

# Geotechnical Data Report

**Veterans Terminal Bulkhead Reconstruction  
North Charleston, South Carolina**

December 10, 2012

Terracon Project No. EN125099

Parsons Brinckerhoff Project No. 173533-04

**Prepared For:**

Parsons Brinckerhoff  
c/o SCSPA Engineering Department  
North Charleston, South Carolina

**Prepared By:**

Terracon Consultants, Inc.  
North Charleston, South Carolina

Offices Nationwide  
Employee-Owned

Established in 1965  
[terracon.com](http://terracon.com)

**Terracon**

Geotechnical ■ Environmental ■ Construction Materials ■ Facilities

December 10, 2012



Veterans Terminal  
2400 South Hobson Avenue  
North Charleston, South Carolina 29405

Attn: Mr. Matthew P. Smith, P.E.  
P: [843] 856 7049  
M: [843] 754 4908  
E: SmithMat@pbworld.com

Re: Geotechnical Data Report  
Veterans Terminal Bulkhead Reconstruction - 173533-04  
North Charleston, South Carolina  
Terracon Project No. EN125099

Dear Mr. Smith:

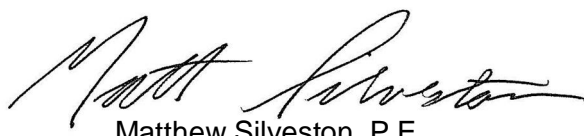
Terracon Consultants, Inc. (Terracon) has completed the geotechnical services for the above referenced project. This investigation was performed in general accordance with the latest statement of work, which was provided by Parsons Brinckerhoff on November 7, 2012. This report presents the findings of the subsurface exploration and the results of the laboratory testing.

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

Sincerely,  
**Terracon Consultants, Inc.**



Ryan N. Keiper, E.I.T.  
Geotechnical Project Manager



Matthew Silveston, P.E.  
Principal  
South Carolina: PE- 20258

Enclosures  
cc: 1 – Client (PDF)

## **APPENDIX A**

### **FIELD EXPLORATION**

Exhibit A-1	Field Testing Summary
Exhibit A-2	Field Exploration Description
Exhibit A-3	Cone Penetration Test Records
Exhibit A-4	Drill Rig Calibration Report
Exhibit A-5	CPT Cone Calibration Reports

Test Designation	Test Type <sup>1</sup>	Latitude <sup>2</sup> (NAD83)	Longitude (NAD83)	Northing <sup>2</sup> (NAD83)	Easting (NAD83)	Northing <sup>2</sup> (NAD27)	Easting (NAD27)	Elevation <sup>2</sup> (U.S. feet)	Termination Depth (feet)	Test Started	Test Completed
BH-1	STB	32.85199	-79.95121	372,269	2,322,056	372,142	2,322,023	0	100.0	11/13/2012	11/13/2012
BH-2	STB	32.85142	-79.95031	372,065	2,322,334	371,937	2,322,301	0	100.0	11/12/2012	11/12/2012
BH-3	STB	32.85119	-79.95018	371,982	2,322,375	371,854	2,322,342	0	100.0	11/14/2012	11/14/2012
CP-1	CPT	32.85160	-79.95004	372,131	2,322,417	372,004	2,322,383	4	Surface Refusal	11/9/2012	NA
CP-1A	CPT	32.85160	-79.94998	372,131	2,322,435	372,004	2,322,402	4	Surface Refusal	11/9/2012	NA
CP-1B	CPT	32.85162	-79.95000	372,139	2,322,429	372,011	2,322,396	2.5	Surface Refusal	11/9/2012	NA
CP-1C	CPT	32.85162	-79.95000	372,139	2,322,429	372,139	2,322,429	2.5	80.38	11/9/2012	11/9/2012
CP-2	CPT	32.85161	-79.95115	372,131	2,322,076	372,004	2,322,043	0	Surface Refusal	11/9/2012	NA
CP-2A	CPT	32.85162	-79.95113	372,135	2,322,082	372,008	2,322,049	0	73.95	11/9/2012	11/9/2012
CP-3	CPT	32.85117	-79.95019	371,974	2,322,372	371,847	2,322,339	2	Surface Refusal	11/9/2012	NA
CP-3A	CPT	32.85118	-79.95019	371,978	2,322,372	371,851	2,322,339	2	76.84	11/9/2012	11/9/2012
P-1	CPT	32.85178	-79.95030	372,196	2,322,336	372,068	2,322,303	2	31.43	11/12/2012	11/12/2012
P-1A	CPT	32.85173	-79.95030	372,178	2,322,336	372,050	2,322,303	2	63.32	11/12/2012	11/12/2012
Bulk Sample	NA	32.85148	-79.95032	372,087	2,322,331	371,959	2,322,298		3	11/27/2012	11/27/2012

1. Soil Test Boring (STB); Cone Penetration Test (CPT)

2. Survey results provided by Parsons Brinckerhoff and reference NAVD88, State Plane NAD83 3900 - South Carolina U.S. Feet, State Plane NAD27 3902 - South Carolina South U.S. Feet, and Geographic NAD83

## Field Exploration Description

The locations of the SBTs and CPTs were surveyed by Parsons Brinckerhoff.

## Cone Penetration Testing

The CPT hydraulically pushes an instrumented cone through the soil while continuous readings are recorded to a portable computer. The instrumented cone has a cross-sectional area of 10 square centimeters (cm<sup>2</sup>) with a 60° conical tip. The cone is advanced through the ground at a constant rate of 2 centimeters per second (2 cm/sec). No soil samples are gathered through this subsurface investigation technique. However, in-situ measurements of tip and side resistance and porewater pressure are taken every 2 centimeters. Porewater pressure measurements are taken directly behind the tip and a load cell located above the cone tip takes side friction measurements. These measurements can be correlated to various soil index properties for geotechnical design. The CPTs were conducted in accordance with ASTM D5778 *Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils*.

## Cone Penetration Classification

The tip resistance (qc) is measured as the maximum force over the projected area of the tip. It is a point stress related to the bearing capacity of the soil. The measured qc must be corrected for porewater pressure effects (Lunne et al, 1997), especially in clays and silts where porewater pressures typically vary greatly from hydrostatic. This corrected value is known as qt, which is reported in the Cone Penetration logs. The u2 position element is required for the measurement of penetration porewater pressures and the correction of tip resistance. The sleeve friction (fs) is used as a measure of soil type and can be expressed by friction ratio:

$$FR = f_s/q_t$$

The estimated stratigraphic profiles included in the Cone Penetration Logs are based on relationships between qt, fs, and U2. The normalized friction ratio (FRN) is calculated by using:

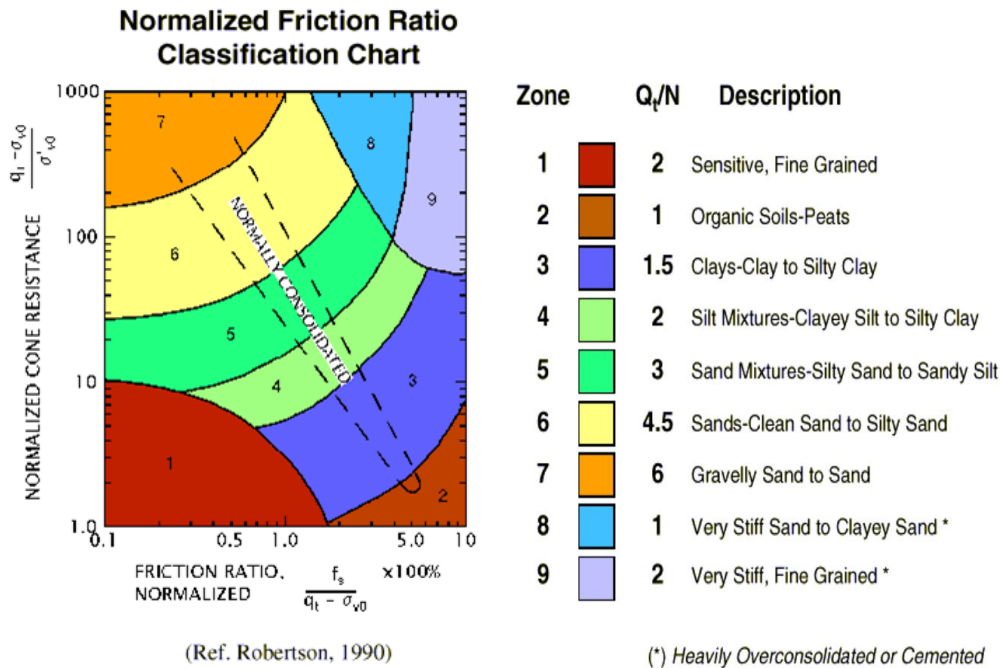
$$FR_N = \frac{f_s}{q_t - \sigma_{vo}'} \times 100\%$$

and is indicative of soil behavior and is used to classify the soil behavior type. Typically, cohesive soils, such as plastic silts and clays, have high FR values, low qt values, and generate large excess penetration porewater pressures. Cohesionless soils, such as sands, have lower FR's, high qt values, and typically do not generate excess penetration porewater pressures. The following graph (Robertson, 1990) presents one of the accepted correlations used to classify soils behavior types.

## Geotechnical Data Report

Veterans Terminal ■ North Charleston, South Carolina

December 10, 2012 ■ Terracon Project No. EN125099



## Soil Test Borings

All soil test borings and operations were conducted in accordance with:

- ASTM D1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils
- ASTM D4220 Standard Practices for Preserving and Transporting Soil
- ASTM D2487 Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Parson Brinckerhoff's field representative supervised all field operations and recorded and visually classified all soil samples.

# CPT LOG NO. CP-1C

Page 1 of 1

**PROJECT:** Veterans Terminal

**CLIENT:** Parsons Brinckerhoff  
c/o SCSPA Engineering Department

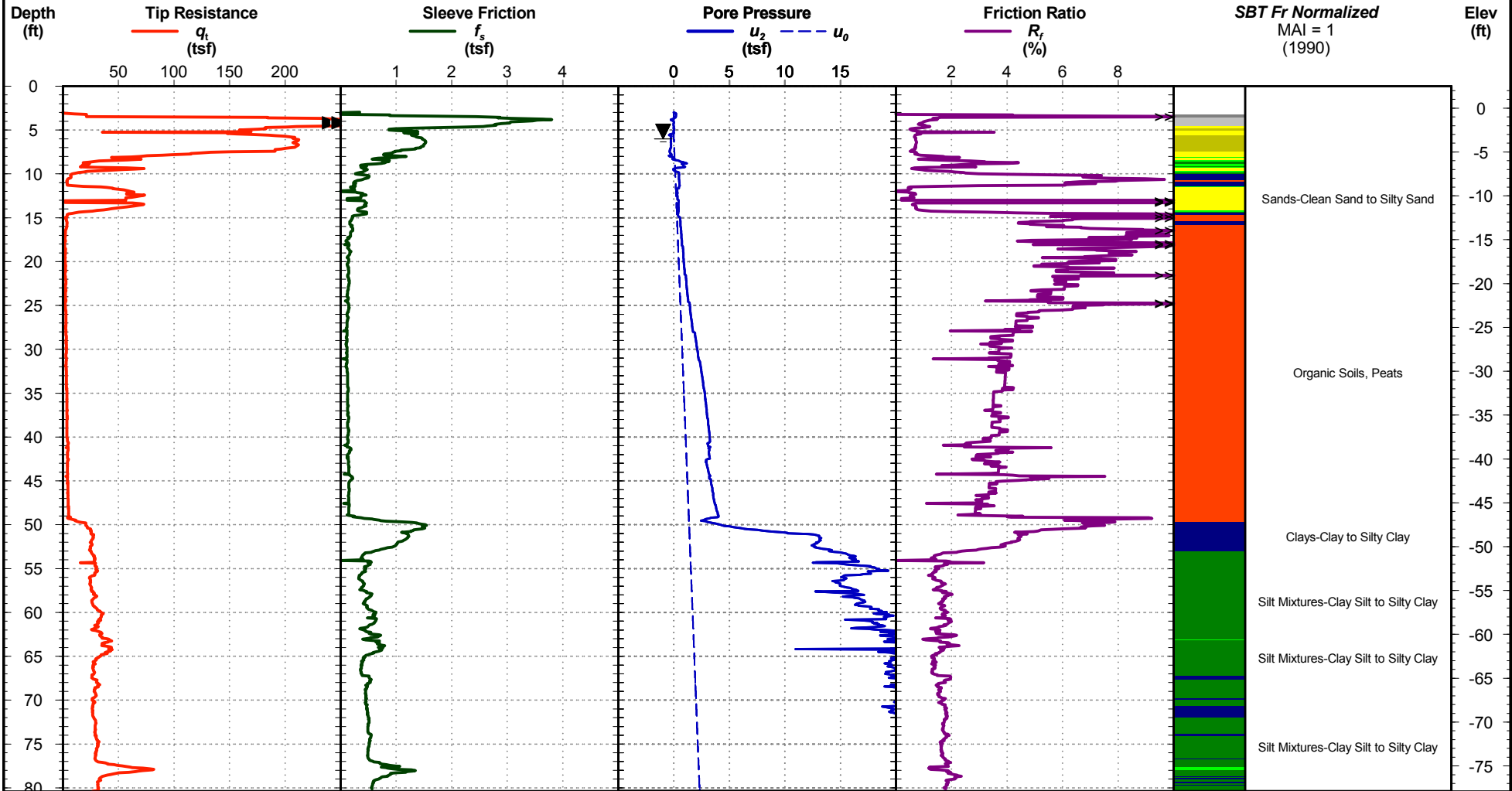
**SITE:** Veterans Terminal  
North Charleston, South Carolina

**BORING LOCATION:**

Elevation: 2.5 ft

Latitude: 32.85162  
Longitude: -79.95000

**OWNER:** South Carolina State Ports Authority  
North Charleston, South Carolina



See Exhibit A-2 for description of field procedures and explanation of CPT data interpretation.

- 1 - Sensitive, Fine Grained Soils
- 2 - Organic Soils, Peats
- 3 - Clays-Clay to Silty Clay

- 4 - Silt Mixtures-Clay Silt to Silty Clay
- 5 - Sand Mixtures-Silty Sand to Sandy Silt
- 6 - Sands-Clean Sand to Silty Sand
- 7 - Gravely Sand to Sand
- 8 - Very Stiff Clay to Clayey Sand
- 9 - Very Stiff Fine Grained Soils

Notes:  
CPT Cone I.D. Number 3752

**WATER LEVEL OBSERVATION**

▼ 6 ft estimated water depth

**Terracon**  
1450 5th Street West  
North Charleston, South Carolina

Test Completed: 11/9/2012

Driller/Rig: B. Rozier/Pagani TG 73

Project No.: EN125099

Termination Depth: 80.38 ft

Termination Criteria: Target Depth

Exhibit: A-3

# CPT LOG NO. CP-2A

Page 1 of 1

**PROJECT:** Veterans Terminal

**CLIENT:** Parsons Brinckerhoff  
c/o SCSPA Engineering Department

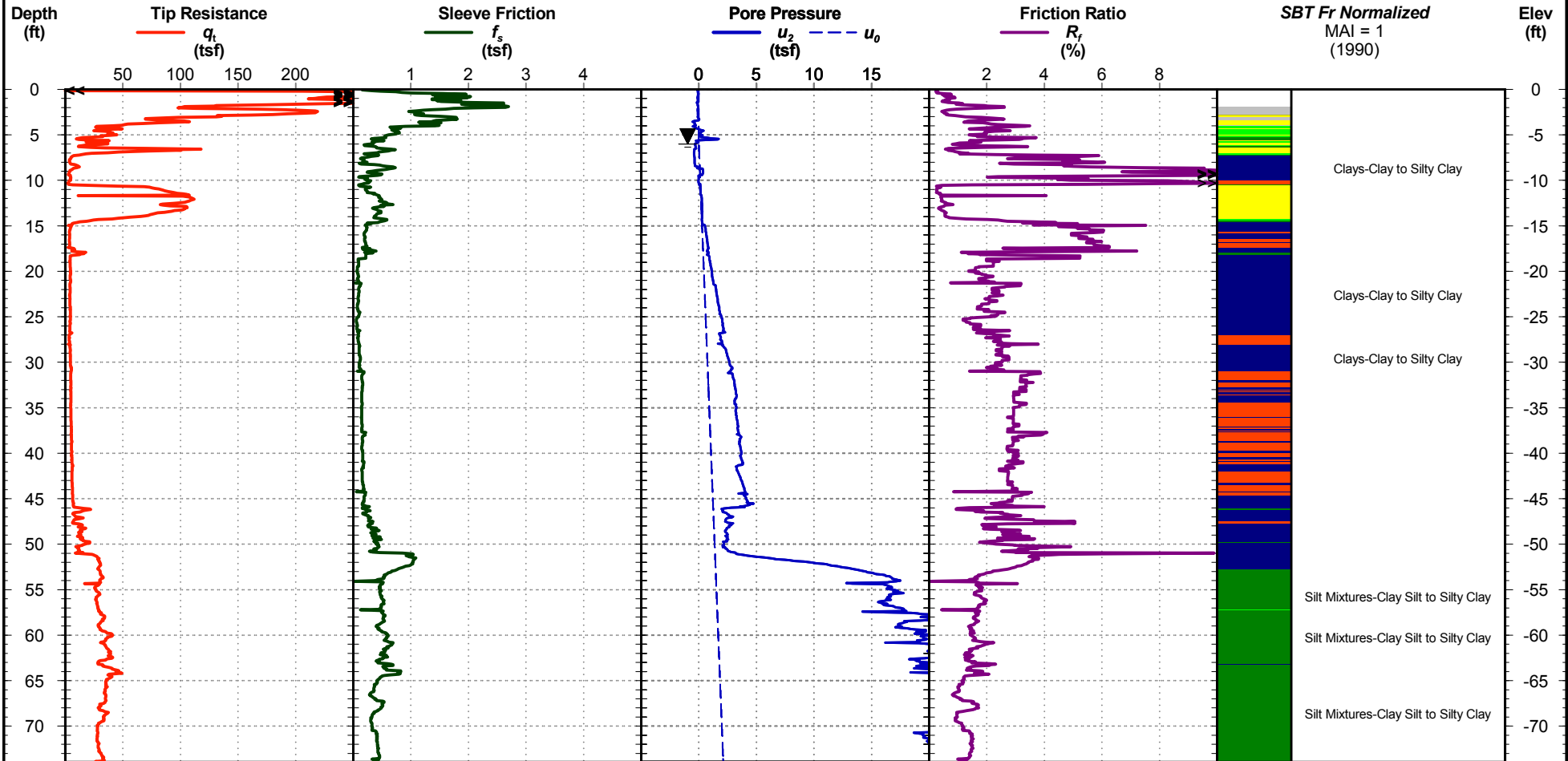
**SITE:** Veterans Terminal  
North Charleston, South Carolina

**BORING LOCATION:**

Elevation: 0.0 ft

Latitude: 32.85162  
Longitude: -79.95113

**OWNER:** South Carolina State Ports Authority  
North Charleston, South Carolina



See Exhibit A-2 for description of field procedures and explanation of CPT data interpretation.

- 1 - Sensitive, Fine Grained Soils
- 2 - Organic Soils, Peats
- 3 - Clays-Clay to Silty Clay

- 4 - Silt Mixtures-Clay Silt to Silty Clay
- 5 - Sand Mixtures-Silty Sand to Sandy Silt
- 6 - Sands-Clean Sand to Silty Sand

- 7 - Gravely Sand to Sand
- 8 - Very Stiff Clay to Clayey Sand
- 9 - Very Stiff Fine Grained Soils

Notes:  
CPT Cone I.D. Number 3752

**WATER LEVEL OBSERVATION**

6 ft estimated water depth

**Terracon**  
1450 5th Street West  
North Charleston, South Carolina

Test Completed: 11/9/2012

Driller/Rig: B. Rozier/Pagani TG 73

Project No.: EN125099

Termination Depth: 73.95 ft

Termination Criteria: Target Depth

Exhibit: A-3



# CPT LOG NO. CP-3A

Page 1 of 1

**PROJECT:** Veterans Terminal

**CLIENT:** Parsons Brinckerhoff  
c/o SCSPA Engineering Department

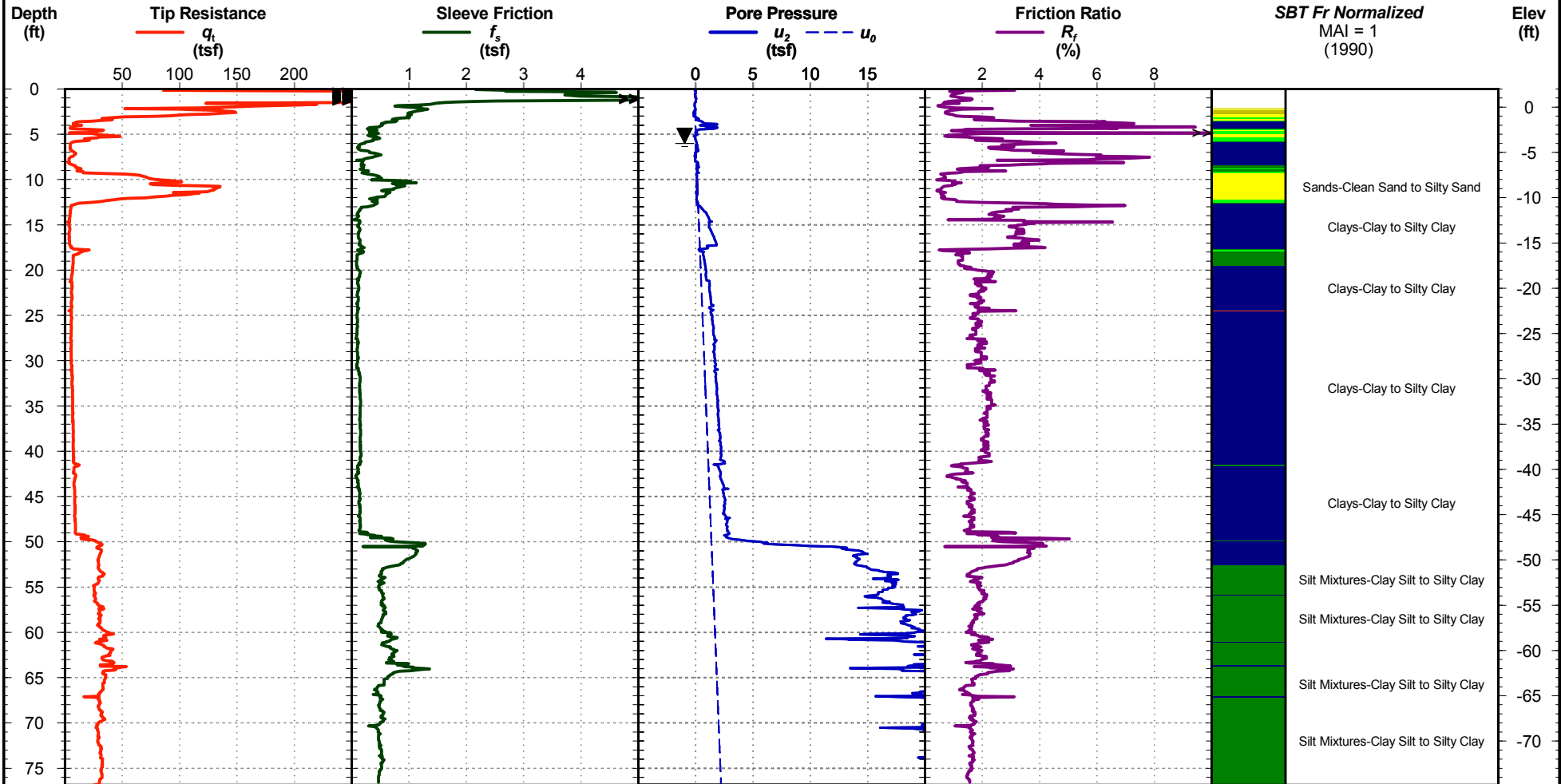
**SITE:** Veterans Terminal  
North Charleston, South Carolina

**BORING LOCATION:**

Elevation: 2.0 ft

Latitude: 32.85118  
Longitude: -79.95019

**OWNER:** South Carolina State Ports Authority  
North Charleston, South Carolina



See Exhibit A-2 for description of field procedures and explanation of CPT data interpretation.

- 1 - Sensitive, Fine Grained Soils
- 2 - Organic Soils, Peats
- 3 - Clays-Clay to Silty Clay

- 4 - Silt Mixtures-Clay Silt to Silty Clay
- 5 - Sand Mixtures-Silty Sand to Sandy Silt
- 6 - Sands-Clean Sand to Silty Sand

- 7 - Gravelly Sand to Sand
- 8 - Very Stiff Clay to Clayey Sand
- 9 - Very Stiff Fine Grained Soils

Notes:  
CPT Cone I.D. Number 3752

**WATER LEVEL OBSERVATION**

▼ 6 ft estimated water depth

**Terracon**  
1450 5th Street West  
North Charleston, South Carolina

Test Completed: 11/9/2012

Driller/Rig: B. Rozier/Pagani TG 73

Project No.: EN125099

Termination Depth: 76.84 ft

Termination Criteria: Target Depth

Exhibit: A-3

# CPT LOG NO. P-1

Page 1 of 1

**PROJECT:** Veterans Terminal

**CLIENT:** Parsons Brinckerhoff  
c/o SCSA Engineering Department

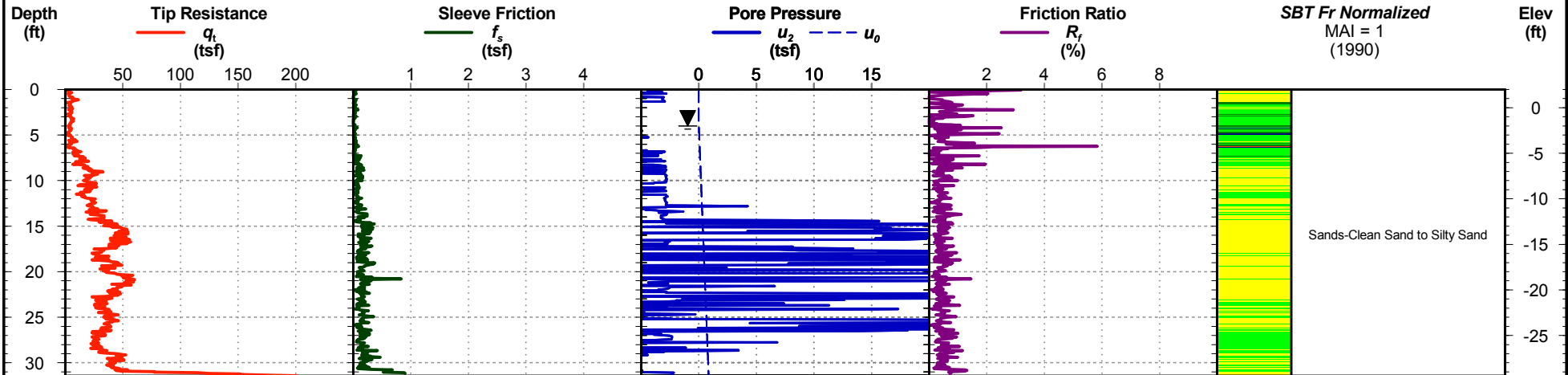
**SITE:** Veterans Terminal  
North Charleston, South Carolina

**BORING LOCATION:**

Elevation: 2.0 ft

Latitude: 32.85178  
Longitude: -79.95030

**OWNER:** South Carolina State Ports Authority  
North Charleston, South Carolina



See Exhibit A-2 for description of field procedures and explanation of CPT data interpretation.

Notes:  
CPT Cone I.D. Number 4156

WATER LEVEL OBSERVATION

▼ 4 ft estimated water depth

**Terracon**  
1450 5th Street West  
North Charleston, South Carolina

Test Completed: 11/12/2012

Driller/Rig: B. Rozier/Pagani TG 73

Project No.: EN125099

Termination Depth: 31.43 ft

Termination Criteria: Refusal

Exhibit: A-3

# CPT LOG NO. P-1A

Page 1 of 1

**PROJECT:** Veterans Terminal

**CLIENT:** Parsons Brinckerhoff  
c/o SCSPA Engineering Department

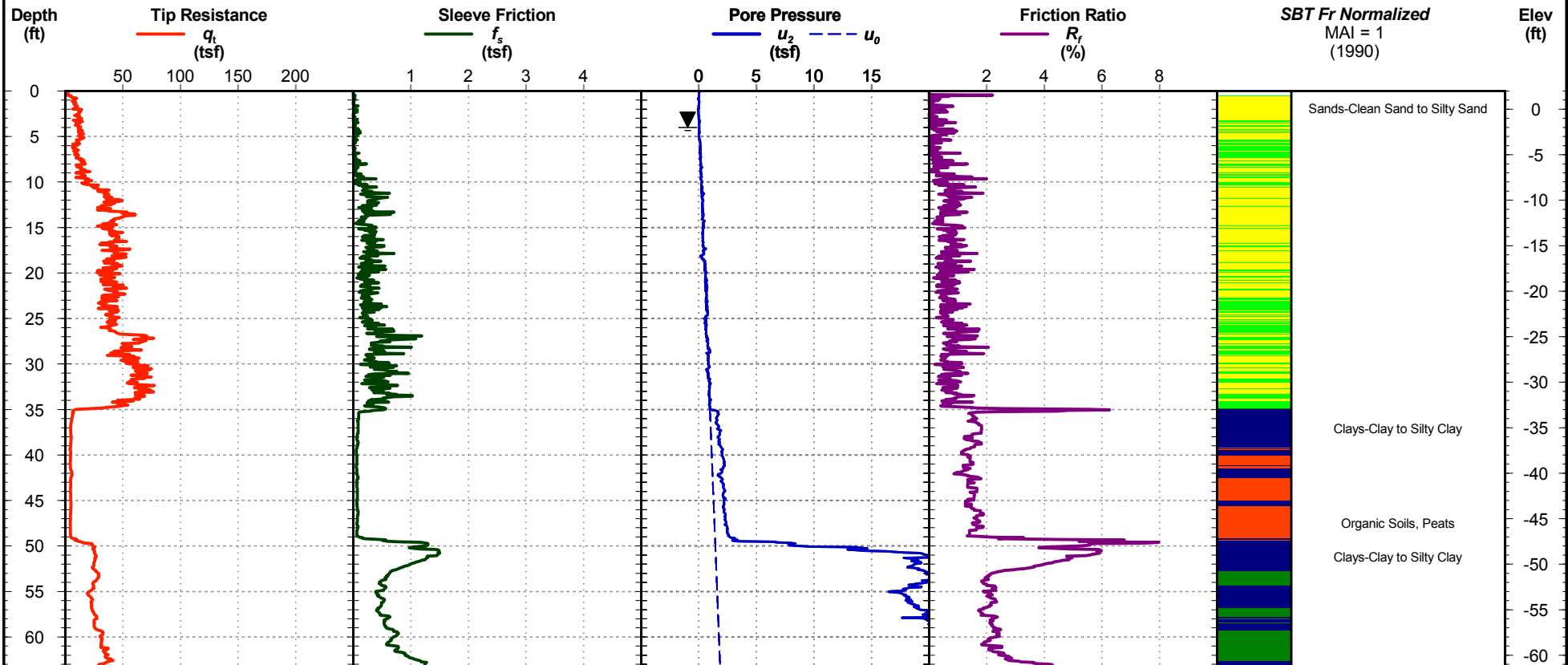
**SITE:** Veterans Terminal  
North Charleston, South Carolina

**BORING LOCATION:**

Elevation: 2.0 ft

Latitude: 32.85173  
Longitude: -79.95030

**OWNER:** South Carolina State Ports Authority  
North Charleston, South Carolina



See Exhibit A-2 for description of field procedures and explanation of CPT data interpretation.

- 1 - Sensitive, Fine Grained Soils
- 2 - Organic Soils, Peats
- 3 - Clays-Clay to Silty Clay

- 4 - Silt Mixtures-Clay Silt to Silty Clay
- 5 - Sand Mixtures-Silty Sand to Sandy Silt
- 6 - Sands-Clean Sand to Silty Sand

- 7 - Gravelly Sand to Sand
- 8 - Very Stiff Clay to Clayey Sand
- 9 - Very Stiff Fine Grained Soils

Notes:  
CPT Cone I.D. Number 4156

**WATER LEVEL OBSERVATION**

▼ 4 ft estimated water depth

**Terracon**  
1450 5th Street West  
North Charleston, South Carolina

Test Completed: 11/12/2012

Driller/Rig: B. Rozier/Track TG 73

Project No.: EN125099

Termination Depth: 63.32 ft

Termination Criteria: Target Depth

Exhibit: A-3

# DRILL RIG SPT HAMMER ENERGY CALIBRATION REPORT

**Drill Rig Model CME-550X SN 347863**

**Terracon Drill Rig No. 975**

**Latta, South Carolina**

January 6, 2012

Project No. EN115050

**Prepared for:**

Terracon Consultants, Inc.  
Charleston, South Carolina

**Prepared by:**

Terracon Consultants, Inc.  
Charleston, South Carolina



## 1.0 PROJECT INFORMATION

ITEM	DESCRIPTION
Drill Rig Identification	CME-550X, SN 347863 (see photograph on cover page)
Drill Rig Owner	Terracon
Drill Rig Operator	Craig Fredrychowski
Testing Date	December 15, 2011
Testing Location	Latta, South Carolina
Terracon Project Number	EN115050
Boring Identification	RA-225
Energy Measurement Depths	33.5 ft, 38.5 ft, 43.5 ft, 48.5 ft
Hammer Type	Automatic
Boring Method	Hollow Stem Auger
Drill Rods	<ul style="list-style-type: none"> <li>■ AWJ</li> <li>■ 1¾" outside diameter</li> <li>■ 3/16" wall thickness</li> </ul>
SPT Calibration Testing Equipment	<ul style="list-style-type: none"> <li>■ 2 foot AWJ rod instrumented w/ 2 strain gauges and 2 accelerometers</li> <li>■ Model 586 PAK Pile Driving Analyzer™ (PDA)</li> </ul>
SPT Calibration Personnel	Craig Skiles Foundations QA HSDPT Basic Level Certification

## 2.0 TEST RESULTS

SPT Hammer Energy Calibration Testing Summary.

Boring	Start Depth <sup>1</sup> (ft)	Rod Length <sup>2</sup> (ft)	Rod Sections <sup>3</sup>			Measured Blow Counts (blows/6 inches)				SPT N <sub>meas</sub> (bpf)	Soil Type <sup>4</sup>
			2 ft	5 ft	10 ft	1 <sup>st</sup> Inc.	2 <sup>nd</sup> Inc.	3 <sup>rd</sup> Inc.	4 <sup>th</sup> Inc.		
RA-225	33.5	38.5	1	7	0	3	5	10	NA	15	Sand
	38.5	43.5	1	8	0	7	8	10	NA	18	Sand
	43.5	48.5	1	9	0	5	7	7	NA	14	Sand
	48.5	53.5	1	10	0	6	9	8	NA	17	Sand

1. Depth from existing ground surface to start of SPT
2. Total rod length from instrumentation to bottom of sampler
3. Two foot section is instrumented and is located at top of drill rods
4. Soil type provided by Terracon Consultants, Inc., Charleston, SC

#### Energy Measurement and Analysis Summary.

Boring	Start Depth <sup>1</sup> (ft)	SPT N <sub>m</sub> (bpf)	No. of Blows <sup>2</sup>	EFV (kip-ft) <sup>3</sup>			ETR (%) <sup>3</sup>		
				Max.	Min.	Ave.	Std. Dev.	Ave.	Std. Dev.
RA-225	33.5	15	15	0.305	0.294	0.300	0.003	85.8	0.8
	38.5	18	18	0.309	0.292	0.302	0.004	86.3	1.3
	43.5	14	14	0.309	0.289	0.299	0.005	85.4	1.5
	48.5	17	17	0.304	0.293	0.300	0.003	85.7	0.8
<b>TOTAL:</b>			<b>64</b>	<b>0.309</b>	<b>0.289</b>	<b>0.300</b>	<b>0.004</b>	<b>85.8</b>	<b>1.2</b>

1. Boring ID and depth from existing ground surface to start of SPT
2. Number of blows used in energy calibration analysis; limited to measurements recorded during the second and third 6-inch sampling intervals at each depth or during the first increment if refusal were encountered
3. EFV = Measured Transferred Energy, ETR = Energy Transfer Ratio.

#### Hammer Blow Rate Summary.

Boring	Start Depth <sup>1</sup> (ft)	SPT N <sub>meas</sub> (bpf)	No. of Blows <sup>2</sup>	BPM <sup>3</sup>			
				Max.	Min.	Ave.	Std. Dev.
RA-225	33.5	15	15	50.5	49.8	50.2	0.2
	38.5	18	18	50.5	49.8	50.2	0.2
	43.5	14	14	50.8	49.8	50.1	0.3
	48.5	17	17	50.6	49.9	50.1	0.2
<b>TOTAL:</b>			<b>64</b>	<b>50.8</b>	<b>49.8</b>	<b>50.2</b>	<b>0.2</b>

1. Boring ID and depth from existing ground surface to start of SPT.
2. Number of blows used in energy calibration analysis. Limited to measurements recorded during the second and third 6-inch sampling intervals at each depth or during the 1st increment if refusal conditions were encountered.
3. BPM = Blows per minute

## 3.0 CONCLUSIONS

### 3.1 Energy Transfer Ratio (ETR) and Hammer Efficiency Correction (C<sub>E</sub>)

Based on our testing and subsequent analysis, drill rig CME-550X (Serial Number 347863) has an **ETR of 85.8% ± 1.2%**. Based on this ETR, the hammer efficiency correction (C<sub>E</sub>) is **1.43**.



Probe No 3752  
 Date of Calibration 20111202  
 Replacement of  
 Calibrated by Fredric Nyström  
 File name 3752 20111202 092927.doc



### Point Resistance

Maximum Load	100	MPa
Range	100	MPa
Scaling Factor	763	
Resolution	32.00	kPa (12 bit resolution)
Resolution	0.9999	kPa (18 bit resolution)
Area factor (a)	0.602	

### ERRORS

Max. Temperature effect when not loaded 62.9937 kPa  
 Temperature range 0 -40 deg. Celsius.

### Local Friction

Maximum Load	0.5	MPa
Range	0.5	MPa
Scaling Factor	6064	
Resolution	0.20	kPa (12 bit resolution)
Resolution	0.0063	kPa (18 bit resolution)
Area factor (b)	0.013	

### ERRORS

Max. Temperature effect when not loaded 0.2268 kPa  
 Temperature range 0 -40 deg. Celsius.

### Pore Pressure

Maximum Load	2.5	MPa
Range	2.5	MPa
Scaling Factor	1317	
Resolution	1.85	kPa (12 bit resolution)
Resolution	0.0579	kPa (18 bit resolution)

### ERRORS

Max. Temperature effect when not loaded 1.7949 kPa  
 Temperature range 0 -40 deg. Celsius.

### Tilt Angle.

### Scaling Factor 1

Range	0 - 40	Deg.
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### BACK-UP MEMORY

## CERTIFICATE FOR CPT PROBE 4156

PROBE NUMBER	4156 (WPC)
DATE OF CALIBRATION	10/16/2012
CALIBRATED BY	Sean Bigler Geoprobe® Systems

### POINT RESISTANCE

Sensor Range	100.00 MPa
Scaling Factor	899
Net Area Factor	0.57

### LOCAL FRICTION

Sensor Range	1.50 MPa
Scaling Factor	2756
Net Area Factor	0.014

### PORE PRESSURE

Sensor Range	5.00 MPa
Scaling Factor	1087

### TILT ANGLE

Range	0-40 deg.
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### CALIBRATION EQUIPMENT

Sensotec® Precision Load Cell Model 73/2537-11-02 Serial No. 804409 Calibration at 0.0, 3000, 6000, 9000, 12000, 15000, 18000, 21000, 24000, 27000, 30000, 27000, 24000, 21000, 18000, 15000, 12000, 9000, 6000, 3000, 0.0 lbs	Calibrated 3/7/2011
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Sensotec® Pressure Transducer Model A-10/6076-08 Serial No. 544931 Calibration at 0.0, 30, 60, 90, 120, 150, 180, 210, 240, 270, 300, 270, 240, 210, 180, 150, 120, 90, 60, 30, 0.0 psi	Calibrated 3/7/2011
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Documentation of NIST Traceability available upon request.

Cone penetration test probe calibration results are accurate at the time of calibration. Geoprobe® Systems does not guarantee probe accuracy at the time of field testing. ISSMFE international reference test procedure for cone penetration testing recommends probe calibration at least every 3 months.



## **APPENDIX B**

### **LABORATORY TESTING**

Exhibit B-1   Laboratory Testing Summary  
Exhibit B-2   Laboratory Results

# Terracon

Exhibit B-1

Page 1 of 1

Sample Identification			USCS Classification and Soil Description		Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Fines Content (%)	Dry Density (pcf)	Organic Content (%)
Boring Number	Depth (ft)	Sample									
BH-1	20 to 22	P1	Gray Fat Clay (CH)		123.3	158	42	116	99.1	38.1	
BH-1	28.5 to 30	S10	Gray Fat Clay (CH)		109.3						11.8
BH-1	30 to 32	P2	Gray Fat Clay (CH)		113.6	170	46	124	99.5		
BH-1	38.5 to 40	S12	Gray Fat Clay (CH)		96.8						8.9
BH-1	57 to 59	P3a	Olive Brown Fat Clay (CH) Cooper Marl		65.2	96	40	56	69.2	73.3	
BH-2	20 to 22	P1	Dark Gray Fat Clay (CH)		109.5	173	44	129	99.5	41.2	
BH-2	28.5 to 30	S10	Dark Gray Fat Clay (CH)		79.9						7.3
BH-2	35 to 37	P2	Dark Gray Fat Clay (CH)		91.1	144	36	108	98.3	36.4	
BH-2	45 to 47	P3	Dark Gray Fat Clay (CH)		98.9	138	36	102	95.9	45.1	
BH-2	65 to 67	P4	Olive Brown Sandy Elastic Silt (MH) Cooper Marl		41.8	70	36	35	60.0	77.0	
BH-2	78.5 to 80	S20	Olive Brown Silt with Sand (ML) Cooper Marl		49.2	45	35	10	77.0		
BH-3	22 to 24	P1a	Dark Gray Fat Clay (CH)		113.4	161	48	113	98.7	43.6	
BH-3	31 to 33	P2	Dark Gray Fat Clay (CH)		93.0	140	42	98	98.0	53.4	
BH-3	33.5 to 35	S12	Dark Gray Fat Clay (CH)		88.5						10.2
BH-3	40 to 42	P3	Dark Gray Fat Clay (CH)		86.6	152	40	112	97.0		
BH-3	68.5 to 70	S18	Olive Brown Sandy Silt (ML) Cooper Marl		39.7	39	31	8	60.7		


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Sample Identification			USCS Classification and Soil Description		pH	Resistivity (ohm-cm)	Chloride - Water Soluble (ppm)		Sulfate - Water Soluble (ppm)		
Boring Number	Depth (ft)	Sample									
BS	0.5 to 3	BS1	Light Gray Gravelly Sand		7.8	7,062	13		40		

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PROJECT: Veterans Terminal

SITE: Veterans Terminal  
North Charleston, South Carolina



PROJECT NUMBER: EN125099

CLIENT: Parsons Brinckerhoff  
c/o SCSPA Engineering Department

## Summary of Laboratory Tests

Exhibit B-1 Page 1 of 1

Sample Identification											
Boring Number	Depth (ft)		Sample	Atterberg Limits (ASTM D4318)	Natural Moisture (ASTM D2216)	One-dimensional Consolidation (ASTM D2435)	UU Triax. Compression (ASTM D2850)	CU Triax. Compression (ASTM D4767)	Organic Content (ASTM D2974)	Fines Content (ASTM D422)	Corrosion Series
BH-1	20	to 22	P1	X	X		X			X	
BH-1	28.5	to 30	S10		X				X		
BH-1	30	to 32	P2	X	X	X				X	
BH-1	38.5	to 40	S12		X				X		
BH-1	57	to 59	P3a	X	X			X		X	
BH-2	20	to 22	P1	X	X		X			X	
BH-2	28.5	to 30	S10		X				X		
BH-2	35	to 37	P2	X	X		X			X	
BH-2	45	to 47	P3	X	X		X			X	
BH-2	65	to 67	P4	X	X			X		X	
BH-2	78.5	to 80	S20	X	X					X	
BH-3	22	to 24	P1a	X	X		X			X	
BH-3	31	to 33	P2	X	X		X			X	
BH-3	33.5	to 35	S12		X				X		
BH-3	40	to 42	P3	X	X	X				X	
BH-3	68.5	to 70	S18	X	X					X	
BS	0.5	to 3	BS1								X
Sum				12	16	2	6	2	4	12	1

PROJECT: Veterans Terminal

PROJECT NUMBER: EN125099



SITE: Veterans Terminal  
North Charleston, South Carolina

CLIENT: Parsons Brinckerhoff  
c/o SCSPA Engineering Department

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. LAB SUMMARY: USCS EN125099 (VETERANS BORINGS), GPJ 73111048, GPJ 12/11/12

## Analytical Results

**TASK NO:** 121129010

**Report To:** Jason Hatch

**Company:** Terracon, Inc. - North Charleston, SC  
1450 Fifth St. West  
North Charleston SC 29405

**Bill To:** Jason Hatch

**Company:** Terracon, Inc. - North Charleston, SC  
1450 Fifth St. West  
North Charleston SC 29405

**Task No.:** 121129010  
**Client PO:**  
**Client Project:** Veterans Terminal EN125099

**Date Received:** 11/29/12  
**Date Reported:** 12/6/12  
**Matrix:** Soil - Geotech

**Customer Sample ID** Bulk 1

**Sample Date/Time:**

**Lab Number:** 121129010-01

Test	Result	Method
Chloride - Water Soluble	0.0013 %	AASHTO T291-91/ ASTM D4327
pH	7.8 units	AASHTO T289-91
Resistivity	7062 ohm.cm	AASHTO T288-91
Sulfate - Water Soluble	0.004 %	AASHTO T290-91/ ASTM D4327

**Abbreviations/ References:**

AASHTO - American Association of State Highway and Transportation Officials.

ASTM - American Society for Testing and Materials.

ASA - American Society of Agronomy.

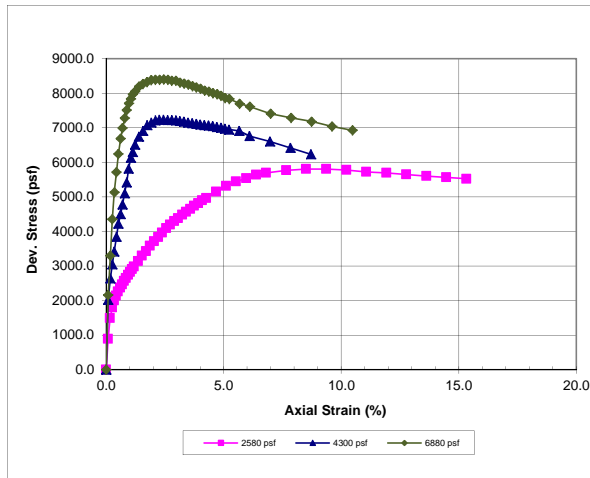
DIPRA - Ductile Iron Pipe Research Association Handbook of Ductile Iron Pipe.



DATA APPROVED FOR RELEASE BY

# Consolidated - Undrained Triaxial Shear Test

ASTM D4767



Project Name	Veterans Terminal
Project Number	EN125099
Project Location	North Charleston, SC
Boring Number	BH-1
Depth	57 to 59 feet
Soil Description	Olive Brown Sandy Fat Clay (CH)

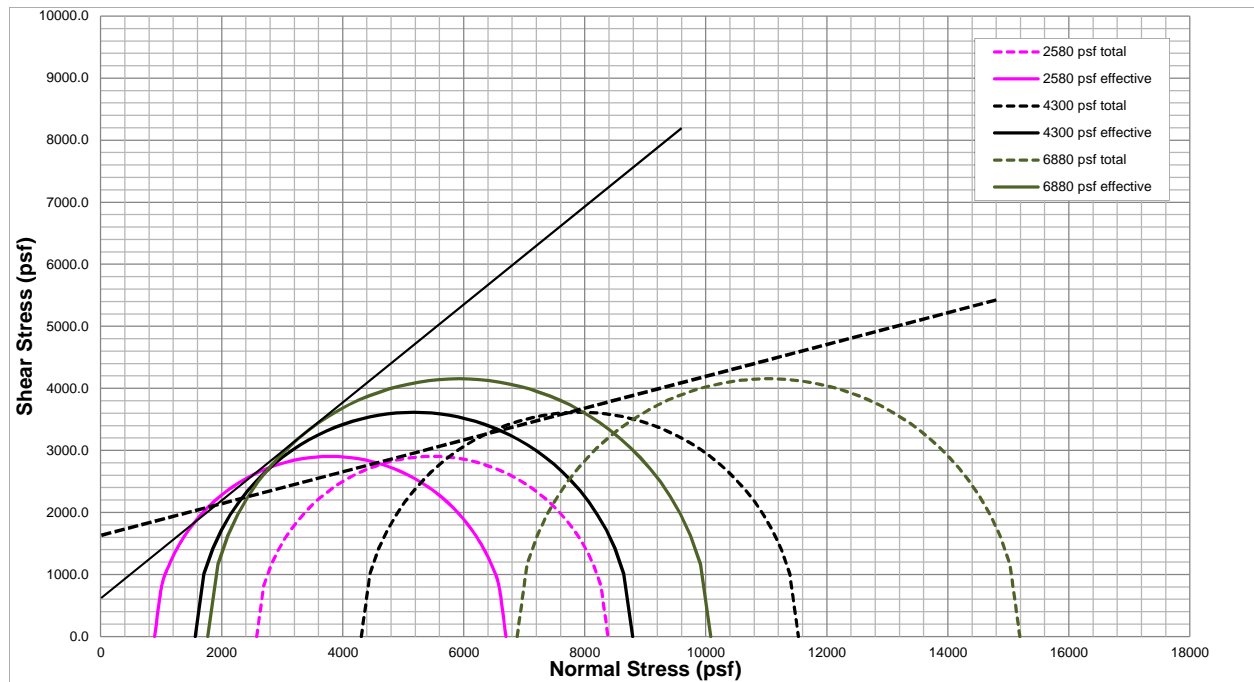
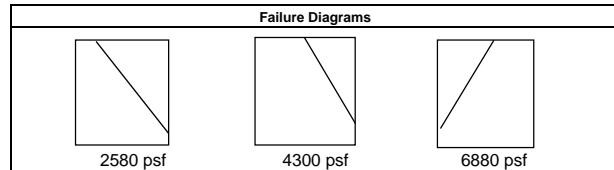
Specimen Number	I	II	III
Effective Consolidation Stress (psf)	2580	4300	6880
Initial wet density (pcf)	106.70	106.59	107.29
Initial dry density (pcf)	73.29	73.21	73.69
Initial water content (%)**	45.6%	45.6%	45.6%
Initial void ratio	1.299	1.301	1.286
Initial Degree of Sat. (%)*	94.8	94.6	95.7
Initial Height	5.9	5.7	5.7
Initial Diameter	2.83	2.86	2.86
Parameter B	1.0	1.0	1.0
Final Degree of Sat. (%)*	100.0	100.0	100.0
Liquid Limit	96		
Plastic Limit	40		
% finer than #200	69.2		

\* Specific Gravity assumed 2.7; wet method of sat.

\*\* obtained from cuttings

\*\*\* failure criterion - at peak strain or 15% strain

Specimen Number	I	II	III
Effective Consolidation Stress (psf)	2580	4300	6880
Total Back Pressure (psf)	3586	3571	3600
Axial Strain at failure (%)***	15.3	2.8	3.1
Deviator Stress at failure (psf)	5805	7227	8309
Pore Pressure at failure (psf)	1685	2742	5112
Effective minor principal stress, $\sigma'_3$ (psf)	893	1564	1771
Effective major principal stress, $\sigma'_1$ (psf)	6698	8791	10080
$\Phi$	14.4°		
$\Phi'$	38.4°		
Cohesion, c (psf)	1600		
Effective Cohesion, c' (psf)	600		
Rate of Strain (% / minute)	0.375		



**Terracon**

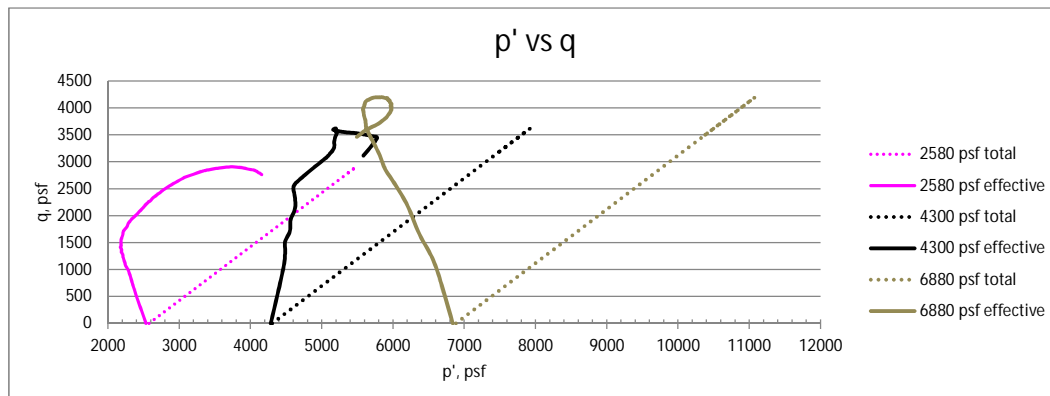
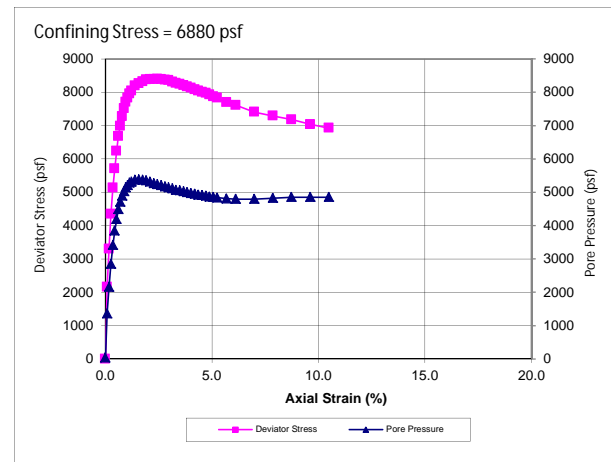
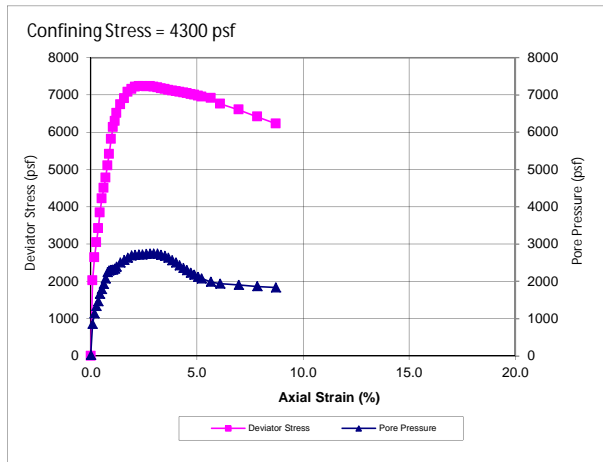
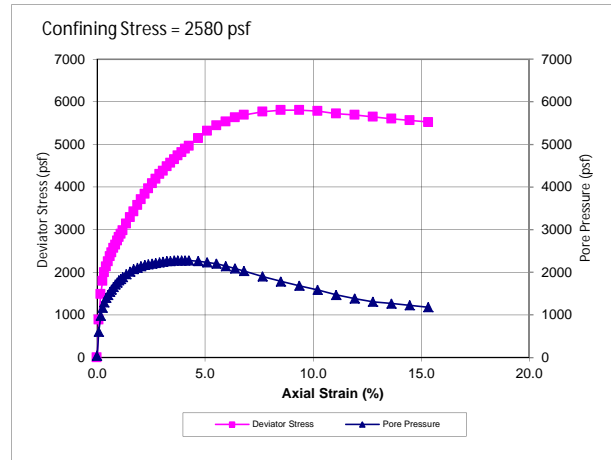
Veterans Terminal  
BH-1 57 to 59 feet Sample P3a  
EN125099

Tested By: JH  
Approved By: RK

# Consolidated - Undrained Triaxial Shear Test

ASTM D4767

Project Name	Veterans Terminal
Project Number	EN125099
Project Location	North Charleston, SC
Boring Number	BH-1
Depth	57 to 59 feet
Soil Description	Olive Brown Sandy Fat Clay (CH)



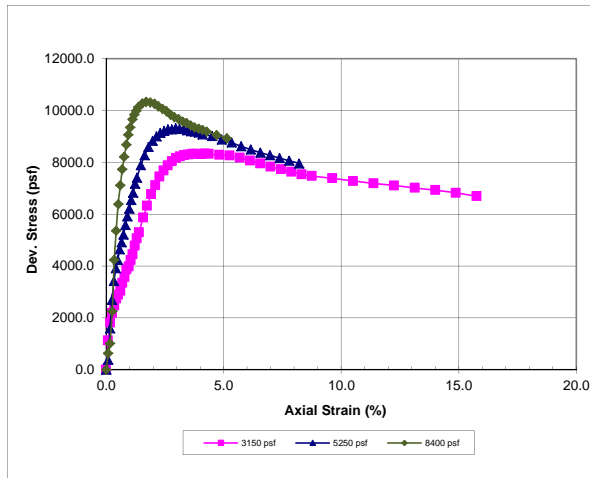
**Terracon**

Veterans Terminal  
BH-1 57 to 59 feet Sample P3a  
EN125099

Tested By: JH  
Approved By: RK

# Consolidated - Undrained Triaxial Shear Test

ASTM D4767



Project Name	Veterans Terminal
Project Number	EN125099
Project Location	North Charleston, SC
Boring Number	BH-2
Depth	65 to 67 feet
Soil Description	Olive Brown Sandy Elastic Silt (MH)

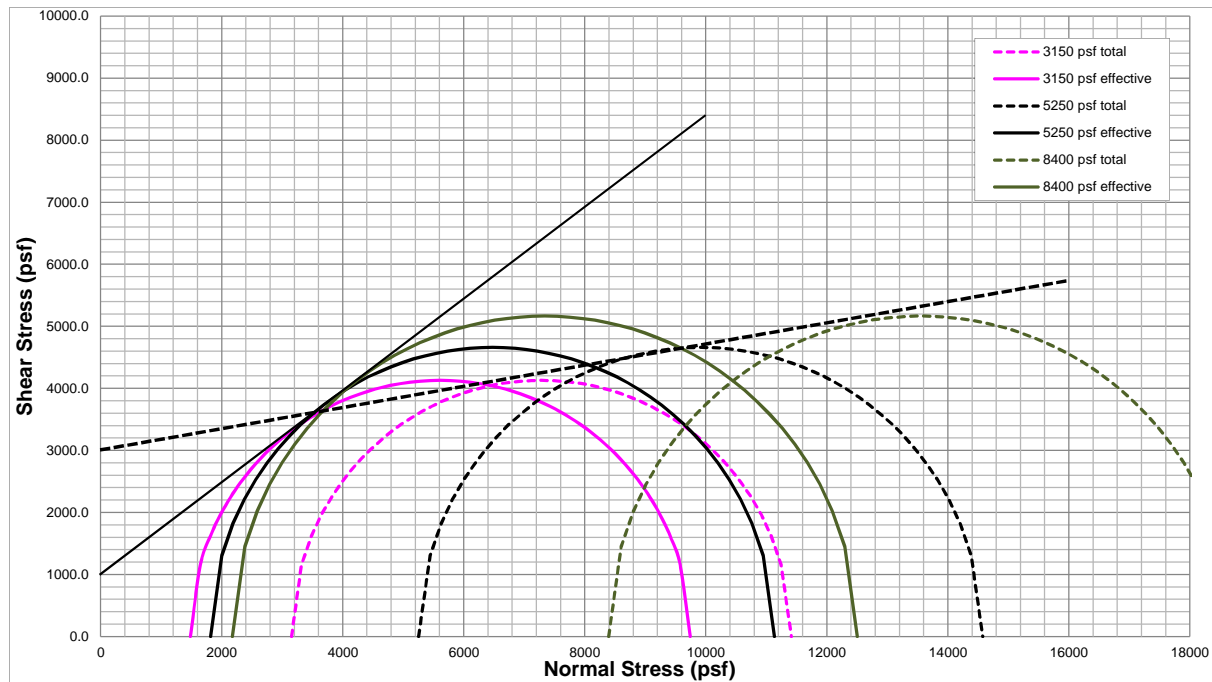
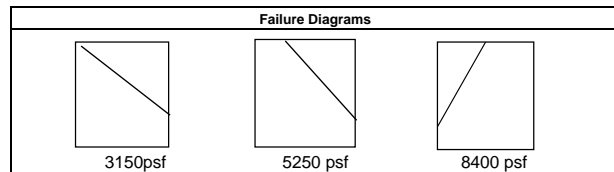
Specimen Number	I	II	III
Effective Consolidation Stress (psf)	3150	5250	8400
Initial wet density (pcf)	108.00	109.66	109.55
Initial dry density (pcf)	76.17	77.34	77.27
Initial water content (%)**	41.8%	41.8%	41.8%
Initial void ratio	1.212	1.178	1.180
Initial Degree of Sat. (%)*	93.1	95.7	95.6
Initial Height	5.7	6.1	5.9
Initial Diameter	2.86	2.85	2.86
Parameter B	1.0	1.0	1.0
Final Degree of Sat. (%)*	100.0	100.0	100.0
Liquid Limit	70		
Plastic Limit	36		
% finer than #200	60.0		

Specimen Number	I	II	III
Effective Consolidation Stress (psf)	3150	5250	8400
Total Back Pressure (psf)	3600	3600	3600
Axial Strain at failure (%)***	13.1	2.8	3.1
Deviator Stress at failure (psf)	8259	9319	10329
Pore Pressure at failure (psf)	1670	3439	6221
Effective minor principal stress, $\sigma'_3$ (psf)	1483	1817	2174
Effective major principal stress, $\sigma'_1$ (psf)	9742	11136	12504
$\Phi$	9.6°		
$\Phi'$	36.5°		
Cohesion, c (psf)	3000		
Effective Cohesion, c' (psf)	1000		
Rate of Strain (% / minute)	0.375		

\* Specific Gravity assumed 2.7; wet method of sat.

