Geotechnical Report

PROJECT NO. SU-3-020(074)103

PCN 17504

COUNTY Ramsey

Bridge #: 0020-103.403

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NORTH DAKOTA DEPARTMENT OF TRANSPORTATION
MATERIALS AND RESEARCH DIVISION

September 2015

SU-3-020(074)103

Railroad Underpass - Bridge #0020-103.403

CERTIFICATION

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly registered professional engineer under the laws of the State of North Dakota. This document was originally issued and sealed by Matthew C. Kurle, Registration number PE-8777 on 9/21/15 and the original document is stored at the North Dakota Department of Transportation.

REGISTERED PROFESSIONAL ENGINEER
MATTHEW C. KURLE
PE-8777
DATE 9-21-15
NORTH DAKOTA

Matthew C. Kurle, P.E.

21 SEPT 2015
Date

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Introduction

This report will provide soils information, deep foundation recommendations, slope stability, compaction and drainage for the construction of the proposed permanent and temporary shoofly structures over ND Highway 20 (Bridge #0020-103.403).

This project is scheduled to be a multi-year project. A temporary shoofly structure is to be constructed in order to replace the existing structure at this location. A project location map is shown in the following Figure.

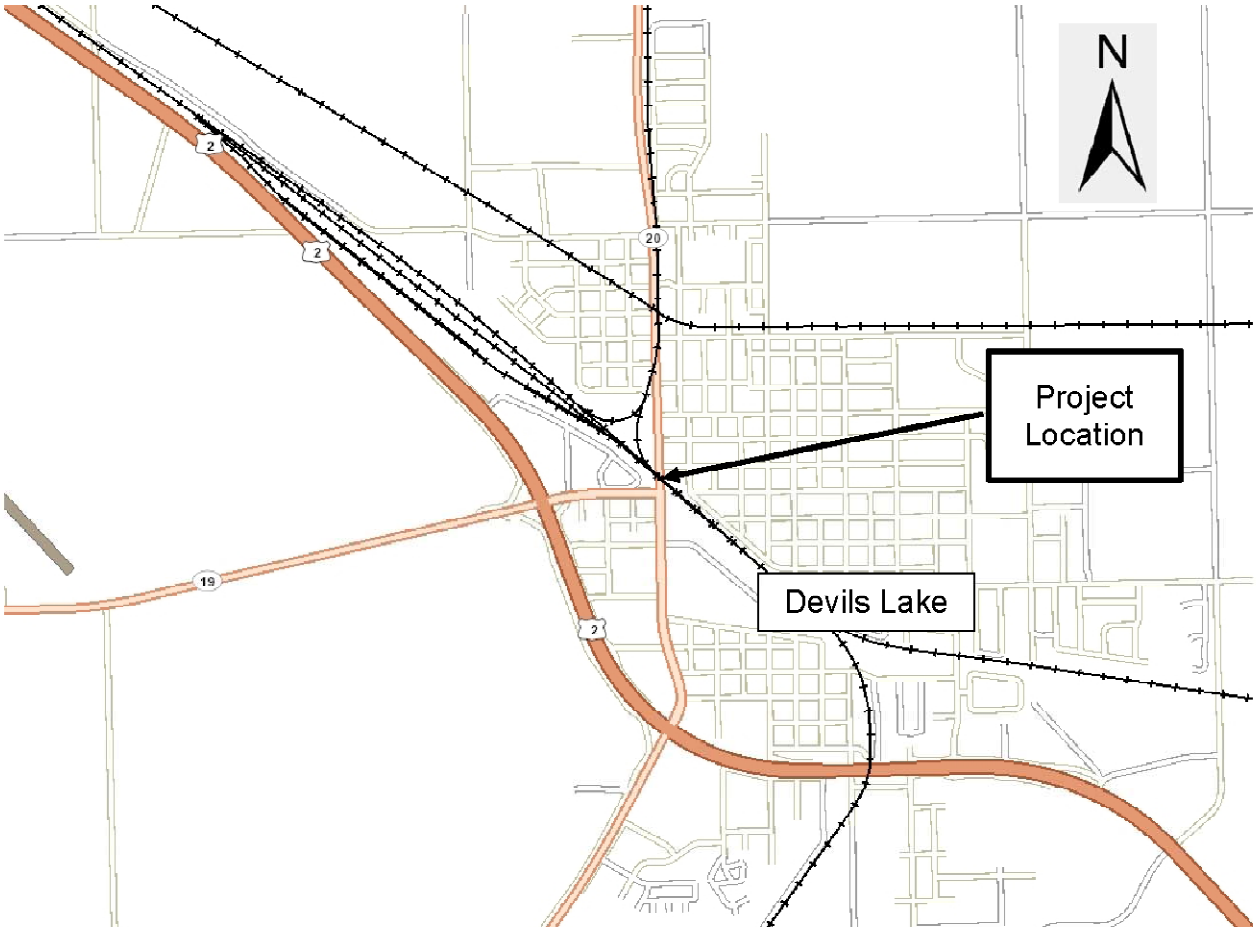

Figure 1 - Project Location Map

Existing Structure Information

The existing structure is skewed at 47° 43' from the centerline of Highway 20.

Bridge #: 0020-103.403
Main Structure Type: Steel Stinger
Number of Spans: 3
Foundation Type: Superstructure - Spread Footings
Retaining Walls - Concrete Caisson Supported
Year Constructed: 1981

The concrete on the existing structure has significant issues with Alkali-Silica Reaction (ASR), which has necessitated its replacement.

Figure 2 - Existing Structure (Looking North)

Soil Borings

One boring was conducted in 2014 for this project. This boring will supplement the 5 borings that were conducted in 1979 for construction of the existing structure and retaining wall. The locations of these borings are shown in the following Figure.

Figure 3 - Boring Location Map

Sampling and Testing Procedures:

These sampling and testing procedures pertain to Boring 1A from 12/9/14.

Shelby tube sampling and split spoon sampling were used to extract the samples from a hollow stem auger.

Shelby tube sampling provides an “undisturbed” sample of fine grained soils for laboratory testing via a thin wall tube that is slowly pushed into the soils to be sampled. Unconfined compression testing equipment was used to determine UC shear strengths. Densities were calculated according to AASHTO test method T 296.

Split spoon samplers are utilized during advancement of the boring to perform the Standard Penetration Test (SPT). The samples are considered “disturbed”, due to the driving nature in which they are obtained. The SPT results in an N-value, or number of blows required to drive the split spoon sampler 1 foot. This N-value is used to estimate the shear strength and friction angle of the soil, define the consistency of cohesive soils and also the relative density of non-cohesive soils.

However, it should be noted that in cohesive soils, the shear strength values determined from the Unconfined Compression tests utilizing Shelby tubes samples are considered more reliable than those estimated from blow counts.

The samples from the split spoon and Shelby tubes are submitted to the laboratory for determination of AASHTO classification, moisture content, dry density, sieve analysis, and Atterberg limits.

Test Results

A summary of the lab analysis has been included in Appendix D.

Proposed Structures

Temporary Shoofly

Length: Approximately 178'
Spans: 5

Permanent

Length: Approximately 186'
Spans: 3

Foundation Recommendation

Steel Piling

Pile recommendations are given as termination elevations. The pile sizes that have been analyzed are HP10x42, HP12x53, HP14x73, and HP14x102.

The software "APile" (v2014) was utilized with the FHWA Method (Reese, Wang, Arrellaga, & Vasquez, 2014). The FHWA Method derives pile load carrying ability from the frictional resistance of the soil around the shaft and the bearing capacity at the pile tip. The computations were performed with the assumption that end of the pile was plugged.

The output from this analysis is in Appendix E.

Temporary Shoofly Structure

The pile termination lengths for the temporary shoofly structure were based on information provided in the 50% plan submittal, Boring 1A conducted on 12/9/2014, and information from Boring 3 conducted on 6/14/1979

Table 1 - Pile Termination Information (Temporary Shoofly Structure)

Pile Type	90% Ultimate Axial Capacity[1]	West Abutment-1	Pier-2	Pier-3	Pier-4	Pier-5	East Abutment-6
	kips	Termination Elevation	Termination Elevation	Termination Elevation	Termination Elevation	Termination Elevation	Termination Elevation
HP10x42	558	1392	1392	1393	1391	1392	1391
HP12x53	698	1393	1393	1393	1391	1392	1391
HP14x73	963	1393	1393	1393	1391	1391	1391
HP14x102	1,355	1391	1391	1391	1389	1389	1388
[1]Based on 50 ksi steel							

The following figures show the unfactored geotechnical resistance at depth from the top of the borings.

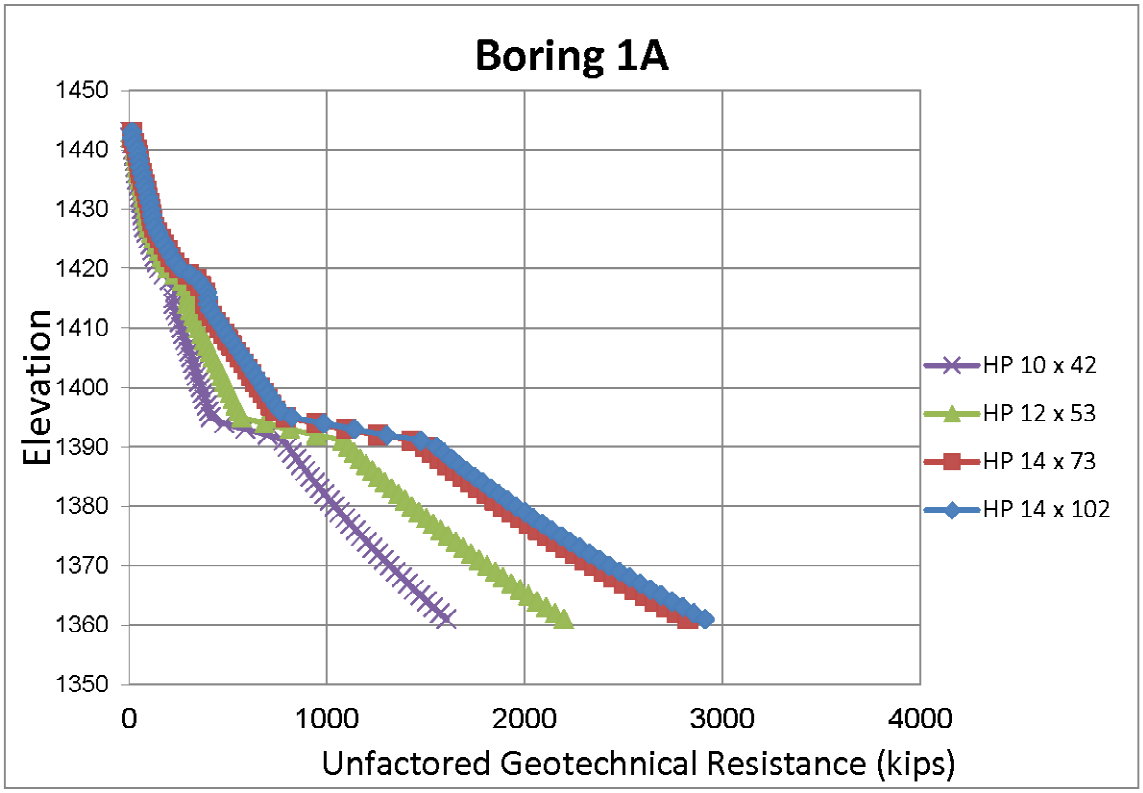

Figure 4 – Unfactored Geotechnical Resistance of Boring 1A

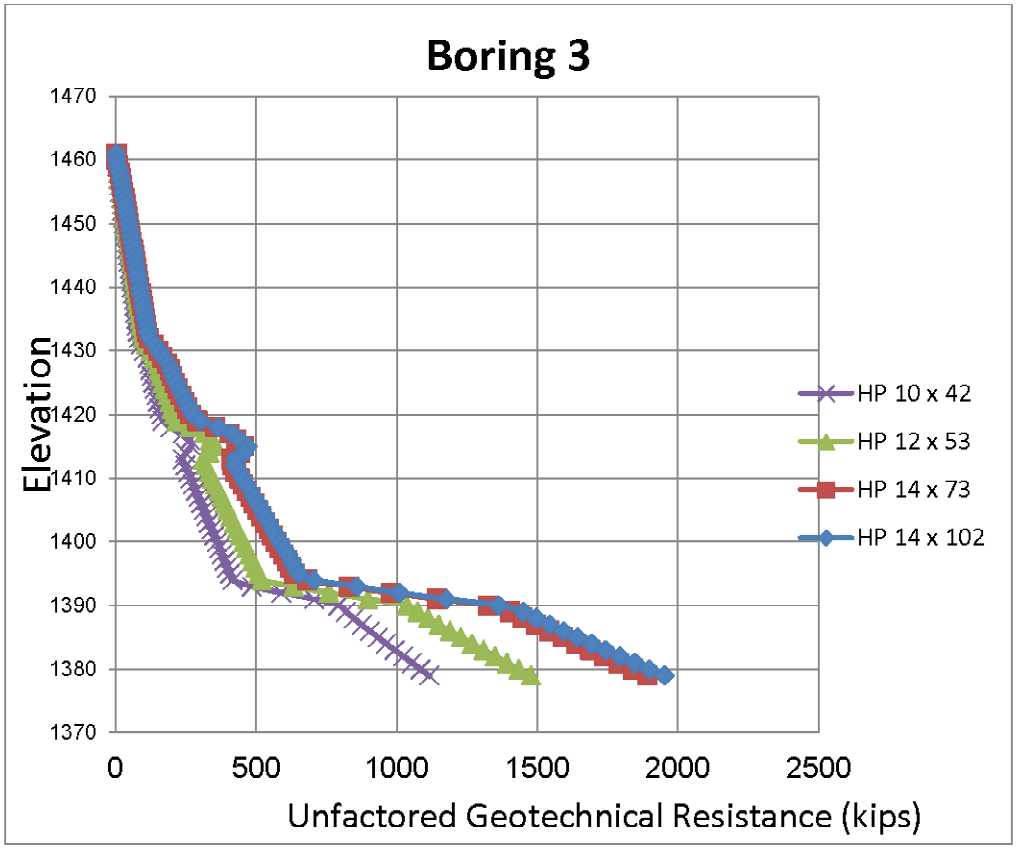

Figure 5 – Unfactored Geotechnical Resistance of Boring 3

Proposed Permanent Structure

The pile termination lengths for the permanent proposed structure were based on information provided in the 50% plan submittal, Boring 1A conducted on 12/9/2014, Boring 1 conducted on 6/13/1979, and information from Boring 3 conducted on 6/14/1979

Table 2 - Pile Termination Information (Proposed Permanent Structure)

Pile Type	90% Ultimate Axial Capacity[1]	West Abutment-1	Peir-2	Pier-3	East Abutment-4
	kips	Termination Elevation	Terminatio n Elevation	Termination Elevation	Termination Elevation
HP10x42	558	1393	1392	1391	1392
HP12x53	698	1393	1392	1391	1392
HP14x73	963	1393	1392	1391	1391
HP14x102	1,355	1391	1389	1388	1389
[1]Based on 50 ksi steel					

The following figure shows the unfactored geotechnical resistance at depth from the top of the boring.

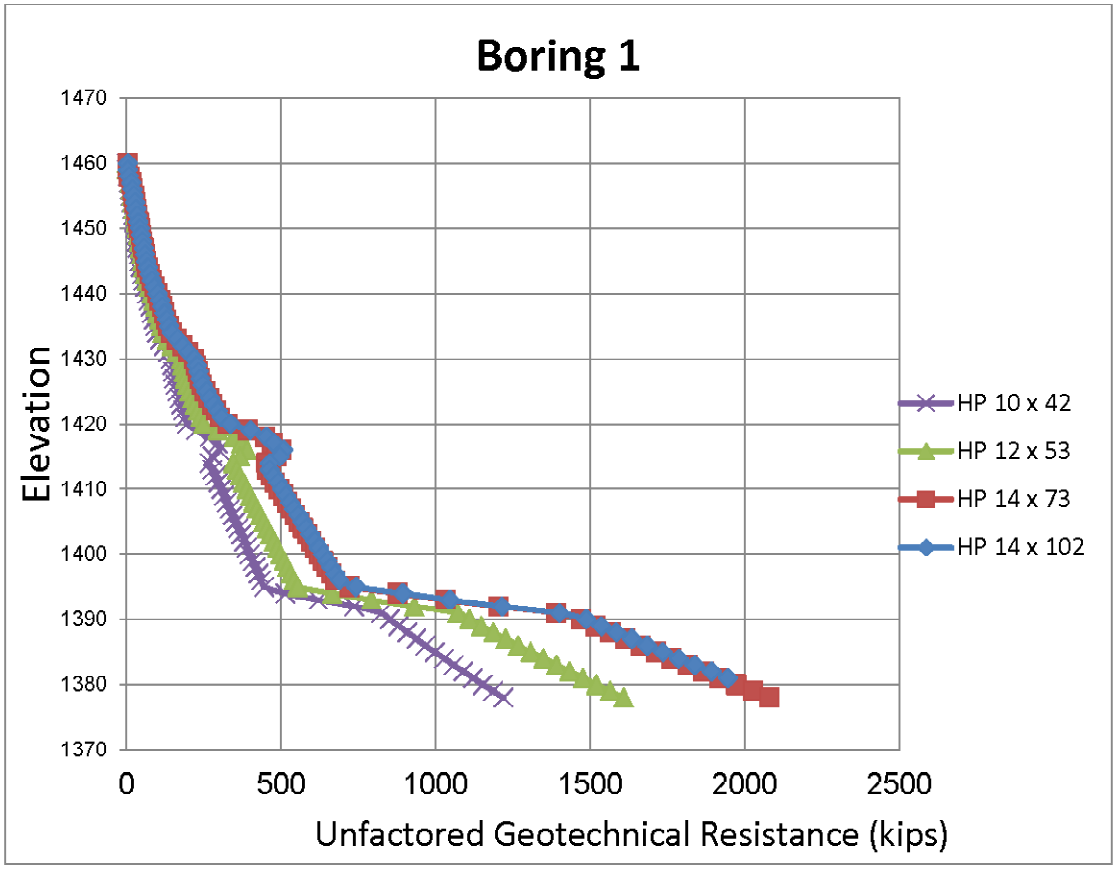

Figure 6 – Unfactored Geotechnical Resistance for Boring 1

Pile Tips

Pile tips will not be required on this project.

Downdrag

Temporary Shoofly Structure

Piling driven through the new embankment construction for the Shoofly Structure should be pre-drilled to an elevation of 1432 for the east embankment and 1430 for the west embankment to account for any downdrag forces. Piers 3 and 4 will not require any pre-drilling.

Proposed Permanent Structure

Downdrag will not be a concern if the pile is driven through the existing embankment and settlement is not expected to occur.

Scour

This structure is not a water conveying structure thus scour was not considered.

Compaction Recommendation

The embankment shall be compacted to 90% of the maximum dry density as determined by AASHTO T-180 and the moisture contents shall comply with section 203.04 E.2.

End Slope Recommendation

The stability analysis was conducted with Slope/W develop by Geo-Slope International. The analysis was a two-dimensional limit equilibrium method.

The endslope recommendation was provided in an earlier memo dated October 17, 2014. A slope of 2.5:1 or flatter for each endslope is sufficient for stability according to that analysis. The results of the analysis are shown in Appendix F.

Drainage Recommendation

Bridge

The drainage off the bridge should be controlled so that water does not drain directly off the bridge ends and causes erosion around the wing-wall. A combination of inlets, downdrains, and/or deckdrains should be used to control water runoff. Water should not be allowed to drain off the bridge as to allow the foreslopes and end slopes to become saturated, which is a common cause of slope failure.

Roadway

Geotechnical memorandums dating back to the 1980's indicate that roadways in this area are prone to seasonal movement due to subsurface water. The original plans for the current structure have an underdrain system in place. This underdrain system has proven to work well in this area as there have been minimal/no maintenance issues with the roadway. An underdrain system similar to the existing one should be incorporated into the final pavement section. Existing typical sections of the current underdrain system can be found in Appendix G.

Settlement

Temporary Shoofly Structure

Based on the preliminary information provided on the shoofly structure as well as past consolidation testing, it can be expected that 2-3" of settlement may occur on the embankment leading up to this structure. 90% of this settlement is expected to occur within 3 months.

Proposed Permanent Structure

The proposed permanent structure is expected to be placed on the current railroad alignment. It is expected that the existing embankment may need to be modified to accommodate the new structure. If additional fill is added to the embankment further analysis should be made to estimate possible settlement.

Retaining Wall

Methods described in Principles of Foundation Engineering by Braja M. Das as well as the AASHTO LRFD Bridge Design Specifications were used to develop a preliminary retaining wall design.

The following figure shows the assumptions used for the retaining wall analysis.

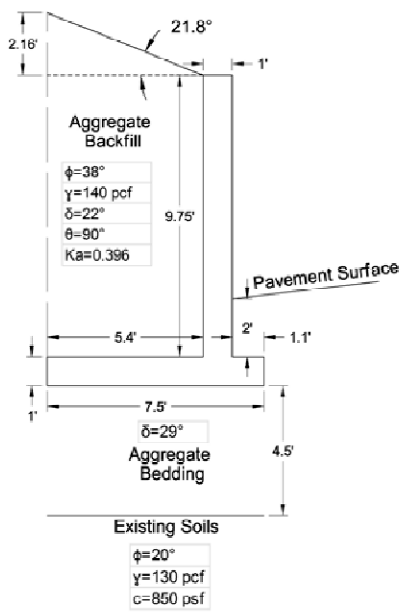

Figure 7 - Assumed Retaining wall Dimensions and Soil Properties

Calculations for the above assumed retaining wall can be found in Appendix H. The Following table is a summary of calculations.

Table 3 - Calculation Summary

Variable	Result	Comment
Frost Depth	7.5 Feet	4.5' of aggregate bedding provided to frost depth.
Active Earth Pressure	4620 lbs	This is a resultant acting at a distance 1/3 the wall height from the base, at an angle of 21.8°.
Passive Earth Pressure	NA	Passive earth pressure is to be ignored in calculations according to 11.6.3.5 of LRFD manual.
Bearing Capacity	3315 psf	This is based on a 2 layered drained system (LRFD 10.6.3.1.2f).
Global Stability	FOS 4+	This FOS is based on the assumed model found in Appendix H.

References

Das, B. M. (2011). *Principles of foundation engineering.* Stanford, CT: Cengage Learning.

Officials, A. A. (2014). *AASHTO LRFD bridge design specifications, U.S. customary units.* Washington, DC: American Association of State Highway and Transportation Officials.

Reese, L. C., Wang, S. T., Arrellaga, J. A., & Vasquez, L. G. (2014). *APILE v2014 - Technical Manual.* Austin, Texas, United States of America: ENSOFT, INC.

APPENDIX A

1979 Foundation Report

MEMO FROM MATERIALS & RESEARCH

FOUNDATION REPORT

PROJECT NO.: FG-3-020( )102 DATE: 8-15-79

COUNTY: Ramsey

LOCATION: Highway No. 20
Underpass Site at Devils Lake

This Foundation Report is based on the results of three (3) test borings identified and referenced as follows:

Test Boring No. 1 is at Station 50+00, 20' right of survey centerline, located on north end of structure site and drilled to a maximum depth of 60.2';

Test Boring No. 2 is at Station 50+46, 35' left of survey centerline, located near the midpoint of the structure site and drilled to a maximum depth of 60.0';

Test Boring No. 3 is at Station 51+37, 35' left of survey centerline, located at the south end of the structure site and drilled to a maximum depth of 60.2'.

The soil foundation at this site can be divided into two separate parts. The upper part, consisting of the glacial deposition, will herein be referred to as Zone No. 1. The lower part, consisting of the Pierre Shale Bedrock Formation, will herein be referred to as

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Zone No. 2. These zones will be described briefly in numerical order as follows:

Zone No. 1 extends from the railroad embankment reference plane (Average Elevation 1459.2) to an average depth of 28.5' (Elevation 1430.7) below the reference plane. This zone comprises the railroad fill and the glacial drift below it. The embankment used in consructing the railroad fill is from drift as well. Thus, all of Zone No. 1 is technically glacial drift.

The soil in Zone No. 1 is within the textural classifications of sandy loam, loam, clay loam and clay. The soil group classifications, in turn, fall within the following: A2-4, A2-6, A6 and A7-6. The A2-4 and A6 soil groups are the most predominant.

The soil structure ranges from a mixed fill to varved and/or lenticular. In the fill there are interbeddings sandy loam and/or clay. Whereas, in the drift there are clay varves and/or sandy lenses interspersed throughout.

The natural consistency of the clay soil ranges from soft to hard. The relative density of the granular type soil ranges from loose to dense.

The natural moisture content ranges from below the shrinkage limit to well above the plastic limit. The highest moisture concentration is at the bottom of the railroad fill. The Consistency Index (C_r) ranges from a low value of 57% to a high value of well over 100%.

This indicates a rather high degree of compressibility which is also of a differential nature.

The shear strength of the soil in Zone No. 1 is dependent upon the combination of friction and cohesion. It is, therefore, a cohesive-frictional type soil. The shear strength is based on an angle of internal friction (Ø) ranging predominantly between 10° and 20° with a cohesive strength value ranging from a low of 0.3 kips/sq.ft. to a high of 2.7 kips/sq.ft. or a mean average cohesive strength of 1.2 kips/sq.ft.

Zone No. 2 extends from the base boundary of Zone No. 1 (Elevation 1430.7) to the maximum depth of test borings. This zone comprises the Pierre Shale Bedrock Formation.

The soil contained in this zone is within the textural classification loam. In its consolidated state, it can further be described as shale. The soil group classifications are A2-7, A6 and A7-5; the predominating soil group classification being A7-5. From these soil group classifications, it becomes apparent that this soil deposition is near the border line of a silt shale and a clay shale.

The soil structure can be described as tightly laminated. When exposed to air and/or water, the laminae break off into plates. Thus, the soil structure can be modified with the word platy. The complete interpretation of the soil structure then can be described as platy and laminated.

The natural state of consistency of the soil in Zone No. 2 can be described as very hard. In its natural state, the soil (plates) are very brittle.

Although there are occasional saturated laminae, the natural moisture content of this soil is predominantly below the plastic limit and often times below the shrinkage limit. The Consistency Index (C_r), therefore, is well above 100% except in the vicinity of a saturated seam, it can drop below 100%, but these are highly localized situations.

The shear strength of the soil in Zone No. 2 is dependent upon the combination of cohesion and friction. It, therefore, can be described as a cohesive-frictional type soil. Thus, the shear strength is based on an angle of internal friction ($\emptyset$) ranging from about 20° to 25° and a cohesive value of 2+ kips/sq.ft. or a compressive strength value (q_u) of more than 8 kips/sq.ft. Based on the aforementioned parameters, it can be concluded that this Pierre Shale Formation is the most durable soil within the depth of test drilling.

CONSOLIDATION DATA

Consolidation tests were conducted on soil specimens obtained from Test Borings No. 1 and No. 3. The core sample from Test Boring No. 1, from which the test specimen was obtained, represents the more sandy type soil between the depths of 18.0' and 27.7'. The core

sample from Test Boring No. 3, from which the test specimen was obtained, represents the lean clay bed between the depths of 20.0' and 30.3'.

The test specimens are representative, as near as possible, of the load settlement conditions in their respective location at this site. Due to the heterogenity of the foundation soil, variation of these results are highly probable outside of the immediate area from which the core samples were obtained.

Each of these soil beds will herein be treated as a separate consolidation condition. Therefore, the data obtained from the core sample from Test Boring No. 1 will be referenced here as "Part No. 1" and the data obtained from the core sample from Test Boring No. 3 will be referenced here as "Part No. 2".

Load settlement graphs have been prepared and identified for each of the test borings for rapid analysis of the data that will follow.

PART NO. 1 - Data From Test Boring No. 1

Thickness of Compressible Soil Bed = 9.7'

Foundation Soil Preconsolidated

P_c (Preconsolidation Value) = 1.8 Tons/sq.ft.

e (Void Ratio @ P_c) = 0.6225

(A) Load Pressure = 0.6 Ton/sq.ft.

Ultimate Load Settlement = $2''^{\pm}$

Rate of Consolidation

% of Ultimate Settlement	Time (t)
10	18± Hours
20	3± Days
30	7± "
40	12± "
50	19± "
60	28± "
70	1.3 Months
80	1.8 "
90	2.7 "

(B) Load Pressure = 1.3 Tons/sq.ft.

Ultimate Load Settlement = 3"±

Rate of Consolidation

% of Ultimate Settlement	Time (t)
10	23± Hours
20	4± Days
30	9± "
40	15± "
50	24± "
60	1.2 Months
70	1.6 "
80	2.3 "
90	3.4 "

(C) Load Pressure = 2.5 Tons/sq.ft.

Ultimate Load Settlement = 4"±

Rate of Consolidation

% of Ultimate Settlement	Time (t)
10	1± Days
20	5± "
30	11± "
40	20± "
50	1.0 Months
60	1.5 "
70	2.1 "
80	2.9 "
90	4.4 "

(D) Load Pressure = 5.0 Tons/sq.ft.

Ultimate Load Settlement = 6"+

Rate of Consolidation

% of Ultimate Settlement	Time (t)
10	2± Days
20	7± "
30	16± "
40	28± "
50	1.4 Months
60	2.1 "
70	2.9 "
80	4.1 "
90	6.1 "

PART NO. 2 - Data From Test Boring No. 3

Thickness of Lean Clay Bed = 10.3'

Foundation Soil Preconsolidated

P_c (Preconsolidation Value) = 2.2 Tons/sq.ft.

e (Void Ratio @ P_c) = 0.5795

(A) Load Pressure = 0.6 Ton/sq.ft.

Ultimate Load Settlement = 1"±

Rate of Consolidation

% of Ultimate Settlement	Time (t)
10	20+ Hours
20	3± Days
30	8± "
40	14± "
50	21+ "
60	1.0 Months
70	1.4 "
80	2.0 "
90	3.0 "

(B) Load Pressure = 1.3 Tons/sq.ft.

Ultimate Load Settlement = 2"±

Rate of Consolidation

% of Ultimate Settlement	Time (t)
10	21 Hours
20	3+ Days
30	8 "
40	14 "
50	22 "
60	1.1 Months
70	1.5 "
80	2.1 "
90	3.1 "

(C) Load Pressure = 2.5 Tons/sq.ft.

Ultimate Load Settlement = 3"±

Rate of Consolidation

% of Ultimate Settlement	Time (t)
10	21± Hours
20	4± Days
30	8± "
40	15± "
50	23± "
60	1.1 Months
70	1.5 "
80	2.2 "
90	3.2 "

(D) Load Pressure = 5.0 Tons/sq.ft.

Ultimate Load Settlement = 5"±

Rate of Consolidation

% of Ultimate Settlement	Time (t)
10	1± Days
20	6± "
30	13± "
40	24± "
50	1.2 Months
60	1.8 "
70	2.5 "
80	3.5 "
90	5.2 "

CONCLUSIONS

In concluding this Foundation Report, the following conditions and/or suggestions relative to the design of the proposed structure are presented.

1. Stable foundation support for the proposed bridge structure must be obtained in Zone No. 2. Depending on substructure details and grade line requirements, the footings will either have to be set down on the bedrock or short piling must be used to transmit the load of the structure to the bedrock formation.

2. Should it be possible to set the footings directly on the bedrock of Zone No. 2, the following load bearing values would be simulated when based on the following critical data:

   c = 2800 lbs/sq.ft.

   h (Depth of footing below ground elevation) = 15'

   b (Width of base) = 4'

   L (Length of footing) = 4' & 12'

Load Bearing (Rectangular Ftgs.) = $\frac{5.52C(1+0.38\frac{h}{b} + 0.44\frac{b}{L}}{3}$

Load Bearing (Rectangular Ftgs.) = $\frac{\frac{5.52 \times 2800}{2000}(1+0.38 \times \frac{15}{4} + 0.44 \times \frac{4}{12})}{3}$

Load Bearing (Rectangular Ftgs.) = $\frac{7.728 \times (2.425 + 0.147)}{3}$

Load Bearing (Rectangular Ftgs.) = 6.6 Tons/sq.ft.

$$\text{Load Bearing (Square Footings)} = \frac{7.95C\ (1 + 0.38\ \frac{h}{b} + 0.44\ \frac{b}{L})}{3}$$

$$\text{Load Bearing (Square Footings)} = \frac{\frac{7.95 \times 2800}{2000}\ (1 + 0.38 \times \frac{15}{4} + 0.44 \times \frac{4}{4})}{3}$$

$$\text{Load Bearing (Square Footings)} = \frac{11.13\ (2.425 + 0.44)}{3}$$

Load Bearing (Square Footings) = 10.6 Tons/sq.ft.

3. Should it be necessary to use piling in the footings, it is suggested that a drilled in pile be used to avoid shattering the brittle bedrock shale.

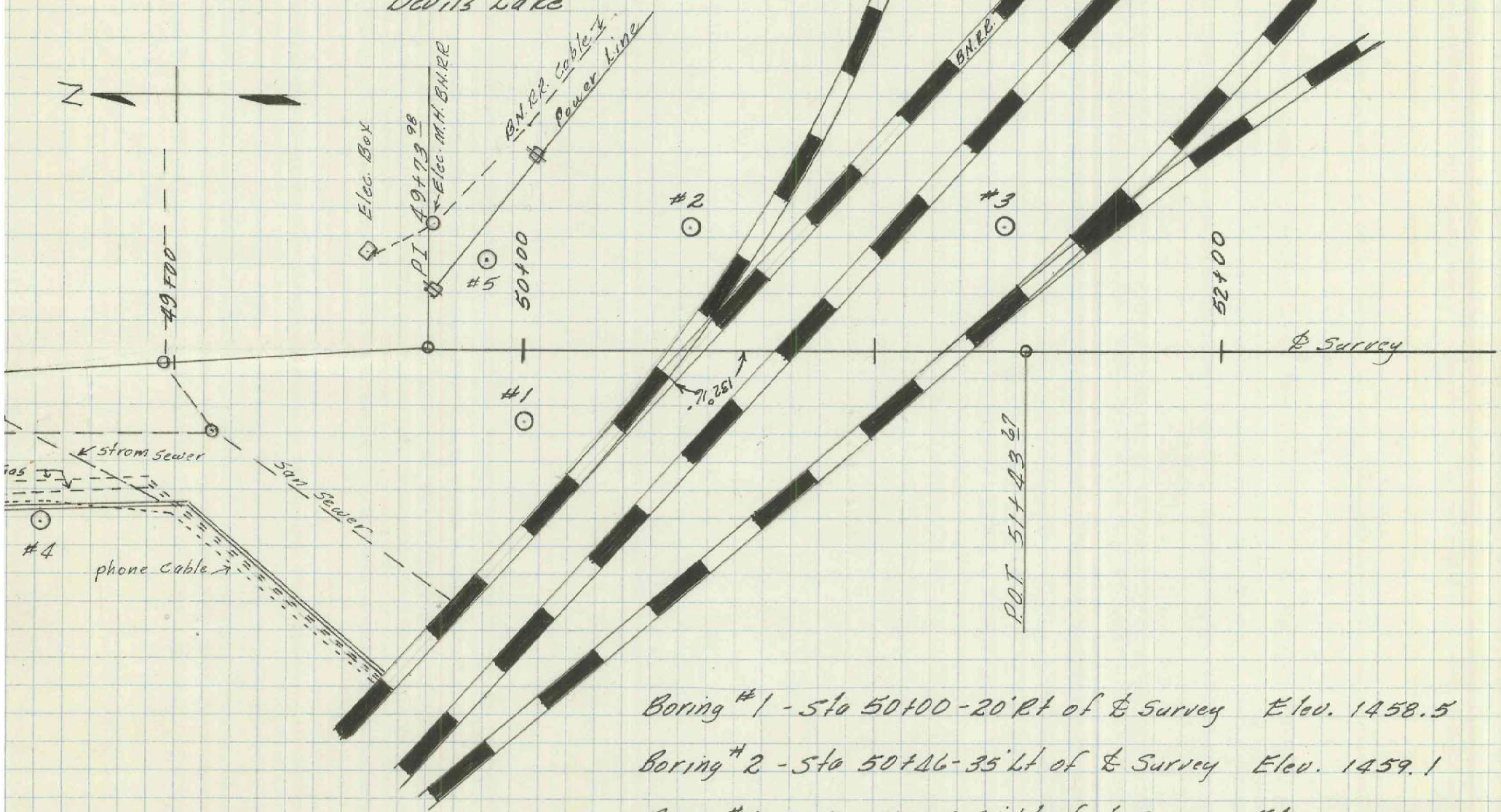
4. Although there was no serious ground water problem encountered at this site, it would be good safety precaution to incorporate parallel longitudinal subdrains in the subgrade approximately 75' back and 75' ahead from midpoint of the structure to intercept ground water that may be trapped by the impermeable bedrock. This can be tied into the drainage system that will intercept the surface runoff waters.

5. The surficial soils at the ends of the structure are fine granular type soils that are very susceptable to erosion. Therefore, erosion control should be incorporated into the design at both ends of the structure to channel runoff waters to points of dissipation without effects of washing and scouring.

C. A. Wold, Soils Engineer

Distribution:
Materials & Research Division
Bridge Division
Burlington Northern Railroad (Final Boring Log Data)
Office File

FG-3-020( )102
Ramsey County
B.N.R.R. Underpass
on ND #20 at
Devils Lake



Boring #1 - Sta 50+00 - 20' Rt of ℄ Survey Elev. 1458.5

Boring #2 - Sta 50+46 - 35' Lt of ℄ Survey Elev. 1459.1

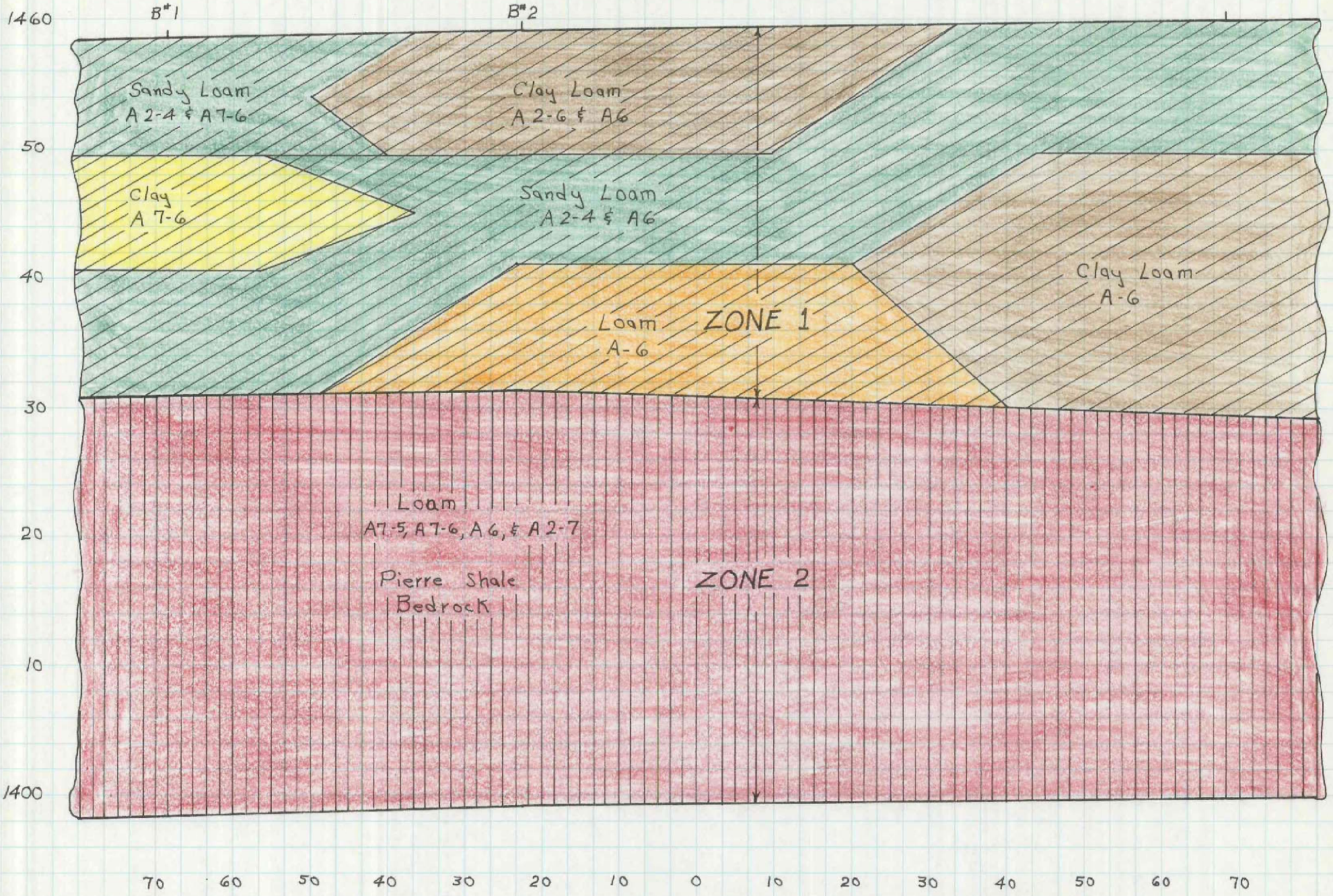
Boring #3 - Sta 51+37 - 35' Lt of ℄ Survey Elev. 1459.9

Boring #4 - Sta 48+60 - 43' Rt of ℄ Survey Elev. 1449.6

Boring #5 - Sta 49+90 - 25' Lt of ℄ Survey Elev. 1457.0

SOIL PROFILE

BN RR Underpass on
N.D. #20 at Devils Lake

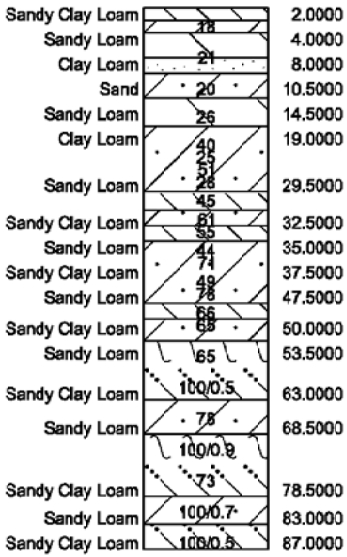


APPENDIX B

Boring Log (Boring 1A from 12/9/14)

STATE	PROJECT NO.	SECTION NO.	SHEET NO.
ND	SU-3-020(074)103	175	1

Boring 1A
5458+33
47' Left



Project Number: SU-3-020(074)103
PCN: 17504
Bridge Number: 0020-103.403
Location: Devils Lake College Drive - Railroad Underpass
Boring Number: 1A
Dates Drilled: 12/3/14

RP + Feet: NA
Station: 5458+33
Offset: 47 feet Left
Orientation: Southwest Quad of Exist Structure
Elevation of Boring: 1443

Depth (ft.)	Textural Class	Soil Class	Sample Type	Test Type	Comp. Strength (psf)	Friction Angle (degr.)	Cohesion (Shear Strength) (psf)	Blow Count (bpf)	Field Moisture (%)	Dry Unit Weight (pcf)
0.0-2.0	SNDY CLY LM	A-7-5(5)	SS	SPT	—	—	NA	31 (frozen)	9.8	—
2.0-4.0	SNDY LM	A-2-6(1)	SS	SPT	—	—	NA	18 (frozen)	8.9	—
5.0-7.0	CLY LM	A-6(5)	3TW	UC	6,540	—	3,270	—	22.4	101.3
7.0-8.0	CLY LM	A-6(6)	SS	SPT	—	—	2,625	20	20.3	—
8.0-9.0	SND	A-2-4(0)	SS	SPT	—	33	—	21	21.9	—
12.0-14.0	SNDY LM	A-2-7(1)	SS	SPT	—	33	—	20	16.1	—
15.0-16.5	CLY LM	A-6(6)	3TW	UC	8,731	—	4,365	—	16.0	117.3
16.5-18.5	CLY LM	A-6(5)	SS	SPT	—	—	3,250	26	17.8	—
20.0-21.0	SNDY LM	A-2-4(0)	3TW	M	—	—	—	—	17.9	—
21.0-23.0	SNDY LM	A-6(2)	SS	SPT	—	—	5,000	40	17.0	—
23.0-25.0	SNDY LM	A-7-5(5)	SS	SPT	—	—	3,125	25	31.0	—
25.0-27.0	SNDY LM	A-2-7(2)	SS	SPT	—	37		51	28.5	—
27.0-29.0	SNDY LM	A-7-6(5)	SS	SPT	—	—	3,500	28	26.5	—
30.0-32.0	SNDY CLY LM	A-7-5(9)	SS	SPT	—	—	5,625	45	28.5	—
33.0-35.0	SNDY LM	A-7-5(9)	SS	SPT	—	—	7,625	61	28.2	—
35.0-37.0	SNDY CLY LM	A-7-5(11)	SS	SPT	—	—	6,875	55	26.4	—
38.0-40.0	SNDY LM	A-7-6(4)	SS	SPT	—	—	5,500	44	26.0	—
40.0-42.0	SNDY LM	A-7-5(7)	SS	SPT	—	—	8,875	71	29.1	—
43.0-45.0	SNDY LM	A-7-6(4)	SS	SPT	—	—	6,125	49	25.4	—
45.0-47.0	SNDY LM	A-7-6(4)	SS	SPT	—	—	9,750	78	23.1	—
48.0-50.0	SNDY CLY LM	A-7-5(7)	SS	SPT	—	—	8,250	66	27.7	—
50.0-52.0	SNDY LM	A-2-7(3)	SS	SPT	—	39	—	65	31.1	—
55.0-57.0	SNDY CLY LM	A-7-5(7)	SS	SPT	—	41	—	100	30.8	—
60.0-61.0	SNDY CLY LM	A-7-5(12)	SS	SPT	—	43	—	100/.5	31.5	—
65.0-67.0	SNDY LM	A-2-7(3)	SS	SPT	—	40	—	78	27.8	—
70.0-71.5	SNDY CLY LM	A-7-5(10)	SS	SPT	—	41	—	100/.9	26.6	—
75.0-77.0	SNDY CLY LM	A-7-5(8)	SS	SPT	—	40	—	73	30.6	—
80.0-81.5	SNDY LM	A-2-7(6)	SS	SPT	—	42	—	100/.7	30.6	—
85.0-87.0	SNDY CLY LM	A-7-5(6)	SS	SPT	—	43	—	100/.5	30.1	—

SS - Split Spoon
3TW - 3" Thin Wall (Shelby Tube)
M - Moisture Test
D - Density Test
UC - Unconfined Compression Test
UU - Unconsolidated Undrained Triaxial Test
SPT - Standard Penetration Test

Friction and Cohesive values for split spoon samples are estimated from the blow counts. These values are used in absence of triaxial strength testing information.

Notes:

THE BORING DATA SHOWN IS FOR NORTH DAKOTA DEPARTMENT OF TRANSPORTATION'S (NDDOT) DESIGN AND ESTIMATING PURPOSES ONLY. THE BORING LOGS ARE ONLY REPRESENTATIVE OF THE EXACT LOCATION FROM WHICH THE SAMPLES WERE TAKEN AND INTERPRETATION BETWEEN THE SAMPLE LOCATIONS IS DISCOURAGED. THE NDDOT ASSUMES NO RESPONSIBILITY IF THE SOIL CONDITIONS ENCOUNTERED DURING CONSTRUCTION DIFFER FROM THOSE SHOWN. FURTHER SOIL INFORMATION MAY BE AVAILABLE AT:

NDDOT
MATERIALS & RESEARCH DIVISION
300 AIRPORT ROAD
BISMARCK, NORTH DAKOTA 58504-6005
PHONE (701)328-6900

SS - Split Spoon
3TW - 3" Thin Wall Shelby Tube
M - Moisture Test
D - Density Test
UC - Unconfined Compression Test
UU - Unconsolidated Undrained Triaxial Test
SPT - Standard Penetration Test

This document is preliminary and not for construction or implementation purposes.

PRELIMINARY

Boring Log

Bridge 0020-103.403 - Boring 1A

APPENDIX C

Boring Logs (Borings 1-5 from 1979)

New Form 25-2-6
Old Form 689

Part 1 of 2

NORTH DAKOTA STATE HIGHWAY DEPARTMENT
SITE SOIL SURVEY
(AASHTO T203-64)

Project FG-3-020( )102 Structure No. _____

County RAMSEY Boring No. 1

Location BN RR UNDERPASS ON ND 20 AT DEVILS LAKE Station 50 + 00 Offset 20' RT. OF SUR. ℄

Date Drilling Started JUNE 12, 1979 Date Finished JUNE 13, 1979

Final Water Level 20.0' Average Seepage Rate (Ft. Rise/Min) 0.29
(Between the Depths of 20.0' & 22.6')

(AASHTO T86-70)

1. Depth 1" = 5'	2. Elev.	3. Profile	4. Core No.	5. Classification	6. Color of Material	7. Characteristics	8. AASHTO M145-66 Soil Group	9. Remarks
0.0' 5 10 15 9.0'	1458.5 1449.5		C1 79R-129 Jar 1; C2 Jar 2; C3 Jar 3; C4 Jar 4; C5 Shelby	Sandy Loam	Blk. & Brn. Varigated-	Mixed Fill & Topsoil- Interbeddings of Clay- Loose-	A2-4 & A7-6	C_r: 121% C_r: n_o: 51% n_e: 51% e_o: 1.032 e_e: 1.036 S: 97%
17.8'	1440.7		79R-130 C6 Jar 5	Clay	Brn.	Lenticular- Silty- Pliable- Some Sand Lenses & Disseminated Pebbles- Medium Stiff-	A7-6	
20 25 27.7'	1430.8		C7 Shelby 79R-131 C8 Jar 6	Sandy Loam	Brn.	Varved & Lenticular- Ferruginous Zones- Dense-	A6	C_r: 120% n_o: 34% n_e: 36% e_o: 0.517 e_e: 0.558 S: 100%
30 35			C9 Shelby 79R-132 C10 79R-133 Jar 7					C_r: 167% n_o: 43% n_e: e_o: 0.751 e_e: S: 94%

40		C11 / Jar 8	Loam (Shale)	Dk. Gry.	Laminated & Platy - Silty & fairly Cohesive - Compact & Very Tight - Some Saturated Lenses - Very Hard -	A7-6	Pierre Shale Bedrock
45							
50		C12 / Jar 9					
55							- C_r: 89%
60.2' 60 Plus	1398.3	C13 / 79 & 134 / Jar 10					

C_r: Consistency Index
n_o: Porosity at beginning of Shear Test
n_e: " " end " " "
e_o: Void Ratio at beginning of Shear Test
e_e: " " " end " " "
S: Degree of Saturation

Boring No. 1

BN RR Underpass at Dempsey Lane

Structure No.

STANDARD PENETRATION TEST

(Wt. of Ham'r. = 140 lbs. - Ht. of Drop = 30")

* AASHTO T206-74

** AASHTO T207-75

Core No.	Depth	% Recovery	% Moisture	* S.P.T. 1st 0.5'	2nd 0.5'	Total	* S.P.T. Drive
1	0.0' - 2.0'	100	17	2	3	5	1.0'
2	2.0' - 4.0'	100	14	2	4	6	1.0'
3	4.0' - 6.0'	80	21	3	3	6	1.0'
4	6.0' - 8.0'	90	20	3	3	6	1.0'
3" Shelby 5	8.2' - 10.2'	85	41				
6	10.2' - 12.2'	90	23	4	4	8	1.0'
3" Shelby 7	18.2' - 20.2'	50	20				
8	20.2' - 22.2'	100	23	20	23	43	1.0'
3" Shelby 9	28.2' - 29.0'	63	31				
10	29.0' - 31.0'	100	28	40	47	87	1.0'
11	38.2' - 40.2'	75	32	45	49	94	1.0'
12	48.2' - 50.2'	80	31	50	54	104	1.0'
13	58.2' - 60.2'	80	27	50	57	107	1.0'

CASING DRIVE LOG

(Wt. of Ham'r. = _____ lbs. - Ht. of Drop = 30")

Ft. of Casing or Hollow Stem Auger	No. of Drops/Ft.
58.2'	H

Note: S = Skin friction on outside wall of casing only.
T = Total Resistance - skin friction plus resistance on drive shoe.
H = Hollow Stem Auger

Form 25-2-15 Rev. 12-14-77

BN RR Underpass
at Devils Lake

Boring No. 1

Structure No.

WATER SEEPAGE DATA

Depth of Test Hole =	22.2'	48.2'
~~(Column of casing in place = ____)~~		
Column of H.Stem Auger in Place =	18.2'	38.2'
Depth to water after bailing =	Hole was Dry	29.4'
" " " at 1 minute =		28.8'
" " " " 5 " =		28.0'
" " " " 15 " =		27.1'
" " " " 30 " =		26.2'
Avg. Seepage Rate (Ft./min. rise) =		0.29

(~~Casing~~ H.Stem Extracted)

Depth to water after bailing =	22.6'
" " " at 1 minute =	22.0'
" " " " 5 " =	21.2'
" " " " ~~30~~ 15 " =	20.0'
" " " " ~~60~~ 30 " =	20.0

Avg. Seepage Rate = 0.29 '/min rise

Final water level after 12 hrs. = 20.0'

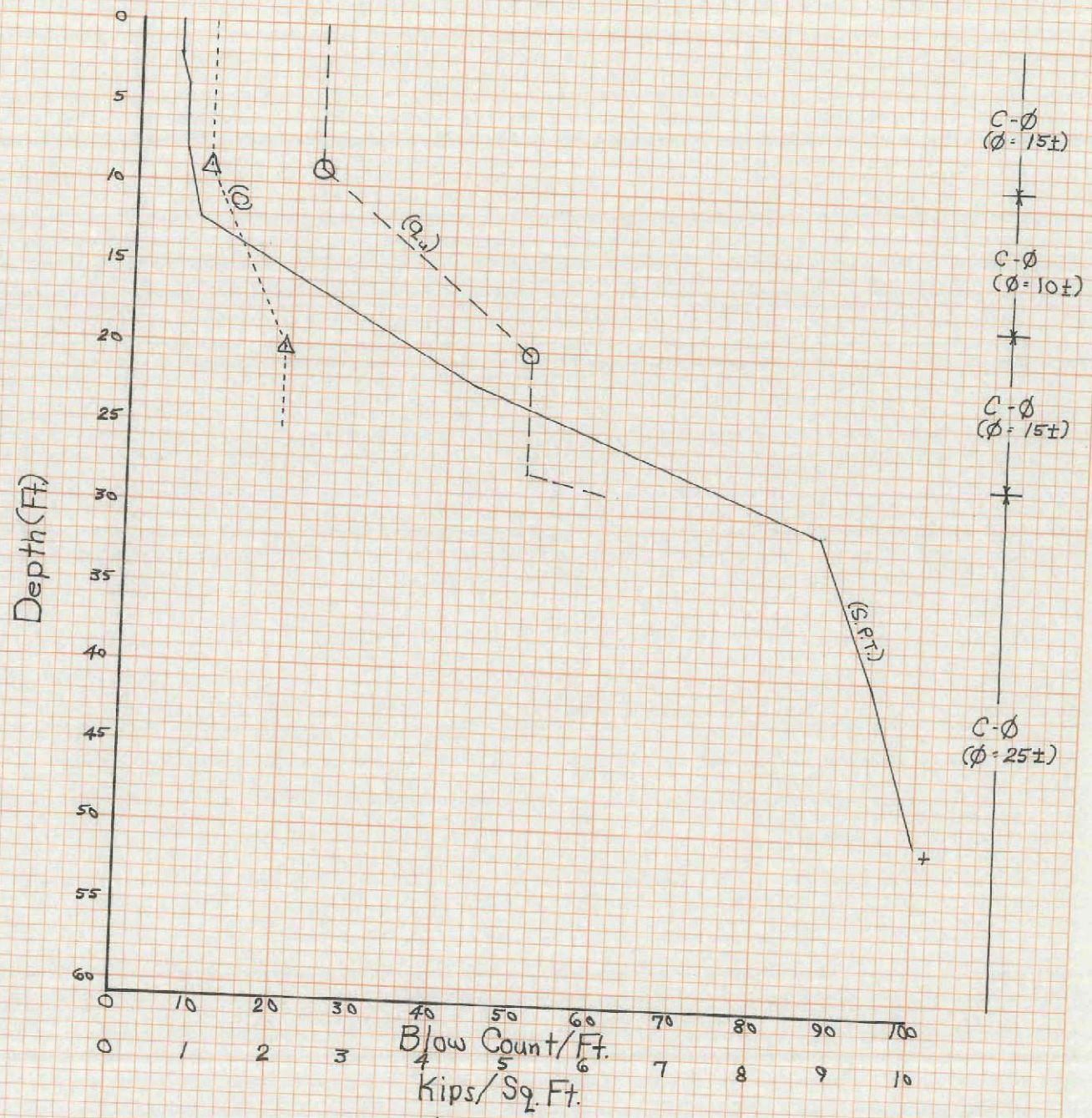
Daily Water Level Record

Date	Ft. of ~~Casing~~ H. Stem	Depth to Water	Hole Depth
6-13-79	18.2'	Hole was dry	22.2'
6-14-79	Extracted	20.0'	60.2'

Form 679

B#1

SOIL STRENGTH



Legend

Standard Penetration Test (S.P.T.) ———

Unconfined Compr. Strength (q_u) – – – –

Cohesion (C) - - - - - - - - - - - - - - - -

⊙: q_u from test

△: C from q_u test

⊙: q_u from triaxial test

△: C from triaxial test

Ø: Frictional &/or Angle of Internal Friction

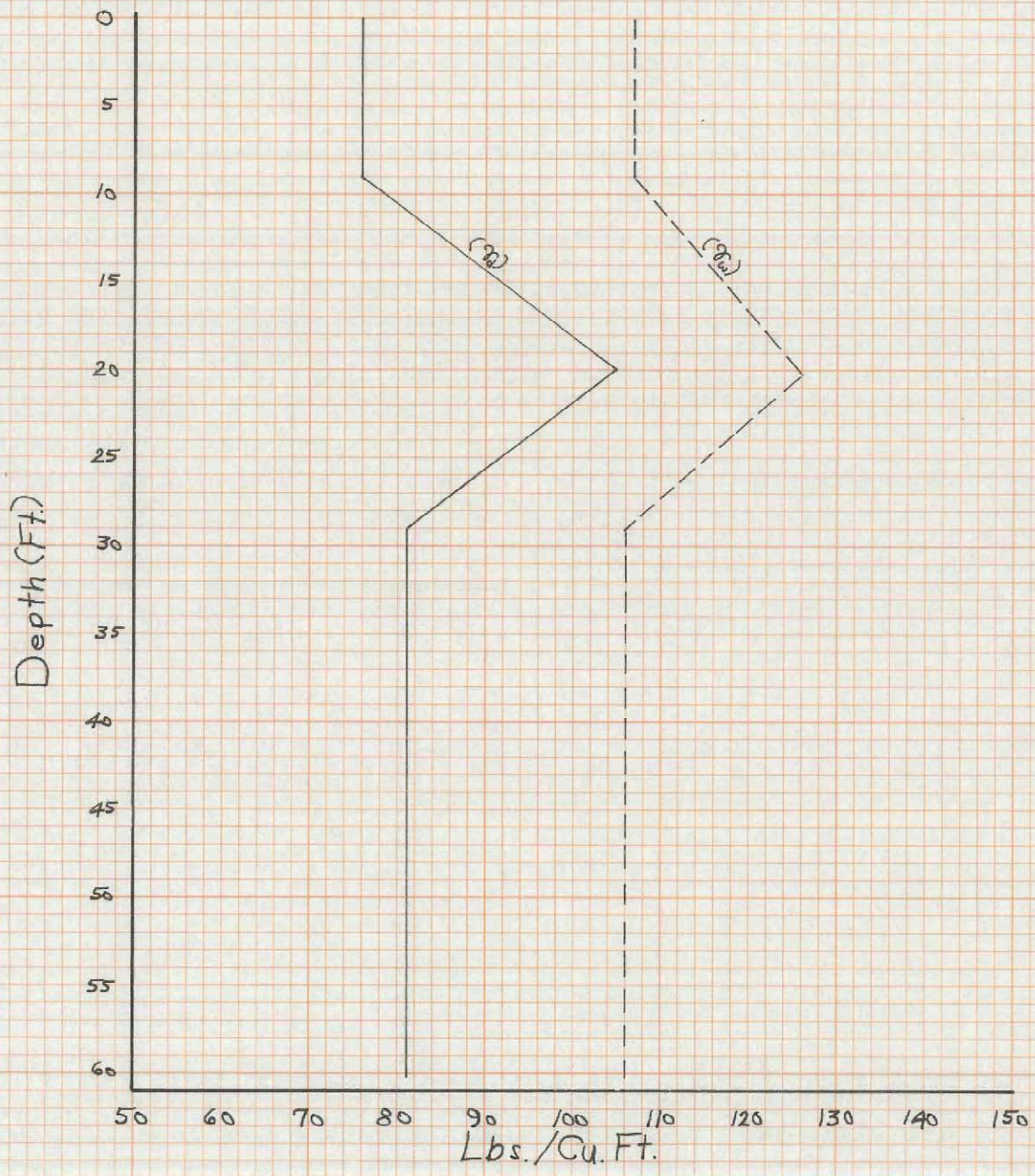
C-Ø: Cohesive - Frictional

C: Cohesive &/or Cohesion

46 0703
KEUFFEL & ESSER CO. MADE IN U.S.A.

B#1

UNIT WEIGHT



Legend

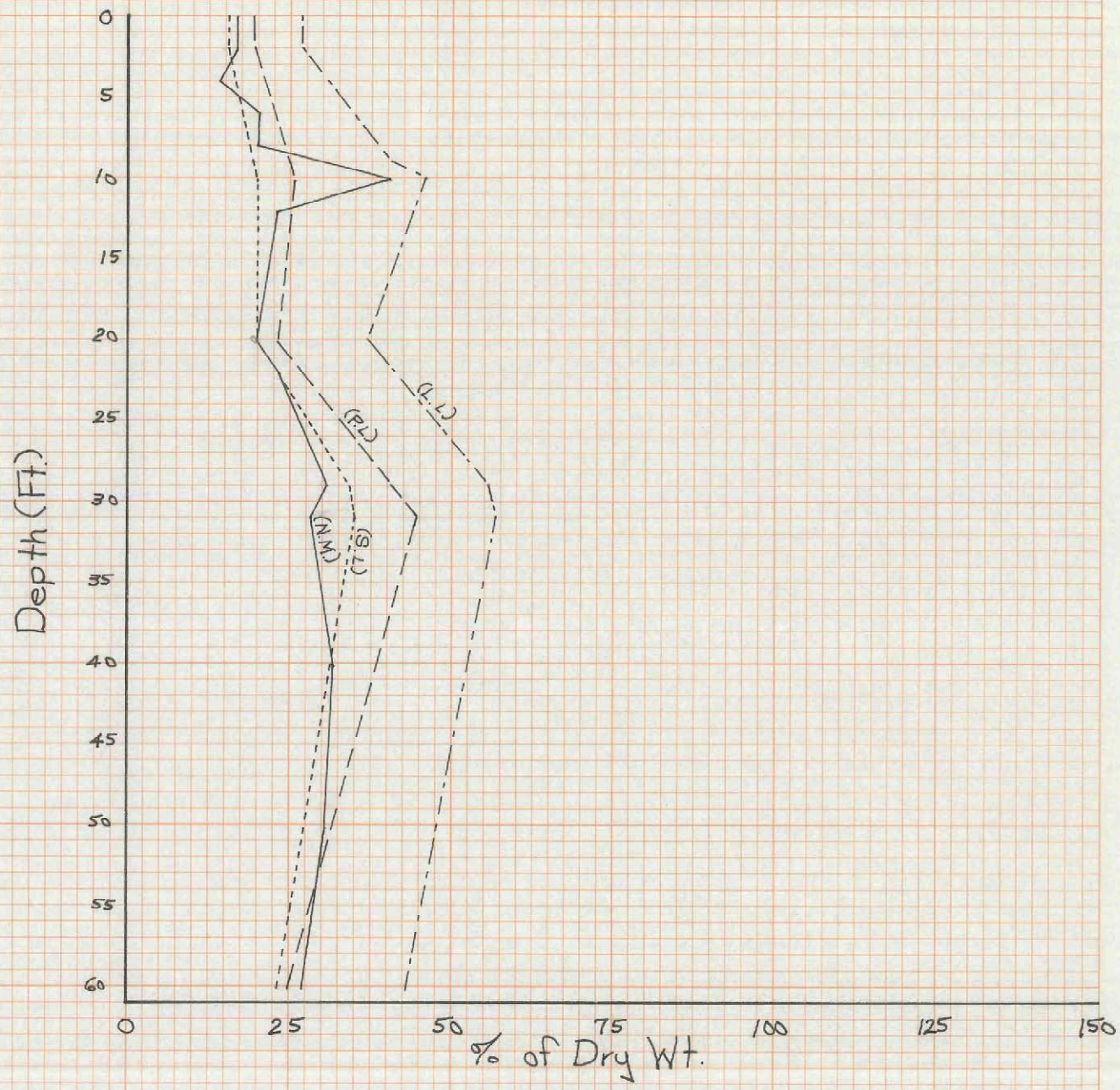
Dry Wt. (γ_d) ————————

Wet Wt. (γ_w) - - - - - - - - -

46 0703
K&E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

B#1

NATURAL MOISTURE & ATTERBERG LIMITS



Legend.

Natural Moisture (N.M) ————————

Shrinkage Limit (S.L) - - - - - - - - - - - - -

Plastic Limit (P.L) — — — — — — — —

Liquid Limit (L.L) —·—·—·—·—·—

46 0703
K+E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

NORTH DAKOTA
STATE HIGHWAY DEPARTMENT

FOUNDATION SOIL SHEAR TEST REPORT

Date 8-10-79

Structure No.

AASHTO T208-70: Unconfined Test

AASHTO T234-74: Triaxial Test

Location: Ramsey County, BN RR Underpass on ND 20 at Devils Lake, Station 50+00, 20' Rt. of survey ℄.

Boring No. 1

Sample No.	79R- 130	131	132
Depth Sample Taken	8.2' - 9.0'	18.2' - 20.2'	28.2' - 29.0'
Type of Sample	3" Shelby	3" Shelby	3" Shelby
Type of Test	Unconfined	Unconfined	Density
Maximum Load (Lbs./sq. ft.)	2291	5007	-----
Typical Angle of Internal Friction	Near 15°	Near 15°	-----
Cohesion (Lbs./sq. ft.)	879	1921	-----
Nat. Field Moisture	41%	20%	31%
Unit Weight Dry (Lbs./cu. ft.)	76	105	81
Sensitivity Factor			

*Disturbed **Unconfined Compressive Strength

Form 680
Rev. 10-1-66
New Form No. 25-2-4

"Buy North Dakota Products"

NORTH DAKOTA
STATE HIGHWAY DEPARTMENT

FOUNDATION SOIL

CONSOLIDATION TEST REPORT

ASTM D2435-65T

Date Aug. 13, 1979

Structure No. BN RR Underpass on ND #20 at Devils Lake

Depth of Test Sample 18.2'-20.2'

Location: Ramsey County, BN RR Underpass on ND #20 at Devils Lake, Sta 50+00

Boring 1

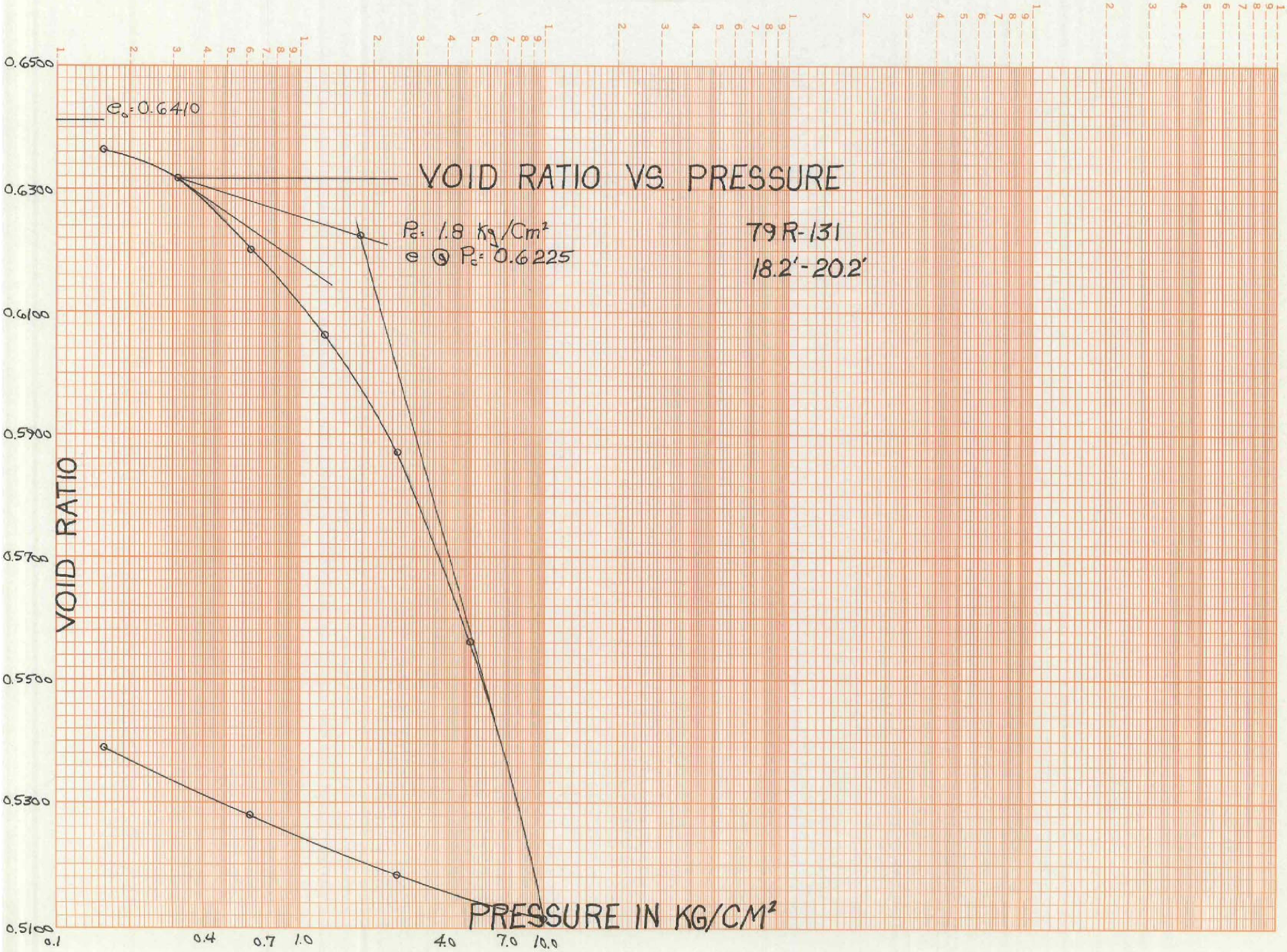
Preconsolidation(Kg/cm^2 = $Tons/ft^2$) = P_c = 1.8

Fitting Method Log Fitting Method

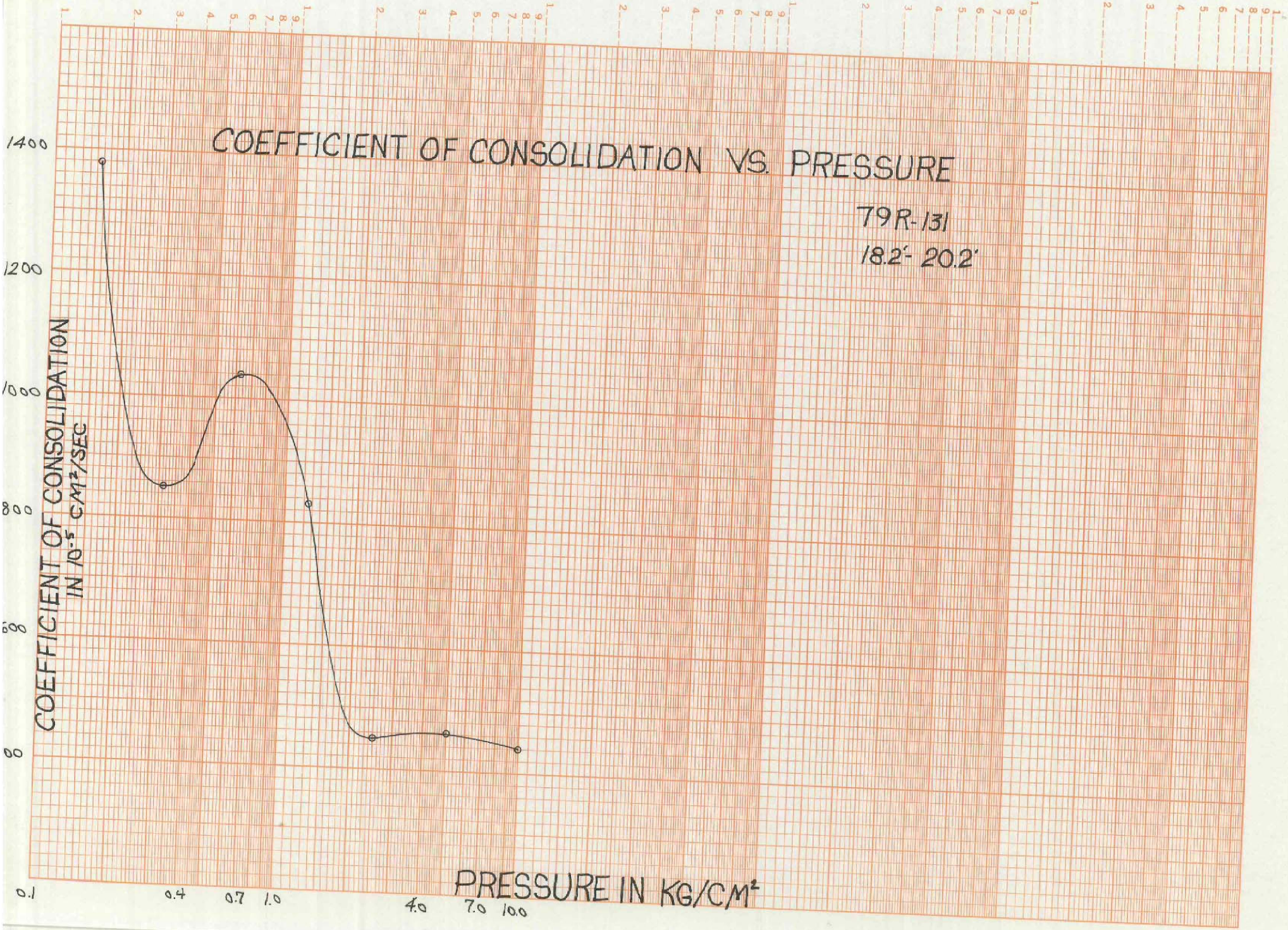
1 Kg/Sq. Cm. = 1.024 T/Sq.Ft.

Applied Pressure (Kg/Sq.Cm.)	Void Ratio	Coef. of Consol. C_v Sq.Cm./Sec.	Compr. Index C_c	Coef. of Permeability K Cm./Sec.
0.0000	0.6410			
0.1579	0.6364	1377.5439×10^{-5}	—	$2445.5537 \times 10^{-10}$
0.3158	0.6319	851.6257×10^{-5}	0.0149	$1483.1913 \times 10^{-10}$
0.6315	0.6204	1040.2257×10^{-5}	0.0382	$2321.1596 \times 10^{-10}$
1.2631	0.6062	830.0622×10^{-5}	0.0472	$1151.8773 \times 10^{-10}$
2.5261	0.5870	455.6968×10^{-5}	0.0638	431.2715×10^{-10}
5.0522	0.5561	462.6060×10^{-5}	0.1026	356.5767×10^{-10}
10.1044	0.5117	440.6546×10^{-5}	0.1475	248.8377×10^{-10}
2.5261	0.5182			
0.6315	0.5279			
0.1579	0.5391			

K+E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 6213



46 6213


COEFFICIENT OF CONSOLIDATION VS. PRESSURE
79R-131
18.2'- 20.2'
COEFFICIENT OF CONSOLIDATION IN 10^{-5} CM²/SEC
1400
1200
1000
800
600
00
PRESSURE IN KG/CM²
0.1
0.4
0.7
1.0
4.0
7.0
10.0

NORTH DAKOTA STATE HIGHWAY DEPARTMENT MATERIALS LABORATORY

Report of Tests on Soil Samples Boring #1

Submitted by R. HARI

Project FB-3-020(102) F-2-279(01)

Date 6-25-72

County RAMSEY

Laboratory Number SX-	1454	1455	1456	1457	1458	1459	1460
Location Station	520+00 CNRR Under RR at 40 # 20 at Devils Lake						
Depth, Ft.	0.0'-2.0'	8.0'-9.0'	9.0'-10.0'	18.0'-20.0'	28.0'-29.0'	29.5'-31.0'	58.0'-60.0'
Distance from Centerline	20' Rt Surv ℄						
Field Sample No. 29R-	129	130	130A	131	132	133	134
% Pass. 3/8" Sieve	100	100	100	99	100	100	100
% Pass. No. 4 Sieve	86	98	97	88	100	100	100
% Pass. No. 10 Sieve	65	91	94	67	100	100	100
% Coarse Sand (-No. 10, + No. 40)	13	14	8	18	51	48	28
% Fine Sand (-No. 40, + No. 200)	24	31	20	15	21	18	29
% Silt (0.074 - 0.005 mm)	19	31	31	25	15	20	30
% Clay (minus 0.005 mm)	8	15	36	14	13	15	14
Lower Liquid Limit	27	41	46	32	56	57	43
Plasticity Index	8	16	20	14	15	13	18
Shrinkage Limit	16	19	20	20	34	35	22
Shrinkage Ratio	1.75	1.69	1.62	1.68	1.28	1.27	1.56
Specific Gravity	2.46	2.47	2.53	2.55	2.27	2.30	2.43
Color	Blk. Brn.	Brown	Brown	Brown	Grey	Grey	Grey
Textural Class	Sndy Lm.	Sndy Lm.	Clay	Sndy Lm.	Sndy Lm.	Sndy Lm.	Sndy Lm.
Soil Class. (AASHO M-145)	A-2-4(0)	A-7-6(4)	A-7-6(11)	A-6 (2)	A-2-7(4)	A-2-7(4)	A-2-6(4)
Soil Number							
Moist., Field Nat. %							
Optimum Moisture *							
Maximum Dry Density *							
~~Pr. of Soil~~ Compact	1	5	5	7	9	10	13
C.B.R. at 90% Compaction							

* By AASHO Test Method No. T

Distribution:

1 Matls. Engr.

3 Soils Engr.

____ Laboratory

____ C. E. Rice

Testing Engineer

Date 7-3-72

Form 25-3-21

New Form 25-2-6
Old Form 689

Part 1 of 2

NORTH DAKOTA STATE HIGHWAY DEPARTMENT
SITE SOIL SURVEY
(AASHTO T203-64)

Project FG-3-020( )102 Structure No. _____

County RAMSEY Boring No. 2

Location BN RR UNDERPASS ON ND 20 AT DEVILS LAKE Station 50 + 46 Offset 35' LT. OF SUR. ℄

Date Drilling Started JUNE 11, 1979 Date Finished JUNE 12, 1979

Final Water Level 24.6' Average Seepage Rate (Ft. Rise/Min) 0.31
(Between the depths of 25.0' & 26.5')

(AASHTO T86-70)

1. Depth 1" = 5'	2. Elev.	3. Profile	4. Core No.	5. Classification	6. Color of Material	7. Characteristics	8. AASHTO-M145-66 Soil Group	9. Remarks
0.0' 5 9.5'	1459.1 1449.6		C1 79R-123 Jar 1; C2 Jar 2; C3 Jar 3; C4 Jar 4; C5 Shelby	Clay Loam	Blk. Brn. (Varigated)	Mixed Fill & Topsoil - Contains Ballast & Interbeddings of Sandy Loam - Pliable to Gritty - Soft -	A2-6 & A6	C_r: 175%; C_r: 143% n_o: 27% n_e: 30% e_o: 0.378 e_e: 0.423 S: 94%
10 15 18.0'	1441.1		79R-124 C6 Jar 5	Sandy Loam	Brn.	Varved & Lenticular - Silty - Numerous Clay Varves - Loose -	A2-4	C_r: 57% n_o: 39% n_e: 40% e_o: 0.640 e_e: 0.652 S: 95%
20 25 27.5'	1431.6		C7 Shelby 79R-125 C8 Jar 6	Loam	Brn.	Lenticular - Contains Sand Lenses - Cohesive - Ferruginous - Disseminated Cobble Stones - Low Permeability - Hard -	A6	C_r: 99% n_o: 35% n_e: 34% e_o: 0.529 e_e: 0.523 S: 100%
30 35			C9 Shelby 79R-126 C10 79R-126 Jar 7					C_r: 167% n_o: 40% n_e: 42% e_o: 0.656 e_e: 0.713 S: 100%

40		C11 / Jar 8	Loam (Shale)	Dk. Gry.	Platy & Laminated– Brittle– Silty– Some Saturated Laminae– Very Tight– Very Hard–	A2-7 A6 A7-5	Pierre Shale Bedrock.
45							
		C12 / Jar 9					
50							
55							
		C13 / 79 R-128 / Jar 10					C_r = 119%
60.0'	1399.1						

C_r: Consistency Index
n_a: Porosity at beginning of shear test
n_e: " " end " " "
e_a: Void Ratio at beginning of shear test
e_e: " " " end " " "
S: Degree of saturation

Boring No. 2

D/I RR Underpass at Dennis Lane

Structure No.

STANDARD PENETRATION TEST

(Wt. of Ham'r. = 140 lbs. - Ht. of Drop = 30")

* AASHTO T206-74

** AASHTO T207-75

Core No.	Depth	% Recovery	% Moisture	* S.P.T. 1st 0.5'	2nd 0.5'	Total	* S.P.T. Drive
1	0.0' - 2.0'	100	16	2	2	4	1.0'
2	2.0' - 4.0'	85	17	2	3	5	1.0'
3	4.0' - 6.0'	100	22	2	3	5	1.0'
4	6.0' - 8.0'	100	21	2	3	5	1.0'
3" Shelby 5	8.0' - 10.0'	75	14/24	—	—	—	—
6	10.0' - 12.0'	100	22	3	5	8	1.0'
3" Shelby 7	18.0' - 20.0'	100	22	—	—	—	—
8	20.0' - 22.0'	100	22	20	25	45	1.0'
3" Shelby 9	28.0' - 29.0'	60	30	—	—	—	—
10	29.0' - 31.0'	80	26	40	60	100	1.0'
11	38.0' - 40.0'	100	29	50	67	117	1.0'
12	48.0' - 50.0'	85	23	60	65	125	1.0'
13	58.0' - 60.0'	100	16	65	70	135	1.0'

CASING DRIVE LOG

(Wt. of Ham'r. = _____ lbs. - Ht. of Drop = 30")

Ft. of Casing or Hollow Stem Auger	No. of Drops/Ft.
58.0'	H

Note: S = Skin friction on outside wall of casing only.
T = Total Resistance - skin friction plus resistance on drive shoe.
H = Hollow Stem Auger

Form 25-2-15 Rev. 12-14-77

Boring No. 2

BN RR Underpass
at Devils Lake
Structure No.

WATER SEEPAGE DATA

Depth of Test Hole =	22.0'	40.0'	60.0'
~~(Column of casing in place =~~			~~)~~
Column of H. Stem Auger in Place =	18.0'	38.0'	58.0'
Depth to water after bailing =	Hole was Dry	32.0'	31.6'
" " " at 1 minute =		31.4'	30.8'
" " " " 5 " =		30.3'	29.1'
" " " " 15 " =		28.8'	27.9'
" " " " 30 " =		28.2'	26.5'
Avg. Seepage Rate (Ft/min rise) =		0.31	0.43

(~~Casing~~ H. Stem Extracted)

Depth to water after bailing = 26.5'

" " " at 1 minute = 25.7'

" " " " 5 " = 25.1'

" " " " ~~30~~ 15 " = 25.0'

" " " " ~~60~~ 30' " = 25.0'

Final water level after 12 hrs. = 24.6'

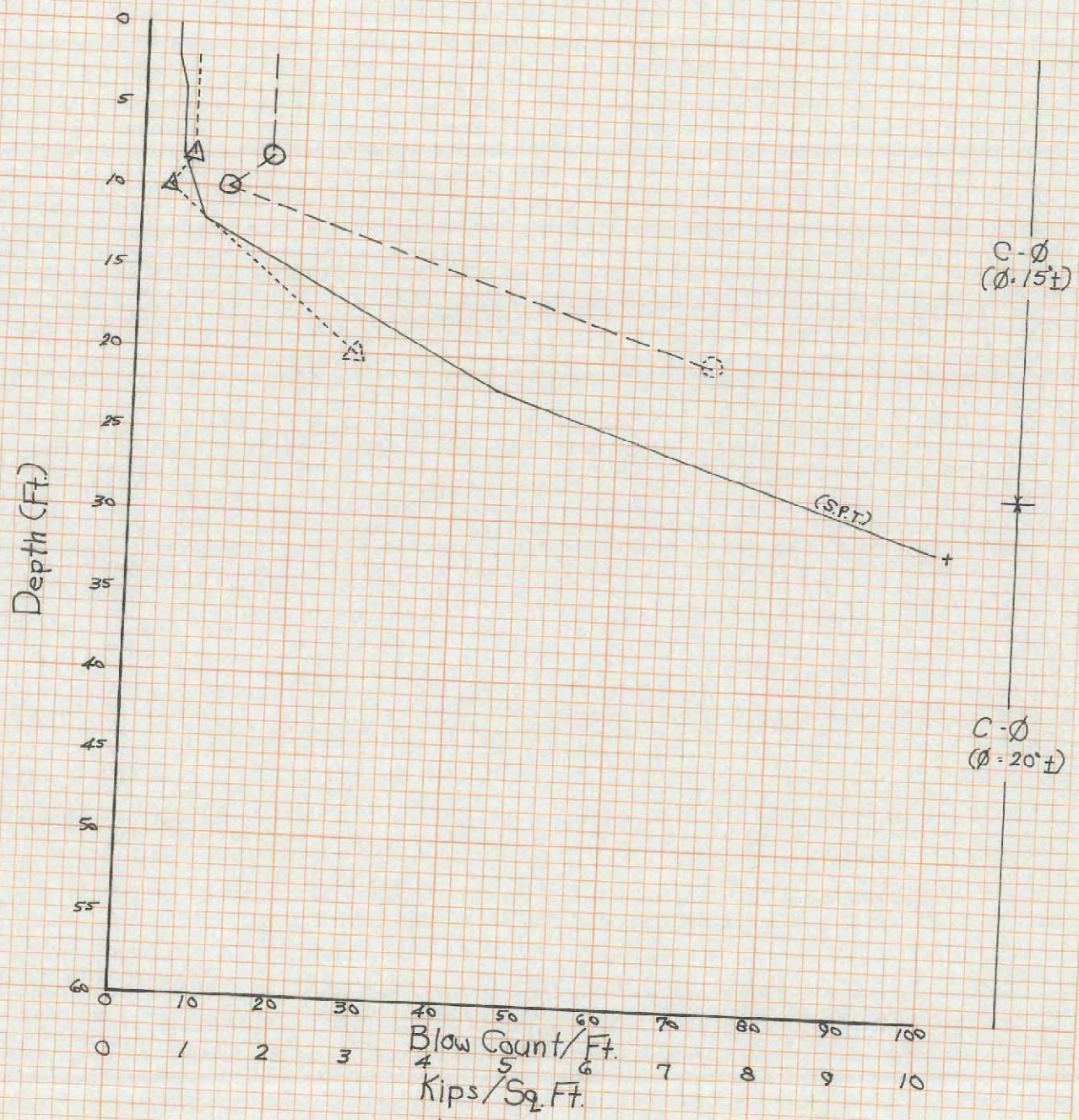
Avg. Seepage Rate = 0.31 ft/min.

Daily Water Level Record

Date	Ft. of ~~Casing~~ H. Stem	Depth to Water	Hole Depth
6-12-79	18.0'	Hole was dry	22.0'
6-13-79	Extracted	24.6'	60.0'

Form 679

SOIL STRENGTH



Legend

Standard Penetration Test (S.P.T.) ————————

Unconfined Compr. Strength (q_u) — — — — — —

Cohesion (C) -

⊙ = q_u from test

△ = C from q_u test

◌ = q_u from triaxial test

△ = C from triaxial test

Ø = Frictional &/or Angle of Internal Friction

C-Ø = Cohesive - Frictional

C = Cohesive &/or Cohesion

B#2

UNIT WEIGHT

Legend

Dry Wt. (γ_d) ————————

Wet Wt. (γ_w) — — — — — —

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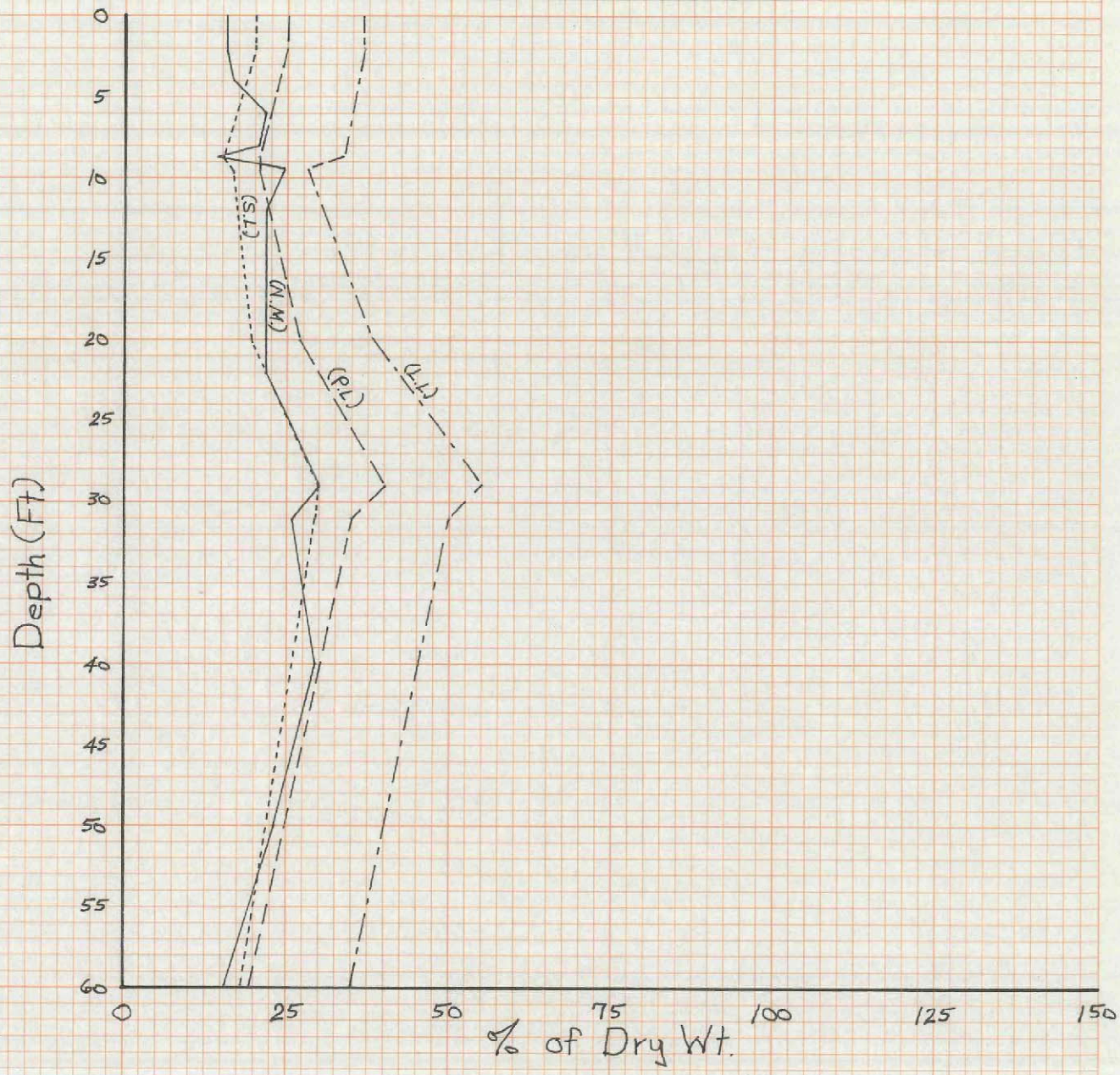
K+E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

B#2

NATURAL MOISTURE & ATTERBERG LIMITS



Legend

Natural Moisture (N.M.) ————

Shrinkage Limit (S.L.) - - - - - - - - - - - -

Plastic Limit (P.L.) — — — — — — — —

Liquid Limit (L.L.) — · — · — · — · —

46 0703
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NORTH DAKOTA
STATE HIGHWAY DEPARTMENT

FOUNDATION SOIL SHEAR TEST REPORT

Date 8-10-79

AASHTO T208-70: Unconfined Test

Structure No.

AASHTO T234-74: Triaxial Test

Location: Ramsey County, BN RR Underpass on ND 20 at Devils Lake, Station 50+46, 35' Lt. of Survey E.

Boring No. 2

Sample No. 79R-	124	124A	125	126
Depth Sample Taken	8.0' - 8.7'	8.7' - 9.5'	18.0' - 20.0'	28.0' - 29.0'
Type of Sample	3" Shelby	3" Shelby	3" Shelby	3" Shelby
Type of Test	Unconfined	Unconfined	Triaxial	Unconfined
Maximum Load (Lbs./sq. ft.)	1602	1100	-----	-----
Typical Angle of Internal Friction	Near 15°	Near 20°	Near 15°	-----
Cohesion (Lbs./sq. ft.)	615	385	2736	-----
Nat. Field Moisture	14%	24%	22%	30%
Unit Weight Dry (Lbs./cu. ft.)	114	95	104	87
Sensitivity Factor				

*Disturbed **Unconfined Compressive Strength

Form 680
Rev. 10-1-66
New Form No. 25-2-4

"Buy North Dakota Products"

NORTH DAKOTA STATE HIGHWAY DEPARTMENT MATERIALS LABORATORY

Report of Tests on Soil Samples

Boring #2

Submitted by R. KASY

Project FE-3-0201(02) F-0-074(01)

Date 6-25-79

County RAMSEY

Laboratory Number	1447	1448	1449	1450	1451	1452	1453
Location Station	50+46 BWRR under + pass on 40 @ 20 ft Devils Lake						
Depth, Ft	20'-20'	20'-27'	27'-29'	18.0'-20.0'	28.0'-29.0'	30.0'-31.0'	50.0'-60.0'
Distance from Centerline	15' Lt Surf. Ex						
Field Sample No. 79R-	123	124	124A	125	126	127	128
% Pass. 3/8" Sieve	100	100	100	100	100	100	100
% Pass. No. 4 Sieve	96	97	99	94	91	87	96
% Pass. No. 10 Sieve	67	85	70	82	72	83	77
% Coarse Sand (-No. 10, + No. 40)	14	10	21	12	23	12	6
% Fine Sand (-No. 40, + No. 200)	19	18	44	18	12	5	19
% Silt (0.074 - 0.005 mm)	30	34	18	33	21	8	37
% Clay (minus 0.005 mm)	14	23	8	19	15	4	16
Lower Liquid Limit	37	37	28	38	35	30	35
Plasticity Index	12	16	7	16	15	15	16
Shrinkage Limit	20	15	17	19	30	23	18
Shrinkage Ratio	1.60	1.82	1.78	1.73	1.36	1.39	1.77
Specific Gravity	2.36	2.51	2.52	2.54	2.30	2.34	2.56
Color	Blk. Brn.	Brown	Black	Brown	Gray	Gray	Gray
Textural Class	Sndy. Lm.	Gl. Lm.	Sndy. Lm.	Lo. Clay	Sndy. Lm.	Sand + Gravel	Lo. Clay
Soil Class. (AASHO M-145)	A-2-6(0)	A-6 (6)	A-2-4(0)	A-6 (5)	A-7-5 (2)	A-2-7 (0)	A-6 (5)
Soil Number							
Moist., Field Nat. %							
Optimum Moisture *							
Maximum Dry Density *							
~~Pk of Soil~~ Approx. ~~27~~	1	5	5	7	9	10	13
C.B.R. at 90% Compaction							

* By AASHO Test Method No. T

Distribution:

1 Matls. Engr.

3 Soils Engr.

___ Laboratory

___ C. E. Rice

Testing Engineer

Date 6-29-79

Form 25-3-21

New Form 25-2-6
Old Form 689

Part 1 of 2

NORTH DAKOTA STATE HIGHWAY DEPARTMENT
SITE SOIL SURVEY
(AASHTO T203-64)

Project FG-3-020( )102 Structure No. _____

County RAMSEY Boring No. 3

Location BN RR UNDERPASS ON ND 20 AT DEVILS LAKE Station 51+37 Offset 35' LT. OF SUR. ℄

Date Drilling Started JUNE 13, 1979 Date Finished JUNE 14, 1979

Final Water Level Boring plugged above water level Average Seepage Rate (Ft. Rise/Min) —

(AASHTO T86-70)

1. 0.0' Depth 1" = 5'	2. 1459.9 Elev.	3. Profile	4. Core No.	5. Classification	6. Color of Material	7. Characteristics	8. AASHTO-M 145-66 Soil Group	9. Remarks
4.2'	1455.7		C1 79R-135 Jar 1; C2 Jar 2	Sandy Loam	Blk.	Mixed Fill - Topsoil & Ballast - Friable - Loose -	A2-4	C_r: 214%
10.2'	1449.7		C3 79R-136 Jar 3; C4 Jar 4; C5 Shelby Lost Sample	Sandy Loam	Brn.	Mixed Fill & Topsoil - Some Interbeddings of Clay - Loose -	A2-4	C_r: 138.3%
30.3'	1429.6		C6 Jar 5; C7 Shelby 79R-137; C8 Jar 6; C9 Shelby Crimped; C10 Jar 7	Clay Loam	Brn.	Lenticular - Pliable - Silty - Occasional Sand Lenses & Occasional Ferruginous Zones - Disseminated Pebbles - Pliable - Medium Stiff -	A6	C_r: 96%; n_o: 36%; n_e: 36%; e_o: 0.560; e_c: 0.574; S: 100%

40		C11 79R-138 Jar 8					C_r: 117 %
45			Loam (Shale)	Dk. Gry.	Platy-Laminated-Silty-Cohesive-Impervious-Tight & Very Hard-	A7-5	Pierre Shale Bedrock.
50		C12 Jar 9					
55							
60.2' 60	1399.7	C13 79R-139 Jar 10					C_r: 117 %

C_r: Consistency Index
n_o: Porosity at beginning of shear test
n_e: " " end " " "
e_o: Void Ratio at beginning of shear test
e_e: " " " end " " "
S: Degree of saturation

Boring No. 3

Devils Lake
Structure No.

STANDARD PENETRATION TEST

(Wt. of Ham'r. = 140 lbs. - Ht. of Drop = 30")

* AASHTO T206-74

** AASHTO T207-75

Core No.	Depth	% Recovery	% Moisture	* S.P.T. 1st 0.5'	2nd 0.5'	Total	* S.P.T. Drive
1	0.0' - 2.0'	80	13	2	3	5	1.0'
2	2.0' - 4.0'	100	12	3	3	6	1.0'
3	4.0' - 6.0'	70	16	3	3	6	1.0'
4	6.0' - 8.0'	80	16	3	3	6	1.0'
Shelby (Last) 5	8.2' - 10.2'			—	—	—	—
6	10.2' - 12.2'	45	22	3	3	6	1.0'
3" Shelby 7	18.2' - 20.2'	100	23	—	—	—	—
8	20.2' - 22.2'	100	20	4	5	9	1.0'
Shelby (Crimped) 9	28.2' - 28.9'			—	—	—	—
10	28.9' - 30.9'	60	32	40	43	83	1.0'
11	38.2' - 40.2'	100	30	45	50	95	1.0'
12	48.2' - 50.2'	85	29	50	55	105	1.0'
13	58.2' - 60.2'	90	31	52	60	112	1.0'

CASING DRIVE LOG

(Wt. of Ham'r. = _____ lbs. - Ht. of Drop = 30")

Ft. of Casing or Hollow Stem Auger	No. of Drops/Ft.
58.2'	H

Note: S = Skin friction on outside wall of casing only.
T = Total Resistance - skin friction plus resistance on drive shoe.
H = Hollow Stem Auger

Form 25-2-15 Rev. 12-14-77

BN RR Underpass
at Devils Lake

Boring No. 3

Structure No.

WATER SEEPAGE DATA

Depth of Test Hole =	22.2'	40.2'
~~(Column of casing in place = ____)~~		
Column of H. Stem Auger in Place =	18.2'	38.2'
Depth to water after bailing =	Hole was Dry	26.1'
" " " at 1 minute =		25.3'
" " " " 5 " =		24.5'
" " " " 15 " =		23.1'
" " " " 30 " =		21.8'
Avg. Seepage Rate (Ft./min rise):		0.37

(~~Casing~~ H. Stem Extracted)

Depth to water after bailing =	Boring plugged above Water level
" " " at 1 minute =	
" " " " 5 " =	
" " " " 30 " =	
" " " " 60 " =	

Final water level after 12 hrs. =

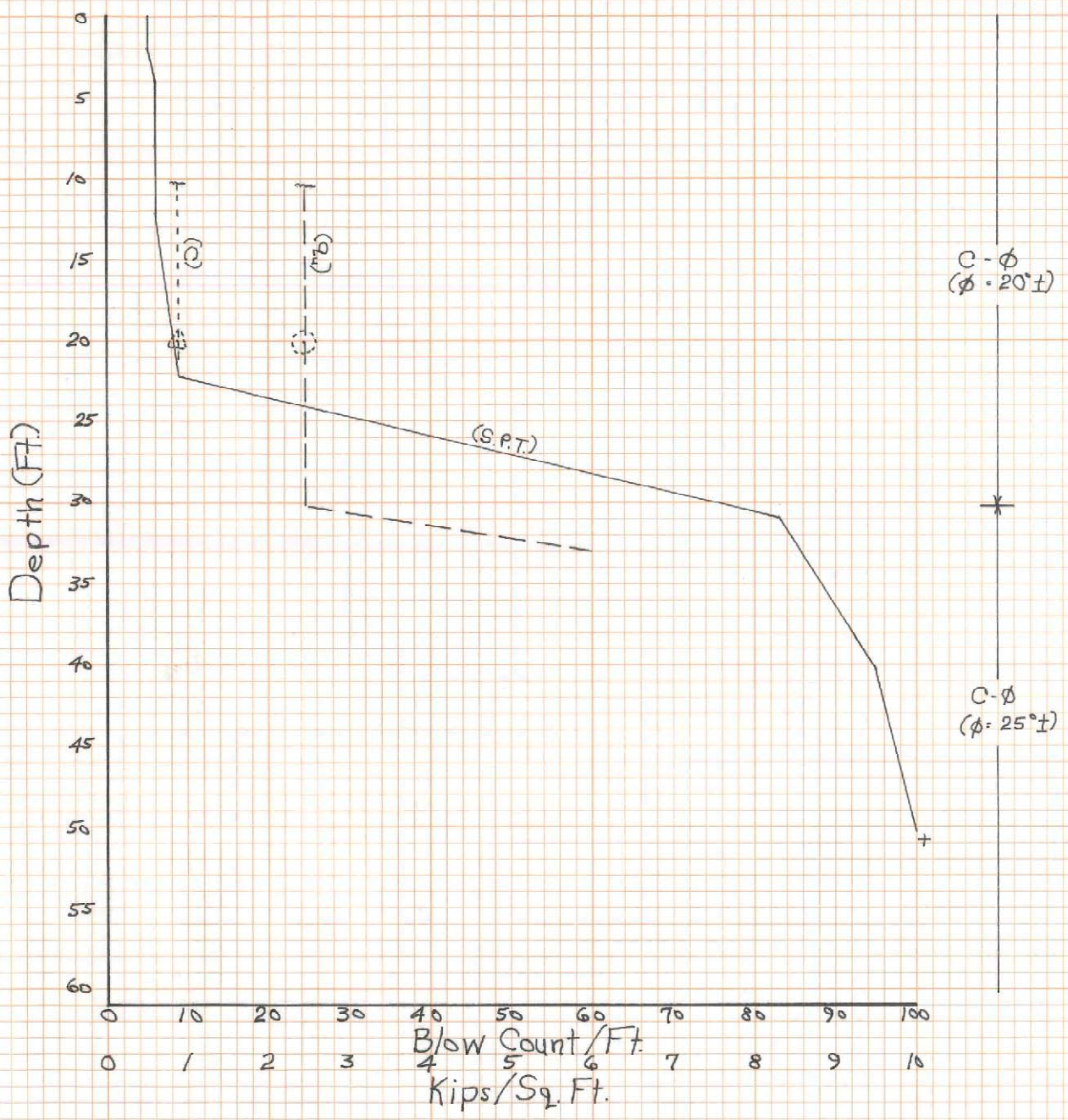
Daily Water Level Record

Date	Ft. of ~~Casing~~ H. Stem	Depth to Water	Hole Depth
6-14-79	18.2'	Hole was dry	22.2'

Form 679

B#3

SOIL STRENGTH



Legend

Standard Penetration Test (S.P.T.) ————

Unconfined Compr. Strength (q_u) – – – – – –

Cohesion (C) - - - - - - - - - - - - - - - -

⊙: q_u from test

△: C from q_u test

⊙: q_u from triaxial test

△: C from triaxial test

Ø: Frictional &/or Angle of Internal Friction

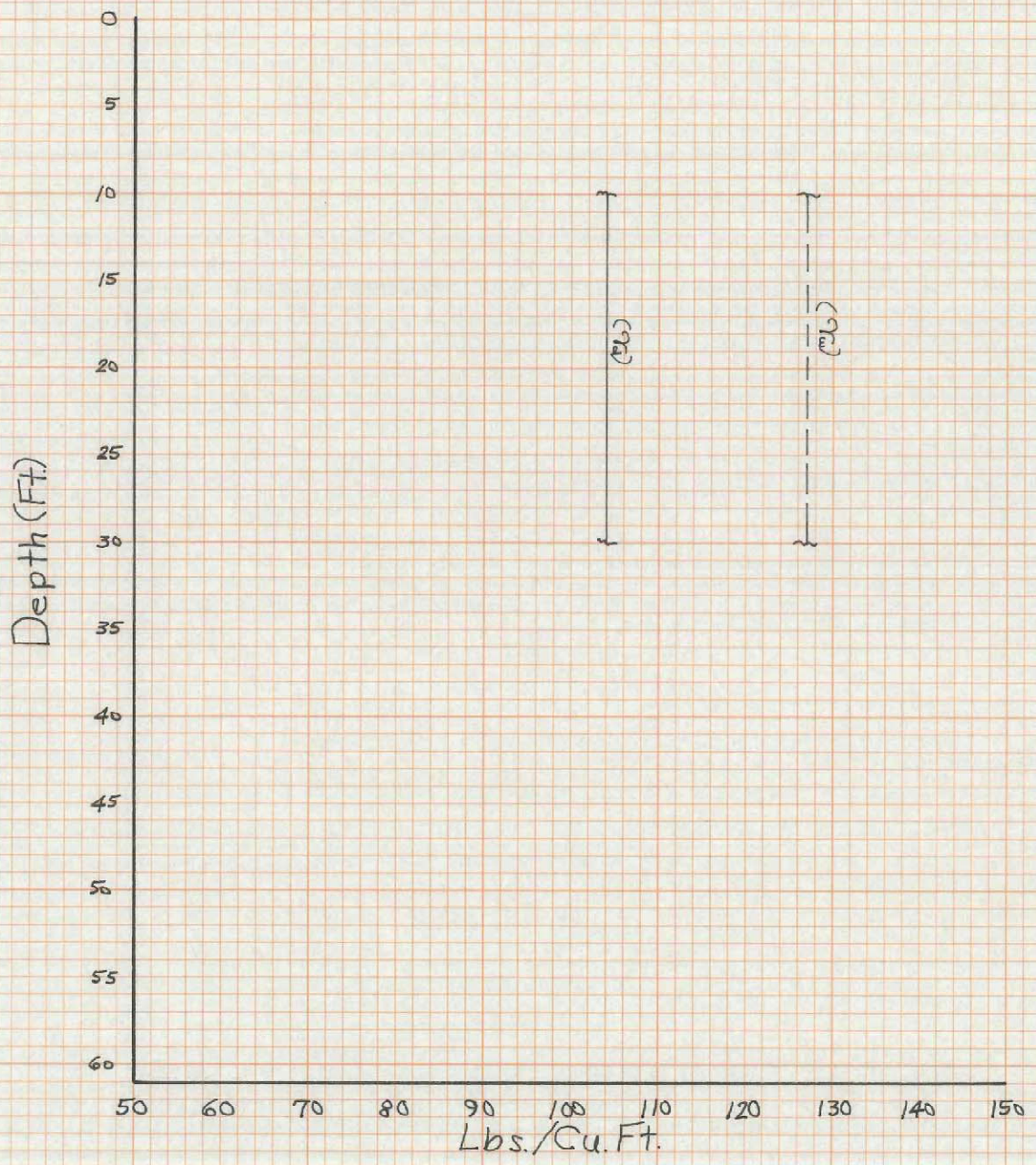
C-Ø: Cohesive - Frictional

C: Cohesive &/or Cohesion

46 0703
K+E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

B# 3

UNIT WEIGHT



Legend

Dry Wt. (γ_d) ————————

Wet Wt. (γ_w) - - - - - - - - -

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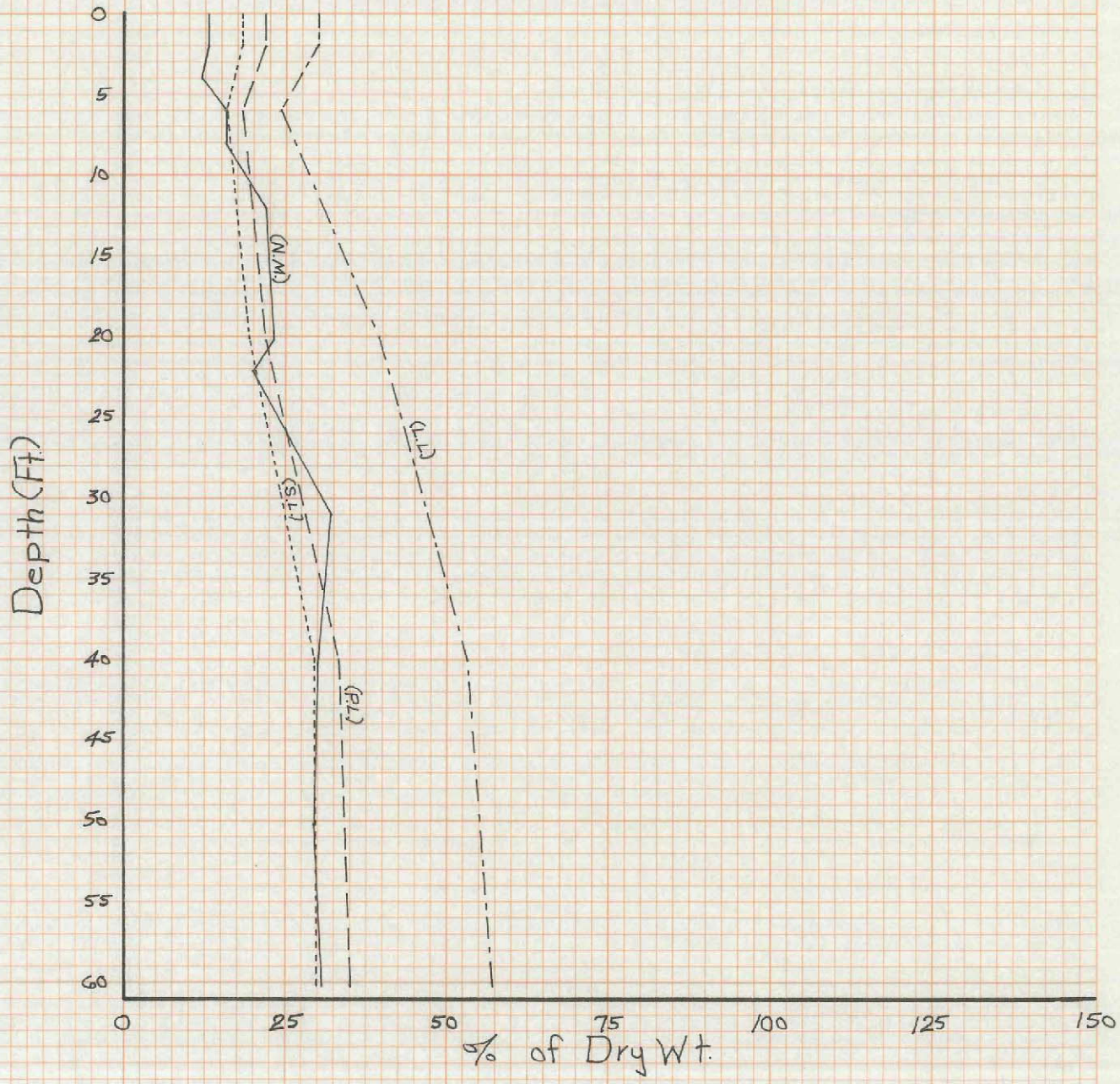
B# 3

NATURAL MOISTURE & ATTERBERG LIMITS



Legend

Natural Moisture (N.M.) ————

Shrinkage Limit (S.L.) · · · · · · · · · ·

Plastic Limit (P.L.) — — — — — — —

Liquid Limit (L.L.) — · — · — · — · —

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NORTH DAKOTA
STATE HIGHWAY DEPARTMENT

FOUNDATION SOIL SHEAR TEST REPORT

Date August 13, 1979

Structure No.

AASHTO T234-70: Triaxial Test

Location: Ramsey County, BN RR Underpass on ND #20 at Devils Lake, Sta. 51+37
Offset: 35' Left of Survey ℄

Boring No. 3

Sample No. 79R-	137
Depth Sample Taken	18.2'-20.2'
Type of Sample	3" Shelby
Type of Test	Triaxial
Maximum Load (Lbs./sq. ft.)	
Typical Angle of Internal Friction	20°
Cohesion (Lbs./sq. ft.)	864
Nat. Field Moisture	23%
Unit Weight Dry (Lbs./cu. ft.)	104
Sensitivity Factor	

*Disturbed

Form 680
Rev. 10-1-66
New Form No. 25-2-4

"Buy North Dakota Products"

NORTH DAKOTA
STATE HIGHWAY DEPARTMENT

FOUNDATION SOIL

CONSOLIDATION TEST REPORT

ASTM D2435-65T

Date Aug. 13, 1979

Structure No. BN RR Underpass at Devils Lake

Depth of Test Sample 18.2'-20.2'

Location: Ramsey County, BN RR Underpass on ND #20 at Devils Lake, Sta. 51+37
Offset: 35' Left of Sur. ℄

Boring 3

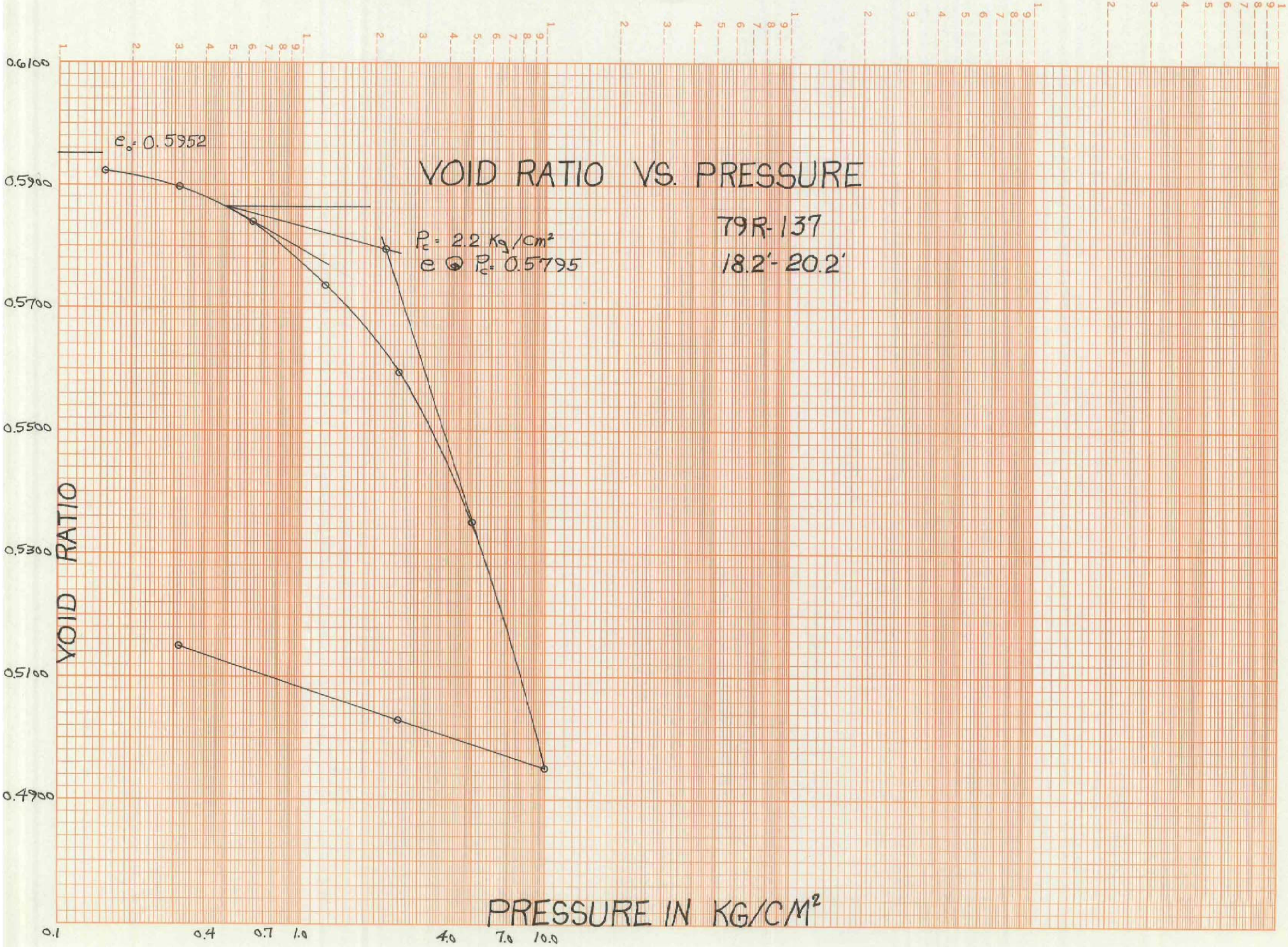
Preconsolidation(Kg/cm^2 = $Tons/ft^2$) = P_c = 2.2

Fitting Method Log Fitting Method

1 Kg/Sq. Cm. = 1.024 T/Sq.Ft.

Applied Pressure (Kg/Sq.Cm.)	Void Ratio	Coef. of Consol. C_v Sq.Cm./Sec.	Compr. Index C_c	Coef. of Permeability K Cm./Sec.
0.0000	0.5952			
0.1579	0.5924	1762.1650×10^{-5}	—	$1958.8226 \times 10^{-10}$
0.3158	0.5897	1090.1572×10^{-5}	0.0090	$1170.6108 \times 10^{-10}$
0.6315	0.5840	1048.1713×10^{-5}	0.0189	$1190.0937 \times 10^{-10}$
1.2631	0.5738	707.4091×10^{-5}	0.0339	721.3451×10^{-10}
2.5261	0.5593	988.4952×10^{-5}	0.0482	321.0084×10^{-10}
5.0522	0.5350	610.0165×10^{-5}	0.0807	376.3192×10^{-10}
10.1044	0.4947	477.6265×10^{-5}	0.1339	248.2225×10^{-10}
2.5261	0.5028			
0.3158	0.5148			

K+E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 6213



K+E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
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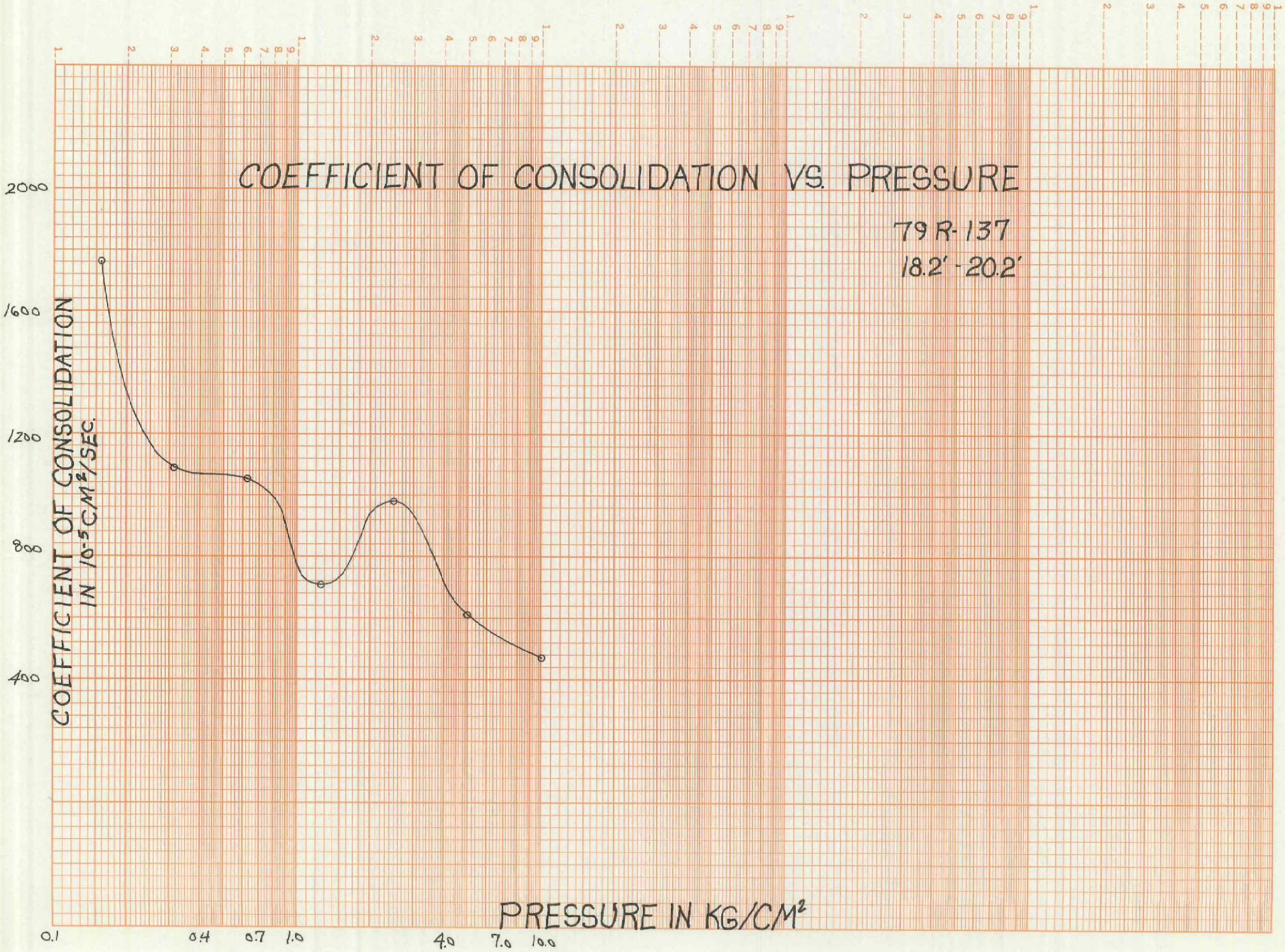
46 6213



NORTH DAKOTA STATE HIGHWAY DEPARTMENT MATERIALS LABORATORY

Report of Tests on Soil Samples

Boring #3

Submitted by R. KARY

Project FG-3-020()102 F-0-079(01)

Date 6-25-79

County RAMSEY

Laboratory Number	SS-	1461	1462	1463	1464	1465		
Location Station		51+37 BNRR UNDERPASS ON ND#20 AT DEVILS LAKE						
Depth, Ft.		0.0'-2.0'	4.2'-6.0'	18.2'-20.2'	38.2'-40.2'	58.2'-60.2'		
Distance from Centerline		35' LT SURF						
Field Sample No.	79R-	135	136	137	138	139		
% Pass. 3/8" Sieve		100	100	100	100	100		
% Pass. No. 4 Sieve		89	98	94	100	100		
% Pass. No. 10 Sieve		74	92	75	100	100		
% Coarse Sand (-No. 10, + No. 40)		24	16	9	32	38		
% Fine Sand (-No. 40, + No. 200)		21	41	15	24	15		
% Silt (0.074 - 0.005 mm)		17	22	30	29	30		
% Clay (minus 0.005 mm)		12	13	20	15	17		
Lower Liquid Limit		30	24	39	53	57		
Plasticity Index		8 22	6 18	17 22	20 33	22 35		
Shrinkage Limit		18	16	19	29	30		
Shrinkage Ratio		1.73	1.81	1.75	1.39	1.36		
Specific Gravity		2.54	2.53	2.59	2.34	2.32		
Color		BLACK	BROWN	BROWN	GRAY	GRAY		
Textural Class		Sndy. Lm.	Sndy. Lm.	Cl. Lm.	Sndy. Lm.	Sndy. Lm.		
Soil Class. (AASHO M-145)		A-2-4(0)	A-2-4(0)	A-6 (6)	A-7-5 (6)	A-7-5 (7)		
Soil Number								
Moist., Field Nat. %								
Optimum Moisture *								
Maximum Dry Density *								
Prof Soil CORE #		1	3	7	11	13		
C.B.R. at 90% Compaction								

* By AASHO Test Method No. T

Distribution:

1 Matls. Engr.

3 Soils Engr.

____ Laboratory

____ C. E. Rice

E.J. Murphy

Testing Engineer

Date 7-2-79

Form 25-3-21

New Form 25-2-6
Old Form 689

Part 1 of 2

NORTH DAKOTA STATE HIGHWAY DEPARTMENT
SITE SOIL SURVEY
(AASHTO T203-64)

Project FG-3-020( )102 Structure No. _____

County RAMSEY Boring No. 4

Location BN RR UNDERPASS ON ND 20 AT DEVILS LAKE Station 48+60 Offset 43' RT. OF SUR. ℄

Date Drilling Started OCT. 2, 1979 Date Finished OCTOBER 2, 1979

Final Water Level ——— Average Seepage Rate (Ft. Rise/Min) ———

(AASHTO T86-70)

1. 0.0' Depth 1" = 5'	2. 1449.6 Elev.	3. Profile	4. Core No.	5. Classification	6. Color of Material	7. Characteristics	8. AASHTO M 145-66 Soil Group	9. Remarks
0.4'	1449.2		C1	Concrete sidewalk.				
2.5'	1447.1		C2 Jar 1	Clay Loam	Gry. Brn	Amorphous-Pliable-Medium stiff-	A7-6	
5			C3 79R-261 Jar 2	Clay Loam	Brn. Gry. (Varigated)	Amorphous-Silty-Pliable-Very stiff-	A7-6	C_r = 105 %
6.7'	1442.9		C4 Jar 3					
10			C5 Shelby Crimped					
			C6 Jar 4	Clay Loam	Brn.	Lenticular-Occasional Gravel & Sand Lenses-Hard-	A6	
15								
17.8'	1431.8		C7 Shelby Crimped					
20			C8 79R-262 Jar 5					C_r = 148 %
25						Platy-Laminated-Silty-Impervious-Very Hard-		
			C9 Jar 6	Clay Loam (Shale)	Dk. Gry.		A7-5	
30								
35								

40.0'/10 Plus	1409.6		C10 / 79R-263 / Jar 7					— C_r = 123%
			C_r =	Consistency	Index			

Boring No. 4

BN RR Underpass @ Devils [illegible]

Structure No.

STANDARD PENETRATION TEST

(Wt. of Ham'r. = 140 lbs. - Ht. of Drop = 30")

* AASHTO T206-74

** AASHTO T207-75

Core No.	Depth	% Recovery	% Moisture	* S.P.T. 1st 0.5'	2nd 0.5'	Total	* S.P.T. Drive
1	0.4' - 2.0'			7	8	15	1.0'
2	2.0' - 4.0'	75	19	12	15	27	1.0'
3	4.0' - 6.0'	80	21	10	15	25	1.0'
4	6.0' - 8.0'	65	23	15	15	30	1.0'
Shelby (Crimped) 5	8.5' - 10.5'						
6	10.5' - 12.5'	55	20	30	45	75	1.0'
Shelby (Crimped) 7	17.5' - 18.2'						
8	18.2' - 20.2'	100	32	30	35	65	1.0'
9	27.5' - 29.5'	100	28	45	55	100	1.0'
10	37.5' - 40.0'	72	32	50	52	102	1.0'

CASING DRIVE LOG

(Wt. of Ham'r. = _____ lbs. - Ht. of Drop = 30")

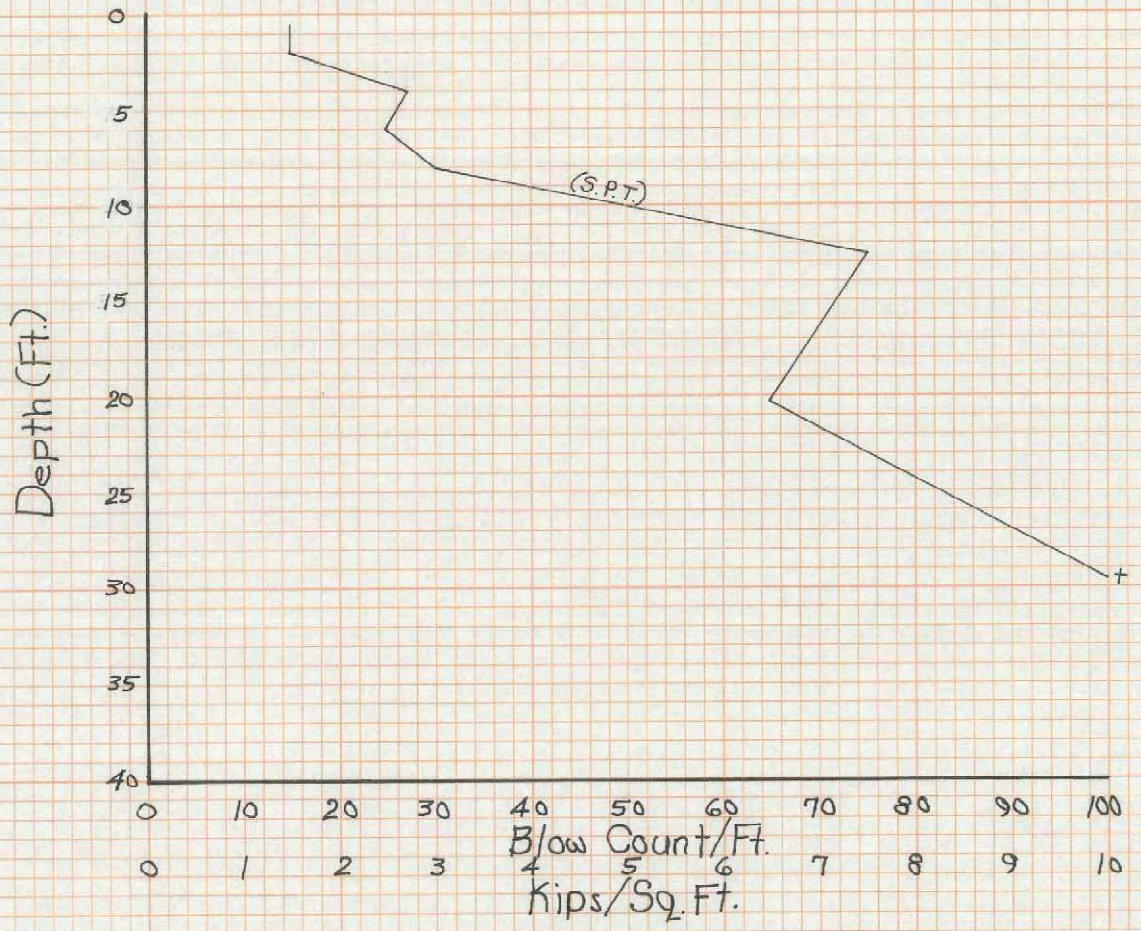
Ft. of Casing or Hollow Stem Auger	No. of Drops/Ft.
37.5'	H

Note: S = Skin friction on outside wall of casing only.
T = Total Resistance - skin friction plus resistance on drive shoe.
H = Hollow Stem Auger

Form 25-2-15 Rev. 12-14-77

B#4

SOIL STRENGTH



Legend

Standard Penetration Test (S.P.T.) ————

Ø = Frictional &/or Angle of Internal Friction

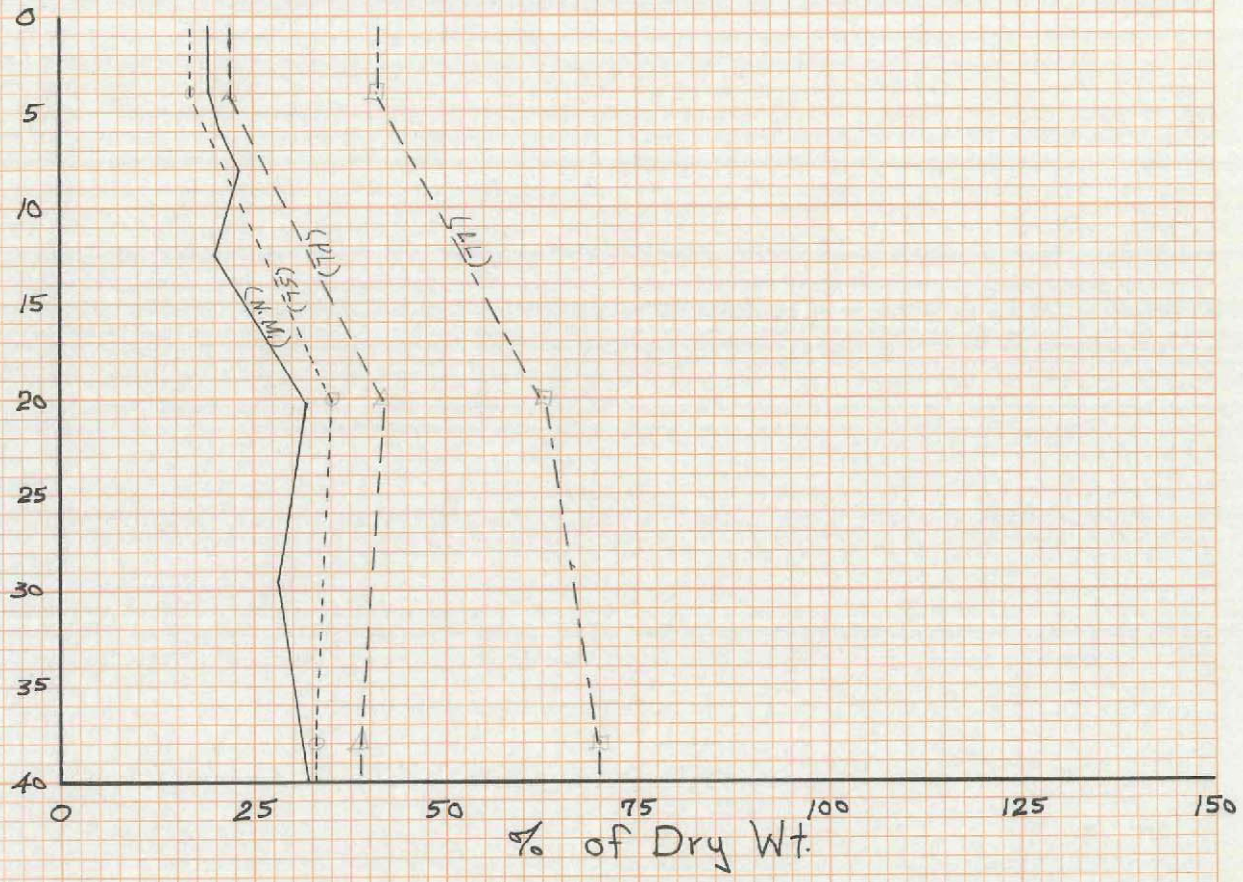
C = Cohesive &/or Cohesion

C-Ø = Cohesive - Frictional

46 0703
K&E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

B#4

NATURAL MOISTURE & ATTERBERG LIMITS



Legend

Natural Moisture (N.M.) ————

Shrinkage Limit (S.L.) - - - - - - - - - - -

Plastic Limit (P.L.) — — — — — — —

Liquid Limit (L.L.) — · — · — · — · —

46 0703
K&E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

NORTH DAKOTA STATE HIGHWAY DEPARTMENT MATERIALS LABORATORY

Report of Tests on Soil Samples

Boring #4

Submitted by R. Kary

Date 10-17-79

Project FG-3-020()102 F-0-079(01)

County Ramsey

Laboratory Number	SS-	1887	1888	1889
Location Station		48+60 B.N. Underpass on Hwy. #20 at Devils Lake		
Depth, Ft.		4.0'-6.0'	18.2'-20.2'	37.5'-40.0'
Distance from Centerline		43' RT ℄		
Field Sample No.	79R-	261	262	263
% Pass. 3/8" Sieve		100	100	100
% Pass. No. 4 Sieve		98	100	100
% Pass. No. 10 Sieve		85	100	100
% Coarse Sand (-No. 10, + No. 40)		10	27	25
% Fine Sand (-No. 40, + No. 200)		17	17	14
% Silt (0.074 - 0.005 mm)		33	33	35
% Clay (minus 0.005 mm)		26	24	26
Lower Liquid Limit		41	63	70
Plasticity Index		19	21	31
Shrinkage Limit		17	35	33
Shrinkage Ratio		1.79	1.27	1.32
Specific Gravity		2.57	2.27	2.35
Color		Brown	Gray	Gray
Textural Class		Cl. Lm.	Cl. Lm.	Cl. Lm.
Soil Class. (AASHO M-145)		A-7-6 (9)	A-7-5 (11)	A-7-5 (16)
Soil Number				
Moist., Field Nat. %				
Optimum Moisture *				
Maximum Dry Density *				
~~Pb. of Soil~~ Core #		3	8	10
C.B.R. at 90% Compaction				

* By AASHO Test Method No. T

Distribution:

1 Matls. Engr.

3 Soils Engr.

____ Laboratory

____ C. E. Rice

E. J. Murphy

Testing Engineer

Date 10-22-79

Form 25-3-21

New Form 25-2-6
Old Form 689

Part 1 of 2

NORTH DAKOTA STATE HIGHWAY DEPARTMENT
SITE SOIL SURVEY
(AASHTO T203-64)

Project FG-3-020( )102 Structure No. _____

County RAMSEY Boring No. 5

Location BN RR UNDERPASS ON ND 20 AT DEVILS LAKE Station 49 + 90 Offset 25' LT. OF SUR. C

Date Drilling Started OCT. 2, 1979 Date Finished OCTOBER 3, 1979

Final Water Level _____ Average Seepage Rate (Ft. Rise/Min) _____

(AASHTO T86-70)

1. 0.0' Depth 1" = 5'	2. 1457.0 Elev.	3. Profile	4. Core No.	5. Classification	6. Color of Material	7. Characteristics	8. AASHTO M145-66 Soil Group	9. Remarks
5			C1 79R-264 Jar 1; C2 Jar 2; C3 Jar 3; C4 Jar 4	Clay Loam	Blk.	Lenticular sandy to silty - Pliable - Medium stiff -	A7-6	
8.5'	1448.5		C5 Shelby 79R-265; C6 Jar 5					
10, 15, 20, 25			C7 Shelby 79R-266; C8 Jar 6	Clay Loam	Brn.	Lenticular - Silty - Pliable - Low Permeability - Very stiff -	A7-6	C_r = 64% n_o = 41% n_e = 41% C_r = 111% e_o = 0.6939 e_e = 0.6946 S = 96% n_o = 35% n_e = 34% C_r = 100% e_o = 0.5384 e_e = 0.5108 C_r = 95% S = 100%
27.6'	1429.4							
30, 35			C9 Shelby 79R-267; C10 Jar 7					C_r = 153%

40			C11 79R-268 Jar 8	Clay (Shale)	Gry.	Tightly Laminated- Silty- Impervious- Very Hard-	A7-5	$C_r = 165\%$
45								
50			C12 Jar 9					
55								
60.3'60 Plus	1396.7		C13 79R-269 Jar 10					$C_r = 176\%$

C_r = Consistency Index
n_o = Porosity at beginning of shear Test.
n_e = " " end " " "
e_o = Void Ratio at beginning of shear Test.
e_e = " " " end " " "
S = Degree of Saturation.

B.N. RR Underpass

Boring No. 5

Structure No.

STANDARD PENETRATION TEST

(Wt. of Ham'r. = 140 lbs. - Ht. of Drop = 30")

* AASHTO T206-74

** AASHTO T207-75

Core No.	Depth	% Recovery	% Moisture	* S.P.T.			* S.P.T. Drive
1	0.0' - 2.0'	100	14	3	5	8	1.0'
2	2.0' - 4.0'	70	15	5	7	12	1.0'
3	4.0' - 6.0'	60	17	8	8	16	1.0'
4	6.0' - 8.0'	90	22	7	8	15	1.0'
3" Shelby 5	8.3' - 10.3'	65	26	—	—	—	
6	10.3' - 12.3'	100	20	12	13	25	1.0'
3" Shelby 7	18.3' - 20.3'	80	22	—	—	—	
8	20.3' - 22.3'	100	23	15	15	30	1.0'
3" Shelby 9	28.3' - 29.3'	70		—	—	—	
10	29.3' - 31.3'	100	34	50	61	111	1.0'
11	38.3' - 40.3'	75	32	55	65	120	1.0'
12	48.3' - 50.3'	85	31	60	63	123	1.0'
13	58.3' - 60.3'	75	30	60	65	125	1.0'

CASING DRIVE LOG

(Wt. of Ham'r. = _____ lbs. - Ht. of Drop = 30")

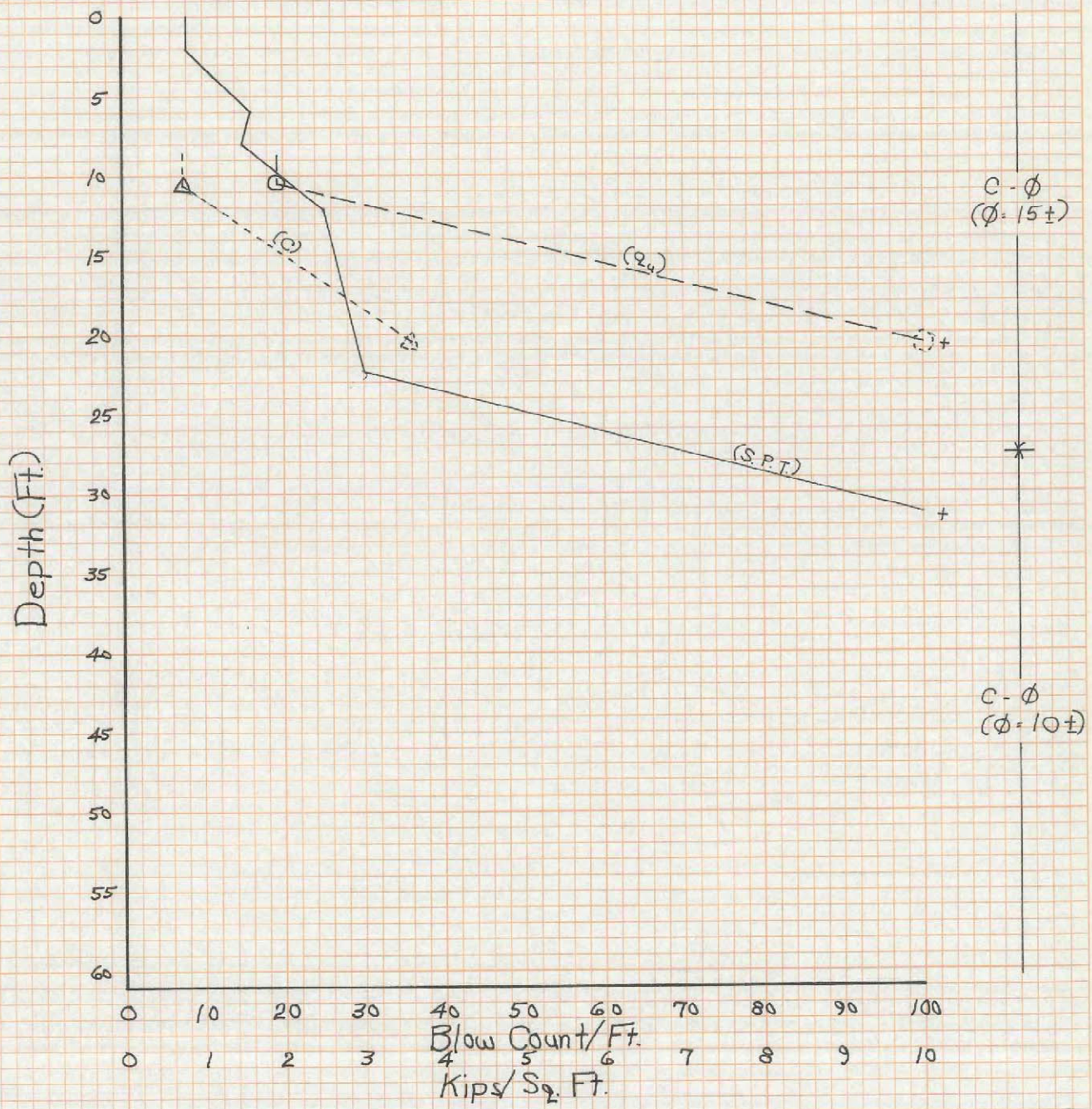
Ft. of Casing or Hollow Stem Auger	No. of Drops/Ft.
58.3'	H

Note: S = Skin friction on outside wall of casing only.
T = Total Resistance - skin friction plus resistance on drive shoe.
H = Hollow Stem Auger

Form 25-2-15 Rev. 12-14-77

B#5

SOIL STRENGTH



Legend

Standard Penetration Test (S.P.T) ————

Unconfined Compr. Strength (q_u) — — — — —

Cohesion (C) - - - - - - - - - - - - - -

⊙ = q_u from test

△ = C from q_u test

⊙ = q_u from triaxial test

△ = C from triaxial test

Ø = Frictional &/or Angle of Internal Friction

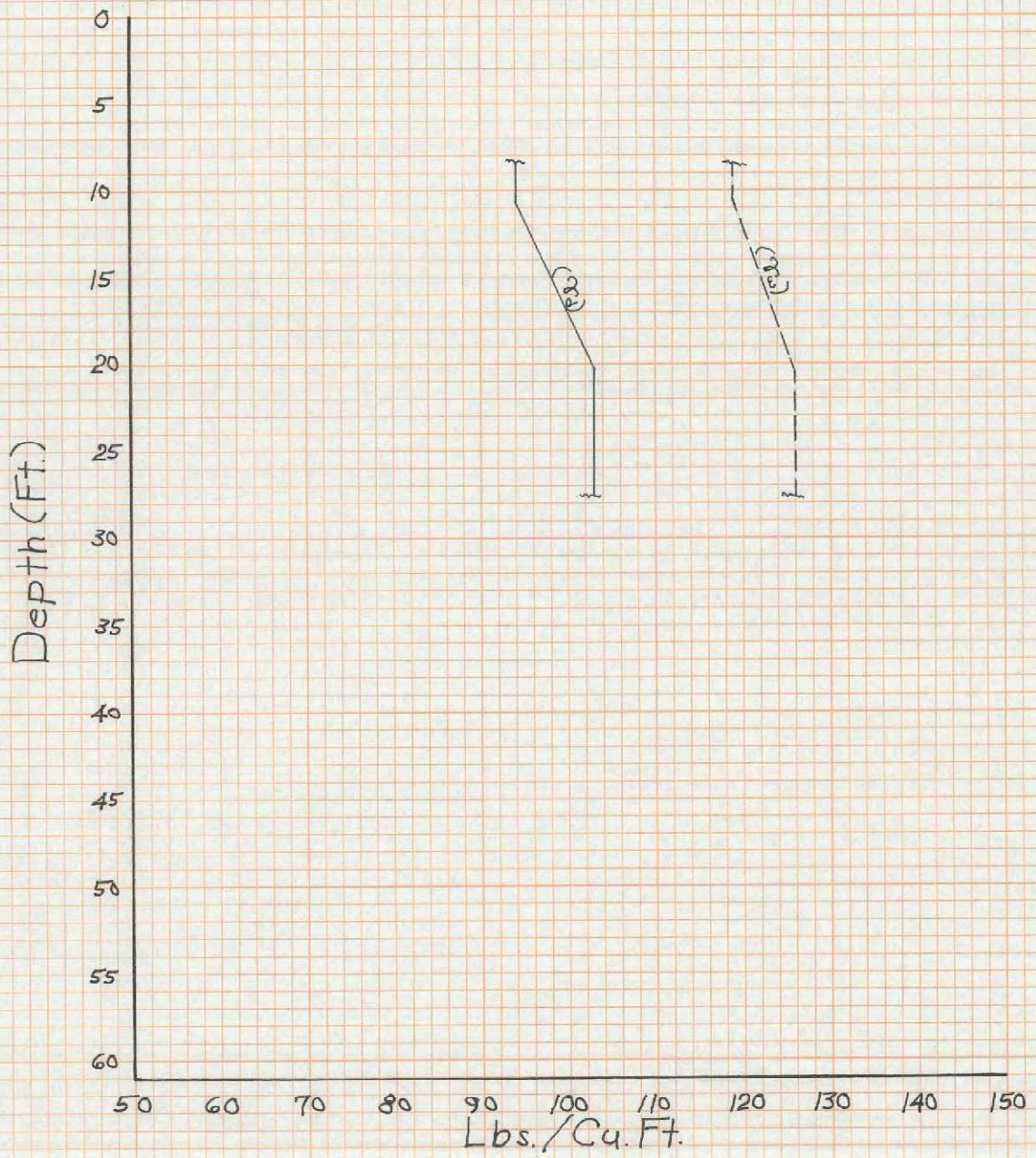
C-Ø = Cohesive - Frictional

C = Cohesive &/or Cohesion

46 0703
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

B#5

UNIT WEIGHT



Legend

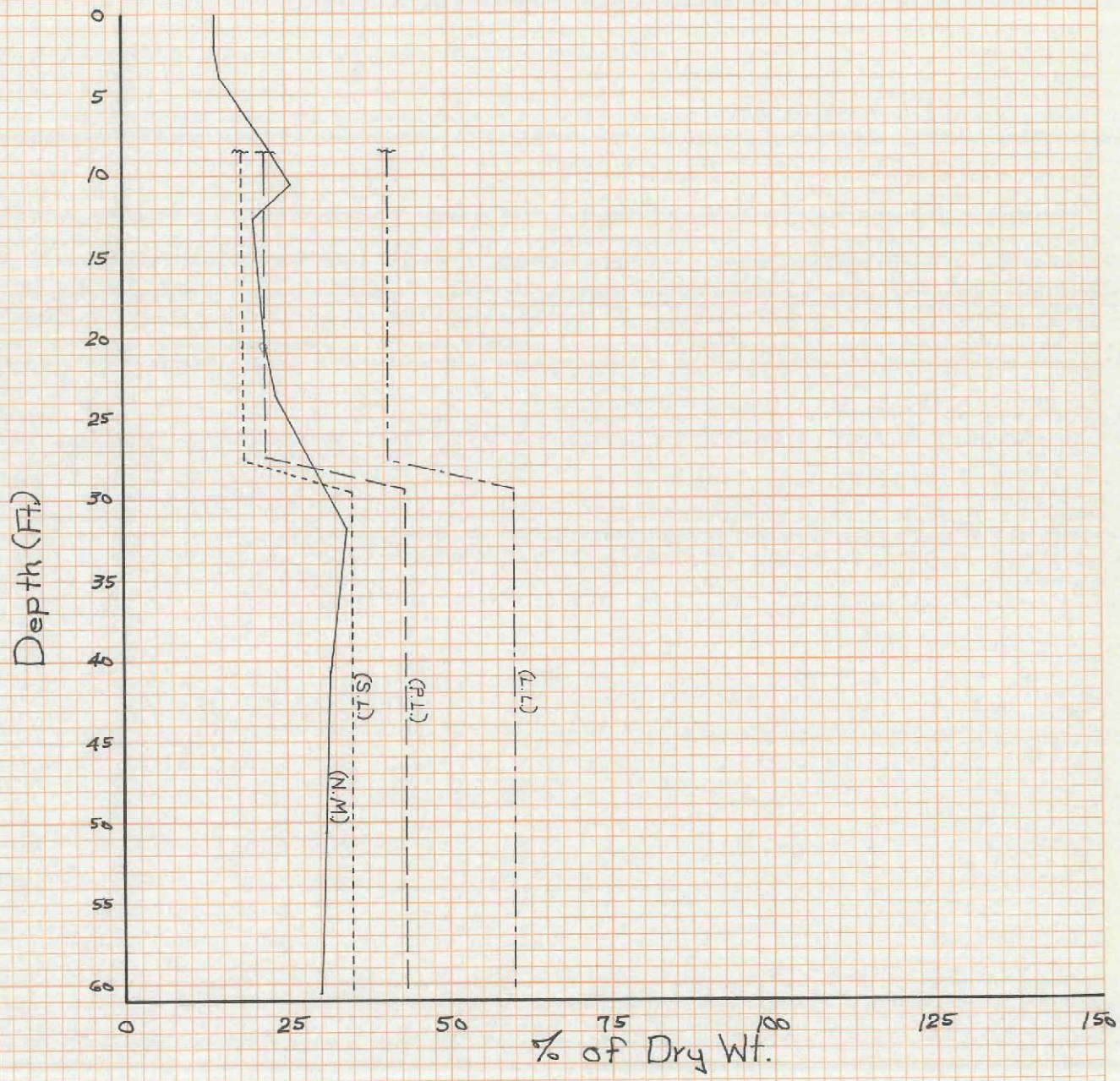
Dry Wt. (γ_d) ————————

Wet Wt. (γ_w) - - - - - - - -

46 0703
K&E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

B #5

NATURAL MOISTURE & ATTERBERG LIMITS



Legend

Natural Moisture (N.M.) ————

Shrinkage Limit (S.L.) - - - - - - - - - -

Plastic Limit (P.L.) — — — — — — —

Liquid Limit (L.L.) —·—·—·—·—

46 0703
K&E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

NORTH DAKOTA
STATE HIGHWAY DEPARTMENT

FOUNDATION SOIL SHEAR TEST REPORT

Date December 3, 1979

AASHTO T208-70: Unconfined Test
AASHTO T234-74: Triaxial Test

Structure No._____

Location: Ramsey County, BN RR Underpass on ND #20 at Devils Lake, Sta. 49+90
25' Left of Survey ℄

Boring No. 5

Sample No. 79R-	265	266
Depth Sample Taken	8.5'-10.3'	18.3'-20.3'
Type of Sample	3" Shelby	3" Shelby
Type of Test	Unconfined	Triaxial
Maximum Load** (Lbs./sq. ft.)	1935	
Typical Angle of Internal Friction	Near 15°	Near 20°
Cohesion (Lbs./sq. ft.)	742	3600
Nat. Field Moisture	26%	22%
Unit Weight Dry (Lbs./cu. ft.)	94	103
Sensitivity Factor		

*Disturbed **Unconfined Compressive Strength

Form 680
Rev. 10-1-66
New Form No. 25-2-4

"Buy North Dakota Products"

NORTH DAKOTA
STATE HIGHWAY DEPARTMENT

FOUNDATION SOIL

CONSOLIDATION TEST REPORT

ASTM D2435-65T

Date 12-3-79

Structure No. _____

Depth of Test Sample 18.3'-20.3'

Location: Ramsey County, BNRR Underpass on ND #20 at Devils Lake, Sta. 49+90
25' Left of Survey ℄

Boring 5

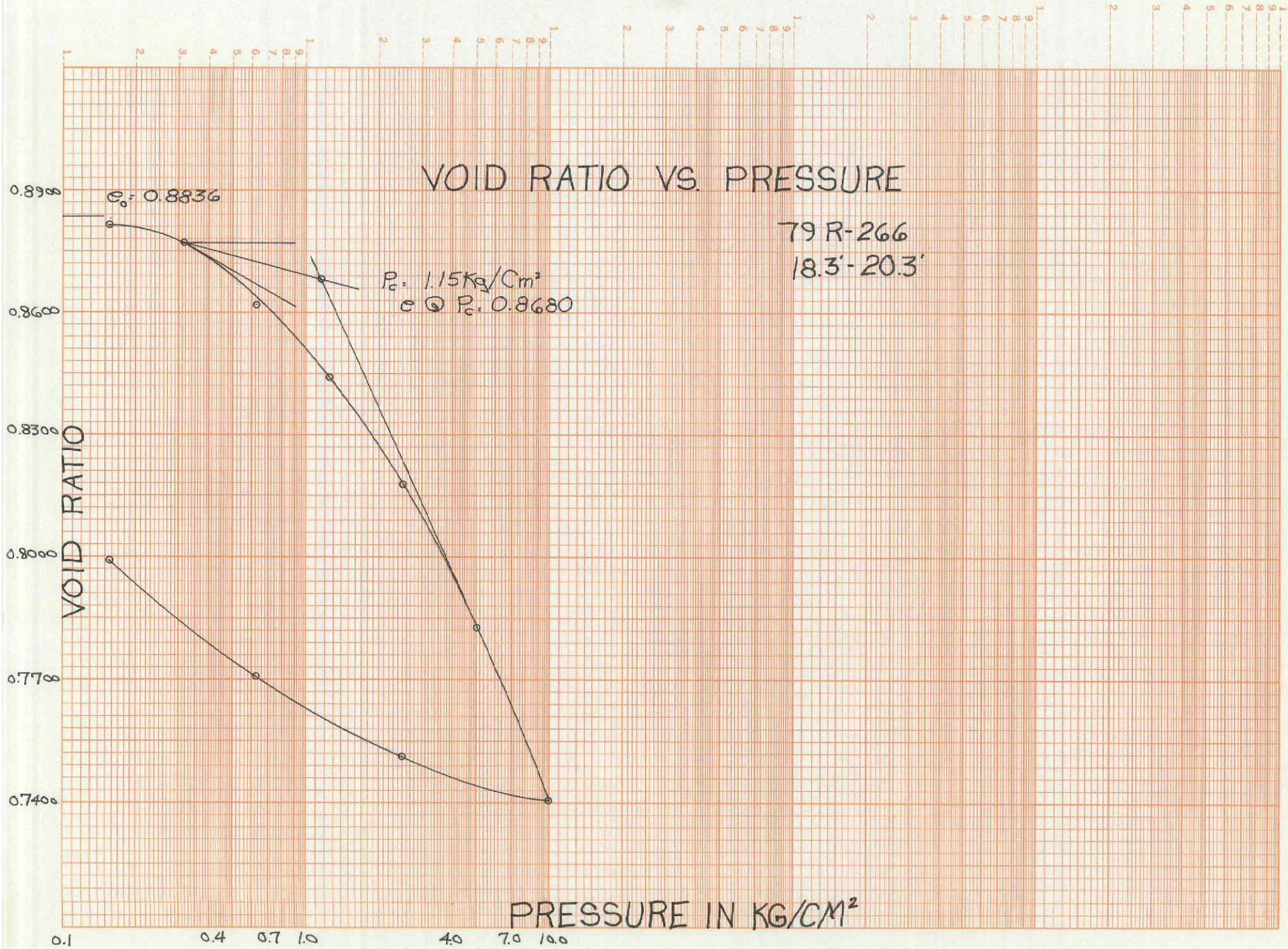
Preconsolidation(kg/cm^2 = $Tons/ft^2$) = P_c = 1.15

Fitting Method Log Fitting Method

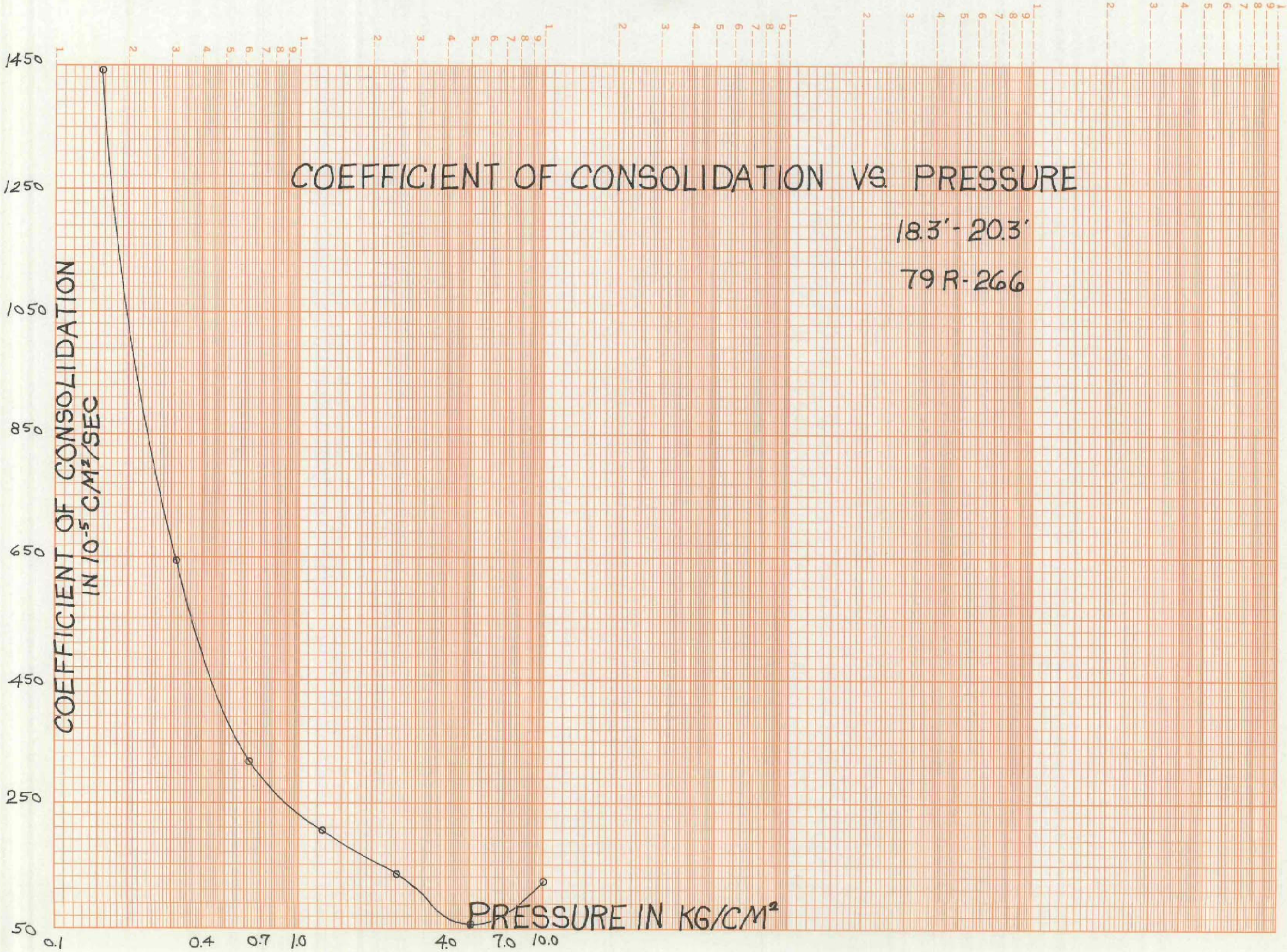
1 Kg/Sq. Cm. = 1.024 T/Sq.Ft.

Applied Pressure (Kg/Sq.Cm.)	Void Ratio	Coef. of Consol. C_v Sq.Cm./Sec.	Compr. Index C_c	Coef. of Permeability K Cm./Sec.
0.0000	0.8836			
0.1579	0.8811	1442.4877×10^{-5}	———	$1212.5552 \times 10^{-10}$
0.3158	0.8772	645.3961×10^{-5}	0.01296	847.4051×10^{-10}
0.6315	0.8619	316.1751×10^{-5}	0.05083	816.0163×10^{-10}
1.2631	0.8440	209.1952×10^{-5}	0.05946	318.4788×10^{-10}
2.5261	0.8179	135.2378×10^{-5}	0.08670	151.5475×10^{-10}
5.0522	0.7828	56.2595×10^{-5}	0.11660	42.9991×10^{-10}
10.1044	0.7404	121.9067×10^{-5}	0.14085	57.3815×10^{-10}
2.5261	0.7514			
0.6315	0.7704			
0.1579	0.7894			

K+E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 6213



K+E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 6213



NORTH DAKOTA
STATE HIGHWAY DEPARTMENT

FOUNDATION SOIL

CONSOLIDATION TEST REPORT

ASTM D2435-65T

Date 12-3-79

Structure No. _____

Depth of Test Sample 28.3'-29.3'

Location: Ramsey County, BN RR Underpass on ND #20 at Devils Lake, Sta. 49+90
25' Left of Survey ℄

Boring 5

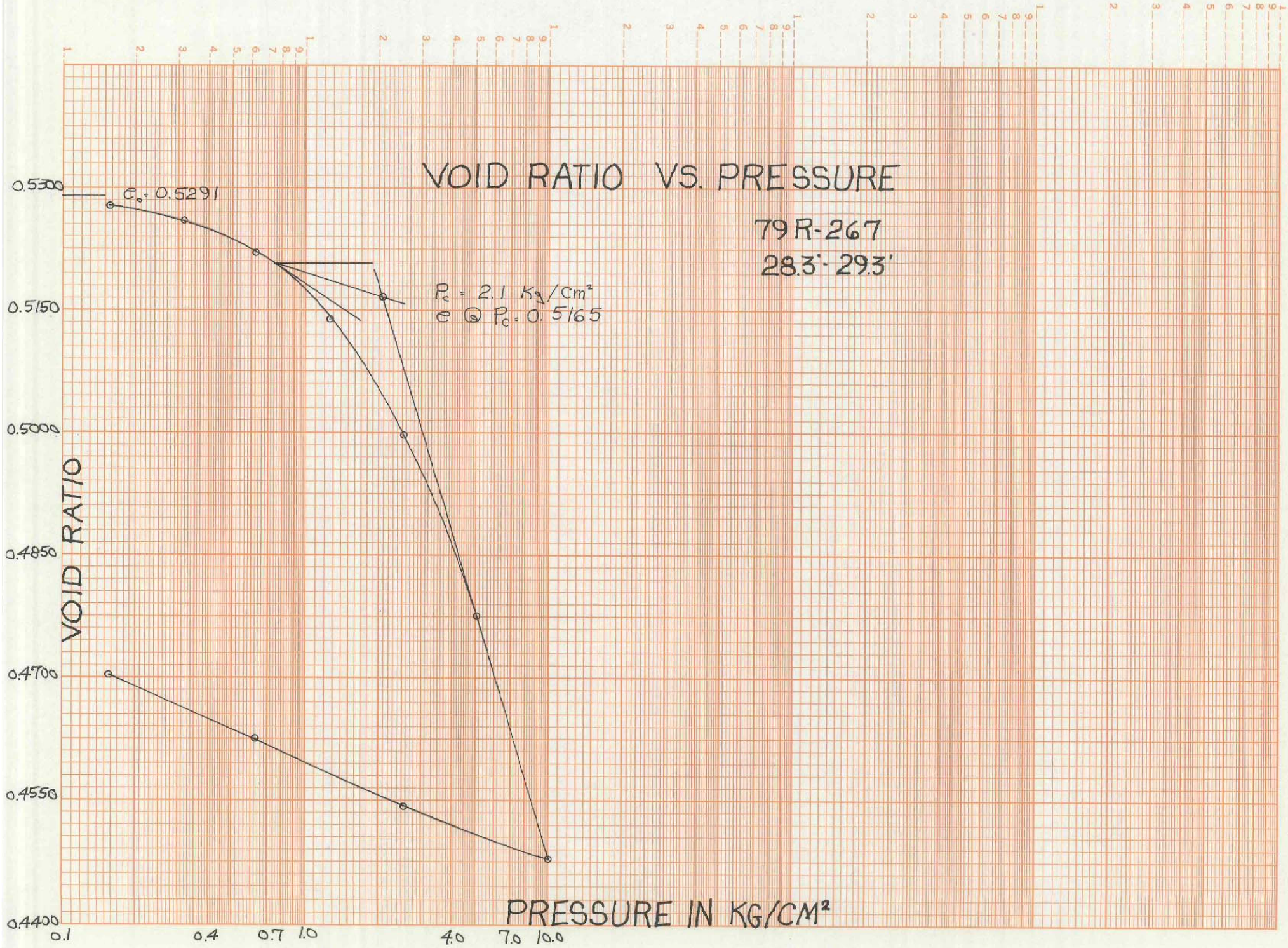
Preconsolidation(Kg/cm^2 = $Tons/ft^2$) = P_c = 2.1

Fitting Method Log Fitting Method

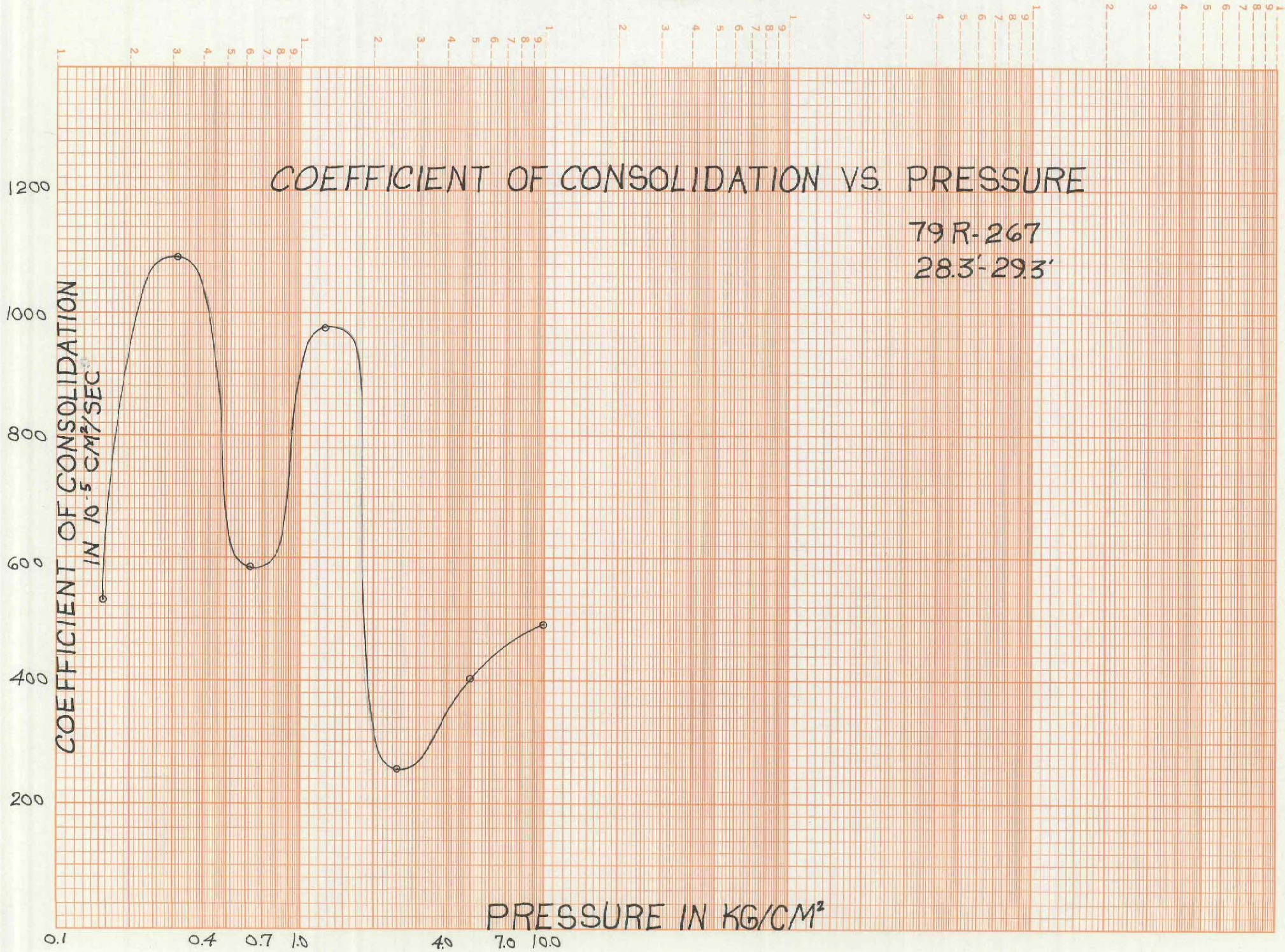
1 Kg/Sq. Cm. = 1.024 T/Sq.Ft.

Applied Pressure (Kg/Sq.Cm.)	Void Ratio	Coef. of Consol. C_v Sq.Cm./Sec.	Compr. Index C_c	Coef. of Permeability K Cm./Sec.
0.0000	0.5291			
0.1579	0.5277	529.0763×10^{-5}	———	769.9093×10^{-10}
0.3158	0.5260	1092.5348×10^{-5}	0.00565	448.8679×10^{-10}
0.6315	0.5223	584.6157×10^{-5}	0.01229	835.0062×10^{-10}
1.2631	0.5141	978.9053×10^{-5}	0.02724	193.6468×10^{-10}
2.5261	0.4997	257.1671×10^{-5}	0.04784	235.3016×10^{-10}
5.0522	0.4775	401.5385×10^{-5}	0.07375	195.4086×10^{-10}
10.1044	0.4479	492.8339×10^{-5}	0.09833	
2.5261	0.4543			
0.6315	0.4625			
0.1579	0.4702			

K+E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 6213



K+E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 6213



APPENDIX D

Lab Results

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-42-2014	**Date Reported**	12/9/2014	**Boring Number**	
County	RAMSEY	**Submitted By**	Naumann	**Project Number**	SU-3-020(074)103
District		**Structure Location**		**PCN**	

Comments

Lab Number	863	864	865	866
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	0.0 - 2.0	2.0 - 4.0	5.0 - 7.0	7.0 - 8.0
Field Sample No.	863	864	865	866
% Pass. 3/8" Sieve	99	81	100	100
% Pass. No. 4 Sieve	96	77	97	97
% Pass. No. 10 Sieve	89	69	90	93
% Coarse Sand (-No. 10 + No.40)	18	18	16	14
% Fine Sand (-No. 40 + No. 200)	23	20	21	24
% Silt (0.074 - 0.005 mm)	24	13	31	32
% Clay (-0.005 mm)	25	18	23	23
Liquid Limit (-No. 40)	47	37	38	38
Plasticity Index (-No. 40)	17	16	15	15
Plastic Limit	30	21	23	23
Soil Color	Brn	Brn	Brn	Brn
Textural Class	SNDY CLY LM	SNDY LM	CLY LM	CLY LM
Soil Class (AASHTO M-145)	A-7-5(5)	A-2-6(1)	A-6(5)	A-6(6)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	9.8	8.9	22.4	20.3

Scott W. Wutzke
Testing Lab. Supervisor

Date Printed: 3/11/2015

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-42-2014	**Date Reported**	12/9/2014	**Boring Number**	
County	RAMSEY	**Submitted By**	Naumann	**Project Number**	SU-3-020(074)103
District		**Structure Location**		**PCN**	

Comments

Lab Number	867	868	869	870
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	8.0 - 9.0	12.0 - 14.0	15.0 - 16.5	16.5 - 18.5
Field Sample No.	867	868	869	870
% Pass. 3/8" Sieve	97	100	96	100
% Pass. No. 4 Sieve	94	93	92	96
% Pass. No. 10 Sieve	87	76	86	90
% Coarse Sand (-No. 10 + No.40)	22	27	10	10
% Fine Sand (-No. 40 + No. 200)	46	19	25	22
% Silt (0.074 - 0.005 mm)	7	15	28	35
% Clay (-0.005 mm)	11	14	23	23
Liquid Limit (-No. 40)	0	43	36	34
Plasticity Index (-No. 40)	0	15	18	13
Plastic Limit	0	28	18	20
Soil Color	Brn	Brn	Drk Gry	Drk Gry
Textural Class	SND	SNDY LM	CLY LM	CLY LM
Soil Class (AASHTO M-145)	A-2-4(0)	A-2-7(1)	A-6(6)	A-6(5)
Frost Class	F2	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	21.9	16.1	16.0	17.8

Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 3/11/2015

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-42-2014	**Date Reported**	12/9/2014	**Boring Number**	
County	RAMSEY	**Submitted By**	Naumann	**Project Number**	SU-3-020(074)103
District		**Structure Location**		**PCN**	

Comments

Lab Number	871	872	873	874
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	20.0 - 21.0	21.0 - 23.0	23.0 - 25.0	25.0 - 27.0
Field Sample No.	871	872	873	874
% Pass. 3/8" Sieve	98	100	99	100
% Pass. No. 4 Sieve	95	98	96	100
% Pass. No. 10 Sieve	88	92	87	90
% Coarse Sand (-No. 10 + No.40)	21	14	25	36
% Fine Sand (-No. 40 + No. 200)	35	31	22	21
% Silt (0.074 - 0.005 mm)	18	32	23	20
% Clay (-0.005 mm)	14	14	17	13
Liquid Limit (-No. 40)	30	31	62	60
Plasticity Index (-No. 40)	7	11	25	22
Plastic Limit	24	20	37	38
Soil Color	Drk Gry	Drk Gry	Drk Gry	Drk Gry
Textural Class	SNDY LM	SNDY LM	SNDY LM	SNDY LM
Soil Class (AASHTO M-145)	A-2-4(0)	A-6(2)	A-7-5(5)	A-2-7(2)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	17.9	17.0	31.0	28.5

Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 3/11/2015

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-42-2014	**Date Reported**	12/9/2014	**Boring Number**	
County	RAMSEY	**Submitted By**	Naumann	**Project Number**	SU-3-020(074)103
District		**Structure Location**		**PCN**	

Comments

Lab Number	875	876	877	878
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	27.0 - 29.0	30.0 - 32.0	33.0 - 35.0	35.0 - 37.0
Field Sample No.	875	876	877	878
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	99	99	99	99
% Pass. No. 10 Sieve	91	91	89	86
% Coarse Sand (-No. 10 + No.40)	26	29	29	24
% Fine Sand (-No. 40 + No. 200)	23	17	16	16
% Silt (0.074 - 0.005 mm)	23	22	29	25
% Clay (-0.005 mm)	19	23	15	22
Liquid Limit (-No. 40)	51	68	68	69
Plasticity Index (-No. 40)	21	30	31	32
Plastic Limit	29	38	37	38
Soil Color	Drk Gry	Drk Gry	Drk Gry	Drk Gry
Textural Class	SNDY LM	SNDY CLY LM	SNDY LM	SNDY CLY LM
Soil Class (AASHTO M-145)	A-7-6(5)	A-7-5(9)	A-7-5(9)	A-7-5(11)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	26.5	28.5	28.2	26.4

Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 3/11/2015

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-42-2014	**Date Reported**	12/9/2014	**Boring Number**	
County	RAMSEY	**Submitted By**	Naumann	**Project Number**	SU-3-020(074)103
District		**Structure Location**		**PCN**	

Comments

Lab Number	879	880	881	882
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	38.0 - 40.0	40.0 - 42.0	43.0 - 45.0	45.0 - 47.0
Field Sample No.	879	880	881	882
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	99	95	93	99
% Pass. No. 10 Sieve	87	85	87	84
% Coarse Sand (-No. 10 + No.40)	23	22	24	22
% Fine Sand (-No. 40 + No. 200)	23	18	24	22
% Silt (0.074 - 0.005 mm)	25	27	23	21
% Clay (-0.005 mm)	17	18	17	19
Liquid Limit (-No. 40)	46	57	49	49
Plasticity Index (-No. 40)	19	25	22	22
Plastic Limit	27	32	27	27
Soil Color	Drk Gry	Drk Gry	Drk Gry	Drk Gry
Textural Class	SNDY LM	SNDY LM	SNDY LM	SNDY LM
Soil Class (AASHTO M-145)	A-7-6(4)	A-7-5(7)	A-7-6(4)	A-7-6(4)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	26.0	29.1	25.4	23.1

Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 3/11/2015

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-42-2014	**Date Reported**	12/9/2014	**Boring Number**	
County	RAMSEY	**Submitted By**	Naumann	**Project Number**	SU-3-020(074)103
District		**Structure Location**		**PCN**	

Comments

Lab Number	883	884	885	886
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	48.0 - 50.0	50.0 - 52.0	55.0 - 57.0	60.0 - 61.0
Field Sample No.	883	884	885	886
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	93	98	98
% Pass. No. 10 Sieve	85	79	87	86
% Coarse Sand (-No. 10 + No.40)	29	29	37	23
% Fine Sand (-No. 40 + No. 200)	16	16	11	17
% Silt (0.074 - 0.005 mm)	21	15	13	22
% Clay (-0.005 mm)	20	19	26	25
Liquid Limit (-No. 40)	68	64	72	74
Plasticity Index (-No. 40)	29	26	32	34
Plastic Limit	39	38	40	40
Soil Color	Drk Gry	Drk Gry	Drk Gry	Drk Gry
Textural Class	SNDY CLY LM	SNDY LM	SNDY CLY LM	SNDY CLY LM
Soil Class (AASHTO M-145)	A-7-5(7)	A-2-7(3)	A-7-5(7)	A-7-5(12)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	27.7	31.1	30.8	31.5

Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 3/11/2015

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-42-2014	**Date Reported**	12/9/2014	**Boring Number**	
County	RAMSEY	**Submitted By**	Naumann	**Project Number**	SU-3-020(074)103
District		**Structure Location**		**PCN**	

Comments

Lab Number	887	888	889	890
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	65.0 - 67.0	70.0 - 71.5	75.0 - 77.0	80.0 - 81.5
Field Sample No.	887	888	889	890
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	97	98	97	96
% Pass. No. 10 Sieve	83	86	76	82
% Coarse Sand (-No. 10 + No.40)	35	27	20	31
% Fine Sand (-No. 40 + No. 200)	16	15	13	16
% Silt (0.074 - 0.005 mm)	16	21	21	16
% Clay (-0.005 mm)	16	23	23	19
Liquid Limit (-No. 40)	67	71	78	83
Plasticity Index (-No. 40)	26	32	19	43
Plastic Limit	41	40	59	40
Soil Color	Drk Gry	Drk Gry	Drk Gry	Drk Gry
Textural Class	SNDY LM	SNDY CLY LM	SNDY CLY LM	SNDY LM
Soil Class (AASHTO M-145)	A-2-7(3)	A-7-5(10)	A-7-5(6)	A-2-7(6)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	27.8	26.6	30.6	30.6

Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 3/11/2015

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
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Report Number	SS-42-2014	**Date Reported**	12/9/2014	**Boring Number**	
County	RAMSEY	**Submitted By**	Naumann	**Project Number**	SU-3-020(074)103
District		**Structure Location**		**PCN**	

Comments

Lab Number	891
Distance From CenterLine (Ft.)	0 ft
Depth, Ft.	85.0 - 87.0
Field Sample No.	891
% Pass. 3/8" Sieve	100
% Pass. No. 4 Sieve	95
% Pass. No. 10 Sieve	76
% Coarse Sand (-No. 10 + No.40)	28
% Fine Sand (-No. 40 + No. 200)	11
% Silt (0.074 - 0.005 mm)	13
% Clay (-0.005 mm)	24
Liquid Limit (-No. 40)	74
Plasticity Index (-No. 40)	35
Plastic Limit	38
Soil Color	Drk Gry
Textural Class	SNDY CLY LM
Soil Class (AASHTO M-145)	A-7-5(6)
Frost Class	F3
Optimum Moisture (%)	
Maximum Dry Density (pcf)	
Ph of Soil	
% Organic Content	
Pocket Pentrometer	
Depth (Ft.) | Moisture (%)	
Avg. Moisture (%)	30.1

Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 3/11/2015

APPENDIX E

APile v2014 Output

Assumptions for Boring #1				
depth (ft)	type	γ' (psf)	Φ (deg)	c (psf)
0-9.0	clay	90	0	875
9.0-17.8	clay	99	0	900
17.8-27.7	clay	63.6	0	1921
27.7-31.2	sand	62.5	33	0
31.2-41.7	clay	59.9	0	3900
41.7-43.7	sand	72.5	37	0
43.7-66.7	clay	66.9	0	6900
66.7-103.7	sand	74.0	41	0

Assumptions for Boring #1A				
depth (ft)	type	γ' (psf)	Φ (deg)	c (psf)
0-8	clay	122.9	0	2625
8-14.5	sand	62.5	33	0
14.5-25.0	clay	59.9	0	3900
25.0-27.0	sand	72.5	37	0
27.0-50.0	clay	66.9	0	6900
50.0-87.0	sand	74.0	41	0

Assumptions for Boring #3				
depth (ft)	type	γ' (psf)	Φ (deg)	c (psf)
0-10.2	clay	87.0	0	875
10.2-30.3	clay	67.0	0	860
30.3-32.6	sand	62.5	33	0
32.6-43.1	clay	59.9	0	3900
43.1-45.1	sand	72.5	37	0
45.1-68.1	clay	66.9	0	6900
68.1-105.1	sand	74.0	41	0

APPENDIX F

Endslope Recommendation

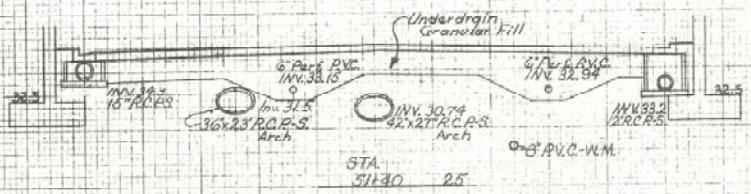
MEMORANDUM

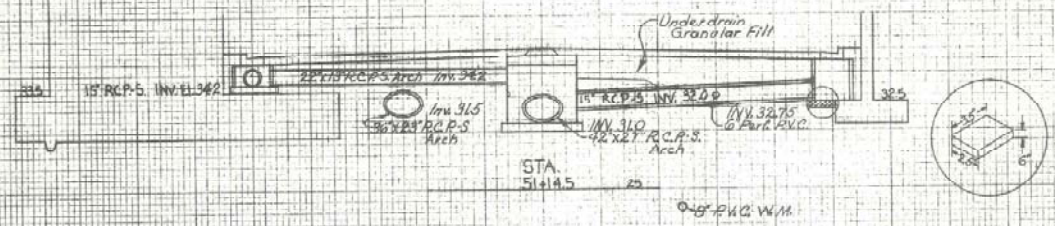
FROM	Jeff Jirava – Materials and Research
TO	Ardin Striefel – Local Government
PROJECT	SU-3-020(074)103
PCN	17504
LOCATION	Bridge #0020-103.403
DATE	1/15/15
SUBJECT	End Slopes for Permanent and Shoofly Bridges

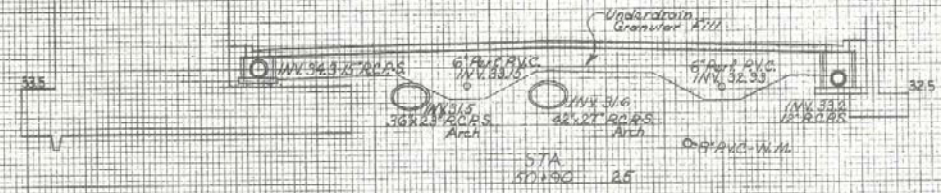
The following are the recommended end slopes for the permanent and shoofly bridges. These are based on the field borings logs and engineering judgment. They will not change, however, the detailed lab results and boring logs will be included in the foundation report. The end slopes should be **2.5:1** or flatter for both the permanent structure and the temporary shoofly.

APPENDIX G

Existing Underdrain System

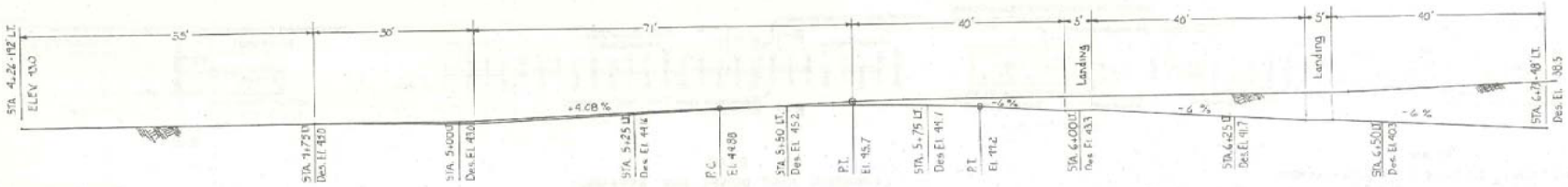




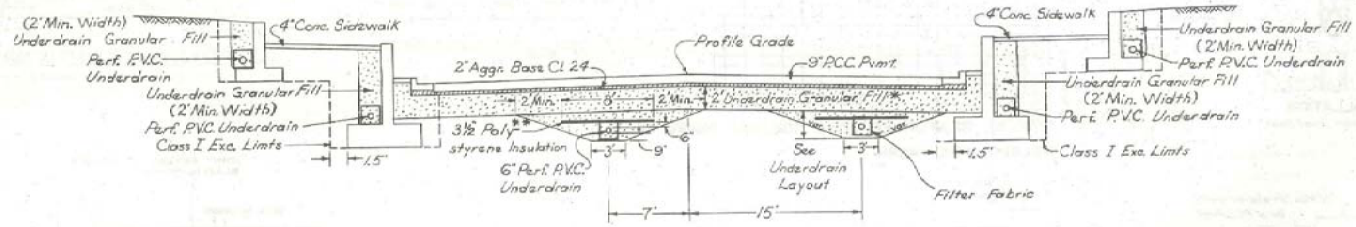


8	N.D.	FG-3-206(6)102	29

PHASE DESIGN	STATE	FED. AID PROJ.
6	N.D.	FG-3-206



Park Sidewalk Grades
Sta. 4+26-192' LT.
to Sta. 6+73-98' LT.



UNDERDRAIN & BACKFILL DETAILS

* Install 2' of Underdrain Granular Fill - Sta. 50+00 to 52+20

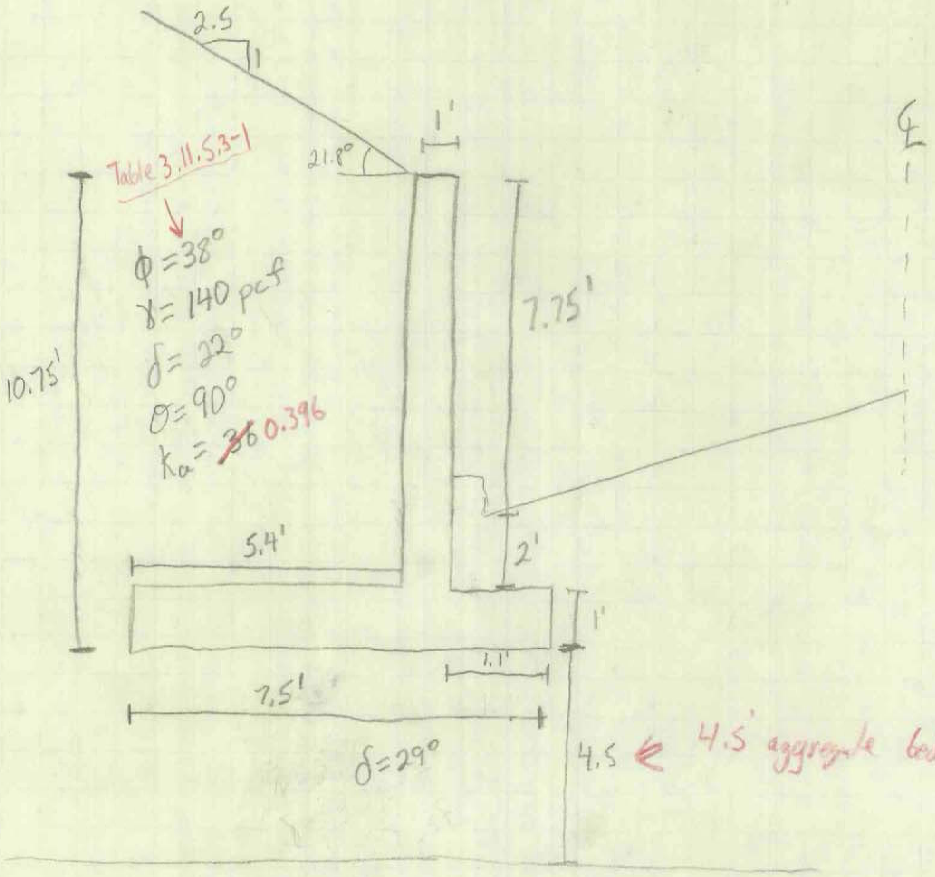
** Install 3½"x8'x21' Polystyrene Insulation - Sta. 50+09 to 52+20 Lt. & Rt.

APPENDIX H

Retaining Wall Calculations

Assumptions

Sizing ⇒ Section 8.2 Principles of Foundation ENGINEERING
Braja M. Das 7th ed

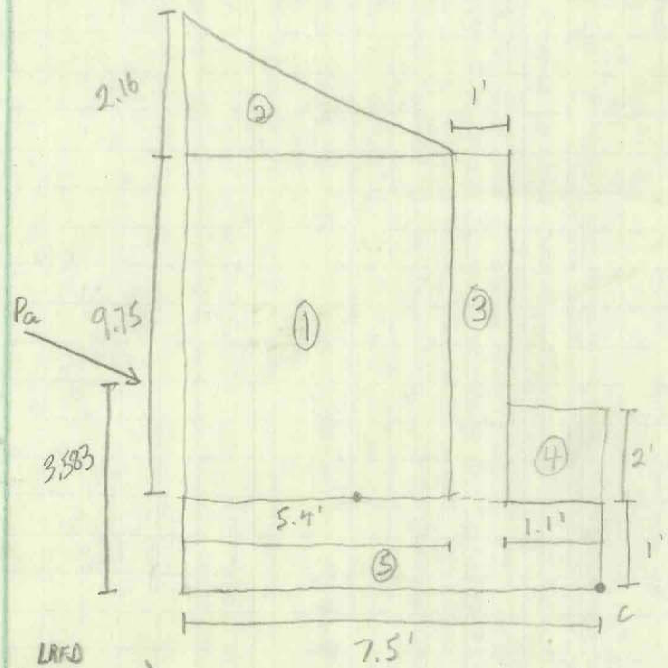


4.5' aggregate bedding to account for frost Depth (10.6.1.2)

$\phi = 20°$
$\gamma = 130$ pcf
$c = 850$ psf

Using $\gamma_{concrete} = 150$ pcf

Loads



Section	Area	Unit Weight	Vertical Load	Mom. Arm from C	Mom.
①	$5.4 \times 9.75 = 52.65 ft^2$	140 pcf	7371 lbs	4.8'	35380.8
②	$\frac{1}{2}(5.4)(2.16) = 5.832 ft^2$	140 pcf	816 lbs	5.7'	4651.2
③	$1(9.75) = 9.75 ft^2$	150 pcf	1462.5 lbs	1.6'	2340.0
④	$2 \times 1.1 = 2.2 ft^2$	140 pcf	308 lbs	.55'	169.4
⑤	$7.5 \times 1 = 7.5 ft^2$	150 pcf	1125 lbs	3.75	4218.75
P_V			1715.7	7.5	12867.75

LRFD (3.11.5.3-2)

$$\Gamma = \left(1 + \sqrt{\frac{\sin(38+22)\sin(38-21.8)}{\sin(90-22)\sin(90+21.8)}}\right)^2 = 2.34$$

Ignore passive resistance see 11.6.3.5

LRFD (3.11.5-3-1)

$$K_a = \frac{\sin^2(90+22)}{2.34(\sin^2(90)\sin(90-22))} = .396$$

$$P_a = .5(140)(10.75+2.16)^2(.396) = 4620 \text{ lbs}$$

$$P_V = 4620 \sin(21.8) = 1715.7 \text{ lbs}$$

$$P_H = 4620 \cos(21.8) = 4289.6 \text{ lbs}$$

Figure 11.6.3.2-1

Eccentricity w/ factored Loads

4.303 see 11.6.3.2-1

Sum of moments about the center of the foundation

Reduction factor RF 1.05 RF

$$e = \frac{-1.5(4289.6)(\cancel{3.583}) + (1.5)(1715.7)(3.75) + 7371(1.05) + 816(\cancel{1.8}) - (.9)(1462.5)(2.15) - 308(3.2)}{7371 + 816 + (.9)(1462.5) + 308 + (1.5)1715.7} \Rightarrow \frac{\cancel{-8010.83}\ -12521.20}{12384.8} = \cancel{-.65'}\ -1.01'$$

11.6.3.3

$\frac{B}{3} \Rightarrow \frac{7.5}{3} = 2.5$ $e < \frac{B}{3}$ or $\cancel{.65}\ -1.01 < 2.5$ therefore the wall passes for eccentricity and overturning

Reduction Factors see pg 11-11 LRFD

STAEDTLER® No. 937 811E Engineer's Computation Pad

SEE LRFD SECTION 10.6.3.4 – Failure by Sliding

Sliding Failure

$V = \Sigma V_c = 7371 + 816 + (.9)1462.5 + 308 + (.9)1125 + (1.5)1715.7 = 13397.3$ lbs Load Factors from Fig C11.5.6-2

$\phi = 38°$

$R_T = (13397.3)\tan(38) = 10467.1$ lbs 10.6.3.4-2

$\varphi = .80$ Table 10.5.5.2-1

$R_R = \varphi R_T \Rightarrow 10467.1(.80) = 8373.7$ lbs

$P_H = 4289.6$ lbs

$P_{H(factored)} = (1.5)4289.6 = 6{,}434.4$ lbs $< R_R = 8373.7$ lbs Passes for Sliding

C11.5.6-2

STAEDTLER® No. 937 816E Engineer's Computation Pad

BEARING CAPACITY

LRFD 10.6.3.1.2f

q_{2c} Ignoring ϕ so $\phi_f = 0°$ and $c = 0.85$ Ksf

$$q_{2c} = 0.85(5.14) + 0.13(7.5)(1)(0.5) + 0 = 4.856 \text{ Ksf}$$

q_{2f} Ignoring c so $\phi_f = 20°$ and $c = 0$

$$q_{2f} = 0 + 0.13(7.5)(6.4)(0.5) + 0.5(0.13)(7.5)(5.4)(0.5) = 4.436 \text{ Ksf}$$

Use q_{2f} since critical

Bearing Capacity in 2 Layered Drained 10.6.3.1.2f

$$q_n = 4.436e^{(0.07)(1)\left(\frac{4.5}{7.5}\right)} = 6.631 \text{ Ksf}$$

Bearing resistance factor is 0.5 LRFD 10.5.5.2.2-1

$$q_n' = 0.5(6.631) = 3.315 \text{ Ksf} \Rightarrow \underline{3315 \text{ psf}}$$

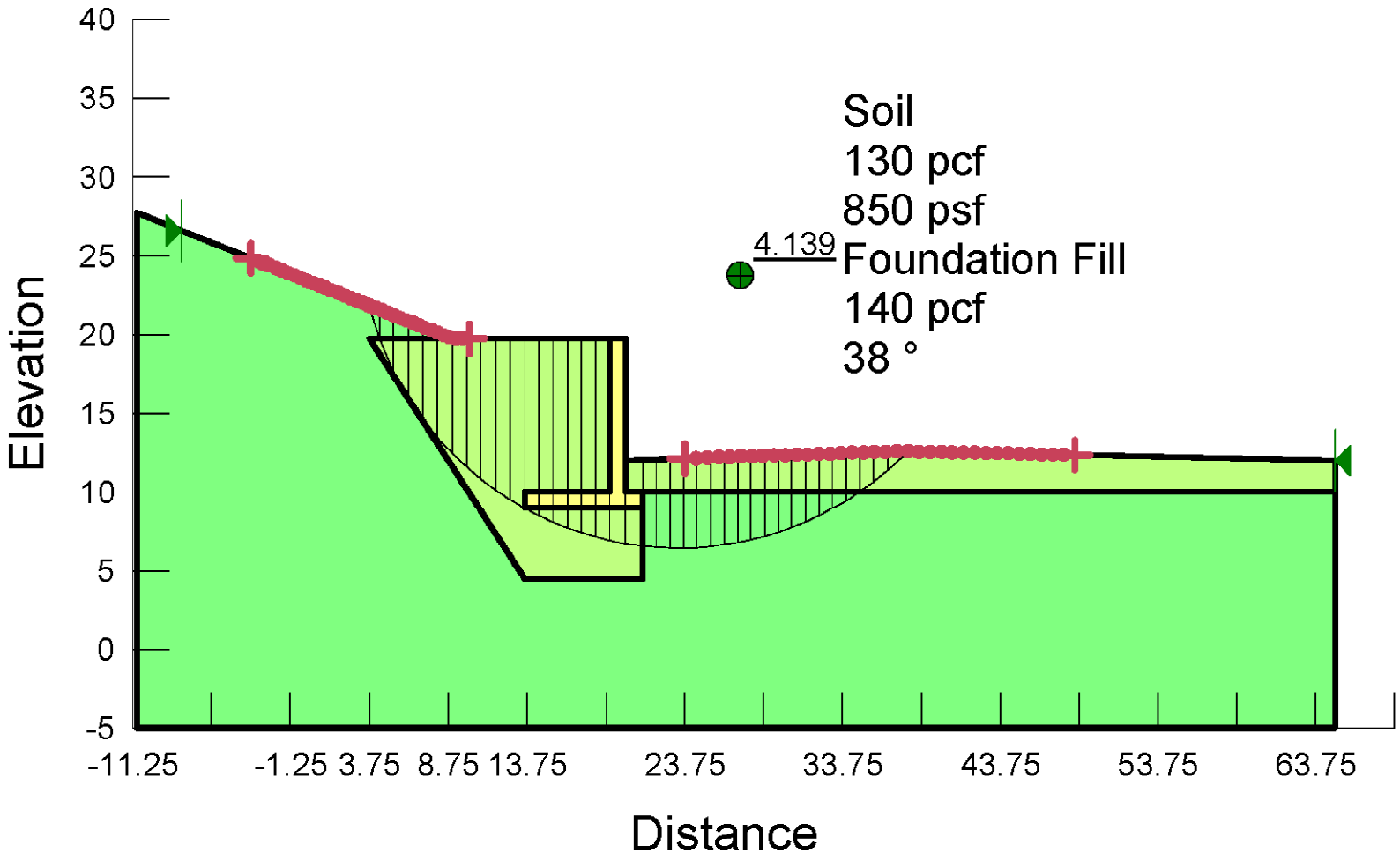
CALCULATE Vertical Stresses

$$\Sigma V = 1.35(7371) + 1.35(816) + 1.25(1462.5) + 1.35(308) + 1.25(1125) + 1.5(1715.7) = 17275.13 \text{ lbs}$$

$$\sigma_v = \frac{\Sigma V}{B \cdot 2e} \qquad \frac{17275.13}{7.5 - 2.02} = 3152.39 \text{ psf}$$

$3152.39 \text{ psf} < 3315 \text{ psf}$

PASS For BEARING CAPACITY


Soil
130 pcf
850 psf
4.139
Foundation Fill
140 pcf
38 °
Elevation
Distance
40
35
30
25
20
15
10
5
0
-5
-11.25
-1.25
3.75
8.75
13.75
23.75
33.75
43.75
53.75
63.75