

FOUNDATION INVESTIGATION REPORT

CONTRACT NO **88-225**



Ministry of
Transportation and
Communications

1

INDEX

<u>Page</u>	<u>Content</u>
1	Index
2	Symbols & Abbreviations
3 - 33	Foundation Investigation Reports for Arrow River Bridge W.P. 129-83-02, Site 48W-99 Hwy. 593, District 19, Thunder Bay Loukala's Creek Culvert W.P. 59-83-02, Site 48W-93 Sec. Hwy. 595, District 19, Thunder Bay

For the purposes of this contract, these reports
supersede all other reports prepared by or for the
Ministry for the above-noted project.

EXPLANATION OF TERMS: USED IN REPORT

2

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:

R Q D (%)	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

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 = $\frac{c_u}{\tau_r}$

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

PHYSICAL PROPERTIES OF SOIL

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

FOUNDATION INVESTIGATION REPORT

For

W.P. 129-83-02; Site 48W-99

Arrow River Bridge (Revised)

Hwy. 593, District 19, Thunder BayINTRODUCTION

This report summarizes the foundation investigation for the proposed bridge replacement at this site.

Two alignments were investigated; the original alignment and Line 'B'. This report is applicable to the area under the plan limits of the proposed Line 'B' alignment and its immediate approaches, extending from Sta. 10+300 to Sta. 10+350 (Line 'B') over which the proposed grade is 352 to 353 m, and the required fill heights are up to 5.4 m.

SITE DESCRIPTION

The site is located near the existing river crossing of Sec. Hwy. #593 and the Arrow River. It lies approximately 29.5 km northwest of Hwy. #61 and 22 km south of Hwy. #588, within the Township of Devon, Concession 3, District of Thunder Bay. At this location the Arrow River flows towards the east.

The revised alignment is 13 to 14 m left (west) of the existing Hwy. 593 ϕ .

FIELD INVESTIGATION

The field work for the original alignment was carried out between 86 05 12 and 86 05 15 utilizing a continuous flight auger machine equipped with 82 mm I.D. hollow-stem augers, B-casing and B-core barrel. The investigation consisted of 4 sampled boreholes, 2 of which were supplemented with cone penetration tests. The boreholes ranged from 12.6 m to 25.7 m in depth.

The field work for the revised alignment (Line 'B') was conducted between 87 01 20 and 87 01 23 utilizing a continuous flight auger machine equipped with 82 mm I.D. hollow-stem augers. This additional investigation consisted of 3 boreholes supplemented with cone penetration tests. The boreholes ranged from 14.2 m to 18.3 m in depth.

Groundwater elevations were measured in open holes at each borehole location.

LABORATORY ANALYSES

Laboratory testing was carried out on representative samples to determine undrained shear strengths, unit weight, Atterberg Limits and grain size characteristics of the overburden material.

The results of the laboratory analyses are illustrated on the Record of Borehole Sheets.

SUBSURFACE CONDITIONS

The Record of Borehole Sheets in the Appendix illustrate the subsurface conditions at the borehole locations. The boreholes are referenced as BH 1-4, and 10-12. The locations and elevations of the boreholes along with the stratigraphical profile based on the borehole data are shown on Dwg. 1298302-1.* The subsurface conditions generally consist of the following materials, commencing with the uppermost layer:

<u>Material</u>	<u>Thickness of Layer</u>
Granular Embankment Fill (at the original alignment)	1.1 m - 1.4 m
Silty Clay (with organic zones)	1.0 m - 2.3 m
Silty sand	4.6 m - 6.1 m
Sandy silt	5.2 m - 7.0 m
Silty sand	0 m - 8.5 m
Heterogeneous Mixture of silt, sand, and gravel; occasional cobbles and boulders	> 6.3 m

At BH 2, which was commenced from the timber bridge deck the silty clay layer was not encountered. Here, the river bottom is immediately underlain by the upper silty sand layer. The following describes the subsurface soil conditions in greater detail.

