

DEPARTMENT OF HIGHWAYS ONTARIO

MEMORANDUM

Mr. J. G. Tillcock,  
District Engineer,  
District #3 (Stratford).

FROM: Foundation Section,  
Materials & Testing Div.,  
Room 107, Lab. Bldg.

DATE: October 28, 1965

OUR FILE REF.

IN REPLY TO

7720. 22/65

SUBJECT:

FOUNDATION INVESTIGATION REPORT  
-- CUT SLOPE FAILURE --  
Hwy. #21 at Goderich, Ontario  
District #3 (Stratford)  
W.J. 65-F-100 -- Cont. 60-147

Attached, please find the report for the above-mentioned site. It is believed that it contains all the necessary information. This information was already given earlier, verbally, to your representative at the site. However, should there be any additional information that you would require, please feel free to contact our Office.

AGS/MdeF  
Attach.

cc: Messrs. J. G. Tillcock (2)  
H. A. Tregaskes  
J. Roy

*A. G. Stermac*  
A. G. Stermac,  
PRINCIPAL FOUNDATION ENGINEER

Foundations Office ✓  
Gen. Files

## TABLE OF CONTENTS

### INTRODUCTION.

### SUBSOIL CONDITIONS:

- (1) Silt with traces of Sand and Clay.
- (2) Clayey Silt with some Sand and traces of Gravel.
- (3) Silty Clay with some Sand and traces of Gravel.
- (4) Sandy Silt with some Gravel and Clay.
- (5) Ground Water.

### RECOMMENDATIONS.

### MISCELLANEOUS.

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# FOUNDATION INVESTIGATION REPORT

-- CUT SLOPE FAILURE --

Hwy. #21 at Goderich, Ontario

District #3 (Stratford)

W.J. 65-F-100 -- Cont. 60-147

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## INTRODUCTION:

A request for a field investigation at the site of a cut slope failure on the South approach to the Maitland River bridge was received from Mr. J. G. Tillcock, District Engineer. The failure location is on the East side of Hwy. 21 at approximate Sta. 20+50. During the spring of this year, approximately 500 cu. yd. of soil slid down from the side of the 75-foot high cut slope. Since the highway was constructed in 1960-61, a number of minor failures have occurred at this same site.

Three borings were subsequently carried out by this Section along the approximate centre of the failed area in order to determine the subsoil conditions and in addition, four piezometers were installed with the purpose of establishing the ground water conditions.

The locations and elevations of the borings are shown on Drawing #65-F-100 and were surveyed in the field by District personnel.

cont'd. /2 ...

SUBSOIL CONDITIONS:

Subsoil at the site consisted of deposits of clayey silt and silty clay overlying sandy silt. The boundaries of the various layers were approximately horizontal. The material in the layers is described in their order of occurrence as follows:

(1) Silt with traces of Sand and Clay:

This material was encountered between El. 101.0 and El. 95.0 and consisted of compact to dense silt containing traces of sand and clay in the following average proportions: silt 91%, sand 2%, clay 7%. The natural moisture content was found to be about 18%.

(2) Clayey Silt with some Sand and traces of Gravel:

This deposit occurs between El. 95.0 and El. 57.0, and El. 37.0 and El. 27.0. The liquid and plastic limit ranges are 25% - 29%, and 13% to 17%, respectively, and the natural moisture content varies from 14% to 25%. Mechanical analyses indicate the following grain size distribution: silt 52%, clay 29%, sand 15%, and gravel 4%. The consistency of the material is classified as very stiff to hard.

(3) Silty Clay with some Sand and traces of Gravel:

This deposit occurs between El. 57.0 and El. 37.0. The liquid and plastic limits averaged approximately 35% and 15%, respectively, and the moisture content averaged about 20%. The material consists of very stiff to hard silty clay containing sand

cont'd. /3 ...

SUBSOIL CONDITIONS: (cont'd.) ...

(3) Silty Clay with some Sand and traces of Gravel: (cont'd.) ...

and gravel in the following average proportions: clay 46%, silt 43%, sand 7%, and gravel 4%. The undrained shear strength is estimated to be in the order of 3,000 - 4,000 p.s.f.

(4) Sandy Silt with some Gravel and Clay:

This deposit was observed below El. 27.0 and consists of very dense sandy silt containing some gravel and clay particles in the following average proportions: clay 12%, silt 40%, sand 34%, and gravel 14%.

(5) Ground Water:

Based on the observations of the piezometers installed at the site, the ground water level is estimated to be as follows:

<u>Borehole</u>	<u>Elevation</u>
1	89.0
2	60.3
3	28.4

The above levels were applicable on September 24, 1965.

RECOMMENDATIONS:

Our review of subsoil conditions at this site indicates that the primary cause of failure is the action of water seeping down the slope very close to the surface. Such a condition results in the loosening or softening of the soil adjacent to the surface and in seepage forces being exerted against the

cont'd. /4 ...

RECOMMENDATIONS: (cont'd.) ...

soil mass. The results of our field investigation have shown that even in the dry season of the year, the ground water is less than 6 feet below the surface for most of the slope, and it is to be presumed that conditions in the spring will be considerably worse. In order to stabilize the slope permanently, it is therefore necessary to ensure that adequate provision for ground water drainage is made, and in view of this fact, our recommendations are as follows:

(1) Cut-off drains should be provided at the top and centre of the existing slope. The two drains should consist of 10' deep x 3' wide trenches filled with a suitable granular filter medium and incorporating a 6-inch diameter, perforated C.I.P.

(2) The drains should traverse the entire failed zone and discharge into the existing 12-inch diameter C.I.P. some 300 ft. west of the centre of the failed zone.

(3) Connecting drains spaced about 80 - 100 feet apart should also be constructed so as to drain down the face of the slope and discharge into the existing catch basins at the toe of the slope.

(4) After completion of the drainage installation, the slope may be re-shaped and sodded.

cont'd. /5 ...

MISCELLANEOUS:

The field work for this project was carried out during the period August 25 - September 1, 1965, under the supervision of Mr. Paul Payer, Project Foundation Engineer. Equipment used was owned and operated by Canadian Longyear Ltd. This report was prepared by Mr. K. G. Selby, Senior Foundation Engineer.

October 1965

APPENDIX I



DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & TESTING DIVISION

## RECORD OF BOREHOLE NO. 1

### FOUNDATION SECTION

JOB 65-F-100 LOCATION Sta. 1+00; 2' Mt. (Base Line) ORIGINATED BY P.P.  
W.P.                      BORING DATE Aug 25 & 26, 1965. COMPILED BY P.P.  
DATUM T.B.N. BOREHOLE TYPE Washbore-BX Casing. CHECKED BY SK

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT						LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W			BULK DENSITY $\rho_{\text{pcf}}$	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	SHEAR STRENGTH P.S.F.						WATER CONTENT % 10      20      30				
101.0	Groundlevel															
0.0	Silt with traces of clay, and sand. Compact to dense.		1	SS	51											Gr 0% Sa 2% Si 91% Cl 7%
95.4			2	SS	36											
5.6			3	SS	27											Gr 4% Sa 13% Si 55% Cl 28%
			4	SS	35											
			5	SS	33											
	Clayey silt with some sand and traces of gravel.		7	SS	47											$\nabla$ Pres. W.L.
	V. stiff to hard.		8	SS	39											Gr 7% Sa 12% Si 49% Cl 32%
			9	SS	40											
	Greyish brown.		10	SS	41											
			11	SS	40											
			12	SS	49											Gr 3% Sa 12% Si 54% Cl 31%
			13	SS	46											
			14	SS	53											
			15	SS	63											Gr 2% Sa 17% Si 52% Cl 29%
64.5																
36.5	End of borehole.															



## RECORD OF BOREHOLE NO. 3

**FOUNDATION SECTION**

DEPARTMENT OF HIGHWAYS - ONTARIO

**MATERIALS & TESTING DIVISION**

JOB 65-F-100

LOCATION Sta. 1+10; 171' Rt. (Base Line)

ORIGINATED BY P.P.

W. P.

BORING DATE Sept. 1, 1965.

COMPILED BY           P.P.          

