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DIST. 19 REGION

W.P. No. 343-87-01

CONT. No. 93-205

W. O. No.

STR. SITE No. 48W-86

HWY. No. 61

LOCATION Hwy 61 & Slate River

No. of PAGES -

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

Ontario

Ministry of Transportation

FILE No. __________ **DATE** __________

REMARKS

Reference. 78/8 81-02.
Site No. 48W-84,
Slate Kiln

COMP A:
SLATE 2 — BH 1
SLATE 3 — BH 2
COMP B —
SLATE 5 → BH 3
SLATE 6 → BH 4

ADM-G-24 79-06

FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 93-205

Ministry of Transportation

Ontario

INDEX

Note: For purposes of the contract, this report supersedes all other Foundation Reports prepared by, or for the Ministry in connection with the above mentioned projects.

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS $\bar{N}$.

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	>200
	VERY SOFT	*SOFT*	*FIRM*	*STIFF*	*VERY STIFF*	*HARD*

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	>50
	VERY LOOSE	*LOOSE*	*COMPACT*	*DENSE*	*VERY DENSE*

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	>3m
JOINTING	*VERY CLOSE*	*CLOSE*	*MOD. CLOSE*	*WIDE*	*VERY WIDE*
BEDDING	*VERY THIN*	*THIN*	*MEDIUM*	*THICK*	*VERY THICK*

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY $= \frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL

e	1,%	VOID RATIO
n	1,%	POROSITY
w	1,%	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_P	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_P	%	PLASTICITY INDEX $= w_L - w_P$
I_L	1	LIQUIDITY INDEX $= \frac{w - w_P}{I_P}$
I_C	1	CONSISTENCY INDEX $= \frac{w_L - w}{I_P}$
e_{max}	1,%	VOID RATIO IN LOOSEST STATE

e_{min}	1,%	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_u	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

FOUNDATION INVESTIGATION REPORT
For
Slate River
Bridge Replacement, Hwy. 61
W.P. 343-87-01, Site No. 48W-86
District 19, Thunder Bay

INTRODUCTION

This report summarizes the information obtained from a foundation investigation carried out at the above mentioned site where a single span structure is proposed to replace the existing single span bridge along the Hwy. 61 crossing the Slate River. Twin Bailey Bridges are also proposed for the detour during construction.

The fieldwork was carried out between 91 06 10 and 91 06 18. Four boreholes (BH 1 to BH 4) were advanced and sampled as part of this project by means of hollow stem augers with a conventional diamond drill (BW casing and BXL core barrel) adopted for rock sampling purposes. These boreholes extended down to depths of 10.7 and 34.8 m below the existing ground surface.

This report contains factual information obtained from this investigation.

SITE DESCRIPTION

The bridge site is located on Hwy. 61, about 1 km north of the junction with Hwy. 608, in the Blake Township, Neebing Township Municipality, District of Thunder Bay.

The existing structure is a 10 m single span bridge founded on timber piles. The topography in the immediate area is generally flat to gently undulating, occupied by agricultural and dairy farming with a few rural homes located along the existing Hwy. 61.

According to available information the overburden is essentially silty clay. Bedrock in this area is "Shale and interbedded Sandstone" of the Rove Formation of the Animikie Group of Middle Precambrian age.

SUBSURFACE CONDITIONS

The subsoil conditions encountered across the site are generally uniform. Sand and clayey silt fills were encountered as much as 4.6 m at BH 3. A thin layer of asphalt pavement (about 0.2 m) was found in the road of existing Highway 61 (BH's 1 and 2). Clayey silt topsoil was found at two borehole locations (about 0.7 m thick) underneath the fill. These materials were found to be underlain by an extensive brown silty clay to clay deposit with a maximum thickness of about 13.3 m at BH 1, which, in turn, overlies a thick deposit of black clayey silt. Thickness of this black clayey silt layer ranges from 8.9 m at BH 1 to 11.7 m at BH 2. Sandy silt to silt layer was encountered underneath this black clayey silt layer with a maximum proven thickness of 3.1 m at BH 1, overlying about 3.9 m thick non-cohesive glacial till. These overburden materials are underlain by a Rove Formation shale bedrock.

The bedrock surface is slightly undulating with an elevation ranged from 191.4 m at BH 1 to 191.6 m at BH 2 which are corresponded to 32.9 m and 32.5 m below the existing ground surface. Bedrock is known to be "Shale with interbedded Sandstone" of the Rove Formation.

The boundaries between the various soil types, in situ and laboratory test results are shown on the attached Record of Borehole sheets in the Appendix. The locations and elevations of the boreholes, along with profiles showing soil stratigraphy based on borehole data, are shown on Dwg. No. 3438701-A.*

A detailed description of the subsurface conditions and embankment fill material is given below.

Fill Material

This material was encountered at all borehole locations. The composition of this fill material ranged from a brown sand and gravel to a brown reworked clayey silt. The thickness of sand and gravel fill, which was found underneath 0.2 m thick asphalt pavement, is about 1.2 m at BH's 1 and 2. Through a Grain Size Distributon test and visual observation, it can be classified as a sand and gravel as shown on Figure 1.

* DWG NO 2 OF THE CONTRACT DWG'S

Overlying the site and encountered underneath the sand and gravel fill is a brown reworked clayey silt fill material with trace to some sand and gravel. The thickness of this layer varies from 1.4 m at BH 4 to 4.6 m at BH 3 as shown on Record of Borehole sheets. This fill has been placed when building the existing highway embankments in this area.

Atterberg Limit tests were performed on these samples as shown on Figure 2. From the plasticity chart, it is evident that the layer can be classified as an inorganic clayey silt with a low plasticity (CL). Grain Size Distribution tests were carried out on these materials. Figure 3 in the Appendix shows the results.

Topsoil

Topsoil was encountered underneath the clayey silt fill at two borehole locations. The thickness of this layer is about 0.7 m at BH's 3 and 4. Through a Grain Size Distribution test and Atterberg Limit test, (Figures 2 and 3), the material can be classified as a clayey silt with trace of organics.

Silty Clay to Clay

This is the predominant stratum found in all boring locations. The proven thickness of this deposit ranges from 11.4 m at BH 2 to 13.3 m at BH 1. This material is brown in colour.

Atterberg Limit tests were performed on these samples and the results are plotted on Figure 4 and summarized as follows:

Index Properties	Range (%)
Natural Moisture Content (w)	37.0-68.0
Liquid Limit (w_L)	42.0-76.0
Plastic Limit (w_P)	18.0-29.0
Plasticity Index (I_P)	22.0-49.0

From the plasticity chart, it is evident that the layer can be classified as an inorganic silty clay to clay with intermediate to high plasticity (CI or CH).

Grain Size Distribution tests were carried out on these materials. Figure 5 in the Appendix shows the results in an envelope form.

Undrained shear strength of the soil was determined by in situ vane tests and by laboratory tests, namely unconfined compression tests. The results are plotted on Figure 6 and the Record of Borehole log sheets in the Appendix and summarized as follows:

Undrained Shear Strength	Cu(kPa)	(Average)	Sensitivity	(Average)
In Situ Vane Tests	42->100	(65)	2-7	(3.2)
Unconfined Compression Tests	14-42	(29)		

As shown on Figure 6, the vane strengths measured within 2 to 4 m (elevation above 216 m) varied from 55 kPa to greater than 100 kPa, indicating a stiff to very stiff consistency. Below 4 m (elevation 216 m and above 208 m), the vane strengths, which varied from 45 kPa to 75 kPa indicated a generally firm to stiff consistency. This silty clay to clay deposit has a sensitivity varying from 2 to 7 based on the measured undisturbed and remoulded vane strengths. This would indicate that the silty clay to clay is generally sensitive.

An odometer test was carried out to investigate the consolidation characteristics of the silty clay to clay. The sample tested is considered representative of the clay deposit was selected from a Shelby tube sample obtained at about elevation 213 m in BH 2. The results of the consolidation test are shown on Figure 7. The preconsolidation pressure is estimated to be about 205 kPa, indicating an over-consolidation ratio of about 1.5 relative to the existing effective overburden stress. The compression index was determined to be about 0.71.

Clayey Silt

In BH's 1 and 2, an 8.9 m to 11.7 m thick layer of clayey silt was encountered between the upper silty clay to clay and the underlying sandy silt to silt layer. This material is black in colour.

Atterberg Limit tests were carried out on this material as shown on Figure 8. Test results indicate that the Liquid Limit varies from 24 to 26 percent with corresponding plasticity indices of 8 and 11 percent. Measured water contents determined from samples of this layer vary from 27 to 29 percent which are higher than the liquid limit. Figure 9 shows the Grain Size Distribution of this material.

The field vane strengths obtained in this stratum varied from 15 kPa to about 75 kPa indicating a soft to stiff consistency. The sensitivity of this deposit varies from 1.5 to about 7 indicating this material being sensitive.

Sandy Silt to Silt

Underlying the thick deposit of clayey silt, a thin layer of grey sandy silt to silt was encountered in BH's 1 and 2. The thickness of this layer ranges from 1.9 m at BH 2 to 3.1 m at BH 1. This layer is basically non-plastic. Figure 10 in the Appendix shows the results of Grain Size Distribution tests.

In this stratum, the 'N' value is about 16 blows/0.3 m indicating a state of compaction described as compact.

Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)

Underlying the sandy silt to silt deposit at a depth ranging from 28.7 m to 32.9 m, a heterogeneous mixture of silt, sand and gravel with occasional boulders of glacial origin was encountered. The thickness of this stratum ranges from about 3.8 m at BH 2 to 3.9 m at BH 1. Rock coring techniques were required to penetrate occasional boulders within the stratum. Figure 11 shows the results of Grain Size Distribution tests for this material.

In this stratum, the 'N' values ranged from 39 to over 100 blows/0.3 m indicating a state of compaction described as dense to very dense.

Bedrock

The glacial till deposit is directly underlain by bedrock of the Rove Formation of the Animikie Group of middle Precambrian age which was proven at two borehole locations by obtaining up to 2.3 m of rock core samples. The bedrock consists mainly of shale with interbedded sandstone. Detailed descriptions of the rock are attached in the Appendix entitled "Description of Rock Core".

Core Recoveries (CR) and Rock Quality Designation (RQD) were determined in situ and also in the laboratory to evaluate the competence and integrity of the rock. Core Recoveries (CR) between 75 and 100 percent and Rock Quality Designation (RQD) values ranges from 0 to 79 percent. Based on these results, the rock can be classified as weak to medium strong rock and slighty weathered to unweathered.

GROUNDWATER CONDITIONS

Groundwater conditions were observed through the measurement of water level in the open boreholes and in piezometers installed at 3 borehole locations. The groundwater level in both open boreholes after completion and piezometers were found to range from depth of 1.5 m to 4.8 m below the existing ground surface which correspond to an approximate elevation of 220.4 m and 219.1 m, respectively. However, it is likely that the groundwater level is subject to seasonal fluctuations.

MISCELLANEOUS

The fieldwork for this investigation was carried out during the period of 91 06 10 to 91 06 18 under the supervision of M. Iampietro, Student Engineer. The equipment was owned and operated by Dominion Soil Investigation Ltd., Thunder Bay.

This report was written by T. C. Kim, Senior Foundation Engineer and reviewed by M. Devata, Chief Foundation Engineer.

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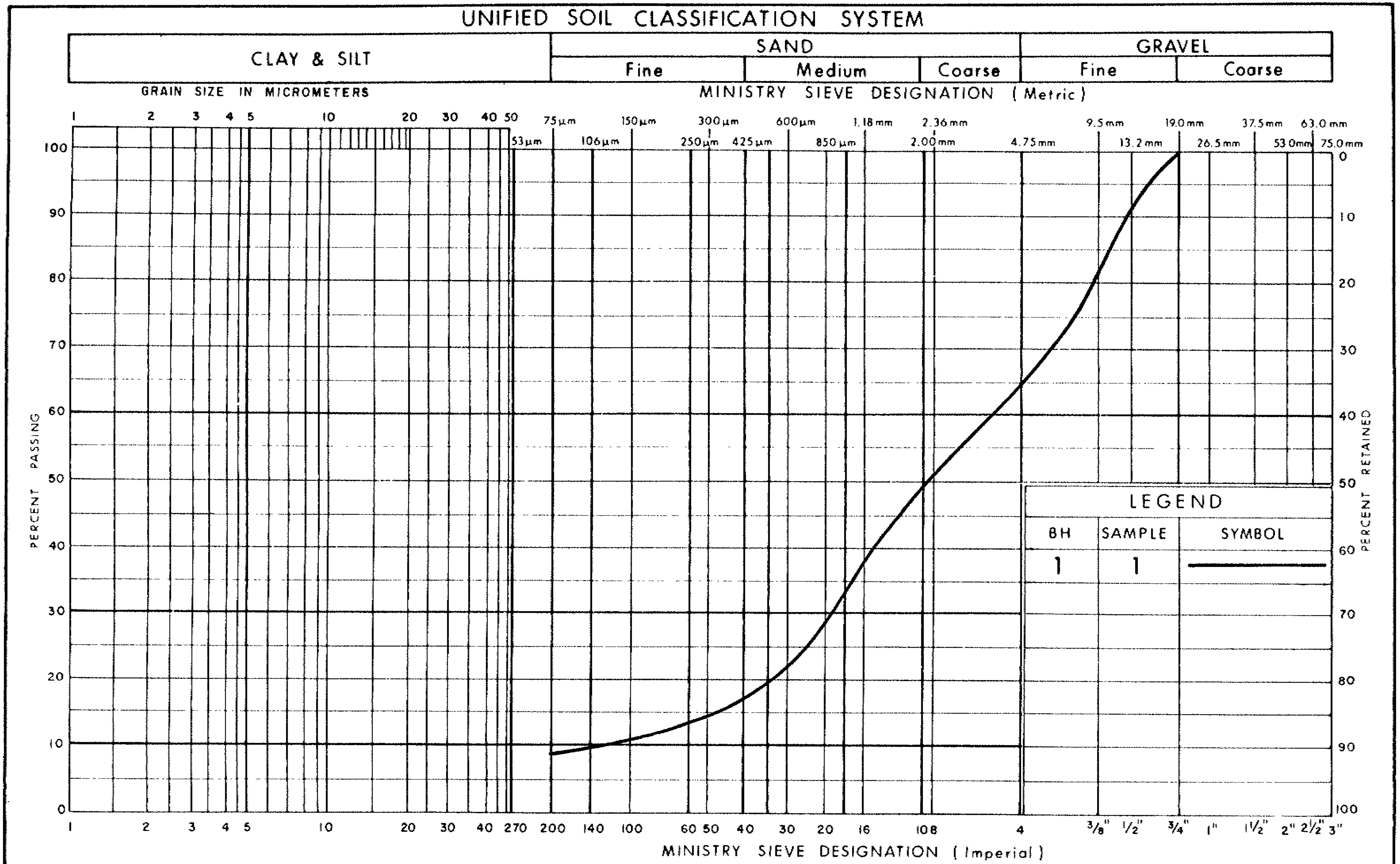
A P P E N D I X

78 12 M



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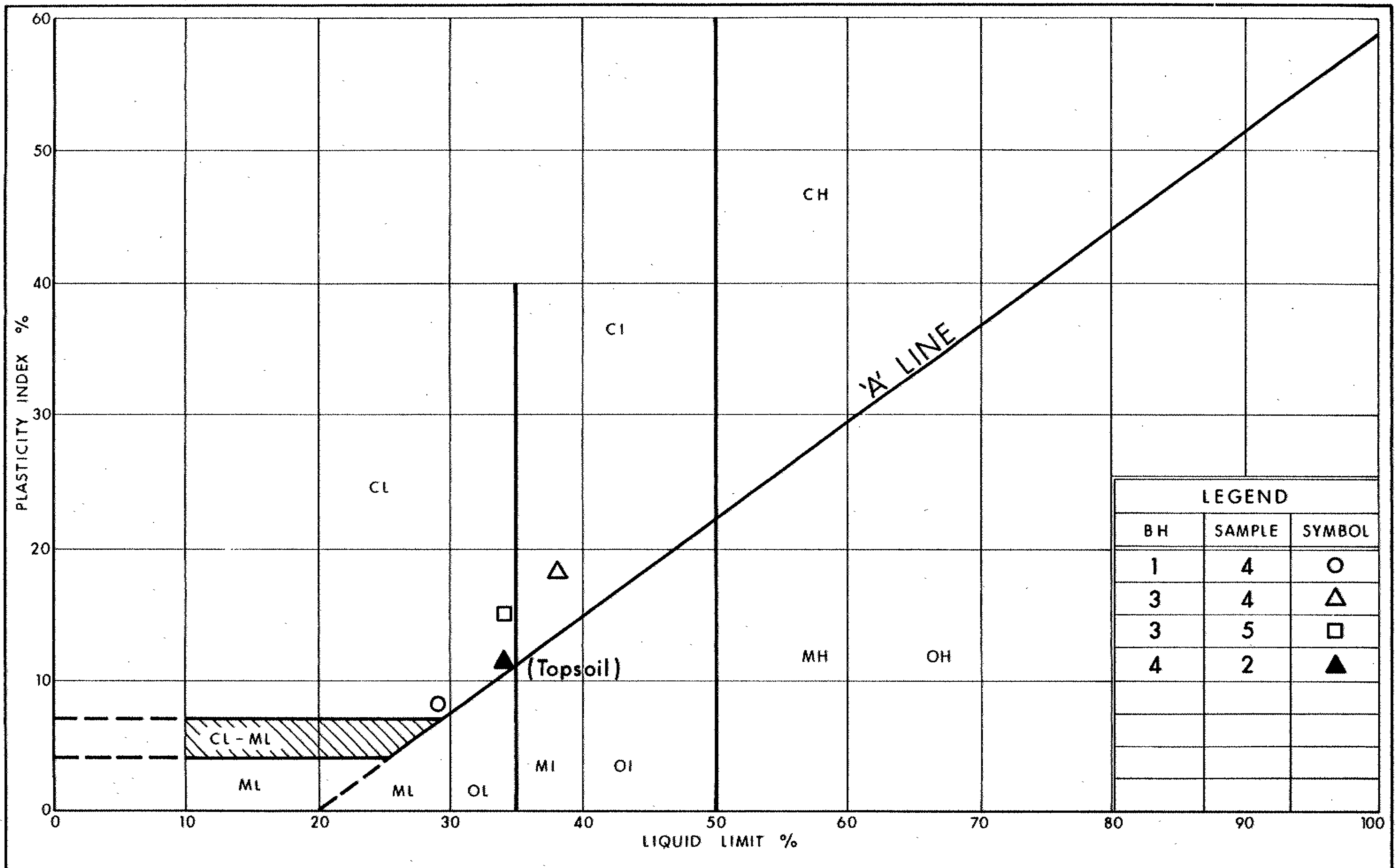
GRAIN SIZE DISTRIBUTION
SAND & GRAVEL (Fill)

FIG No 1

WP 343-87-01



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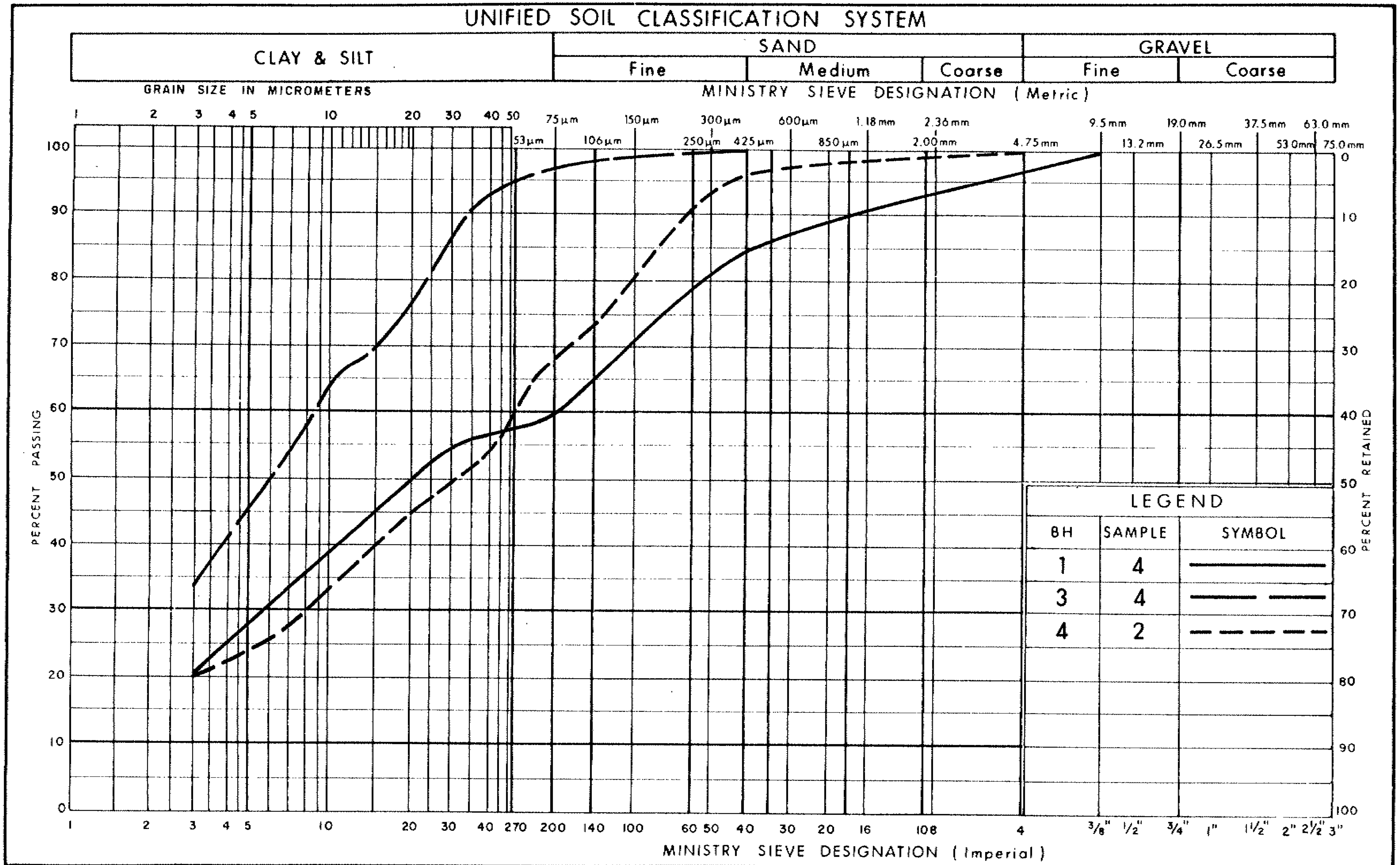
PLASTICITY CHART

CLAYEY SILT, TRACE TO SOME SAND & GRAVEL
(Fill and Topsoil)

FIG No 2

W P 343-87-01



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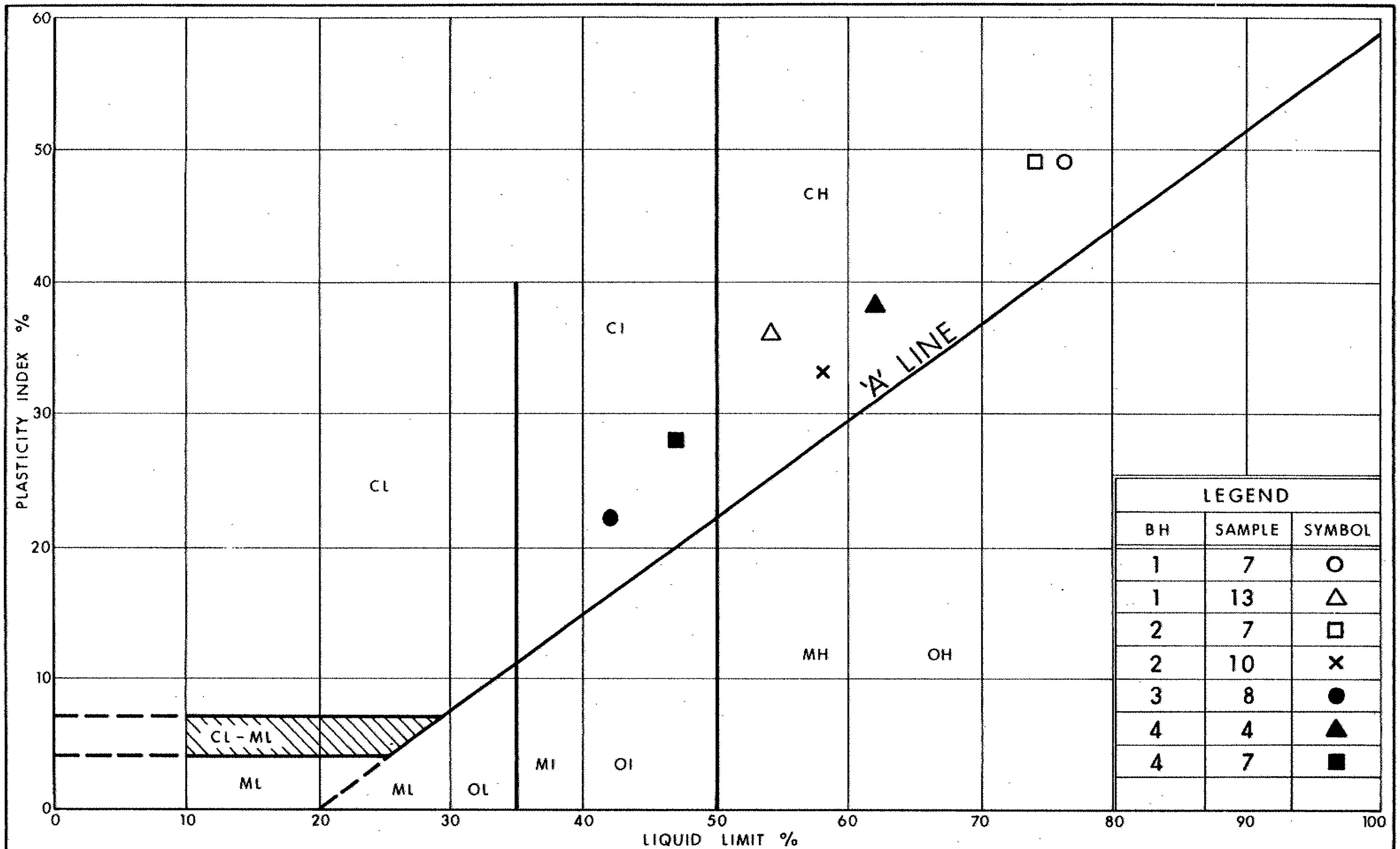
GRAIN SIZE DISTRIBUTION

CLAYEY SILT, TRACE TO SOME SAND & GRAVEL
(Fill and Topsoil)

FIG No 3

W P 343-87-01



LEGEND

BH	SAMPLE	SYMBOL
1	7	○
1	13	△
2	7	□
2	10	×
3	8	●
4	4	▲
4	7	■

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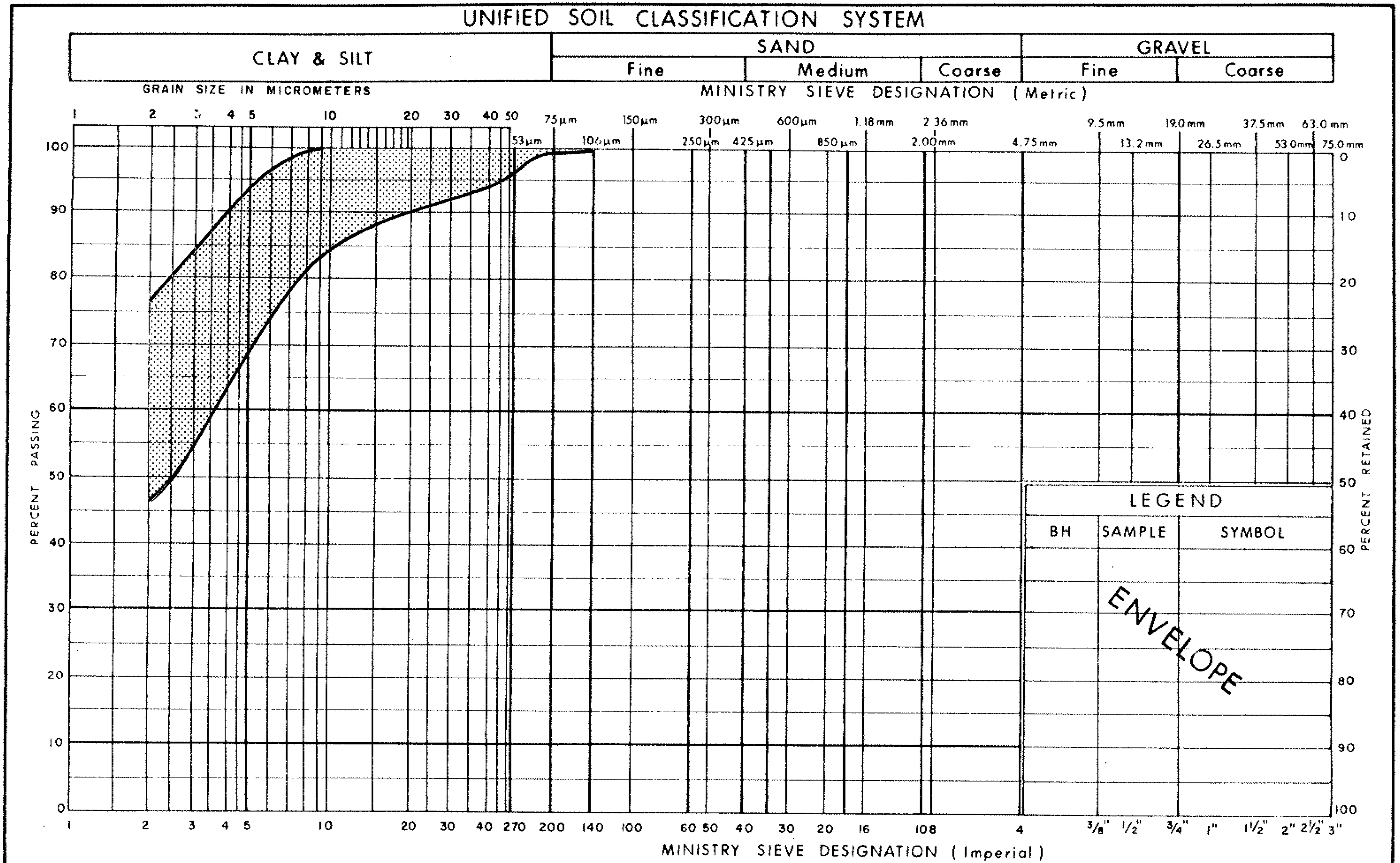
PLASTICITY CHART
SILTY CLAY TO CLAY

FIG No 4
W P 343-87-01



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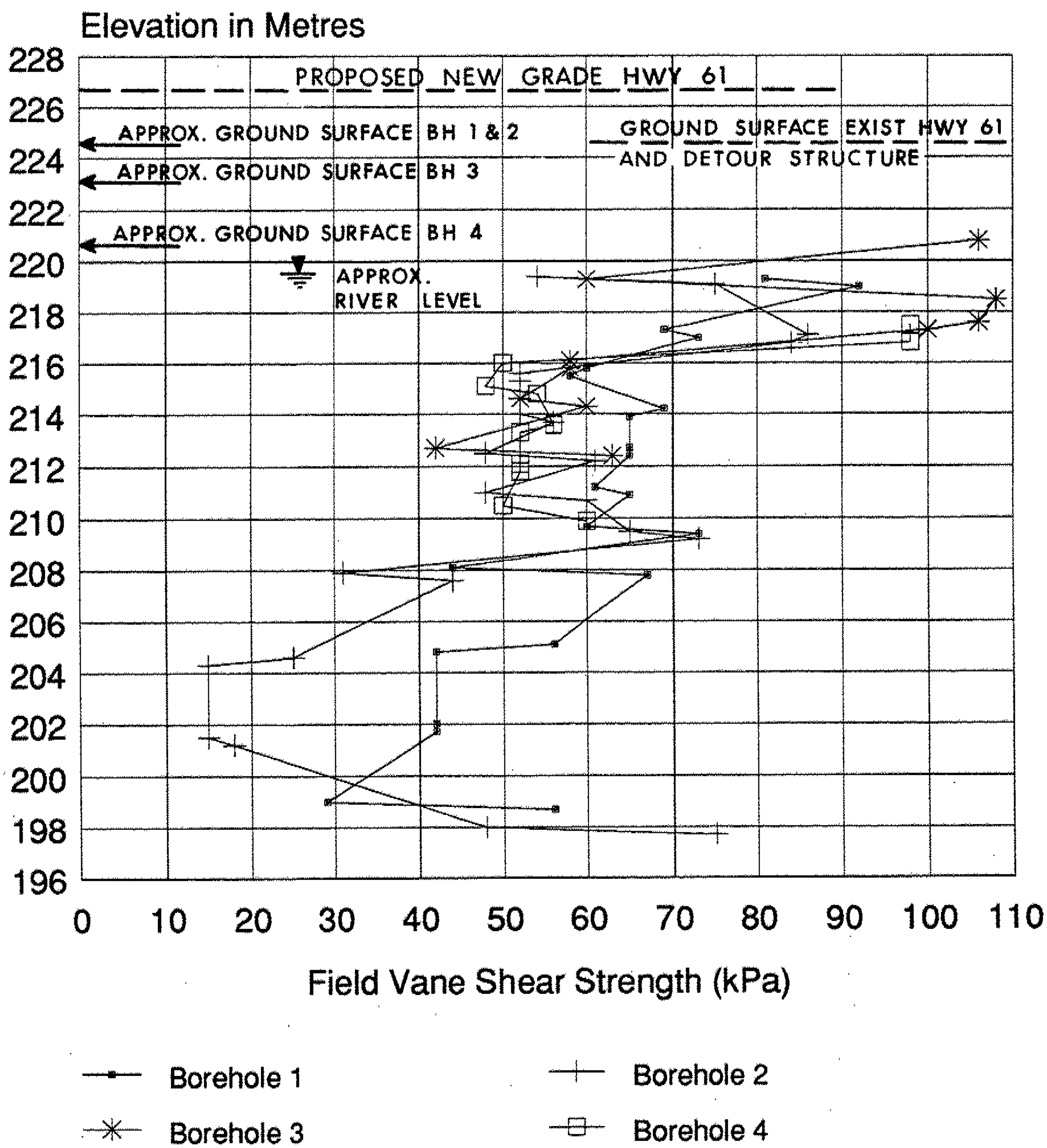
GRAIN SIZE DISTRIBUTION
SILTY CLAY TO CLAY

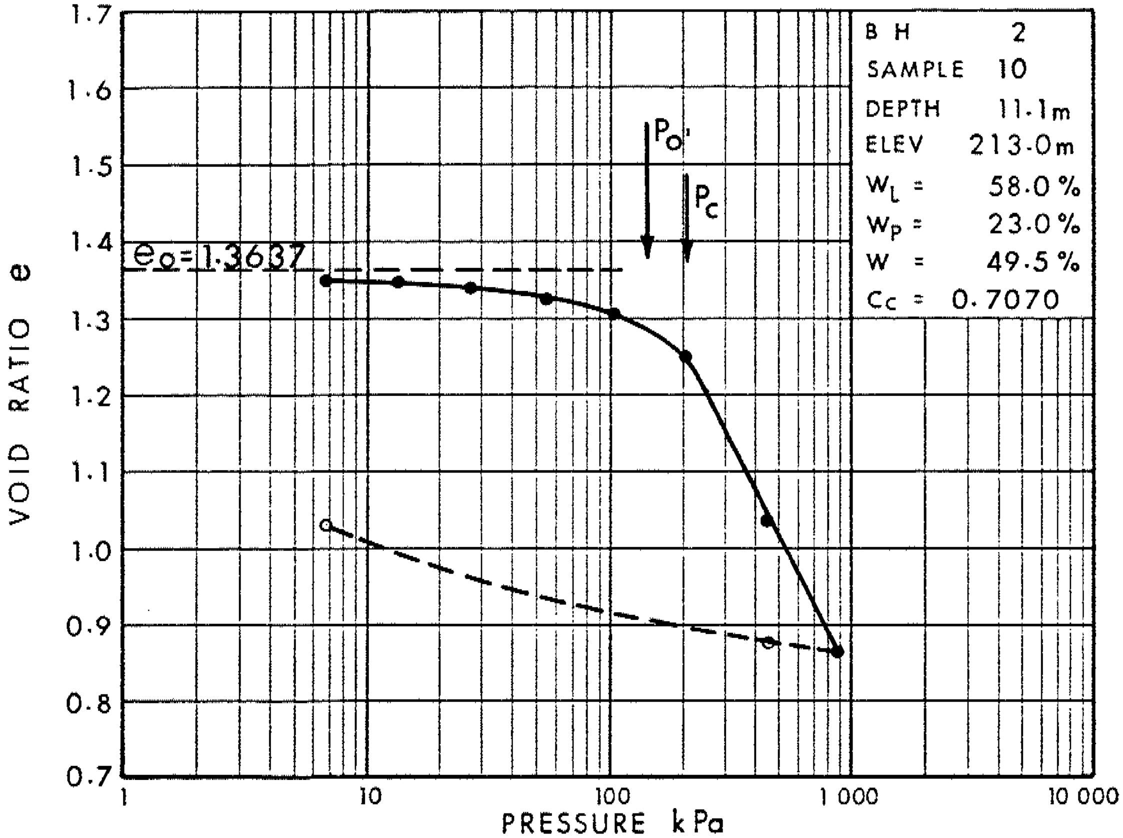
FIG No 5

W P 343-87-01

FIGURE 6. PROFILE OF FIELD VANE STRENGTH Vs. ELEVATION



VOID RATIO - PRESSURE CURVES



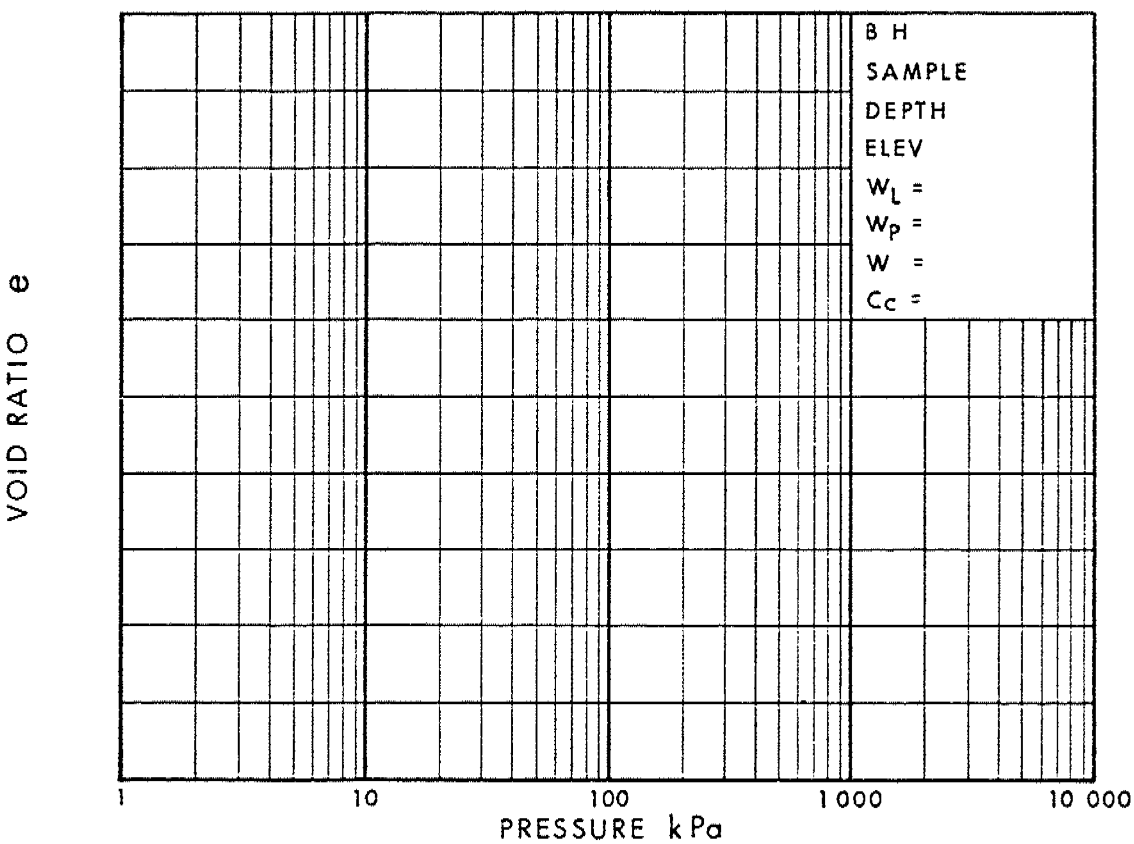
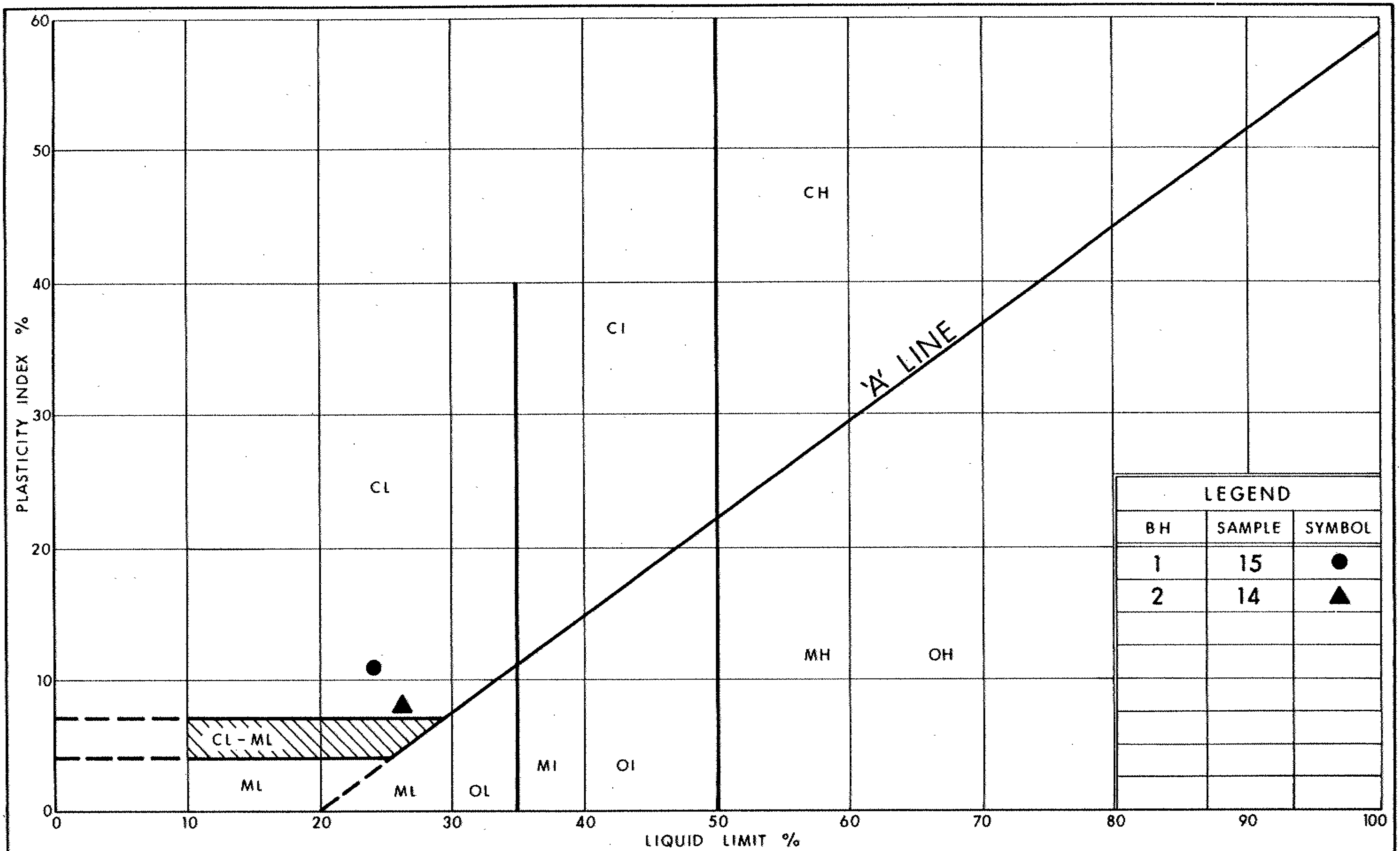