The main deposits are the upper silty sand, the sandy silt and the lower silty sand which together extend for a total thickness of 11.5 m to 18.3 m. All of these deposits are interlayered and could be described as a unit as silty sand to sandy silt. In addition, the deposits contain occasional slightly cohesive silt layers.

* NOTE: Refer to Sheet No. 2 of the Contract Drawings.

Embankment Fill

Fill material was encountered immediately beneath the roadway shoulder. The depth of fill varies from 1.1 m in BH 3 to 1.4 m in BH 1 and overlies a silty clay stratum. The material consists of a non-cohesive mixture of varying amounts of silt, sand, and gravel. The moisture content of this material, as determined from a laboratory test performed on a typical sample of this material is 7%.

A typical grain size distribution curve for the fill material is shown on Figure 1.

Based on 'N' values ranging from 5 to 14 blows per 0.3 m, the material is in a loose to compact state.

Silty Clay (CI-CH); trace/with sand
occasional organic (OH) zones _ _ _

This material is the natural surficial deposit across the site except at BH #2, in the river channel, where it was not encountered. It varies in thickness from 0 to 2.1 m.

Occasional organics were present within this deposit especially on the north side of the river channel where they influence the soil properties making it extremely soft and compressible. Within the river channel the upper 1.0± m contains silty sand, gravel and cobbles typical of river bottoms.

Properties of the material, as determined by field and laboratory tests, are summarized as follows:

		<u>Range</u>	<u>Average</u>	<u>Median</u>
Natural Moisture Content	(w)	24.5 - 93.0%	49.0%	41.8%
Liquid Limit	(w _L)	31.5 - 77.5%	55.8%	56.8%
Plastic Limit	(w _p)	19.0 - 38.0%	27.3%	25.8%
Shear Strength	(C _u)			
- field vane (undisturbed)		50 - 88 kPa	N/A	N/A
- unconfined compression		46 kPa (one test)		
Unit Weight	8	19.0 kN/m ³ (one test)		

Based on 'N' values generally ranging from 3 to 17 and shear strength values ranging from 46 to 86 kPa, the consistency of this deposit is soft to very stiff. Remolded shear strengths indicate a sensitivity of 2 to 4.

The results of the Atterberg Limit tests indicate that the material generally exhibits intermediate plasticity. The organic content tends to increase the plastic behaviour.

Figure 2 illustrates a typical grain size distribution for this material.

Upper Silty Sand; trace gravel, trace clay

This non-cohesive deposit underlies the 'Silty Clay' across most of the site, except at some locations within the river channel where it is at the ground surface. The thickness of the deposit ranges from 4.6 to 6.1 m.

Occasional gravel zones and slightly cohesive silty pockets were encountered in the upper few metres of this deposit on the north side of the river at BH #1 and #10. Occasional sandy silt layers are present throughout the deposit.

Figure 3 illustrates a typical grain size distribution for this material.

Based on 'N' values ranging from 3 to 22, the state of compaction of the material is very loose to compact, but generally compact since the lower 'N' values may have resulted from soil disturbance during sampling.

Sandy Silt; trace clay

This non-cohesive material underlies the 'Upper Silty Sand' where it extends for thicknesses ranging from 4.6 to 7.0 m.

The deposit is interlayered with occasional silty sand layers and contains occasional slightly cohesive silt zones.

The results of natural moisture content tests indicate a range of 18% to 26%.

Based on the results of Standard Penetration Tests ranging from 2 to 39, the state of compaction of this deposit ranges from very loose to dense. However,

unbalanced hydrostatic head problems encountered in a number of boreholes led to artificially low 'N' values and it is anticipated that the deposit is generally in a compact to very dense state.

Figure 4 illustrates a representative grain size distribution for this deposit.

Lower Silty Sand; trace clay

This non-cohesive deposit underlies the 'Sandy Silt' except at the north side of the river where it is discontinuous (BH #1, BH #10). It's thickness increases towards the south where it reaches a maximum of 8.5 m at BH #3.

The deposit is interlayered with occasional silty sand layers.

The results of natural moisture content tests indicate a range of 18% to 22%.

Based on the results of Standard Penetration Tests ranging from 19 to 60, the state of compaction of this deposit ranges from compact to very dense.

Figure 5 illustrates a representative grain size distribution for this deposit.

Heterogeneous Mixture of Silt, Sand, and Gravel

Occasional Cobbles (Till)

This non-cohesive material underlies the sandy silt layer in BH #1 and #10 and the lower silty sand layer in BH #2, #11 and #12. Sandy zones are contained within this deposit in BH 1 at elevation 333.5 m to 335 m. The full extent of this material was not investigated but is at least 6.3 m in thickness. The deposit contains an appreciable gravel content and occasional cobbles. Occasional boulders are also anticipated. Rock coring techniques were employed at times to advance the boreholes in this material.

A typical grain size distribution for this material is shown on Figure 6. The results can be summarized as follows:

	<u>Range</u>
Gravel	43 - 56%
Sand	26 - 34%
Silt	10 - 24%
Clay	1 - 4%

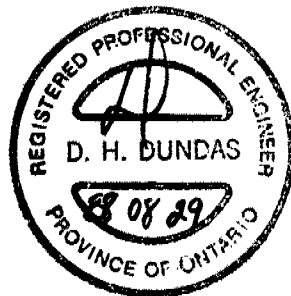
Based on 'N' values ranging from 61 to over 100 blows per 0.3 m, the material is in a very dense state.

Groundwater

Groundwater level observations were carried out in the open boreholes. At the time of the investigation the stabilized groundwater level was at or very near the river water level (Elevation 347±m).

Miscellaneous

The fieldwork for this project was carried out under the supervision of Ms. I. Steblynsky, Trainee Engineer, and Mr. D. Dundas, Senior Foundations Engineer, using equipment owned and operated by Dominion Soil Investigation Inc. The report was written by Mr. D. Dundas, Senior Foundations Engineer and reviewed by Mr. M. Devata, Chief Foundations Engineer (East).



D. H. Dundas

D. H. Dundas, P. Eng.
Sr. Foundations Engineer

M. Devata

M. Devata, P. Eng.
Chief Foundations Engineer (East)

APPENDIX



RECORD OF BOREHOLE No 1

METRIC

W P 129-83-02 LOCATION STA. 10 + 342.4; 0/s 15.2 m Rt. 4 Line 'B' ORIGINATED BY FS
DIST 19 HWY 593 BOREHOLE TYPE H-S Auger, B-Casing, Wash Boring, B Rock Core, COMPILED BY FS
DATUM Geodetic DATE 86 05 12 - 13 Cone Test CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _p	W	W _L		
349.3	Ground Surface																
0.0	Mixture of Gravel, Sand and Silt, Trace Clay (Embankment Fill)		1	SS	14								0				34 48 13 5
347.9	Compact																
1.4	Silty Clay		2	SS	8												
346.7	Trace Sand	Stiff															
2.6	Gravelly Zones		3	SS	10												51 28 14 7
	Silty Zones		4	TW	PH								40				0 1 98 1
	Silty Sand		5	SS	11												
	Trace Clay		6	SS	15												
			7	SS	17												
			8	SS	22												
340.6	Compact												0				0 79 17 4
8.7	Sandy Silt		9	SS	12												
	Trace Clay		10	SS	14								0				0 22 74 4
			11	SS	20												
335.2	Compact		12	SS	17												
14.1	Sandy Zones		13	SS	40								0				7 76 15 2
	Heterogeneous Mixture of Silt, Sand and Gravel		14	SS	61												
	Occasional Cobbles (Till)		15	RC													
	Dense to Very Dense		16	SS	100	10 cm							0				56 31 10 3
328.9			17	SS	120	18 cm											
20.4	End of Borehole																

