AGENCY OF TRANSPORTATION **OFFICE MEMORANDUM**

To: Brandon Kipp, P.E., Pavement Management Project Manager

END CEE

From: Eric Denardo, Geotechnical Engineer, via Callie Ewald, P. E., Geotechnical Engineering Manager

Date: November 15, 2017

Subject: Essex NH 2931(2) Mast Arm Geotechnical Data Report

1.0 INTRODUCTION

We have completed our geotechnical investigation for the traffic signal mast arm foundation for the Essex NH 2931(2) project located at the intersection of Vermont Route 117 and Vermont Route 289 in Essex, Vermont. In conjunction with a pavement reclaim project, this project consists of the replacement of the existing signal with a mast arm and foundation. Contained herein are the results of our subsurface investigation, geotechnical analysis, and additional design parameters as determined using the 2014 AASHTO LRFD *Bridge Design Specifications*.

2.0 FIELD INVESTIGATION

The field investigation was conducted on October 23, 2017. One standard penetration boring was drilled in the approximate location of the mast arm to determine the subsurface profile for design and construction of the mast arm foundation. The location of this boring can be found in Table 2.1, as well as in the attached Boring Location Plan. The boring location was provided by Brandon Kipp as part of the Geotechnical Request Form dated October 10, 2017. The values for the Northing and Easting are based on the Vermont State Plane Grid NAD 83 Coordinate System, and were located in the field using a handheld Trimble GPS unit. Elevations for the borings were then taken off a VTrans survey file. The locations and elevations of the borings should be considered accurate only to the degree implied by the method used to determine them.

Table 2.1: Boring Locations

Boring	Northing (ft)	Easting (ft)	Elevation (ft)
B-101	723049.5	1491186.6	287.2

The boring was performed in general accordance with AASHTO T206, *Standard Method of Test for Penetration Test and Split-Barrel Sampling of Soils*. During the boring operations, split spoon samples and standard penetration tests (SPT) were taken continuously for the first 14 feet and then at 5 foot intervals from 20 feet until a depth of approximately 27 feet. Initially, cohesive material was encountered at a depth of 10 feet however no material was able to be recovered. Typically for mast arm borings, SPTs are taken continuously to a depth of 12 feet and then at 5 foot intervals to a depth of 27 feet. Due to the lack of recovery from 10 to 12 feet, an additional test was completed from 12 to 14 feet. Cohesive material was identified at depths of 14 to 16 feet and was sampled accordingly using two Shelby tubes in accordance with AASHTO T207, *Thin Walled Tube Sampling of Soils.* No bedrock was encountered during the drilling process.

Soil samples were visually identified in the field and SPT blow counts were recorded on the boring log. Soil samples were preserved and returned to Construction and Materials Bureau Central laboratory for testing and further evaluation. Upon completion of the laboratory testing, the boring log was revised to reflect the results of the laboratory classification results. The attached boring log displays the types of soils and strata encountered and includes the laboratory test results, SPT data, and any pertinent observations made by the boring crew.

3.0 FIELD AND LABORATORY TESTS

The standard penetration resistance of the in-situ soil is determined by the number of blows required to drive a 2 inch OD split barrel sampler into the soil with a 140 pound hammer dropped from a height of 30 inches, in accordance with procedures specified in AASHTO T206. During the standard penetration test (SPT), the sampler is driven for a total length of 2 feet, while counting the blows for each 6 inch increment. The SPT N-value, which is defined as the sum of the number of blows required to drive the sampler through the second and third increments, is commonly used with established correlations to estimate a number of soil parameters, particularly the shear strength and density of cohesionless soils. The N-values provided on the boring log are raw values and have not been corrected for energy, borehole diameter, rod length, or overburden pressure. The Vermont Agency of Transportation has determined a hammer energy correction factor, C_E, to account for the efficiency of the SPT hammer on the drill rig. For this project, a CME 55 track rig was used, with a C_E of 1.41. This value, included on the boring log, was used in soil parameter calculations. Laboratory tests were conducted on all samples to evaluate grain size, moisture content, percent finer than No. 200 sieve, and liquid and plastic limits when applicable. Results for this testing can be found on the attached boring log.

