FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 93-223

Ontario

Ministry of
Transportation

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 (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

FOUNDATION INVESTIGATION REPORT
For
Proposed Hoiles Creek Bridge Replacement
Highway 11, 26.8 km East of Junction Hwy. 625
W.P. 290-85-02, Site No. 48E-7
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 five span timber bridge along the Hwy. 11 crossing the Hoiles Creek.

The fieldwork was carried out between 91 08 26 and 91 08 28. 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 11.6 and 14.2 m below the existing ground surface.

This report contains factual information obtained from this investigation.

SITE DESCRIPTION

The Hoiles Creek Bridge is located on Highway 11, approximately 42 km east of the Town of Longlac, about 27 km east of Jct. Highway 625, in the Thunder Bay District. The existing structure is an asphalt covered 5 span longitudinally laminated timber bridge founded on timber piles. The topography in the immediate area is generally flat to gently undulating. The immediate vicinity of the site is occupied by bush land.

SUBSURFACE CONDITIONS

The subsoil conditions encountered across the site are generally uniform. Sand with gravel fills were encountered at three borehole locations (BH's 1, 2, and 3) as much as 3.7 m in the road embankment of existing Highway 11. Sandy silt topsoil was found at three borehole locations (up to 2.1 m thick) from the ground surface or underneath the sand fill. On the other hand, silt materials were encountered at all borehole locations (up to 1.6 m thick) overlying about 1.9 m thick sand and gravel layer. These upper materials were found to underlain by an extensive silty sand to sandy silt deposit with a maximum thickness of about 8.7 m at BH 4. A 1.5 m thin layer of cohesive glacial till was found at BH 3. These overburden materials are underlain by a Granodiorite and Meta-Basalt bedrock.

The bedrock surface is slightly undulating with an elevation ranging from 269.4 m at BH 3 to 272.0 m at BH 1 which are corresponded to 12.6 m and 11.3 m below the existing ground surface. Bedrock is known to be "Granodiorite and Meta-Basalt of the Superior Province".

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. 2908502-A*.

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

Fill Material

This material was encountered at three borehole locations (BH's 1, 2 and 3). The thickness of this layer ranges from 2.1 m at BH's 2 and 3 to 3.7 m at BH 1. Through a Grain Size Distribution test and visual observation, it can be classified as a sand with gravel, some silt, trace of clay as shown on Figure 1.

* SHEET NO 79 OF THE CONTRACT DWG'S

Topsoil

Topsoil was encountered from the surface at BH 4 or underneath the sand fill at two borehole locations (BH's 1 and 3). The thickness of this layer ranges from 0.9 m at BH 1 to about 2.1 m at BH's 3 and 4. Through a Grain Size Distribution tests and organic content test (Figure 2), the material can be classified as a sandy silt with trace of organics.

Silt

This material was found underneath sand fill or topsoil at three borehole locations (BH's 1, 2 and 3) and within silty sand to sandy silt layer at BH 4. The thickness of this layer ranges from 1.0 m at BH 1 to 1.6 m at BH 2. Through Grain Size Distribution tests and visual observation, it can be classified as a silt, trace to some clay with trace of sand as shown on Figure 3. In this stratum, the "N" values range from 4 to 38 blows/0.3 m indicating the state of compaction described as loose to compact.

Sand and Gravel

This stratum was encountered underneath the silt layer or sandy silt layer above the lower silty sand to sandy silt layer on the east side of creek at two borehole locations (BH's 2 and 4). The thickness of this layer ranges from 0.8 m at BH 4 to 1.9 m at BH 2. A Grain Size Distribution test was carried out on this material. Figure 4 in the Appendix shows the result. Through Grain Size Distribution test and visual observation, it can be classified as a sand and gravel with some silt, trace of clay. In this stratum, the "N" values range from 13 to 34 blows/0.3 m indicating the state of compaction described as compact to dense.

Silty Sand to Sandy Silt

This stratum was encountered underneath the upper materials at all boreholes. The thickness of this layer ranges from 5.5 m at BH 3 to 8.7 m at BH 4. This layer is basically non-plastic. Figure 5 in the Appendix shows the results of Grain Size Distribution tests. Based on the Grain Size Distribution tests and visual observation, it can be classified as silty sand to sandy silt, trace of clay with occasional silt layers. In this stratum, the "N" values range from 5 to over 100 blows/0.3 m indicating the state of compaction described as loose to very dense.

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

This material was found underneath the silty sand to sandy silt layer at BH 3. The thickness of this layer is about 1.5 m.
An Atterberg Limit test was carried out on this material and the result is plotted on Figure 6 and summarized as follows.

Property	Percentage
Natural Moisture Content (w)	9.5
Liquid Limit (w_L)	25
Plastic Limit (w_p)	13
Plasticity Index (Ip)	12

From the plasticity chart, it is evident that the layer can be classified as a heterogeneous mixture of clayey silt, sand and gravel (CL).

A Grain Size Distribution test was carried out on this material as shown on Figure 7 in the Appendix. In this stratum, the "N" value is over 100 blows/0.3 m indicating the consistency of this deposit described as hard.

Bedrock

The overburden is directly underlain by bedrock of the Granodiorite and Meta-Basalt of the Superior Province which was proven at two borehole locations (BH's 1 and 2) by obtaining up to 1.9 m of rock core samples. The bedrock consists mainly of Granodiorite with interbedded meta-basalt. Detailed descriptions of the rock core 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) vary between 93 and 100 percent and Rock Quality Designation (RQD) values ranges from 32 to 91 percent. Based on these results, the rock can be classified as strong rock and slightly weathered to unweathered.

GROUNDWATER CONDITIONS

Groundwater conditions were observed through the measurement of water level in the open boreholes. The groundwater level in both open boreholes after completion was found to range from depth of 4.2 m to 4.9 m below the existing ground surface which correspond to an approximate elevation of 278.7 m and 277.5 m, respectively. However, it is likely that the groundwater level is subject to seasonal fluctuations with the creek water level.

MISCELLANEOUS

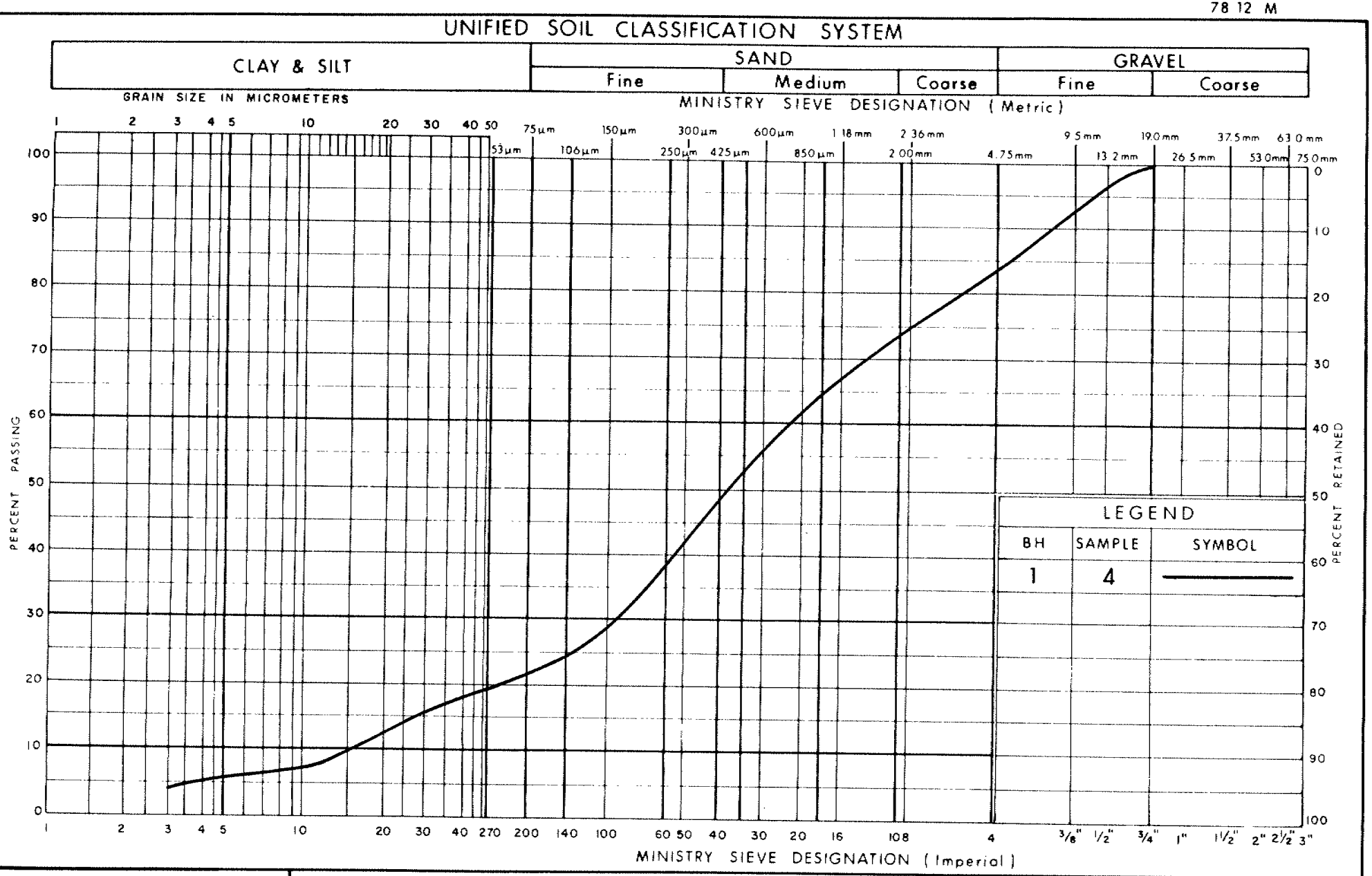
The fieldwork for this investigation was carried out during the period of 91 08 26 to 91 08 28 under the supervision of M. Iampietro, Student Engineer. The equipment was owned and operated by Dominion Soil Investigation Inc., Thunder Bay.

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

for T.C. Kim, P. Eng.
Senior Foundation Engineer

M. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX



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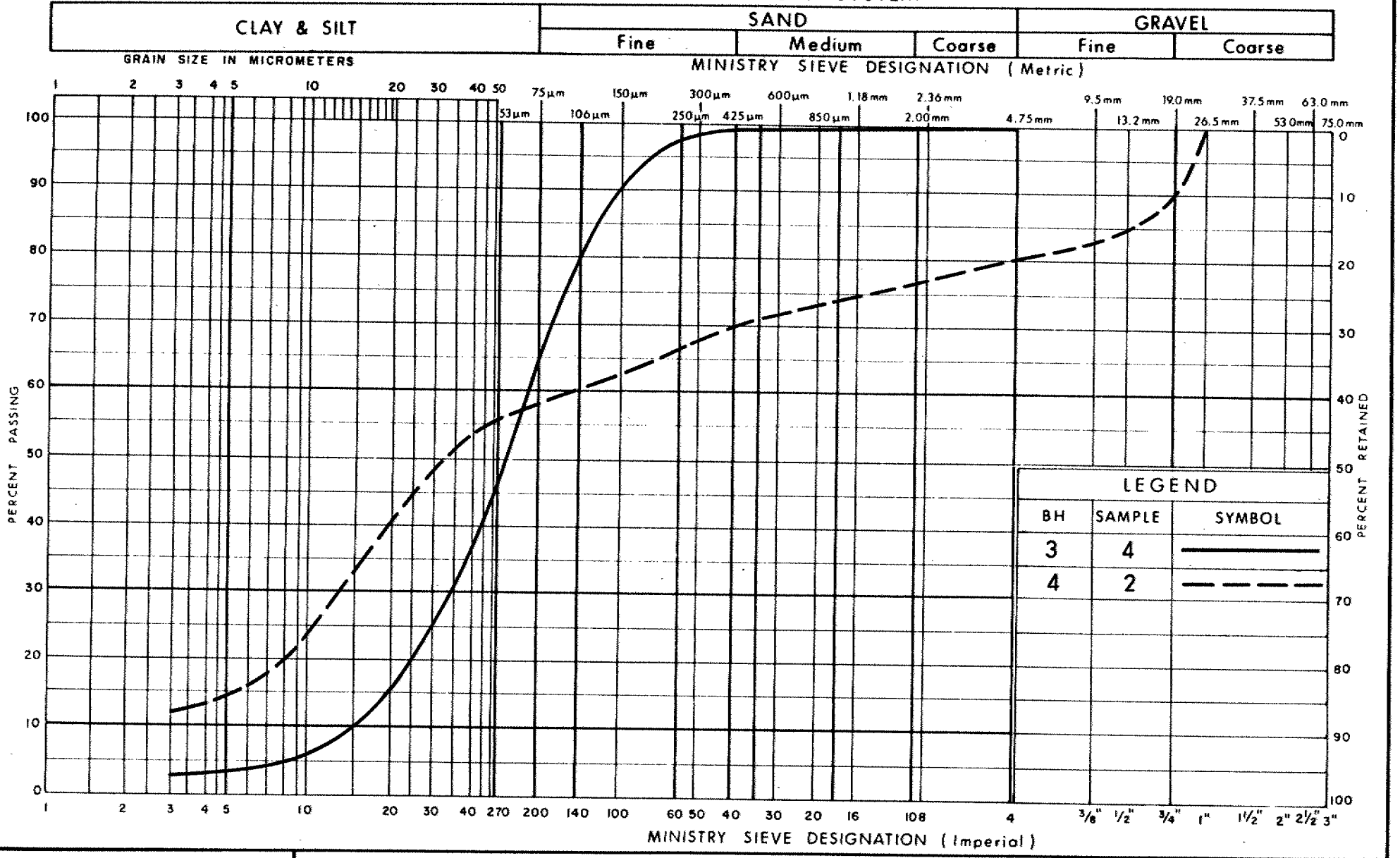
GRAIN SIZE DISTRIBUTION
SAND WITH GRAVEL (Fill)

