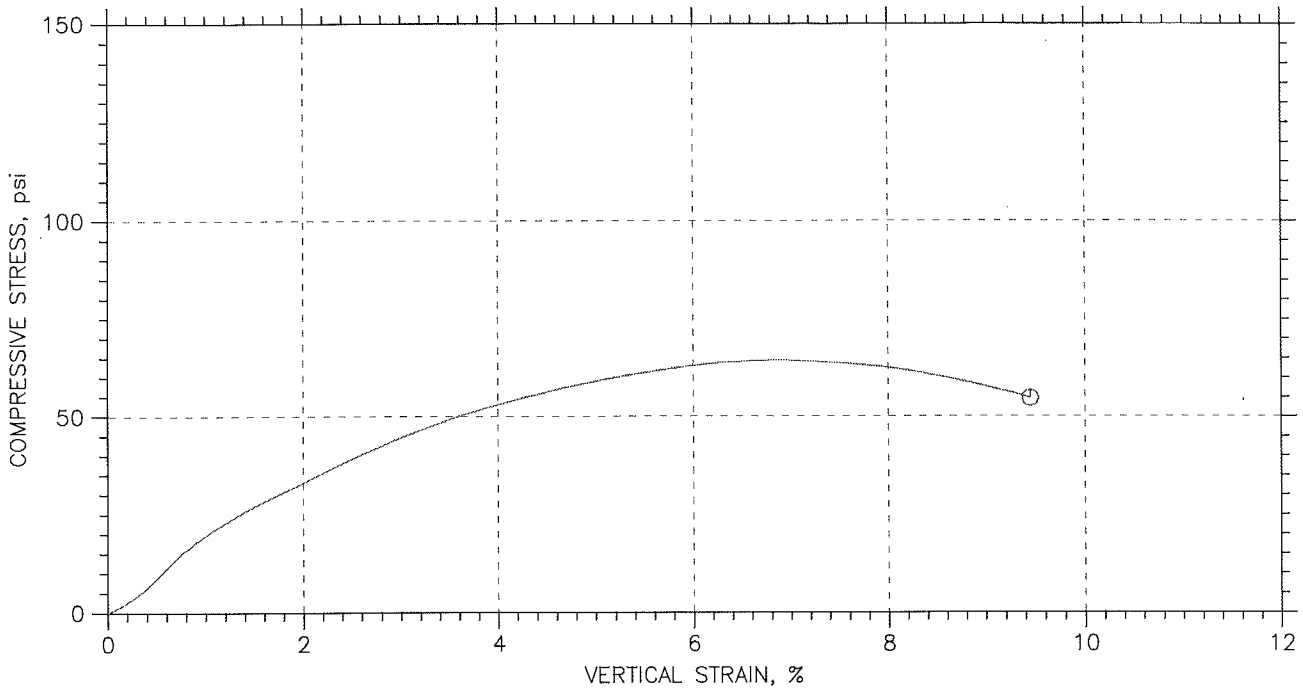


Symbol		⏲			
Test No.		1			
Initial	Diameter, in	2.764			
	Height, in	5.944			
	Water Content, %	23.67			
	Dry Density, pcf	96.67			
	Saturation, %	88.65			
	Void Ratio	0.705			
Unconfined Compressive Strength, psi		40.48			
Undrained Shear Strength, psi		20.24			
Time to Failure, min		1.6706			
Strain Rate, %/min		1			
Measured Specific Gravity		2.64			
Liquid Limit		---			
Plastic Limit		---			
Plasticity Index		---			
Failure Sketch					

NRCS Natural Resources Conservation Service

Project: PLUM CREEK SITE #12
Location: TX
Project No.: 14-1227
Boring No.: 210.1
Sample Type: CORE
Description: ~15+25 cL AS 175' RIGHT, F14-324
Remarks:

UNCONFINED COMPRESSION TEST REPORT

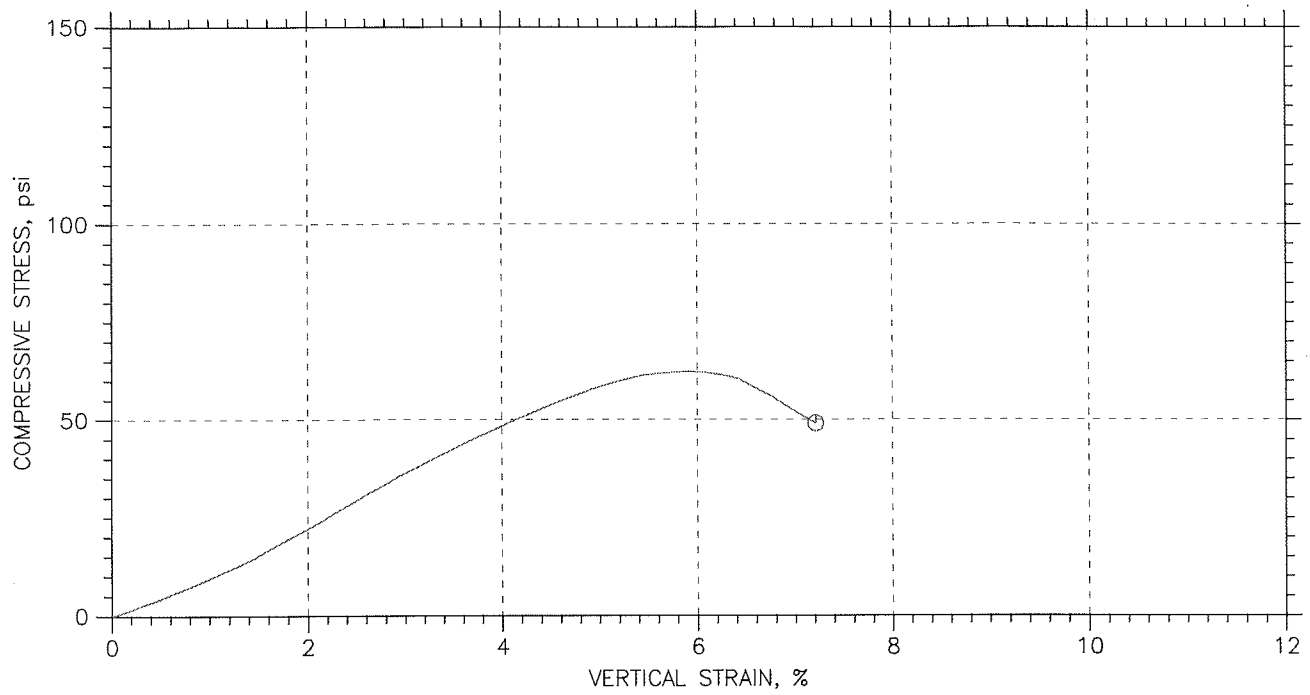


Symbol		⏲			
Test No.		1			
Initial	Diameter, in	2.767			
	Height, in	5.897			
	Water Content, %	19.69			
	Dry Density, pcf	107.6			
	Saturation, %	96.45			
	Void Ratio	0.543			
Unconfined Compressive Strength, psi		64.47			
Undrained Shear Strength, psi		32.24			
Time to Failure, min		7.001			
Strain Rate, %/min		1			
Measured Specific Gravity		2.66			
Liquid Limit		---			
Plastic Limit		---			
Plasticity Index		---			
Failure Sketch					

NRCS Natural Resources Conservation Service

Project: PLUM CREEK SITE #12
Location: TX
Project No.: 14-1228
Boring No.: 210.2
Sample Type: CORE
Description: ~15+25 cL AS 175' RIGHT, F14-325
Remarks:

UNCONFINED COMPRESSION TEST REPORT



Symbol		⏲			
Test No.		1			
Initial	Diameter, in	2.765			
	Height, in	6.104			
	Water Content, %	19.27			
	Dry Density, pcf	109.			
	Saturation, %	95.79			
	Void Ratio	0.541			
Unconfined Compressive Strength, psi		62.31			
Undrained Shear Strength, psi		31.16			
Time to Failure, min		6.0023			
Strain Rate, %/min		1			
Measured Specific Gravity		2.69			
Liquid Limit		---			
Plastic Limit		---			
Plasticity Index		---			
Failure Sketch					

NRCS Natural Resources Conservation Service

Project: PLUM CREEK SITE #12
Location: TX
Project No.: 14-1229
Boring No.: 211.1
Sample Type: CORE
Description: ~17+25 cL AS 175' RIGHT, F14-326
Remarks: