COLLEGE OF ENGINEERING
THE CHARLES E. VIA, JR. DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
VIRGINIA TECH

ASCE VIRGINIA TECH
VIRGINIAS STUDENT SYMPOSIUM 2024

Geotechnical Competition

2024 Virginias Symposium
Virginia Tech

1. Objective: The objective of the geotechnical competition is to develop an accurate prediction of the geotechnical behavior of the soil underlying an embankment using given information regarding subsurface, boundary, and initial conditions, as well as the geotechnical/ structural/hydraulic loading. The competition may involve using hand calculations, available geotechnical software, empirical correlations, or developing a simple but accurate computer code for making this prediction.

   For the 2024 Symposium, the competing teams will estimate the settlement of an instrumented embankment as described in the Project Description.

2. Geotech data: Input data for the problem including problem description, boring logs, and test data are attached.

3. Eligibility: A team will consist of one or two undergraduate students.

   Team members are automatically ineligible if they participated in the 2024 ASCE GeoPrediction competition of the GeoInstitute of ASCE. Similarly, competition teams will not use any information from or interact with students or teams that participated in the 2024 GeoPrediction competition.

4. Submittal: Each team's submittal will, at a minimum, include the following.

   a. A report that shall be no more than three (3) pages long (not including any references and title page). One-inch margins, single spacing, and 12-point Time New Roman font are required. Include the completed Table 1 in your report.

   b. The report shall document the methods (assumptions, correlations used, analytical procedures, numerical procedures, computer software, etc.) that the team employed to develop the solution. References used must be properly cited using ASCE format for journals.

   c. The cover page must include the name of the institution; names, and email addresses of each team member; as well as the name and contact information of the faculty that advised the team in developing their prediction.

   d. Reports are submitted electronically in PDF format by 6 pm Eastern Standard Time on Saturday, 2 March 2024. The symposium organizers will provide instructions for submitting documents.

      The team must provide a statement in the report regarding any team member's participation in the national GeoInstitute GeoPrediction competition.

      The team will receive confirmation of receipt by email. Please contact Dr. Joseph Dove (jodove@vt.edu) if a confirmation email is not received within 24 hours of submission. Late submissions are not accepted.

5. Judging: The submitted reports will be judged and ranked by an anonymous panel of geo-professionals. Initial judging will be based on criterial (a) through (d) below.

a. Format, length, grammar, English usage	15%
b. Clarity of technical presentation	15%
c. Logical and concise use of appropriate geotechnical methods and principles	20%
d. Accuracy of predicted performance	20%
e. Presentation at the Symposium	30%

6. Presentation: Teams will present their results in an 8-minute (maximum) presentation that describes their methods and predicted behavior for viewing by judges and the public. The order and location of the presentations will be determined at the conference site. It is expected that a room with a projector and computer will be used for these presentations.

7. The winning team will be announced at the Symposium.

8. If data in the Data Package are illegible or if questions arise, please contact: Dr. Joseph Dove (jodove@vt.edu).

Project Description

Compression of soil layers due to the increase in stress caused by construction activities is a fundamental calculation of soil mechanics. The competition problem this year involves determining the settlement caused by the construction of a roadway embankment.

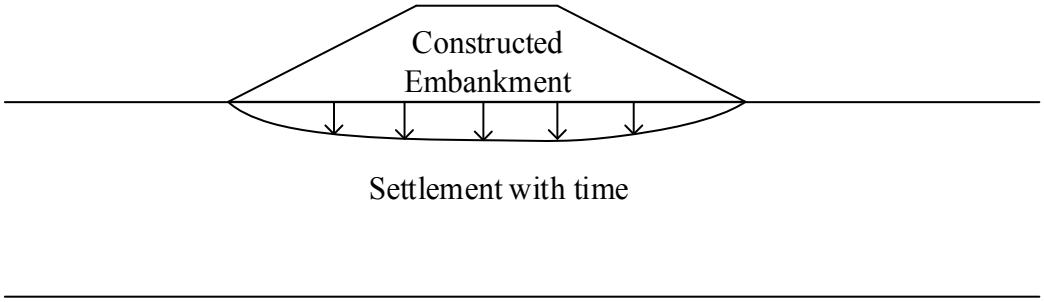


Figure 1 – Schematic of embankment settlement

Please refer to the attached data package for figures and data referenced in this section. A roadway embankment was constructed as shown in Figure 2. The cross section of the embankment at two locations, A and B, is shown in Figure 3. At location A, the embankment is 40 feet in height, with a crest width of 130 feet, and side slopes of 2H:1V. The embankment is constructed of rock fill with a 3' thick 'cohesive cap.' At location B, the embankment has the same dimensions, but is 44 feet in height. Settlement was measured at the centerline of the roadway embankment under the constructed embankment.

The ground surface elevation at location A prior to the construction of the embankment was 722.8 ft. At location B, it was 717.9 feet. The construction speed of each embankment is shown in Figure 4.

To speed up settlement, prior to embankment construction, wick drains were installed. These extend the full width from toe to toe of the embankment. These wick drains were 60' long and had a 5' center to center spacing (in all directions). The top of each wick drain is connected to a horizontal drain that allows water to be removed from under the embankment to outside of the embankment.

A schematic showing wick drain distribution is shown in Figure 4. The number of wick drains is dictated by the 5' center to center spacing in both dimensions. The wick drains are prefabricated vertical drains (PVD) 4" wide with a formed polypropylene core covered with filter fabric. Ameridrain PVD 407 can be assumed with a typical water flow rate (ASTM D4491) of 70 gpm/ft2 and a discharge capacity (ASTM D4716) of 1.6 gpm. Other properties can be assumed based on this PVD type.

Soil properties are found in Borings 1, 2, and 3 taken near location A and B. In addition, one unconfined compression test (Boring 1) and two consolidation tests (Boring 3) are provided.

Your task is to complete Table 1 and include it in your report. What is the total primary settlement (settlement of the existing ground surface) that occurred from construction of the

embankment at Location A and Location B? Your settlement estimate will be compared to measured settlement of the original ground surface at Location A and B at the end of primary consolidation settlement.

Finally, as extra credit, how long would it take for the end of primary consolidation settlement at Location B in days if time zero (0) was the start of embankment construction? Your time will be compared to measurements of excess water pressure dissipation from embankment construction.

Table 1 – Predictions

Required:

Location	Settlement Estimate (inches)
A	
B	

Extra Credit:

Location	Time to end of primary consolidation (days)
B	

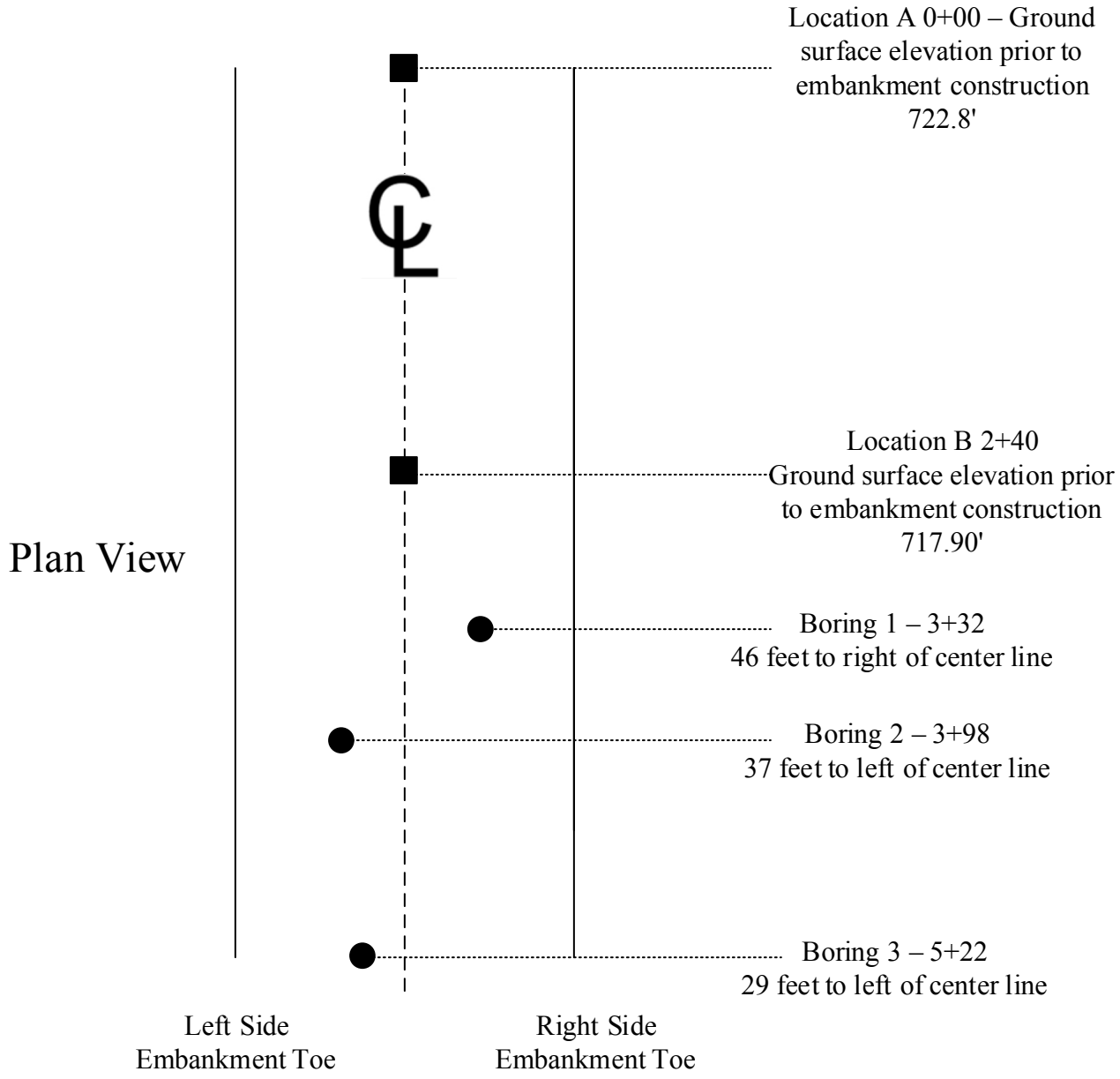
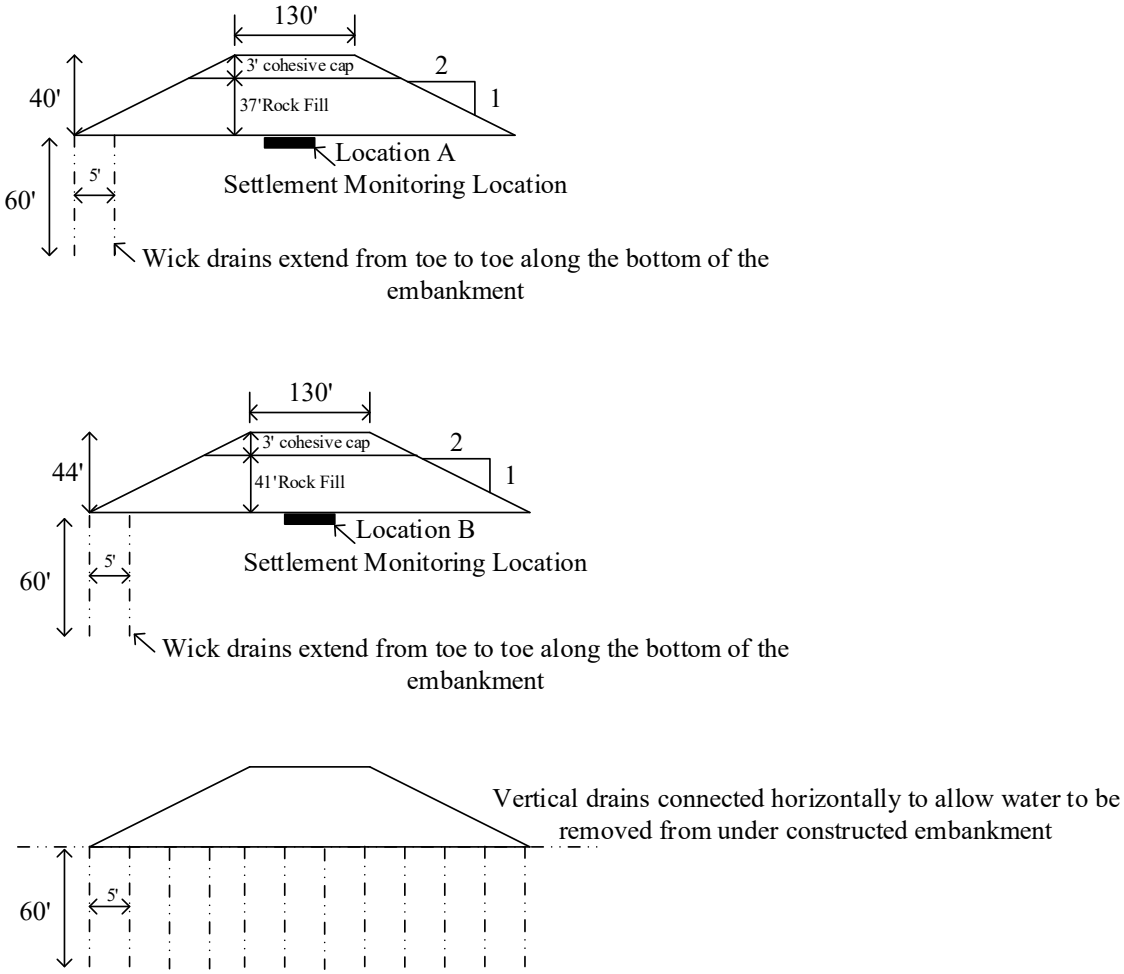


Figure 2 – Plan view of roadway embankment showing location of settlement measurements and soil boring locations *not to scale – dimensions can be taken from indicated stations (for example, location B is 240 feet away from location A at the roadway centerline)

2024 – GeoPrediction Rules

Embankment Cross Sections



Wick drain distribution – Note* not to scale in number

Figure 3 – Cross sections of constructed embankment at location A and location B

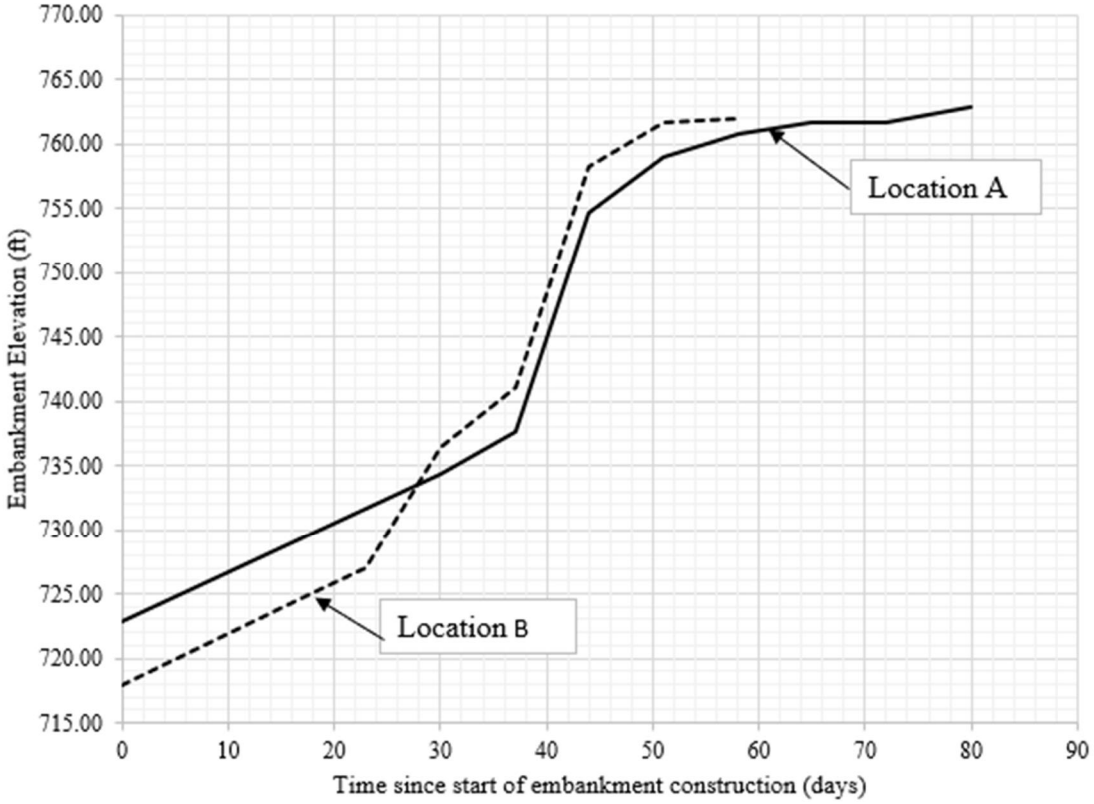
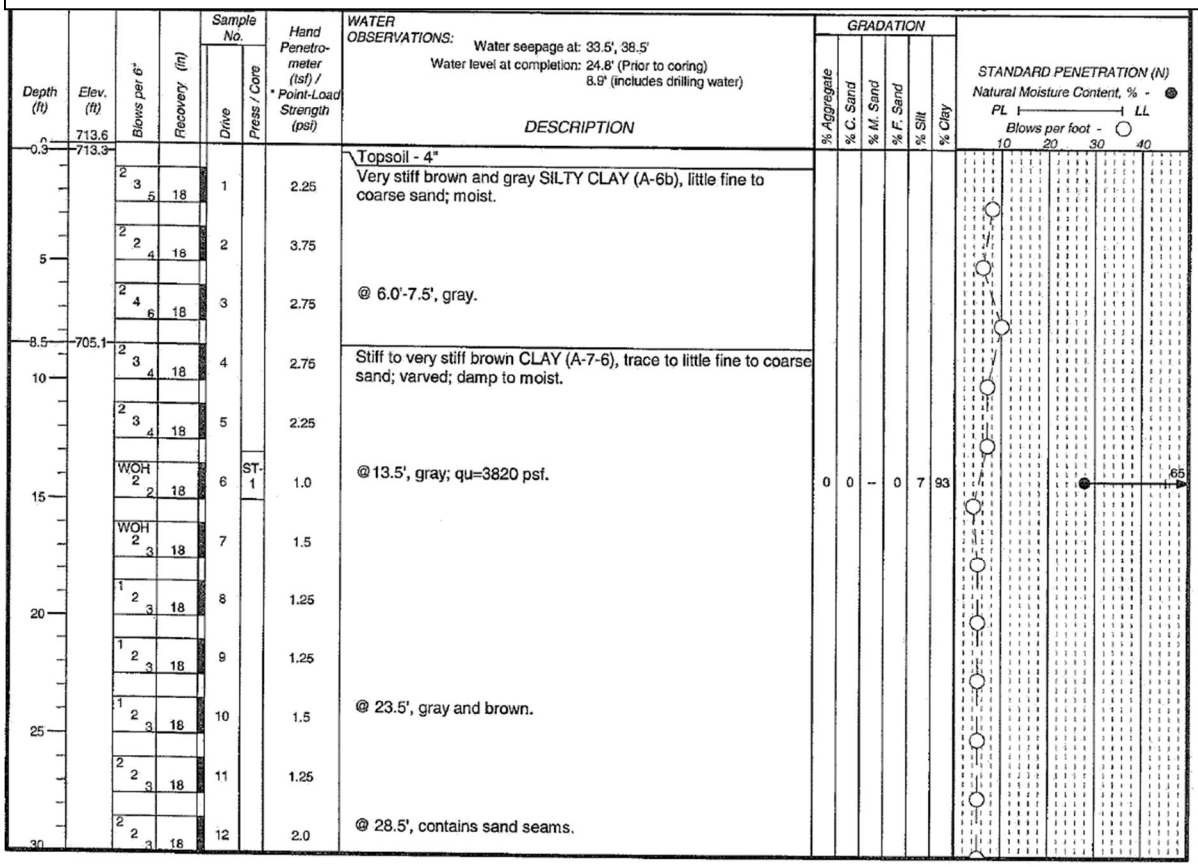


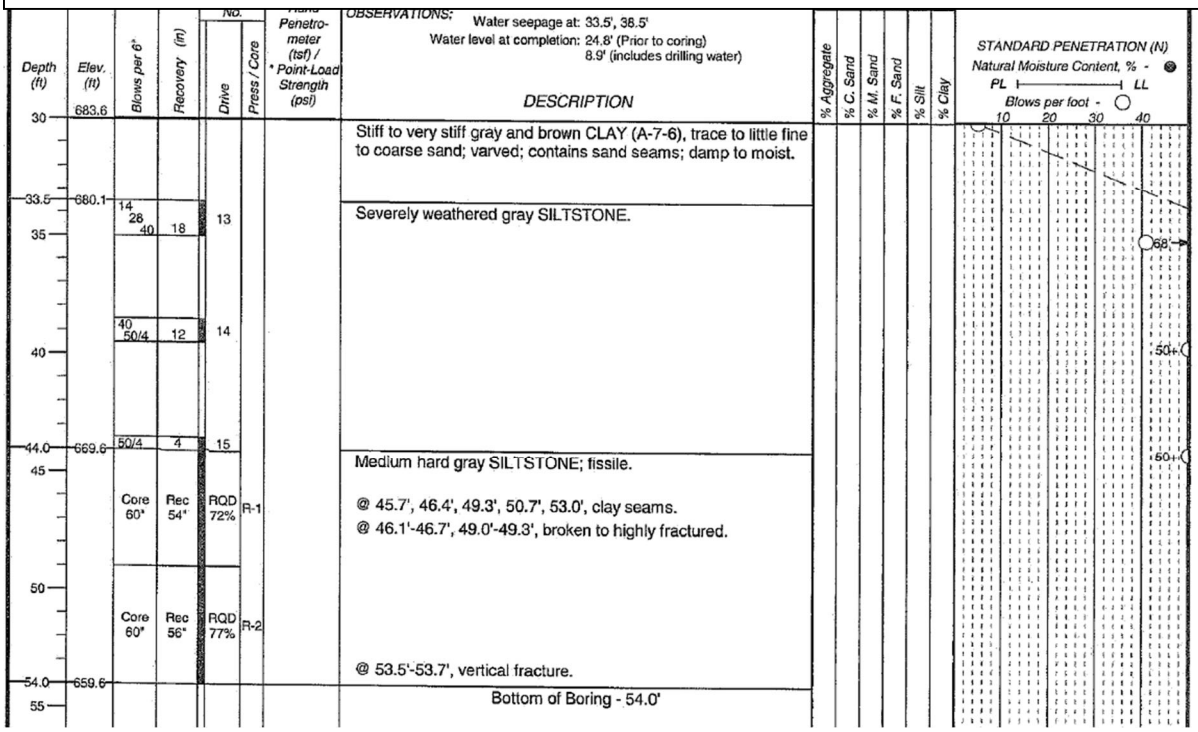
Figure 4 – Speed of embankment construction at location A and B

Boring Logs and Lab Data

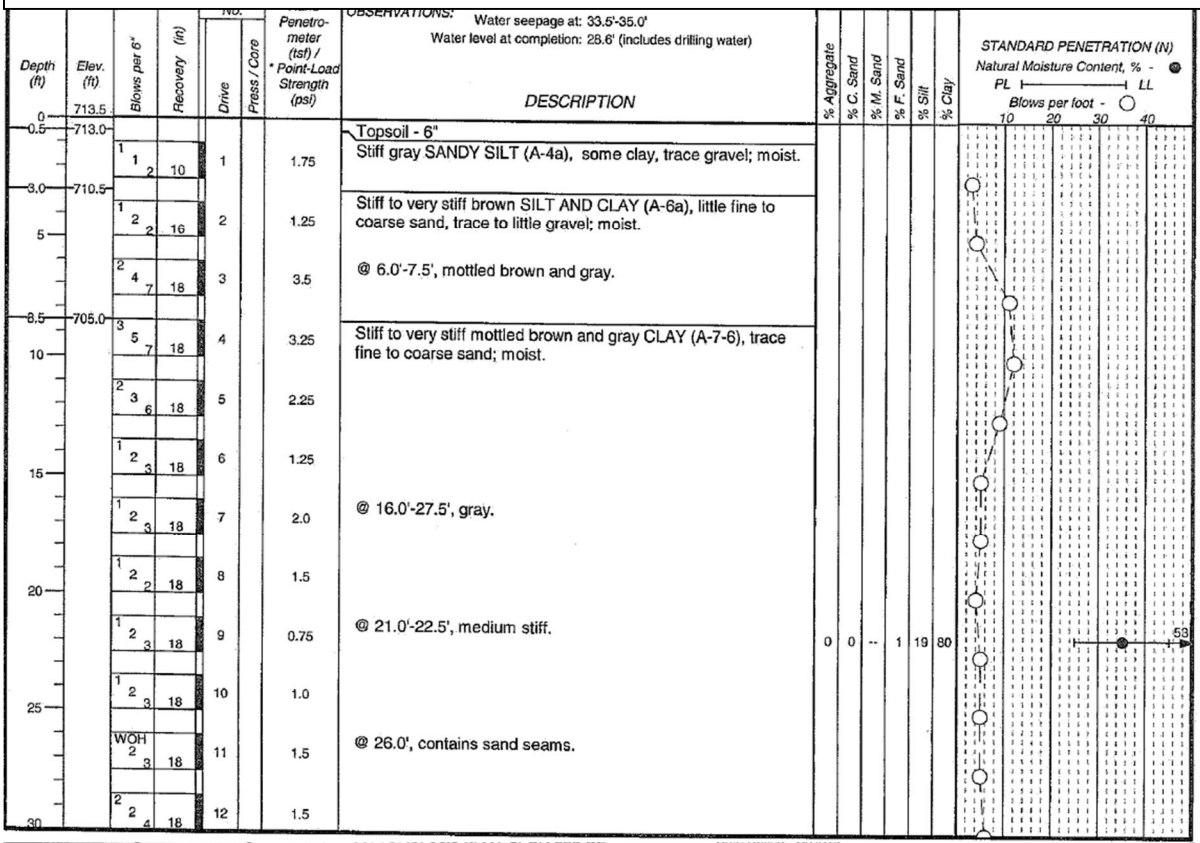
Boring 1

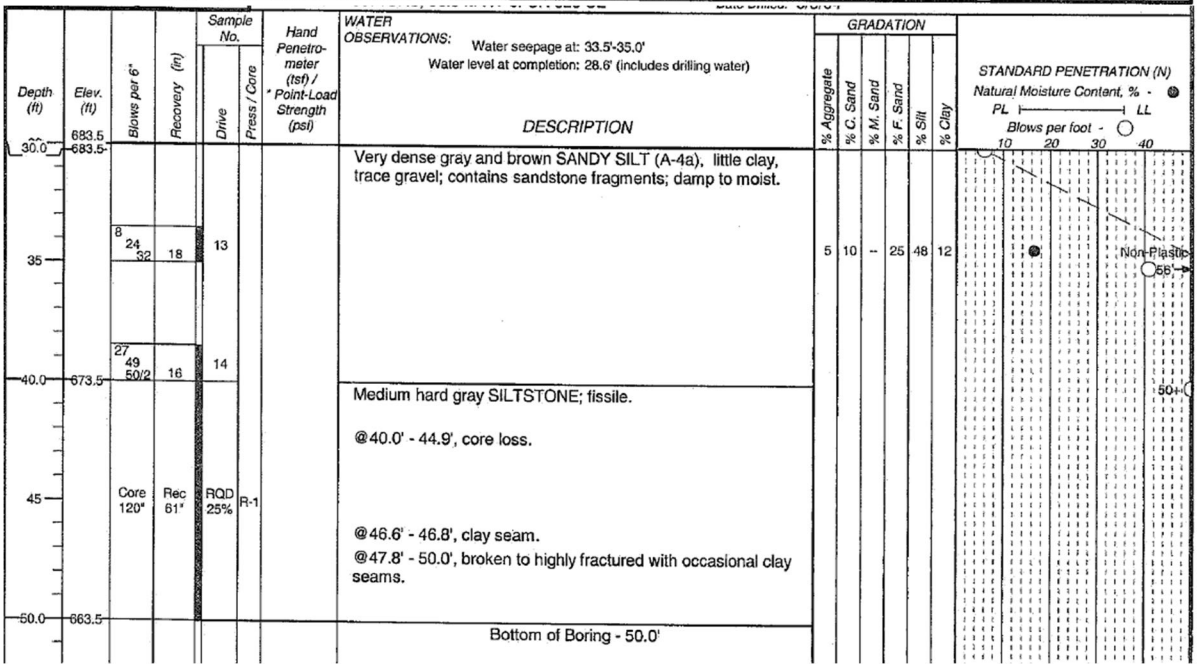

Depth (ft)
Elev. (ft)
Blows per 6"
Recovery (in)
Sample No.
Drive
Press / Core
Hand Penetrometer (tsf) / * Point-Load Strength (psi)
WATER OBSERVATIONS: Water seepage at: 33.5', 38.5'
Water level at completion: 24.8' (Prior to coring)
8.9' (includes drilling water)
DESCRIPTION
GRADATION
% Aggregate
% C. Sand
% M. Sand
% F. Sand
% Silt
% Clay
STANDARD PENETRATION (N)
Natural Moisture Content, % -
PL
LL
Blows per foot -
10
20
30
40
0.3
713.6
713.3
Topsoil - 4"
Very stiff brown and gray SILTY CLAY (A-6b), little fine to coarse sand; moist.
@ 6.0'-7.5', gray.
8.5
705.1
Stiff to very stiff brown CLAY (A-7-6), trace to little fine to coarse sand; varved; damp to moist.
@13.5', gray; qu=3820 psf.
@ 23.5', gray and brown.
@ 28.5', contains sand seams.
ST-1
0 0 -- 0 7 93
65

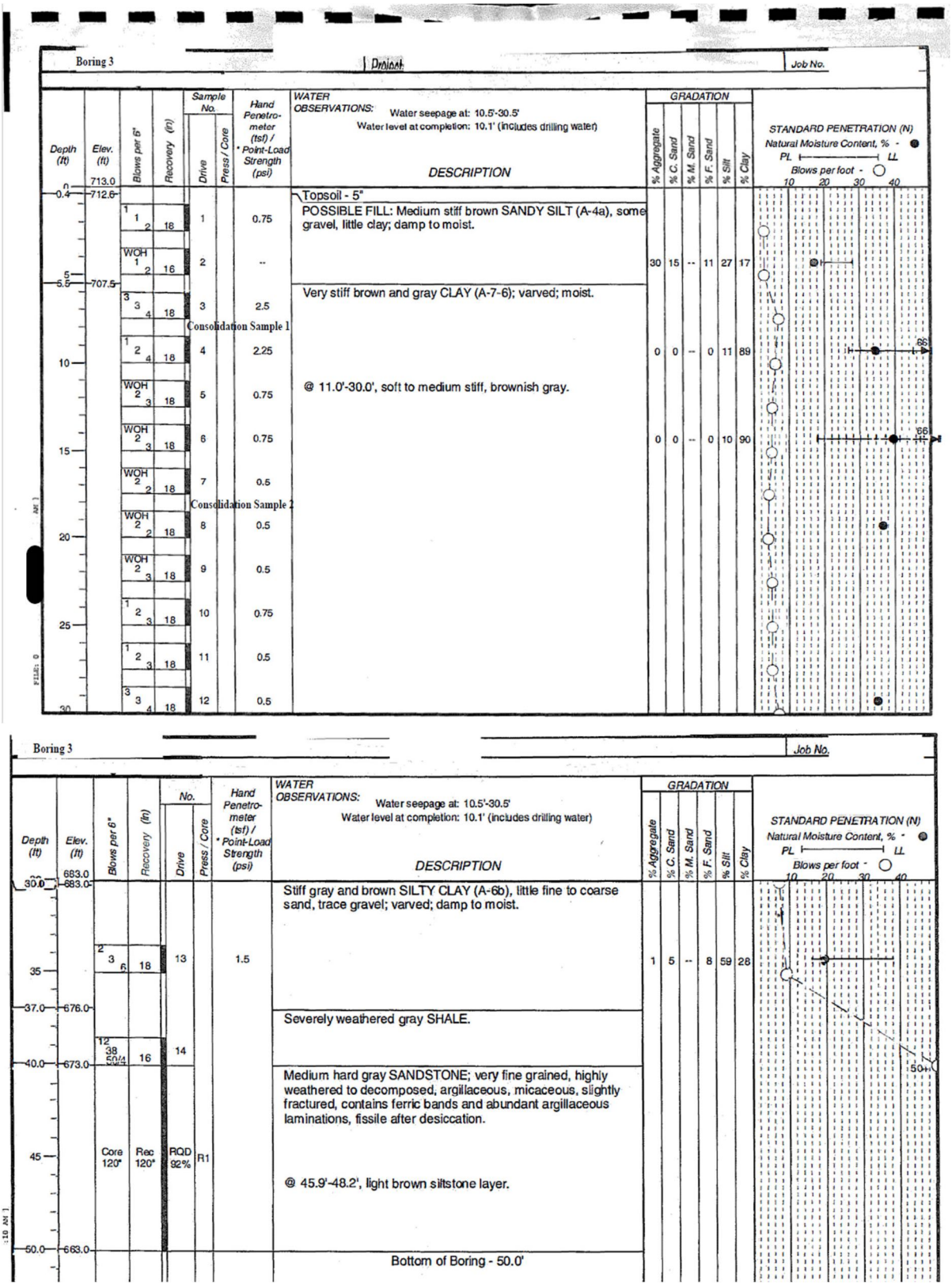
Boring 1 Cont.



Boring 2


Depth (ft)
Elev. (ft)
Blows per 6"
Recovery (in)
Sample No.
Drive
Press / Core
Penetrometer (tsf) / * Point-Load Strength (psi)
OBSERVATIONS: Water seepage at: 33.5'-35.0'
Water level at completion: 28.6' (includes drilling water)
DESCRIPTION
% Aggregate
% C. Sand
% M. Sand
% F. Sand
% Silt
% Clay
STANDARD PENETRATION (N)
Natural Moisture Content, % -
PL
LL
Blows per foot -
713.5
713.0
Topsoil - 6"
Stiff gray SANDY SILT (A-4a), some clay, trace gravel; moist.
710.5
Stiff to very stiff brown SILT AND CLAY (A-6a), little fine to coarse sand, trace to little gravel; moist.
@ 6.0'-7.5', mottled brown and gray.
705.0
Stiff to very stiff mottled brown and gray CLAY (A-7-6), trace fine to coarse sand; moist.
@ 16.0'-27.5', gray.
@ 21.0'-22.5', medium stiff.
0 0 -- 1 19 80
53
@ 26.0', contains sand seams.


Depth (ft)
Elev. (ft)
Blows per 6"
Recovery (in)
Sample No.
Drive
Press / Core
Hand Penetrometer (tsf) / * Point-Load Strength (psi)
WATER OBSERVATIONS: Water seepage at: 33.5'-35.0'
Water level at completion: 28.6' (includes drilling water)
DESCRIPTION
GRADATION
% Aggregate
% C. Sand
% M. Sand
% F. Sand
% Silt
% Clay
STANDARD PENETRATION (N)
Natural Moisture Content, % -
PL
LL
Blows per foot -
683.5
Very dense gray and brown SANDY SILT (A-4a), little clay, trace gravel; contains sandstone fragments; damp to moist.
5 10 -- 25 48 12
Non-Plastic
55+
673.5
50+
Medium hard gray SILTSTONE; fissile.
@40.0' - 44.9', core loss.
Core 120"
Rec 61"
RQD 25%
R-1
@46.6' - 46.8', clay seam.
@47.8' - 50.0', broken to highly fractured with occasional clay seams.
663.5
Bottom of Boring - 50.0'



Boring 3

Project

Job No.

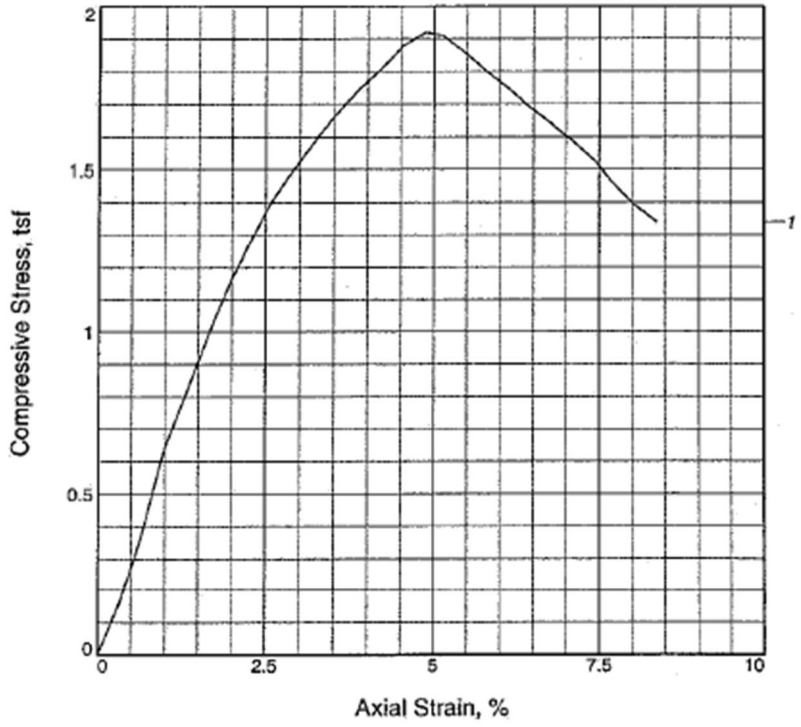
Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ⊢ LL Blows per foot - ○ 10 20 30 40
0	713.0						WATER OBSERVATIONS: Water seepage at: 10.5'-30.5' Water level at completion: 10.1' (includes drilling water)							
0.4	712.6	1 1 2	18	1		0.75	Topsoil - 5" POSSIBLE FILL: Medium stiff brown SANDY SILT (A-4a), some gravel, little clay; damp to moist.							
5		WOH 1 2	16	2		--		30	15	--	11	27	17	
5.5	707.5	3 3 4	18	3		2.5	Very stiff brown and gray CLAY (A-7-6); varved; moist.							
		Consolidation Sample 1												
		1 2 4	18	4		2.25		0	0	--	0	11	89	65
10		WOH 2 3	18	5		0.75	@ 11.0'-30.0', soft to medium stiff, brownish gray.							
		WOH 2 3	18	6		0.75		0	0	--	0	10	90	66
15		WOH 2 2	18	7		0.5								
		Consolidation Sample 2												
		WOH 2 2	18	8		0.5								
20		WOH 2 3	18	9		0.5								
		1 2 3	18	10		0.75								
25		1 2 3	18	11		0.5								
		3 3 4	18	12		0.5								
30														

Boring 3

Job No.

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	No. Drive	No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ⊢ LL Blows per foot - ○ 10 20 30 40
30.0	683.0						WATER OBSERVATIONS: Water seepage at: 10.5'-30.5' Water level at completion: 10.1' (includes drilling water)							
	683.0						Stiff gray and brown SILTY CLAY (A-6b), little fine to coarse sand, trace gravel; varved; damp to moist.							
35		2 3 6	18	13		1.5		1	5	--	8	59	28	
37.0	676.0						Severely weathered gray SHALE.							
40.0	673.0	12 38 50/4	16	14			Medium hard gray SANDSTONE; very fine grained, highly weathered to decomposed, argillaceous, micaceous, slightly fractured, contains ferric bands and abundant argillaceous laminations, fissile after desiccation.							50+
45		Core 120"	Rec 120"	RQD 92%	R1		@ 45.9'-48.2', light brown siltstone layer.							
50.0	663.0						Bottom of Boring - 50.0'							

UNCONFINED COMPRESSION TEST

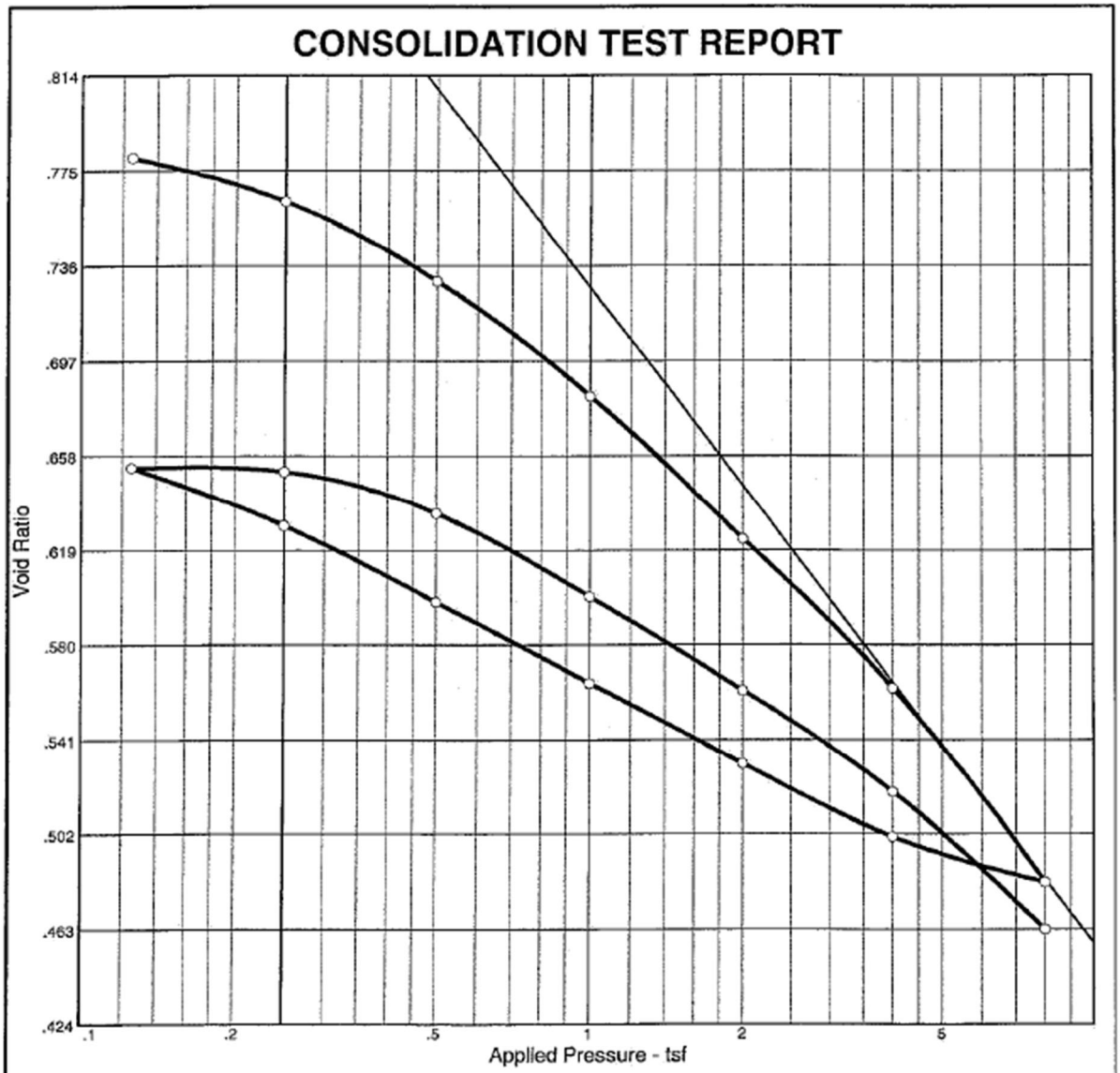


Sample No.	1			
Unconfined strength, tsf	1.911			
Undrained shear strength, tsf	0.955			
Failure strain,	5.1			
Strain rate, in./min.	0.06			
Water content, %	38.5			
Wet density, pcf	116.9			
Dry density, pcf	84.4			
Saturation, %	100.0			
Void ratio	1.0865			
Specimen diameter, in.	2.85			
Specimen height, in.	6.26			
Height/diameter ratio	2.20			

Description: Fat clay

LL = 65	**PL** = 28	**PI** = 37	**Assumed GS**= 2.82	**Type:** 2.8" press tube

Boring 1, Sample ST – 1

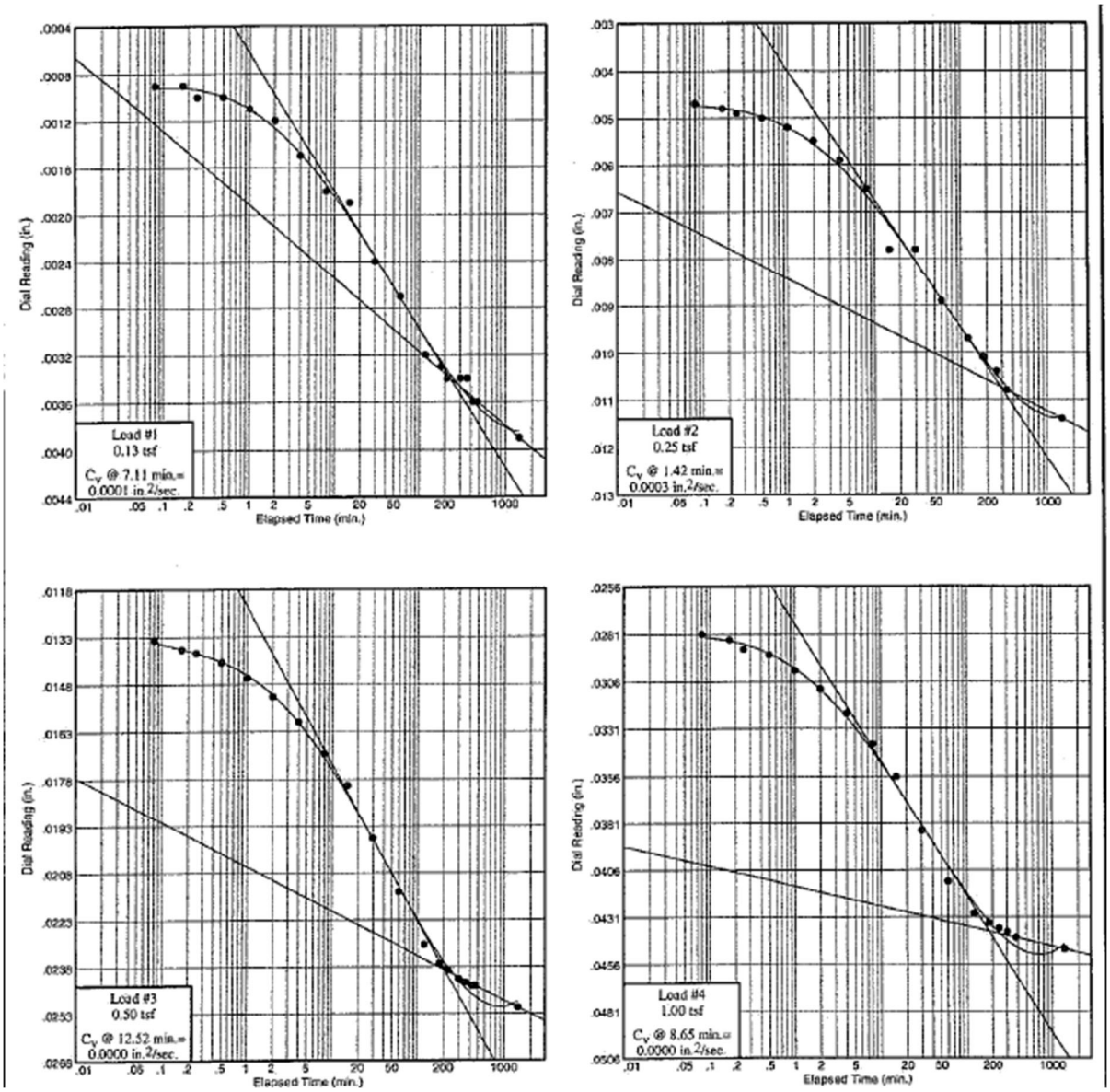


Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
100.0 %	28.7 %	95.9	57	31	2.75	CH	A-7-6(36	0.790

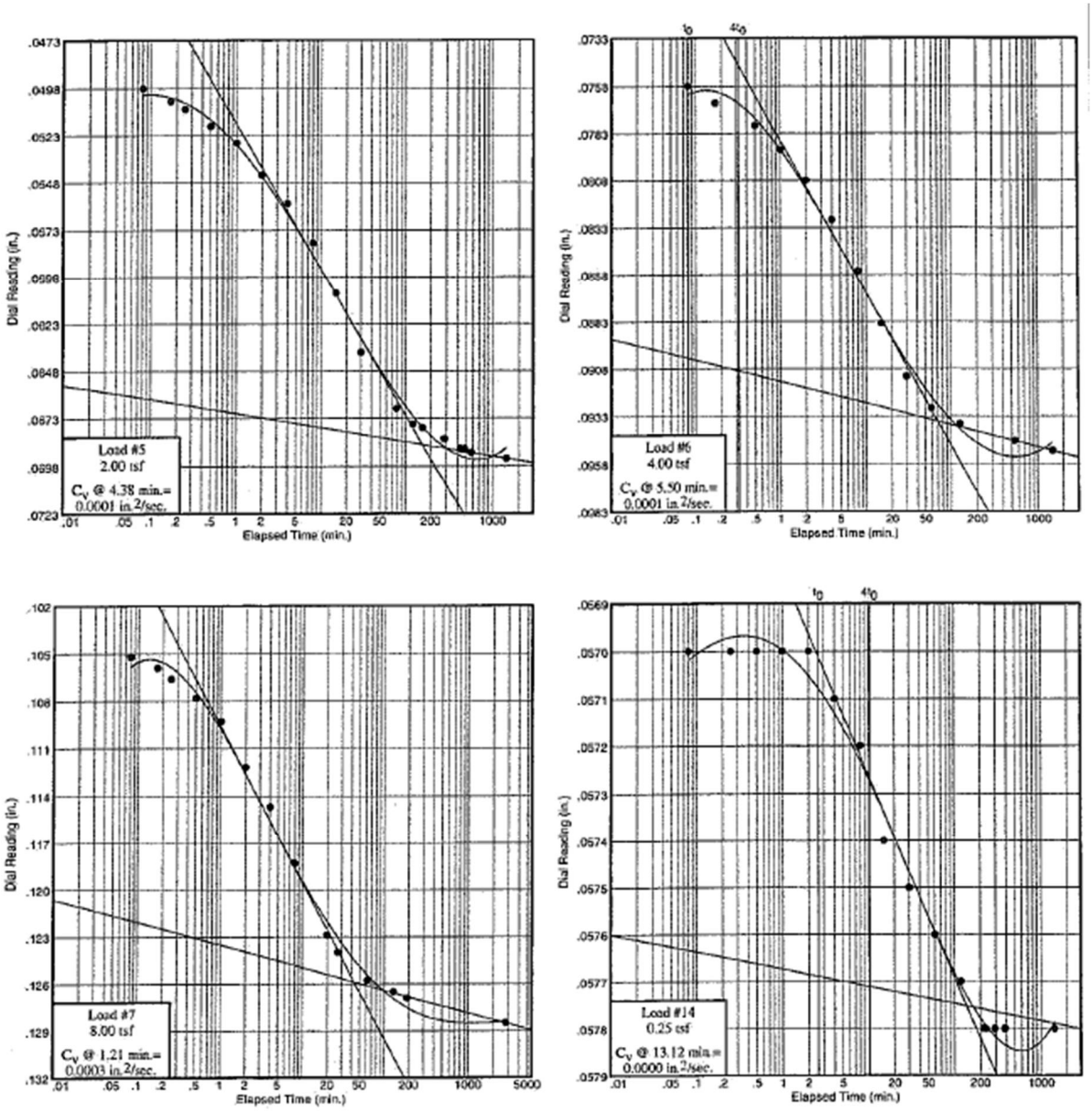
MATERIAL DESCRIPTION

Fat clay

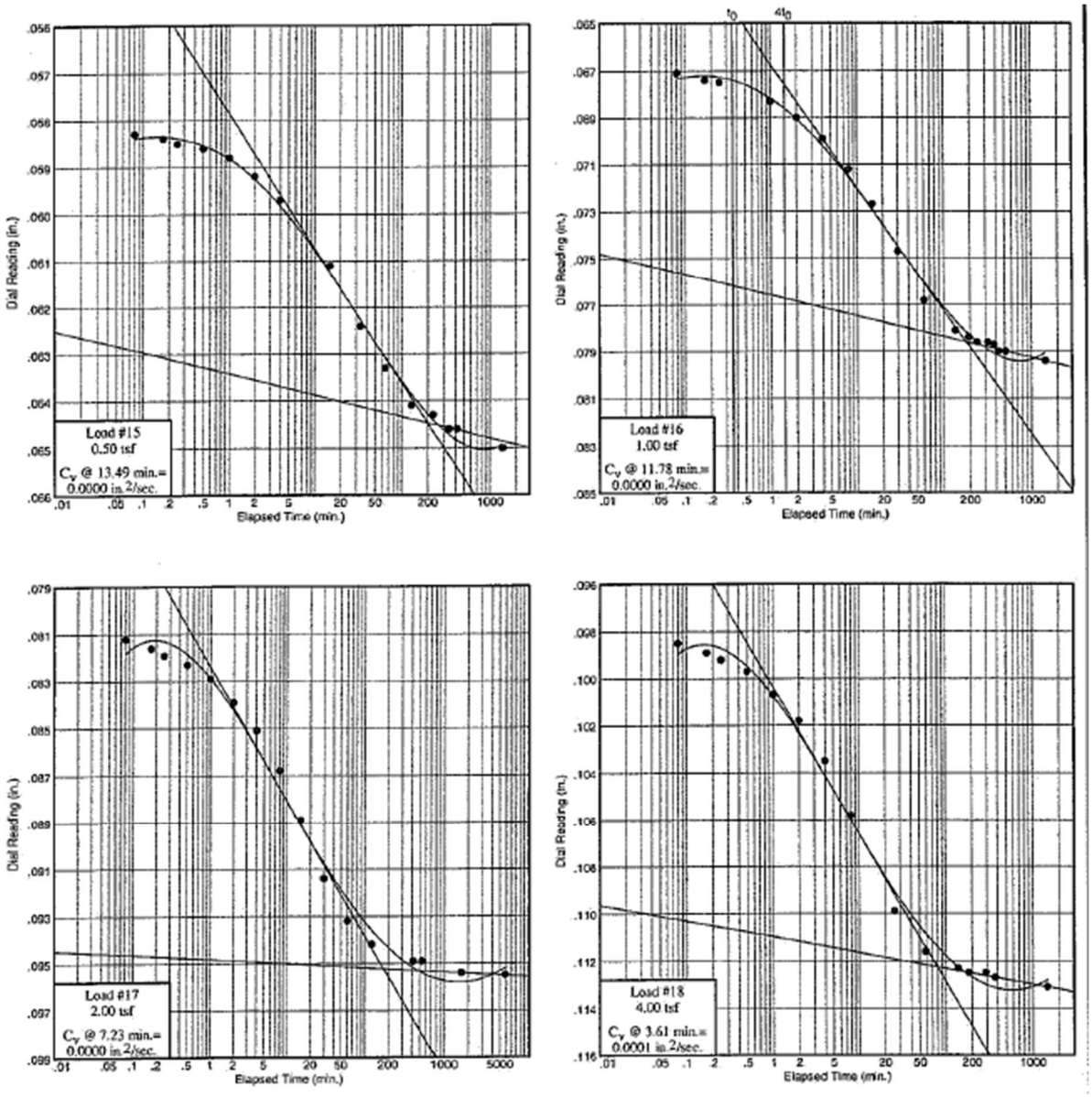
Boring 3, Consolidation Sample 1 – Depth 8'



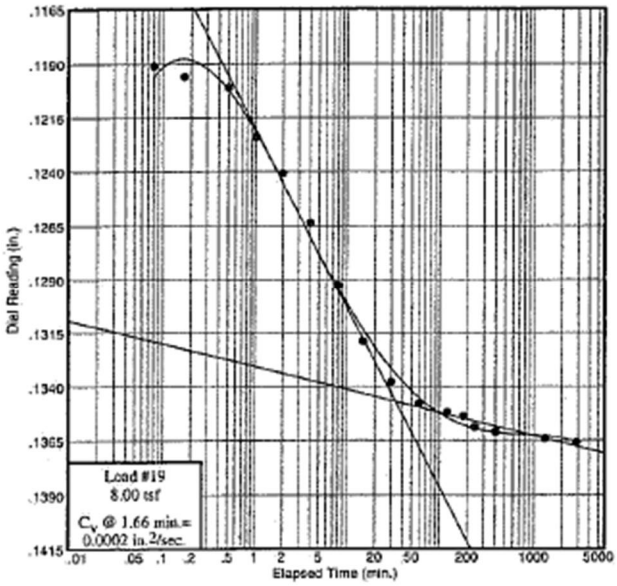
Boring 3, Consolidation Sample 1 – Depth 8'



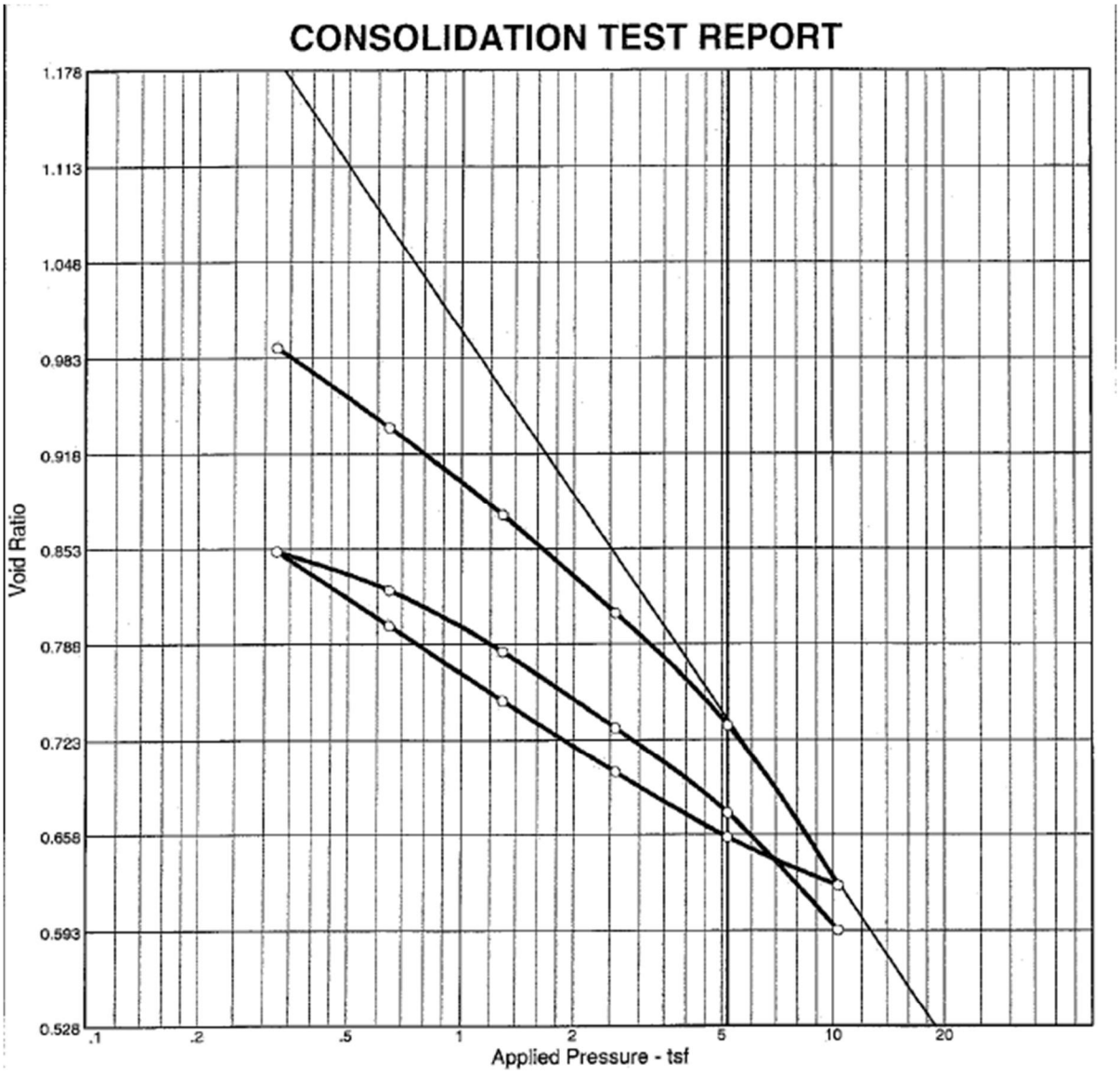
Boring 3, Consolidation Sample 1 – Depth 8’



Boring 3, Consolidation Sample 1 – Depth 8'



Boring 3, Consolidation Sample 1 – Depth 8’

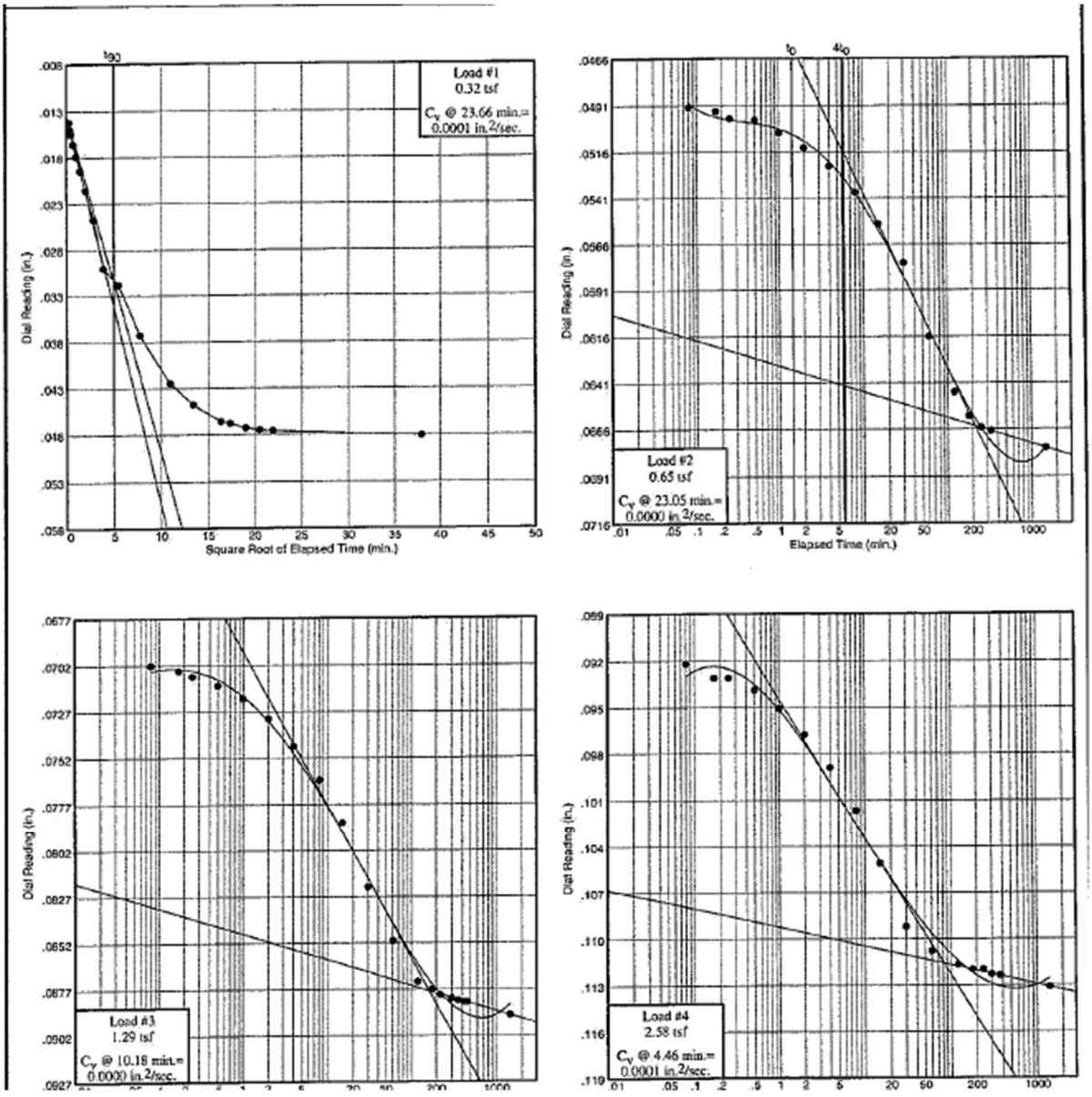


Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
100.3 %	40.4 %	82.0	67	41	2.79	CH	A-7-6(48	1.124

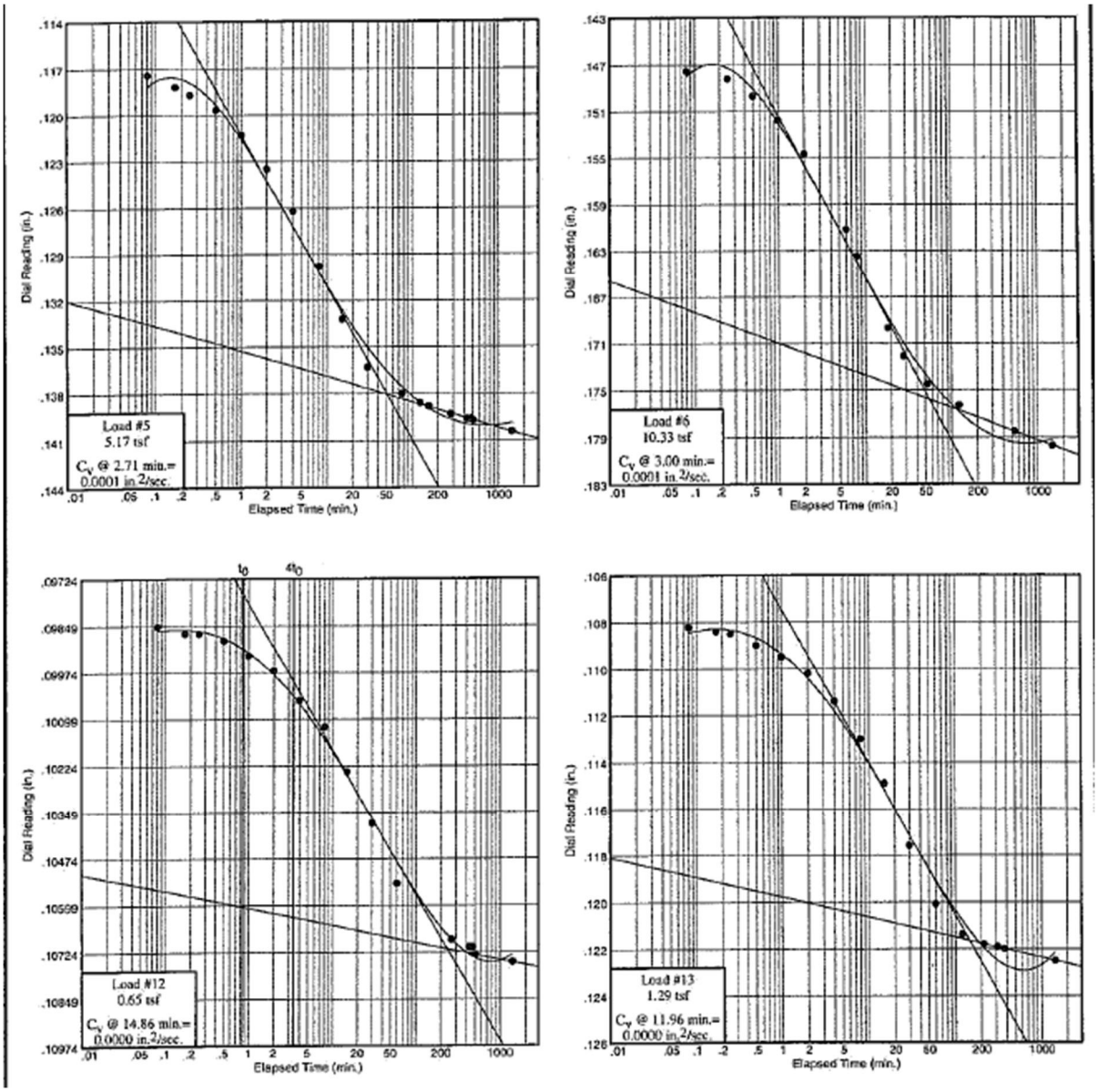
MATERIAL DESCRIPTION

Fat clay

Boring 3, Consolidation Sample 2 – Depth 18'



Boring 3, Consolidation Sample 2 – Depth 18'



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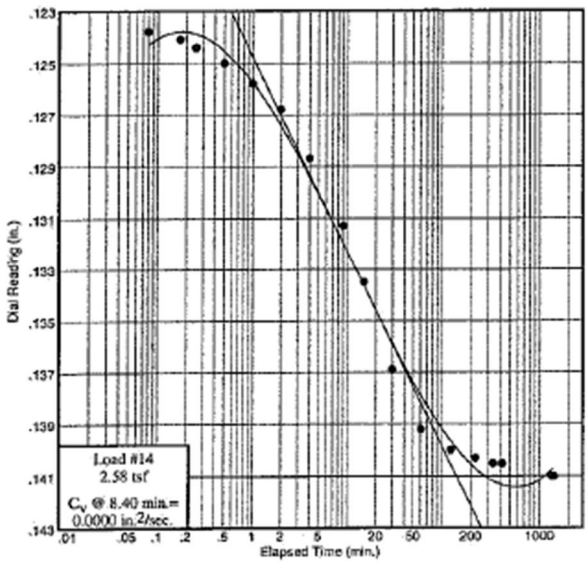

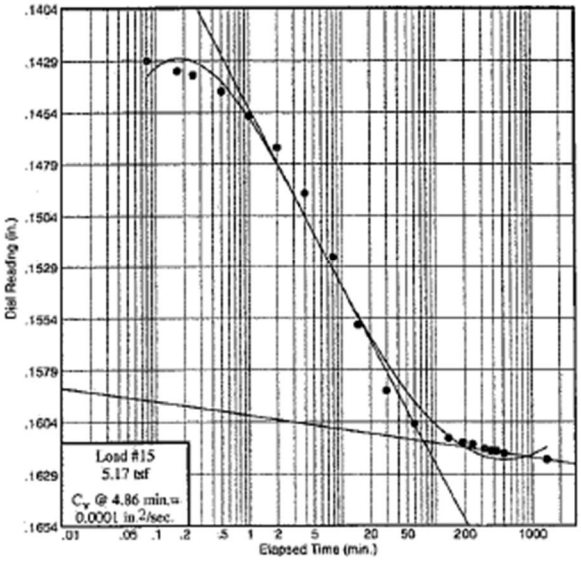

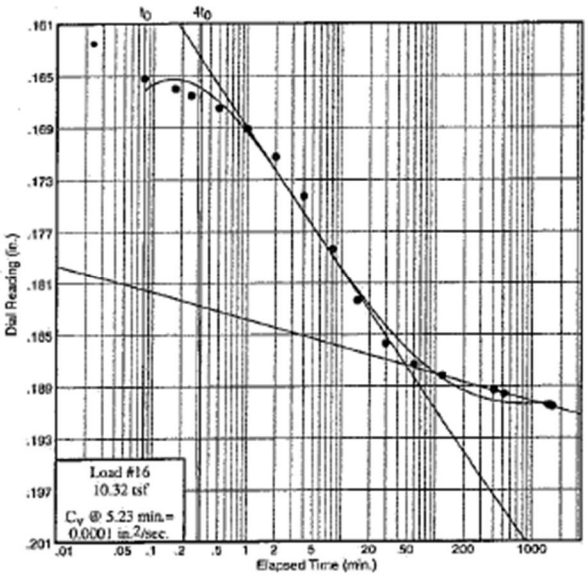

Boring 3, Consolidation Sample 2 – Depth 18'