FIG No 1
WP 290-85-02

10

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION

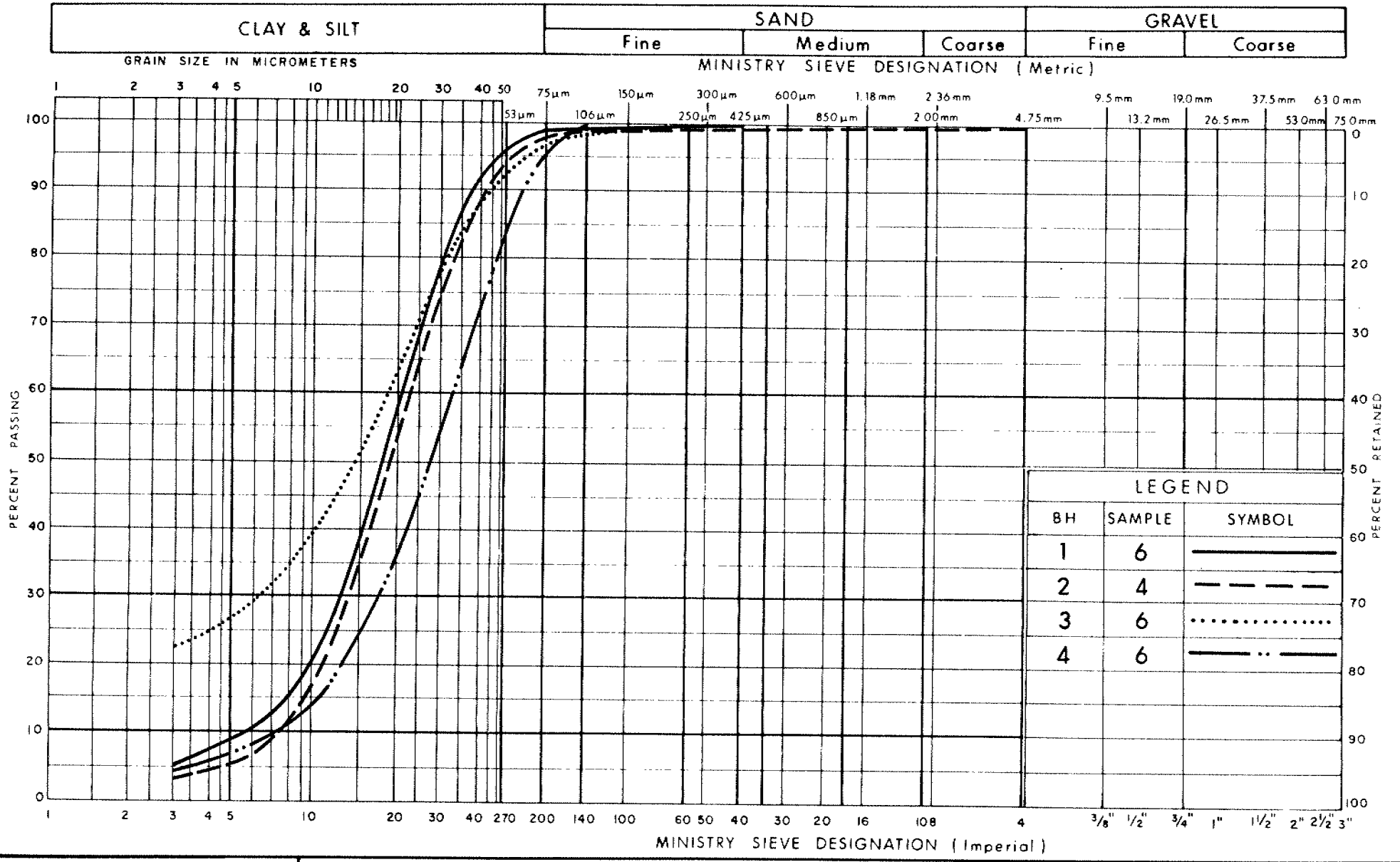
SANDY SILT, TRACE OF ORGANICS (Topsoil)

FIG No 2

W P 290-85-02

11

UNIFIED SOIL CLASSIFICATION SYSTEM



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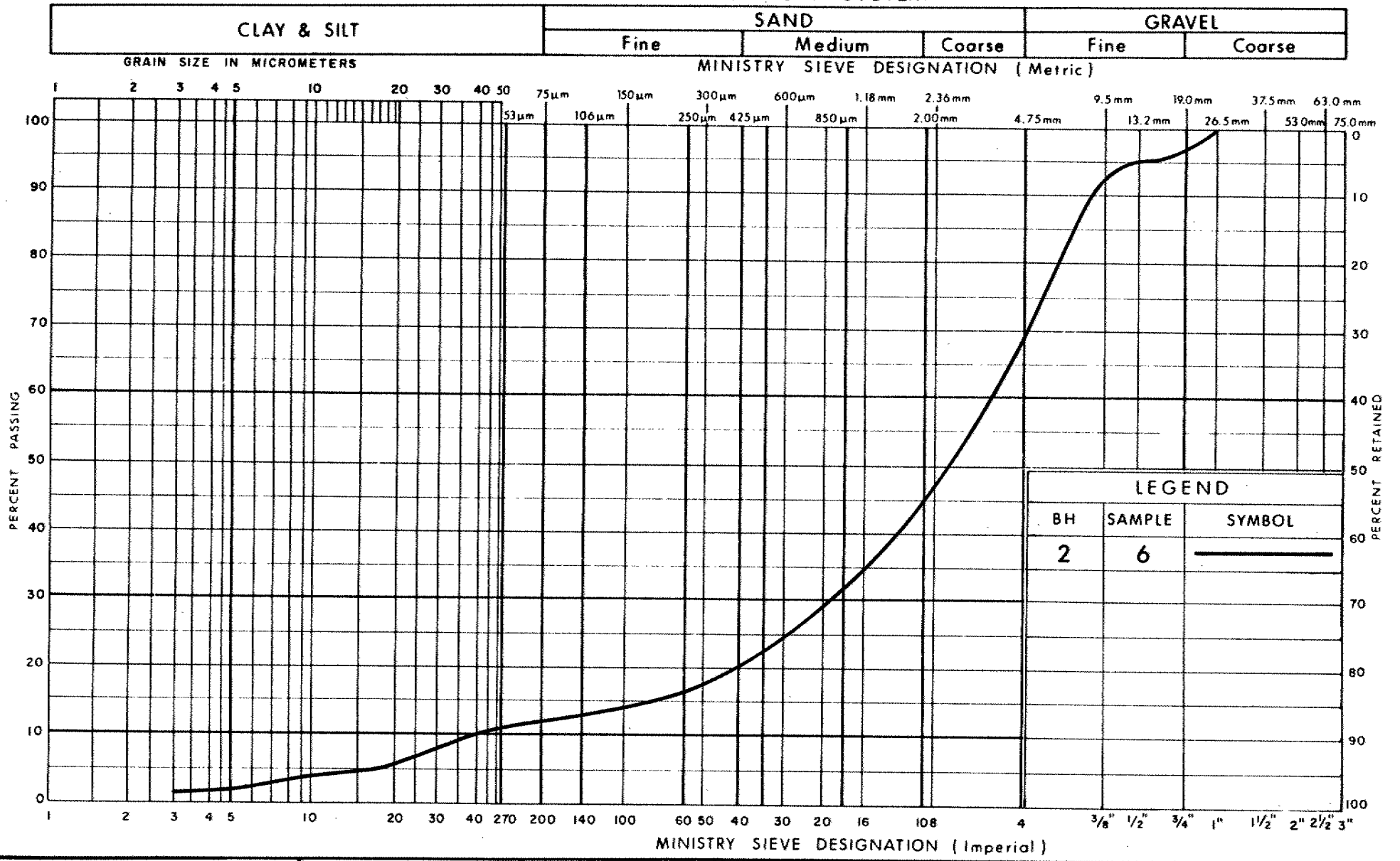
GRAIN SIZE DISTRIBUTION
SILT

FIG No 3
W P 290-85-02

UNIFIED SOIL CLASSIFICATION SYSTEM



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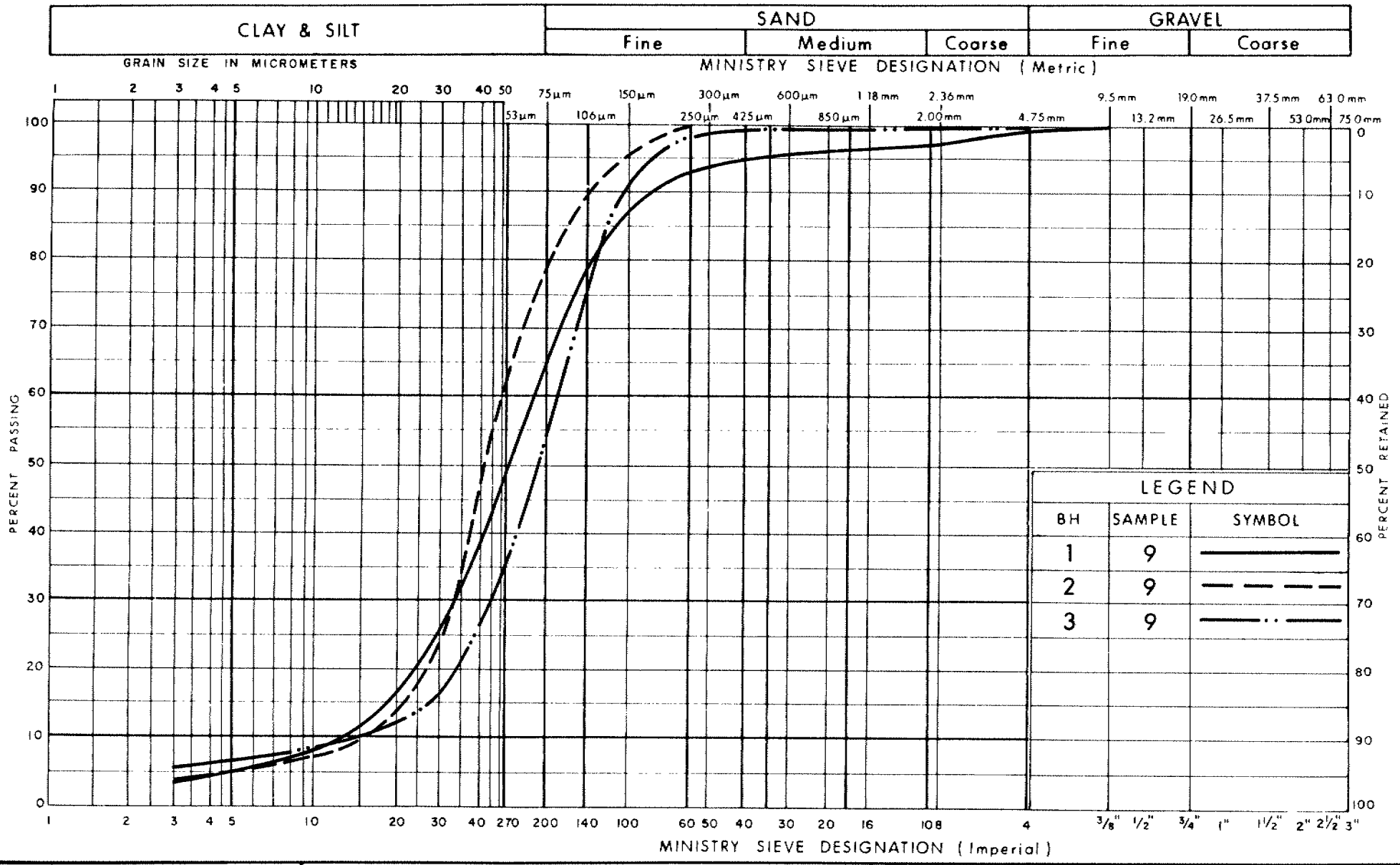
GRAIN SIZE DISTRIBUTION
SAND & GRAVEL

FIG No 4
W P 290-85-02

UNIFIED SOIL CLASSIFICATION SYSTEM



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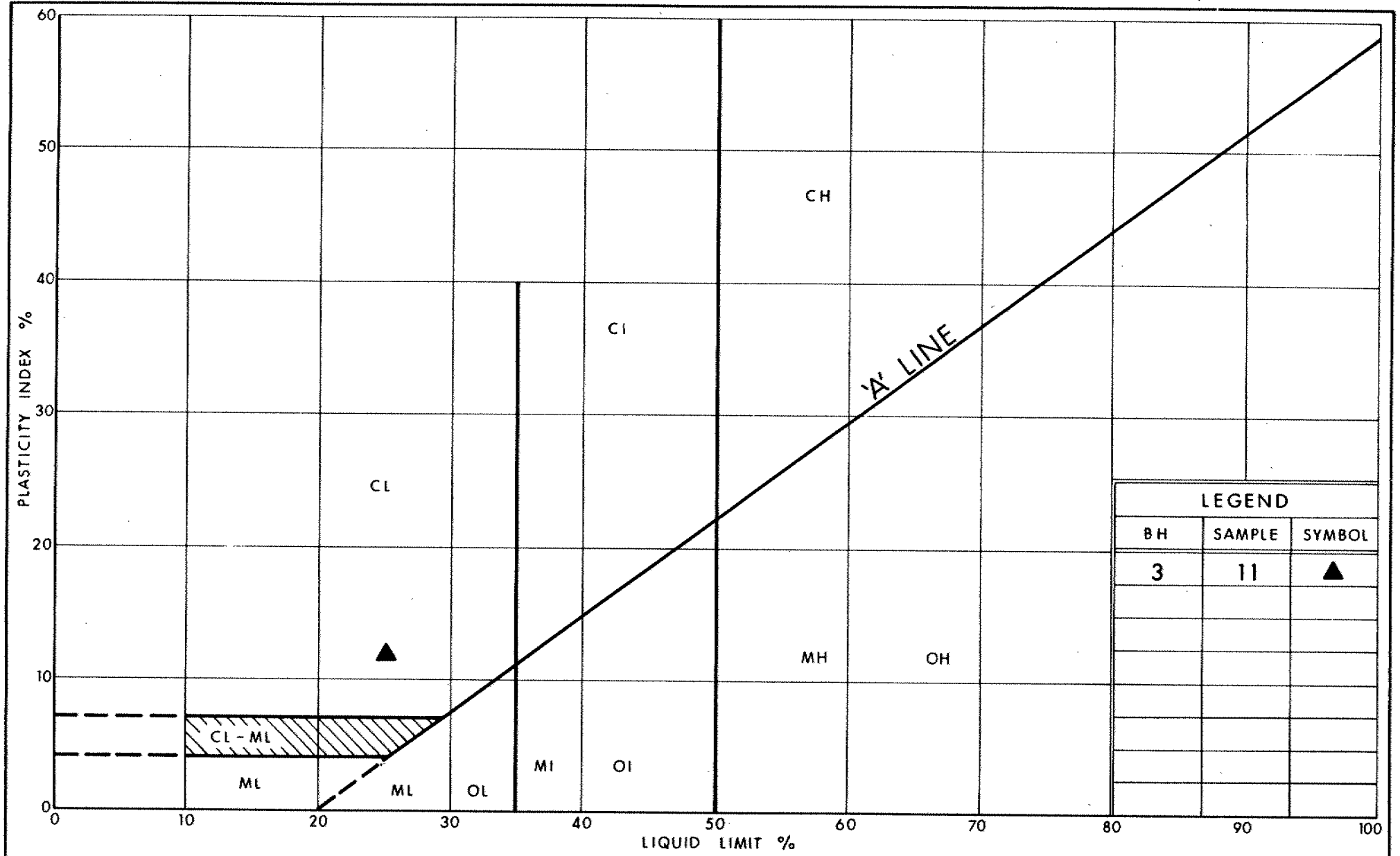
GRAIN SIZE DISTRIBUTION
SILTY SAND TO SANDY SILT

FIG No 5
W P 290-85-02

14



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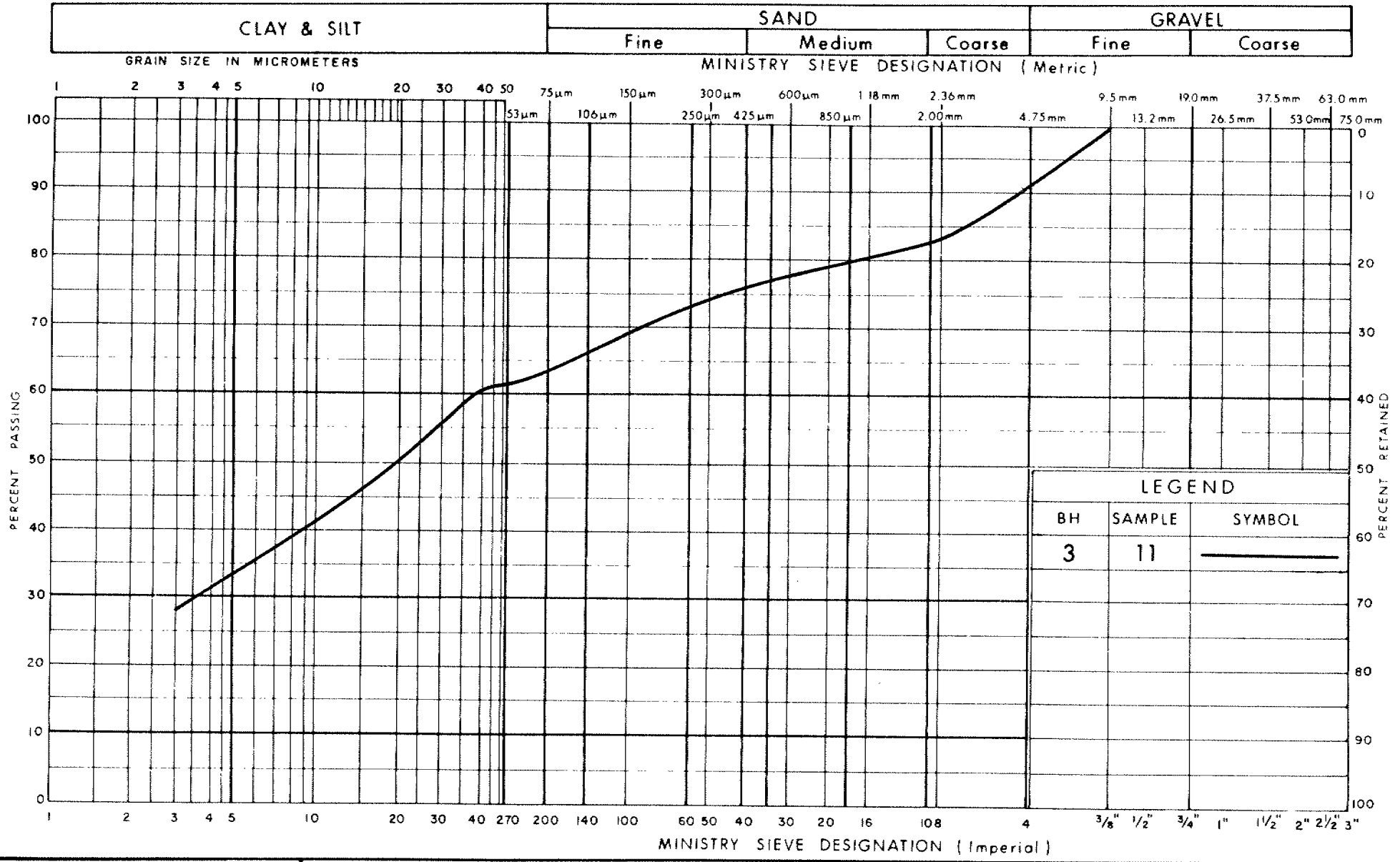
PLASTICITY CHART
HET MIXTURE OF
CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 6
WP 290-85-02

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION
HET MIXTURE OF
CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 7
W P 290-85-02

RECORD OF BOREHOLE No 1 — 1 OF 1 — METRIC

W.P. 290-85-02 LOCATION Sta. 12+563.0; O/S 4.2 m Rt. ℄ Hwy 11 ORIGINATED BY MI

DIST 19 HWY 11 BOREHOLE TYPE HS Auger, BXL Rock Core COMPILED BY AD

DATUM Geodetic DATE 91 08 27-28 CHECKED BY TCK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
283.3	Ground Surface										
0.0	Sand with Gravel Loose to compact (Fill)		1	SS	9		283				
			2	SS	17		282				
			3	SS	12		281				
279.6		Brown	4	SS	9		280		o		16 63 18 3
3.7	Sandy Silt, some organics Compact (Topsoil)	Black	5	SS	17		279				
278.7		Black				▼					
4.6	Silt, trace of sand Compact	Grey	6	SS	24		278		o		0 1 95 4
277.7											
5.6	Silty Sand to Sandy Silt Occ. Silt layers Loose to very dense		7	SS	8		277				
			8	SS	6		276				
			9	SS	43		275				
			10	SS	50/8cm		274		o		2 34 61 3
272.0							273				
11.3	Bedrock Granodiorite and Meta-Basalt of the Superior province		11	BXL RC	REC 100%		272				RQD 91%
270.4							271				
12.9	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2 1 OF 1 METRIC

W.P. 290-85-02 LOCATION Sta. 12+591.5; O/S 4.3 m Lt. ℄ Hwy 11 ORIGINATED BY MI

DIST 19 HWY 11 BOREHOLE TYPE HS Auger, BXL Rock Core COMPILED BY AD

DATUM Geodetic DATE 91 08 26 CHECKED BY TCK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
283.6	Ground Surface										
0.0	Sand with Gravel Loose to compact (Fill)		1	SS	15		283				
			2	SS	7		282				
281.5											
2.1	Silt, trace of sand compact		3	SS	23		281				
			4	SS	16				○		0 2 97 1
279.9							280				
3.7	Sand and Gravel compact to dense		5	SS	34						
			6	SS	13	▼	279		○		31 57 10 2
278.0	Brown										
5.6	Grey						278				
	Silty Sand to Sandy Silt occ. Silt layers compact to very dense		7	SS	100		277				
			8	SS	61		276				
			9	SS	26		275		○		0 23 74 3
			10	SS	66		274				
271.3			11	SS	50	/13cm	273				
12.3	Bedrock Granodiorite and Meto-Basalt of the Superior province		12	RC	REC 93%		272				RQD 32%
			13	BXL RC	REC 95%		271				RQD 88%
269.4							270				
14.2	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 3 1 OF 1 METRIC

W.P. 290-85-02 LOCATION Sta 12+555.6; O/S 20m Lt. ℄ Hwy 11 ORIGINATED BY MI

DIST 19 HWY 11 BOREHOLE TYPE HS Auger COMPILED BY AD

DATUM Geodetic DATE 91 08 28 CHECKED BY TCK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
282.0	Ground Surface										
0.0	Sand with Gravel compact (Fill)		1	SS	10		281				
279.9	Brown		2	SS	11		280				
2.1	Black Sandy Silt, trace of organics Loose to compact (Topsoil)		3	SS	4		279			organics 6.4 %	
277.8	Black		4	SS	6				w=56.5		0 35 63 2
4.2	Grey Silt, some clay, trace of sand Loose		5	SS	12	▼	278				
276.4			6	SS	4		277		o		0 3 76 21
5.6	Silty Sand to Sandy Silt occ. Silt layers Loose to very dense		7	SS	5		276				
			8	SS	16		275				
			9	SS	56		274		o		0 50 45 5
270.9			10	SS	100	/28cm	273				
11.1	Het. Mixture of Clayey Silt, Sand and Gravel Hard (Glacial Till)						272				
			11	SS	100	/25cm	271		o ⊢		9 28 40 23
269.4							270				
12.6	End of Borehole at probable bedrock										

+³, ×⁵ : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 4 1 OF 1 METRIC

W.P. 290-85-02 LOCATION Sta 12+598.3; o/s 20m Lt. ℄ Hwy 11 ORIGINATED BY MI

DIST 19 HWY 11 BOREHOLE TYPE HS Auger COMPILED BY AD

DATUM Geodetic DATE 91 08 28 CHECKED BY TCK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
282.7	Ground Surface										
0.0	Sandy Silt, some Gravel trace of organics (Topsoil) compact		1	SS	13		282				
280.6			2	SS	20		281		c		20 22 48 10
2.1	Sand and Gravel compact		3	SS	28		280				
279.8	Brown										
2.9	Grey		4	SS	33		279				
			5	SS	52	▼					
	Silt		6	SS	38		278		o		0 2 96 2
			7	SS	40		277				
			8	SS	47		276				
	Silty Sand to Sandy Silt occ. Silt layers compact to very dense		9	SS	20		275				
			10	SS	56		274				
271.1							273				
11.6	End of Borehole at probable bedrock						272				

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

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

ROCK CORE DESCRIPTION
WP 290-85-02

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	11	11.28-12.85	100	91	11.28-12.85	**GRANODIORITE** (chlorite-bearing), medium dark grey to greyish orange pink; coarse to fine grained; strong; unweathered to slightly weathered; fractures moderately close to very close spaced, dipping to near vertical, undulating to planar, smooth.
2	12	12.34-12.70	93	32	12.34-12.52	**META-BASALT** (chloritized), greenish black; fine grained; weak; unweathered to slightly weathered; fractures close to extremely close spaced, dipping, undulating, smooth.
	13	12.70-14.23	95	88	12.52-14.23	**GRANODIORITE** (chlorite-bearing), medium dark grey to greyish orange pink; coarse to fine grained; strong; unweathered to slightly weathered; fractures moderately close to very close spaced, dipping, undulating to planar, smooth.

***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

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 290-85-02 DIST 19

HWY 11 STR SITE 48E-7

Proposed Hoiles Creek Bridge Replacement
26.8 km East of Junction Hwy. 625

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GEOCRES 42F-13 DATE MAR 3 1 1992

FOUNDATION INVESTIGATION REPORT
For
Proposed Hoiles Creek Bridge Replacement
Highway 11, 26.8 km East of Junction Hwy. 625
W.P. 290-85-02, Site No. 48E-7
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 five span timber bridge along the Hwy. 11 crossing the Hoiles Creek. A single Bailey Bridge is also proposed for the detour during construction.

The fieldwork was carried out between 91 08 26 and 91 08 28. 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 11.6 and 14.2 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. 2908502-A.

SITE DESCRIPTION

The Hoiles Creek Bridge is located on Highway 11, approximately 42 km east of the Town of Longlac, about 27 km east of Jct. Highway 625, in the Thunder Bay District. The existing structure is an asphalt covered 5 span longitudinally laminated timber bridge founded on timber piles. The topography in the immediate area is generally flat to gently undulating. The immediate vicinity of the site is occupied by bush land.

SUBSURFACE CONDITIONS

The subsoil conditions encountered across the site are generally uniform. Sand with gravel fills were encountered at three borehole locations (BH's 1, 2, and 3) as much as 3.7 m in the road embankment of existing Highway 11. Sandy silt topsoil was found at three borehole locations (up to 2.1 m thick) from the ground surface or underneath the sand fill. On the other hand, silt materials were encountered at all borehole locations (up to 1.6 m thick) overlying about 1.9 m thick sand and gravel layer. These upper materials were found to underlain by an extensive silty sand to sandy silt deposit with a maximum thickness of about 8.7 m at BH 4. A 1.5 m thin layer of cohesive glacial till was found at BH 3. These overburden materials are underlain by a Granodiorite and Meta-Basalt bedrock.

The bedrock surface is slightly undulating with an elevation ranging from 269.4 m at BH 3 to 272.0 m at BH 1 which are corresponded to 12.6 m and 11.3 m below the existing ground surface. Bedrock is known to be "Granodiorite and Meta-Basalt of the Superior Province".

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. 2908502-A.

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

Fill Material

This material was encountered at three borehole locations (BH's 1, 2 and 3). The thickness of this layer ranges from 2.1 m at BH's 2 and 3 to 3.7 m at BH 1. Through a Grain Size Distribution test and visual observation, it can be classified as a sand with gravel, some silt, trace of clay as shown on Figure 1.

Topsoil

Topsoil was encountered from the surface at BH 4 or underneath the sand fill at two borehole locations (BH's 1 and 3). The thickness of this layer ranges from 0.9 m at BH 1 to about 2.1 m at BH's 3 and 4. Through a Grain Size Distribution tests and organic content test (Figure 2), the material can be classified as a sandy silt with trace of organics.

Silt

This material was found underneath sand fill or topsoil at three borehole locations (BH's 1, 2 and 3) and within silty sand to sandy silt layer at BH 4. The thickness of this layer ranges from 1.0 m at BH 1 to 1.6 m at BH 2. Through Grain Size Distribution tests and visual observation, it can be classified as a silt, trace to some clay with trace of sand as shown on Figure 3. In this stratum, the "N" values range from 4 to 38 blows/0.3 m indicating the state of compaction described as loose to compact.

Sand and Gravel

This stratum was encountered underneath the silt layer or sandy silt layer above the lower silty sand to sandy silt layer on the east side of creek at two borehole locations (BH's 2 and 4). The thickness of this layer ranges from 0.8 m at BH 4 to 1.9 m at BH 2. A Grain Size Distribution test was carried out on this material. Figure 4 in the Appendix shows the result. Through Grain Size Distribution test and visual observation, it can be classified as a sand and gravel with some silt, trace of clay. In this stratum, the "N" values range from 13 to 34 blows/0.3 m indicating the state of compaction described as compact to dense.

Silty Sand to Sandy Silt

This stratum was encountered underneath the upper materials at all boreholes. The thickness of this layer ranges from 5.5 m at BH 3 to 8.7 m at BH 4. This layer is basically non-plastic. Figure 5 in the Appendix shows the results of Grain Size Distribution tests. Based on the Grain Size Distribution tests and visual observation, it can be classified as silty sand to sandy silt, trace of clay with occasional silt layers. In this stratum, the "N" values range from 5 to over 100 blows/0.3 m indicating the state of compaction described as loose to very dense.

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

This material was found underneath the silty sand to sandy silt layer at BH 3. The thickness of this layer is about 1.5 m.
An Atterberg Limit test was carried out on this material and the result is plotted on Figure 6 and summarized as follows.

Property	Percentage
Natural Moisture Content (w)	9.5
Liquid Limit (w_L)	25
Plastic Limit (w_P)	13
Plasticity Index (Ip)	12

From the plasticity chart, it is evident that the layer can be classified as a heterogeneous mixture of clayey silt, sand and gravel (CL).

A Grain Size Distribution test was carried out on this material as shown on Figure 7 in the Appendix. In this stratum, the "N" value is over 100 blows/0.3 m indicating the consistency of this deposit described as hard.

Bedrock

The overburden is directly underlain by bedrock of the Granodiorite and Meta-Basalt of the Superior Province which was proven at two borehole locations (BH's 1 and 2) by obtaining up to 1.9 m of rock core samples. The bedrock consists mainly of Granodiorite with interbedded meta-basalt. Detailed descriptions of the rock core 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) vary between 93 and 100 percent and Rock Quality Designation (RQD) values ranges from 32 to 91 percent. Based on these results, the rock can be classified as strong rock and slightly weathered to unweathered.

GROUNDWATER CONDITIONS

Groundwater conditions were observed through the measurement of water level in the open boreholes. The groundwater level in both open boreholes after completion was found to range from depth of 4.2 m to 4.9 m below the existing ground surface which correspond to an approximate elevation of 278.7 m and 277.5 m, respectively. However, it is likely that the groundwater level is subject to seasonal fluctuations with the creek water level.

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 30 m in length which will replace the existing 23 m 5 span timber bridge along the Highway 11 crossing the Hoiles Creek. A single Bailey bridge is also proposed for the detour during construction of the permanent structure (about 43 m long 6 m wide, 20 m north of the centreline of Highway 11). It is understood that the highway grade will be the same as the existing elevation of about 283.5 m at bridge location. However, this would involve the additional placement and compaction of up to 1.5 m fill for the Bailey bridge approach at west abutment location.

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

Proposed Replacement Bridge Foundations

In view of the weak nature of the silty sand to sandy silt layers, especially on the west bank, conventional spread footing shallow foundation 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 very dense basal stratum and driven to bedrock.

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
HP 310 X 79	1150 kN	900 kN	W. Abut. 272.0 m
HP 310 X 110	1600 kN	1100 kN	E. Abut. 271.3 m

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

During pile driving, the steel "H" piles 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 should not contain particle sizes greater than 75 mm.

Proposed Bailey Bridge Structure

In consideration of the existence of weak sandy silt topsoil on the west bank, the existing sand fill material and sandy silt topsoil should be excavated at the west abutment location to an elevation of about 278.5 m and the excavation can be backfilled with compacted Granular "A" core as high as an elevation of 281 m (Figure 8).

Spread footings founded on compacted Granular "A" core at the west abutment or sandy silt at the east abutment, may be used to support the temporary Bailey Bridge abutments. For the purpose of the O.H.B.D.C., the following design values are recommended:

	Factored Bearing Capacity at U.L.S. (kPa)	Allowable Capacity S.L.S. Type II (kPa)	Proposed Footing Elevation (m)
W. Abutment	600	240	281 (excavation to Elev. 278.5 m)
E. Abutment	600	240	281

A footing width of 2.5 m with an embedded depth of 2.6 m was used in the calculation of the above capacities.

The sliding resistance may be computed by assuming the coefficient of friction 0.7 between the underside of footings and compacted Granular "A" and 0.58 between the underside of footings and sandy 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.

Dewatering

No major dewatering difficulties are anticipated for footing excavations in consideration of the low groundwater level in sandy material. However, if localized seepage or surface water is to accumulate in excavations, it can be controlled by perimeter ditches and pumping from corner sumps as shown on Figure 9.

Frost Protection

The footings and pile caps should be placed so as to have a minimum earth cover of 2.6 m to allow for frost protection.

Approaches and Excavations

No stability problems are anticipated for permanent embankment and cut slopes constructed to a 2:1 geometry. However, the slope surface should be protected from erosion of the sand with gravel fill by a thin layer of topsoil as per current MTO standards. Suitable protection measures should also be provided to the creek banks adjacent to the abutments. Such measures may include appropriately sized rip-rap underlain by suitable granular filter.

Temporary cut slopes will also stand at a 2:1 geometry.

MISCELLANEOUS

The fieldwork for this investigation was carried out during the period of 91 08 26 to 91 08 28 under the supervision of M. Iampietro, Student Engineer. The equipment was owned and operated by Dominion Soil Investigation Inc., Thunder Bay.

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

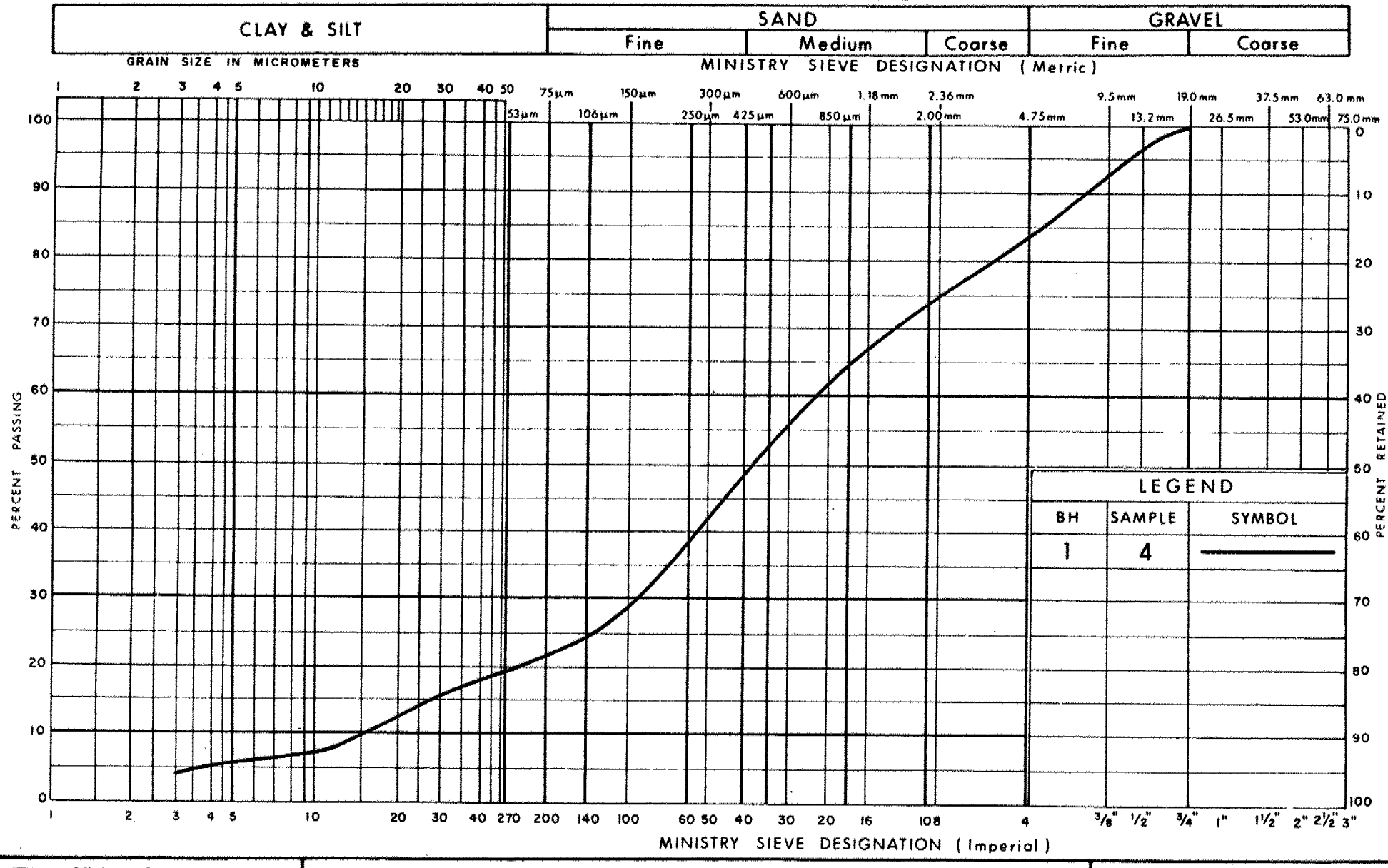
Tae C. Kim, P. Eng.
Senior Foundation Engineer

M. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX

78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM

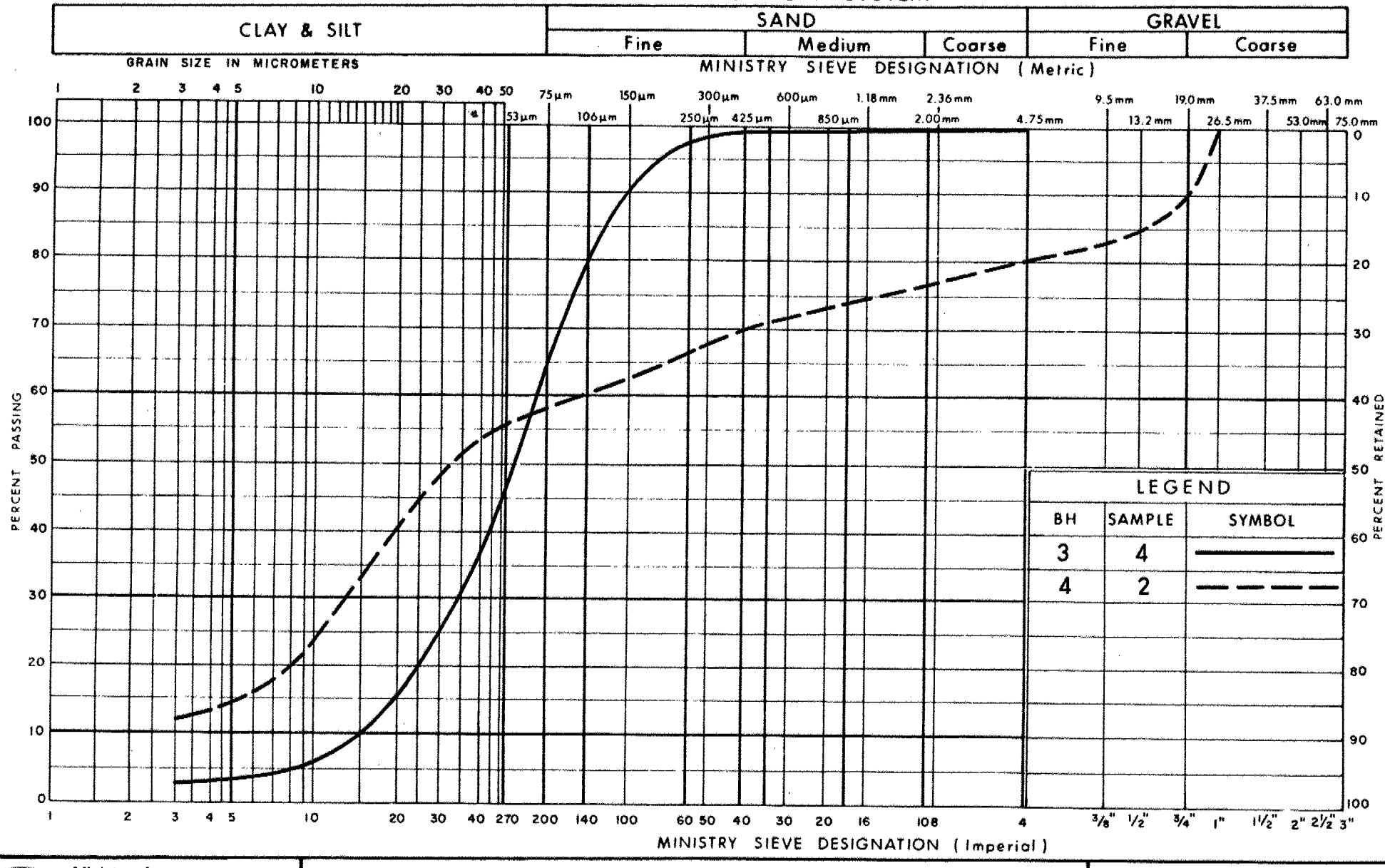


Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
SAND WITH GRAVEL (Fill)

FIG No 1
WP 290-85-02

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

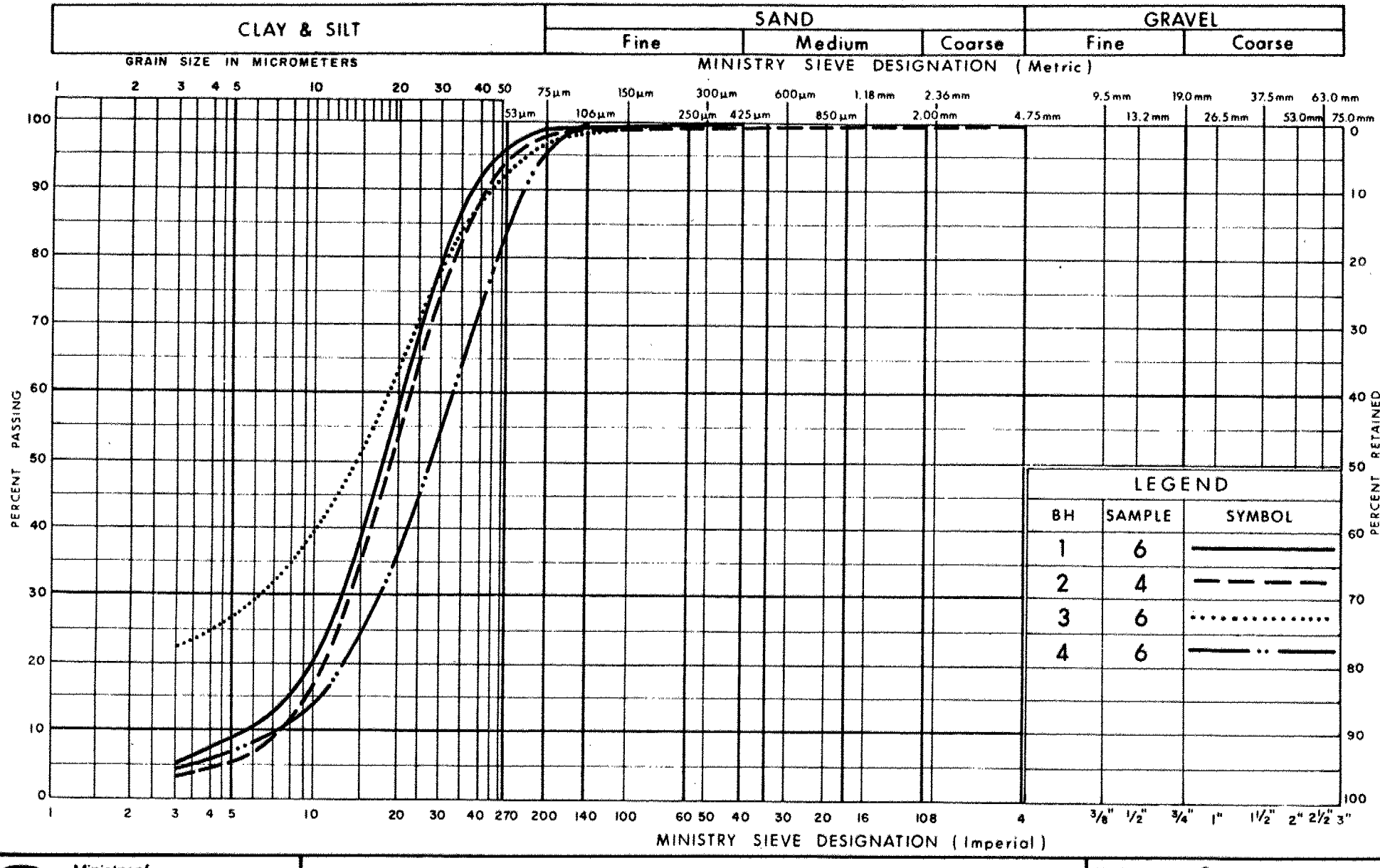
GRAIN SIZE DISTRIBUTION

SANDY SILT, TRACE OF ORGANICS (Topsoil)