Fig 7

Oct 75, FF-S-21



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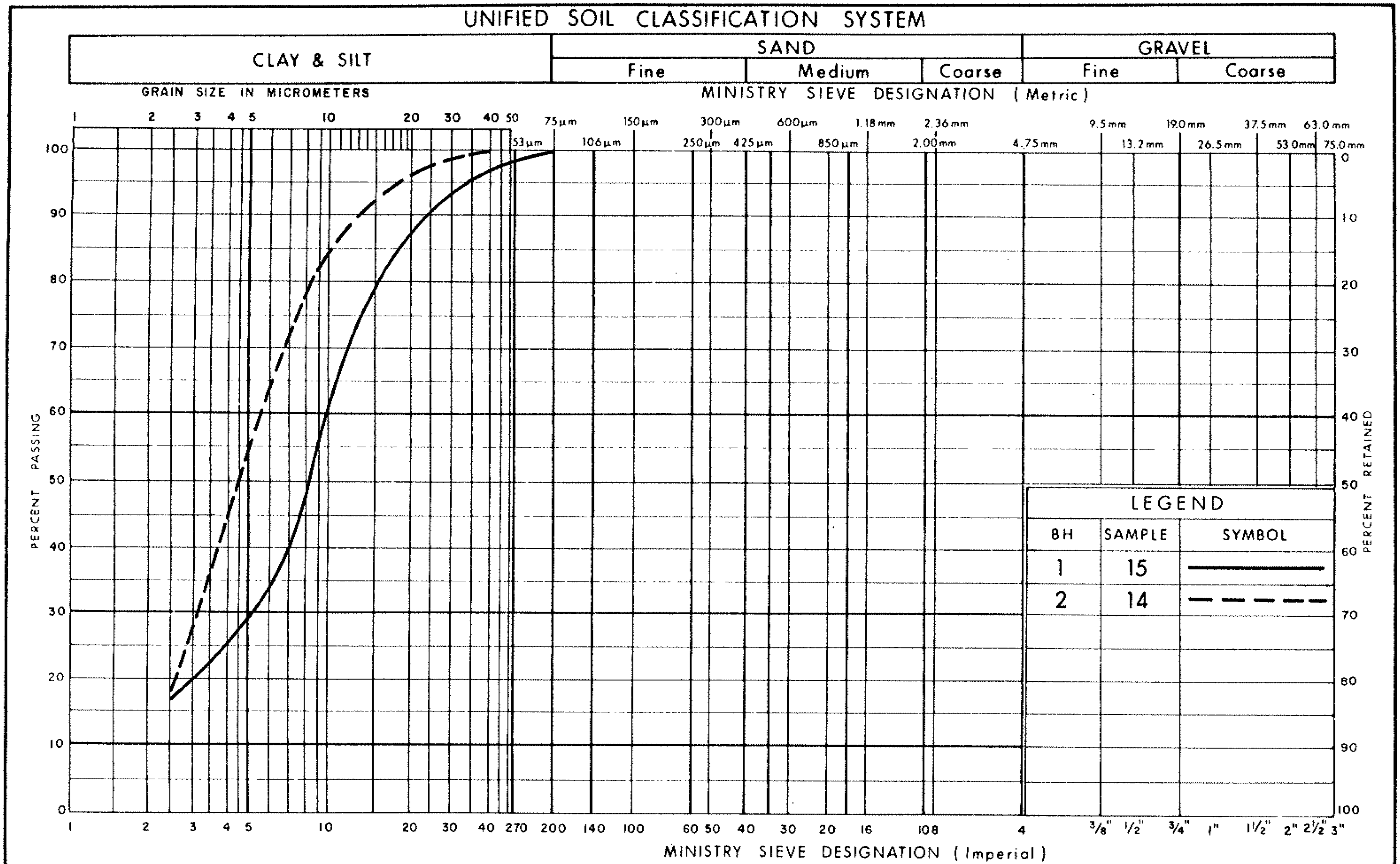
PLASTICITY CHART
CLAYEY SILT

FIG No 8
W P 343-87-01



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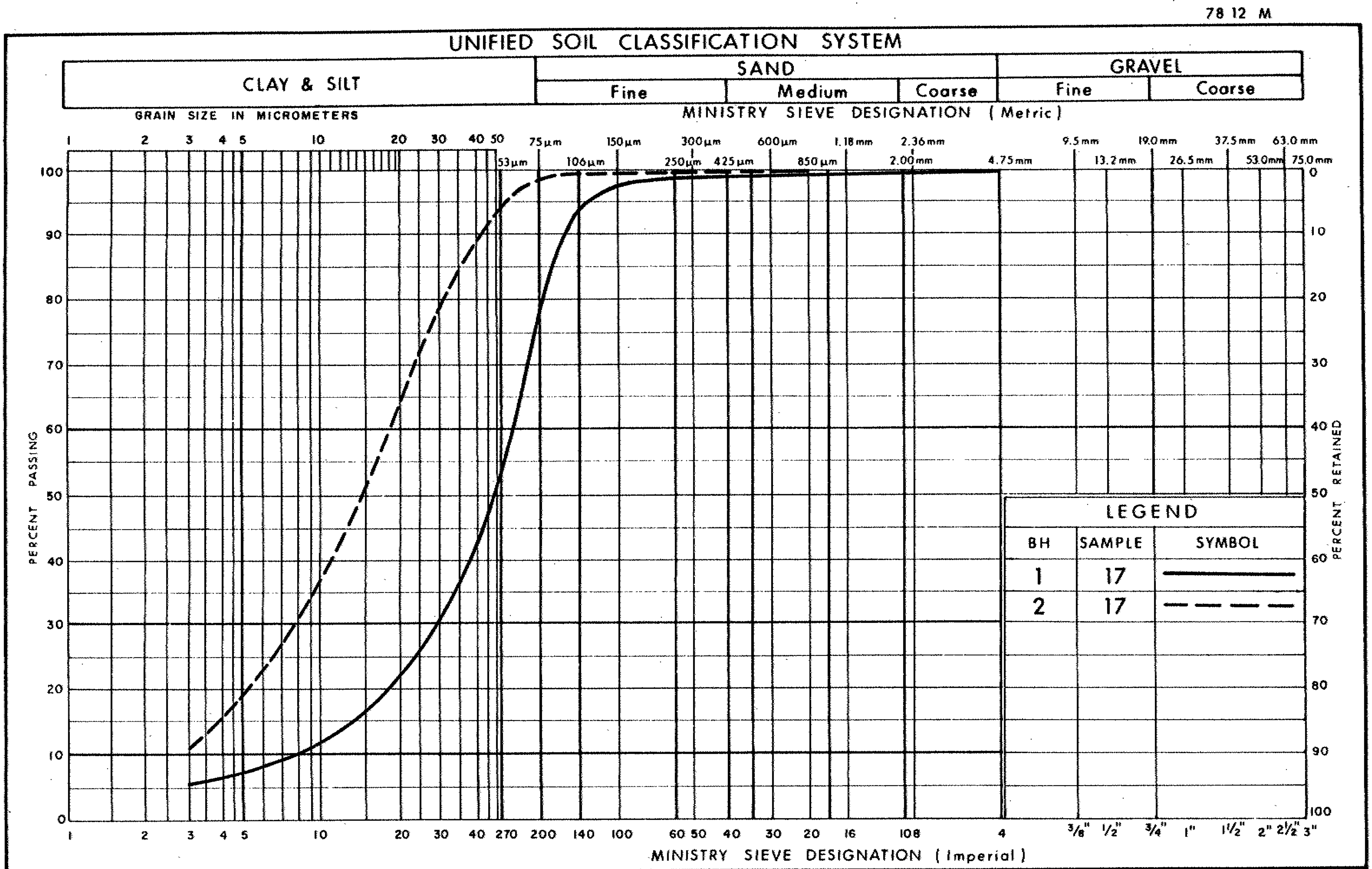
GRAIN SIZE DISTRIBUTION
CLAYEY SILT

FIG No 9

W P 343-87-01



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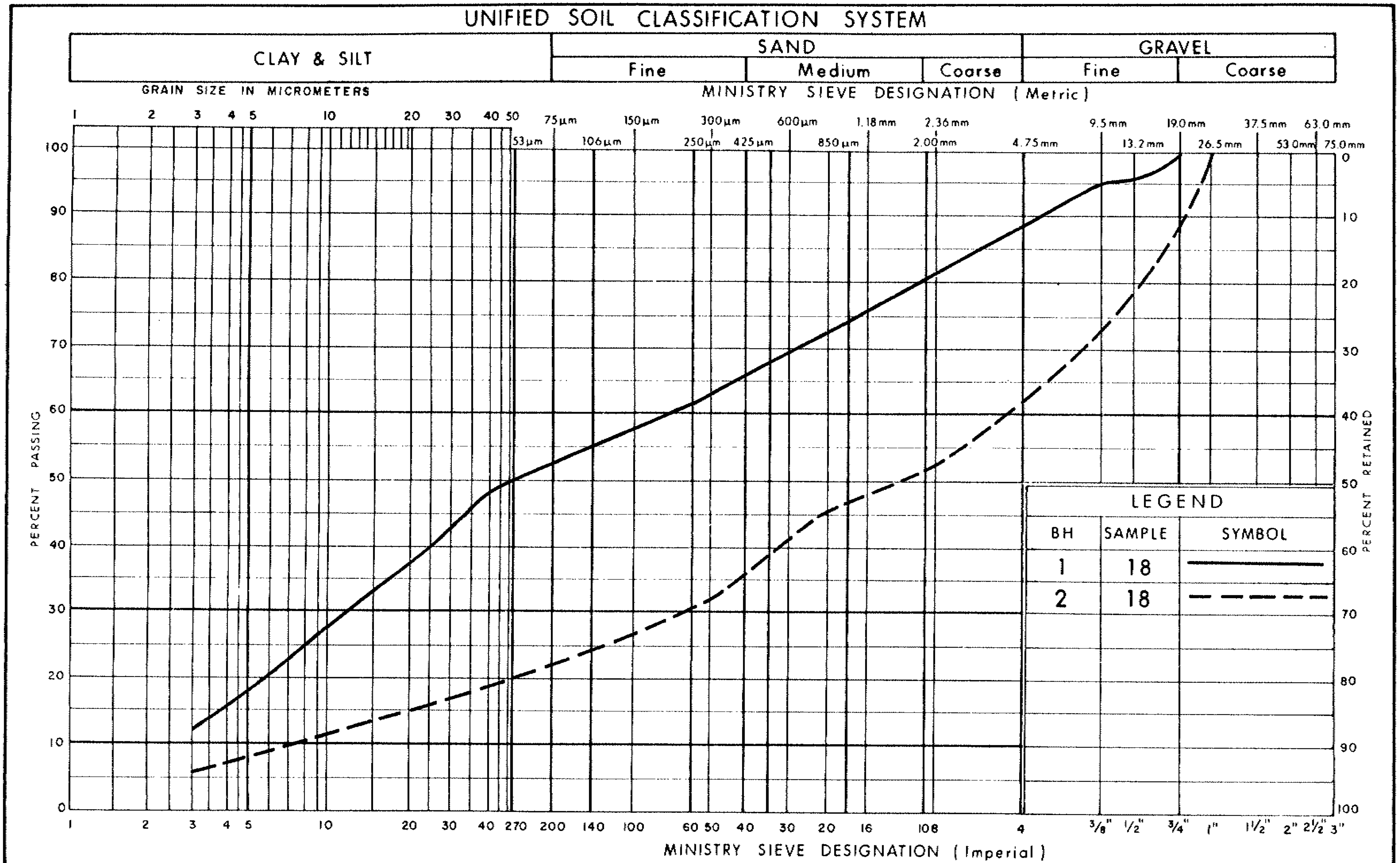
GRAIN SIZE DISTRIBUTION
SANDY SILT TO SILT

FIG No 10
W P 343-87-01



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GRAIN SIZE DISTRIBUTION

HET MIXTURE OF SILT, SAND & GRAVEL (Glacial Till)

FIG No 11

W P 343-87-01

RECORD OF BOREHOLE No 1

METRIC

W.P. 343-87-01 LOCATION Sta 22+449.5; o/s 4.4m Rt. from ℄ of HWY 61 ORIGINATED BY MI

DIST 19 HWY 61 BOREHOLE TYPE HS Auger, BXL Rock Core COMPILED BY AD

DATUM Geodectic DATE 91 06 13 to 91 06 14 CHECKED BY TCK

Soil Profile

ELEV / DEPTH	DESCRIPTION
224.3	Asphalt Surface
0.0	Asphalt
0.2	Sand and Gravel (Fill) Compact
222.9 / 1.4	Clayey Silt, trace to some Sand and Gravel Firm to Very Stiff (Fill)
220.6 / 3.7	Silty Clay to Clay Stiff (Brown)
207.3 / 17.0	Clayey Silt Firm to Stiff (Black)
198.4 / 25.9	Sandy Silt to Silt (Grey)
195.3 / 29.0	Het. Mixture of Silt, Sand and Gravel occ. boulders (Glacial Till) Dense to Very Dense
193.8 / 30.5	Continued

Samples

NUMBER	TYPE	'N' VALUES
1	SS	22
2	SS	19
3	SS	15
4	SS	7
5	SS	13
6	SS	8
7	TW	PH
8	SS	5
9	TW	PH
10	SS	6
11	TW	PH
12	SS	5
13	TW	PH
14	SS	0
15	TW	PH
16	SS	0
17	SS	0

Ground water conditions: P1

Elevation scale: 224, 222, 220, 218, 216, 214, 212, 210, 208, 206, 204, 202, 200, 198, 196, 194

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE: 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m³

Remarks & Grain Size Distribution (%)

Sample depth	Unit weight / remarks	GR	SA	SI	CL
Sample 1		35	56	9	0
Sample 4	organics 4%	3	38	43	16
Sample 7		0	0	8	92
Sample 13		0	0	40	60
Sample 15	organics 4%	0	0	84	16
Sample 17		0	23	71	6

Continued

$+^3$, $\times^5$: Numbers refer to Sensitivity

15 ◇ 5 (20 above, 10 below) (%) STRAIN AT FAILURE

Continued

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 1

METRIC

W.P. 343-87-01 LOCATION Sta 22+449.5; o/s 4.4m Rt. from ℄ of HWY 61 ORIGINATED BY MI

DIST 19 HWY 61 BOREHOLE TYPE HS Auger, BXL Rock Core COMPILED BY AD

DATUM Geodectic DATE 91 06 13 to 91 06 14 CHECKED BY TCK

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.8	Continued							
30.5	Het. Mixture of Silt, Sand and Gravel occ. boulders Dense to Very Dense (Glacial Till)	18	SS	39		192	oH	12 36 44 8
191.4								
32.9	Bedrock Shale with interbedded Sandstone of the Rove Formation	19	RC	REC	95%	190		RQD 79%
189.9								
34.4	End of Borehole							

Column headings also include: SOIL PROFILE; SAMPLES; STRAT PLOT; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE, 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³.

June 13,1991
* GROUND WATER CONDITIONS

PIEZO. NO.	GROUND WATER ELEVATION (Metres)
1	219.5

$+^3$, $\times^5$: Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 2

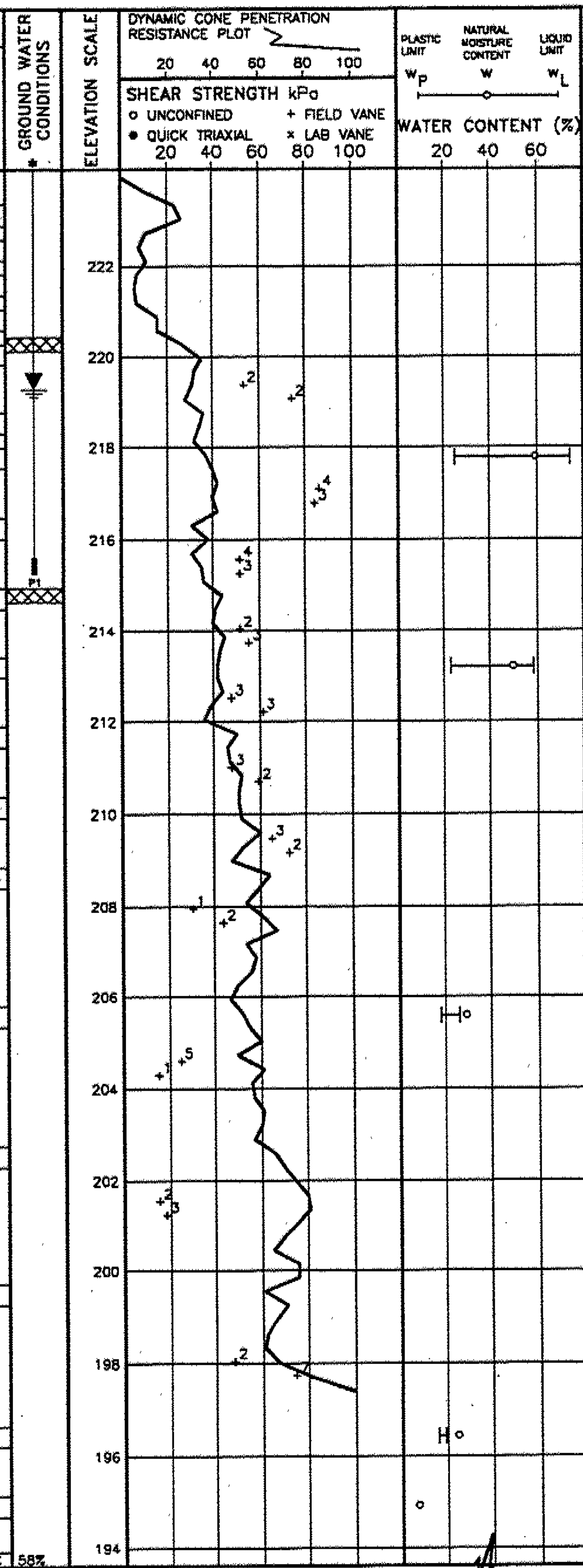
 METRIC

W.P. 343-87-01 LOCATION Sta 22+474.5; o/s 5.2m Lt. from ℄ of HWY 61 ORIGINATED BY MI

DIST 19 HWY 61 BOREHOLE TYPE HS Auger, BXL Rock Core, Cone Test COMPILED BY AD

DATUM Geodectic DATE 91 06 10 to 91 06 13 CHECKED BY TCK

ELEV DEPTH	SOIL PROFILE DESCRIPTION	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
224.1	Asphalt Surface						
0.0	Asphalt						
0.2	Sand and Gravel (Fill) Compact	1	SS	12			
222.7 / 1.4	Clayey Silt, trace to some Sand and Gravel Firm (Fill)	2	SS	5			
		3	SS	7			
		4	SS	6			
220.4 / 3.7	Silty Clay to Clay Stiff	5	SS	9			
		6	TW	PH			
		7	SS	4			
		8	TW	PH	P1		
		9	SS	3			
		10	TW	PH		16.9	0 0 32 68
		11	SS	3			
	Brown	12	TW	PH			
209.0 / 15.1	Black; Clayey Silt Soft to Stiff	13	SS	1			
		14	TW	PH			0 0 85 15
		15	SS	0			
	Black	16	SS	0			
197.3 / 26.8	Grey; Sandy Silt to Silt Compact	17	SS	16			0 1 92 7
195.4 / 28.7	Het. Mixture of Silt, Sand and Gravel occasional boulders Dense to Very Dense (Glacial Till)	18	SS	39			37 40 20 3
193.6 / 30.5		19	RC	REC 58%			RQD 38%



Continued Continued

$+^3$, $\times^5$: Numbers refer to Sensitivity

15-◇-5 (20 above, 10 below) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 2

METRIC

W.P. 343-87-01 LOCATION Sta 22+474.5; o/s 5.2m Lt. from ℄ of HWY 61 ORIGINATED BY MI

DIST 19 HWY 61 BOREHOLE TYPE HS Auger, BXL Rock Core, Cone Test COMPILED BY AD

DATUM Geodetic DATE 91 06 10 to 91 06 13 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
193.6	Continued										
30.5	Het. Mixture of Silt, Sand and Gravel, occ. boulders Dense to Very Dense (Glacial Till)		20	RC	REC	56%					RQD 16%
			21	SS	100	/8cm					
191.6							192				
32.5	Bedrock Shale with interbedded Sandstone of the Rove Formation		22	RC	REC	75%					RQD 50%
			23	RC	REC	100%					RQD 0%
			24	RC	REC	96%	190				RQD 35%
189.3											
34.8	End of Borehole										

June 19, 1991
• GROUND WATER CONDITIONS

PIEZO. NO.	GROUND WATER ELEVATION (Metres)
1	219.3

$+^3, \times^5$: Numbers refer to Sensitivity

15◇5 (20 above, 10 below) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 3

1 OF 1 METRIC

W.P. 343-87-01 LOCATION Sta 22+440.0; o/s 18m Rt from ℄ of HWY 61 ORIGINATED BY MI

DIST 19 HWY 61 BOREHOLE TYPE HS Auger COMPILED BY AD

DATUM Geodectic DATE 91 06 18 CHECKED BY TCK

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
223.1	Ground Surface				
0.0	Brown Clayey Silt, trace to some Sand and Gravel Stiff to Very Stiff (Fill)	1	SS	12	
		2	SS	4	
		3	SS	5	
		4	SS	10	0 4 71 25 organics 3%
		5	SS	2	
218.5 4.6	Clayey Silt, trace organics (Topsoil) Very Stiff	6	SS	3	
217.8 5.3	Silty clay to Clay Stiff	7	SS	3	
		8	SS	3	0 0 59 41
		9	SS	4	
212.4 10.7	End of Borehole				

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, 'N' VALUES); GROUND WATER CONDITIONS *; ELEVATION SCALE (222, 220, 218, 216, 214); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL.

Field vane readings (sensitivity): >100 (3), 2, 6, 4, 4, 3, 3, 3, 2, 3. Piezometer P1.

June 19, 1991
* GROUND WATER CONDITIONS

PIEZO. NO.	GROUND WATER ELEVATION (Metres)
1	220.3

$+^3$, $\times^5$: Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 4 — 1 OF 1 — METRIC

W.P. 343-87-01 LOCATION Sta 22+483.3; o/s 22.4m Rt from ℄ of HWY 61 ORIGINATED BY MI

DIST 19 HWY 61 BOREHOLE TYPE HS Auger COMPILED BY AD

DATUM Geodectic DATE 91 06 18 CHECKED BY TCK

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
220.6	Ground Surface						
0.0	Brown Clayey Silt, trace to some Sand and Gravel (Fill) Soft	1	SS	2	▼	220	
219.2 / 1.4	Clayey Silt, trace organics (Topsoil) Soft	2	SS	2			0 31 48 21
218.5 / 2.1	Silty Clay to Clay Stiff	3	SS	2		218	
		4	SS	4			
		5	TW	PH			
		6	SS	3		216	
		7	TW	PH		214	0 1 57 42
		8	SS	3			
		9	TW	PH		212	
209.9 / 10.7	End of Borehole					210	

Column headings: SOIL PROFILE; SAMPLES; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60); UNIT WEIGHT γ kN/m³.

Field vane readings (sensitivity): +5, +6, +5, +5, +3, +4, +3, +3, +3, +3, 2

$+^3$, $\times^5$: Numbers refer to Sensitivity   15-◇-5 (20 / 10) (%) STRAIN AT FAILURE

ROCK CORE DESCRIPTION
WP 343-87-01

	CORE RECOVERY				CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	19	32.87-34.39	95	79	32.87-33.03	**SANDSTONE**, medium dark grey to medium light grey; fine grained; medium strong; unweathered to slightly weathered; fractures close spaced, flat to near vertical, planar, smooth.
					33.03-34.39	**SHALE**, black to dark grey; fine grained; weak; unweathered to slightly weathered; fractures moderately close to very close spaced, flat to near vertical, planar to undulating, smooth.
2	19	30.18-30.48	58	38	30.18-32.51	**OVERBURDEN** (boulder till).
	20	30.48-31.29	56	16		
	22	32.51-33.02	75	50	32.51-34.80	**SHALE**, black to medium grey; fine grained; weak; unweathered to slightly weathered; fractures extremely close to moderately close spaced, flat to near vertical, planar to undulating, smooth.
	23	33.02-33.38	100	0		
	24	33.38-34.80	96	35		

***CR** = CORE RECOVERY

***RQD** = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

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Ontario

FOUNDATION DESIGN SECTION

foundation investigation and design report

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

CONT 93-205

WP 343-87-01 DIST 19

HWY 61 STR SITE 48W-86

Slate River
Bridge Replacement, Hwy. 61

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FOUNDATION INVESTIGATION REPORT

For

Slate River

Bridge Replacement, Hwy. 61

W.P. 343-87-01, Site No. 48W-86

District 19, Thunder Bay

INTRODUCTION

This report summarizes the information obtained from a foundation investigation carried out at the above mentioned site where a single span structure is proposed to replace the existing single span bridge along the Hwy. 61 crossing the Slate River. Twin Bailey Bridges are also proposed for the detour during construction.

The fieldwork was carried out between 91 06 10 and 91 06 18. Four boreholes (BH 1 to BH 4) were advanced and sampled as part of this project by means of hollow stem augers with a conventional diamond drill (BW casing and BXL core barrel) adopted for rock sampling purposes. These boreholes extended down to depths of 10.7 and 34.8 m below the existing ground surface.

This report contains factual information obtained from this investigation pertaining to structure foundations, approach embankments and related earthworks for the bridge structures as shown on Dwg. No. 3438701-A.

SITE DESCRIPTION

The bridge site is located on Hwy. 61, about 1 km north of the junction with Hwy. 608, in the Blake Township, Neebing Township Municipality, District of Thunder Bay.

The existing structure is a 10 m single span bridge founded on timber piles. The topography in the immediate area is generally flat to gently undulating, occupied by agricultural and dairy farming with a few rural homes located along the existing Hwy. 61.

According to available information the overburden is essentially silty clay. Bedrock in this area is "Shale and interbedded Sandstone" of the Rove Formation of the Animikie Group of Middle Precambrian age.

SUBSURFACE CONDITIONS

The subsoil conditions encountered across the site are generally uniform. Sand and clayey silt fills were encountered as much as 4.6 m at BH 3. A thin layer of asphalt pavement (about 0.2 m) was found in the road of existing Highway 61 (BH's 1 and 2). Clayey silt topsoil was found at two borehole locations (about 0.7 m thick) underneath the fill. These materials were found to be underlain by an extensive brown silty clay to clay deposit with a maximum thickness of about 13.3 m at BH 1, which, in turn, overlies a thick deposit of black clayey silt. Thickness of this black clayey silt layer ranges from 8.9 m at BH 1 to 11.7 m at BH 2. Sandy silt to silt layer was encountered underneath this black clayey silt layer with a maximum proven thickness of 3.1 m at BH 1, overlying about 3.9 m thick non-cohesive glacial till. These overburden materials are underlain by a Rove Formation shale bedrock.

The bedrock surface is slightly undulating with an elevation ranged from 191.4 m at BH 1 to 191.6 m at BH 2 which are corresponded to 32.9 m and 32.5 m below the existing ground surface. Bedrock is known to be "Shale with interbedded Sandstone" of the Rove Formation.

The boundaries between the various soil types, in situ and laboratory test results are shown on the attached Record of Borehole sheets in the Appendix. The locations and elevations of the boreholes, along with profiles showing soil stratigraphy based on borehole data, are shown on Dwg. No. 3438701-A.

A detailed description of the subsurface conditions and embankment fill material is given below.

Fill Material

This material was encountered at all borehole locations. The composition of this fill material ranged from a brown sand and gravel to a brown reworked clayey silt. The thickness of sand and gravel fill, which was found underneath 0.2 m thick asphalt pavement, is about 1.2 m at BH's 1 and 2. Through a Grain Size Distributon test and visual observation, it can be classified as a sand and gravel as shown on Figure 1.

Overlying the site and encountered underneath the sand and gravel fill is a brown reworked clayey silt fill material with trace to some sand and gravel. The thickness of this layer varies from 1.4 m at BH 4 to 4.6 m at BH 3 as shown on Record of Borehole sheets. This fill has been placed when building the existing highway embankments in this area.

Atterberg Limit tests were performed on these samples as shown on Figure 2. From the plasticity chart, it is evident that the layer can be classified as an inorganic clayey silt with a low plasticity (CL). Grain Size Distribution tests were carried out on these materials. Figure 3 in the Appendix shows the results.

Topsoil

Topsoil was encountered underneath the clayey silt fill at two borehole locations. The thickness of this layer is about 0.7 m at BH's 3 and 4. Through a Grain Size Distribution test and Atterberg Limit test, (Figures 2 and 3), the material can be classified as a clayey silt with trace of organics.

Silty Clay to Clay

This is the predominant stratum found in all boring locations. The proven thickness of this deposit ranges from 11.4 m at BH 2 to 13.3 m at BH 1. This material is brown in colour.

Atterberg Limit tests were performed on these samples and the results are plotted on Figure 4 and summarized as follows:

Index Properties	Range (%)
Natural Moisture Content (w)	37.0-68.0
Liquid Limit (w_L)	42.0-76.0
Plastic Limit (w_P)	18.0-29.0
Plasticity Index (I_P)	22.0-49.0

From the plasticity chart, it is evident that the layer can be classified as an inorganic silty clay to clay with intermediate to high plasticity (CI or CH).

Grain Size Distribution tests were carried out on these materials. Figure 5 in the Appendix shows the results in an envelope form.

Undrained shear strength of the soil was determined by in situ vane tests and by laboratory tests, namely unconfined compression tests. The results are plotted on Figure 6 and the Record of Borehole log sheets in the Appendix and summarized as follows:

Undrained Shear Strength	Cu(kPa) (Average)		Sensitivity (Average)	
In Situ Vane Tests	42->100	(65)	2-7	(3.2)
Unconfined Compression Tests	14-42	(29)		

As shown on Figure 6, the vane strengths measured within 2 to 4 m (elevation above 216 m) varied from 55 kPa to greater than 100 kPa, indicating a stiff to very stiff consistency. Below 4 m (elevation 216 m and above 208 m), the vane strengths, which varied from 45 kPa to 75 kPa indicated a generally firm to stiff consistency. This silty clay to clay deposit has a sensitivity varying from 2 to 7 based on the measured undisturbed and remoulded vane strengths. This would indicate that the silty clay to clay is generally sensitive.

An odometer test was carried out to investigate the consolidation characteristics of the silty clay to clay. The sample tested is considered representative of the clay deposit was selected from a Shelby tube sample obtained at about elevation 213 m in BH 2. The results of the consolidation test are shown on Figure 7. The preconsolidation pressure is estimated to be about 205 kPa, indicating an over-consolidation ratio of about 1.5 relative to the existing effective overburden stress. The compression index was determined to be about 0.71.

Clayey Silt

In BH's 1 and 2, an 8.9 m to 11.7 m thick layer of clayey silt was encountered between the upper silty clay to clay and the underlying sandy silt to silt layer. This material is black in colour.

Atterberg Limit tests were carried out on this material as shown on Figure 8. Test results indicate that the Liquid Limit varies from 24 to 26 percent with corresponding plasticity indices of 8 and 11 percent. Measured water contents determined from samples of this layer vary from 27 to 29 percent which are higher than the liquid limit. Figure 9 shows the Grain Size Distribution of this material.

The field vane strengths obtained in this stratum varied from 15 kPa to about 75 kPa indicating a soft to stiff consistency. The sensitivity of this deposit varies from 1.5 to about 7 indicating this material being sensitive.

Sandy Silt to Silt

Underlying the thick deposit of clayey silt, a thin layer of grey sandy silt to silt was encountered in BH's 1 and 2. The thickness of this layer ranges from 1.9 m at BH 2 to 3.1 m at BH 1. This layer is basically non-plastic. Figure 10 in the Appendix shows the results of Grain Size Distribution tests.

In this stratum, the 'N' value is about 16 blows/0.3 m indicating a state of compaction described as compact.

Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)

Underlying the sandy silt to silt deposit at a depth ranging from 28.7 m to 32.9 m, a heterogeneous mixture of silt, sand and gravel with occasional boulders of glacial origin was encountered. The thickness of this stratum ranges from about 3.8 m at BH 2 to 3.9 m at BH 1. Rock coring techniques were required to penetrate occasional boulders within the stratum. Figure 11 shows the results of Grain Size Distribution tests for this material.

In this stratum, the 'N' values ranged from 39 to over 100 blows/0.3 m indicating a state of compaction described as dense to very dense.

Bedrock

The glacial till deposit is directly underlain by bedrock of the Rove Formation of the Animikie Group of middle Precambrian age which was proven at two borehole locations by obtaining up to 2.3 m of rock core samples. The bedrock consists mainly of shale with interbedded sandstone. Detailed descriptions of the rock are attached in the Appendix entitled "Description of Rock Core".

Core Recoveries (CR) and Rock Quality Designation (RQD) were determined in situ and also in the laboratory to evaluate the competence and integrity of the rock. Core Recoveries (CR) between 75 and 100 percent and Rock Quality Designation (RQD) values ranges from 0 to 79 percent. Based on these results, the rock can be classified as weak to medium strong rock and slighty weathered to unweathered.

GROUNDWATER CONDITIONS

Groundwater conditions were observed through the measurement of water level in the open boreholes and in piezometers installed at 3 borehole locations. The groundwater level in both open boreholes after completion and piezometers were found to range from depth of 1.5 m to 4.8 m below the existing ground surface which correspond to an approximate elevation of 220.4 m and 219.1 m, respectively. However, it is likely that the groundwater level is subject to seasonal fluctuations.

DISCUSSION AND RECOMMENDATIONS

The recommendations in this report apply to the bridge structures and related approaches.

It is proposed to construct a single span bridge structure about 25 m in length which will replace the existing 10 m single span bridge along the Highway 61 crossing the Slate River. Twin Bailey bridges are also proposed for the detour during construction of the permanent structure (about 40 m long, 20 m east of the centreline of Highway 61). It is understood that an increase in grade for the approach embankment will be required. This would involve the additional placement and compaction of up to 2.0 m fill for the permanent approach and about 4.0 m fill for the Bailey Bridge approach at North abutment location.

Recommendations pertaining to the foundations of the new bridge and Bailey Bridges, and related earth works are summarized as follows:

Proposed Replacement Bridge Foundations

In view of the low shear strength and compressibility of the extensive silty clay to clay and clayey silt layers, conventional spread footing shallow foundations are not applicable at this site. It is recommended that the abutments may be supported on end-bearing steel 'H' piles, equipped with reinforced tips in order to facilitate pile penetration through the basal glacial till stratum and driven to bedrock.

In consideration of the negative skin friction forces (additional downdrag forces), which will be induced as a result of the consolidation of the underlying cohesive deposit due to the imposed load of embankment at the abutment locations, the following design parameters are suggested for the purpose of the O.H.B.D.C..

Pile Type	Factored Axial Capacity at U.L.S.	Axial Capacity at S.L.S. Type II	Bedrock Elevations
HP310x79	910 kN	740 kN	S.Abutment 191.4 m
HP310x110	1360 kN	990 kN	N.Abutment 191.6 m

Battered piles should be installed, where required, to resist lateral loads on the abutments.

During pile driving, the Steel 'H' pile should be set to a termination of 8 blows for the last 12 millimetres of penetration using a hammer transferring about 60 kilojoules of energy per blow/to the pile.

Provision should be made to restrike all piles to confirm the set after adjacent piles have been driven. Piles that do not meet the design set criteria on the first restrike would require additional restriking. A minimum of 48 hours should be allowed before restriking a pile.

In order to enhance pile driving, the fill material immediately below pile caps, if perched within the embankment fill, should not contain particle sizes greater than 75 mm.

Proposed Bailey Bridge Structure

In consideration of the existence of organic topsoil at this location, existing fill material and organic topsoil should be excavated to an elevation of about 218.0 m and the excavation can be backfilled with compacted Granular 'A' core or compacted clayey silt as high as possible (Figure 12).

Spread footing founded on compacted Granular 'A' core or clayey silt may be used to support the temporary bridge abutment. For a footing embedment depth of 2.2 m, a factored bearing capacity of 200 kPa at U.L.S. may be used for design. Where the resultant load is inclined, this factored capacity should be reduced by an appropriate inclination factor as defined by Figure 6-7.3.3.5 in the O.H.B.D.C. As a guideline, a spread footing 3 m wide subjected to a vertical bearing pressure of 200 kPa could result in settlement in the order of 200 mm. A bearing capacity of 130 kPa would correspond to a S.L.S. Type II.

For the temporary bridge abutments, it is considered that a higher amount of settlement can be tolerated than normally would be the case for permanent foundations. Further, because the soil conditions on both sides of the river are similar, the amount of differential settlement should be modest during the life of the temporary structure.

Should the capacity of a conventional spread footing not be sufficient to support the temporary Bailey Bridge abutments, timber friction piles driven into the silty clay to clay stratum could be used. For preliminary design using an effective stress approach, the skin friction may be calculated as described in the Commentary to the O.H.B.D.C., Section 6-8.3.3.2. As a design example, the factored axial capacity at U.L.S. of a nominal 0.3 m diameter and 10 m long timber pile is 240 kN. Again, because expected differential settlements between the two temporary bridge abutments are considered to be modest, a S.L.S. design capacity is not provided at this time.

The sliding resistance may be computed by assuming the coefficent of friction 0.7 between the underside of footings and compacted Granular 'A' and 0.53 between the underside of footings and compacted clayey silt.

Other Considerations

Lateral Earth Pressures

Free draining material such as Granular 'A' or Granular 'B' is recommended as an appropriate backfill material to prevent hydrostatic pressure build-up on the abutment walls. Design parameters of the soil are given below for the purpose of the O.H.B.D.C.

	Granular 'A'	Granular 'B'
Angle of Internal Friction (ϕ)	35°	30°
Unit Weight (kN/m^3), γ	22.8	21.2
Coefficient of Active Earth Pressure (Ka)	0.27	0.33
Coefficient of Earth Pressure at Rest (Ko)	0.43	0.5

The earth pressure coefficient at rest is to be used when the design of abutment walls are rigid and unyielding.

The earth pressure coefficient at rest is to be used when the design of abutment walls are rigid and unyielding.

Frost Protection

The spread footings on the Granular 'A' core or pile caps should be placed so as to have a minimum earth cover of 2.2 m to allow for frost protection.

Settlement of Approach Embankments

Based on currently available information, it is our understanding that the proposed grade of the roadway at the approach embankments will be raised by up to 2.0 m. Consequently, the additional fill will act as a surcharge and induce settlement within the underlying silty clay to clay and clayey silt strata.