\*\* obtained from cuttings

\*\*\* failure criterion - at peak strain or 15% strain



**Terracon**

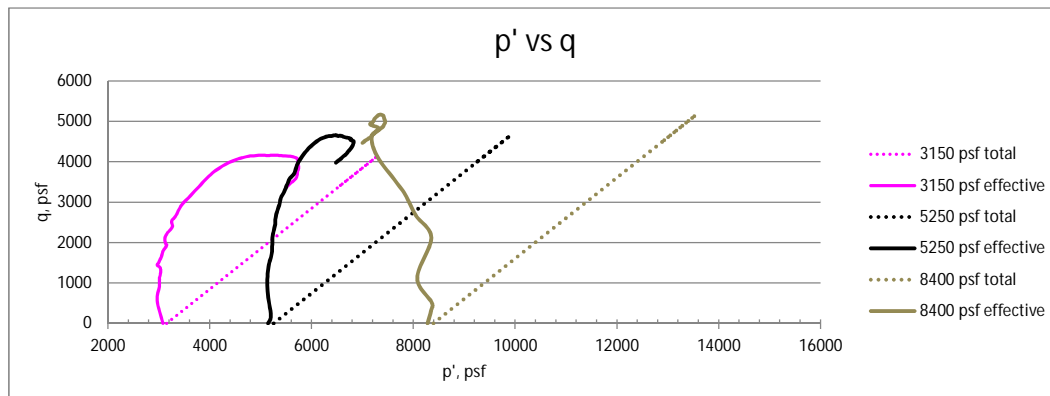
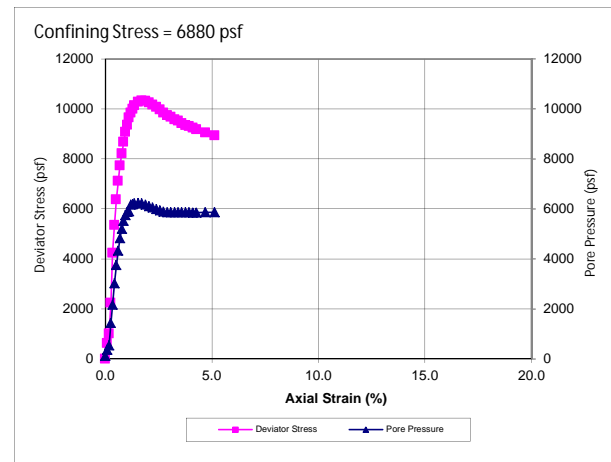
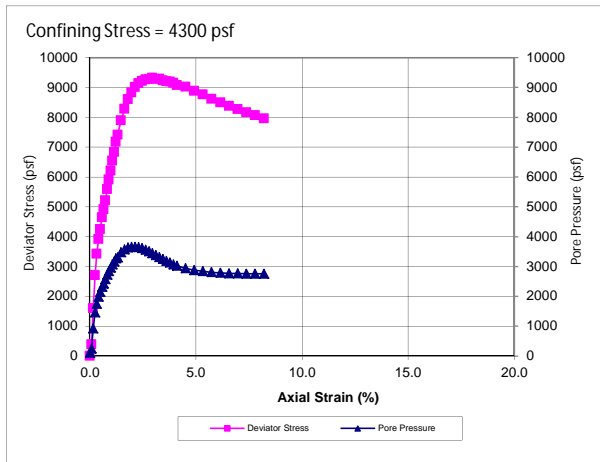
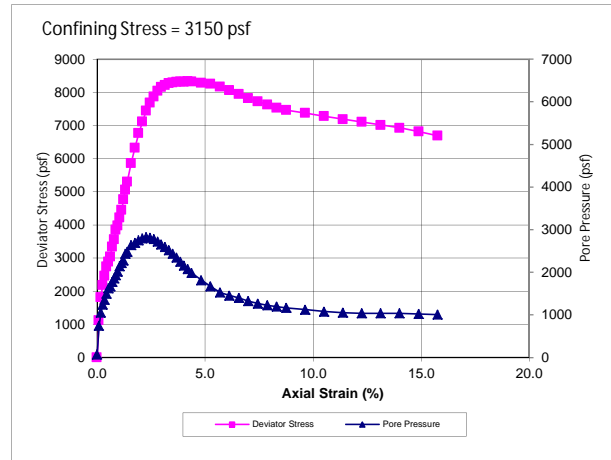
Veterans Terminal  
BH-2 65 to 67 feet Sample P4  
EN125099

Tested By: JH  
Approved By: RK

# Consolidated - Undrained Triaxial Shear Test

ASTM D4767

Project Name	Veterans Terminal
Project Number	EN125099
Proj. Location	North Charleston, SC
Boring Number	BH-2
Depth	65 to 67 feet
Soil Description	Olive Brown Sandy Elastic Silt (MH)



**Terracon**

Veterans Terminal  
BH-2 65 to 67 feet Sample P4  
EN125099

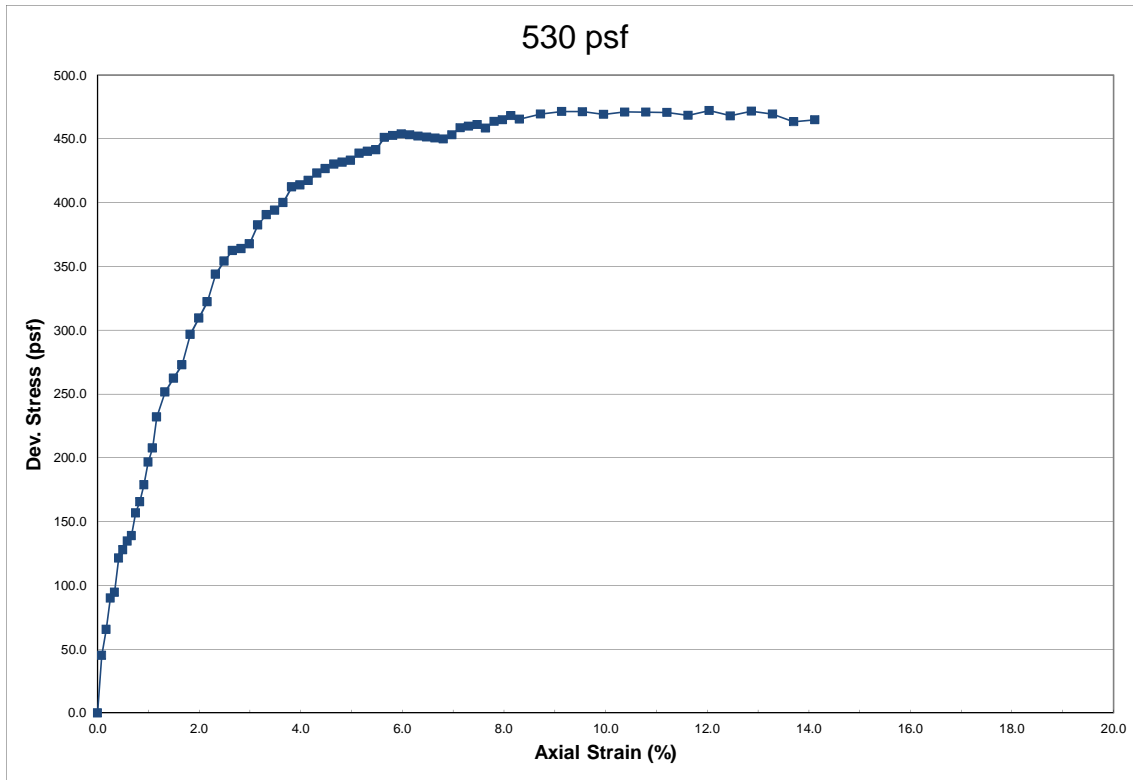
Tested By: JH  
Approved By: RK



## Unconsolidated - Undrained Triaxial Shear Test

Sample Number	BH-1
Project Number	EN125099
Project Name	Veterans Terminal
Sample Depth	20 to 22 feet

Description	Gray Fat Clay (CH)
Wet density (pcf)	85.06
Dry density (pcf)	38.09
Water content	123.3%
Void Ratio	0.770
Degree of Sat.	97.8
Max Dev Stress(psf)	472
Sp. Gravity (est)	2.7
LL=	158
PL=	42
PI=	116



Veterans Terminal  
BH-1 20 to 22 feet Sample P1  
EN125099

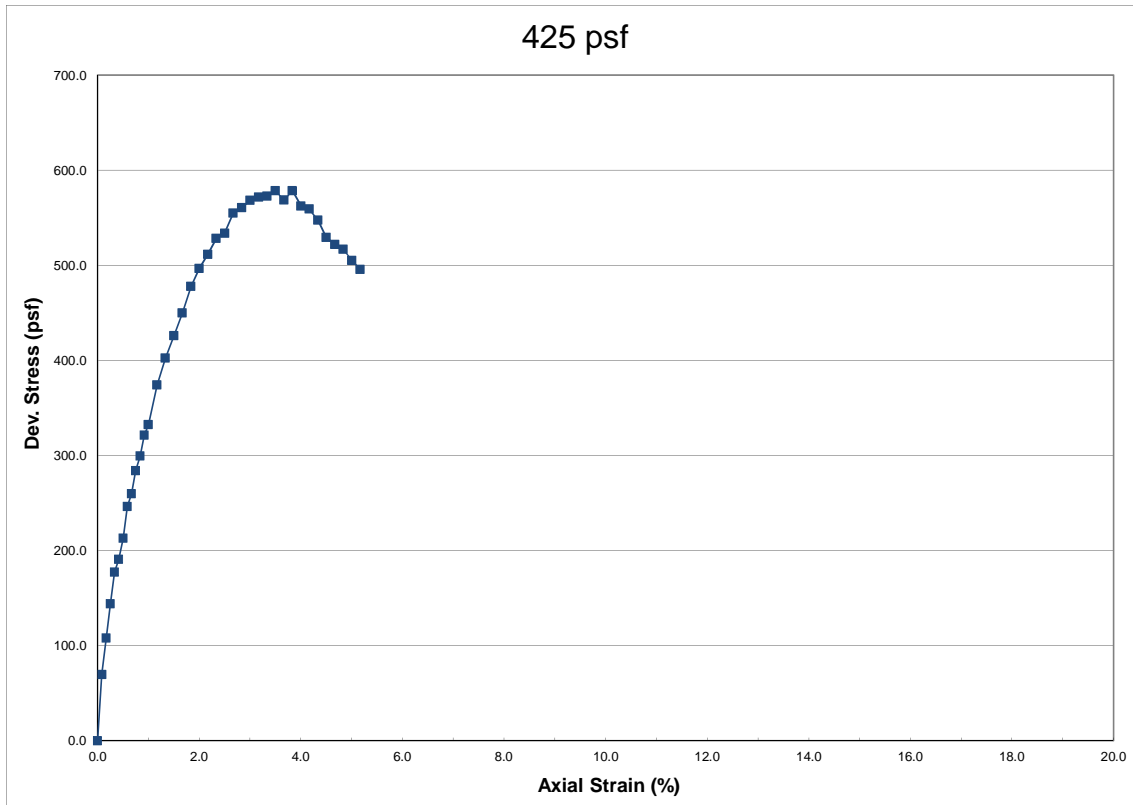
Tested By: JH

Approved By: RK

## Unconsolidated - Undrained Triaxial Shear Test

Sample Number	BH-2
Project Number	EN125099
Project Name	Veterans Terminal
Sample Depth	20 to 22 feet

Description	Dark Gray Fat Clay (CH)
Wet density (pcf)	86.34
Dry density (pcf)	41.22
Water content	109.5%
Void Ratio	0.751
Degree of Sat.	96.3
Max Dev Stress(psf)	578
Sp. Gravity (est)	2.7
LL=	173
PL=	44
PI=	129



Veterans Terminal  
BH-2 20 to 22 feet Sample P1  
EN125099

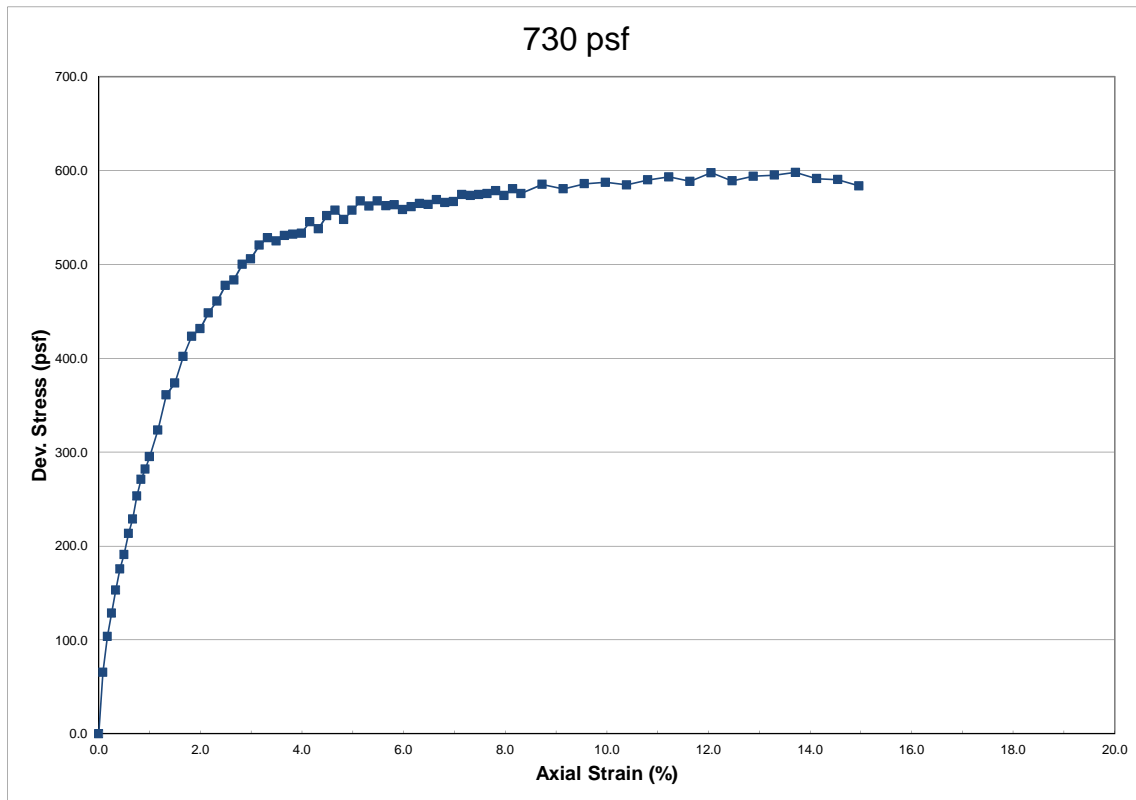
Tested By: JH

Approved By: RK

## Unconsolidated - Undrained Triaxial Shear Test

Sample Number	BH-2
Project Number	EN125099
Project Name	Veterans Terminal
Sample Depth	35 to 37 feet

Description	Dark Gray Fat Clay (CH)
Wet density (pcf)	90.43
Dry density (pcf)	36.38
Water content	148.5%
Void Ratio	0.780
Degree of Sat.	111.0
Max Dev Stress(psf)	598
Sp. Gravity (est)	2.7
LL=	144
PL=	34
PI=	108



Veterans Terminal  
BH-2 35 to 37 feet Sample P2  
EN125099

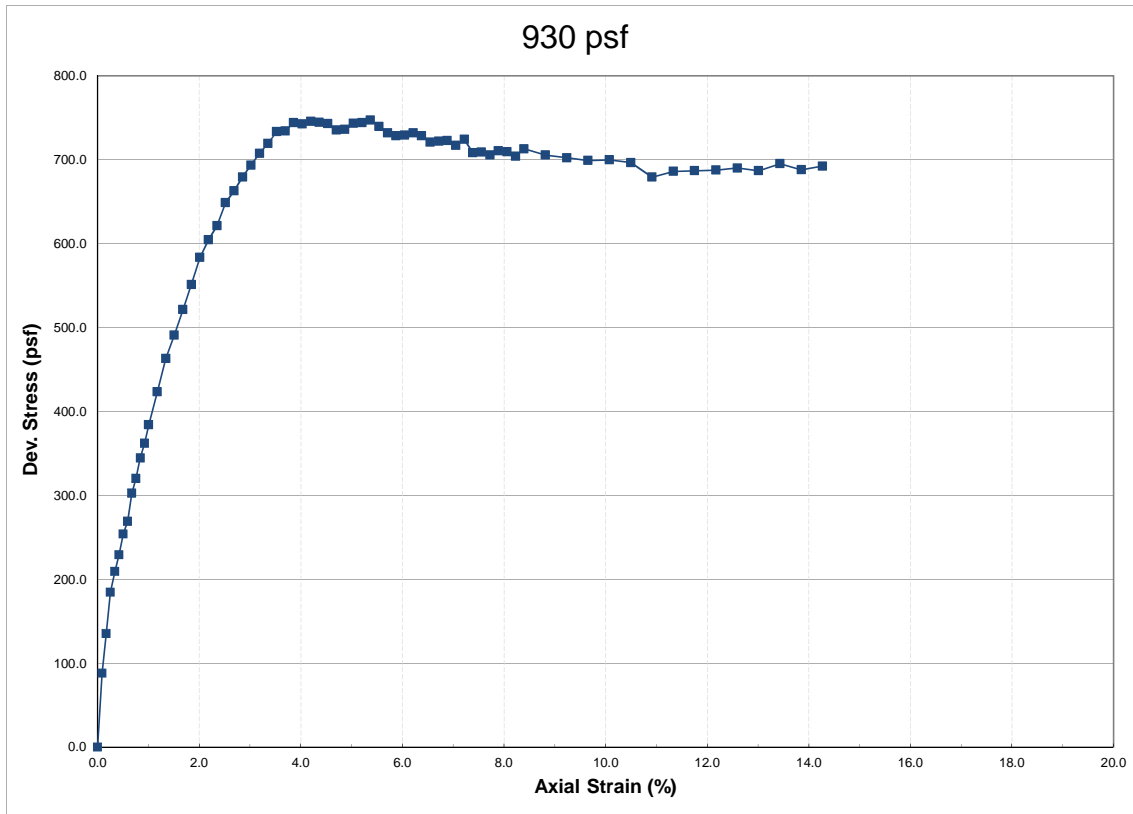
Tested By: JH

Approved By: RK

## Unconsolidated - Undrained Triaxial Shear Test

Sample Number	BH-2
Project Number	EN125099
Project Name	Veterans Terminal
Sample Depth	45 to 47 feet

Description	Dark Gray Fat Clay (CH)
Wet density (pcf)	89.74
Dry density (pcf)	45.11
Water content	98.9%
Void Ratio	0.727
Degree of Sat.	98.4
Max Dev Stress(psf)	747
Sp. Gravity (est)	2.7
LL=	138
PL=	36
PI=	102



Veterans Terminal  
BH-2 45 to 47 feet Sample P3  
EN125099

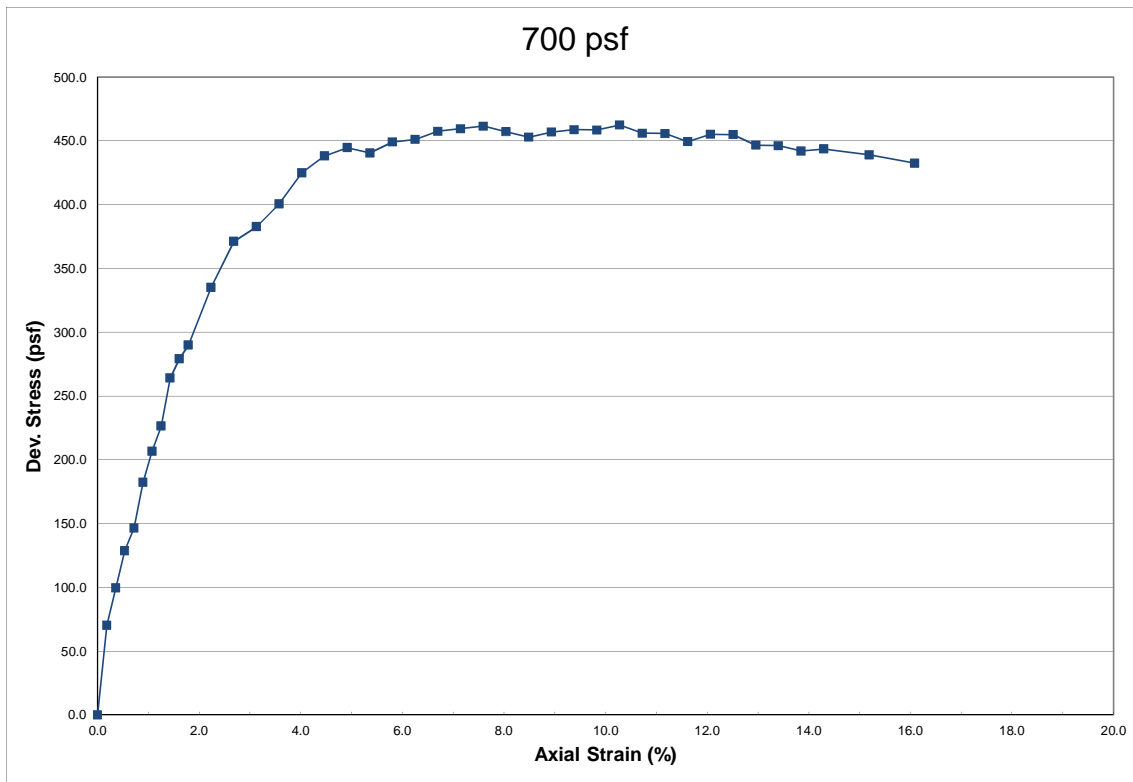
Tested By: JH

Approved By: RK

## Unconsolidated - Undrained Triaxial Shear Test

Sample Number	BH-3
Project Number	EN125099
Project Name	Veterans Terminal
Sample Depth	22 to 24 feet

Description	Gray Fat Clay (CH)
Wet density (pcf)	93.06
Dry density (pcf)	43.60
Water content	113.4%
Void Ratio	0.736
Degree of Sat.	107.7
Max Dev Stress(psf)	462
Sp. Gravity (est)	2.7
LL=	161
PL=	48
PI=	113



Veterans Terminal  
BH-3 22 to 24 feet Sample P1a  
EN125099

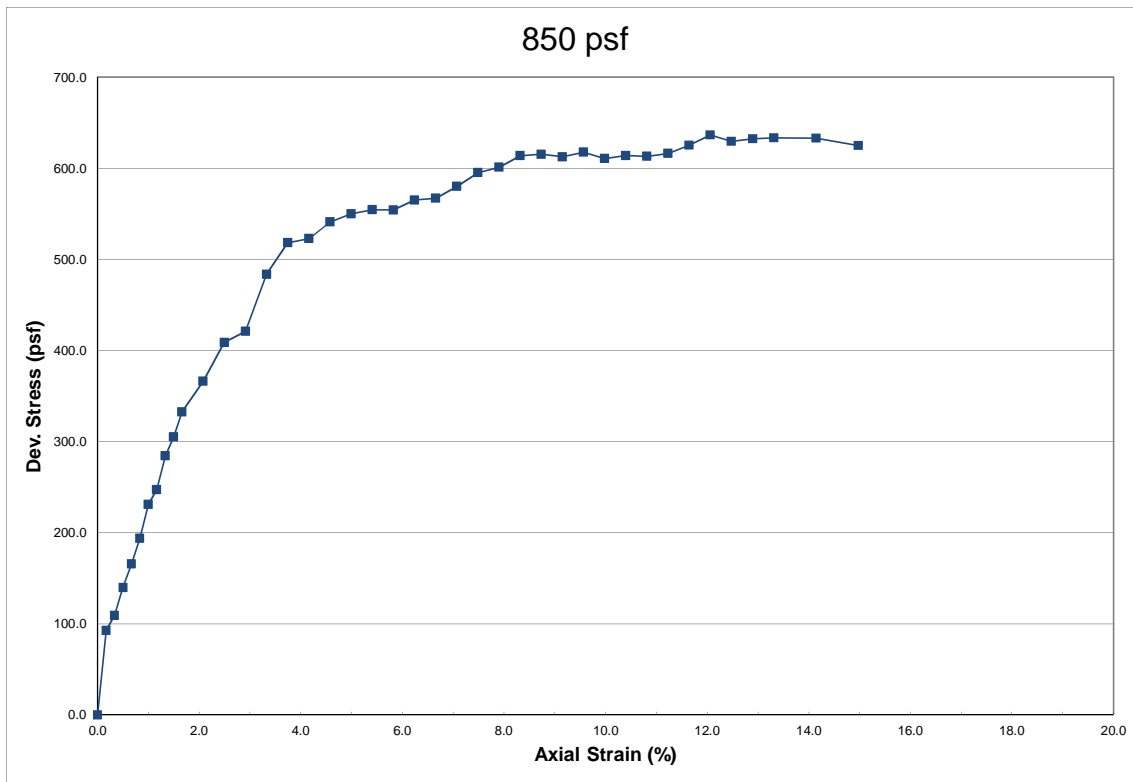
Tested By: JH

Approved By: RK

## Unconsolidated - Undrained Triaxial Shear Test

Sample Number	BH-3
Project Number	EN125099
Project Name	Veterans Terminal
Sample Depth	31 to 33 feet

Description	Dark Gray Fat Clay (CH)
Wet density (pcf)	103.09
Dry density (pcf)	53.43
Water content	93.0%
Void Ratio	0.677
Degree of Sat.	117.6
Max Dev Stress(psf)	636
Sp. Gravity (est)	2.7
LL=	140
PL=	42
PI=	98

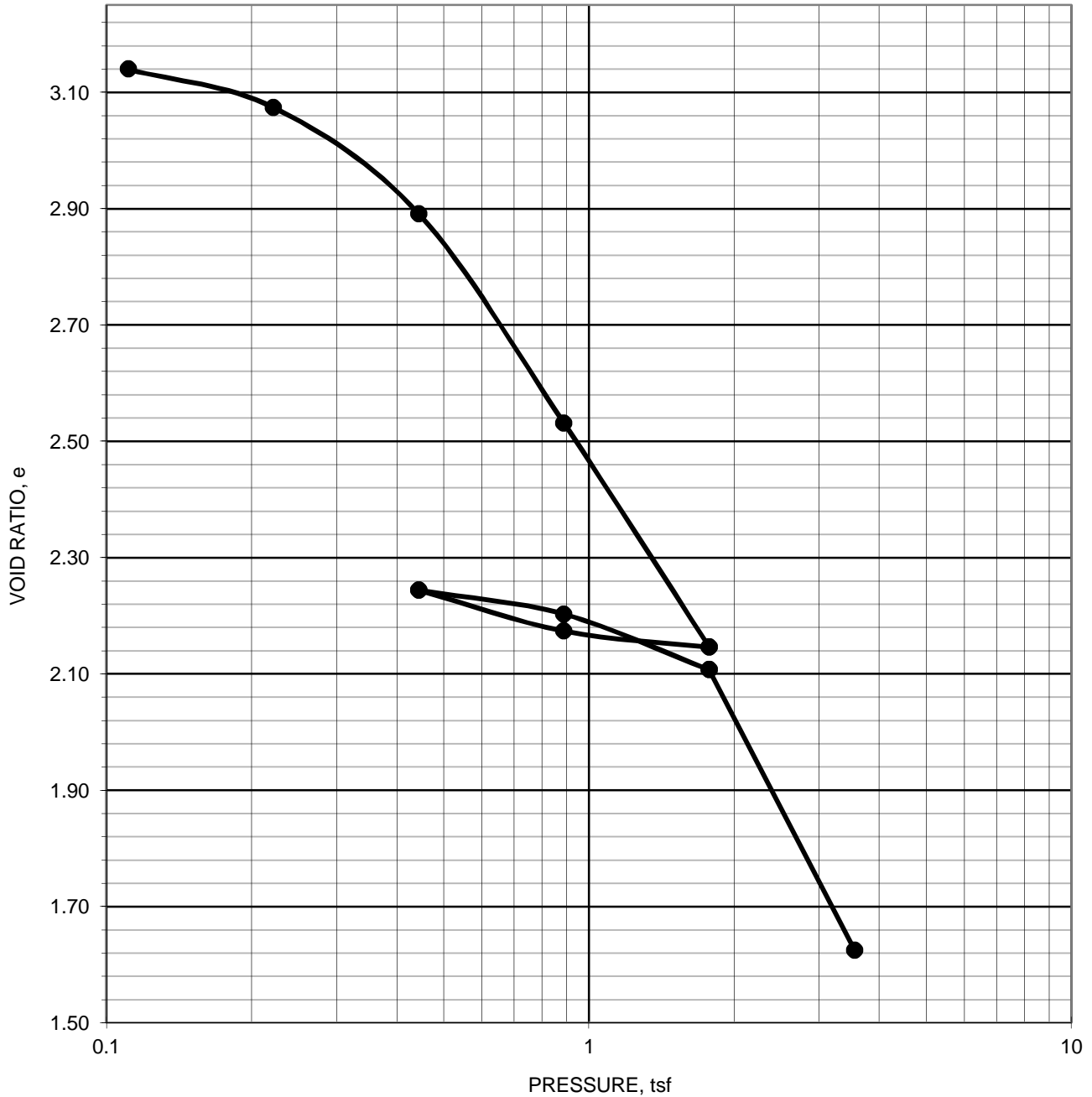


Veterans Terminal  
BH-3 31 to 33 feet Sample P2  
EN125099

Tested By: JH

Approved By: RK

# ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS ASTM D2435



DIAMETER, mm	63.50	HEIGHT, mm	25.40	PROPERTY		BEFORE TEST	AFTER TEST	
OVERBURDEN PRESSURE*, tsf			0.84	MOISTURE, %		113.6	92.2	
PRECONSOL. PRESSURE*, tsf			0.84	DRY DENSITY, pcf		40.3	48.0	
OVER CONSOLIDATION RATIO*			1.00	SATURATION, %		96	100	
COMPRESSION INDEX*			2.408	VOID RATIO		3.179	2.473	
RECOMPRESSION INDEX*			0.194	SAMPLE TYPE		UNDISTURBED		
Liquid Limit	170	Plastic Limit	46	Plasticity Index	124	SPECIFIC GRAVITY (assumed)		2.7
SAMPLE DESCRIPTION		Gray Fat Clay (CH)				% Finer #200		99.5
BORING NO.	BH-1		SAMPLE NO.	P2		DEPTH	30 to 32 feet	

\*Values determined by reconstructed field curve

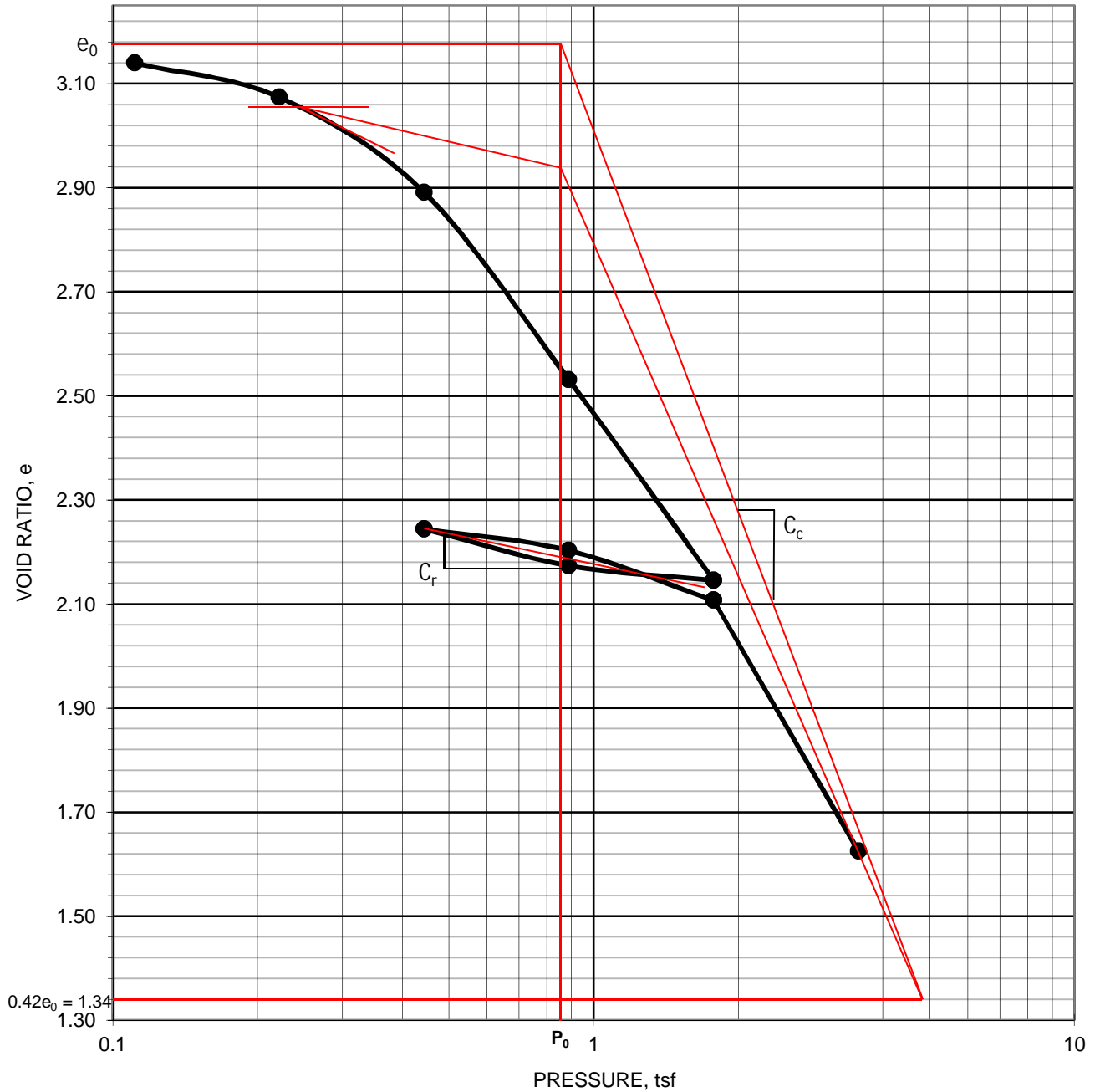
Veterans Terminal  
BH-1 30 to 32 feet Sample P1  
EN125099

**Terracon**

TESTED BY  
APPROVED BY

JH  
RK

# ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS ASTM D2435



DIAMETER, mm	63.50	HEIGHT, mm	25.40	PROPERTY	BEFORE TEST	AFTER TEST	
OVERBURDEN PRESSURE*, tsf		0.84		MOISTURE, %	113.6	92.2	
PRECONSOL. PRESSURE*, tsf		0.84		DRY DENSITY, pcf	40.3	48.0	
OVER CONSOLIDATION RATIO*		1.00		SATURATION, %	96	100	
COMPRESSION INDEX*		2.408		VOID RATIO	3.179	2.473	
RECOMPRESSION INDEX*		0.194		SAMPLE TYPE	UNDISTURBED		
Liquid Limit	170	Plastic Limit	46	Plasticity Index	124	SPECIFIC GRAVITY (assumed)	2.7
SAMPLE DESCRIPTION		Gray Fat Clay (CH)			% Finer #200		99.5
BORING NO.	BH-1		SAMPLE NO.	P2		DEPTH	30 to 32 feet

\*Values determined by reconstructed field curve

**Veterans Terminal**  
BH-1 30 to 32 feet Sample P1  
EN125099

**Terracon**

TESTED BY  
APPROVED BY

JH  
RK



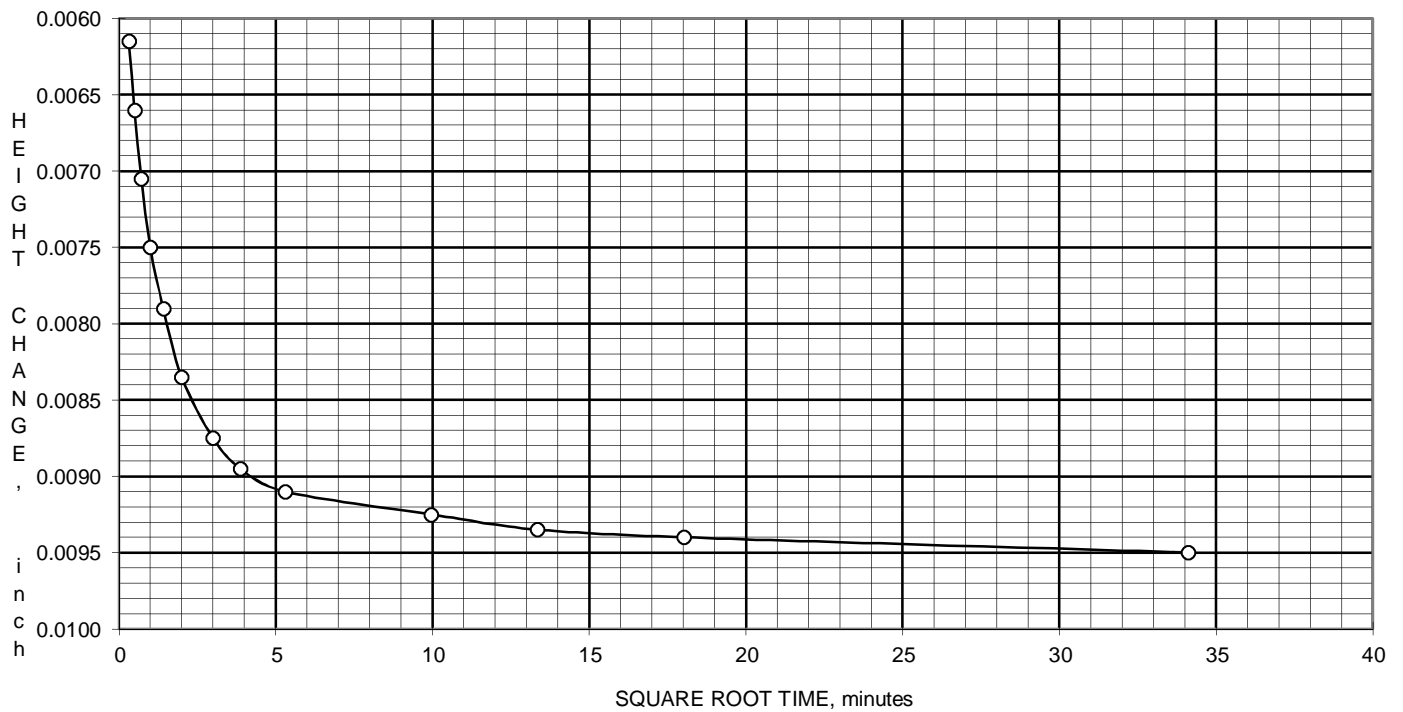
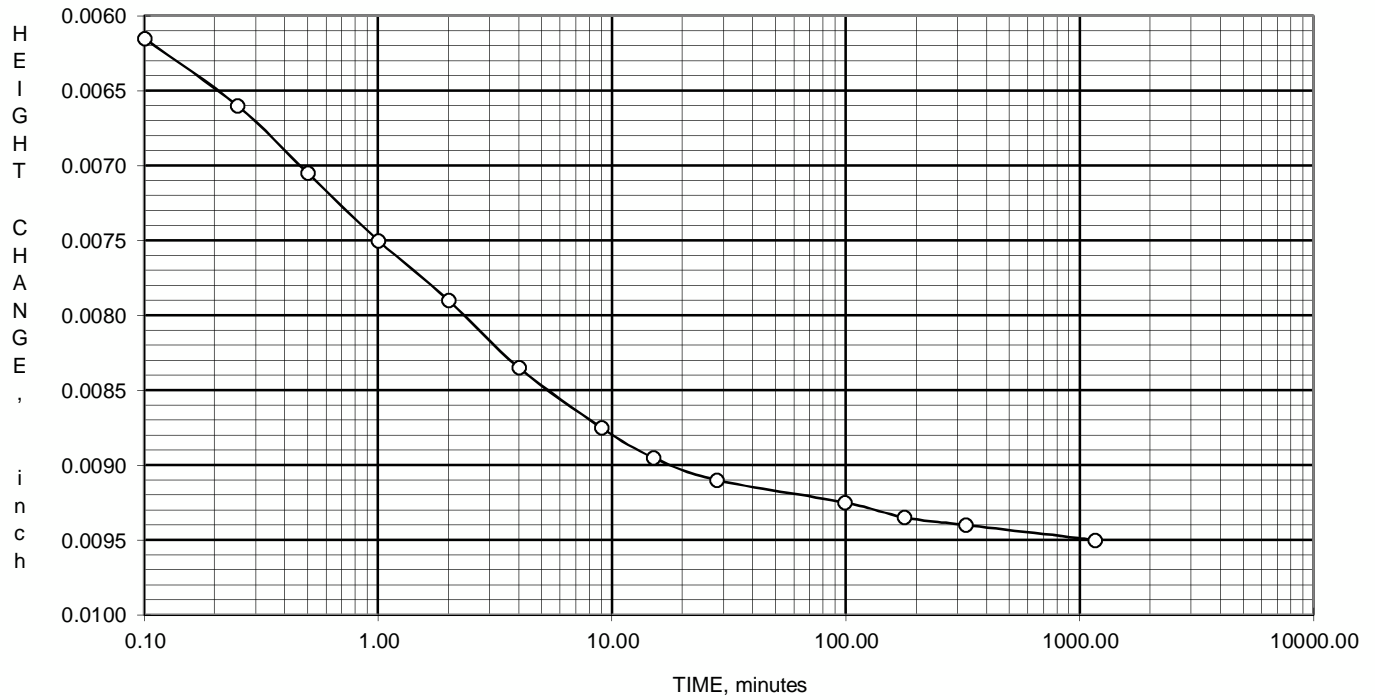
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Veterans Terminal  
North Charleston, South Carolina  
173533-04 (EN125099)

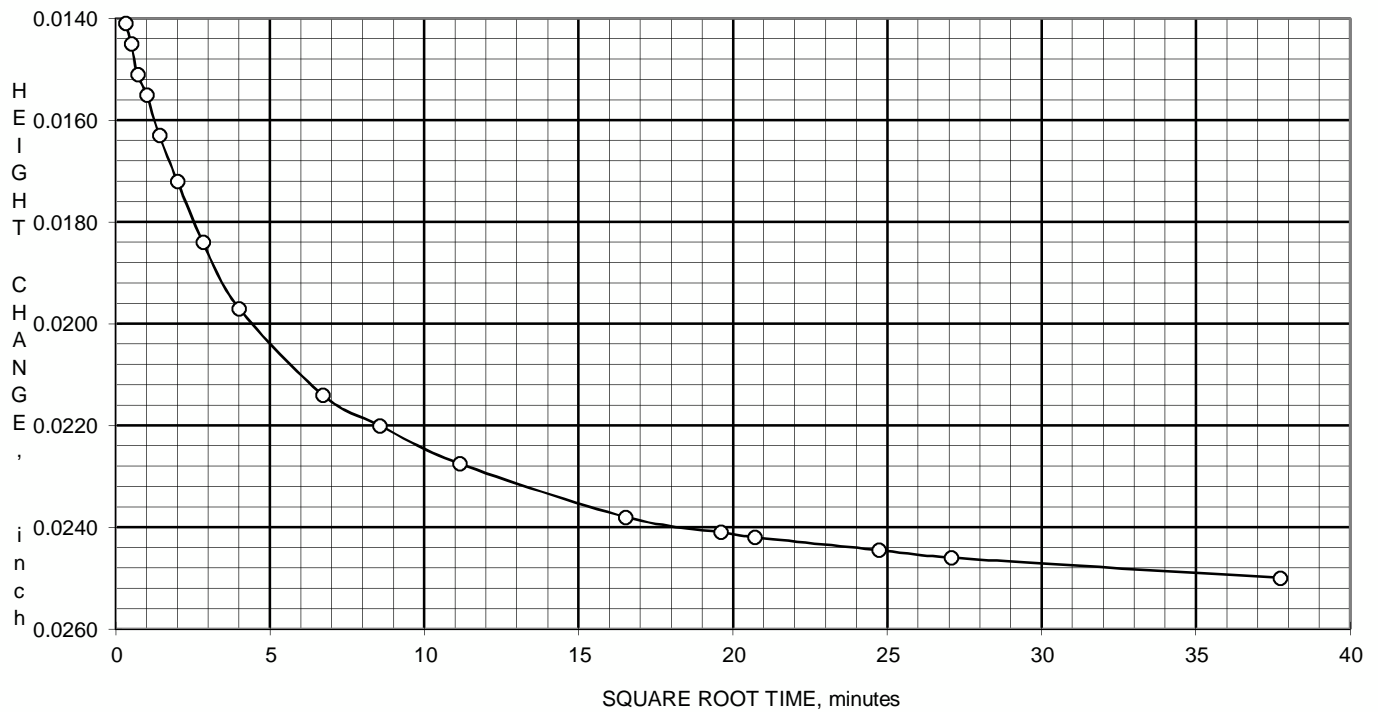
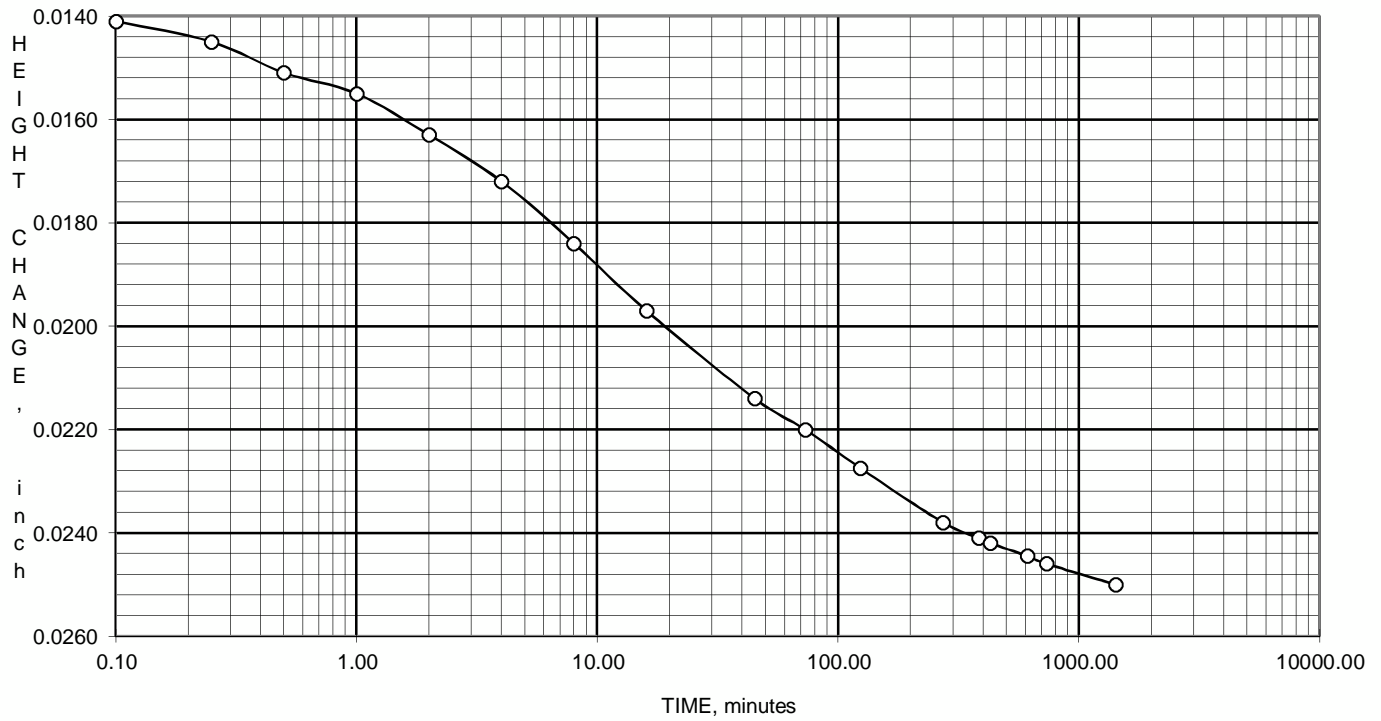
BH-1  
Sample P2  
30 to 32 feet

<u>Pressure</u> <u>tsf</u>	<u>Cv50</u> <u>cm2/sec</u>	<u>Cv90</u> <u>cm2/sec</u>	<u>Av</u> <u>cm2/g</u>	<u>Mv</u> <u>cm2/g</u>	<u>k</u> <u>cm/sec</u>
0.111	6.17E-03	1.57E-02	3.65E-04	8.74E-05	5.39E-07
0.222	5.11E-04	1.38E-03	6.07E-04	1.47E-04	7.50E-08
0.444	4.67E-04	1.79E-03	8.42E-04	2.07E-04	9.64E-08
0.889	1.39E-04	3.19E-04	8.27E-04	2.13E-04	2.95E-08
1.778	1.30E-04	2.96E-04	4.42E-04	1.25E-04	1.62E-08
0.889	N.A.	N.A.	3.17E-05	1.01E-05	N.A.
0.444	N.A.	N.A.	1.62E-04	5.12E-05	N.A.
0.889	4.99E-04	8.90E-04	9.51E-05	2.93E-05	1.46E-08
1.778	2.92E-04	6.12E-04	1.10E-04	3.43E-05	1.00E-08
3.556	4.12E-05	5.43E-05	2.77E-04	8.91E-05	3.67E-09

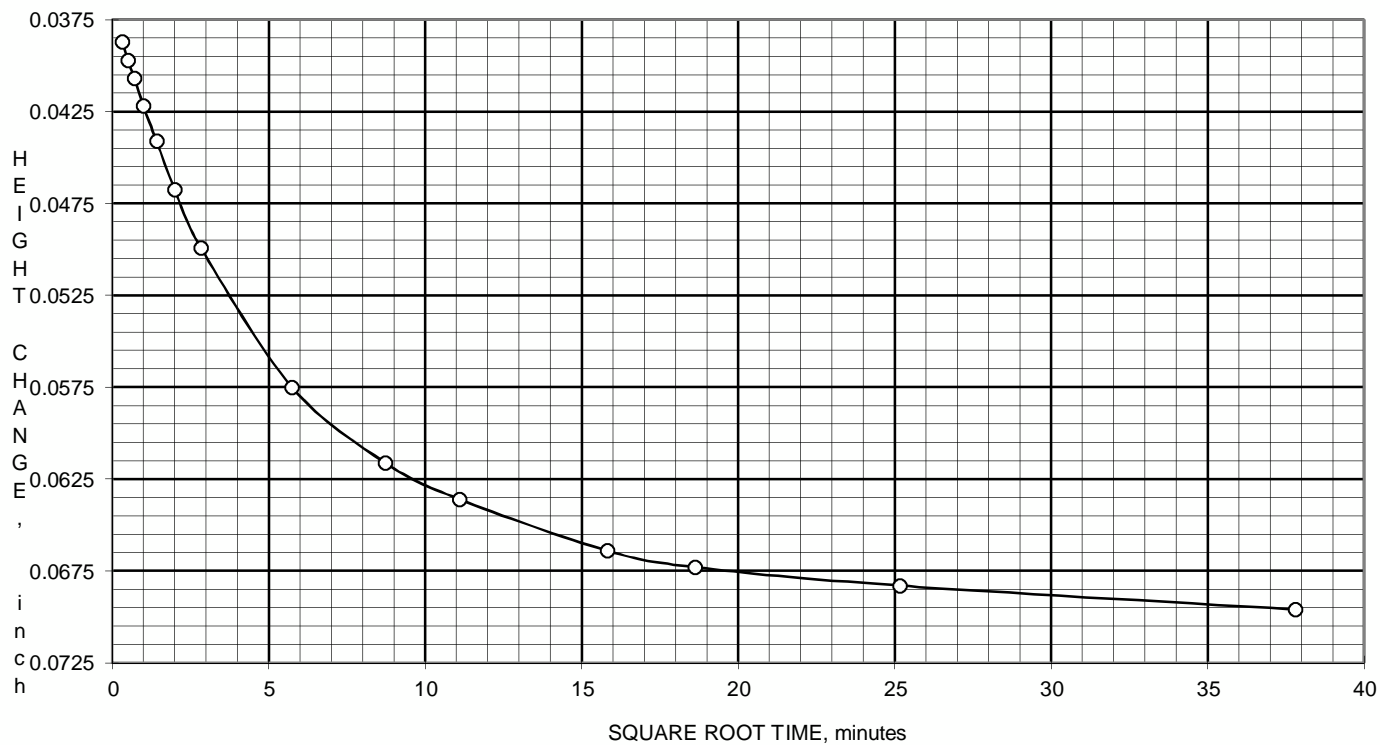
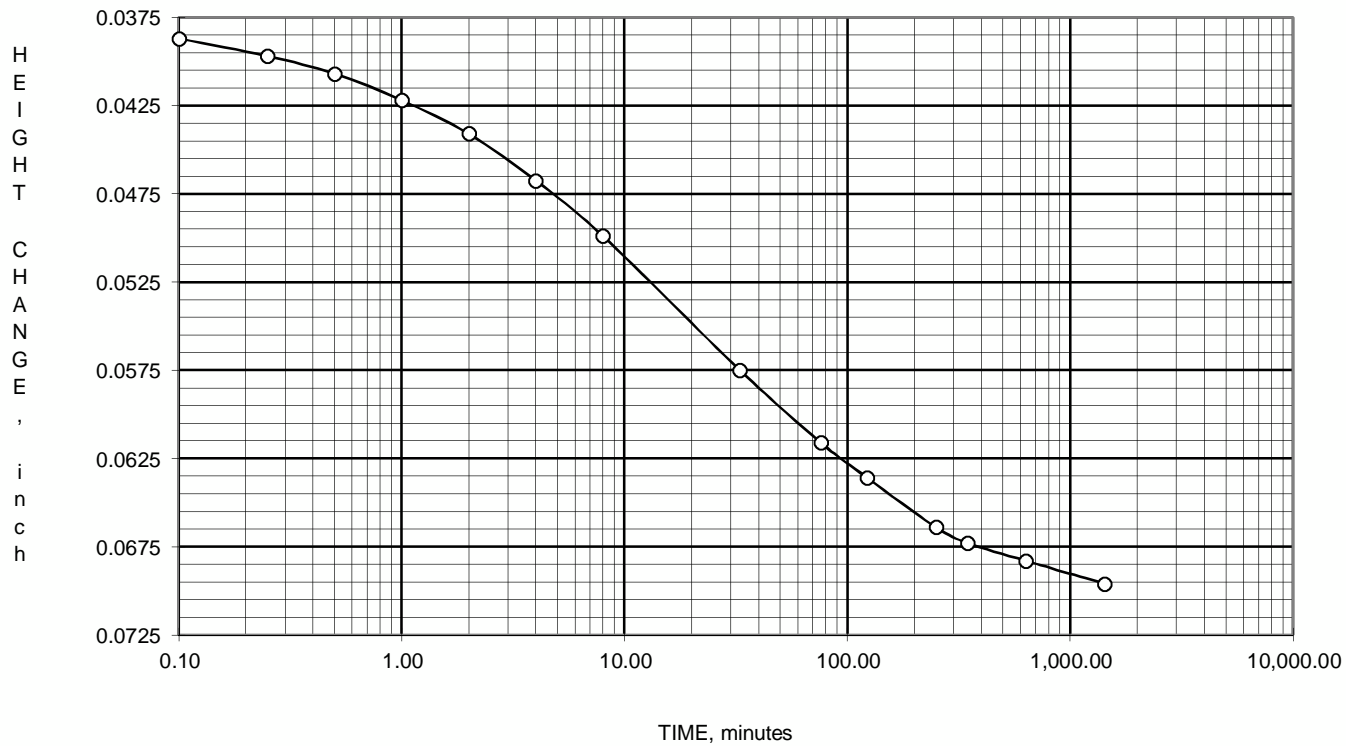
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TO	0.11	tsf	t90	1.4	min.



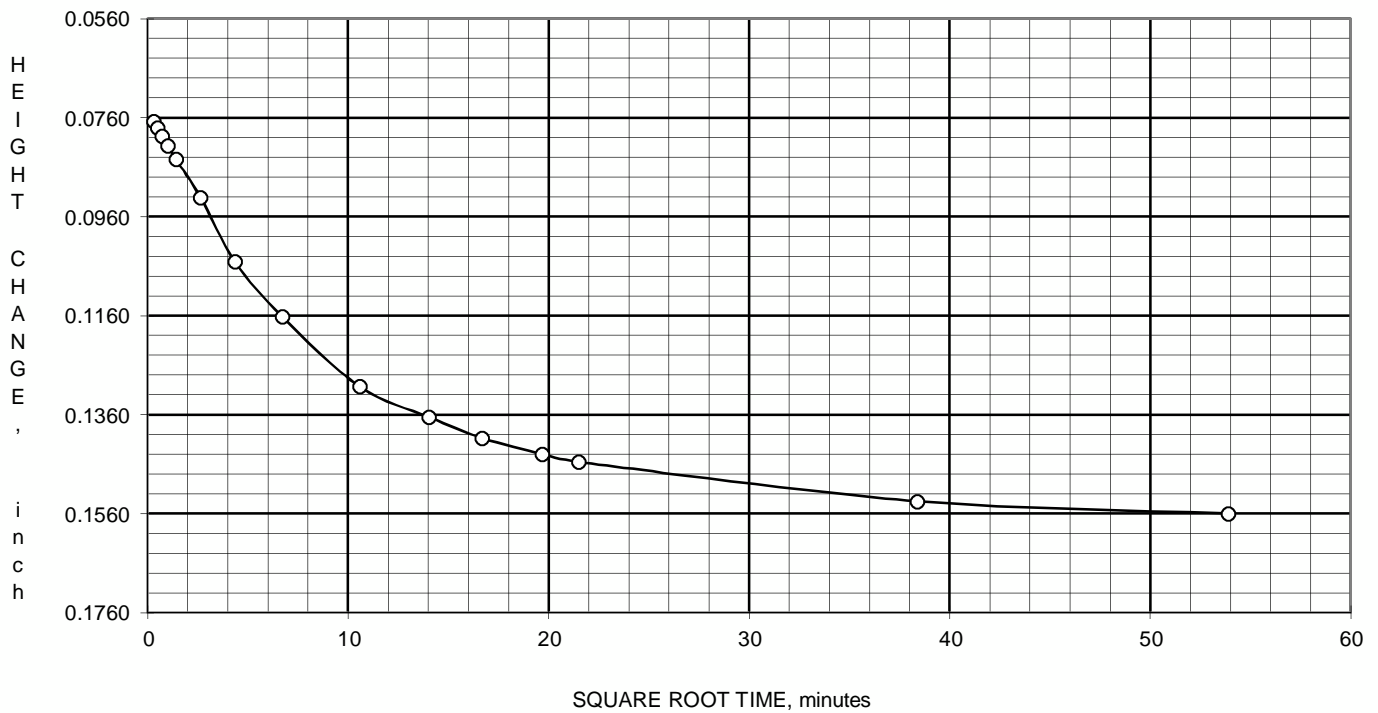
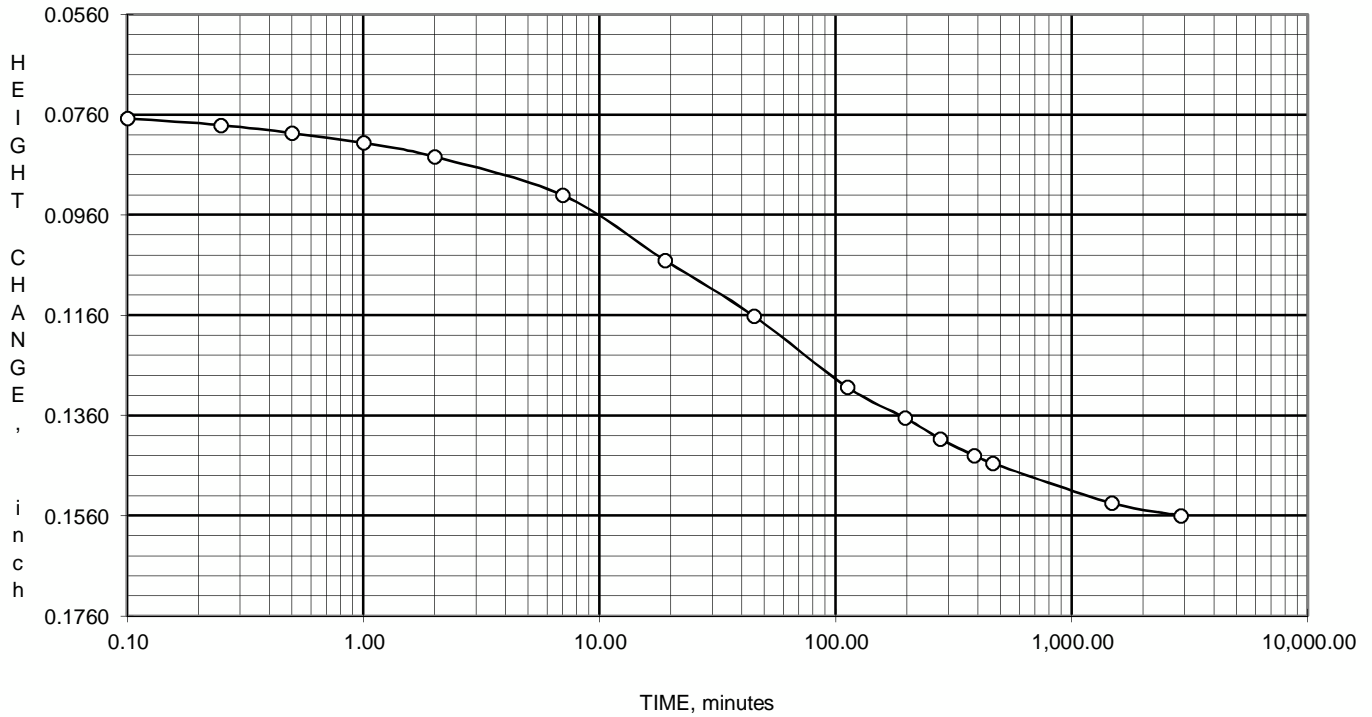
FROM	0.11	tsf	t50	10.0	min.
TO	0.22	tsf	t90	16.0	min.



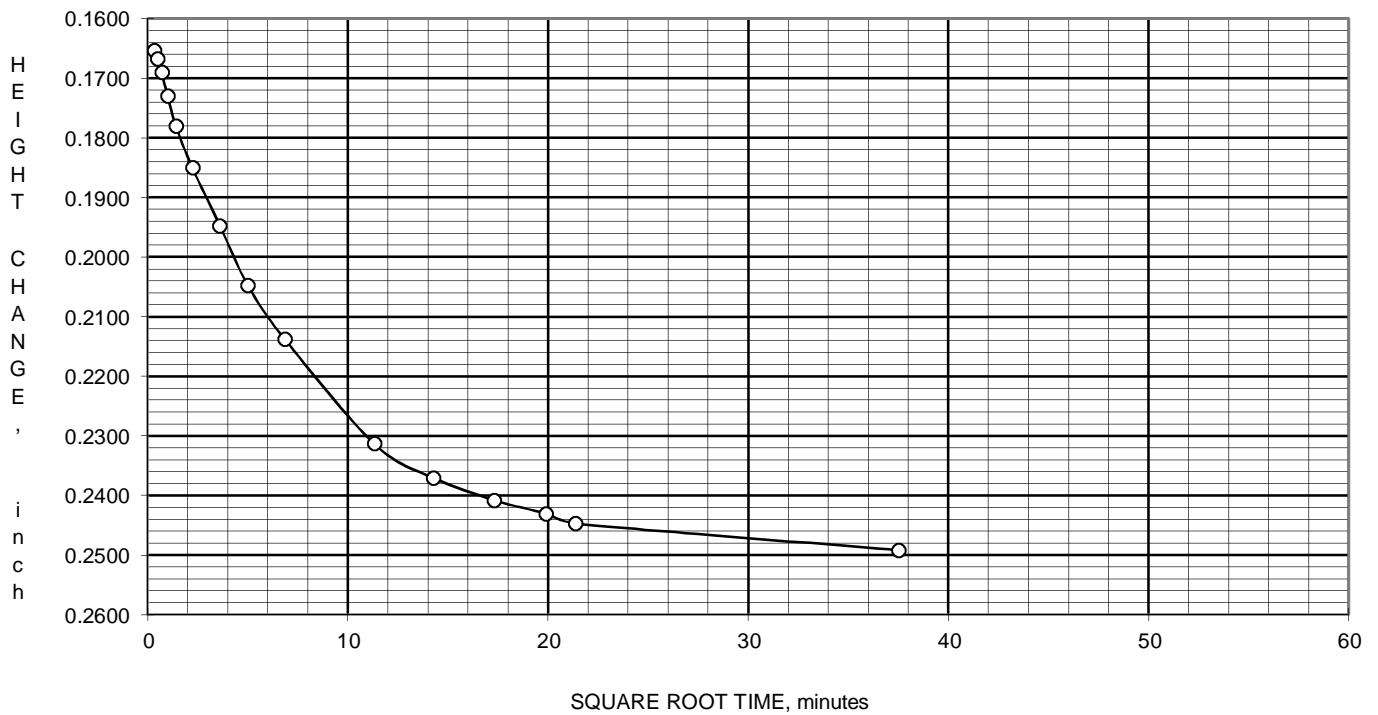
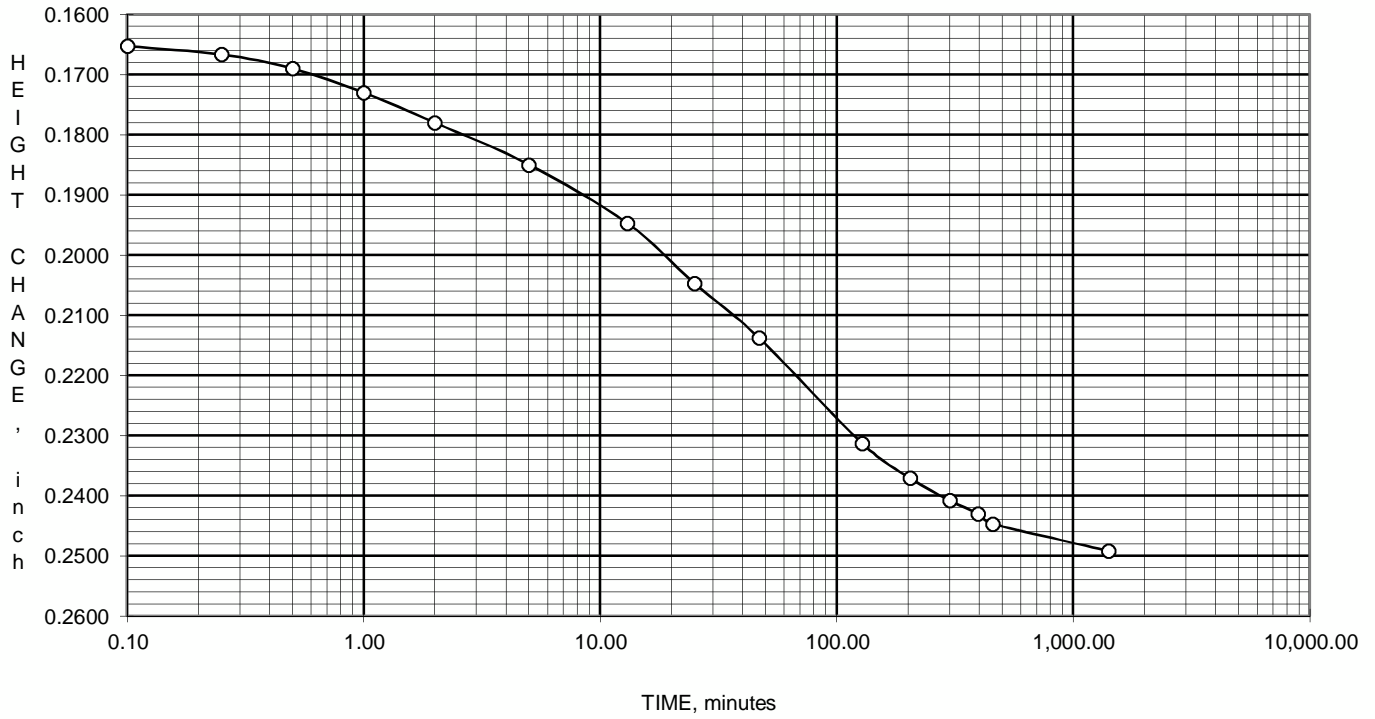
FROM	0.22	tsf	t50	10.3	min.
TO	0.44	tsf	t90	11.6	min.



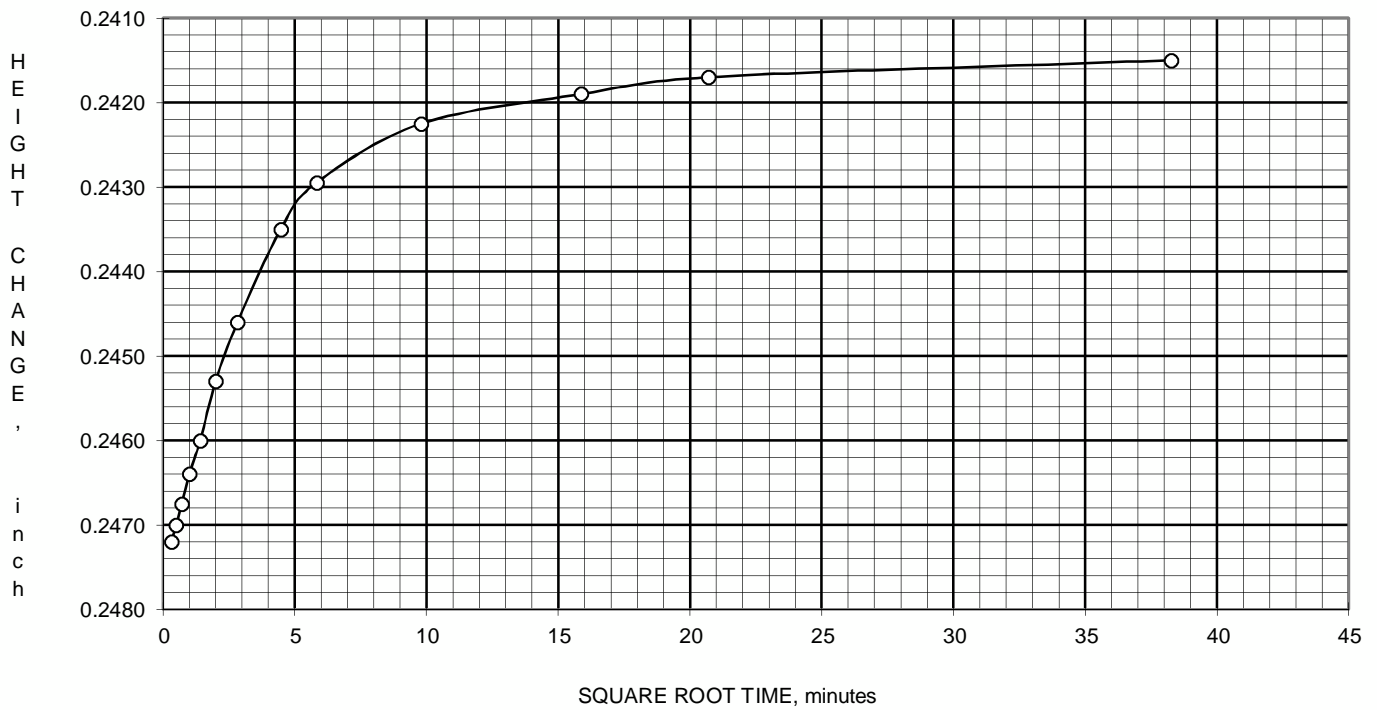
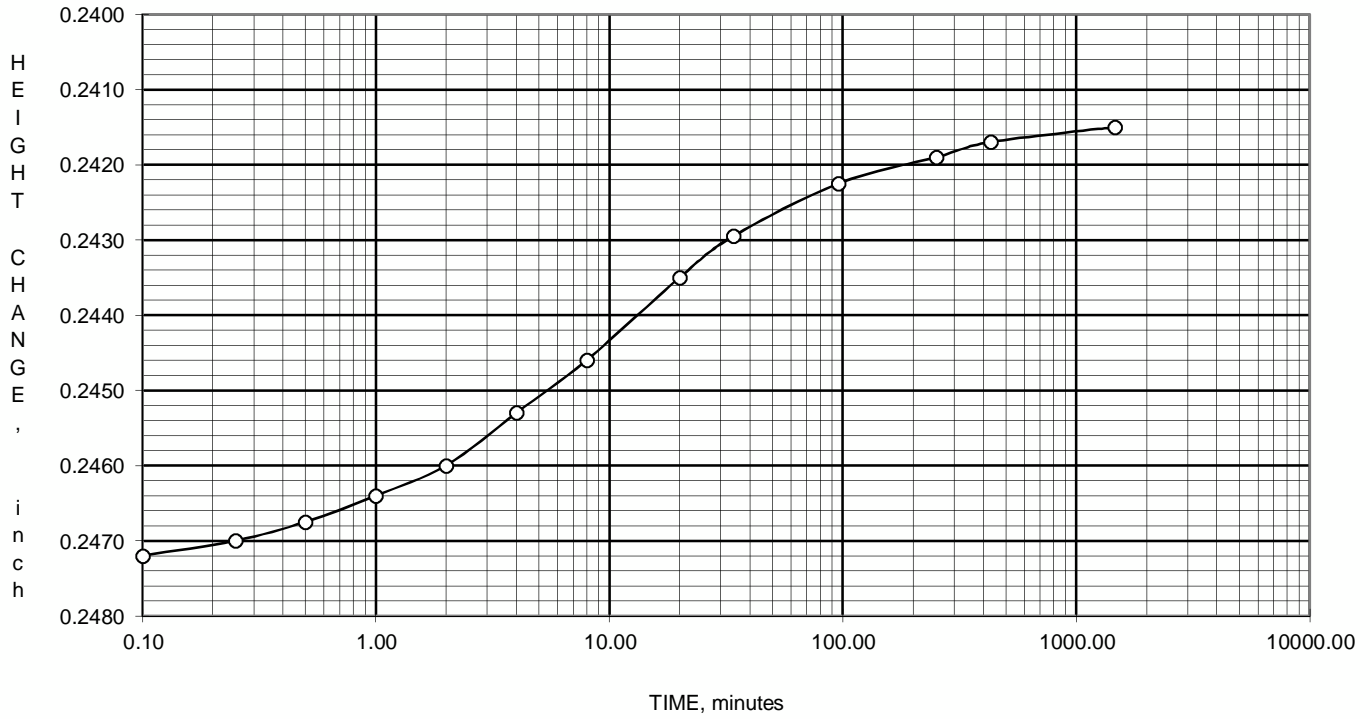
FROM	0.44	tsf	t50	30.0	min.
TO	0.89	tsf	t90	56.3	min.



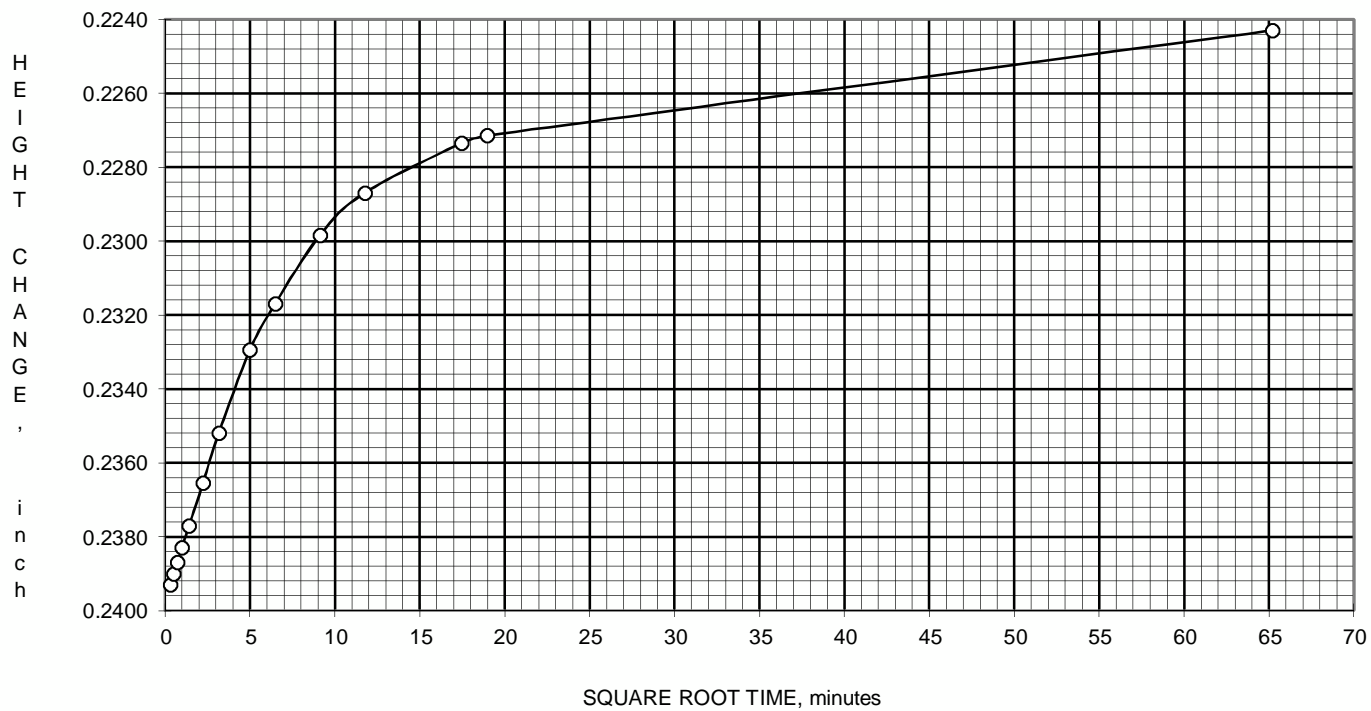
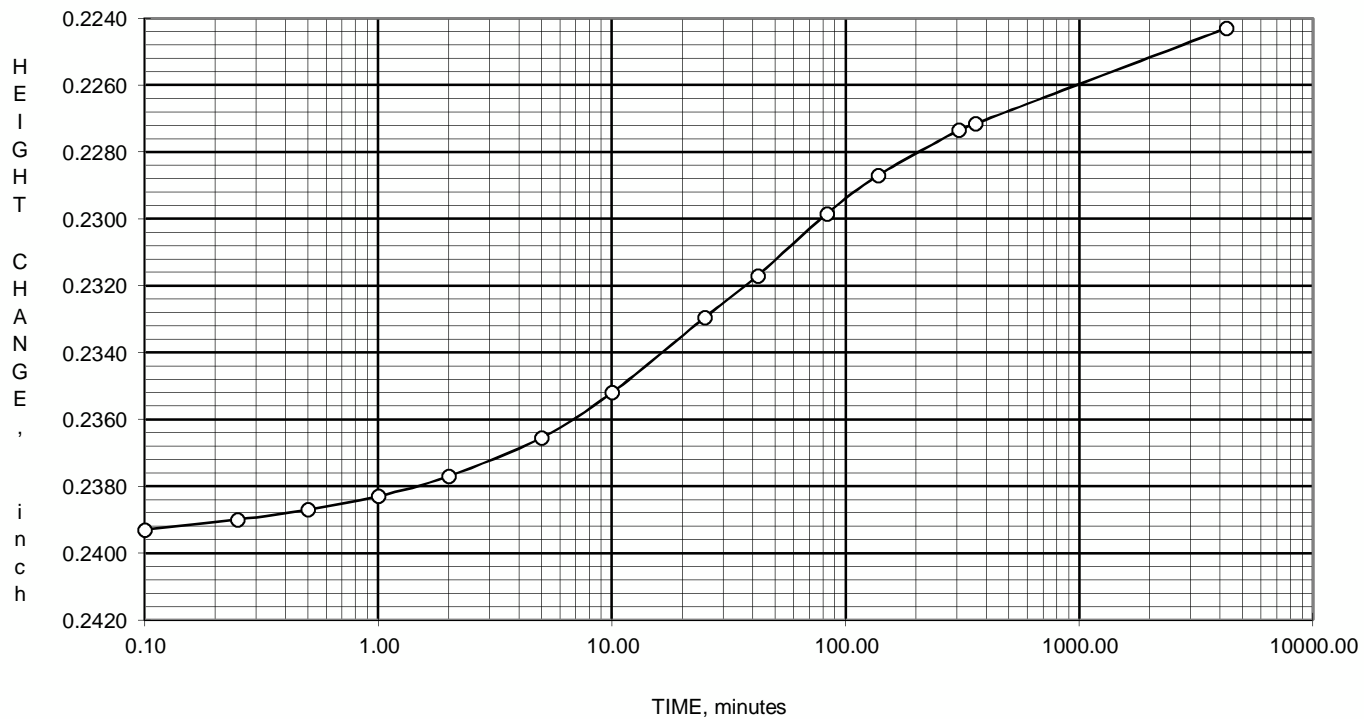
FROM	0.89	tsf	t50	26.0	min.
TO	1.78	tsf	t90	49.0	min.



FROM 1.78 tsf  
TO 0.89 tsf

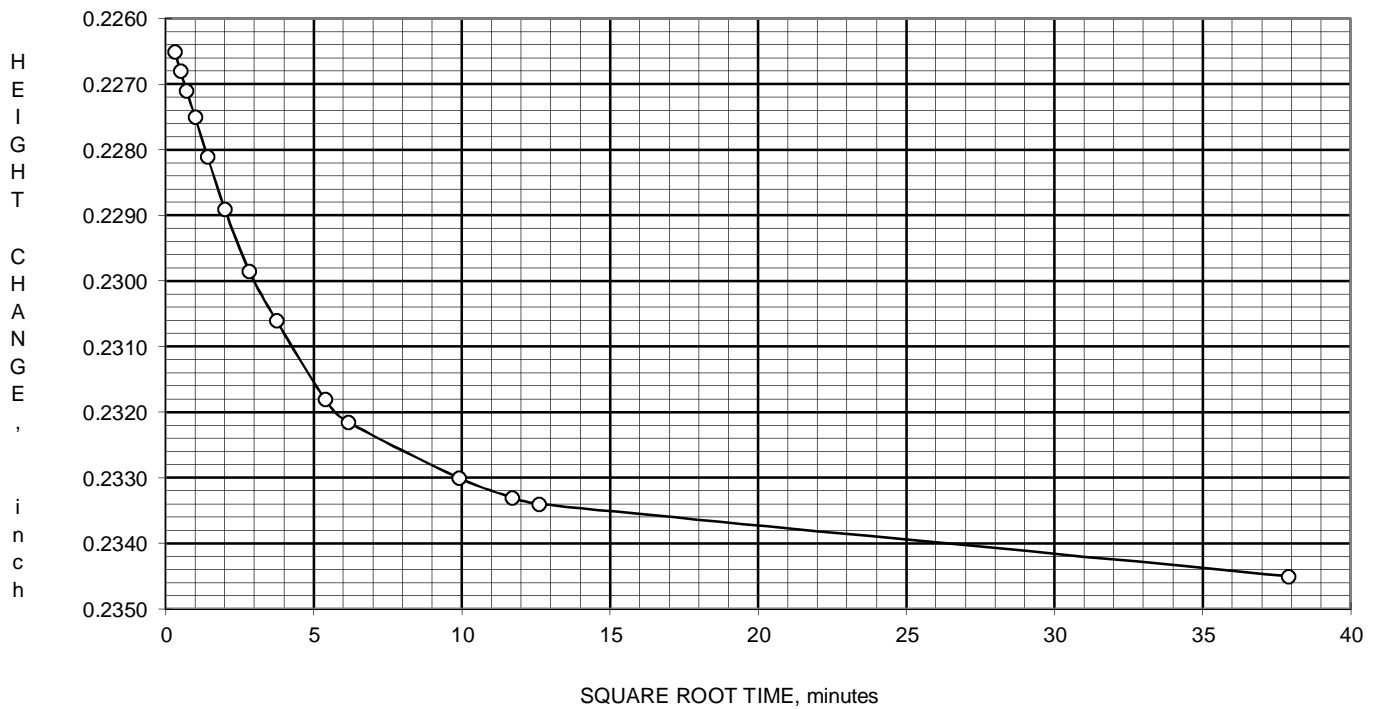
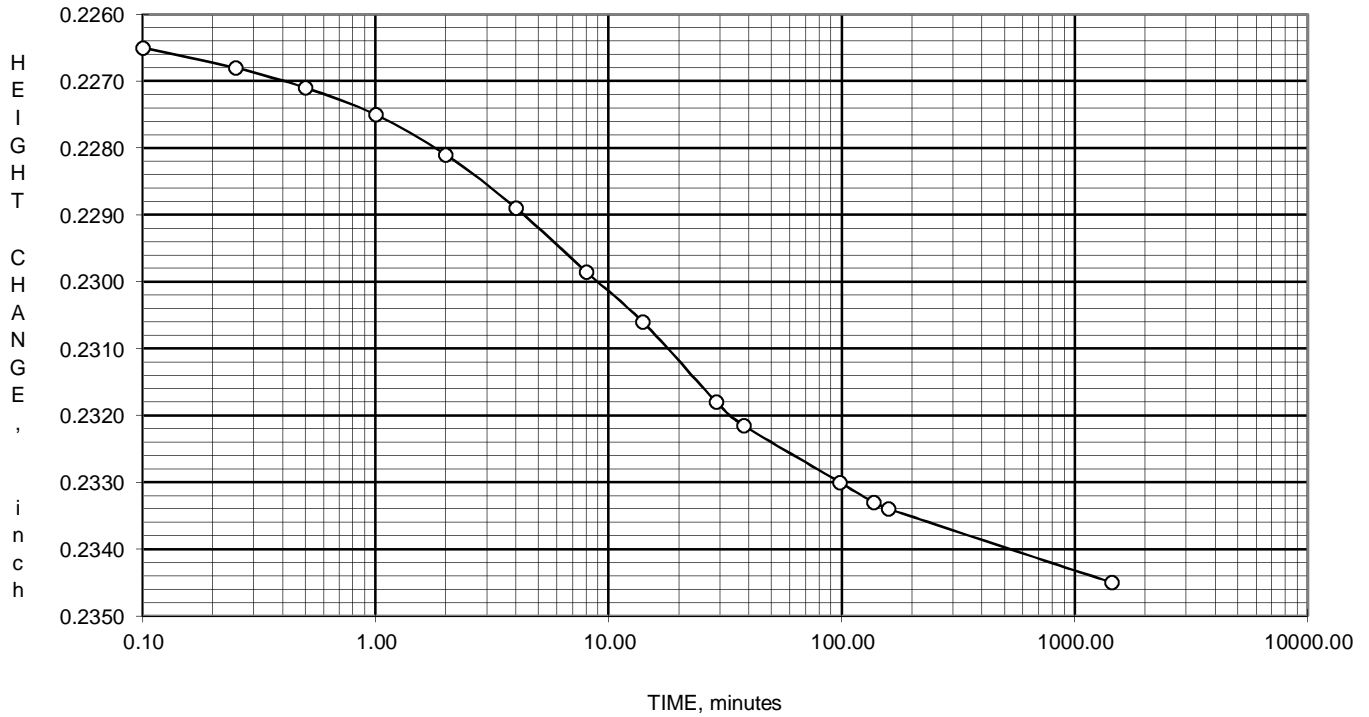


FROM 0.89 tsf  
TO 0.44 tsf

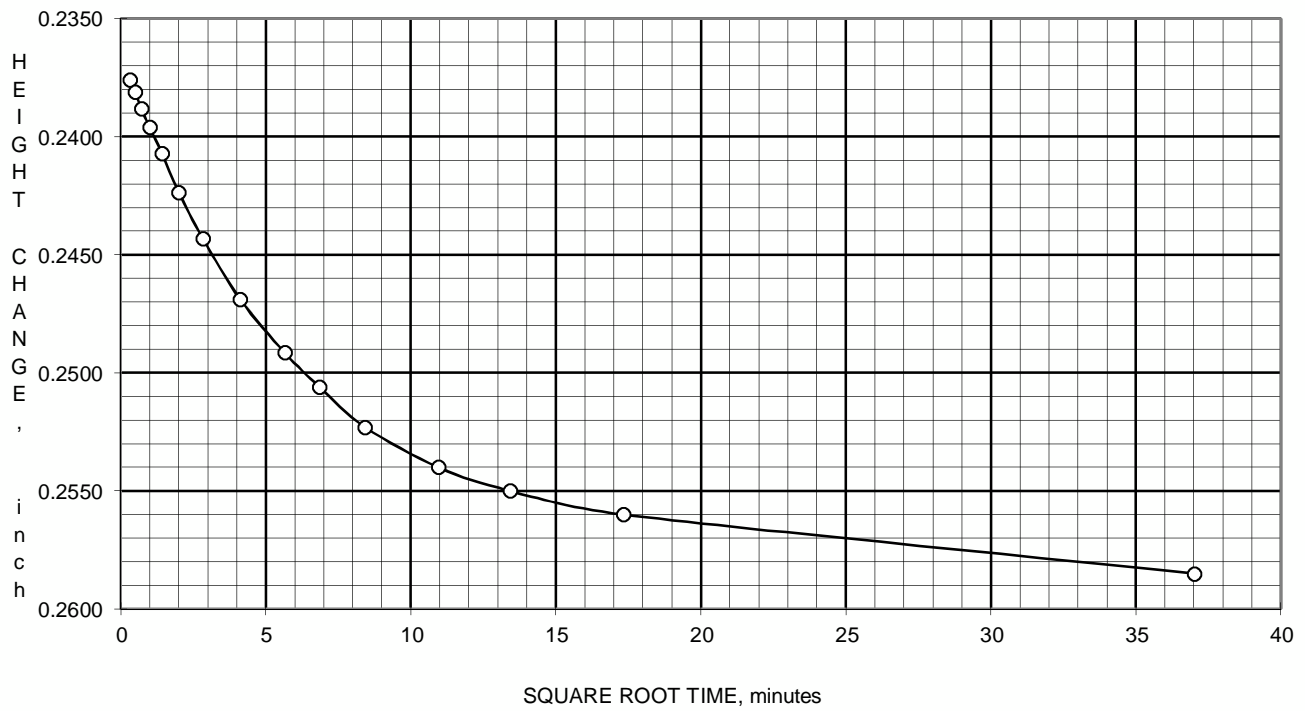
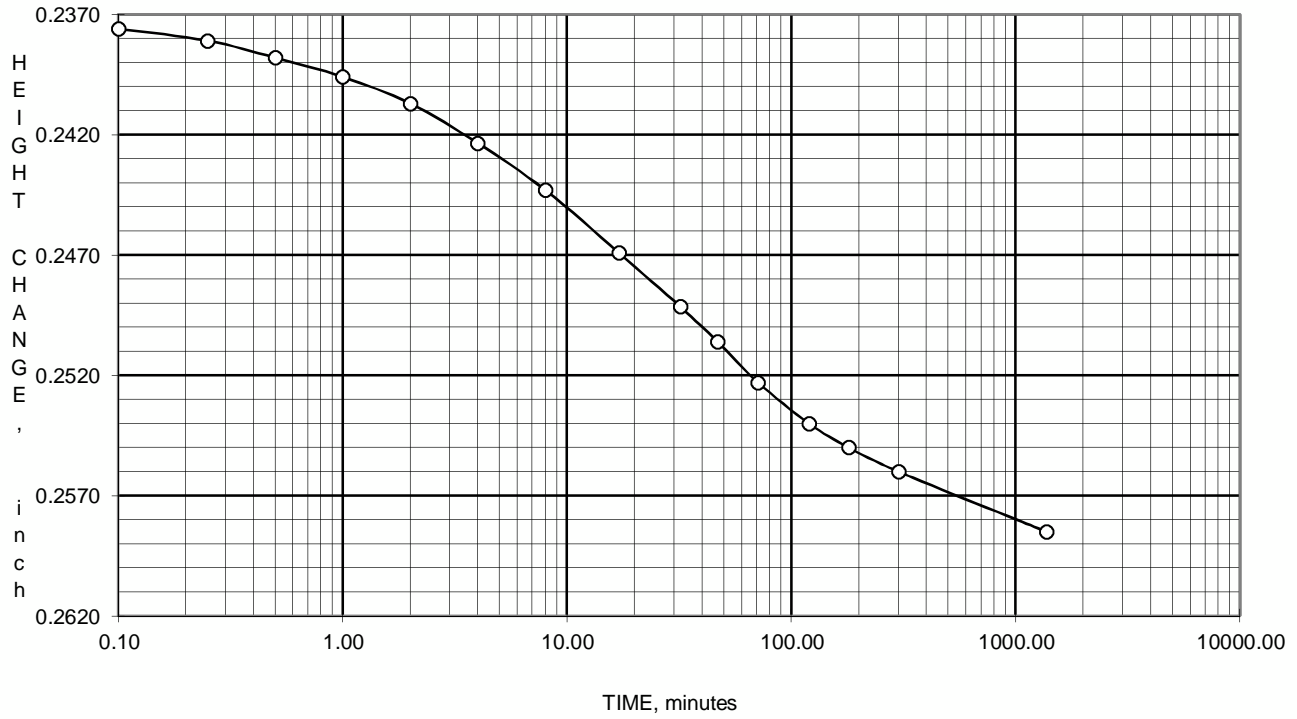




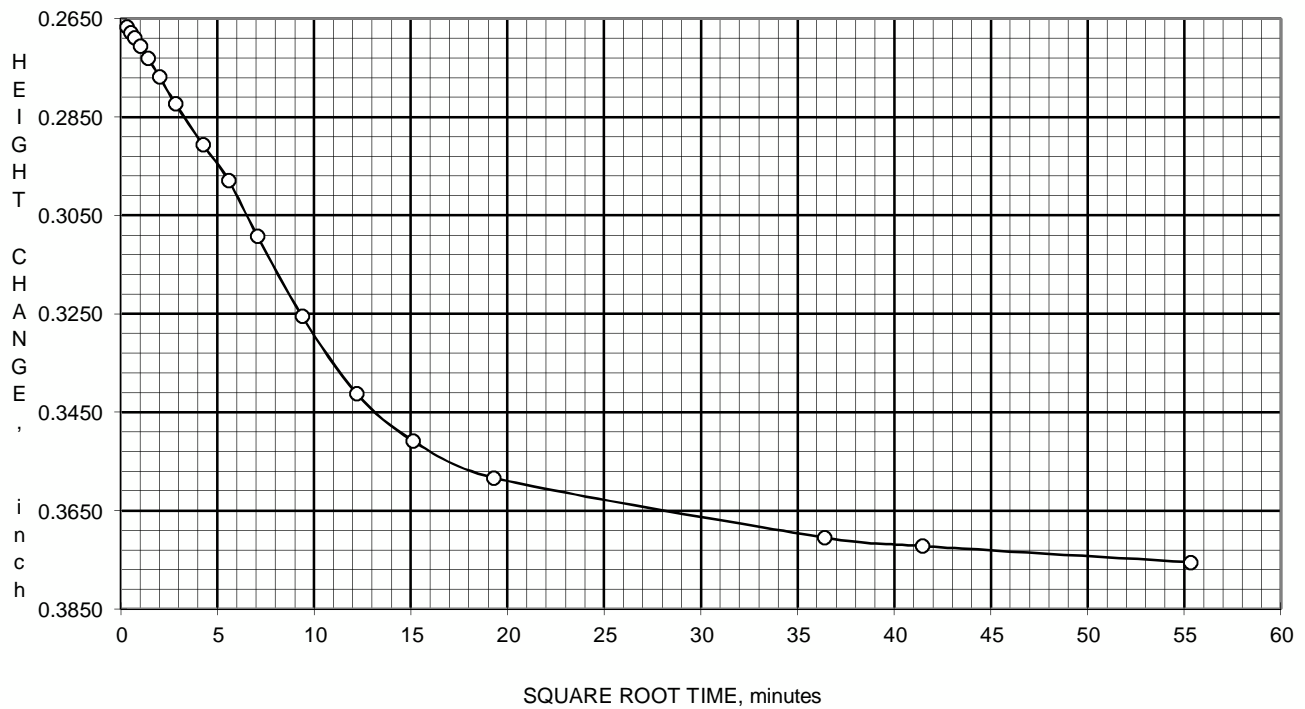
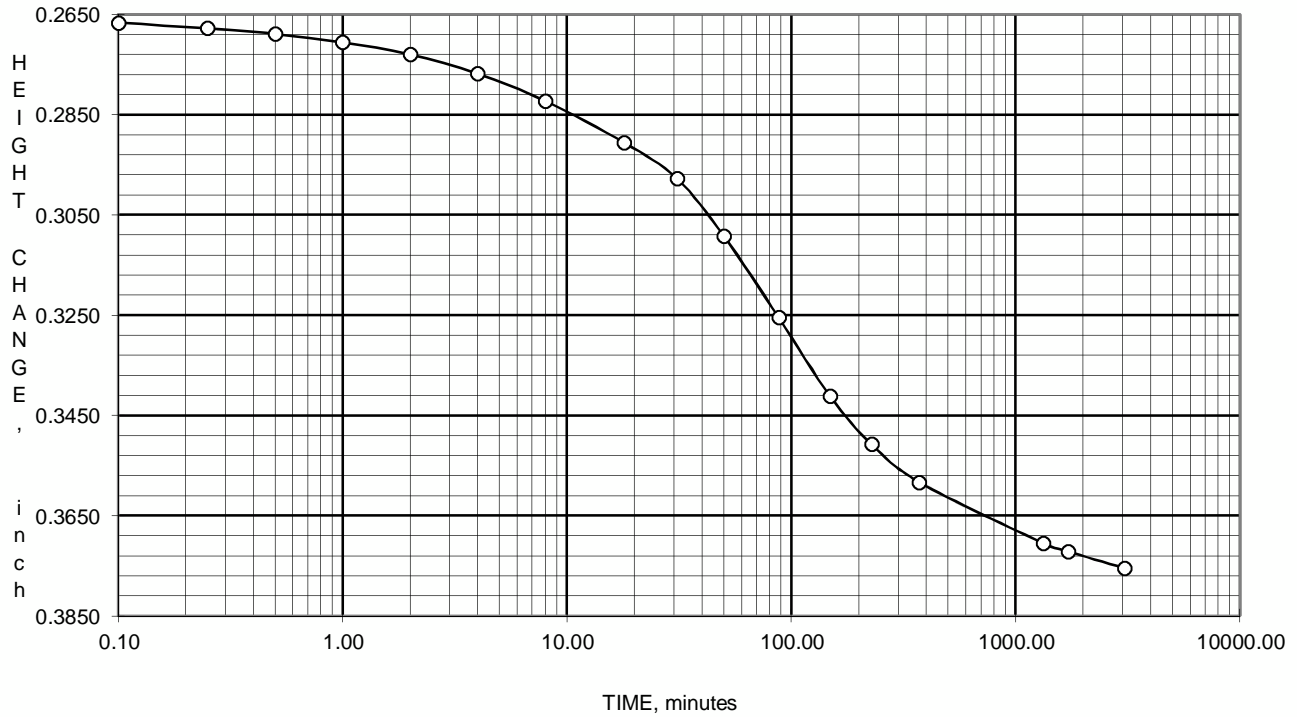
FROM	0.44	tsf	t50	6.3	min.
TO	0.89	tsf	t90	15.2	min.



FROM	0.89	tsf	t50	10.3	min.
TO	1.78	tsf	t90	21.2	min.

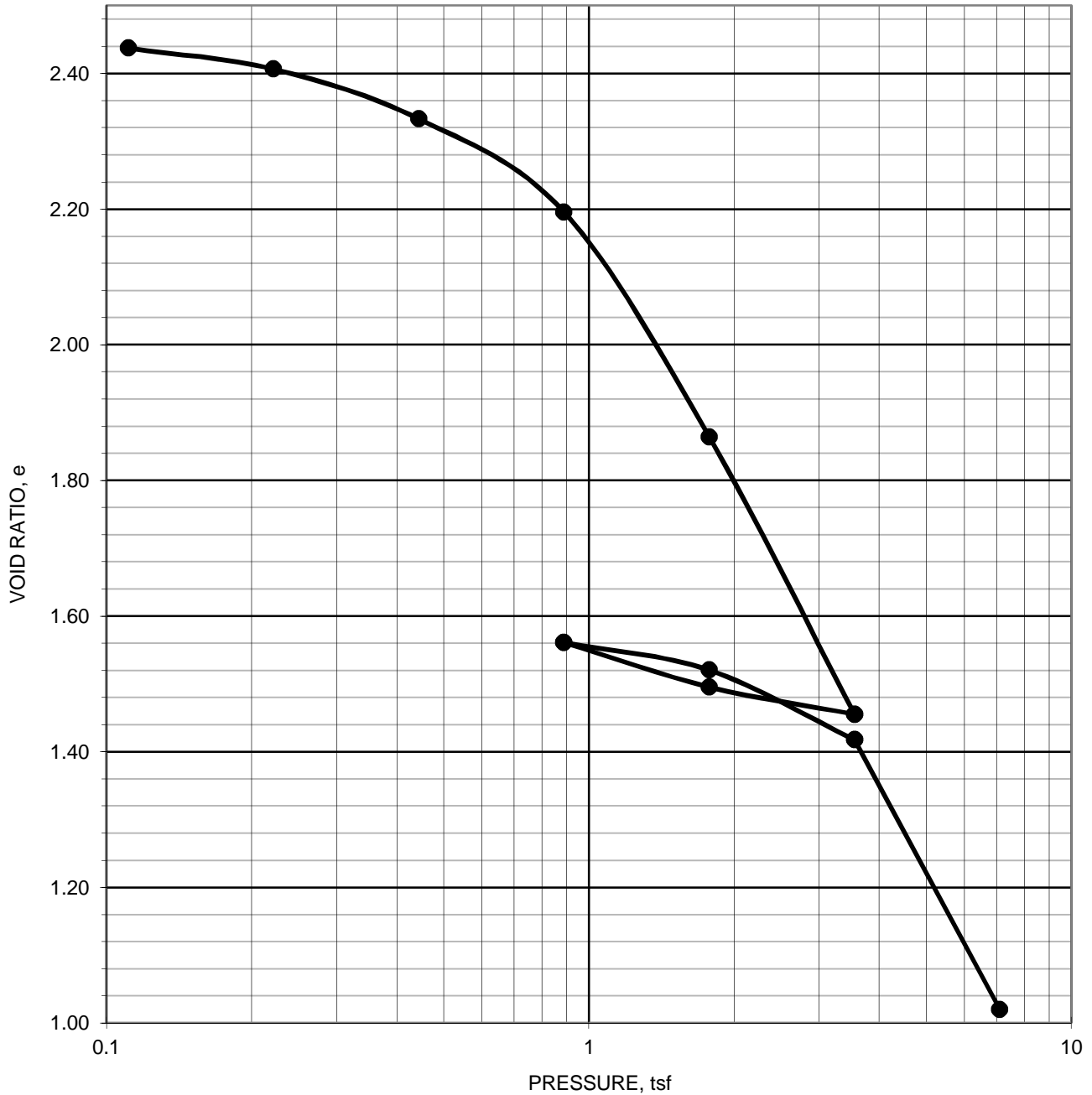


FROM	1.78	tsf	t50	60.0	min.
TO	3.56	tsf	t90	196.0	min.



# ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS

## ASTM D2435



DIAMETER, mm	63.50	HEIGHT, mm	20.00	PROPERTY		BEFORE TEST	AFTER TEST	
OVERBURDEN PRESSURE*, tsf			1.12	MOISTURE, %		86.6	73.7	
PRECONSOL. PRESSURE*, tsf			1.12	DRY DENSITY, pcf		48.8	55.1	
OVER CONSOLIDATION RATIO*			1.00	SATURATION, %		95	101	
COMPRESSION INDEX*			1.930	VOID RATIO		2.455	1.828	
RECOMPRESSION INDEX*			0.206	SAMPLE TYPE		UNDISTURBED		
Liquid Limit	152	Plastic Limit	40	Plasticity Index	112	SPECIFIC GRAVITY (assumed)		2.7
SAMPLE DESCRIPTION		Dark Gray Fat Clay (CH)				% Finer #200		97.0
BORING NO.	BH-3		SAMPLE NO.	P3		DEPTH	40 to 42 feet	

\*Values determined by reconstructed field curve

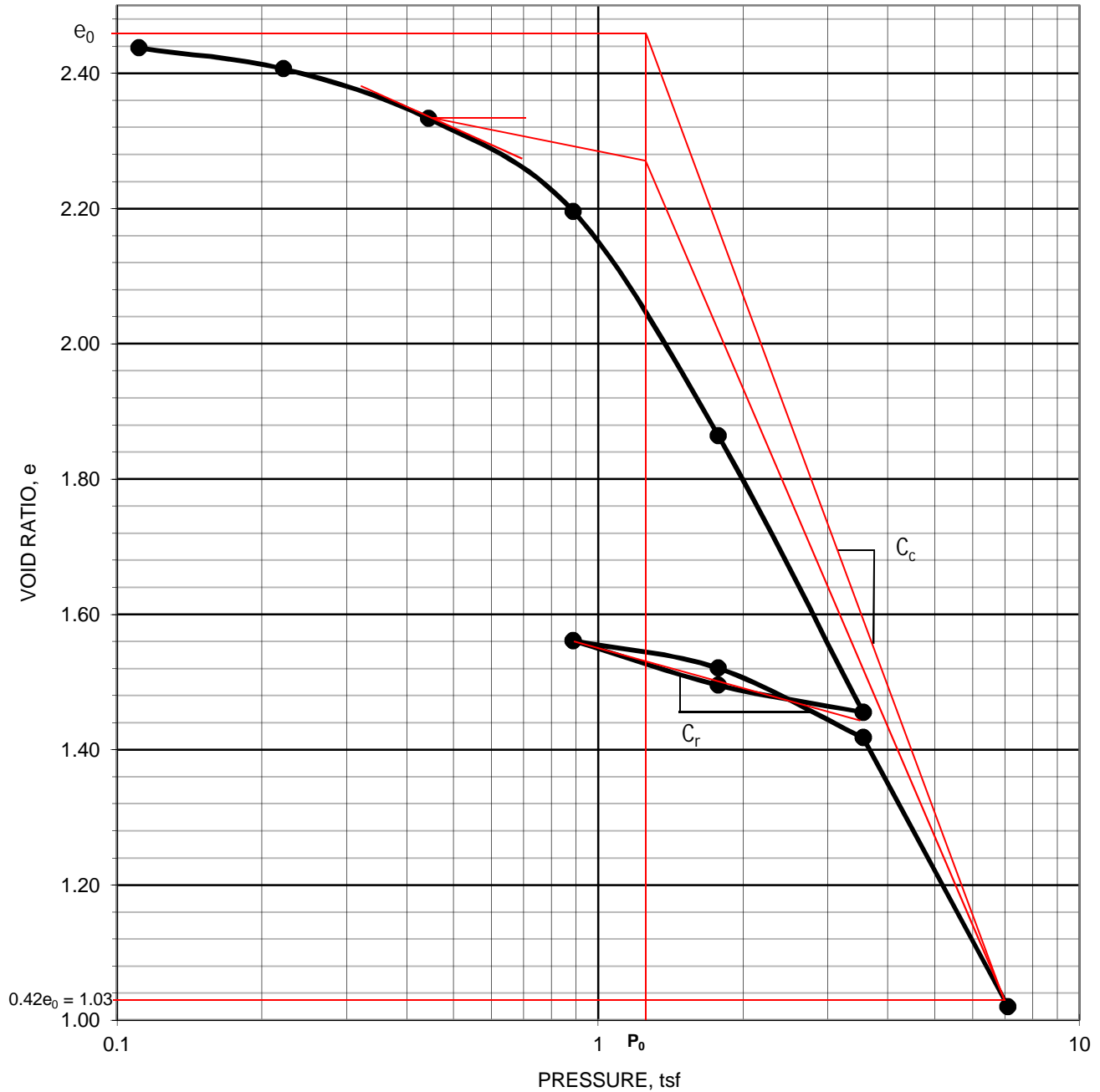
Veterans Terminal  
BH-3 40 to 42 feet Sample P3  
EN125099

**Terracon**

TESTED BY  
APPROVED BY

JH  
RK

# ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS ASTM D2435



DIAMETER, mm	63.50	HEIGHT, mm	20.00	PROPERTY		BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE*, tsf			1.12	MOISTURE, %		86.6	73.7
PRECONSOL. PRESSURE*, tsf			1.12	DRY DENSITY, pcf		48.8	55.1
OVER CONSOLIDATION RATIO*			1.00	SATURATION, %		95	101
COMPRESSION INDEX*			1.930	VOID RATIO		2.455	1.828
RECOMPRESSION INDEX*			0.206	SAMPLE TYPE		UNDISTURBED	
Liquid Limit	152	Plastic Limit	40	Plasticity Index	112	SPECIFIC GRAVITY (assumed)	
SAMPLE DESCRIPTION		Dark Gray Fat Clay (CH)			% Finer #200		97.0
BORING NO.	BH-3		SAMPLE NO.	P3		DEPTH	40 to 42 feet

\*Values determined by reconstructed field curve

Veterans Terminal  
BH-3 40 to 42 feet Sample P3  
EN125099

Terracon

TESTED BY  
APPROVED BY

JH  
RK

## ADDITIONAL CONSOLIDATION DATA

Veterans Terminal  
North Charleston, South Carolina  
173533-04 (EN125099)

BH-3

40 to 42 feet

	<u>Pressure</u> <u>tsf</u>	<u>Cv50</u> <u>cm2/sec</u>	<u>Cv90</u> <u>cm2/sec</u>	<u>Av</u> <u>cm2/g</u>	<u>Mv</u> <u>cm2/g</u>	<u>k</u> <u>cm/sec</u>
1	0.111	3.02E-03	1.67E-03	1.65E-04	4.79E-05	1.45E-07
2	0.222	1.53E-03	1.13E-03	2.86E-04	8.33E-05	1.28E-07
3	0.444	1.16E-03	8.61E-04	3.37E-04	9.89E-05	1.14E-07
4	0.889	7.22E-04	7.68E-04	3.16E-04	9.47E-05	6.84E-08
5	1.778	2.51E-04	2.56E-04	3.81E-04	1.19E-04	3.00E-08
6	3.556	9.18E-05	6.73E-05	2.35E-04	8.20E-05	7.53E-09
7	1.778	N.A.	N.A.	2.30E-05	9.35E-06	N.A.
8	0.889	N.A.	N.A.	7.57E-05	3.03E-05	N.A.
9	1.778	4.42E-04	8.45E-04	4.69E-05	1.83E-05	8.09E-09
10	3.556	3.46E-04	5.83E-04	5.90E-05	2.34E-05	8.10E-09
11	7.111	1.21E-04	1.17E-04	1.14E-04	4.73E-05	5.71E-09

1

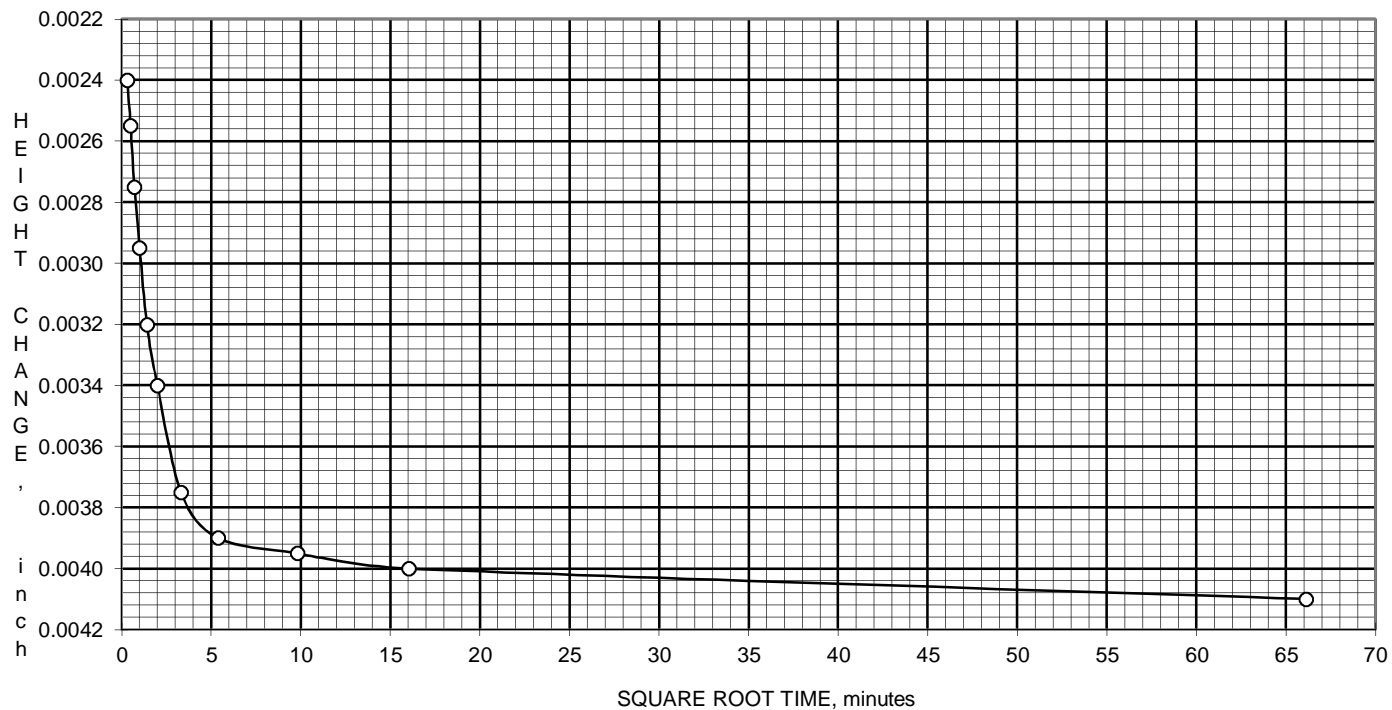
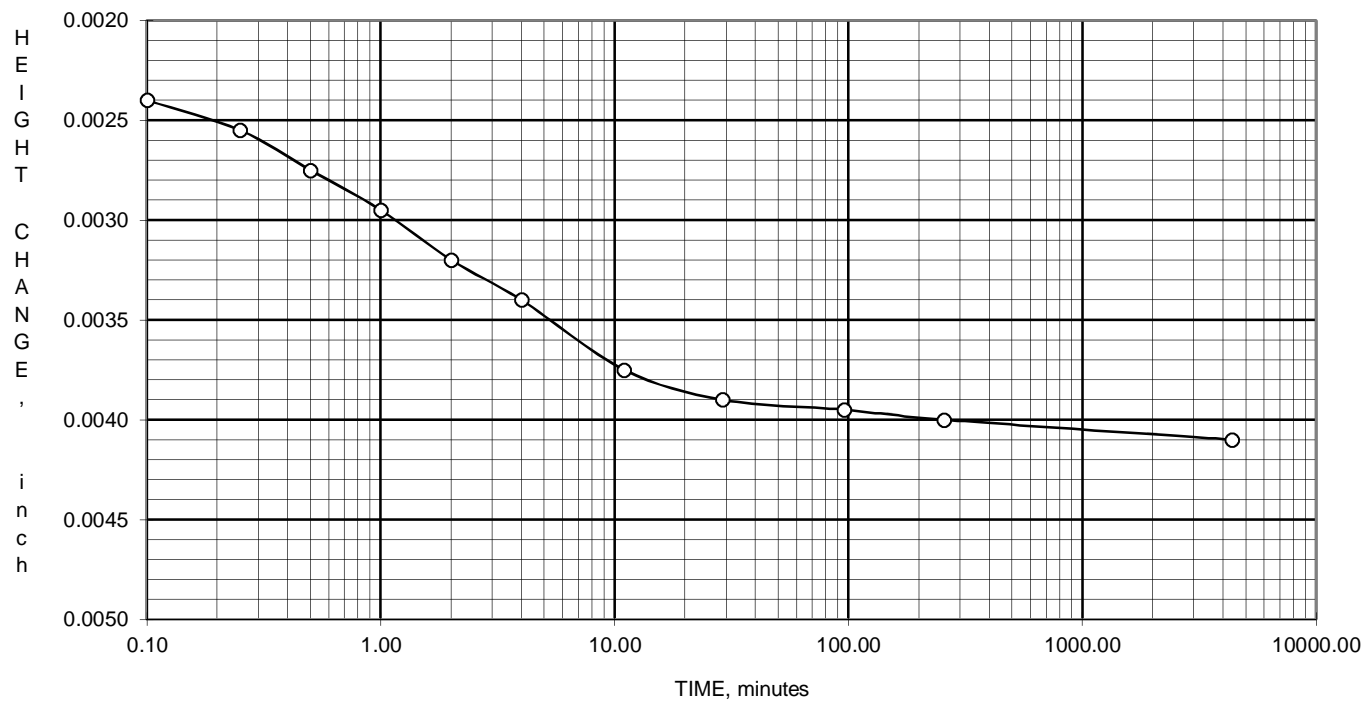
Veterans Terminal

BH-3

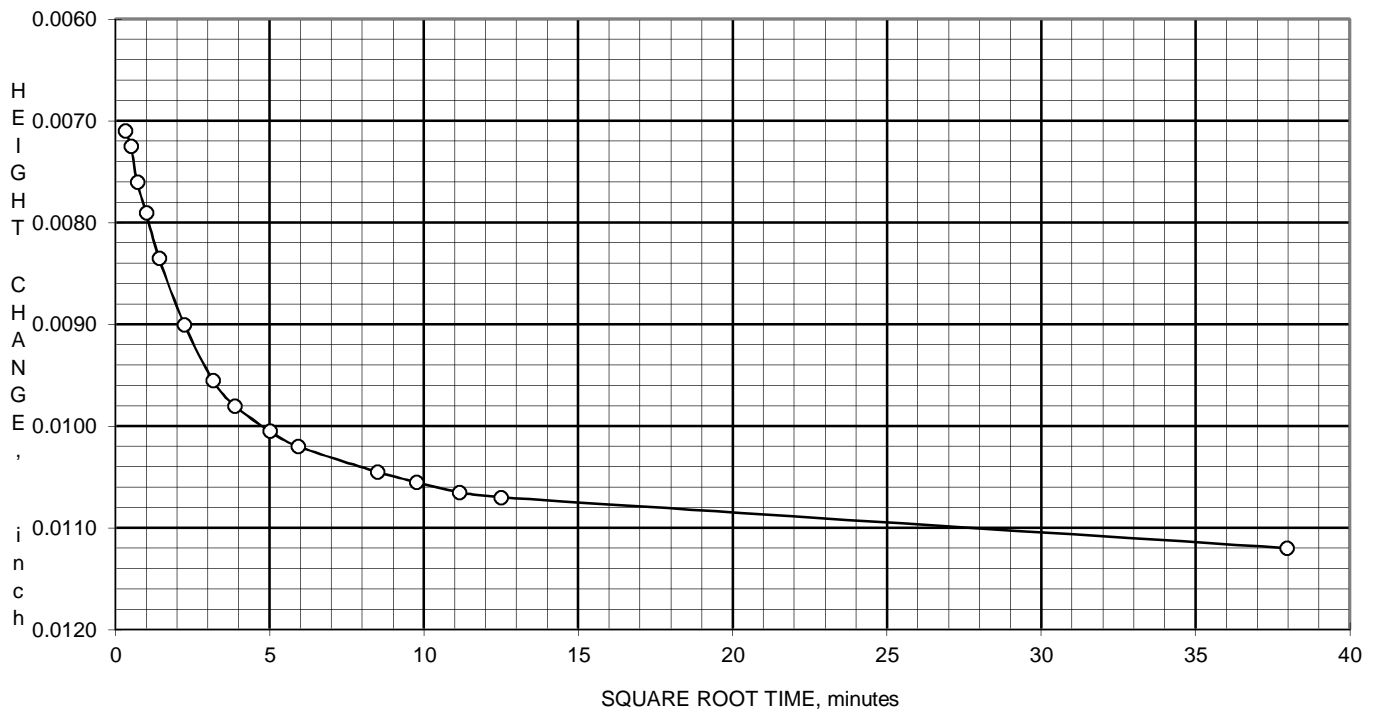
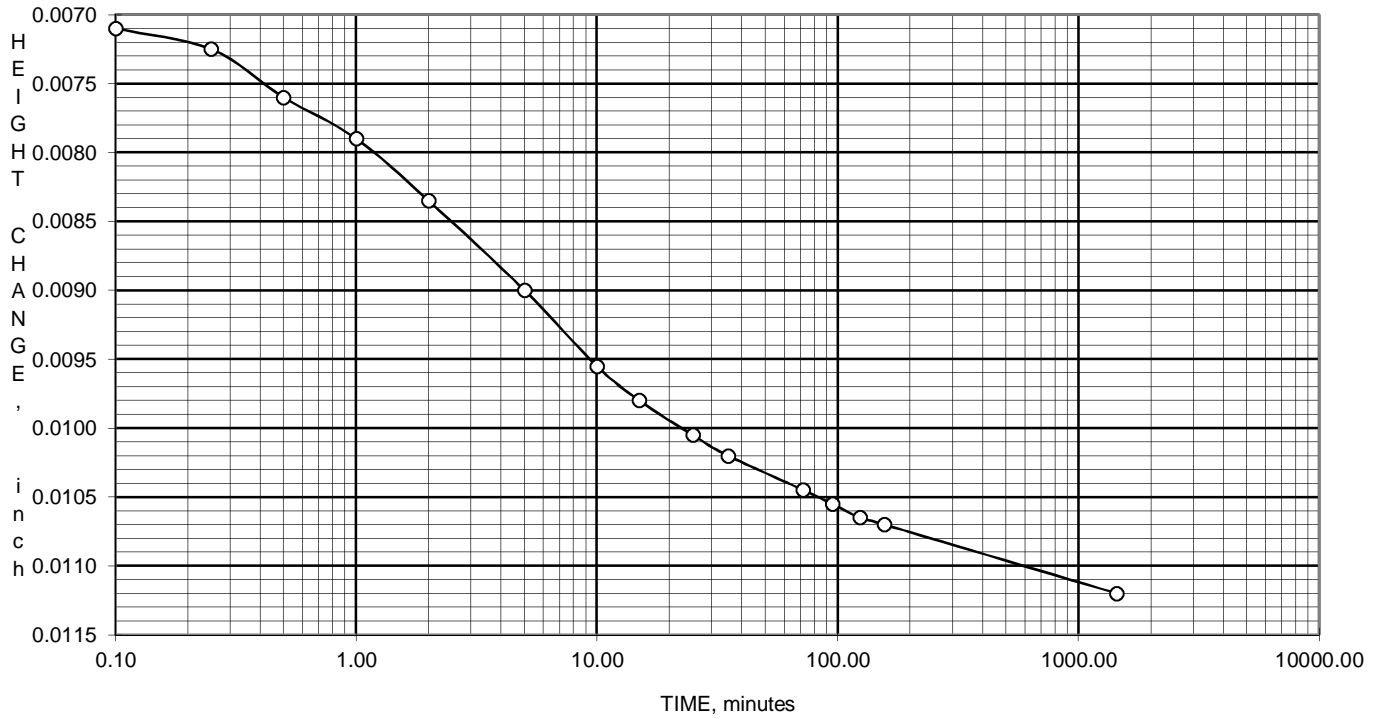
EN125099

11.21.12

FROM	0.00	tsf	t50	1.1	min.
TO	0.11	tsf	t90	8.4	min.

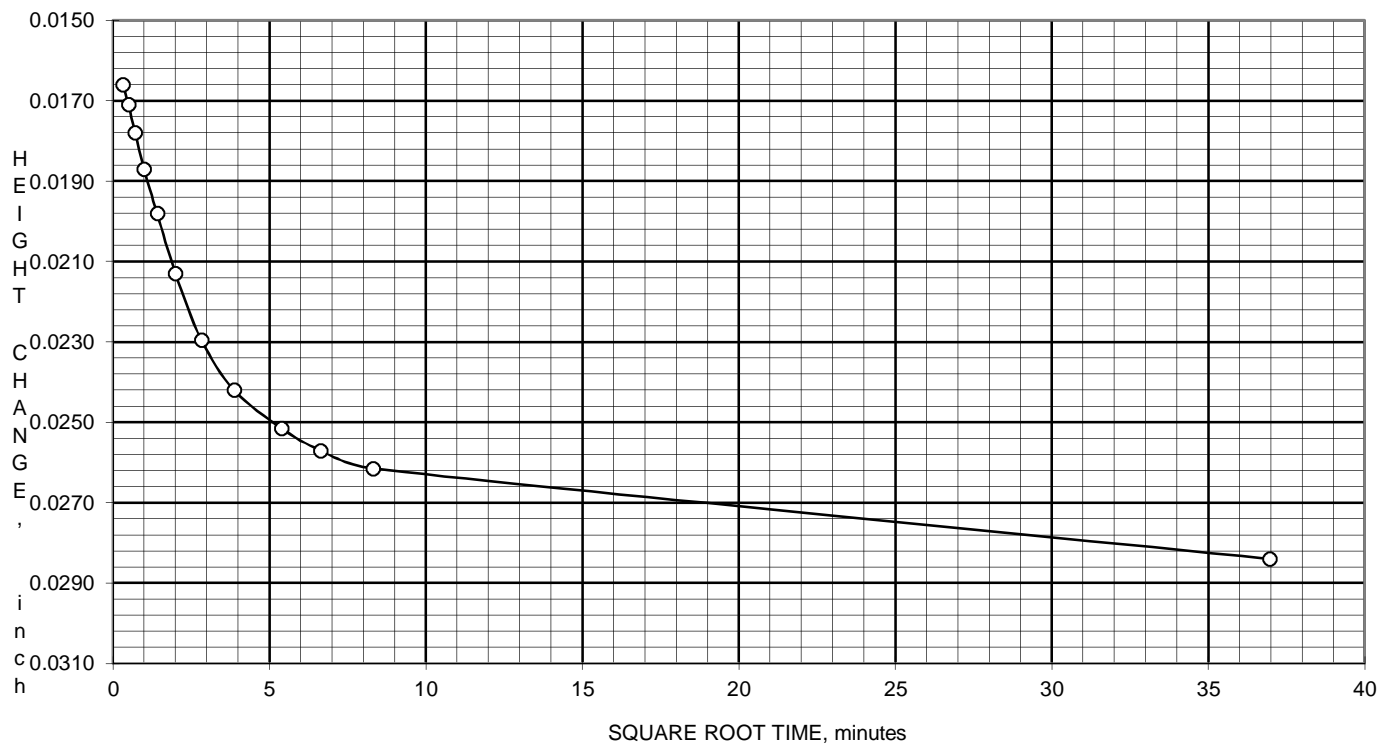
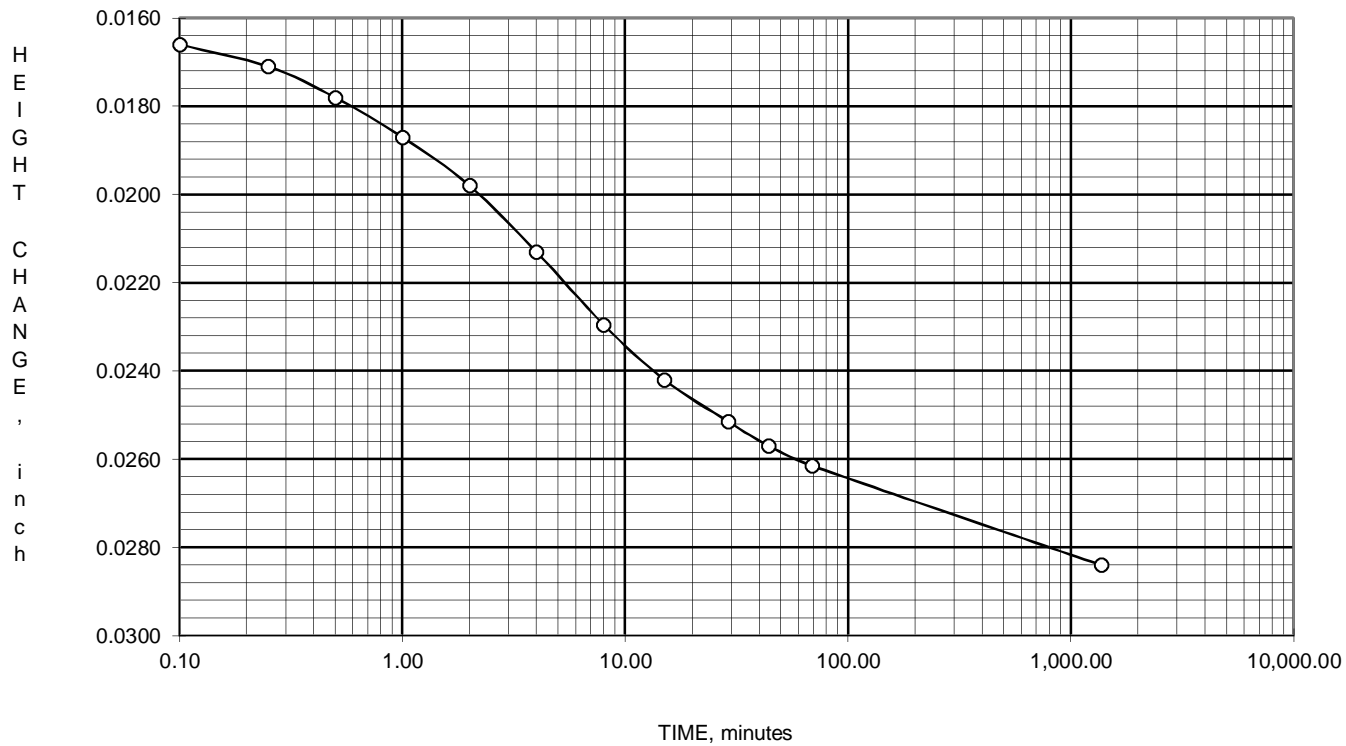


FROM	0.11	tsf	t50	2.1	min.
TO	0.22	tsf	t90	12.3	min.

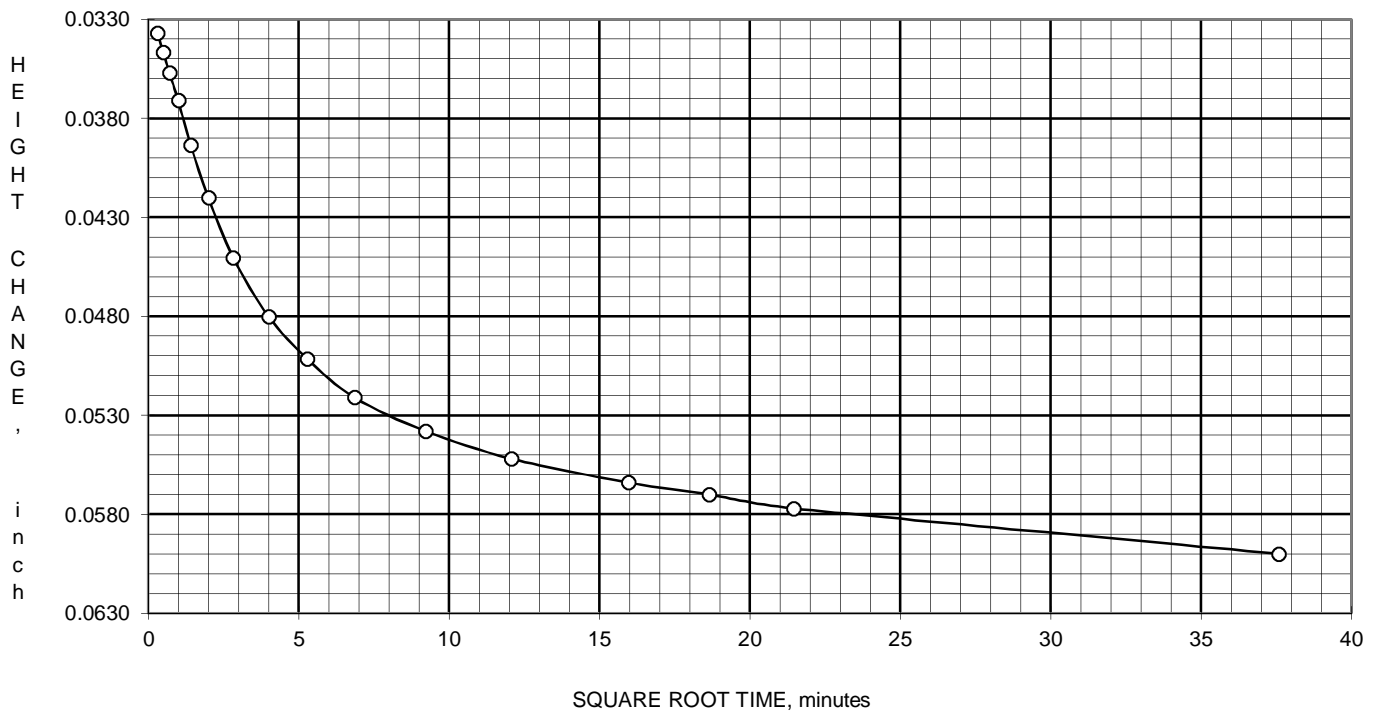
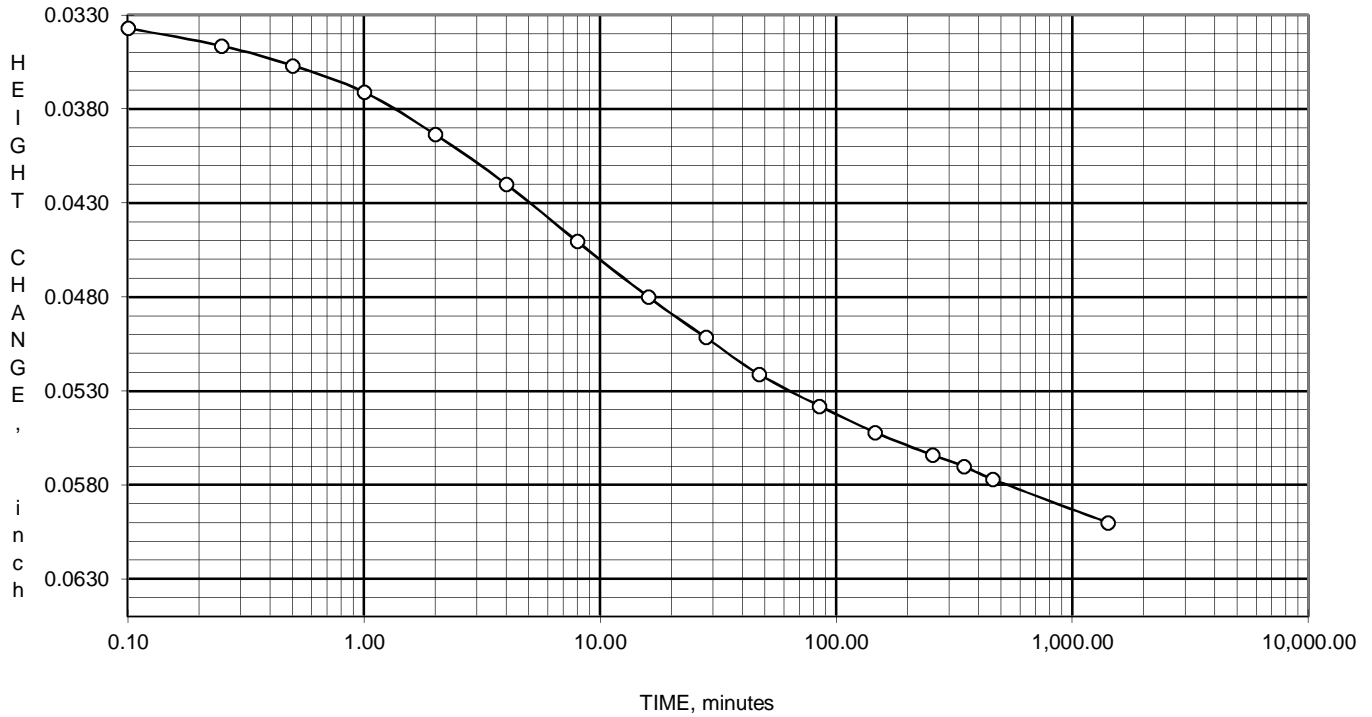




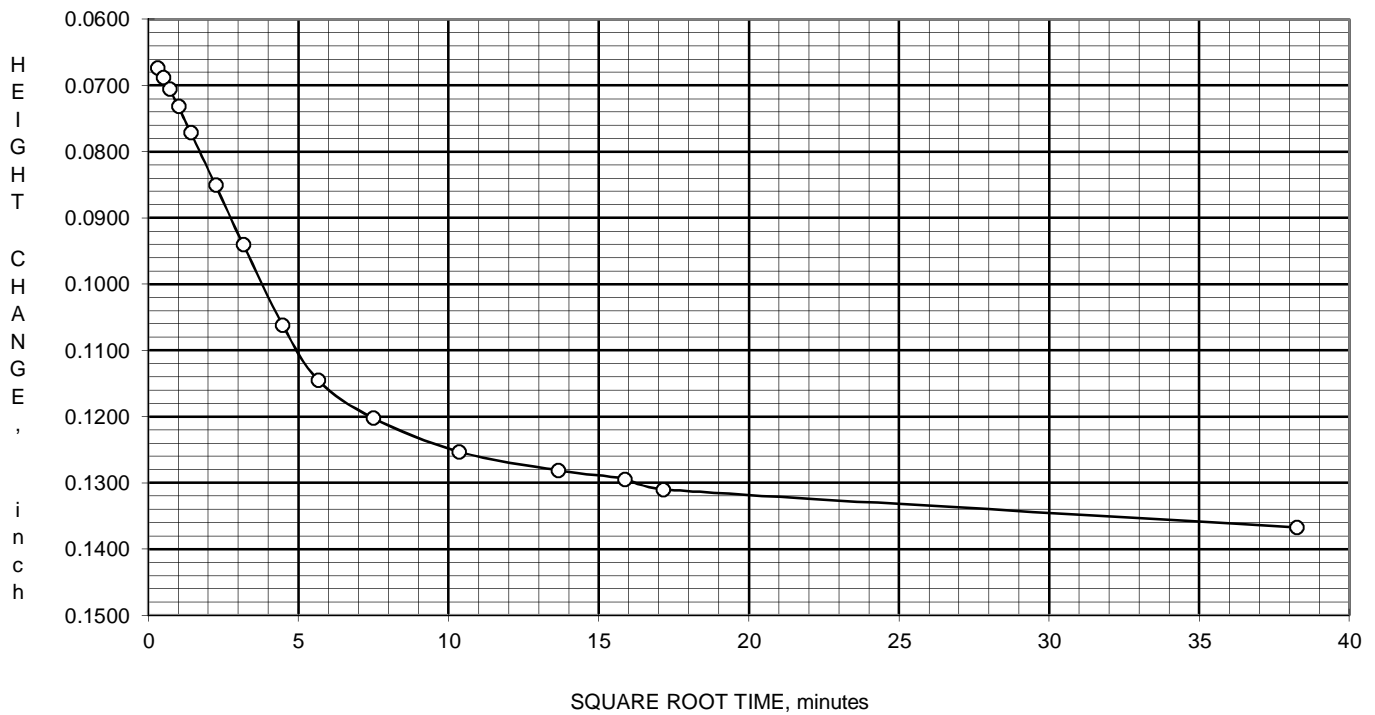
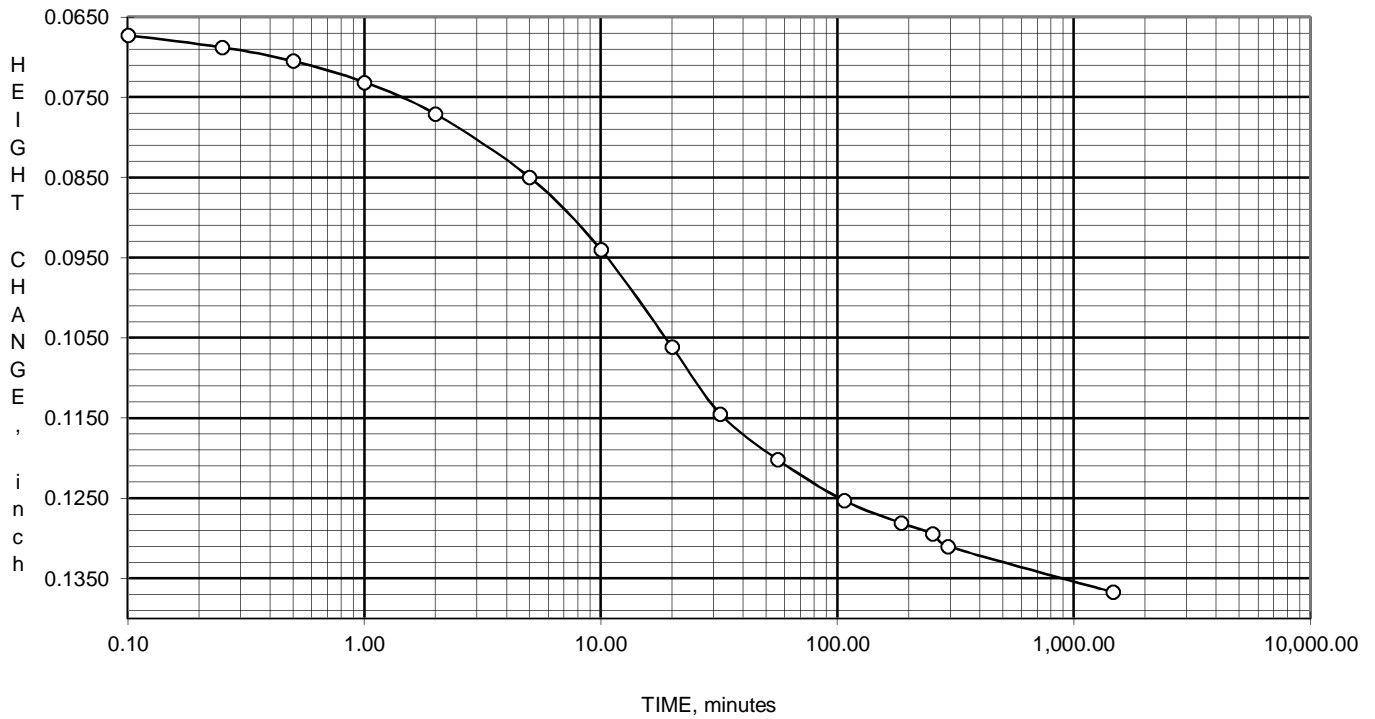
FROM	0.22	tsf	t50	2.7	min.
TO	0.44	tsf	t90	15.6	min.