FIG No 2

W P 290-85-02

UNIFIED SOIL CLASSIFICATION SYSTEM

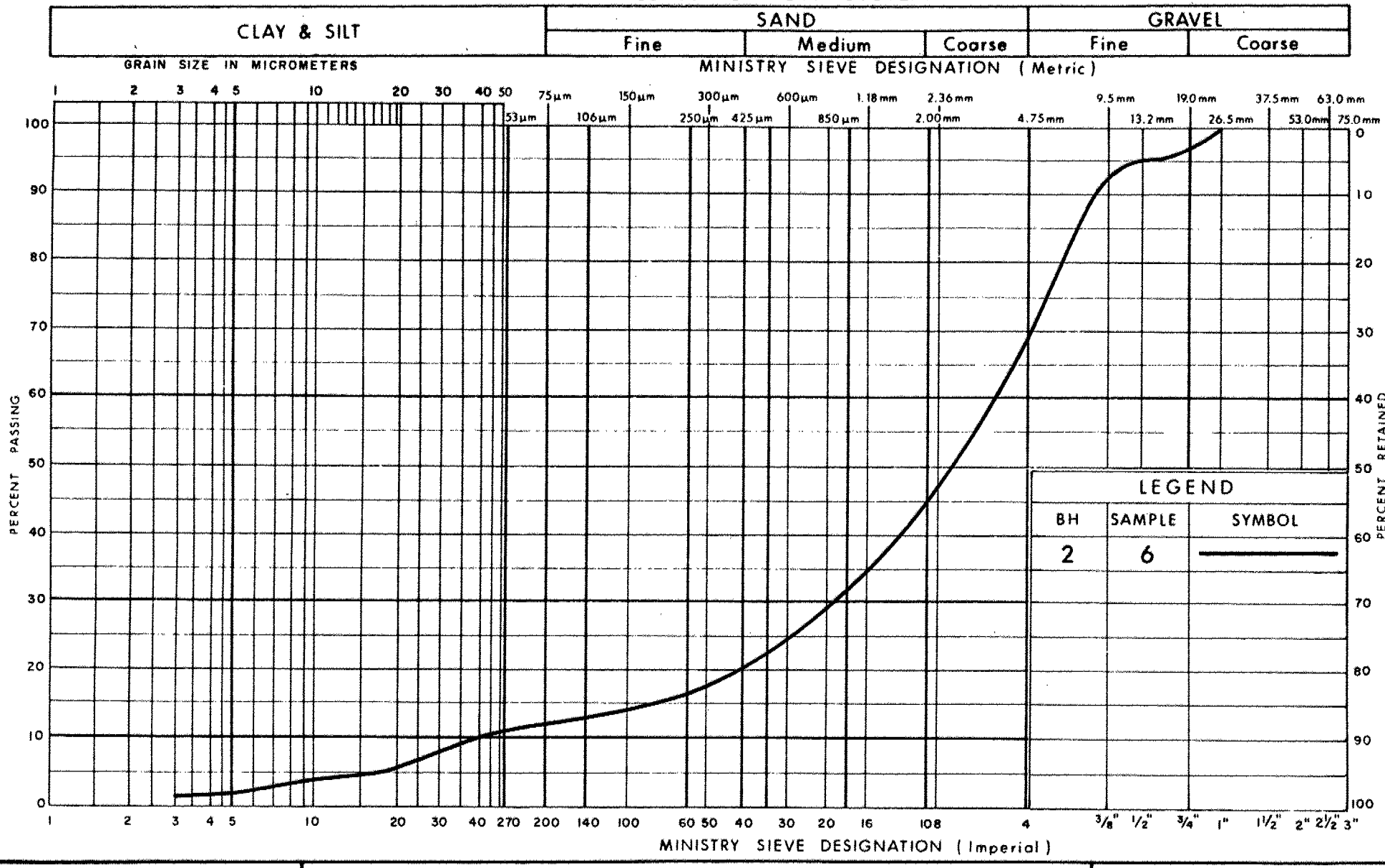


Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
SILT

FIG No 3
W P 290-85-02

UNIFIED SOIL CLASSIFICATION SYSTEM



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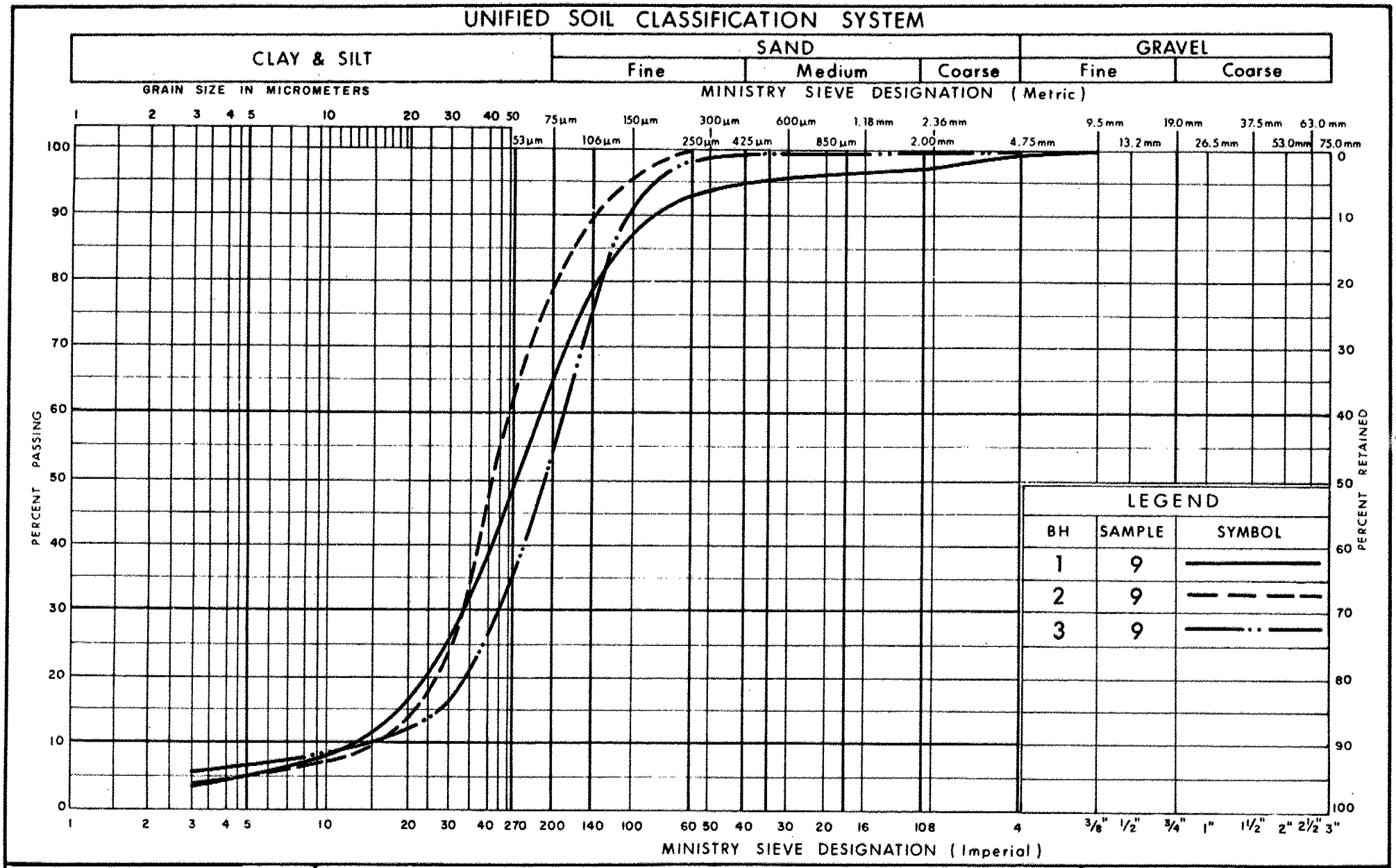
GRAIN SIZE DISTRIBUTION
SAND & GRAVEL

FIG No 4
W P 290-85-02



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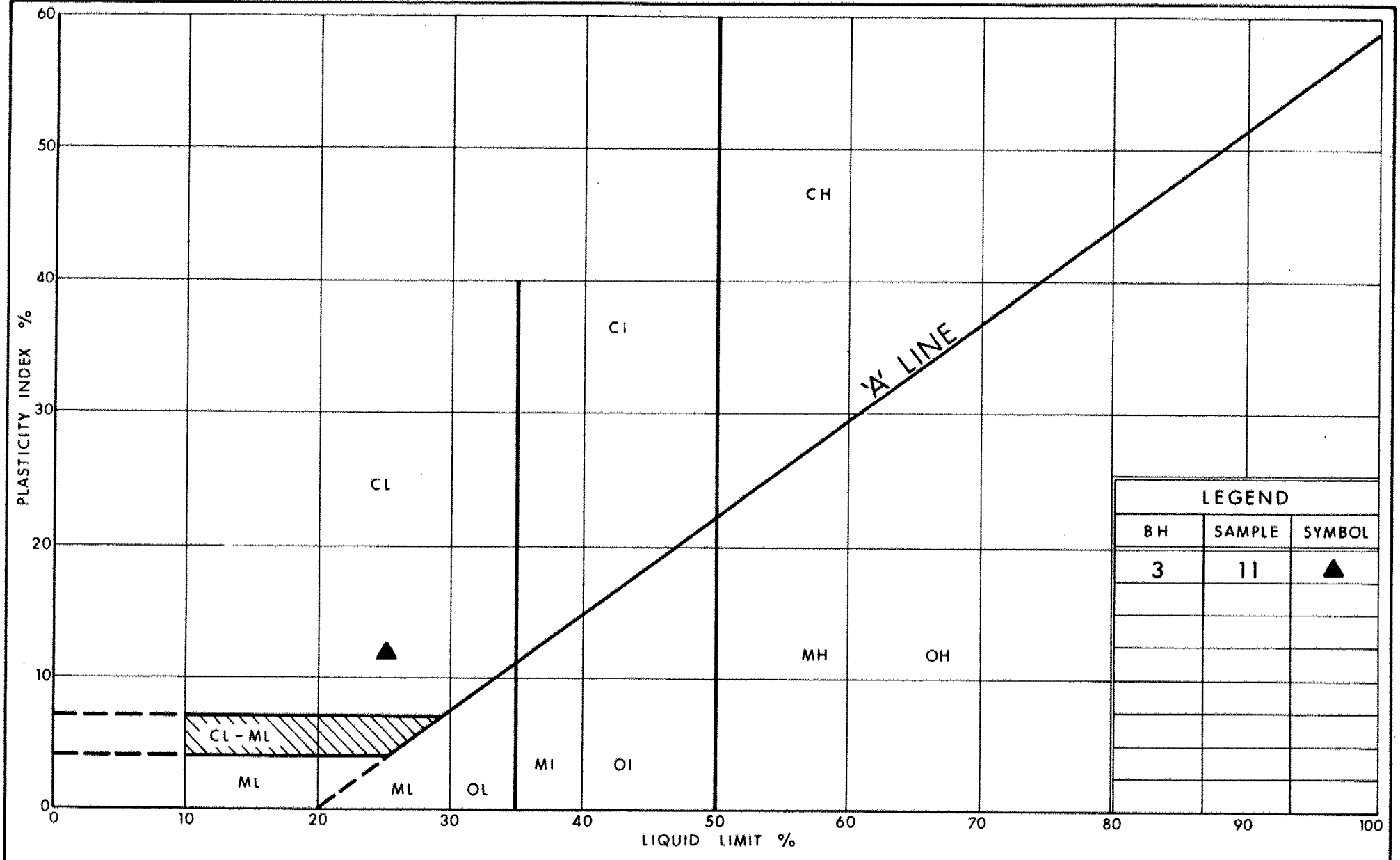
GRAIN SIZE DISTRIBUTION
SILTY SAND TO SANDY SILT