To minimize settlement, total embankment loading should not exceed the preconsolidation pressure, σ'_p, of the silty clay to clay. Based on the results of the consolidation test and our previous experience with similar cohesive deposits, it is estimated that σ'_p, is about 205 kPa. Since the field vane shear strengths were found to be reasonably constant with depth, it is anticipated that σ'_p, would not vary significantly with depth. Accordingly, the silty clay at mid-level of the stratum is considered to be preconsolidated by about 65 kPa in excess of the existing effective overburden stress. Assuming that the unit weight of compacted granular fill is about 21 kN/m^3, 2.0 m of such fill would correspond to a surcharge of 42 kPa. As such, the proposed additional embankment loading will not result in stresses higher than σ'_p. Based on the recompression index, C_r, obtained from the consolidation test, the magnitude of settlement of the approach embankment will be modest, being in the order of 80 mm. Consideration should be given to placing and compacting the additional fill well in advance of bridge construction to allow some settlement to take place prior to final road grading as shown on Figure 13.

Stability of Approach Embankment

The stability analyses were carried out based on a minimum design undrained shear strength of 60 kPa for the silty clay to clay, as established by field vane tests. For additional earth fill of 2.0 m, the results of the 'total stress' analyses indicate that the approach embankments, with side slopes not steeper than 2H:1V, should be stable.

However, it should be noted that there is no sufficient space to build 2H:1V slope at the west side of the north approach toward Slate River with the existing centreline of Highway 61. It is therefore recommended that the existing centreline be shifted about 4 m easterly or more steep slope of less than 1.3H:1V be considered using rockfill material or reinforced earth slope.

Construction Consideration

Prior to embankment construction, topsoil, organics and other foreign materials should be removed from the fill placement area. Such locations should be excavated and backfilled with an approved, compacted free-draining, granular material. Clean earth fill at suitable water content should be used as embankment fill.

The fill should be placed in thin layers and compacted as per MTO standards. The fill should be keyed into the pre-existing slope in accordance with current MTO standards and practice.

Excavations for abutments, pile-caps and footing construction may be carried out in temporary open cuts with side slopes maintained at gradients not steeper than 1.5H:1V through the silty clay to clay. Some groundwater seepage into the excavations should be expected at elevations below the groundwater table. The seepage can be controlled by pumping from properly filtered sumps located at the base of the excavations. Sumps should be located outside the load-bearing and foundation areas. All excavations should be carried out according to the guidelines contained in the latest edition of the Ontario Occupational Health and Safety Act. To prevent softening of the exposed silty clay to clay, it is recommended that Granular 'A' material be placed on the excavation base to provide protection to the founding stratum as soon as the base of the excavation has been inspected.

For erosion protection purposes, the embankment side slopes should be covered with a layer of topsoil and proper seeded in order to enhance adequate vegetation cover. Suitable protection measures should also be provided to the river banks adjacent to the abutments. Such measures may include appropriately sized rip-rap underlain by suitable granular filter.

MISCELLANEOUS

The fieldwork for this investigation was carried out during the period of 91 06 10 to 91 06 18 under the supervision of M. Iampietro, Student Engineer. The equipment was owned and operated by Dominion Soil Investigation Ltd., Thunder Bay.

This report was written by T. C. Kim, Senior Foundation Engineer and reviewed by M. Devata, Chief Foundation Engineer.

LICENSED PROFESSIONAL ENGINEER
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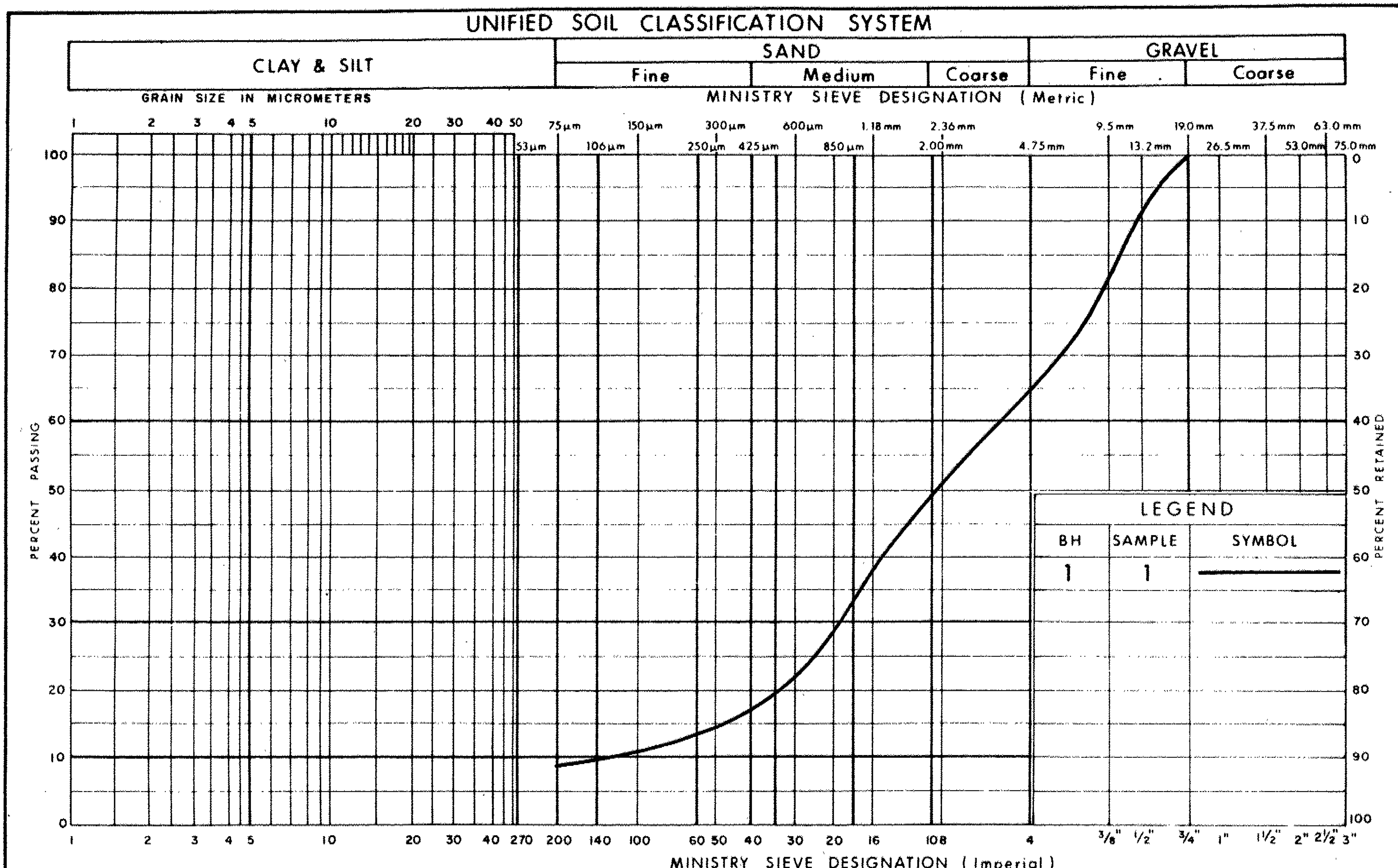
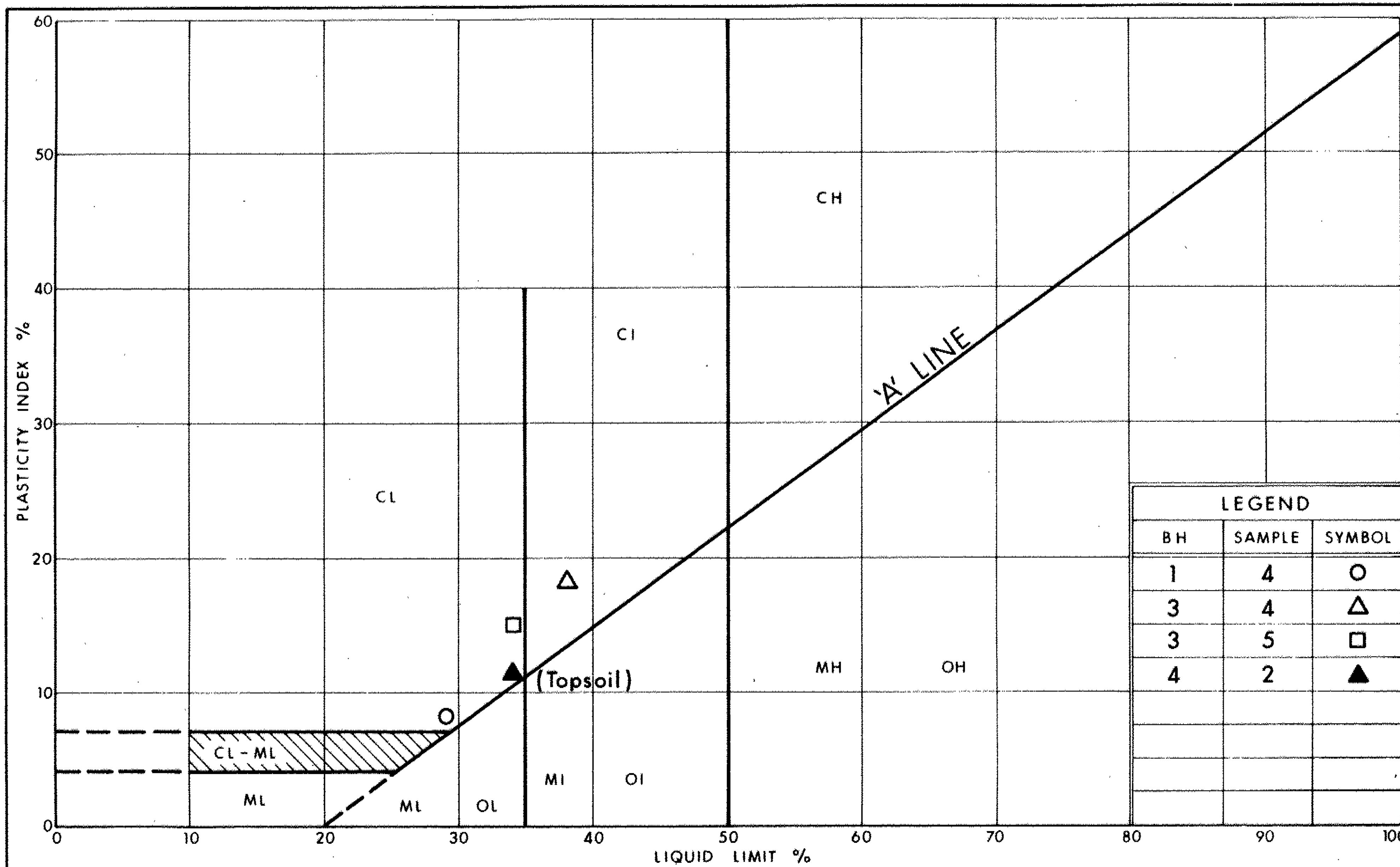
APPENDIX

78 12 M



Ministry of Transportation Ontario	GRAIN SIZE DISTRIBUTION SAND & GRAVEL (Fill)	FIG No 1 W P 343-87-01



LEGEND

BH	SAMPLE	SYMBOL
1	4	○
3	4	△
3	5	□
4	2	▲

Ministry of Transportation
Ontario

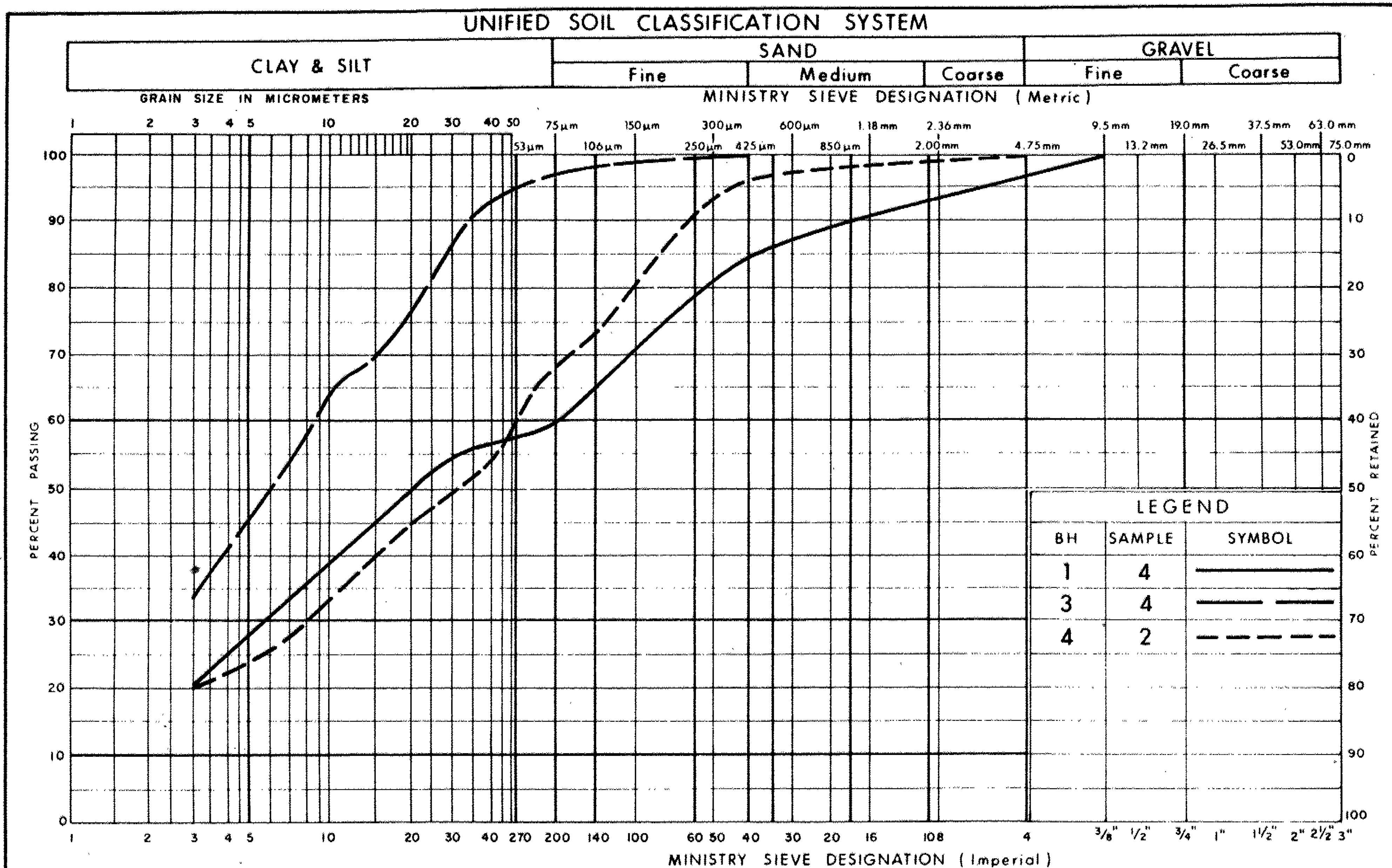
PLASTICITY CHART

CLAYEY SILT, TRACE TO SOME SAND & GRAVEL
(Fill and Topsoil)

FIG No 2

W P 343-87-01

78 12 M

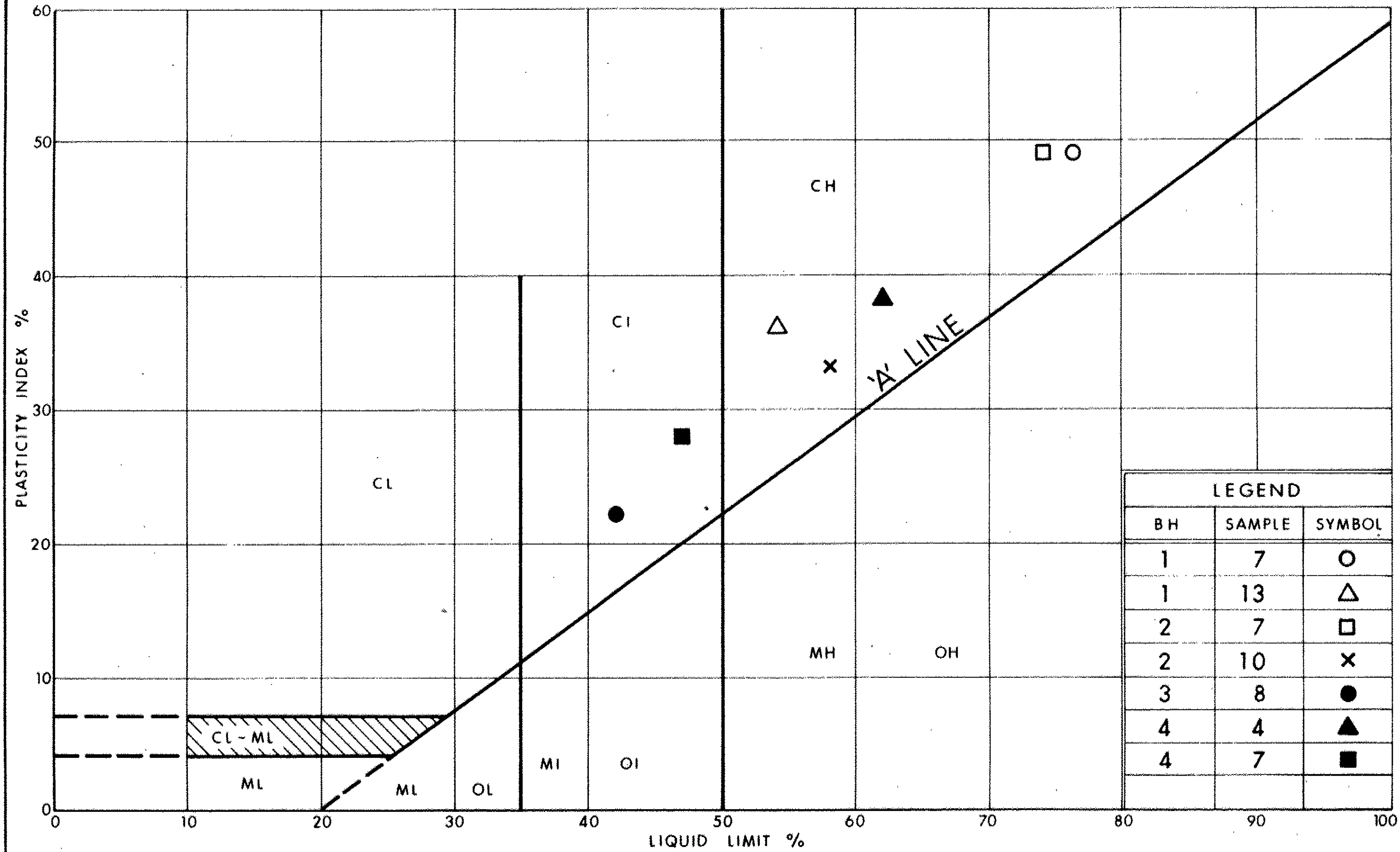


Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
CLAYEY SILT, TRACE TO SOME SAND & GRAVEL
(Fill and Topsoil)

FIG No 3

W P 343-87-01



BH	SAMPLE	SYMBOL
1	7	○
1	13	△
2	7	□
2	10	×
3	8	●
4	4	▲
4	7	■

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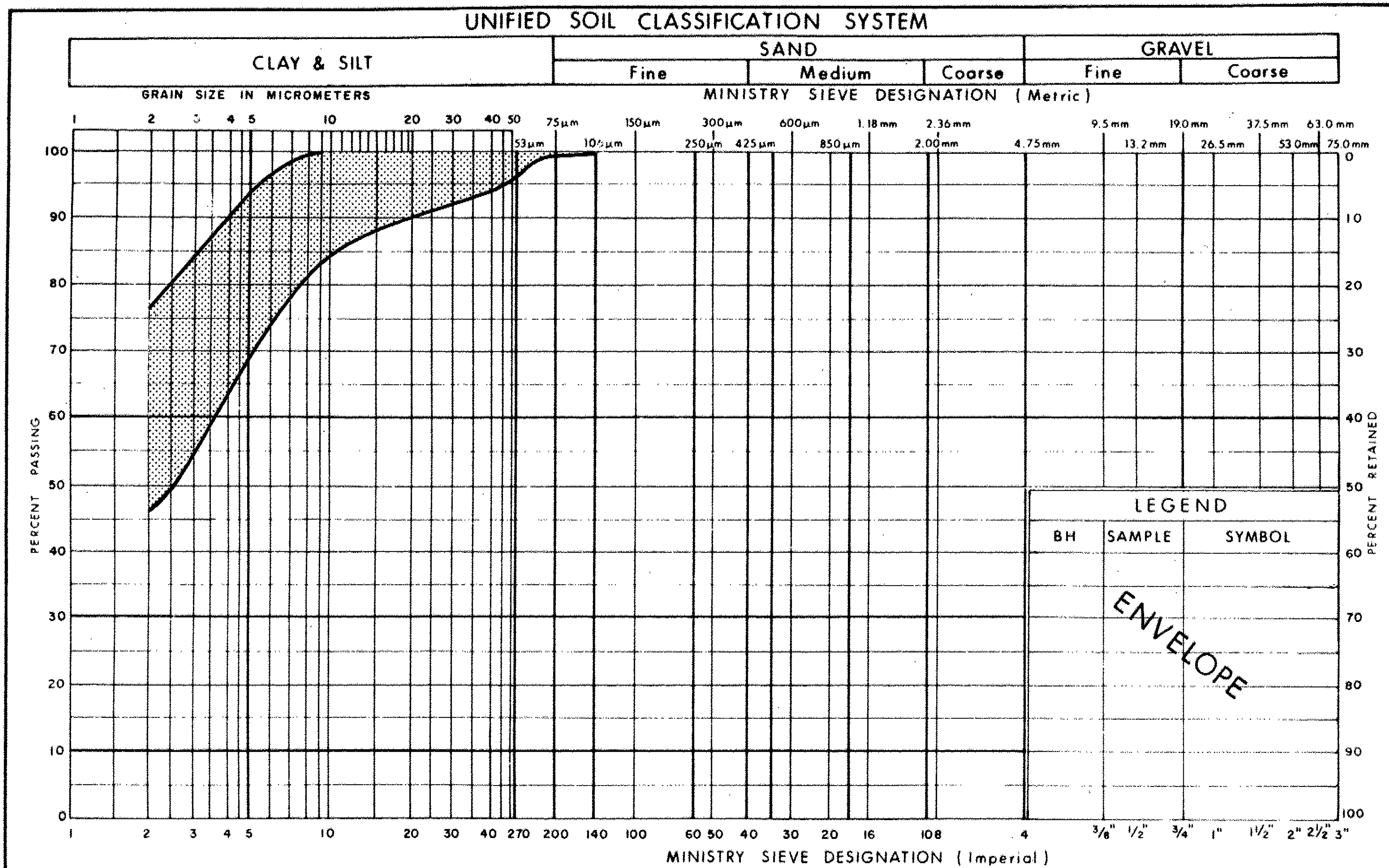
Ontario

PLASTICITY CHART
SILTY CLAY TO CLAY

FIG No 4
W P 343-87-01

78 12 M



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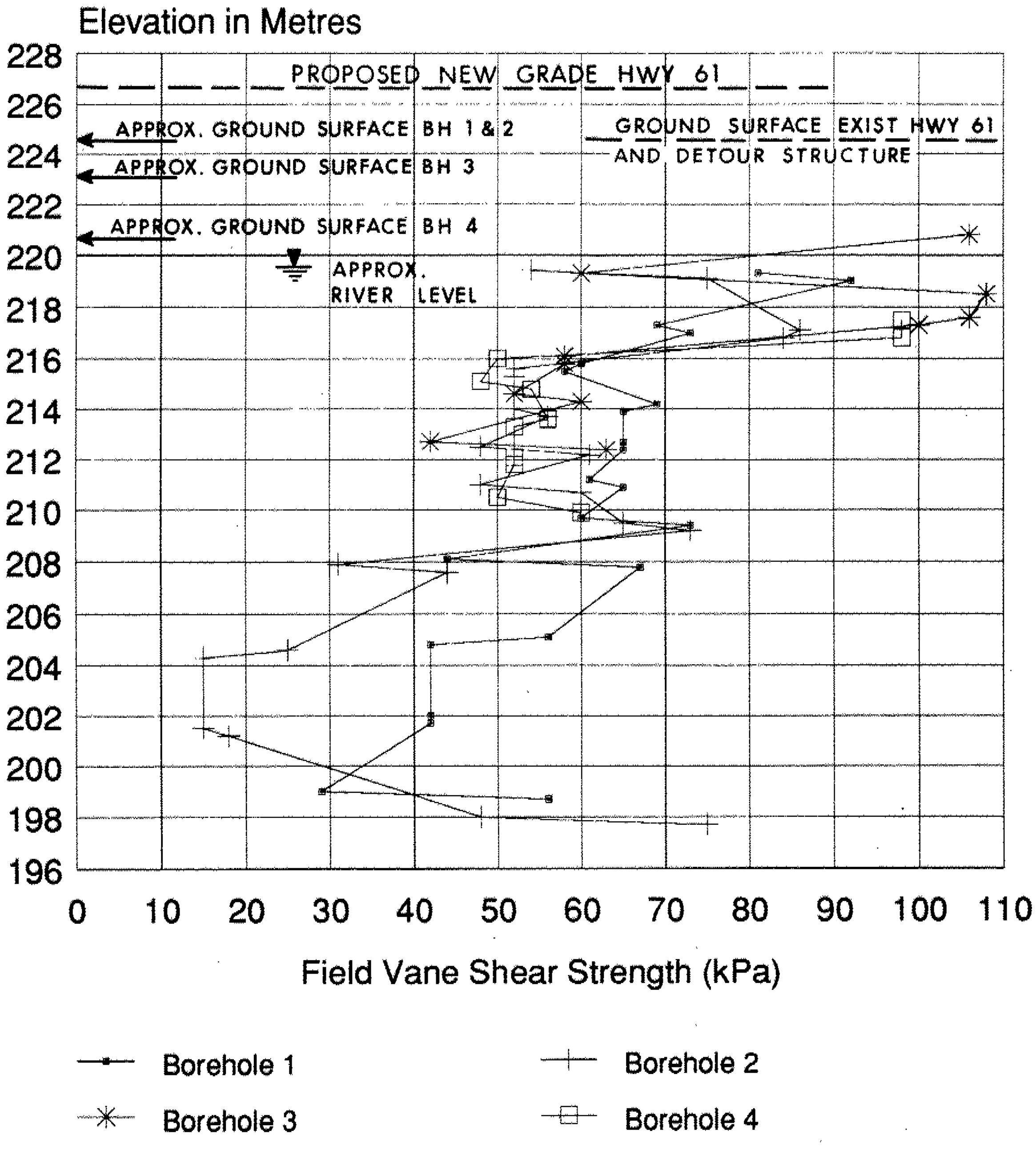
GRAIN SIZE DISTRIBUTION
SILTY CLAY TO CLAY

FIG No 5

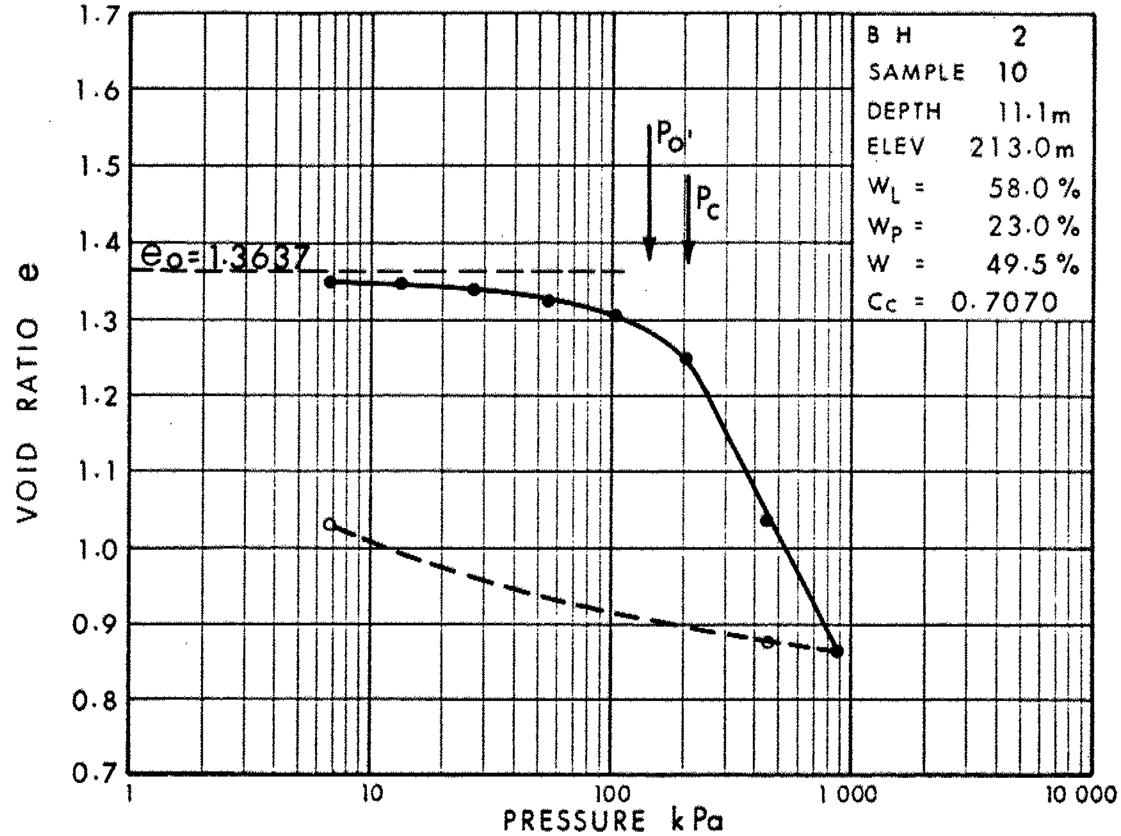
WP 343-87-01

FIGURE 6. PROFILE OF FIELD VANE STRENGTH Vs. ELEVATION



 WP 343-87-01

VOID RATIO - PRESSURE CURVES



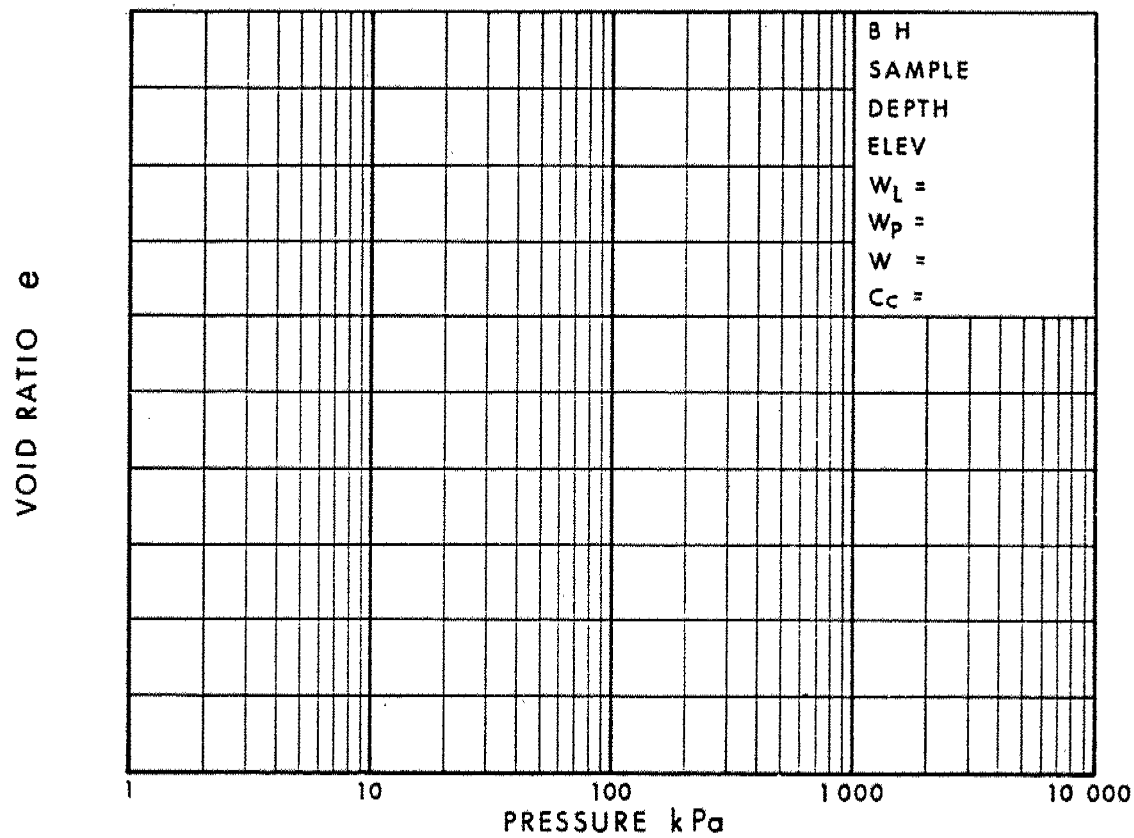
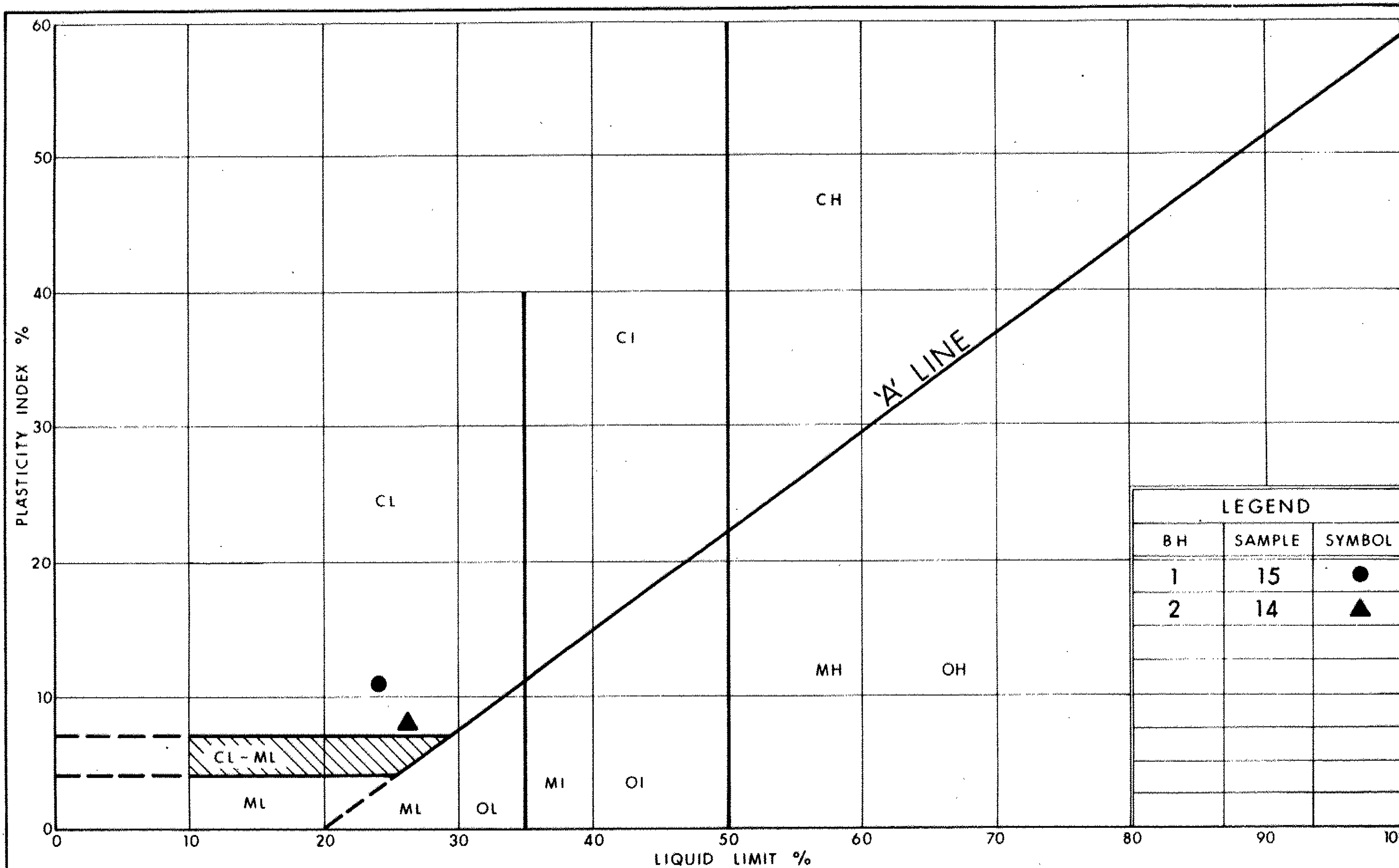


Fig 7

Oct 75, FF-S-21



LEGEND		
BH	SAMPLE	SYMBOL
1	15	●
2	14	▲

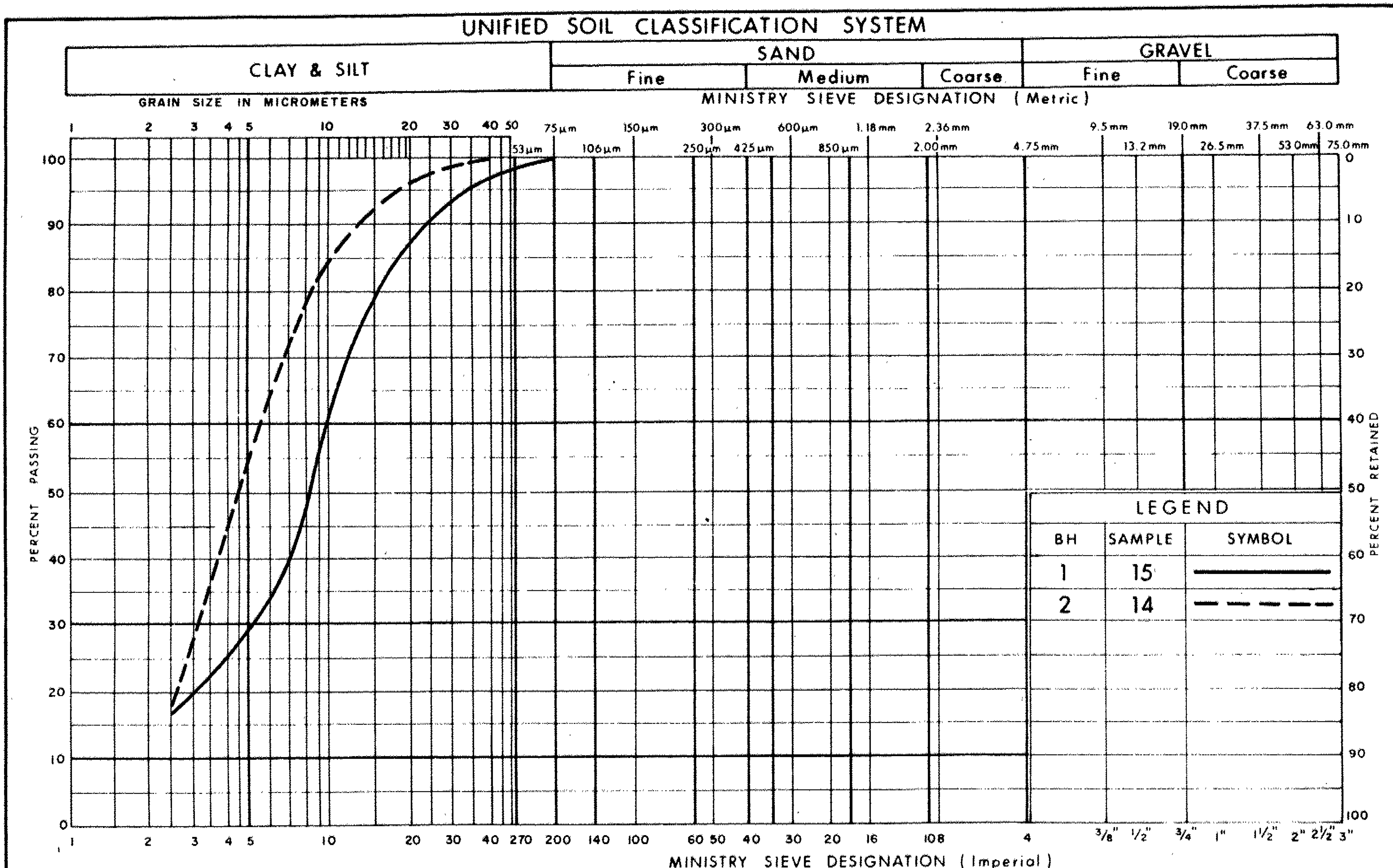
Ministry of Transportation
Ontario

PLASTICITY CHART
CLAYEY SILT

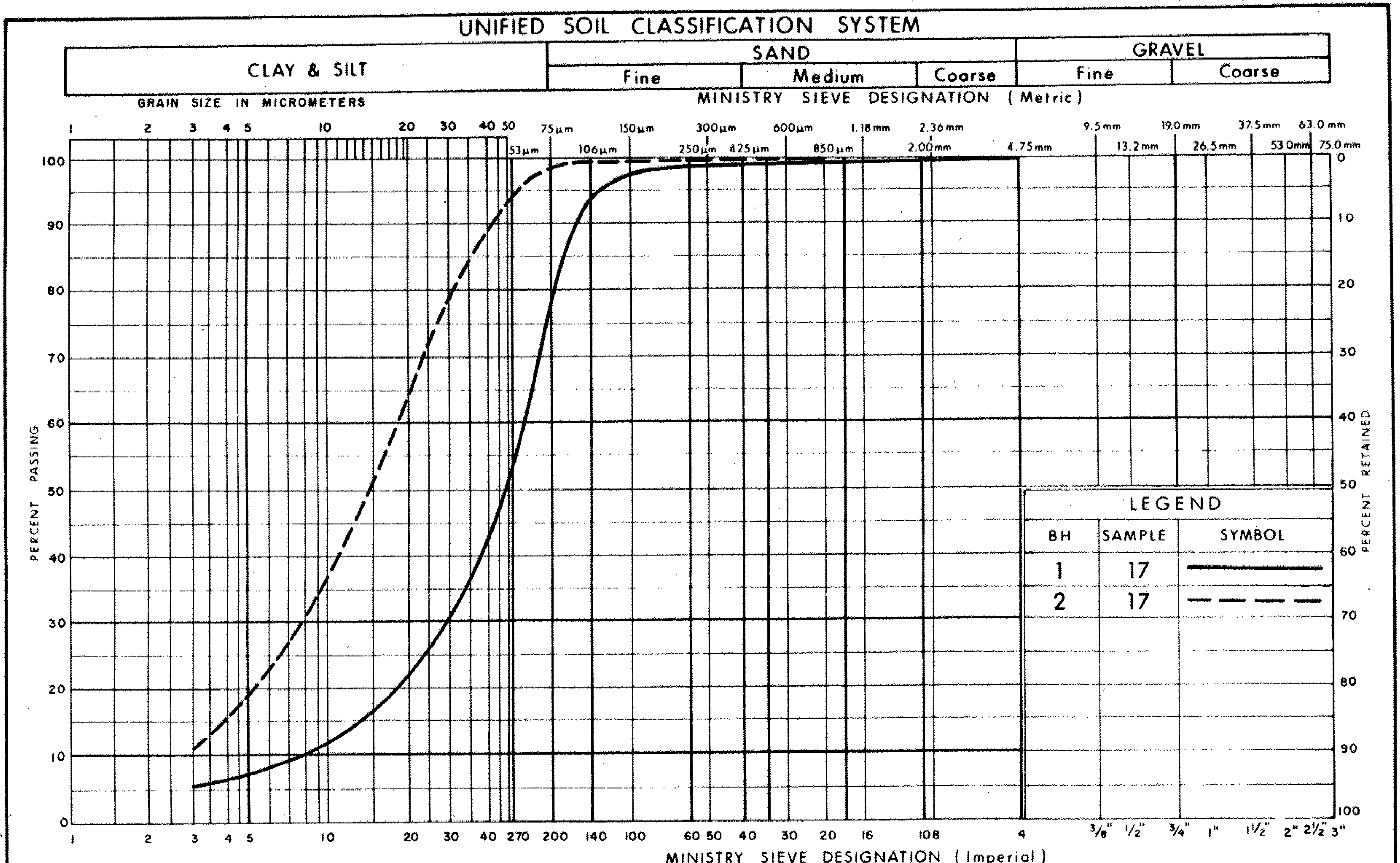
FIG No 8

WP 343-87-01

78 12 M



Ministry of Transportation Ontario	GRAIN SIZE DISTRIBUTION CLAYEY SILT	FIG No 9 W P 343-87-01