Three Consolidated undrained triaxial tests were performed on the undisturbed samples taken from 14 to 16 feet and 16 to 18 feet in accordance with AASHTO T297, *Consolidated Undrained Triaxial Compression Test on Cohesive Soils*. The tube samples were tested at the approximate in-situ consolidation pressure, as well as half and double the in-situ pressure, in order to develop a Mohr circle and determine design parameters for the cohesive soil layer. Since pore pressures are measured during the test, both drained and undrained shear strength parameters can be determined from this procedure. Following the strength testing, laboratory tests were performed to determine the soil classification of each sample tested.

4.0 SOIL PROFILE

Review of laboratory data and the boring log revealed the following information pertaining to the soil strata. It should be noted that groundwater elevations are subject to change given the fact that the borehole was generally left open for a short period of time. Because groundwater elevations can fluctuate seasonally and are affected by temperature and precipitation, groundwater may be encountered during construction when not previously noted in the log.

4.1 B-101 The ground surface elevation at B-101 was approximately 287.2 feet. Groundwater was encountered during drilling operations on October 23, 2017 at a depth of 3.6 feet below the ground surface corresponding to an approximate elevation of 283.6 feet. The material encountered from a depth of 8 feet and below was identified as clay in the field and an in-situ sample was recovered accordingly. Upon further lab testing and classification, the layer was determined to be low plasticity silt.

Table 4.1: B-101 Soil Strata

Depth (Below Ground Surface Elevation)	Soil Profile
0 – 4 feet	Medium Dense Gravelly Sand
4 – 8 feet	Medium Dense Sandy Gravel
8 – 27 feet	Loose Silt

5.0 RECOMMENDATIONS

5.1 Design Guidelines

The Geotechnical Engineering unit of VTrans has developed *Materials and Research Engineering Instructions (MREI) 10-01*, which "standardizes VTrans' foundation designs for overhead structures such as signal or sign bridges, mast arms, and strain poles during plan (preliminary and final) development or construction." This document should be referenced for the contractor's use. The document is available on the Agency's website at the following address:

https://outside.vermont.gov/agency/vtrans/external/docs/construction/03GeotechEng/Engineering/Mast%20Arm%20and%20Overhead%20Sign%20Support%20Foundations%20MREI%2010-01%20Engineering.pdf

5.2 Design Parameters

Based on the soil profile above, laboratory testing, and the attached boring log, the in-situ soil properties can be found in Table 5.1, while common construction materials can be found in Table 5.2. These values should be used in the design of the mast arm foundation.

The borehole was generally only open for a short time period during the drilling and clean-up activities. In addition, the soils at the site contain fines and produce water slowly. Since groundwater elevations can fluctuate seasonally and are affected by temperature and precipitation, a groundwater level of 2 feet below the ground surface is recommended for design.

The values listed below should be used when designing any substructure units. It is recommended that values of K_o be used for calculating earth pressures where the structure is not allowed to deflect longitudinally, away from or into the retained soil mass. Values for K_a should be utilized for an active earth pressure condition where the structure is moving away from the soil mass and K_p where the structure is moving toward the soil mass. K_a and K_p values are based on a vertical back of wall and a horizontal ground surface behind the wall.

Table 5.1: Engineering Properties of In-Situ Soils

	B-101		
	Medium Dense Gravelly Sand	**Medium Dense Sandy Gravel**	**Loose Silt**
Unit Weight, γ (lbs/ft^3):	115	120	110
Internal Friction Angle, ϕ (degrees):	34	35	25.3*
Soil Modulus, k (lb/in^3):	90	60	20
Cohesion, C (psf)	-	-	58*
Coefficient of Friction, f			
- mass concrete cast against soil:	0.55	0.55	0.32
- soil against precast/formed concrete:	0.44	0.44	0.25
Active Earth Pressure Coef., K_a:	0.28	0.27	0.40
Passive Earth Pressure Coef., K_p:	3.54	3.69	2.49
At-Rest Earth Pressure Coefficient, K_o:	0.44	0.43	0.57

**Laboratory tested value*

Table 5.2: Properties of Construction Materials

	703.04 - Granular Borrow	**704.08 - Granular Backfill for Structures**
Density (lb/ft^3):	130	140
Internal Friction Angle, φ (degrees):	32	34
Coefficient of Friction, f		
- mass concrete cast against soil:	0.45	0.55
- soil against precast/formed concrete:	0.40	0.48
Active Earth Pressure Coefficient, K_a:	0.31	0.40
Passive Earth Pressure Coefficient, K_p:	3.25	2.49
At-Rest Earth Pressure Coefficient, K_o:	0.47	0.57

6.0 CONCLUSION

We recommend this report be included with the contract documents when the project is advertised.

If you have any questions or would like to discuss this report, please contact us by phone at (802) 828-2561. A computer generated boring log is attached and available in the M:\Projects\15v021\MaterialsResearch folder.

Attachments: Boring Location Plan – 1 Page
Boring Log – 1 Page
Consolidated Undrained Triaxial Test Results – 3 Pages

cc: Read File/
Project File/CEE
END

VT ROUTE 289
RAMP D
MM 2.078
STA. 109+72

VT ROUTE 289
RAMP D
MM 2.095
STA. 110+59

GUIDE POST

GUIDE POST

GUIDE POST

GUIDE POST

GUIDE POST

LIGHT POLE

TRAFFIC LIGHT

PI STA 111+18.43

UE AER E&T

UE AER E&T

UE AER E&T

SEE PREVIOUS SHEET

110+00

111+00

112+00

0+25

MATCHLINE STA.

SPAN WIRE

S

G

B-101

TRAFFIC LIGHT

LIGHT POLE

LIGHT POLE

COMB
28
74
74975

N

VT STATE PLANE GRID

NOT TO SCALE

0 20 40
SCALE IN FEET

BORING CHART

HOLE N.	SURVEY STATION	OFFSET (FT)	NORTHING (FT)	EASTING (FT)	GROUND ELEV. (FT)
B-101	110+80	50.1 RT	723049.5	1491186.6	287.2

PROJECT NAME: ESSEX
PROJECT NUMBER: NH 2931(2)

FILE NAME: z15v02lbdr.dgn
PROJECT LEADER: C. LATHROP
DESIGNED BY: S. LAMPHERE
PLAN SHEET 10

PLOT DATE: $$$$DATE$$$
DRAWN BY: J. GOODALL
CHECKED BY: C. LATHROP
SHEET $S"$ OF $T"$

STATE OF VERMONT
AGENCY OF TRANSPORTATION
CONSTRUCTION AND
MATERIALS BUREAU
CENTRAL LABORATORY

BORING LOG

Essex
NH 2931(2)
VT 117/289 Mast Arm

Boring No.: **B-101**
Page No.: 1 of 1
Pin No.: 15v021
Checked By: END

Boring Crew: Olden, Judkins, Gonyaw
Date Started: 10/23/17 Date Finished: 10/23/17
VTSPG NAD83: N 723049.50 ft E 1491186.60 ft
Station: 110+80 Offset: 50.10
Ground Elevation: 287.2 ft

	Casing	Sampler
Type:	WB	SS
I.D.:	4 in	1.5 in
Hammer Wt:	N.A.	140 lb.
Hammer Fall:	N.A.	30 in.
Hammer/Rod Type:		Auto/AWJ
Rig:	CME 55 TRACK	C_E = 1.41

Groundwater Observations

Date	Depth (ft)	Notes
10/23/17	3.6	W.T. during drilling

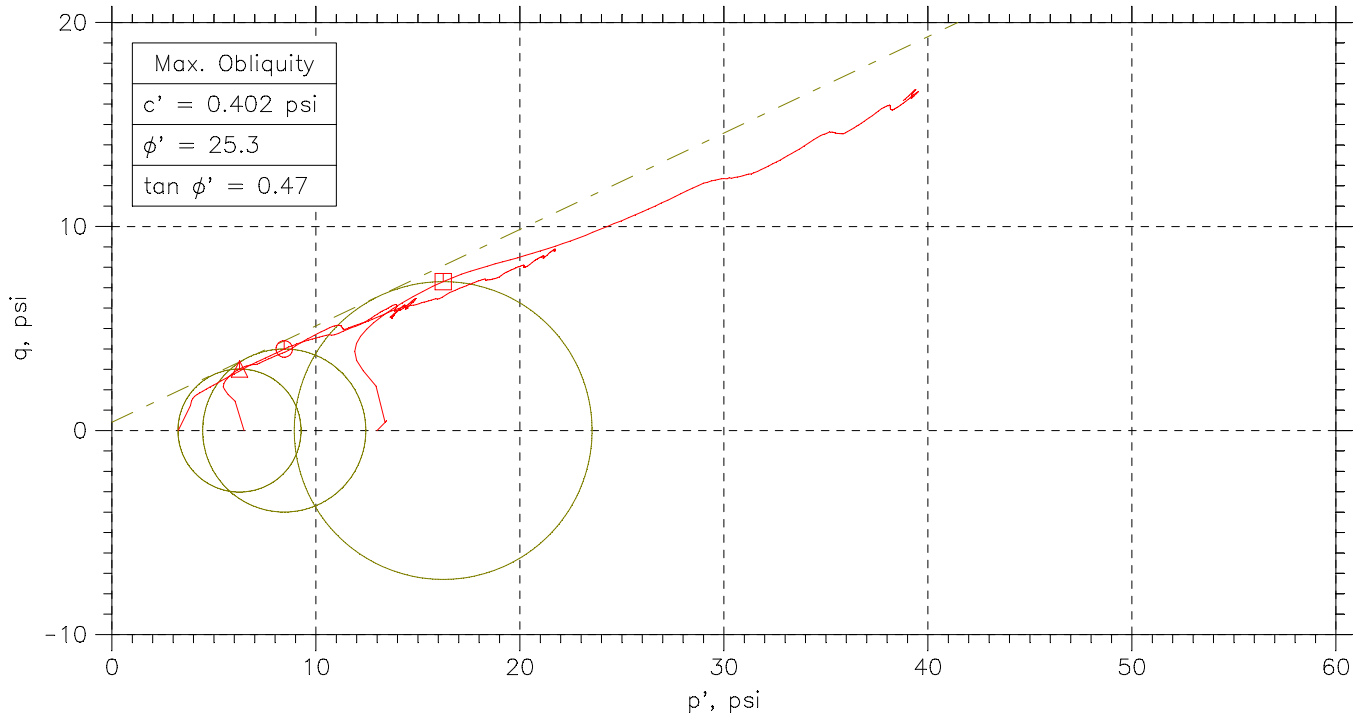
Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %	LL %	PI %
		A-3, GrSa, brn, Moist, Rec. = 0.8 ft, Lab Note: Broken rock was within sample.	3-3-7-8 (10)	5.5	35.6	55.3	9.1		
		A-3, GrSa, brn, Moist, Rec. = 1.3 ft, Lab Note: Broken rock, sticks, and twigs were within sample.	4-4-3-3 (7)	11.6	20.5	70.6	8.9		
5		A-1-a, SaGr, brn, Wet, Rec. = 1.2 ft	3-5-6-7 (11)	12.3	51.6	40.4	8.0		
		A-1-a, SaGr, brn, Wet, Rec. = 1.3 ft	6-6-4-5 (10)	12.0	54.5	38.2	7.3		
		A-2-4, SiGrSa, brn, Moist, Rec. = 0.6 ft, Lab Note: A small amount of clay was within sample. Sample tested non-plastic. Field Note: Cleaned out casing 6.9-8.0 feet.		10.5	35.7	37.8	26.5		
			3-4-3-4 (7)	20.3	10.2	27.1	62.7	21	6
		A-4, SaSi, gry, Moist, Rec. = 0.4 ft, Field Note: Cleaned out casing 9.5-10.0 feet.							
10		Field Note:, No Recovery, Appears to be clay, Field Note: Cleaned out casing 11.1-12.0 feet.	1-2-2-2 (4)						
		A-4, Si, gry, Moist, Rec. = 2.0 ft, Lab Note: A small amount of clay was within sample. Sample tested non-plastic.	WH (WH)	23.2	1.8	11.9	86.3		
		A-4, Si, gry, Moist, Lab Note: Material from triaxial test "A" and "C". Sample tested non-plastic.		21.7	1.8	11.9	86.3		
15		Visual Description:, Si, gry, Moist, Lab Note: Material from triaxial test "B". Field Note: Cleaned out casing 19.0-20.0 feet.							
20		A-4, Si, gry, Moist, Rec. = 1.8 ft, Field Note: Cleaned out casing 22.4-25.0 feet.	1-1-3-3 (4)	23.5	1.4	5.6	93.0	24	3
25		A-4, Si, gry, Moist, Rec. = 2.0 ft, Lab Note: A small amount of clay was within sample. Sample tested non-plastic.	1-2-2-3 (4)	22.8	0.5	8.9	90.6		
		Hole stopped @ 27.0 ft							