+³, x⁵: Numbers refer to
Sensitivity

20
15
5
5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No 2

METRIC

W P 129-83-02 LOCATION STA. 10 + 325.8, °/s 11.4 m Rt. 4 Line 'B' ORIGINATED BY FS
DIST 19 HWY 593 BOREHOLE TYPE H-S Auger, Wash Boring, B Rock Core COMPILED BY FS
DATUM Geodetic DATE 86 05 15 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100						SHEAR STRENGTH		
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	x LAB VANE	20	40	60						
349.3	Bridge Deck																GR SA SI CL			
0.0	Air																			
347.3	Water Level						348													
2.0	Water																			
345.9	River Bottom						346													
3.4	Silty Sand Trace Clay Compact	Silty Zones	1	SS	9		344						○				0 27 67 6			
			2	SS	14		342													
			3	SS	15		340													
340.6	Sandy Silt Trace Clay Compact		4	SS	13		338													
8.7			5	SS	17		336						○				0 20 76 4			
			6	SS	11		334													
335.1	Silty Sand Trace Clay Compact		7	SS	23		332													
14.2			8	SS	155	25 cm	330						○				43 34 22 1			
330.4	Heterogeneous Mixture of Silt, Sand & Gravel Occasional Cobbles (Till) Very Dense		9	RC																
328.3			10	SS	96	20 cm														
21.0	End of Borehole																			

+³, x⁵: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa	WATER CONTENT (%)			
350.1	Ground Surface							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	20 40 60			kN/m ³	GR SA SI CL

[illegible]

+3, x5: Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

10

RECORD OF BOREHOLE No 4

METRIC

W.P. 129-83-02 LOCATION STA. 10 + 340.5; 0/s 9.1 m Lt. 4 Line 'B' ORIGINATED BY JD
 DIST 19 HWY 593 BOREHOLE TYPE H-S Auger COMPILED BY FS
 DATUM Geodetic DATE 86 05 15 CHECKED BY DD

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100				
347.4	Ground Surface														
0.0	Silty Clay Topsoil		1	SS	3										GR SA SI CL
346.4	Sand														0 28 52 20
1.0	Some Organics Firm		2	SS	5										
	Silty Sand		3	SS	17										
	Trace Clay		4	SS	5										
			5	SS	11										3 76 17 4
	Loose to Compact		6	SS	7										
341.7															
5.7	Sandy Silt		7	SS	16										9 9 87 4
	Trace Clay		8	SS	22										
			9	SS	29										
	Compact		10	SS	24										
334.8			11	SS	21										
12.6	End of Borehole														

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 10

METRIC

W P 129-83-02 LOCATION Sta. 10 + 338.7, Line 'B' ORIGINATED BY I.S./D.D.
DIST 19 HWY 593 BOREHOLE TYPE Hollow Stem Auger, Cone Test COMPILED BY I.S.
DATUM Geodetic DATE 87 01 20 CHECKED BY D.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT Wp	NATURAL MOISTURE CONTENT W	LIQUID LIMIT Wl	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	VALUES									
347.5	Ground Surface				***									
0.0	Silty Clay (CL to CI)		1	CS										GR SA SI CL
346.5	*with organic (OH) zones		2	SS	4									0 26 53 21
1.0	with gravel		3	SS	15									57 22 18 3
	loose to compact (slightly cohesive)		4	SS	3									56 26 14 4
	Silty Sand		5	SS	6									
	trace gravel		6	SS	6									
	trace clay		7	SS	9									
	loose (LACUSTRINE)		8	SS	5									
341.1			9	SS	10									
6.4	Sandy Silt		10	SS	7									0 17 74 9
	trace clay		11	SS	12									
	very loose to compact (LACUSTRINE)		12	SS	12									
			13	SS	2									1 11 80 8
334.1			14	SS	32									
333.3	Heterogeneous Mixture of Silt, sand and gravel		15	SS	100									
14.2	End of Borehole													
	* Some sand soft (LACUSTRINE)													
	** trace clay occ. cobbles and boulders very dense (TILL)													
	*** N Values reduced by an unbalanced hydrostatic head condition													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 11

METRIC

W P 129-83-02 LOCATION Sta. 10 + 325.7, 0.8 m LT. of 4 Line 'B' ORIGINATED BY I.S./D.D.
 DIST 19 HWY 593 BOREHOLE TYPE Hollow Stem Auger, Cone Test COMPILED BY I.S.
 DATUM Geodetic DATE 87 01 21 CHECKED BY D.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
346.9	Water Surface													
0.0	Water (ice)													
346.1	River Bottom													
0.8	Silty sand, gravel and cobbles		1	SS	27		346	augered						
344.8	* Silty Clay (CL to CI)		2	SS	17								15 51 21 13	
2.1	Silty Sand trace gravel trace clay loose to compact (LACUSTRINE)		3	SS	6		344							
			4	SS	11									
			5	SS	10									
			6	SS	14		342						2 55 35 8	
			7	SS	8									
			8	SS	20		340						1 47 45 7	
339.9			9	SS	21								0 46 49 5	
7.0	Sandy Silt trace clay Compact to Dense (LACUSTRINE)		10	SS	38		338							
			11	SS	33		336							
			12	SS	36		334							
334.1	Silty Sand trace clay dense to very dense (LACUSTRINE)		13	SS	35		332							
12.8			14	SS	60								0 66 30 4	
331.4	**		15	SS	60								45 33 17 5	
15.8	End of Borehole													
	*with sand some gravel very stiff													
	** Heterogeneous Mixture of Silt, Sand and Gravel trace clay occ. cobbles and boulders very dense (TILL)													

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

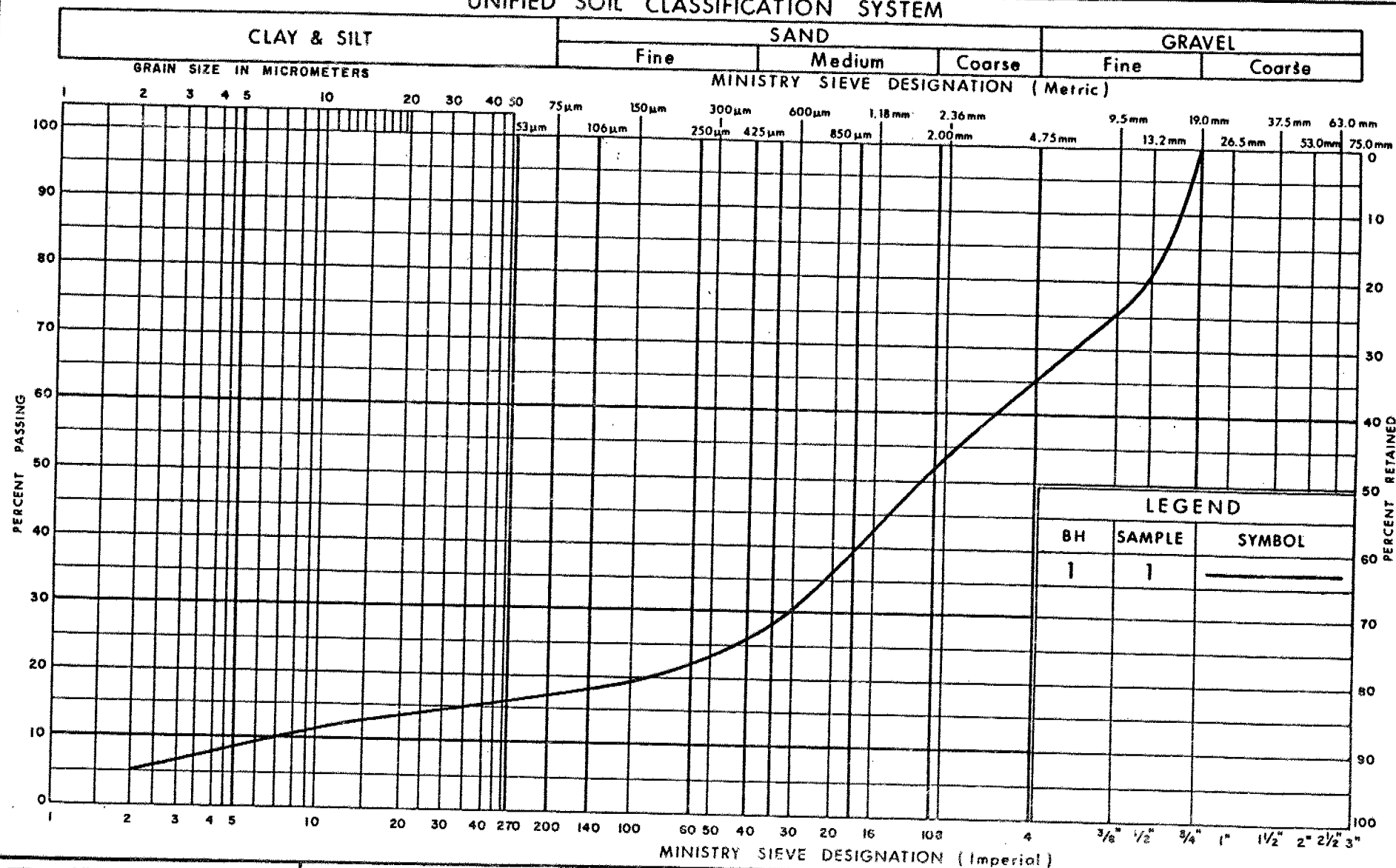
RECORD OF BOREHOLE No 12

METRIC

W P 129-83-02 LOCATION Sta. 10+314.4, 1.2 m LT of Line 'B' ORIGINATED BY IS
DIST 19 HWY 593 BOREHOLE TYPE HOLLOW STEM AUGER, CONE TEST COMPILED BY IS
DATUM Geodetic DATE 87 01 22 CHECKED BY DD

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			'N' VALUES	20					
347.8	GROUND SURFACE												
0.0	Silty Clay (CL to CI) some sand firm (LACUSTRINE)		1	CS									
			2	SS	6								
345.7			3	SS	8								
2.1	with gravel		4	SS	6								
	Silty Sand trace gravel trace clay loose to compact (LACUSTRINE)		5	SS	10								
			6	SS	12								
			7	SS	15								
			8	SS	15								
340.8			9	SS	15								
7.0			10	SS	19								
	Sandy Silt trace clay compact (LACUSTRINE)		11	SS	22								
			12	SS	23								
335.6			13	SS	27								
12.2			14	SS	22								
	Silt Sand trace clay compact to dense (LACUSTRINE)		15	SS	38								
			16	SS	24								
330.1													
17.7													
329.5													
18.3	End of Borehole		17	SS	60	70 cm							
	* Heterogeneous Mixture of Silt, Sand and Gravel trace clay occ. cobbles and boulders very dense (TILL)												

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

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GRAIN SIZE DISTRIBUTION
GRAVEL, SAND & SILT
(EMBANKMENT FILL)

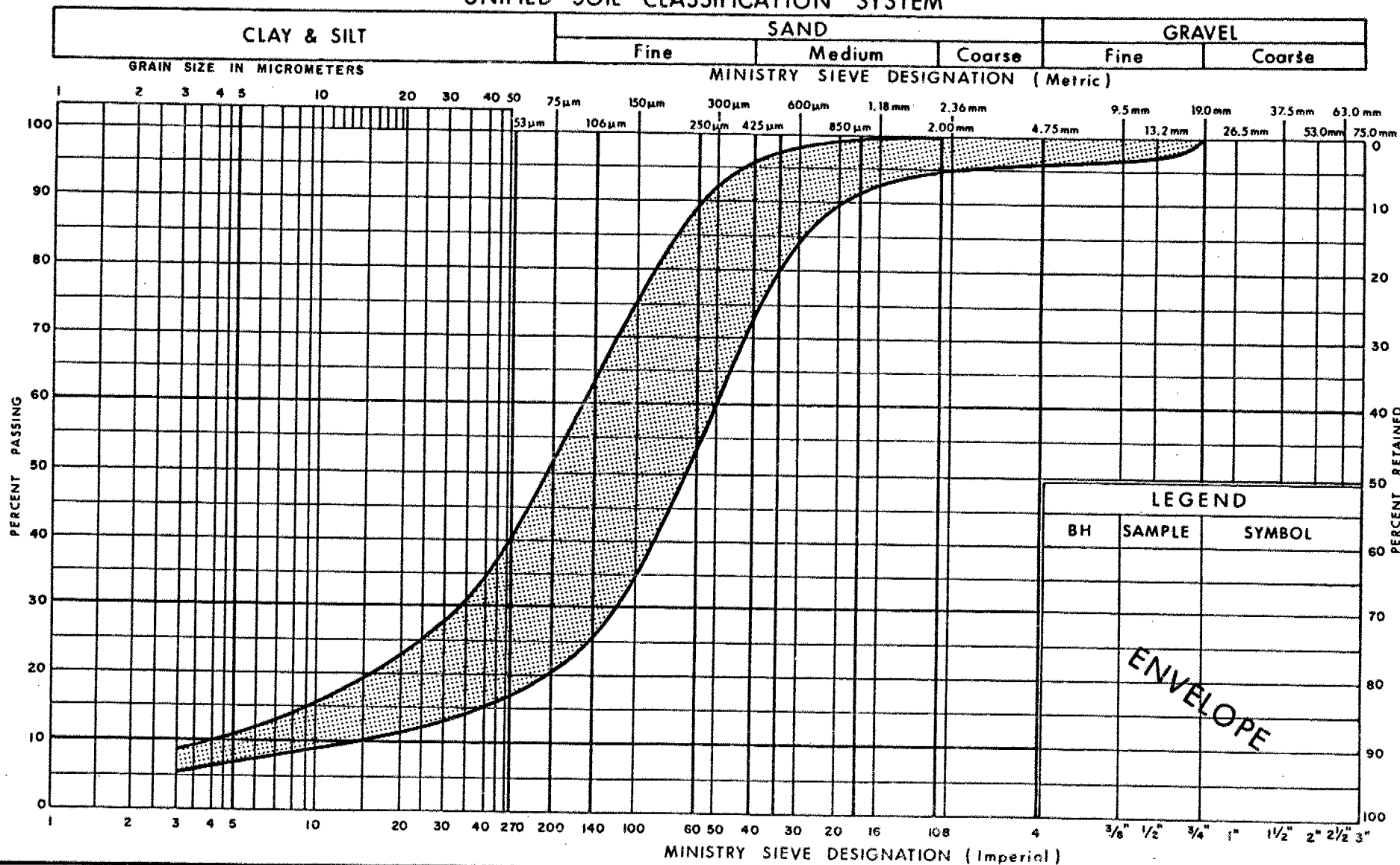
FIG No 1

WP 129-83-02

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GRAIN SIZE DISTRIBUTION
SILTY CLAY (C1-CH); TRACE/WITH SAND
OCC ORGANIC (OH) ZONES

W P 129-83-02



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GRAIN SIZE DISTRIBUTION

Upper SILTY SAND
TRACE GRAVEL, TRACE CLAY

FIG No 3

W P 129-83-02

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GRAIN SIZE DISTRIBUTION
Lower SILTY SAND, TRACE CLAY

W P 129-83-02

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Communications

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

FIG No 6

W P 129-83-02

FOUNDATION INVESTIGATION REPORT
For
W.P. 59-83-02; Str. Site #48W-93
Loukola's Creek Culvert
Sec. Hwy #595, District 19, Thunder Bay

INTRODUCTION

This report summarizes the results of a foundation investigation required for the proposed structure at this site.

The field work for the investigation was carried out during the period from 86 04 29 to 86 04 30 utilizing continuous flight auger machines equipped with 82 mm I.D. hollow-stem augers. The investigation consisted of three sampled boreholes. The boreholes ranged from 11.6 m to 21.3 m in depth.