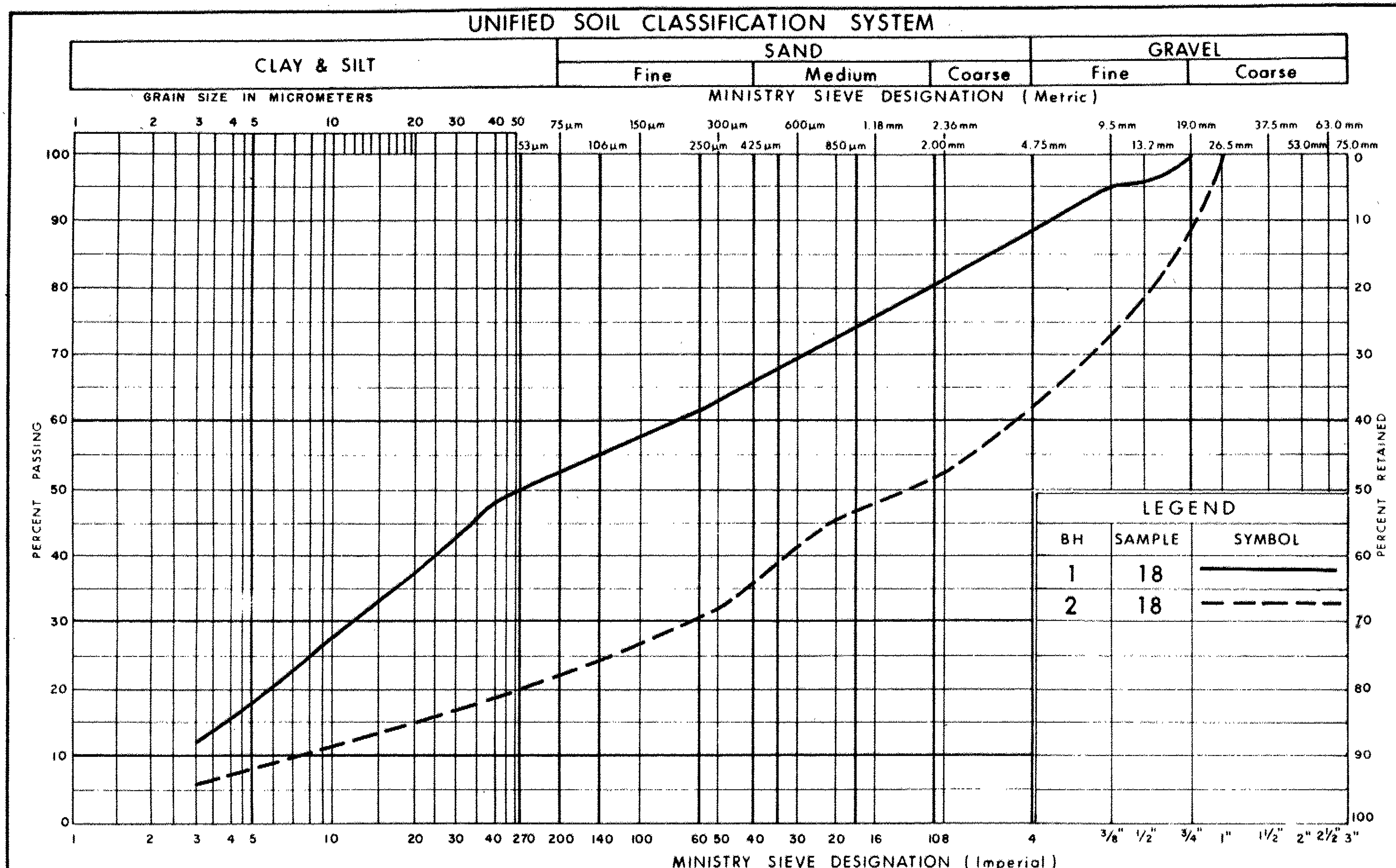
Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
SANDY SILT TO SILT

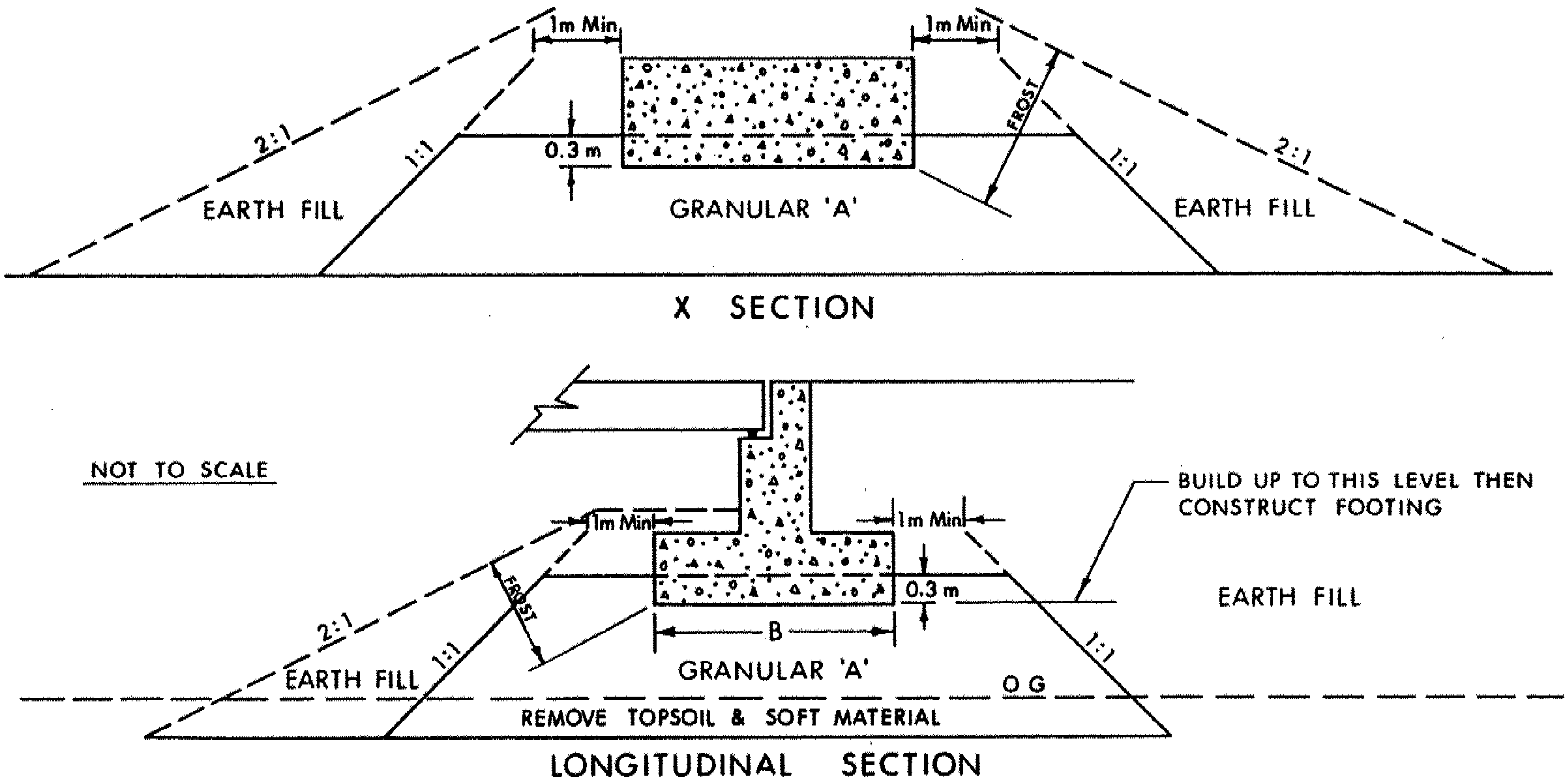
FIG No 10

W P 343-87-01

78 12 M



Ministry of Transportation Ontario	GRAIN SIZE DISTRIBUTION HET MIXTURE OF SILT, SAND & GRAVEL (Glacial Till)	FIG No 11 W P 343-87-01



NOTES:

1 - REMOVE TOPSOIL &/OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' & EARTH FILL.

2 - PLACE GRANULAR 'A' & EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO CURRENT M T O STANDARDS.

3 - CONSTRUCT CONCRETE FOOTING.

4 - PLACE REMAINDER OF GRANULAR 'A' & EARTH FILL AS REQUIRED.

Ministry of Transportation Ontario	ABUTMENT ON COMPACTED FILL SHOWING GRANULAR 'A' CORE	FIG No 12 W P 343-87-01

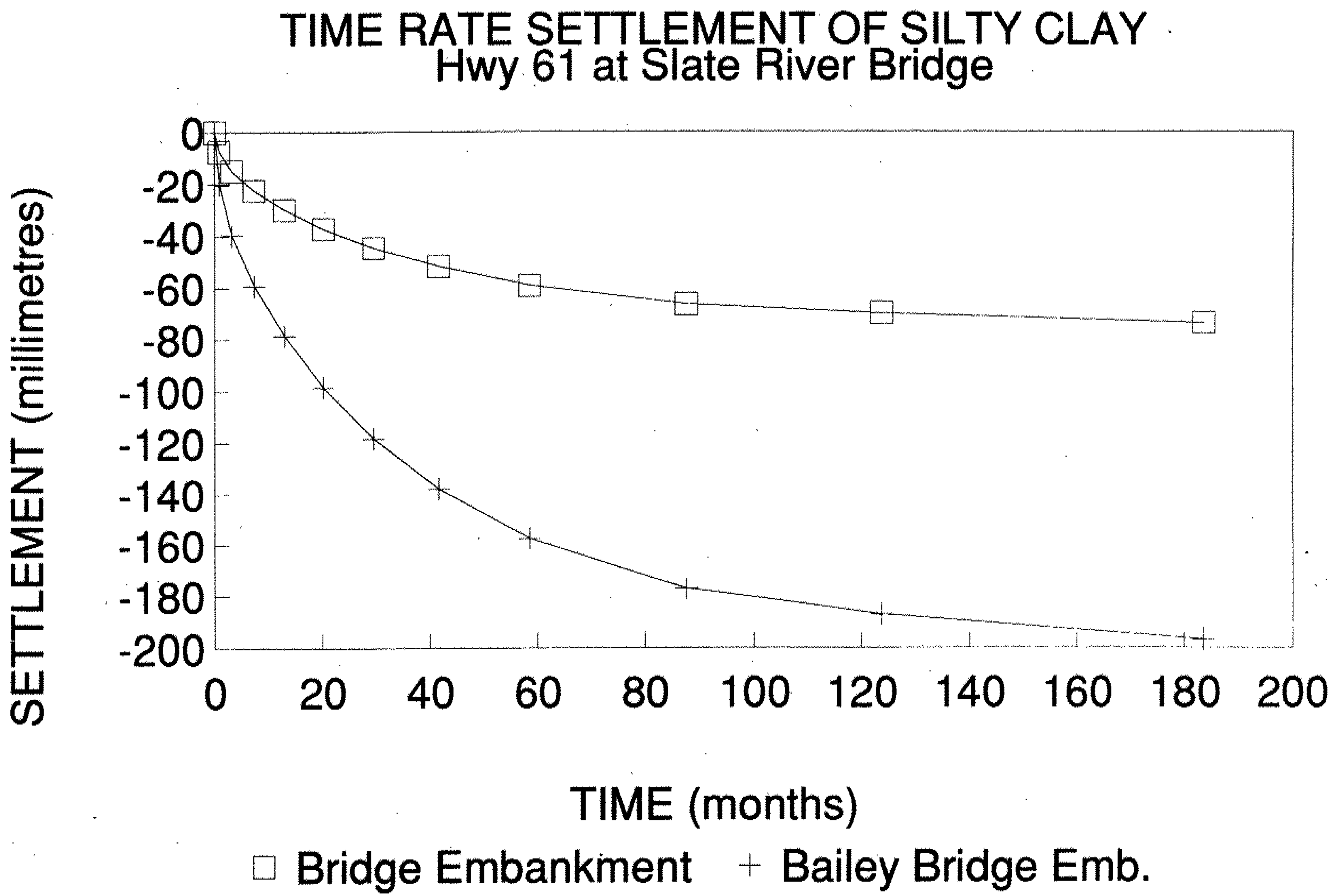


Fig. 13

WP 343-87-01

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS $\bar{N}$.

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	>200
	VERY SOFT	*SOFT*	*FIRM*	*STIFF*	*VERY STIFF*	*HARD*

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	>50
	VERY LOOSE	*LOOSE*	*COMPACT*	*DENSE*	*VERY DENSE*

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND/OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R.Q.D.), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	>3m
JOINTING	*VERY CLOSE*	*CLOSE*	*MOD. CLOSE*	*WIDE*	*VERY WIDE*
BEDDING	*VERY THIN*	*THIN*	*MEDIUM*	*THICK*	*VERY THICK*

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY $= \frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ''	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL
e	1, %	VOID RATIO
n	1, %	POROSITY
w	1, %	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_p	%	PLASTIC LIMIT
w_s	%	SHRINKAGE LIMIT
I_p	%	PLASTICITY INDEX $= w_L - w_p$
I_L	1	LIQUIDITY INDEX $= \frac{w - w_p}{I_p}$
I_C	1	CONSISTENCY INDEX $= \frac{w_L - w}{I_p}$
e_{max}	1, %	VOID RATIO IN LOOSEST STATE
e_{min}	1, %	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_u	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

RECORD OF BOREHOLE No 1

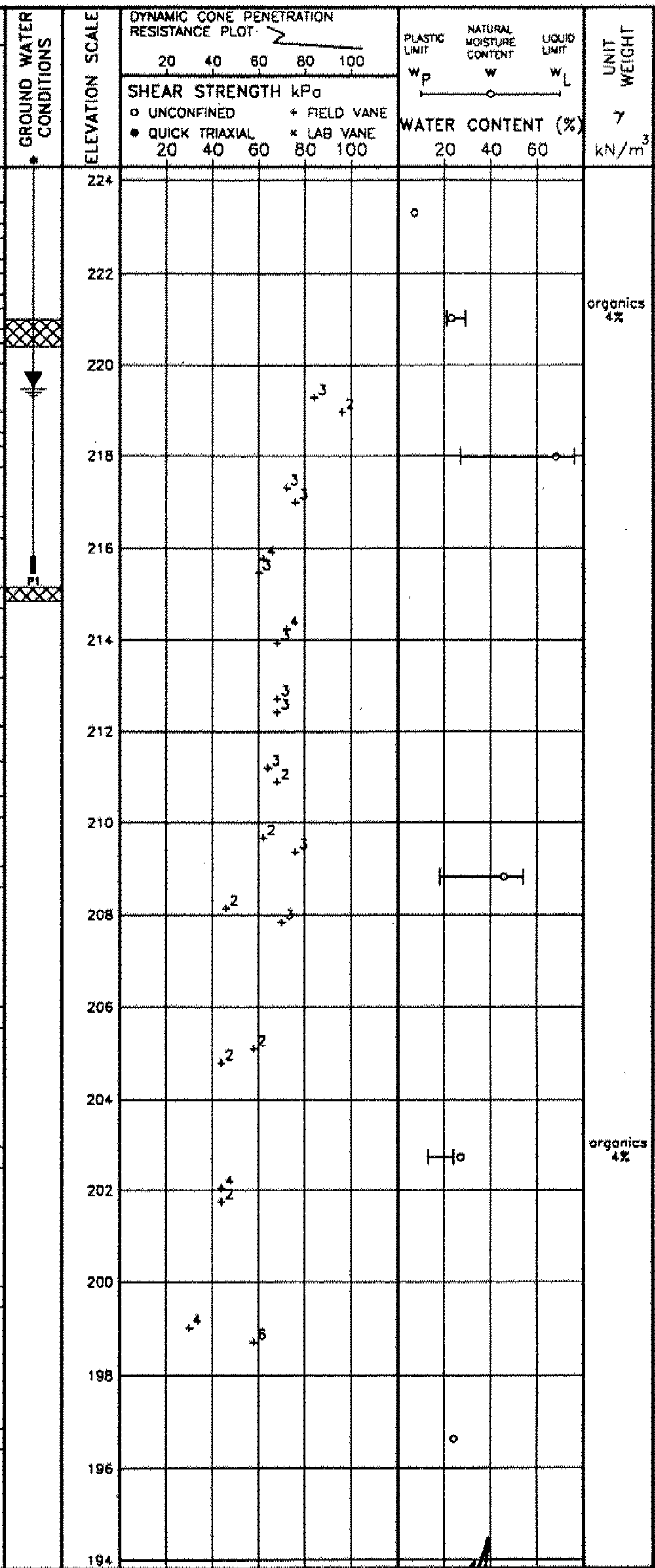
METRIC

W.P. 343-87-01 LOCATION Sta 22+449.5; o/s 4.4m Rt. from ℄ of HWY 61 ORIGINATED BY MI

DIST 19 HWY 61 BOREHOLE TYPE HS Auger, BXL Rock Core COMPILED BY AD

DATUM Geodectic DATE 91 06 13 to 91 06 14 CHECKED BY TCK

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
224.3	Asphalt Surface				
0.0	Asphalt				
0.2	Sand and Gravel (Fill) Compact				
222.9		1	SS	22	35 56 9 0
1.4	Clayey Silt, trace to some Sand and Gravel Firm to Very Stiff (Fill)	2	SS	19	
		3	SS	15	
220.6		4	SS	7	organics 4% — 3 38 43 16
3.7	Silty Clay to Clay Stiff	5	SS	13	
		6	SS	8	
		7	TW	PH	0 0 8 92
		8	SS	5	
		9	TW	PH	
		10	SS	6	
		11	TW	PH	
		12	SS	5	
		13	TW	PH	0 0 40 60
207.3	Brown				
17.0	Black				
	Clayey Silt Firm to Stiff	14	SS	0	
		15	TW	PH	organics 4% — 0 0 84 16
		16	SS	0	
198.4	Black				
25.9	Grey Sandy Silt to Silt	17	SS	0	0 23 71 6
195.3					
29.0	Het. Mixture of Silt, Sand and Gravel occ. boulders (Glacial Till) Dense to Very Dense				
193.8					
30.5					