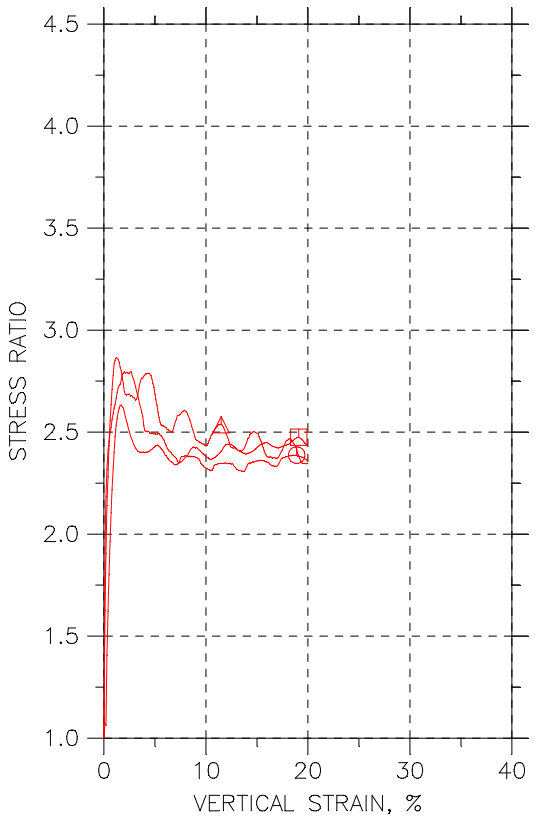
Remarks:
Hole collapsed at 1.4 feet.

Notes:
1. Stratification lines represent approximate boundary between material types. Transition may be gradual.
2. N Values have not been corrected for hammer energy. C_E is the hammer energy correction factor.
3. Water level readings have been made at times and under conditions stated. Fluctuations may occur due to other factors than those present at the time measurements were made.

BORING LOG 2 ESSEX NH2931(2).GPJ VERMONT AOT.GDT 11/15/17

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767





Symbol		◷	△	□	
Sample No.					
Test No.		C	A	B	
Depth		14-16	14-16	16-18	
Initial	Diameter, in	2.883	2.879	2.878	
	Height, in	5.95	5.81	5.85	
	Water Content, %	21.7	21.7	21.8	
	Dry Density, pcf	106.4	106.3	107.1	
	Saturation, %	101.5	101.2	103.9	
	Void Ratio	0.572	0.574	0.562	
Before Shear	Water Content, %	23.0	23.9	21.5	
	Dry Density, pcf	103.6	102.	106.1	
	Saturation*, %	100.0	100.0	100.0	
	Void Ratio	0.615	0.64	0.577	
	Back Press., psi	43.99	41.	28.97	
Ver. Eff. Cons. Stress, psi		3.245	6.485	13.01	
Shear Strength, psi		8.896	6.478	16.72	
Strain at Failure, %		18.9	11.5	19.1	
Strain Rate, %/min		0.06667	0.02177	0.096	
B-Value		0.95	0.95	1.08	
Estimated Specific Gravity		2.68	2.68	2.68	
Liquid Limit		NP	NP	NP	
Plastic Limit		NP	NP	NP	

Project:

Location:

Project No.: Essex

Boring No.: B101

Sample Type: ST

Description: 18" into sample

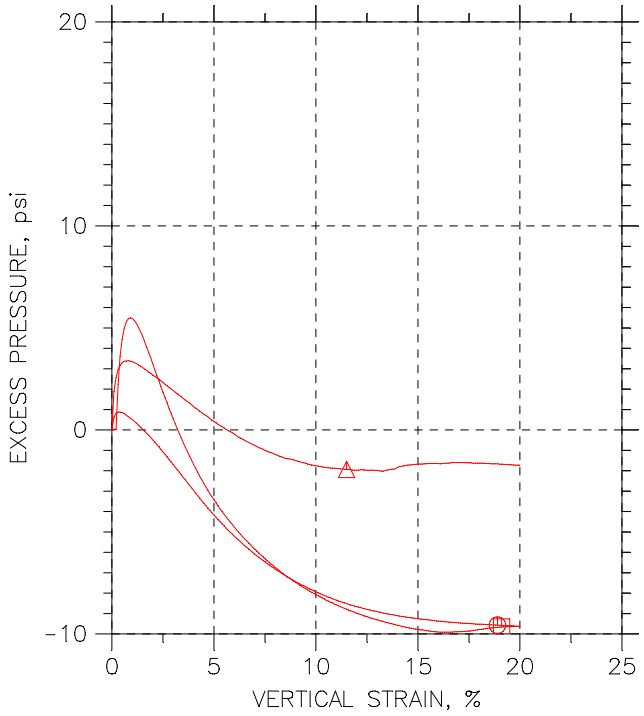
Remarks:

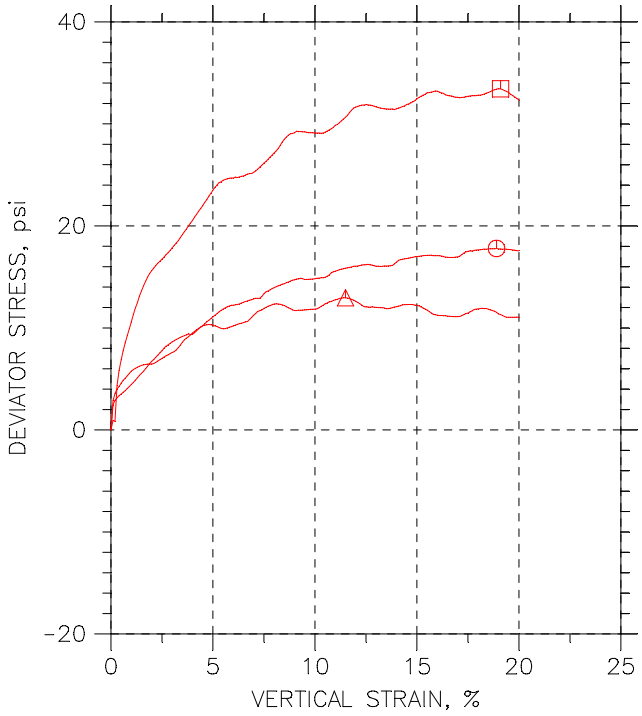
Phase calculations based on start and end of test.

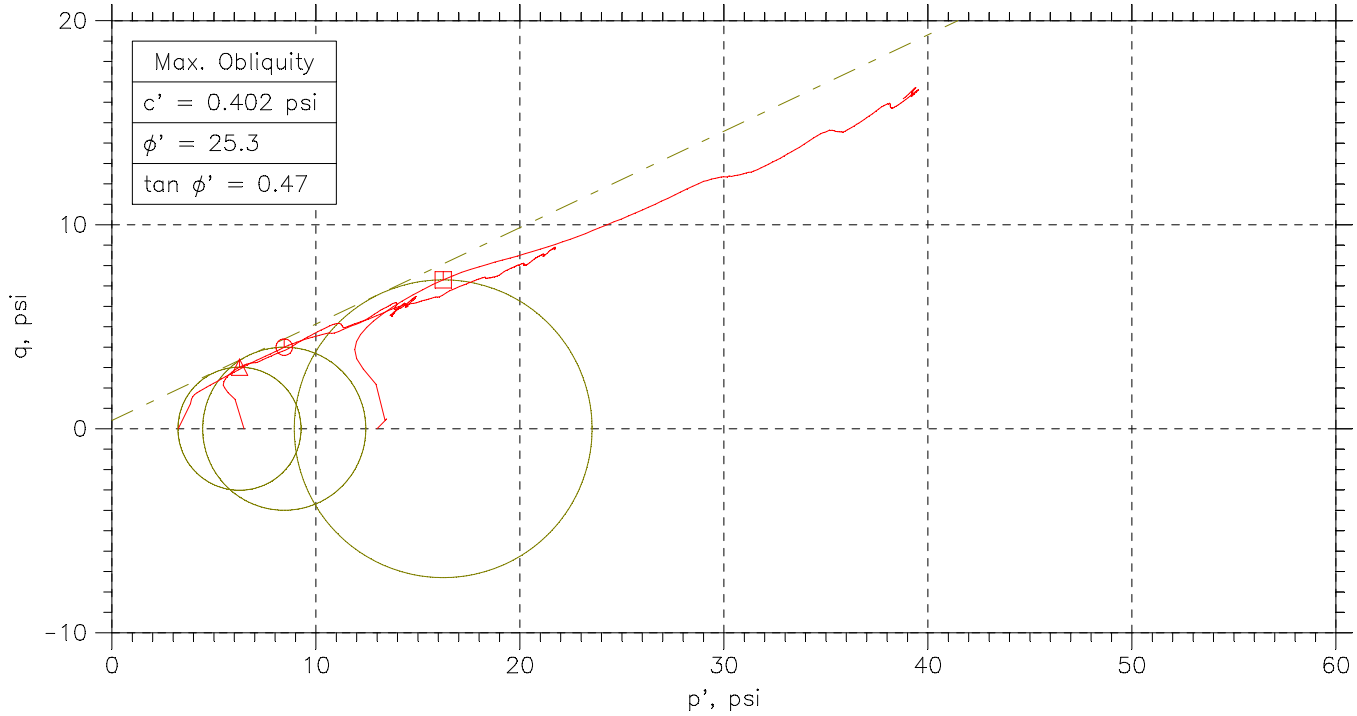
* Saturation is set to 100% for phase calculations