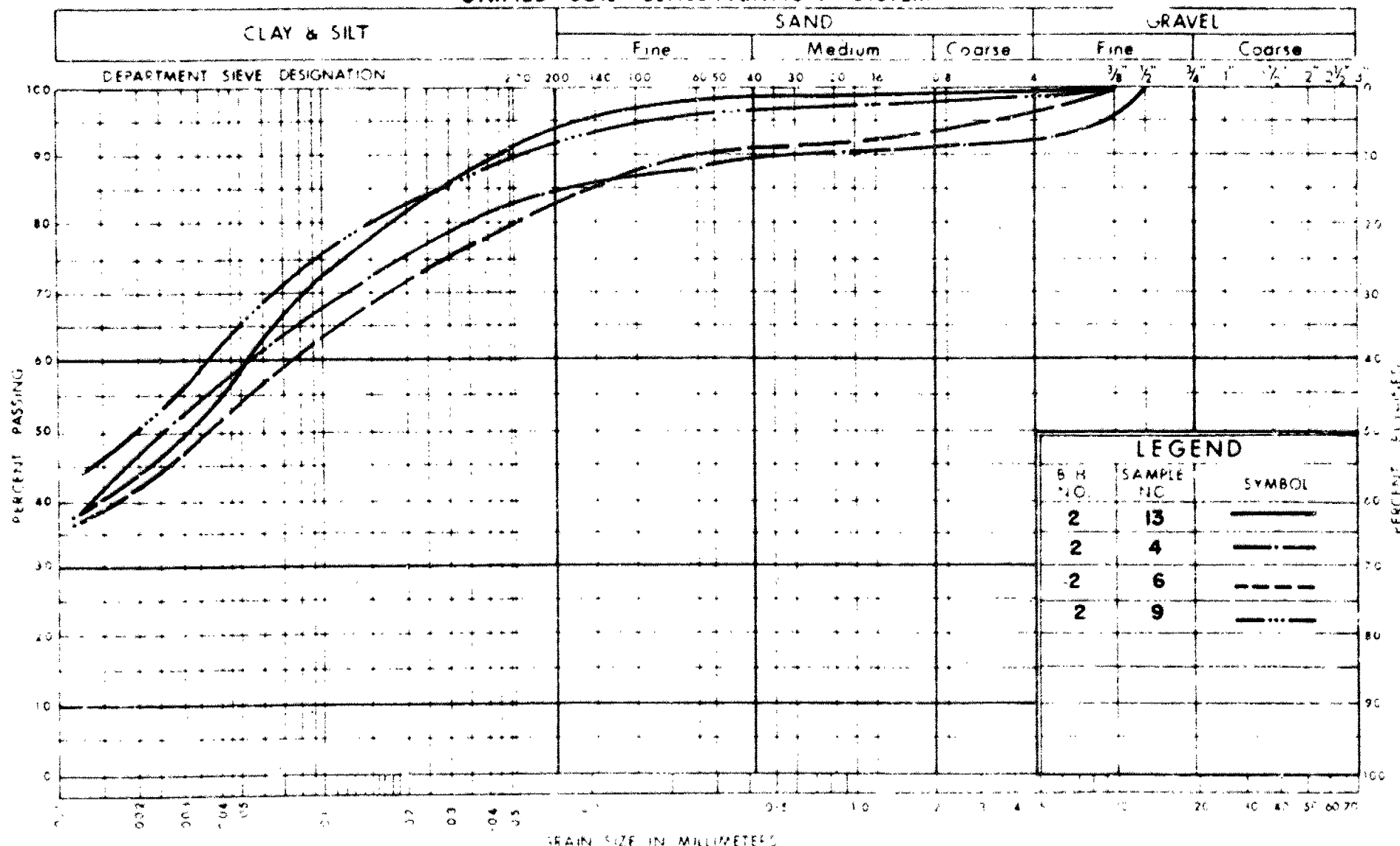
DATUM T.B.M.

BOREHOLE TYPE Washbore - BX Casing.

CHECKED BY                     

[illegible]

# UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION

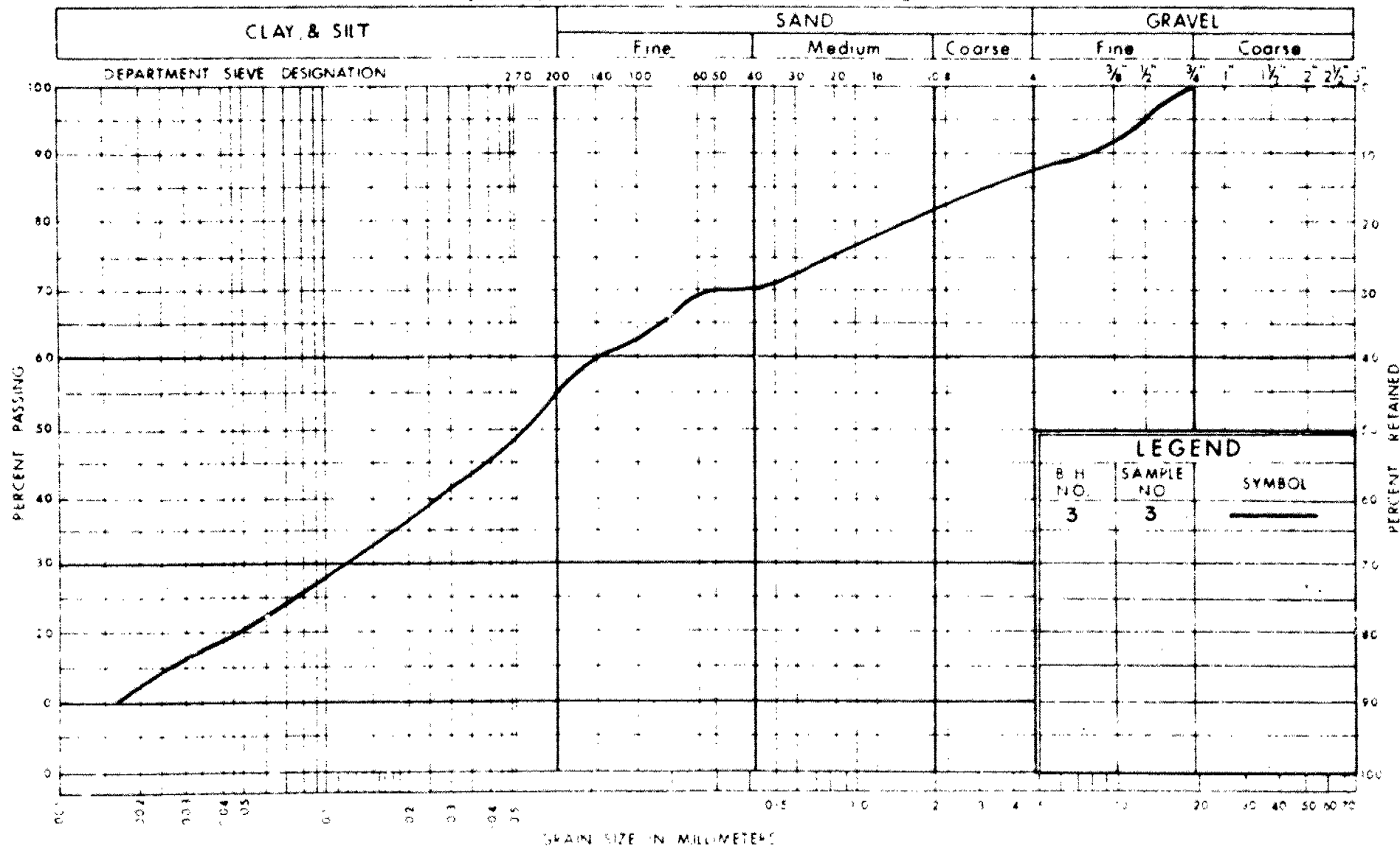
ONTARIO

GRAIN SIZE DISTRIBUTION  
SILTY CLAY & CLAYEY SILT  
WITH SOME SAND & TRACES OF GRAVEL

W.P. No.

JOB No. 65-F-100

# UNIFIED SOIL CLASSIFICATION SYSTEM



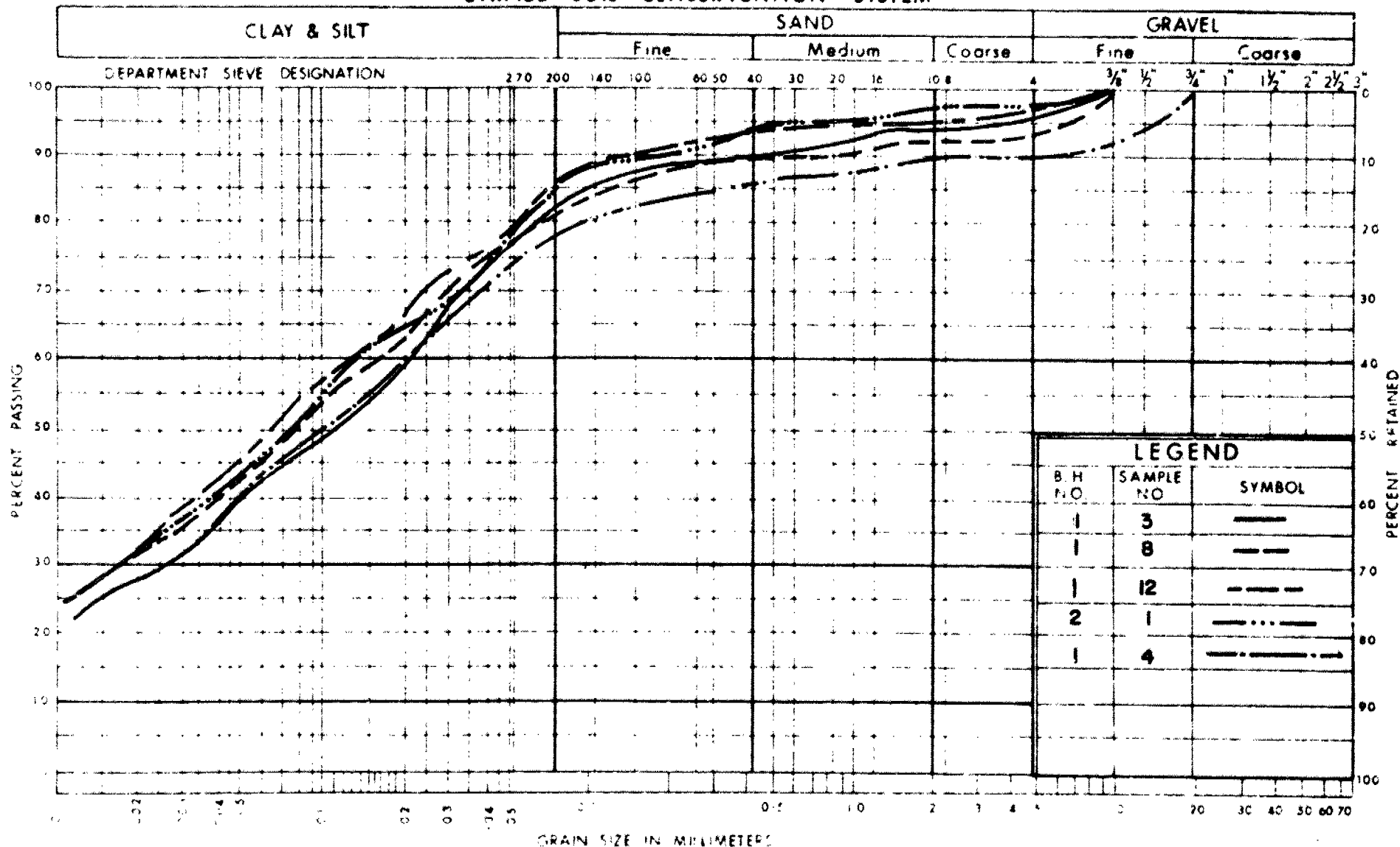
DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION

GRAIN SIZE DISTRIBUTION  
SANDY SILT  
WITH SOME GRAVEL & CLAY

W.P. No.

JOB No. 65-F-100

# UNIFIED SOIL CLASSIFICATION SYSTEM



ONTARIO

DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION

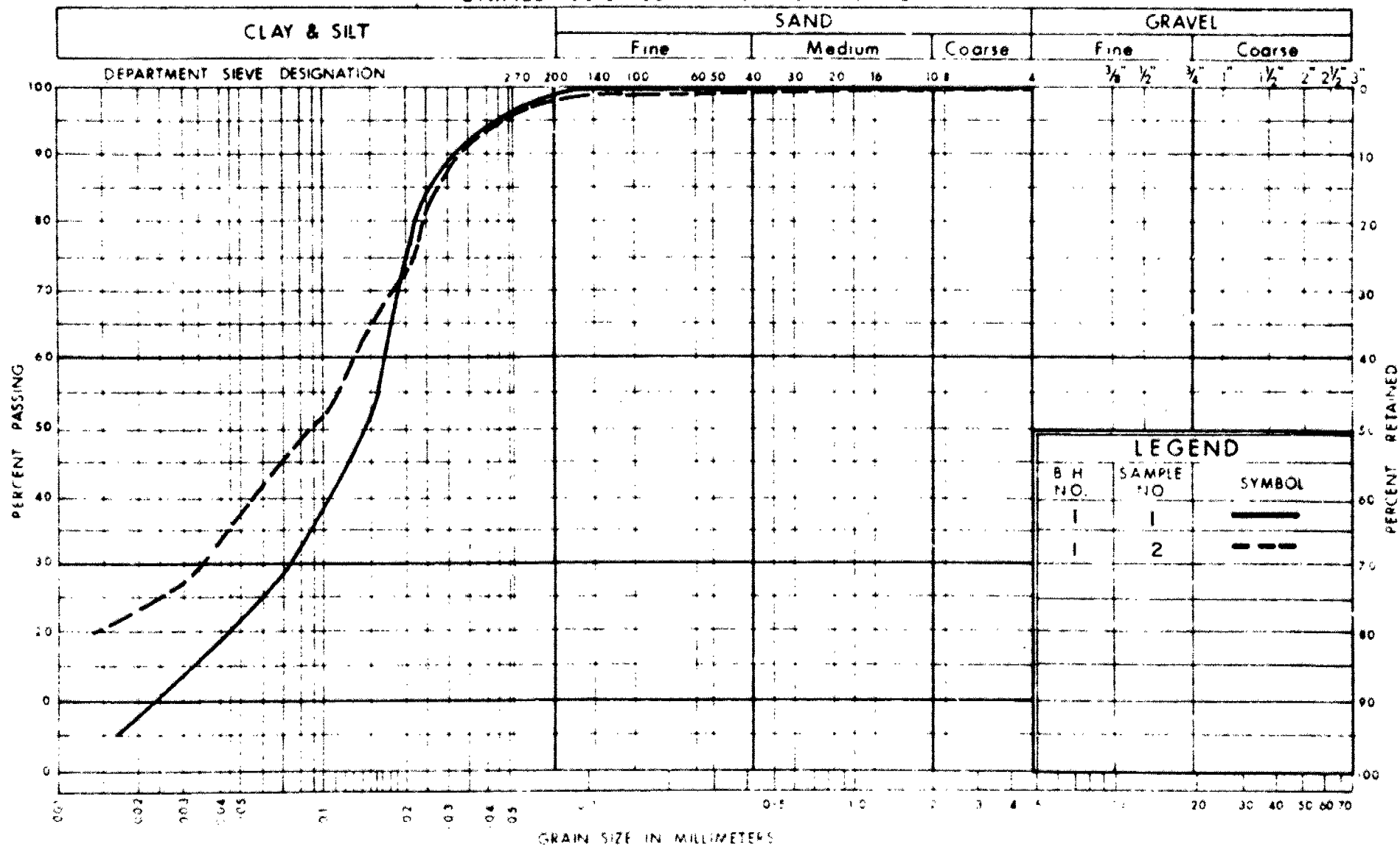
GRAIN SIZE DISTRIBUTION  
CLAYEY SILT

WITH SOME SAND & TRACE OF GRAVEL.

WP No

JOB No. 65-F-100

## UNIFIED SOIL CLASSIFICATION SYSTEM



ONTARIO

DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION

# GRAIN SIZE DISTRIBUTION SILT

WITH TRACE OF SAND & CLAY

WP No.

JOB No. 65-F-100

## ABBREVIATIONS USED IN THIS REPORT

### PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE 'N' - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

### DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS:-

<u>CONSISTENCY</u>	<u>'N' BLOWS / FT.</u>	<u>c LB. / SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
VERY SOFT	0 - 2	0 - 250	VERY LOOSE	0 - 4
SOFT	2 - 4	250 - 500	LOOSE	4 - 10
FIRM	4 - 8	500 - 1000	COMPACT	10 - 30
STIFF	8 - 15	1000 - 2000	DENSE	30 - 50
VERY STIFF	15 - 30	2000 - 4000	VERY DENSE	> 50
HARD	> 30	> 4000		

### TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.B.	SCRAPER BUCKET SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE
S.T.	SLOTTED TUBE SAMPLE		
	P.H.		SAMPLE ADVANCED HYDRAULICALLY
	P.M.		SAMPLE ADVANCED MANUALLY

### SOIL TESTS

Q <sub>u</sub>	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V.	FIELD VANE
Q <sub>cu</sub>	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Q <sub>d</sub>	DRAINED TRIAXIAL	S	SENSITIVITY



## ABBREVIATIONS USED IN THIS REPORT

### SOIL PROPERTIES

$\gamma$	UNIT WEIGHT OF SOIL (BULK DENSITY)
$\gamma_s$	UNIT WEIGHT OF SOLID PARTICLES
$\gamma_w$	UNIT WEIGHT OF WATER
$\gamma_d$	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
$\gamma'$	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
$S_r$	DEGREE OF SATURATION
$w_L$	LIQUID LIMIT
$w_p$	PLASTIC LIMIT
$I_p$	PLASTICITY INDEX
s	SHRINKAGE LIMIT
$I_L$	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
$I_c$	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
$e_{max}$	VOID RATIO IN LOOSEST STATE
$e_{min}$	VOID RATIO IN DENSEST STATE
$I_D$	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY $D_r$ IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
Q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
$m_v$	COEFFICIENT OF VOLUME CHANGE = $\frac{-\Delta e}{(1+e)\Delta\sigma}$
$c_v$	COEFFICIENT OF CONSOLIDATION
$C_c$	COMPRESSION INDEX = $\frac{\Delta e}{\Delta \log_{10} \sigma}$
$T_v$	TIME FACTOR = $\frac{C_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
$\tau_f$	SHEAR STRENGTH
$c'$	EFFECTIVE COHESION INTERCEPT
$\phi'$	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
$c_u$	APPARENT COHESION
$\phi_u$	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
$\mu$	COEFFICIENT OF FRICTION
$S_i$	SENSITIVITY

### GENERAL

$\pi$	= 3.1416
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

### STRESS AND STRAIN

u	PORE PRESSURE
$\sigma$	NORMAL STRESS
$\bar{\sigma}$	NORMAL EFFECTIVE STRESS ( $\bar{\sigma}$ IS ALSO USED)
$\tau$	SHEAR STRESS
$\epsilon$	LINEAR STRAIN
$\gamma$	SHEAR STRAIN
$\nu$	POISSON'S RATIO ( $\mu$ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
$\eta$	COEFFICIENT OF VISCOSITY

### EARTH PRESSURE

d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
$\delta$	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
$K_0$	COEFFICIENT OF EARTH PRESSURE AT REST

### FOUNDATIONS

B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
$k_s$	MODULUS OF SUBGRADE REACTION

### SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
$\beta$	ANGLE OF SLOPE TO HORIZONTAL

DEPARTMENT OF HIGHWAYS ONTARIO  
MEMORANDUM

65-15-100  
the report on  
successful

To: Mr. S. Starnac,  
Principal Foundation Engineer,  
Downsview, Ontario.

From: District #3, Stratford.

Date: August 9th, 1965.

Our File Ref.

IN REPLY TO

SUBJECT: Contract No. 60-147, Cut Slope Failure South of the  
Maitland River Bridge, Highway No. 21 at Goderich.

The Grading on this particular section was carried out in 1960-61. Only minor failure has been evident until this Spring, when approx. 500 C.Y. of Topsoil and Clay slid to the shoulder of the Highway.

Seepage zones are not well defined so we would therefore request that your Section carry out an investigation and make recommendations for corrective measures.

An early reply would be appreciated as we would like to have vegetation established this season if possible.

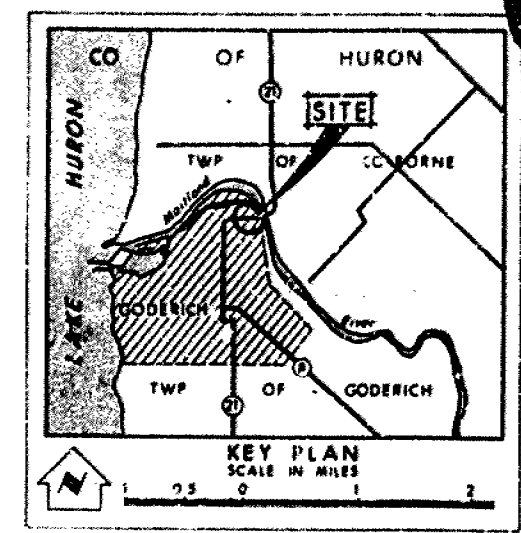
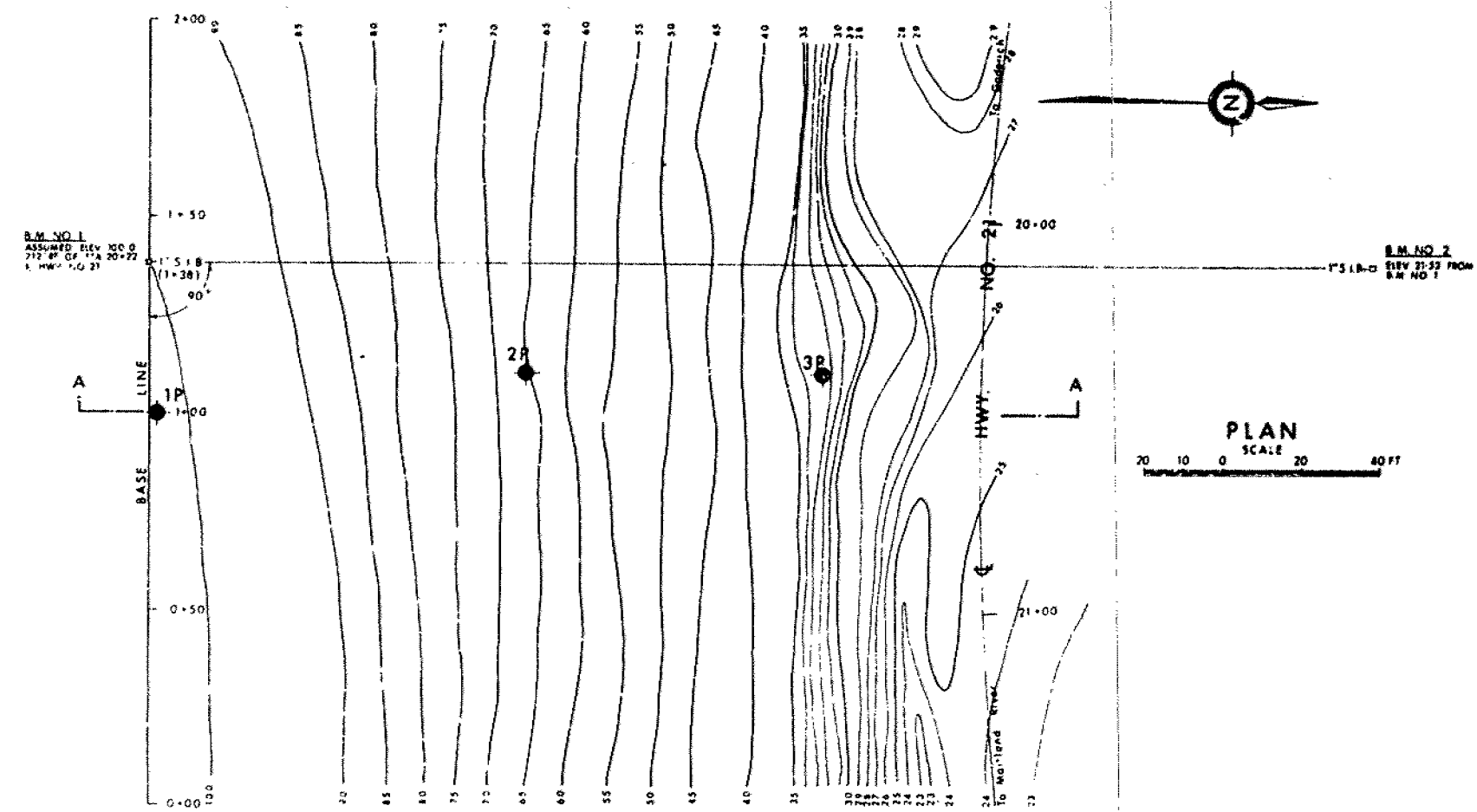
HKB/dw

J. B. Tillcock  
J. G. Tillcock,  
District Engineer.

A foundation investigation can be carried out at this location corner of structures and also establishing the water table.

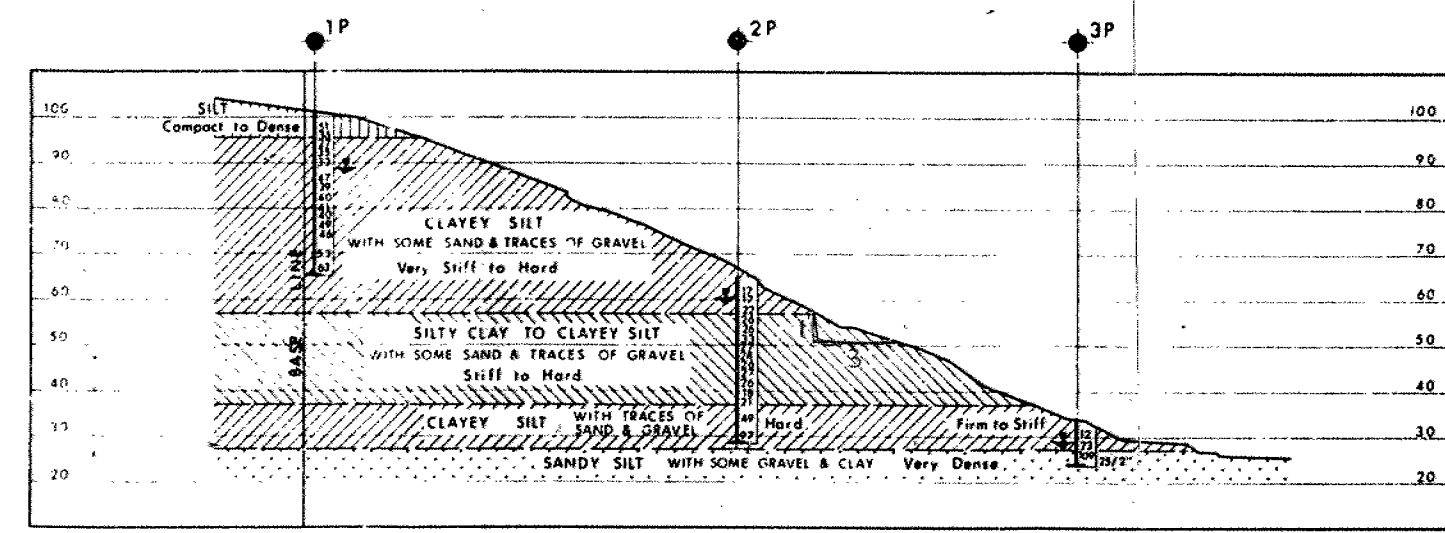
M. Devata  
Aug 18/68

4545+00 E  
4544700 W 40715



# LEGEND

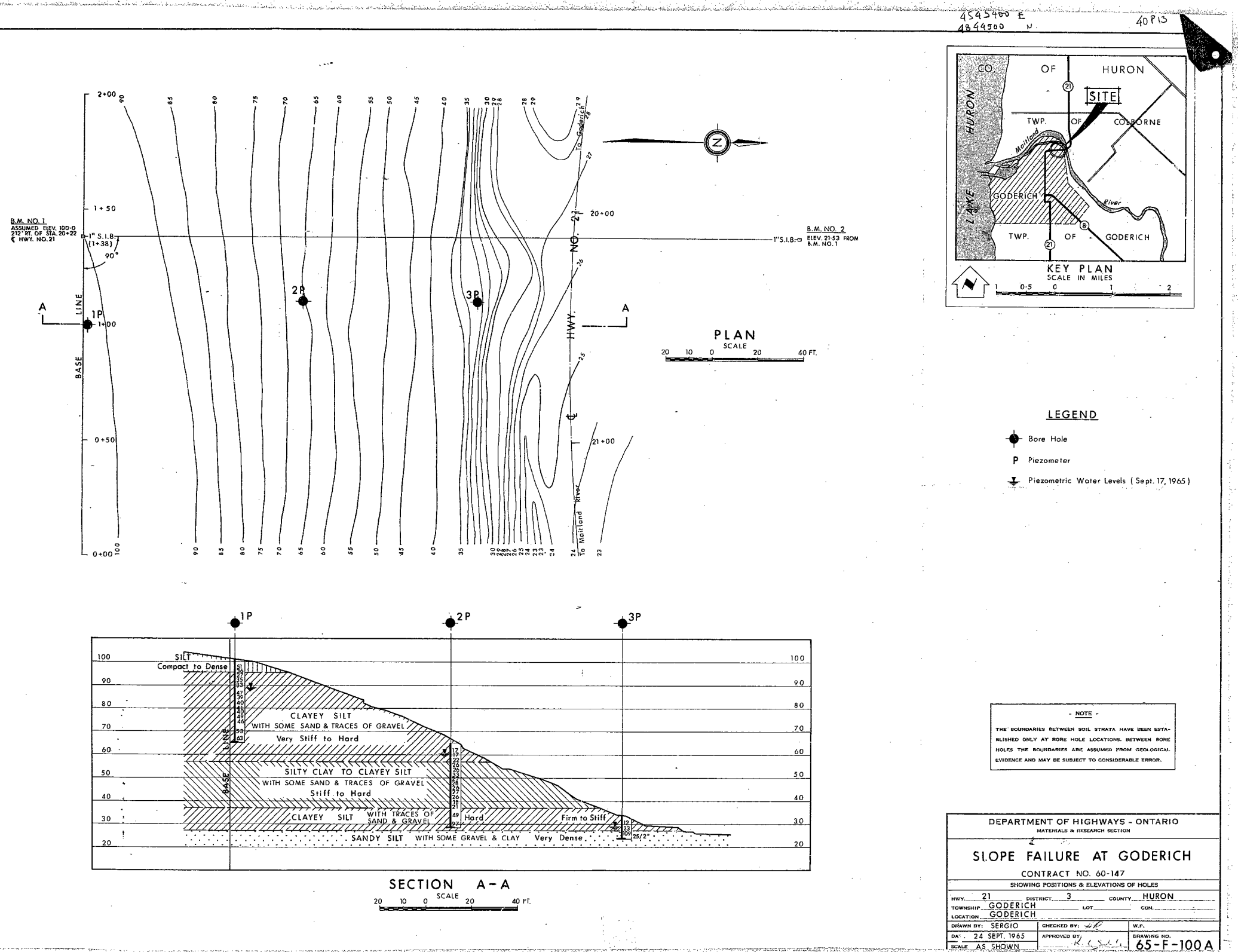
- Bore Hole
- P Piezometer
- ⬇ Piezometric Water Levels (Sept 17, 1965)



NOTE  
THE BOUNDARIES BETWEEN SOIL STRATA HAVE BEEN ESTABLISHED ONLY AT BORE HOLE LOCATIONS. BETWEEN BORE HOLES THE BOUNDARIES ARE ASSUMED FROM GEOLOGICAL EVIDENCE AND MAY BE SUBJECT TO CONSIDERABLE ERROR.

DEPARTMENT OF HIGHWAYS - ONTARIO			
MATERIALS & RESEARCH SECTION			
SLOPE FAILURE AT GODERICH			
CONTRACT NO. 60-147			
SHOWING POSITIONS & ELEVATIONS OF HOLES			
HWY. 21	DISTRICT 3	COUNTY HURON	
TOWNSHIP GODERICH	LOT	CON.	
LOCATION GODERICH			
DRAWN BY: SERGIO	CHECKED BY: [Signature]	W.P.	
DATE 24 SEPT 1965	APPROVED BY: [Signature]	DRAWING NO.	
SCALE AS SHOWN		65-F-100A	

#65-F-100  
CONT. #60-147  
HWY #21  
SLOPE FAILURE  
AT GODERICH



DEPARTMENT OF HIGHWAYS ONTARIO

MEMORANDUM

TO: Mr. J. G. Tillcock,  
District Engineer,  
District #3 (Stratford).

FROM: Foundation Section,  
Materials & Testing Div.,  
Room 107, Lab. Bldg.

DATE: October 28, 1965

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IN REPLY TO No. 22/65

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W.J. 65-F-100 -- Cont. 60-147

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A. G. Stermac,  
PRINCIPAL FOUNDATION ENGINEER

Foundations Office ✓  
Gen. Files

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RECOMMENDATIONS.

MISCELLANEOUS.

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FOUNDATION INVESTIGATION REPORT

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W.J. 65-F-100 -- Cont. 60-147

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INTRODUCTION:

A request for a field investigation at the site of a cut slope failure on the South approach to the Maitland River bridge was received from Mr. J. G. Tillcock, District Engineer. The failure location is on the East side of Hwy. 21 at approximate Sta. 20+50. During the spring of this year, approximately 500 cu. yd. of soil slid down from the side of the 75-foot high cut slope. Since the highway was constructed in 1960-61, a number of minor failures have occurred at this same site.

Three borings were subsequently carried out by this Section along the approximate centre of the failed area in order to determine the subsoil conditions and in addition, four piezometers were installed with the purpose of establishing the ground water conditions.

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This deposit occurs between El. 95.0 and El. 57.0, and El. 37.0 and El. 27.0. The liquid and plastic limit ranges are 25% - 29%, and 13% to 17%, respectively, and the natural moisture content varies from 14% to 25%. Mechanical analyses indicate the following grain size distribution: silt 52%, clay 29%, sand 15%, and gravel 4%. The consistency of the material is classified as very stiff to hard.

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Based on the observations of the piezometers installed at the site, the ground water level is estimated to be as follows:

<u>Borehole</u>	<u>Elevation</u>
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2	60.3
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RECOMMENDATIONS:

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RECOMMENDATIONS: (cont'd.) ...

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(1) Cut-off drains should be provided at the top and centre of the existing slope. The two drains should consist of 10' deep x 3' wide trenches filled with a suitable granular filter medium and incorporating a 6-inch diameter, perforated C.I.P.

(2) The drains should traverse the entire failed zone and discharge into the existing 12-inch diameter C.I.P. some 300 ft. west of the centre of the failed zone.

(3) Connecting drains spaced about 80 - 100 feet apart should also be constructed so as to drain down the face of the slope and discharge into the existing catch basins at the toe of the slope.

(4) After completion of the drainage installation, the slope may be re-shaped and sodded.

cont'd. /5 ...

MISCELLANEOUS:

The field work for this project was carried out during the period August 25 - September 1, 1965, under the supervision of Mr. Paul Payer, Project Foundation Engineer. Equipment used was owned and operated by Canadian Longyear Ltd. This report was prepared by Mr. K. G. Selby, Senior Foundation Engineer.

October 1965

APPENDIX I

MATERIALS &amp; TESTING DIVISION

FOUNDATION SECTION

LOCATION Sta. 1400; 2' ht. (Base Line)

ORIGINATED BY P.P.

W. P.

BORING DATE Aug 25 & 26, 1965.

COMPILED BY \_\_\_\_\_ P.P.

DATUM T.B.A.

BOREHOLE TYPE Washbore-BX Casing.

CHECKED BY AK

SOIL PROFILE			SAMPLES			ELEV SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT ——— W <sub>L</sub>		BULK DENSITY γ P.C.F.	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	SHEAR STRENGTH P.S.F.	PLASTIC LIMIT ——— W <sub>P</sub>	WATER CONTENT ——— W		
101.0	Groundlevel											
0.0	Silt with traces of clay, and sand.  Compact to dense.		1	SS	51	100						Gr 0% Sa 2% Si 91% Cl 7%
95.4			2	SS	36							
5.6			3	SS	27							Gr 4% Sa 13% Si 55% Cl 28%
			4	SS	35							
			5	SS	33	90						
	Clayey silt with some sand and traces of gravel.		7	SS	47							▼ Piez. W.L.
			8	SS	39							Gr 7% Sa 12% Si 49% Cl 32%
	V. stiff to hard.		9	SS	40							
			10	SS	41	80						
	Greyish brown.		11	SS	40							
			12	SS	49							Gr 3% Sa 12% Si 54% Cl 31%
			13	SS	46							
			14	SS	53	70						
64.5			15	SS	63							Gr 1% Sa 17% Si 54% Cl 28%
36.5	End of borehole.					60						



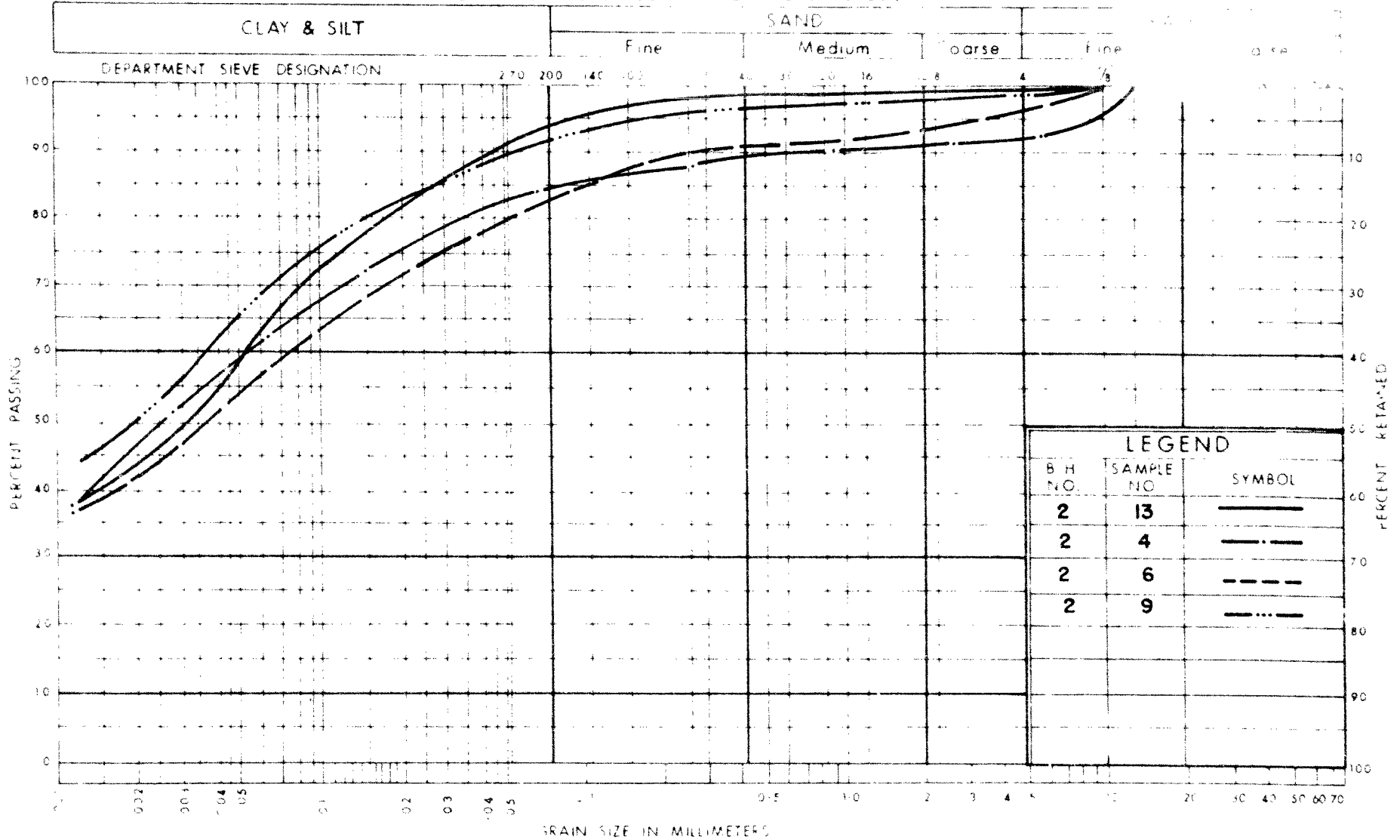
FOUNDATION SECTION

CHECKED BY

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE				LIQUID LIMIT ——— WL PLASTIC LIMIT ——— WP WATER CONTENT ——— W			BULK DENSITY P.C.F.	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	BLOWS / FOOT	SHEAR STRENGTH P.S.F.				WATER CONTENT % 10 20 30				
33.1	Groundlevel													
0.0	Clayey silt with some sand and gravel. Firm to stiff. Greyish brown.		1	SS	12	30								Gr 1% Sa 8% Si 56% Cl 35% Piez W.L.
			2	SS	23									
27.1														
6.0	Sandy silt with some gravel, and clay.		3	SS	109									
23.6	V. dense.		4	SS	25/2"									
9.5	End of borehole.					20								



# UNIFIED SOIL CLASSIFICATION SYSTEM



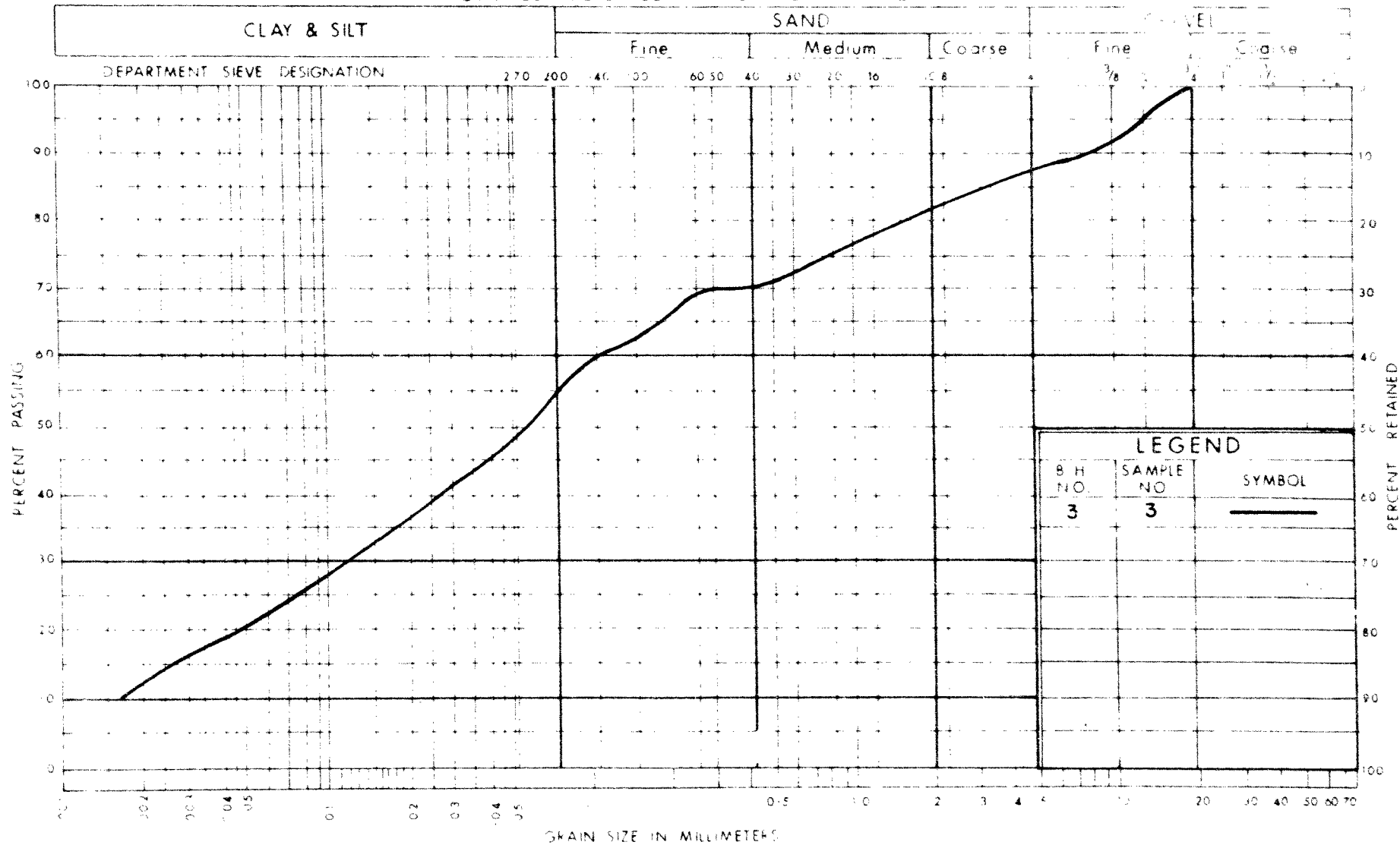
DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION

GRAIN SIZE DISTRIBUTION  
SILTY CLAY & CLAYEY SILT  
WITH SOME SAND & TRACES OF GRAVEL

WP No

JOB No. 65-F-100

# UNIFIED SOIL CLASSIFICATION SYSTEM



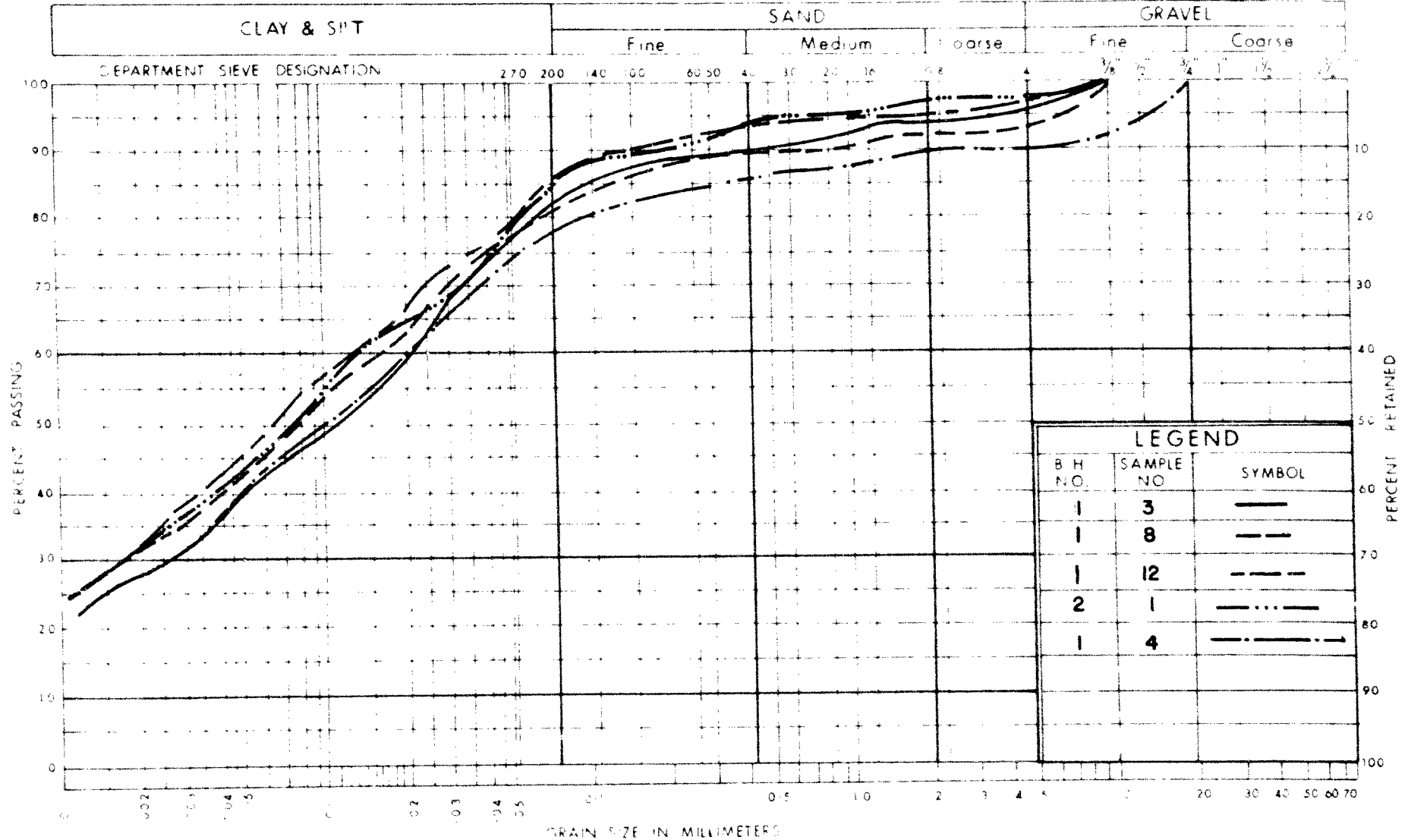
DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION

GRAIN SIZE DISTRIBUTION  
SANDY SILT  
WITH SOME GRAVEL & CLAY

WP No.