Continued

$+^3$, $\times^5$: Numbers refer to Sensitivity

15-○-5 (20 above, 10 below) (%) STRAIN AT FAILURE

Continued

RECORD OF BOREHOLE No 1

METRIC

W.P. 343-87-01 LOCATION Sta 22+449.5; o/s 4.4m Rt. from ℄ of HWY 61 ORIGINATED BY MI

DIST 19 HWY 61 BOREHOLE TYPE HS Auger, BXL Rock Core COMPILED BY AD

DATUM Geodectic DATE 91 06 13 to 91 06 14 CHECKED BY TCK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.8	Continued										
30.5	Het. Mixture of Silt, Sand and Gravel occ. boulders Dense to Very Dense (Glacial Till)		18	SS	39		192		oH		12 36 44 8
191.4 / 32.9	Bedrock Shale with interbedded Sandstone of the Rove Formation		19	RC	REC	95%	190				RQD 79%
189.9 / 34.4	End of Borehole										

June 13,1991

* GROUND WATER CONDITIONS

PIEZO. NO.	GROUND WATER ELEVATION (Metres)
1	219.5

$+^3$, $\times^5$: Numbers refer to Sensitivity

15◇5 (20 above, 10 below) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 2

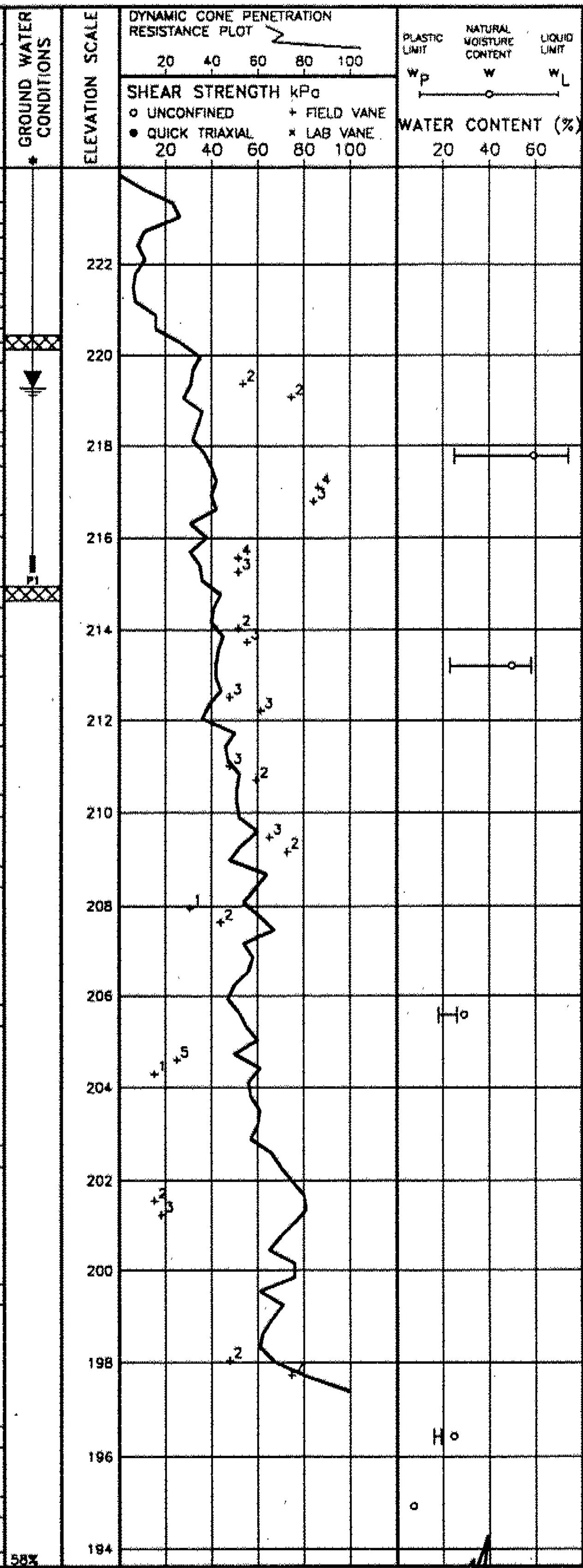
METRIC

W.P. 343-87-01 LOCATION Sta 22+474.5; o/s 5.2m Lt. from ℄ of HWY 61 ORIGINATED BY MI

DIST 19 HWY 61 BOREHOLE TYPE HS Auger, BXL Rock Core, Cone Test COMPILED BY AD

DATUM Geodectic DATE 91 06 10 to 91 06 13 CHECKED BY TCK

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
224.1	Asphalt Surface								
0.0	Asphalt								
0.2	Sand and Gravel (Fill) Compact	1	SS	12					
222.7 / 1.4	Clayey Silt, trace to some Sand and Gravel Firm (Fill)	2	SS	5					
		3	SS	7					
		4	SS	6					
220.4 / 3.7	Silty Clay to Clay Stiff	5	SS	9					
		6	TW	PH					
		7	SS	4					
		8	TW	PH					
		9	SS	3					
		10	TW	PH	16.9	0	0	32	68
		11	SS	3					
		12	TW	PH					
209.0 / 15.1	Brown / Black								
	Clayey Silt Soft to Stiff	13	SS	1					
		14	TW	PH		0	0	85	15
		15	SS	0					
		16	SS	0					
197.3 / 26.8	Black / Grey								
	Sandy Silt to Silt Compact	17	SS	16		0	1	92	7
195.4 / 28.7	Het. Mixture of Silt, Sand and Gravel occasional boulders Dense to Very Dense (Glacial Till)	18	SS	39		37	40	20	3
193.6 / 30.5		19	RC	REC 58%		RQD 38%			



Continued Continued

$+^3$, $\times^5$: Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 2

METRIC

W.P. 343-87-01 | LOCATION Sta 22+474.5; o/s 5.2m Lt. from ℄ of HWY 61 | ORIGINATED BY MI

DIST 19 HWY 61 | BOREHOLE TYPE HS Auger, BXL Rock Core, Cone Test | COMPILED BY AD

DATUM Geodectic | DATE 91 06 10 to 91 06 13 | CHECKED BY TCK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.6	Continued										
30.5	Het. Mixture of Silt, Sand and Gravel, occ. boulders Dense to Very Dense (Glacial Till)		20	RC	REC	56%					RQD 16%
			21	SS	100	/8cm					
191.6							192				
32.5	Bedrock Shale with interbedded Sandstone of the Rove Formation		22	RC	REC	75%					RQD 50%
			23	RC	REC	100%					RQD 0%
			24	RC	REC	96%	190				RQD 35%
189.3											
34.8	End of Borehole										

June 19, 1991

* GROUND WATER CONDITIONS

PIEZO. NO.	GROUND WATER ELEVATION (Metres)
1	219.3

Legend: Dynamic cone penetration resistance plot 20 40 60 80 100; Shear strength kPa: o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE, 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; Water content 20 40 60.

$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 ◊ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No 3

METRIC

W.P. 343-87-01 LOCATION Sta 22+440.0; o/s 18m Rt from ℄ of HWY 61 ORIGINATED BY MI

DIST 19 HWY 61 BOREHOLE TYPE HS Auger COMPILED BY AD

DATUM Geodectic DATE 91 06 18 CHECKED BY TCK

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa (+ FIELD VANE, sensitivity)	WATER CONTENT	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
223.1	Ground Surface							
0.0	Brown							
	Clayey Silt, trace to some Sand and Gravel Stiff to Very Stiff (Fill)	1	SS	12	222			
		2	SS	4				
		3	SS	5		>100 +3		
		4	SS	10	220	+2	w_p–w–w_L	0 4 71 25
218.5		5	SS	2		+6	w_p–w	organics 3%
4.6 / 217.8	Clayey Silt, trace organics (Topsoil) Very Stiff	6	SS	3	218	+4		
5.3	Silty clay to Clay Stiff	7	SS	3		+4, +3		
		8	SS	3	216	+3, +3	w_p–w–w_L	0 0 59 41
		9	SS	4	214	+2, +3		
212.4 / 10.7	End of Borehole							

Ground water conditions: P1 piezometer; water level symbol at approx. elev. 220.3.

June 19, 1991

* GROUND WATER CONDITIONS

PIEZO. NO.	GROUND WATER ELEVATION (Metres)
1	220.3

+3, ×3 : Numbers refer to Sensitivity

20 / 15-○-5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 4

METRIC

W.P. 343-87-01 LOCATION Sta 22+483.3; o/s 22.4m Rt from ℄ of HWY 61 ORIGINATED BY MI

DIST 19 HWY 61 BOREHOLE TYPE HS Auger COMPILED BY AD

DATUM Geodectic DATE 91 06 18 CHECKED BY TCK

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
220.6	Ground Surface					
0.0	Brown Clayey Silt, trace to some Sand and Gravel (Fill) Soft	1	SS	2	▼	
219.2 / 1.4	Clayey Silt, trace organics (Topsoil) Soft	2	SS	2		0 31 48 21
218.5 / 2.1	Silty Clay to Clay Stiff	3	SS	2		
		4	SS	4		
		5	TW	PH		
		6	SS	3		
		7	TW	PH		0 1 57 42
		8	SS	3		
		9	TW	PH		
209.9 / 10.7	End of Borehole					

Elevation scale: 220, 218, 216, 214, 212, 210

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: o UNCONFINED; + FIELD VANE; • QUICK TRIAXIAL; × LAB VANE — 20 40 60 80 100

Field vane sensitivities plotted (top to bottom): 5, 6, 5, 5, 3, 4, 3, 3, 3, 3, 2

WATER CONTENT (%): PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L — 20 40 60

UNIT WEIGHT γ kN/m^3

$+^3$, $\times^5$: Numbers refer to Sensitivity

15◇5 (20 above, 10 below) (%) STRAIN AT FAILURE

ROCK CORE DESCRIPTION
WP 343-87-01

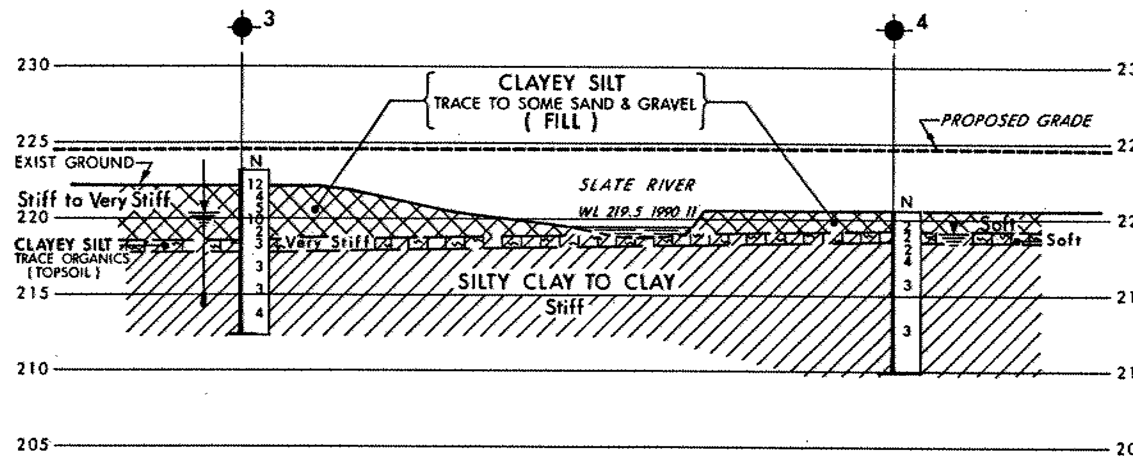
CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	19	32.87-34.39	95	79	32.87-33.03	**SANDSTONE**, medium dark grey to medium light grey; fine grained; medium strong; unweathered to slightly weathered; fractures close spaced, flat to near vertical, planar, smooth.
					33.03-34.39	**SHALE**, black to dark grey; fine grained; weak; unweathered to slightly weathered; fractures moderately close to very close spaced, flat to near vertical, planar to undulating, smooth.
2	19	30.18-30.48	58	38	30.18-32.51	**OVERBURDEN** (boulder till).
	20	30.48-31.29	56	16		
	22	32.51-33.02	75	50	32.51-34.80	**SHALE**, black to medium grey; fine grained; weak; unweathered to slightly weathered; fractures extremely close to moderately close spaced, flat to near vertical, planar to undulating, smooth.
	23	33.02-33.38	100	0		
	24	33.38-34.80	96	35		

***CR** = CORE RECOVERY
***RQD** = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

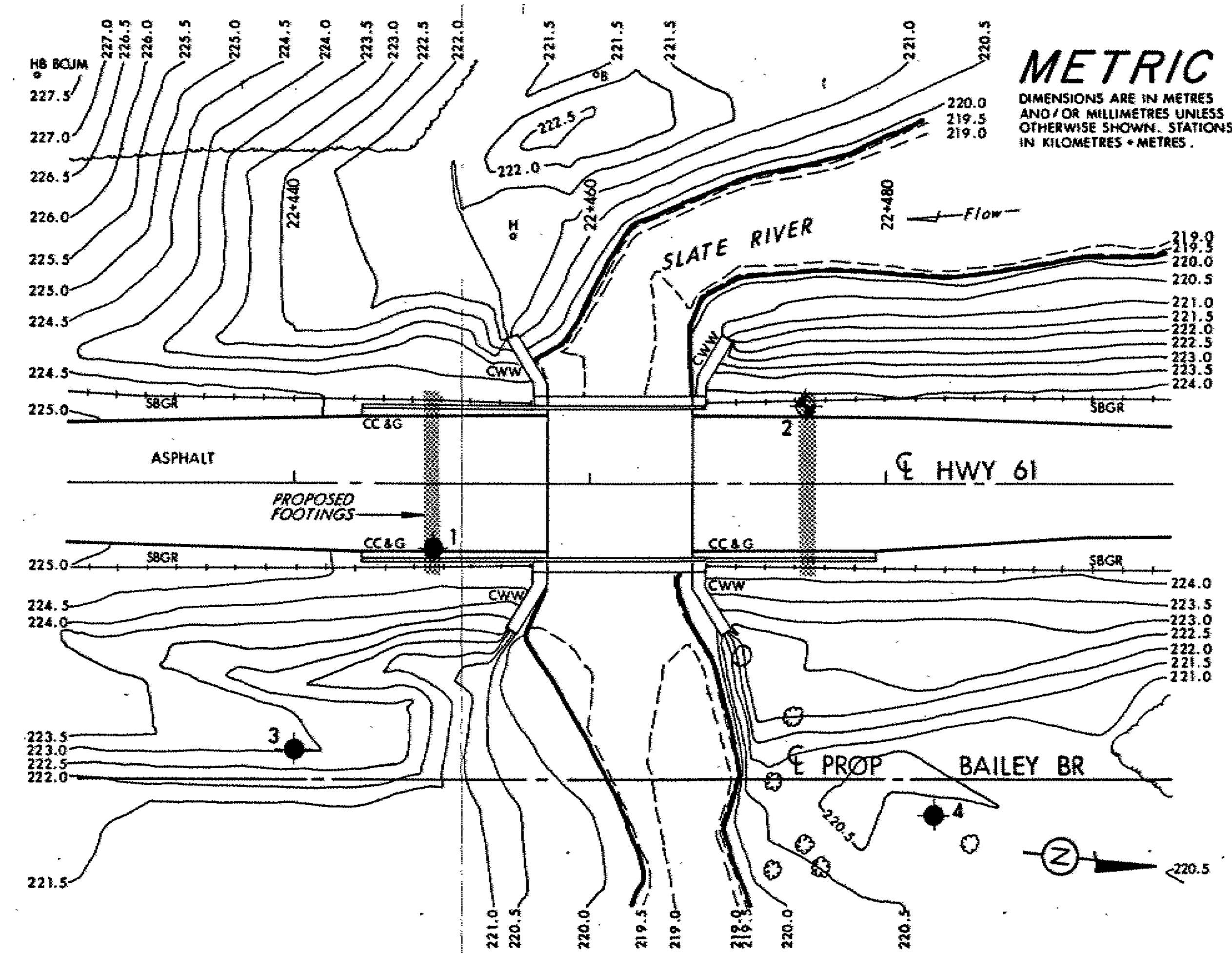
Logged by: DAW, Soils and Aggregates Section

MINISTRY OF TRANSPORTATION, ONTARIO PH-D-207 88 10



SECTION ALONG ℄ PROP BAILEY BRIDGE

SCALE 5m 0 5m

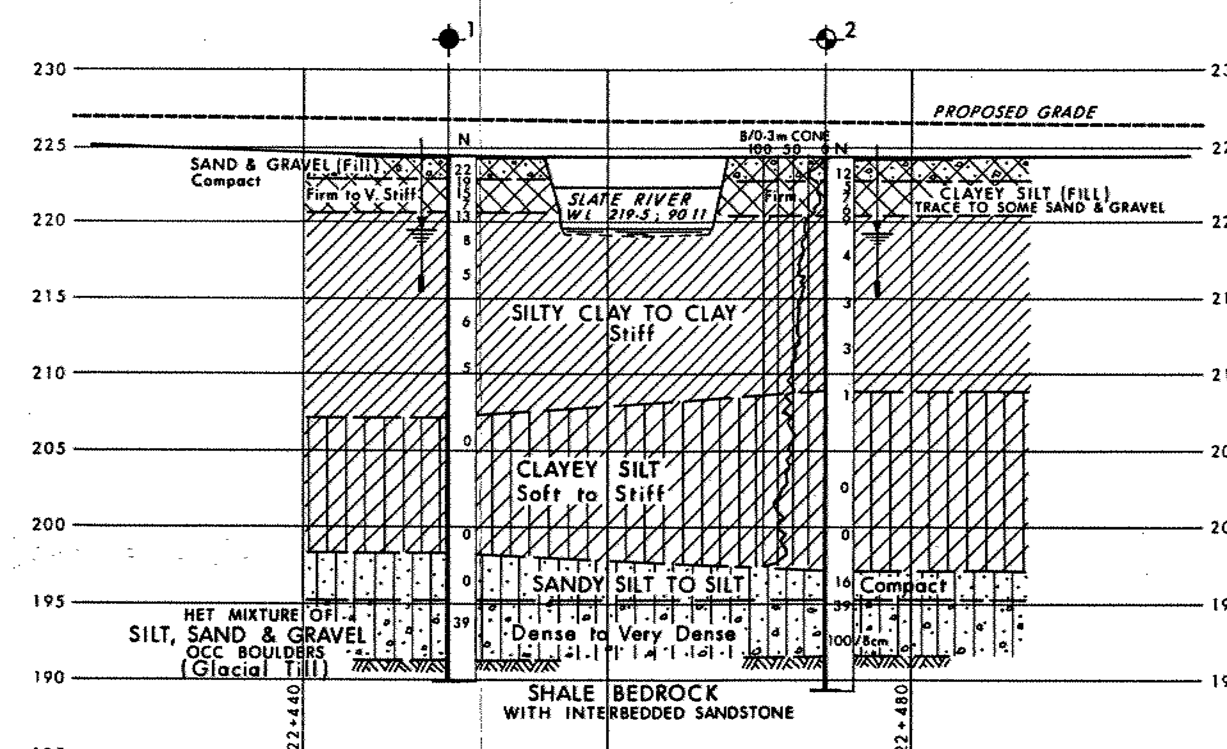


PLAN

SCALE 5m 0 5m

METRIC

DIMENSIONS ARE IN METRES AND / OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.



℄ PROFILE HWY 61

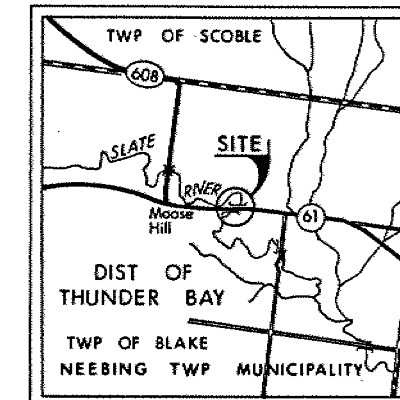
SCALE 5m 0 5m

CONT No
WP No 343-87-01

SLATE RIVER

BORE HOLE LOCATIONS & SOIL STRATA

SHEET



KEY PLAN

SCALE 1km 0 1km

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation 1991 06
- Piezometer

No	ELEVATION	STATION	OFFSET
1	224.3	22+449.5	4.4m Rt
2	224.1	22+474.5	5.2m Lt
3	223.1	22+440.0	18.0m Rt
4	220.6	22+483.3	22.4m Rt

NOTE

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV.	DATE	BY	DESCRIPTION

Geocres No 52A-108

REF No E-441-61-1 ; 1990 12

HWY No 61			DIST 19
SUBM'D T K	CHECKED	DATE 1991 12 12	SITE 48W-86
DRAWN R S	CHECKED	APPROVED	DWG 3438701-A