FIG No 5
W P 290-85-02

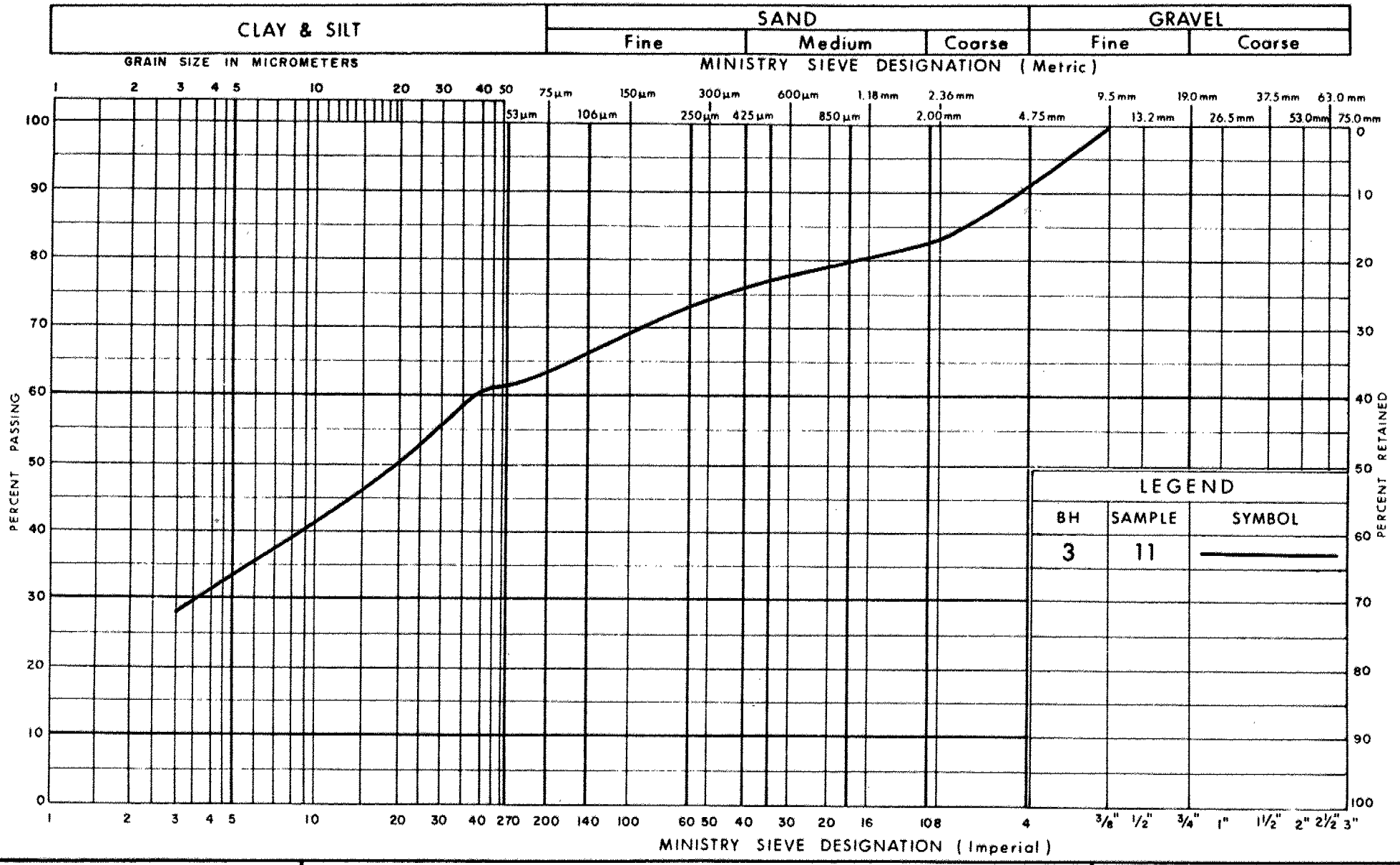


Ministry of Transportation
Ontario

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

FIG No 6
WP 290-85-02

UNIFIED SOIL CLASSIFICATION SYSTEM



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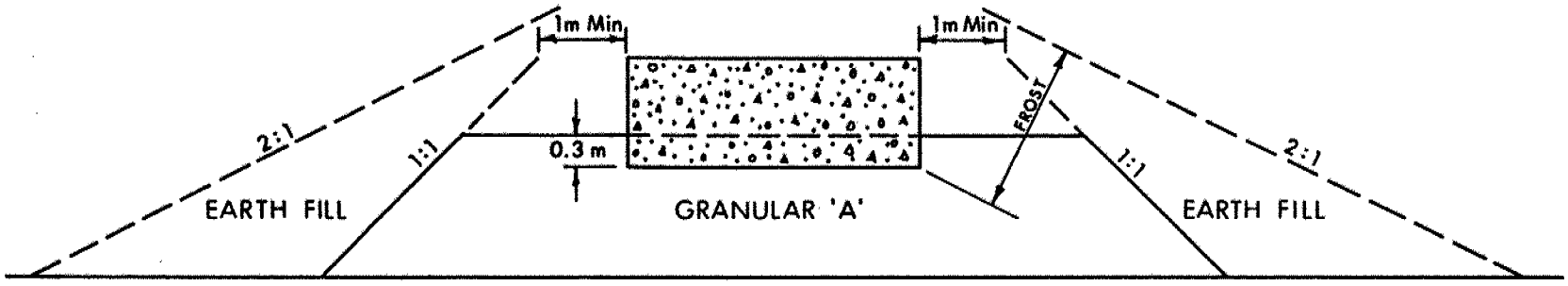
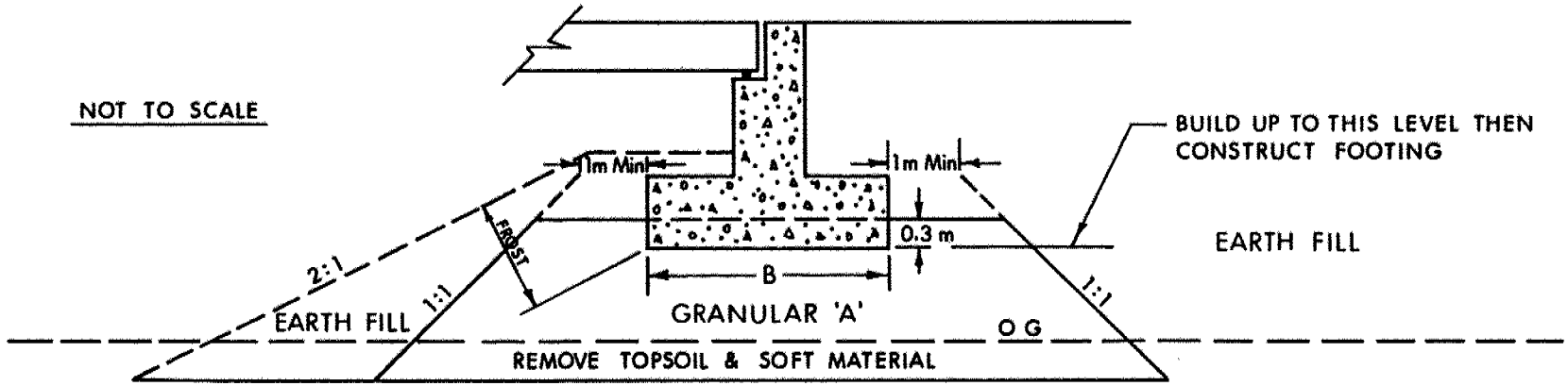
GRAIN SIZE DISTRIBUTION
HET MIXTURE OF
CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 7
W P 290-85-02



X SECTION



LONGITUDINAL SECTION

NOTES:

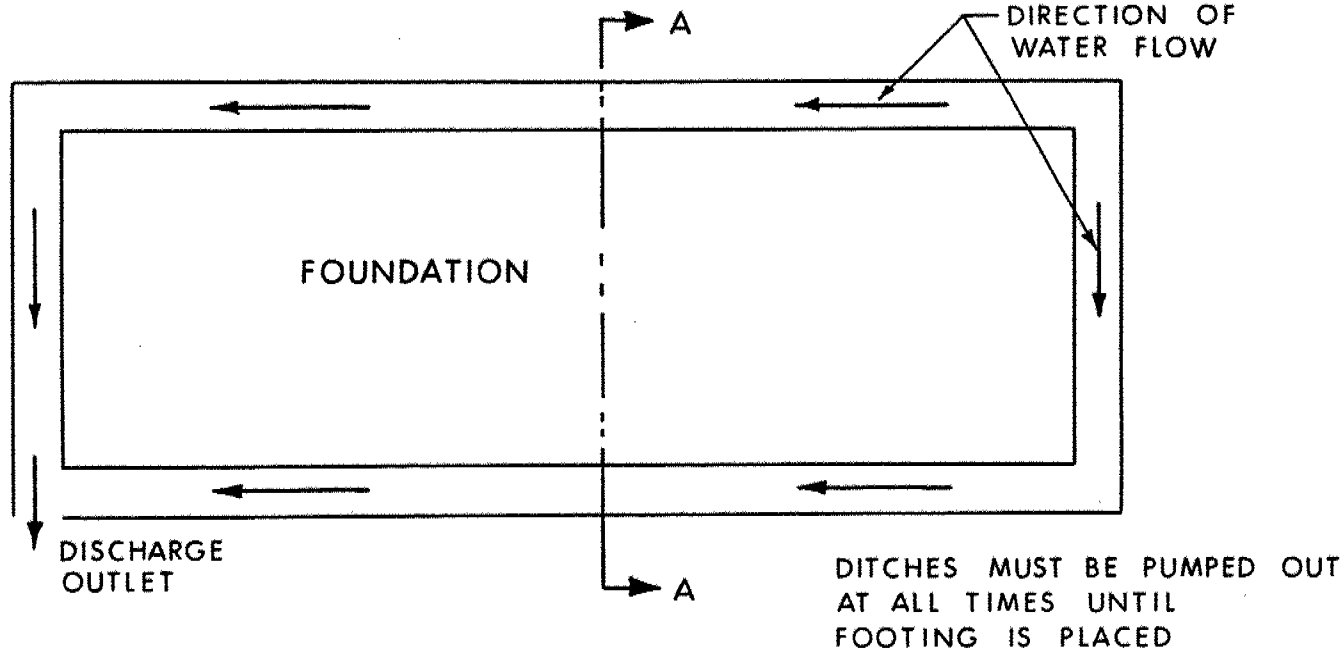
1 - REMOVE TOPSOIL &/OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' & EARTH FILL.

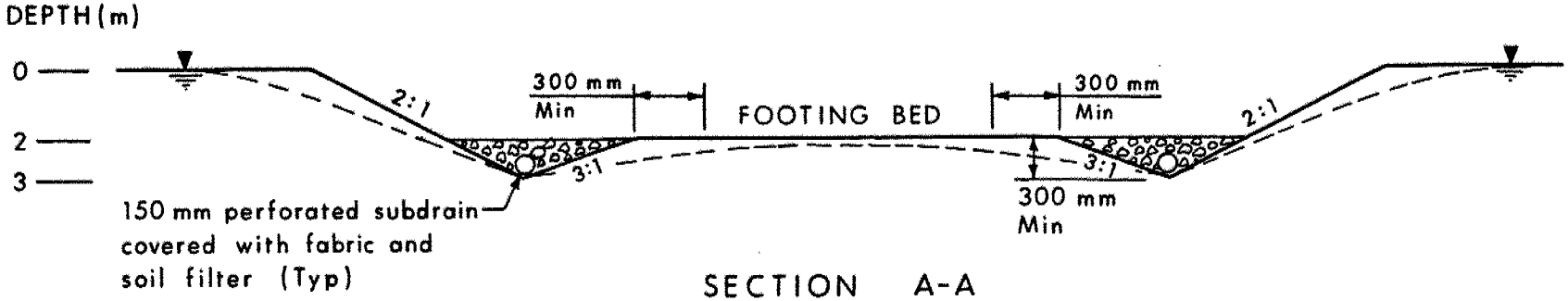
2 - PLACE GRANULAR 'A' & EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO CURRENT M T O STANDARDS.

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 8 W P 290-85-02





SECTION A-A
(NTS)

DEWATERING SCHEME - PERIMETER DITCHES

WP 290-85-02
FIG 9

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 — 1 OF 1 — METRIC

W.P. 290-85-02 LOCATION Sta. 12+563.0; O/S 4.2 m Rt. ℄ Hwy 11 ORIGINATED BY MI

DIST 19 HWY 11 BOREHOLE TYPE HS Auger, BXL Rock Core COMPILED BY AD

DATUM Geodetic DATE 91 08 27-28 CHECKED BY TCK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES 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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
283.3	Ground Surface										
0.0	Sand with Gravel Loose to compact (Fill)		1	SS	9		283				
			2	SS	17		282				
			3	SS	12		281				
279.6	Brown		4	SS	9		280		o		16 63 18 3
3.7	Sandy Silt, some organics Compact (Topsoil)	Black	5	SS	17		279				
278.7	Black Grey					▼					
4.6	Silt, trace of sand Compact		6	SS	24		278		o		0 1 95 4
277.7											
5.6	Silty Sand to Sandy Silt Occ. Silt layers Loose to very dense		7	SS	8		277				
			8	SS	6		276				
			9	SS	43		275				
			10	SS	50/8cm		274		o		2 34 61 3
272.0							273				
11.3	Bedrock Granodiorite and Meta-Basalt of the Superior province		11	BXL RC	REC 100%		272				RQD 91%
270.4							271				
12.9	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 2 — 1 OF 1 — METRIC

W.P. 290-85-02 LOCATION Sta. 12+591.5; O/S 4.3 m Lt. ℄ Hwy 11 ORIGINATED BY MI

DIST 19 HWY 11 BOREHOLE TYPE HS Auger, BXL Rock Core COMPILED BY AD

DATUM Geodetic DATE 91 08 26 CHECKED BY TCK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
283.6	Ground Surface										
0.0	Sand with Gravel Loose to compact (Fill)		1	SS	15						
			2	SS	7						
281.5											
2.1	Silt, trace of sand compact		3	SS	23						
			4	SS	16				o		0 2 97 1
279.9											
3.7	Sand and Gravel compact to dense		5	SS	34						
			6	SS	13	▼			o		31 57 10 2
278.0	Brown Grey										
5.6	Silty Sand to Sandy Silt occ. Silt layers compact to very dense		7	SS	100						
			8	SS	61						
			9	SS	26				o		0 23 74 3
			10	SS	66						
271.3			11	SS	50/13cm						
12.3	Bedrock Granodiorite and Meta-Basalt of the Superior province		12	RC	REC 93%						RQD 32%
			13	BXL RC	REC 95%						RQD 88%
269.4											
14.2	End of Borehole										