Tue, 14-NOV-2017 07:08:51

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767





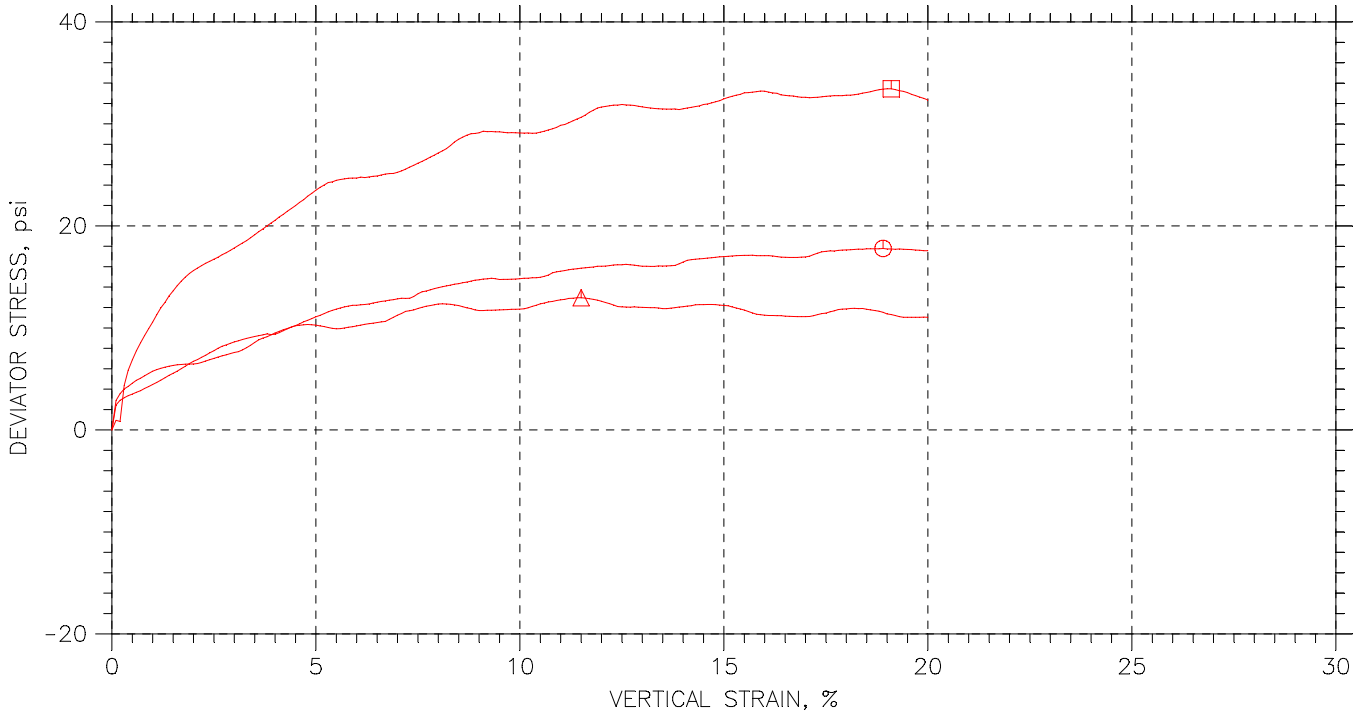


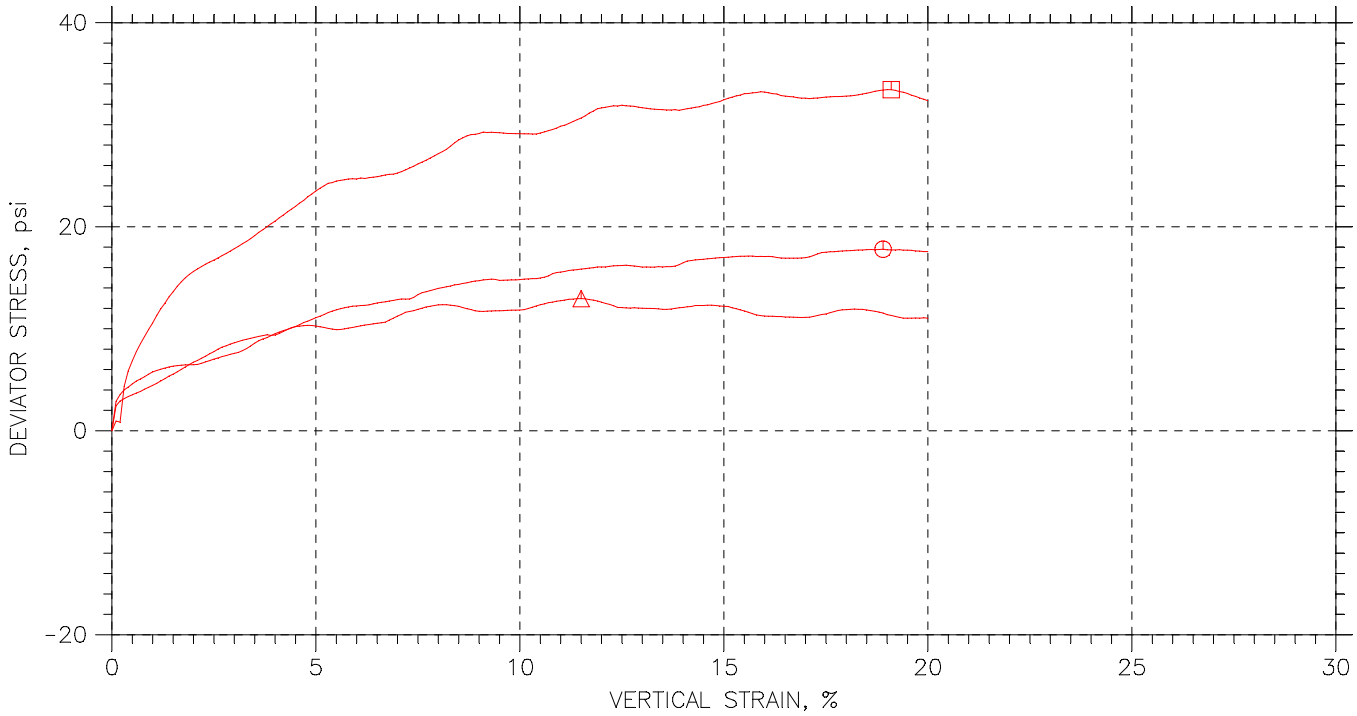
	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⏲		C	14-16	END	11-8-17	CEE		ESSEB101U1CUC.dat
△		A	14-16	END	11-3-17	CEE		ESSEB101U1CUA.dat
◳		B	16-18	END	11-6-17	CEE		ESSEB101U2CUB.dat

Project:	Location:	Project No.: Essex
Boring No.: B101	Sample Type: ST	
Description: 18" into sample		
Remarks:		

Tue, 14-NOV-2017 07:08:51

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767





	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊙		C	14-16	END	11-8-17	CEE		ESSEB101U1CUC.dat
△		A	14-16	END	11-3-17	CEE		ESSEB101U1CUA.dat
◳		B	16-18	END	11-6-17	CEE		ESSEB101U2CUB.dat

Project:	Location:	Project No.: Essex
Boring No.: B101	Sample Type: ST	
Description: 18" into sample		
Remarks:		

Tue, 14-NOV-2017 07:08:52