JOB No. 65-F -100

# UNIFIED SOIL CLASSIFICATION SYSTEM



ONTARIO

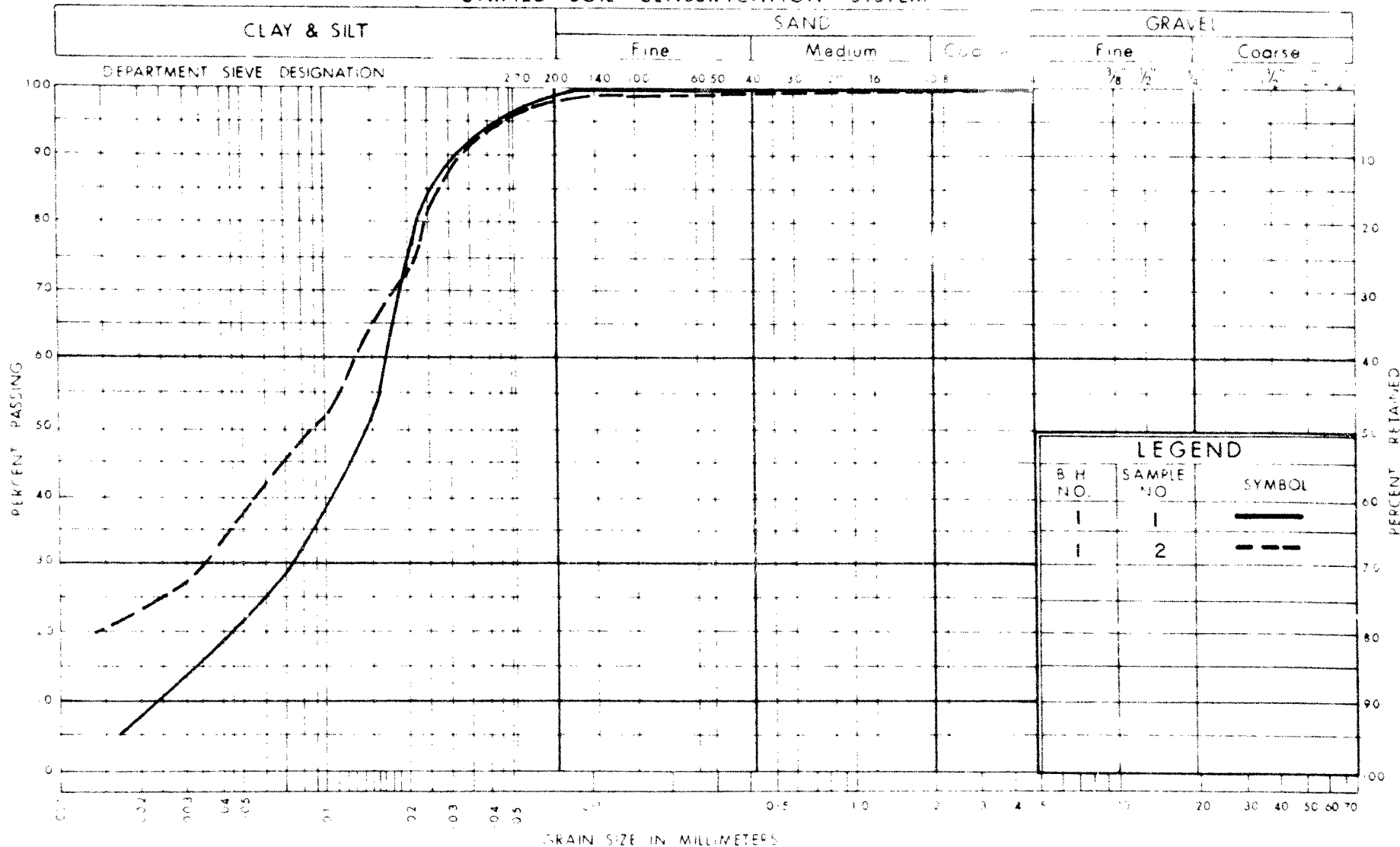
DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION

GRAIN SIZE DISTRIBUTION  
CLAYEY SILT  
WITH SOME SAND & TRACE OF GRAVEL.

WP No

JOB No. 65-F-100

# UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION

## GRAIN SIZE DISTRIBUTION SILT

WITH TRACE OF SAND & CLAY

WP No.

JOB No. 65-F-100

## ABBREVIATIONS USED IN THIS REPORT

### PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE 'N' - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

### DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS:-

<u>CONSISTENCY</u>	<u>'N' BLOWS / FT.</u>	<u>c LB. / SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
VERY SOFT	0 - 2	0 - 250	VERY LOOSE	0 - 4
SOFT	2 - 4	250 - 500	LOOSE	4 - 10
FIRM	4 - 8	500 - 1000	COMPACT	10 - 30
STIFF	8 - 15	1000 - 2000	DENSE	30 - 50
VERY STIFF	15 - 30	2000 - 4000	VERY DENSE	> 50
HARD	> 30	> 4000		

### TYPE OF SAMPLE

S.S	SPLIT SPOON	T.W.	THINWALL OPEN
W.S	WASHED SAMPLE	T.P.	THINWALL PISTON
S.B	SCRAPER BUCKET SAMPLE	O.S	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S	FOIL SAMPLE
C.S	CHUNK SAMPLE	R.C	ROCK CORE
S.T	SLOTTED TUBE SAMPLE		
	P.H	SAMPLE ADVANCED HYDRAULICALLY	
	P.M.	SAMPLE ADVANCED MANUALLY	

### SOIL TESTS

Q <sub>u</sub>	UNCONFINED COMPRESSION	L.V	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V.	FIELD VANE
Q <sub>cu</sub>	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Q <sub>d</sub>	DRAINED TRIAXIAL	S	SENSITIVITY

## ABBREVIATIONS USED IN THIS REPORT

### SOIL PROPERTIES

$\gamma$	UNIT WEIGHT OF SOIL (BULK DENSITY)
$\gamma_s$	UNIT WEIGHT OF SOLID PARTICLES
$\gamma_w$	UNIT WEIGHT OF WATER
$\gamma_d$	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
$\gamma'$	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
$S_r$	DEGREE OF SATURATION
$w_L$	LIQUID LIMIT
$w_p$	PLASTIC LIMIT
$I_p$	PLASTICITY INDEX
s	SHRINKAGE LIMIT
$I_L$	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
$I_C$	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
$e_{max}$	VOID RATIO IN LOOSEST STATE
$e_{min}$	VOID RATIO IN DENSEST STATE
$I_D$	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY $D_r$ IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
$m_v$	COEFFICIENT OF VOLUME CHANGE = $\frac{-\Delta e}{(1+e)\Delta\sigma}$
$c_v$	COEFFICIENT OF CONSOLIDATION
$C_c$	COMPRESSION INDEX = $\frac{\Delta e}{\Delta \log_{10} \sigma}$
$T_v$	TIME FACTOR = $\frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
$\tau_f$	SHEAR STRENGTH
$c'$	EFFECTIVE COHESION INTERCEPT
$\phi'$	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
$c_u$	APPARENT COHESION
$\phi_u$	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
$\mu$	COEFFICIENT OF FRICTION
$S_t$	SENSITIVITY

### GENERAL

$\pi$	= 3.1416
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

### STRESS AND STRAIN

u	PORE PRESSURE
$\sigma$	NORMAL STRESS
$\sigma'$	NORMAL EFFECTIVE STRESS ( $\bar{\sigma}$ IS ALSO USED)
$\tau$	SHEAR STRESS
$\epsilon$	LINEAR STRAIN
$\gamma$	SHEAR STRAIN
$\nu$	POISSON'S RATIO ( $\mu$ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
$\eta$	COEFFICIENT OF VISCOSITY

### EARTH PRESSURE

d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
$\delta$	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
$K_0$	COEFFICIENT OF EARTH PRESSURE AT REST

### FOUNDATIONS

B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
$k_s$	MODULUS OF SUBGRADE REACTION

### SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
$\beta$	ANGLE OF SLOPE TO HORIZONTAL

MEMORANDUM

65-F-100  
*aka report on  
 Maitland*

To: Mr. A. Stermac,  
 Principal Foundation Engineer,  
 Downsview, Ontario.

FROM: District #3, Stratford.

DATE: August 9th, 1965.

OUR FILE REF.

IN REPLY TO

SUBJECT: Contract No. 60-147, Cut Slope Failure South of the  
 Maitland River Bridge, Highway No. 21 at Goderich.

The Grading on this particular section was carried out in 1960-61. Only minor failure has been evident until this Spring, when approx. 500 C.Y. of Topsoil and Clay slid to the shoulder of the Highway.

Seepage zones are not well defined so we would therefore request that your section carry out an investigation and make recommendations for corrective measures.

An early reply would be appreciated as we would like to have vegetation established this season if possible.

*J. G. Tillcock*  
 J. G. Tillcock,  
 District Engineer.

HKB/bw