ELEVATION SCALE: 283, 282, 281, 280, 279, 278, 277, 276, 275, 274, 273, 272, 271, 270

+³, ×⁵: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 3 — 1 OF 1 — METRIC

W.P. 290-85-02 LOCATION Sta 12+555.6; O/S 20m Lt. ℄ Hwy 11 ORIGINATED BY MI

DIST 19 HWY 11 BOREHOLE TYPE HS Auger COMPILED BY AD

DATUM Geodetic DATE 91 08 28 CHECKED BY TCK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
282.0	Ground Surface										
0.0	Sand with Gravel compact (Fill)		1	SS	10		281				
279.9	Brown		2	SS	11		280				
2.1	Black Sandy Silt, trace of organics Loose to compact (Topsoil)		3	SS	4		279			organics 6.4 %	
			4	SS	6				w=56.5		0 35 63 2
277.8	Black		5	SS	12		278				
4.2	Grey Silt, some clay, trace of sand Loose		6	SS	4	▼	277	o			0 3 76 21
276.4											
5.6	Silty Sand to Sandy Silt occ. Silt layers Loose to very dense		7	SS	5		276				
			8	SS	16		275				
			9	SS	56		274	o			0 50 45 5
270.9			10	SS	100	/28cm	273				
11.1	Het. Mixture of Clayey Silt, Sand and Gravel Hard (Glacial Till)		11	SS	100	/25cm	272		o		9 28 40 23
269.4							271				
12.6	End of Borehole at probable bedrock						270				

+³, ×⁵: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 4 1 OF 1 METRIC

W.P. 290-85-02 LOCATION Sta 12+598.3; o/s 20m Lt. ℄ Hwy 11 ORIGINATED BY MI

DIST 19 HWY 11 BOREHOLE TYPE HS Auger COMPILED BY AD

DATUM Geodetic DATE 91 08 28 CHECKED BY TCK

SOIL PROFILE			SAMPLES			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 (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
282.7	Ground Surface										
0.0	Sandy Silt, some Gravel trace of organics (Topsoil) compact		1	SS	13		282				
280.6			2	SS	20		281		o		20 22 48 10
2.1	Sand and Gravel compact Brown		3	SS	28		280				
279.8											
2.9	Grey		4	SS	33		279				
			5	SS	52	▼					
	Silt		6	SS	38		278		o		0 2 96 2
			7	SS	40		277				
	Silty Sand to Sandy Silt occ. Silt layers compact to very dense		8	SS	47		276				
			9	SS	20		275				
			10	SS	56		274				
271.1							273				
11.6	End of Borehole at probable bedrock						272				

+3, ×5: Numbers refer to Sensitivity

20
15◇5 (%) STRAIN AT FAILURE
10

ROCK CORE DESCRIPTION
WP 290-85-02

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	11	11.28-12.85	100	91	11.28-12.85	**GRANODIORITE** (chlorite-bearing), medium dark grey to greyish orange pink; coarse to fine grained; strong; unweathered to slightly weathered; fractures moderately close to very close spaced, dipping to near vertical, undulating to planar, smooth.
2	12	12.34-12.70	93	32	12.34-12.52	**META-BASALT** (chloritized), greenish black; fine grained; weak; unweathered to slightly weathered; fractures close to extremely close spaced, dipping, undulating, smooth.
	13	12.70-14.23	95	88	12.52-14.23	**GRANODIORITE** (chlorite-bearing), medium dark grey to greyish orange pink; coarse to fine grained; strong; unweathered to slightly weathered; fractures moderately close to very close spaced, dipping, undulating to planar, smooth.

***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

METRIC

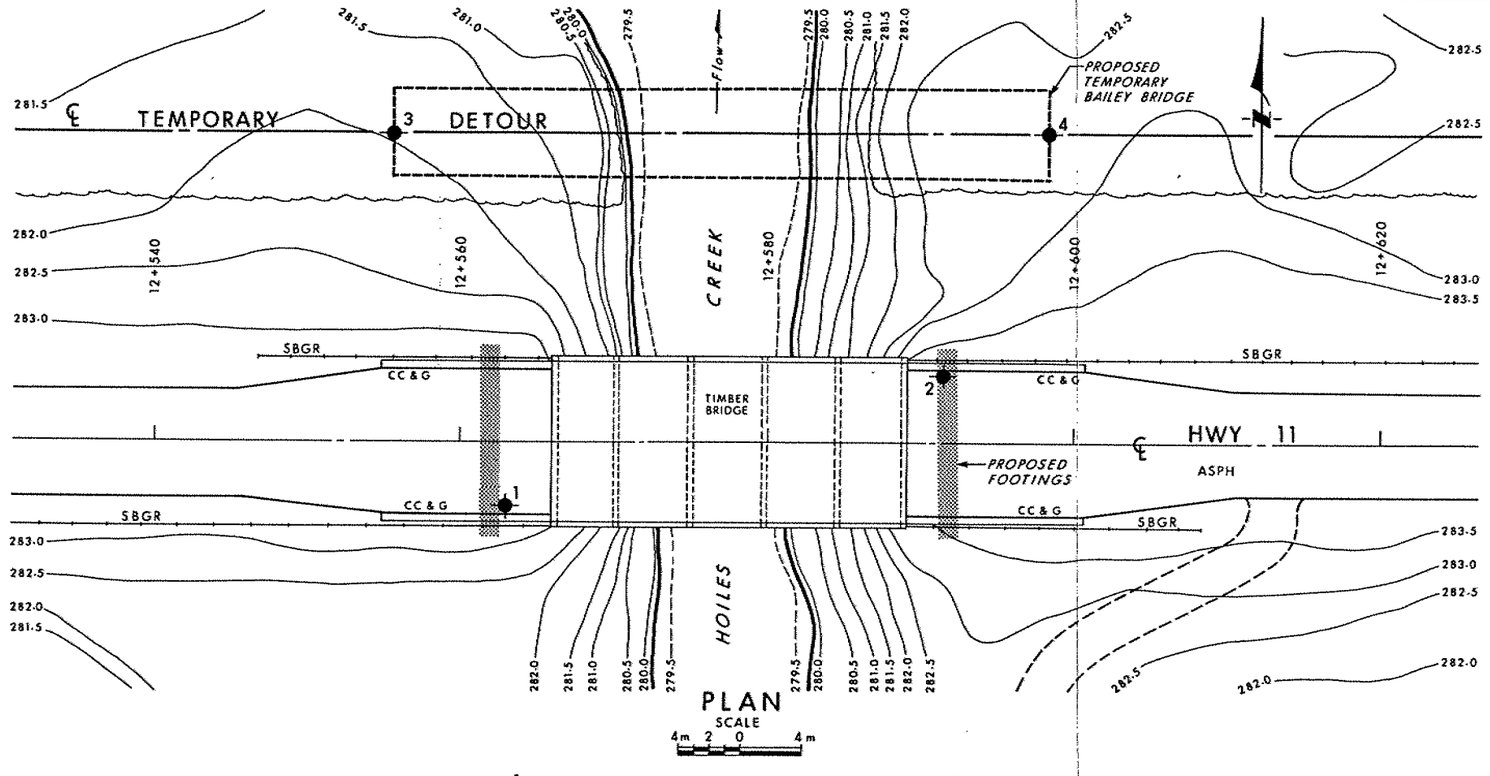
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

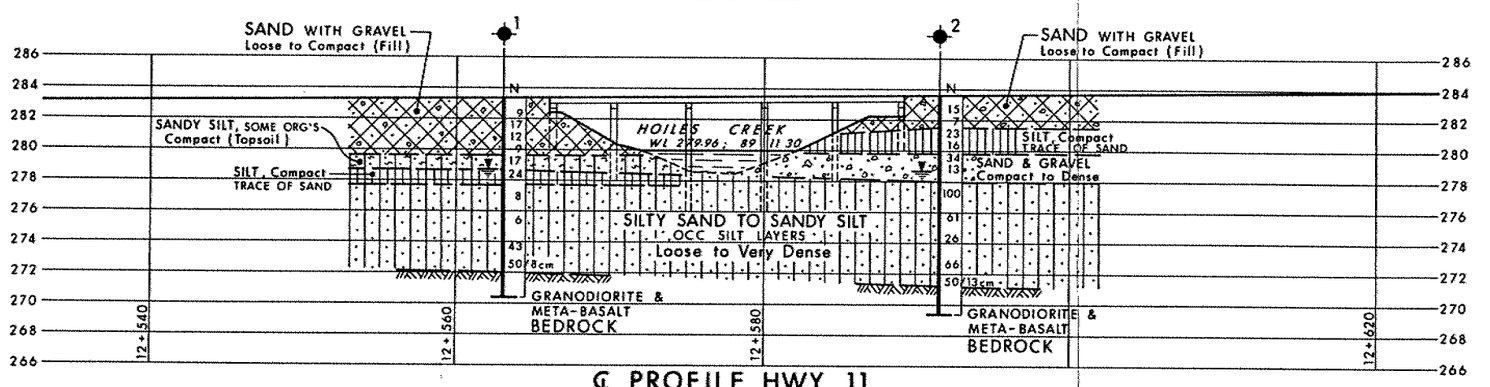
CONT No
WP No 290-85-02

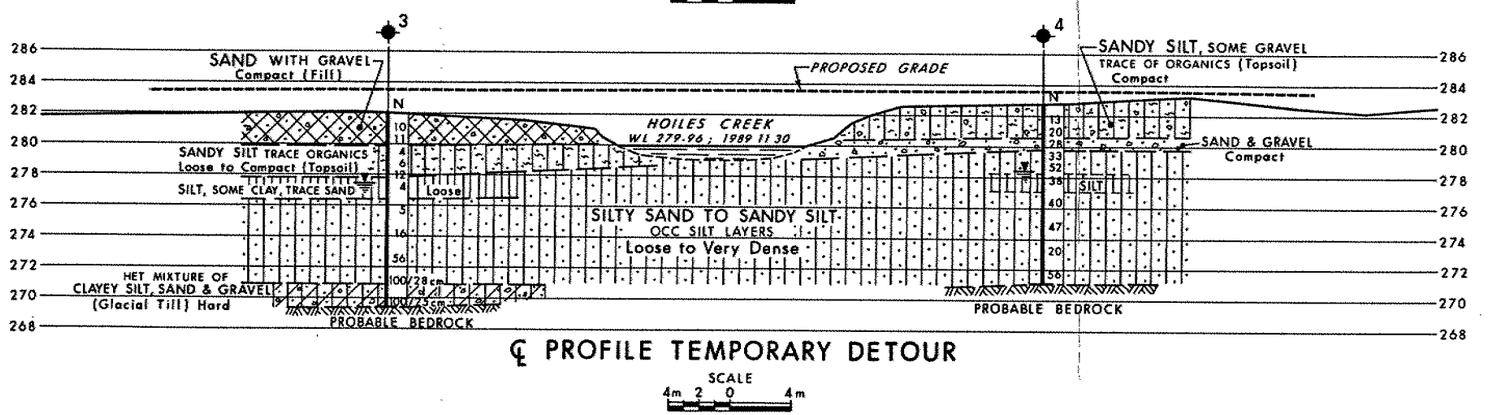
HOILES CREEK

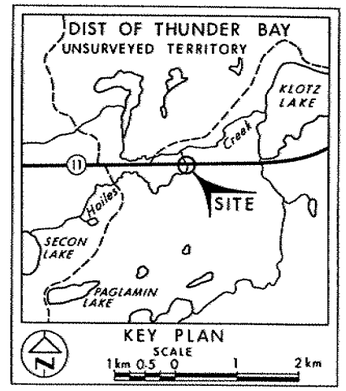
BORE HOLE LOCATIONS & SOIL STRATA

SHEET









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)
- WL at time of investigation 91 08

No	ELEVATION	STATION	OFFSET
1	283.3	12+563.0	4.2m Rt
2	283.6	12+591.5	4.3m Lt
3	282.0	12+555.6	20.0m Lt
4	282.7	12+598.3	20.0m Lt

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 42F-13

HWY No 11			DIST 19
SUBM'D T K	CHECKED TK	DATE 1992 03 09	SITE 48E-7
DRAWN GP	CHECKED JS	APPROVED	DWG 2908502-A

REF No E-494855-11-1; 1990 05