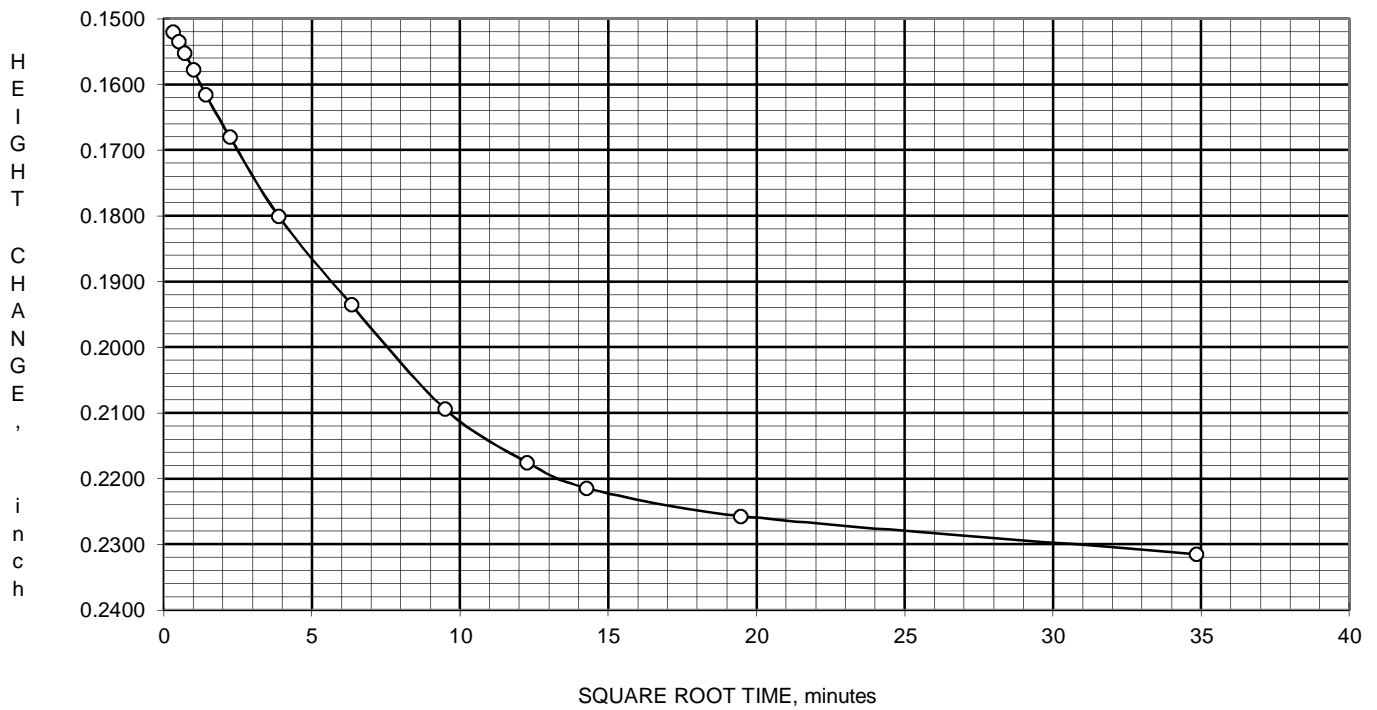
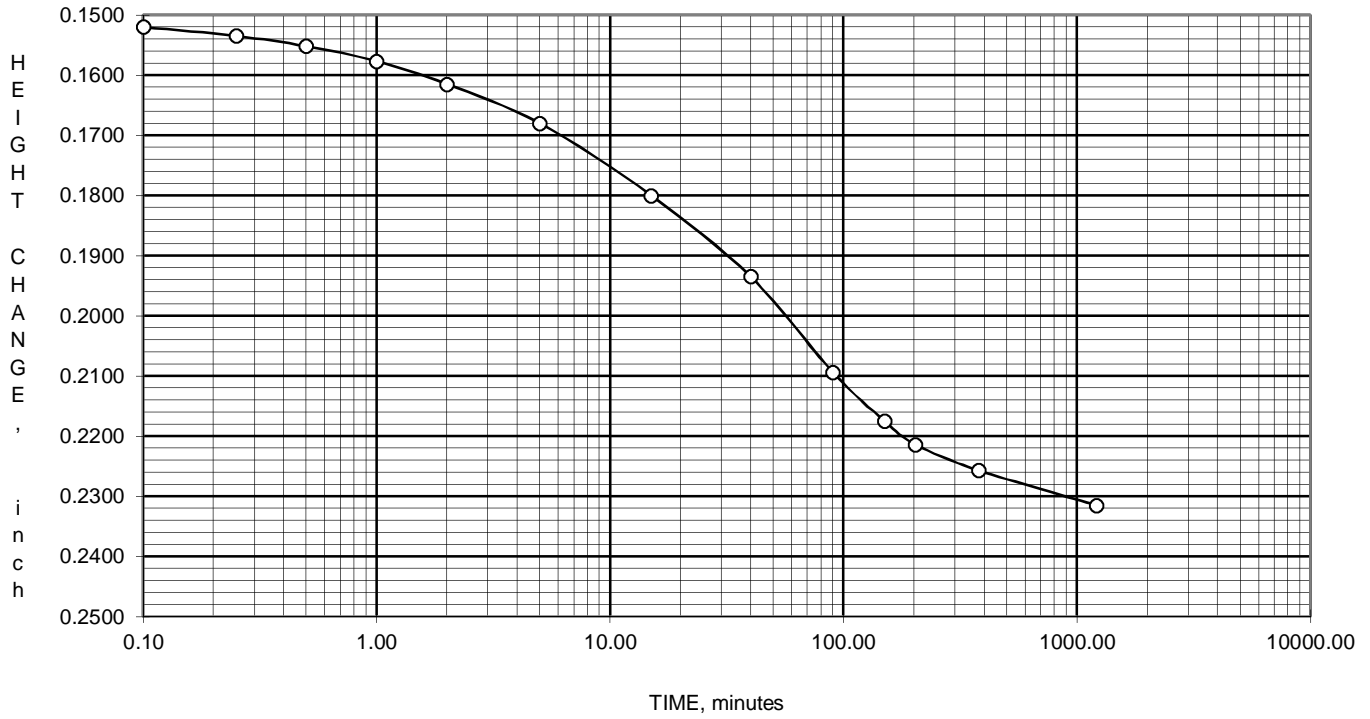
FROM	0.44	tsf	t50	4.1	min.
TO	0.89	tsf	t90	16.4	min.



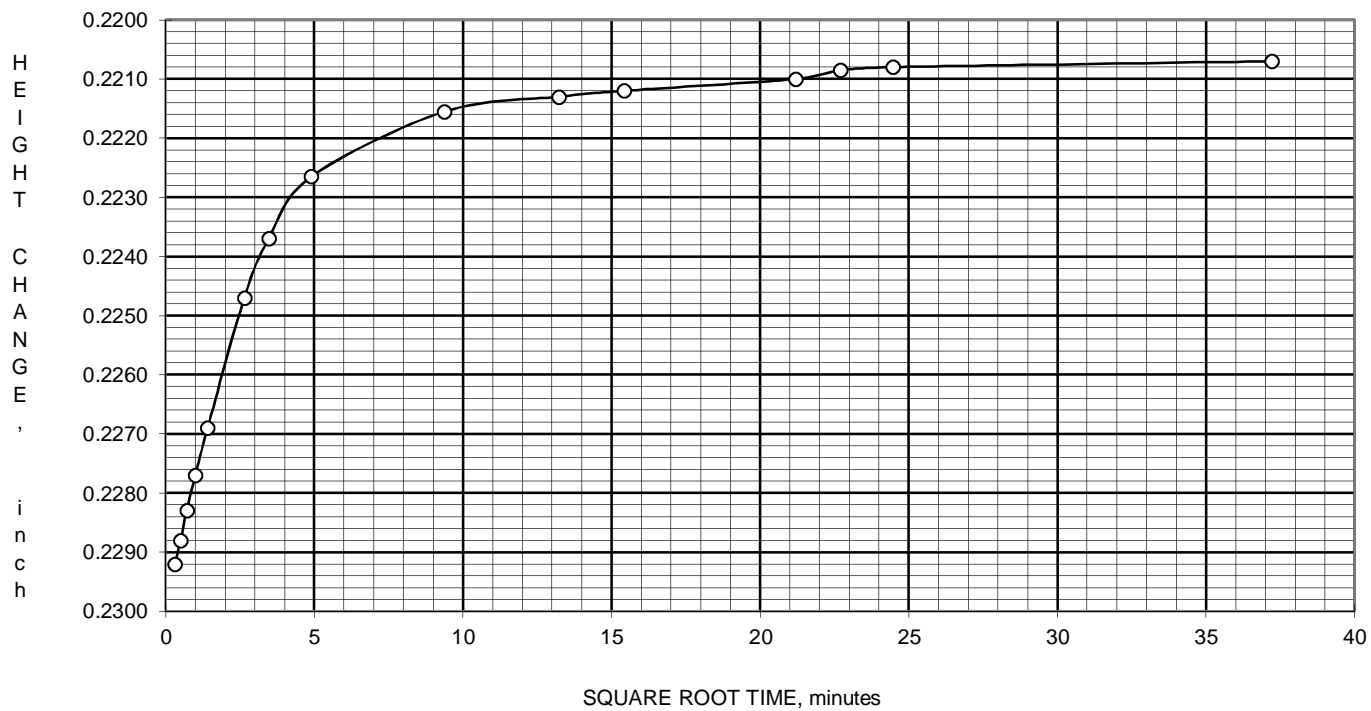
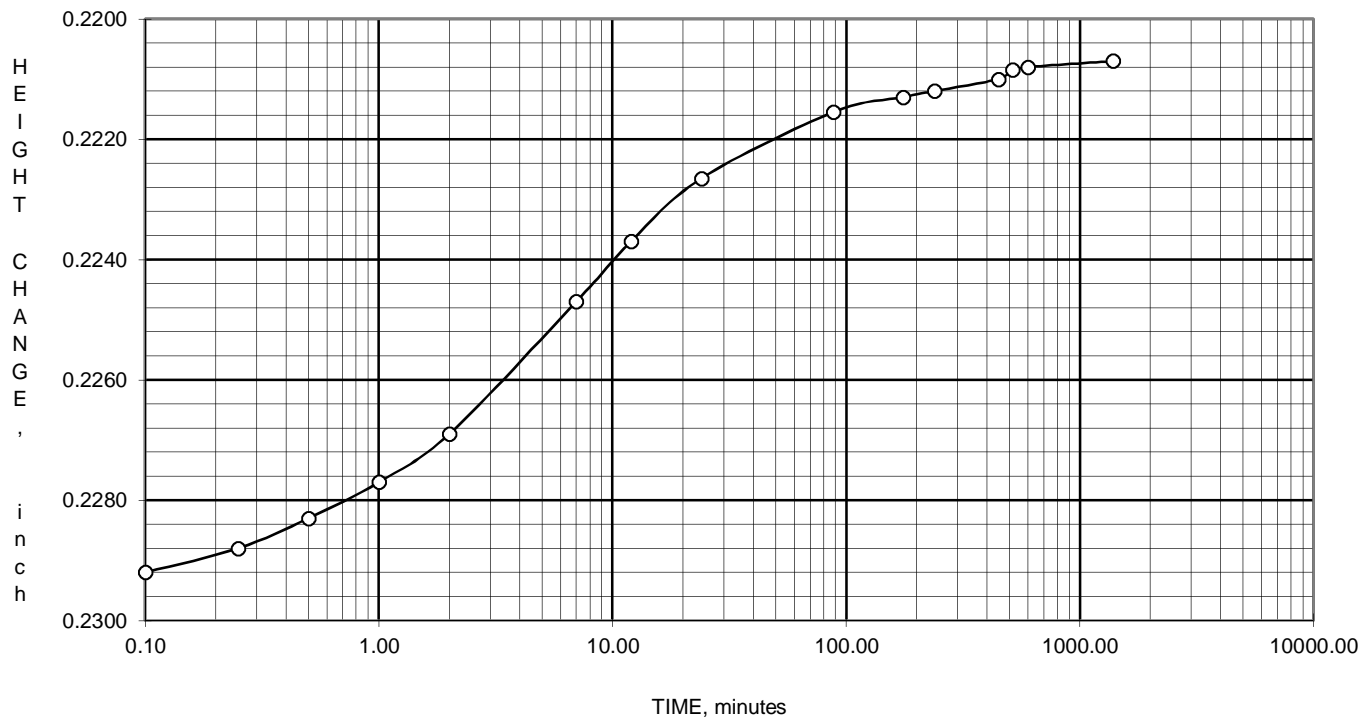
FROM	0.89	tsf	t50	10.0	min.
TO	1.78	tsf	t90	42.3	min.



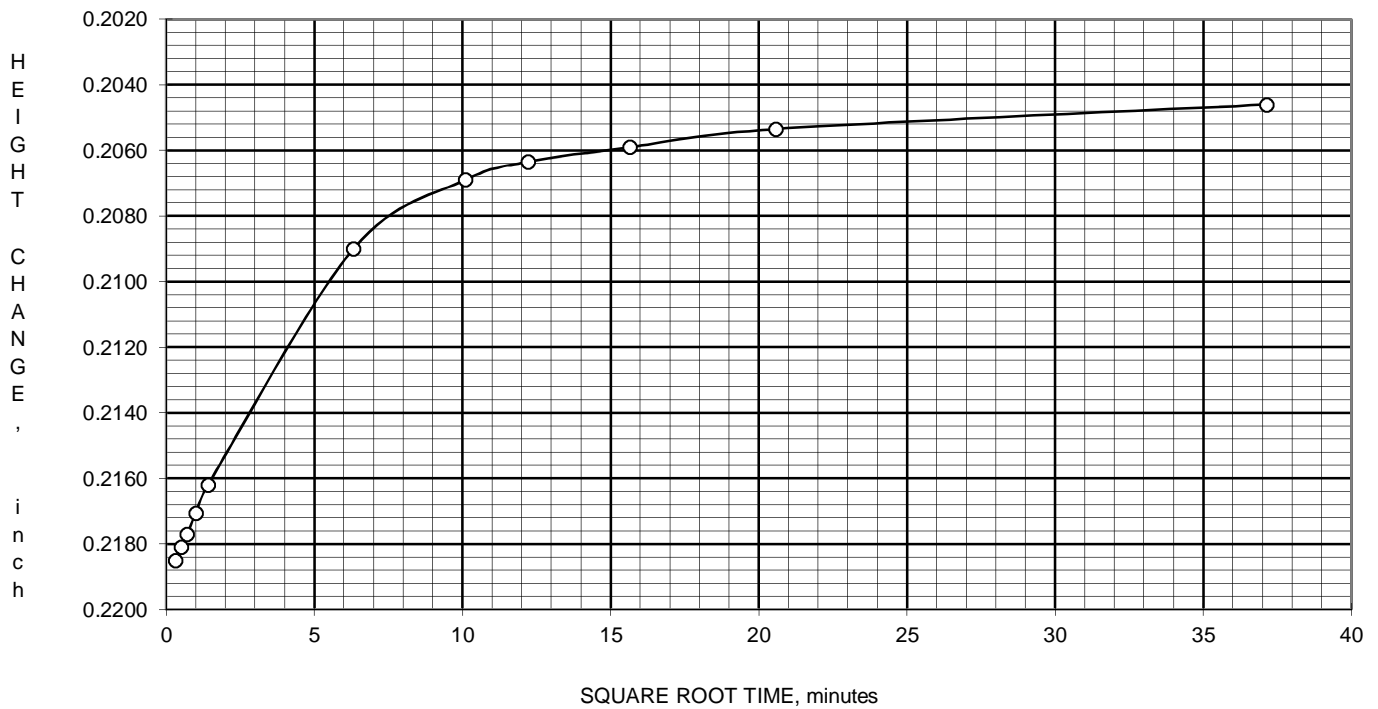
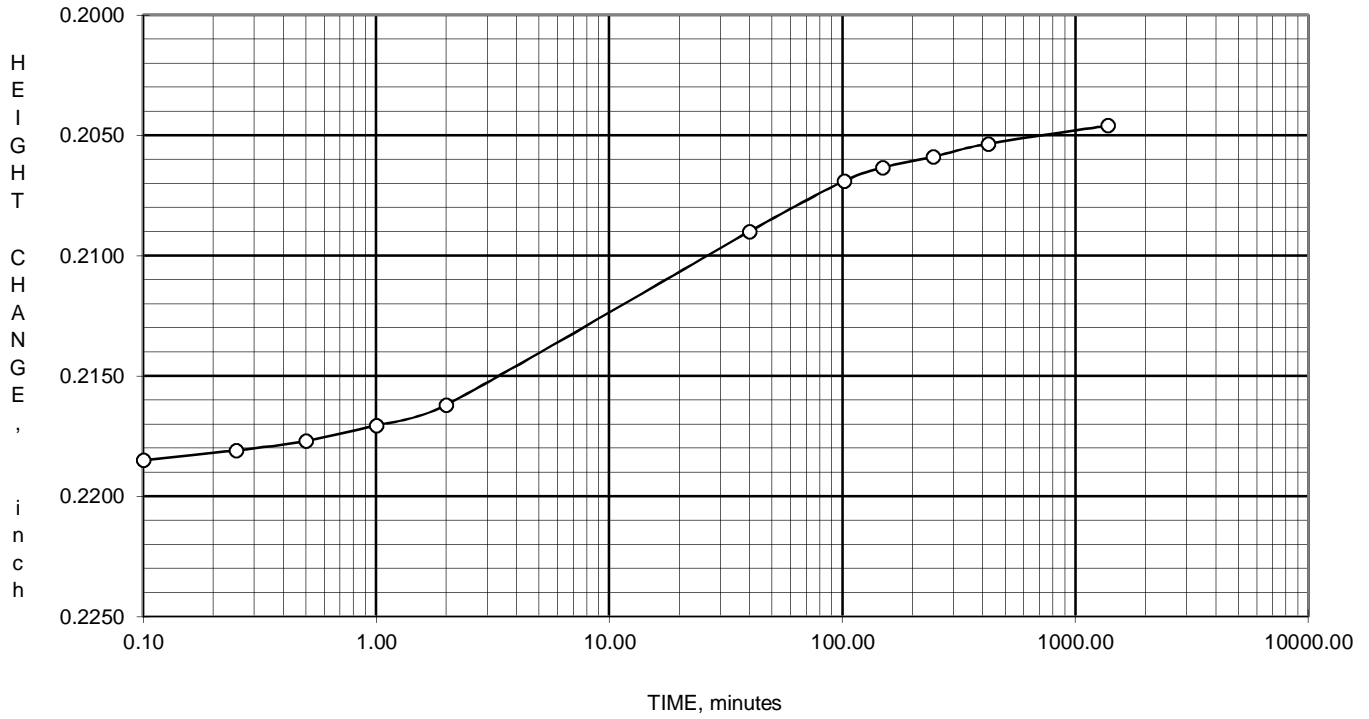
FROM	1.78	tsf	t50	21.0	min.
TO	3.56	tsf	t90	123.2	min.



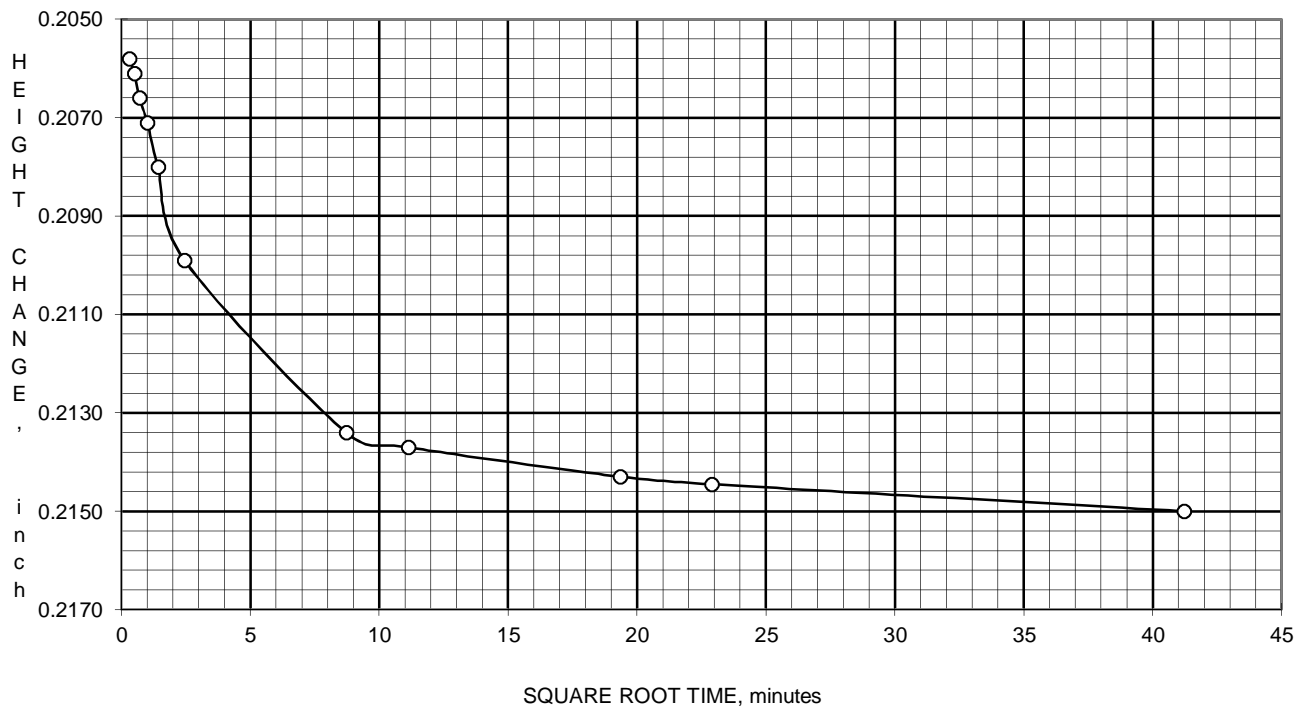
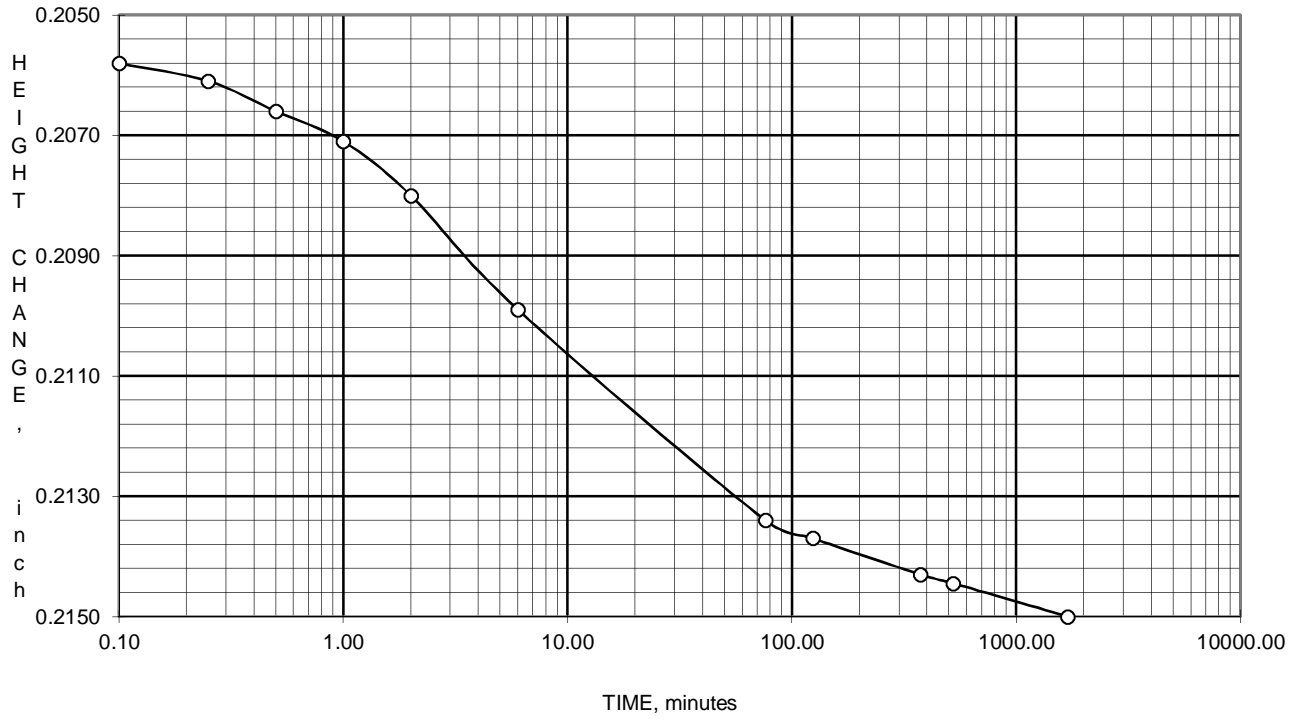
FROM 3.56 tsf  
TO 1.78 tsf



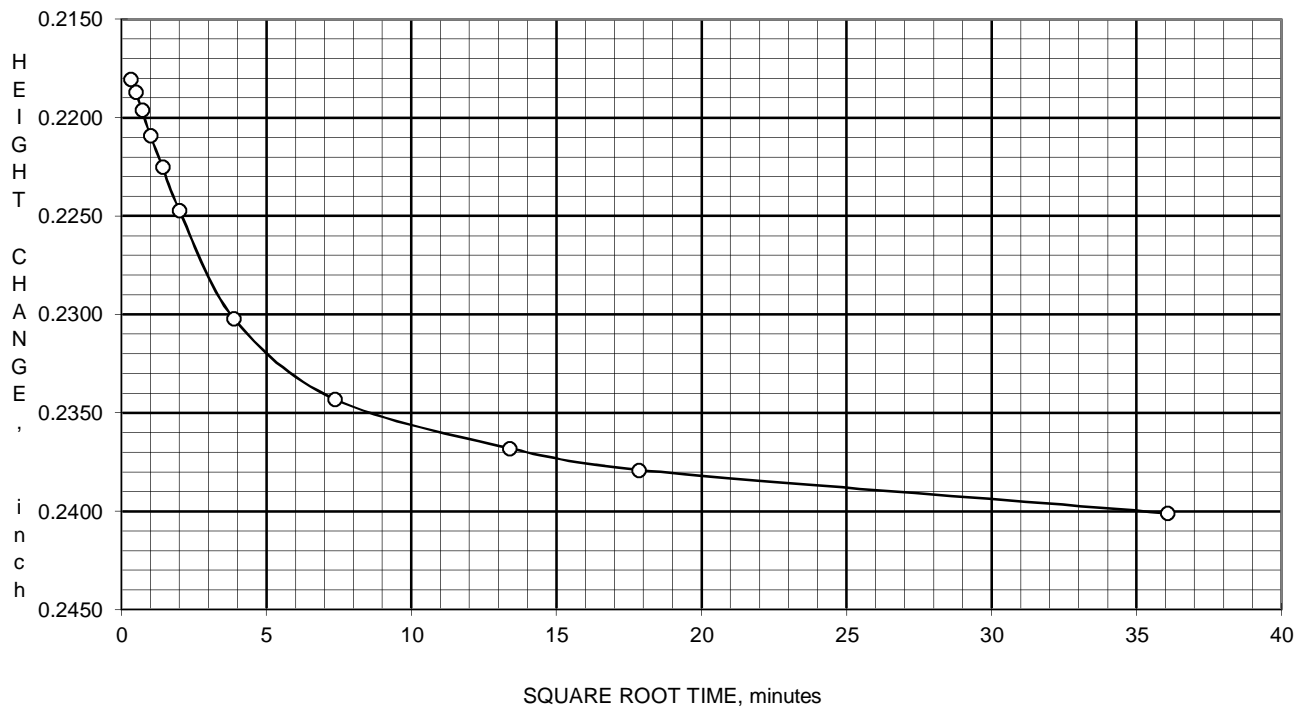
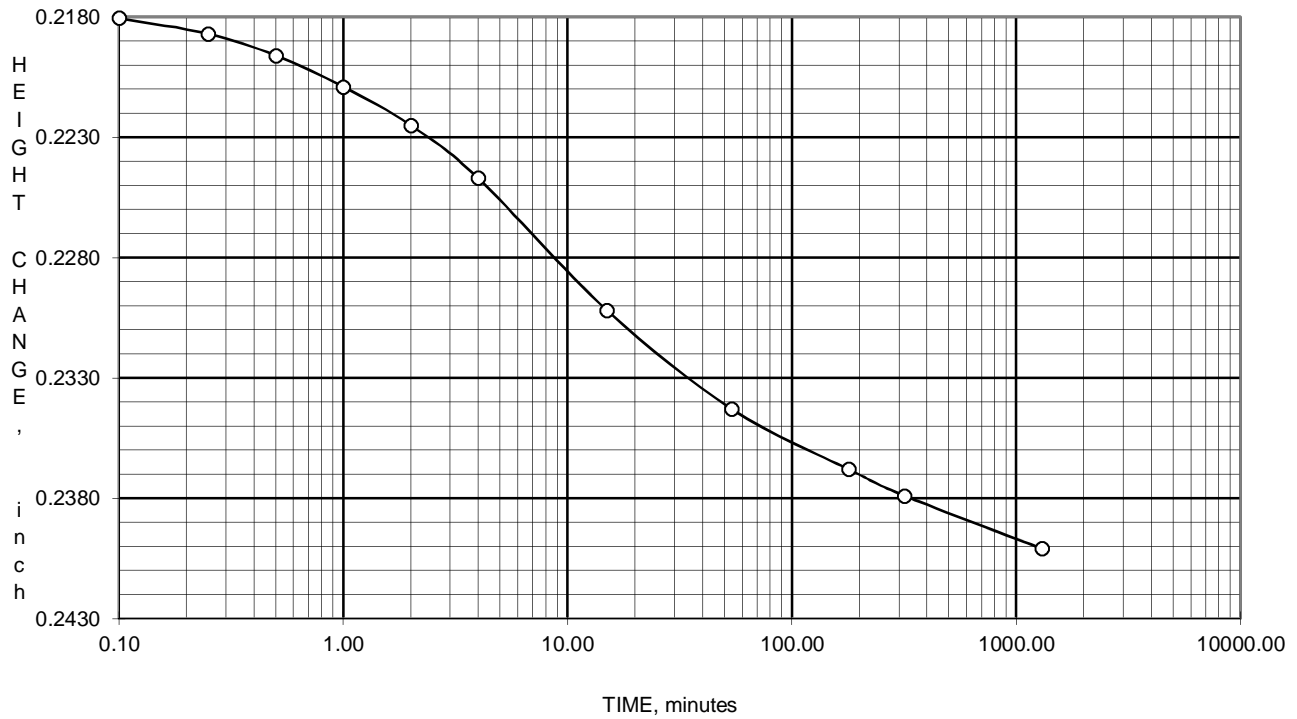
FROM 1.78 tsf  
TO 0.89 tsf



FROM	0.89	tsf	t50	4.0	min.
TO	1.78	tsf	t90	9.0	min.



FROM	1.78	tsf	t50	4.8	min.
TO	3.56	tsf	t90	12.3	min.





FROM	3.56	tsf	t50	11.0	min.
TO	7.11	tsf	t90	49.0	min.