SITE DESCRIPTION

The site is located at the existing creek crossing of Sec. Hwy #595 and Loukola's Creek, approximately 13 km south of South Gillies. It lies within Concession II, Township of Pearson.

SUBSURFACE CONDITIONS

The Record of Borehole Sheets in the Appendix illustrate the subsurface conditions at the borehole locations. The boreholes are referenced as BH 1 to 3. The locations and elevations of the boreholes along with a stratigraphical profile based on the borehole data are shown on Dwg. 598302-A.

The subsurface conditions on either side of the timber bridge deck generally consist of a surficial layer of granular base course (shoulder fill) underlain by a stratum of silty clay. The surficial layer of fill material ranges from 1.7 m to 2.9 m in thickness. The silty clay stratum was encountered to a depth of 21.3 m. The full extent of this deposit, however, was not investigated. The following describes the subsurface soil conditions in greater detail.

EMBANKMENT MATERIAL (Fill)

Fill material was encountered immediately beneath the roadway shoulder. The depth of fill varies from 1.7 m in BH 2 to 2.9 m in BH 3, and overlies a silty clay stratum. The material consists of a non-cohesive mixture of varying amounts of silt, sand, and gravel, with a few cobbles. Some fine to coarse wood fibres are found within this layer from 1.4 m to 2.9 m in BH 3. The moisture content of this material, as determined from 3 laboratory tests ranges from 6.5% at a depth of 1.0 m in BH 2, to 38% at a depth of 1.8 m in BH 3.

Typical grain-size distribution curves for the fill-material are shown on Figure 1.

Based on "N" values ranging from 5 to 15 blows per 0.3 m, the material is in a loose to compact state.

SILTY CLAY; TRACE SAND

This material underlies the shoulder fill at all borehole locations. Since the full extent of this material was not investigated, its full depth is not known, but is at least 21.3 m. Organics are found within this deposit at the first borehole location at a depth of 3.6 m to 4.4 m.

Occasional fine and course wood fibres were encountered in BH 3 from 2.9 m to 6.4 m in depth while occasional pockets of silt were found commencing at a depth of 8.8 m in this borehole.

Physical properties of seven samples of this material, as determined from field and laboratory tests, are summarized as follows:

	<u>Range</u>	<u>Average</u>	<u>Median</u>
Moisture Content (w)	26.0 - 60.0	39.1	37.5
Liquid Limit (w_L)	40.5 - 75.0	59.7	59.0
Plastic Limit (w_p)	18.5 - 34.0	26.4	25.5
Shear Strength (c_u)	35.0 \rightarrow 107 kPa	--	--
Unit Weight (γ)	18.3 - 20.0 kN/m ³	--	--

The results of seven Atterberg Limits Tests are shown on Figure 2.

The results of grain-size distribution tests conducted on seven samples of this material are shown in envelope form on Figure 3. The results can be summarized as follows:

	<u>Range</u>
Gravel	0 - 2%
Sand	0 - 12%
Silt	23 - 57%
Clay	40 - 76%

From the above results, it can be concluded that this material normally exhibits a high plasticity, which generally decreases with depth. Based on "N" values ranging from 3 to 23 blows per 0.3 m, together with shear strength measurements, the consistency of this material is firm to very stiff.

Groundwater level observations were carried out in the open boreholes. At the time of the investigation the stabilized groundwater level was at or very near the creek water level, and ranged in depth from 0.5 m to 0.8 m (elevation of 96.0 m approximately).

MISCELLANEOUS

The field work for this project was carried out under the supervision of Mr. F. Saccon, Project Foundations Engineer. The equipment used was owned and operated by Dominion Soil Investigation Inc.

The Foundation Investigation portion of the report was written by Mr. F. Saccon. The Foundation Design portion of the report was written by Mr. D. Dundas, Senior Foundations Engineer. The report was reviewed by Mr. M. Devata, Chief Foundations Engineer (East).



D. H. Dundas
D. H. Dundas, P. Eng.
Sr. Foundations Engineer

M. Devata
M. Devata, P. Eng.
Chief Foundations Engineer (East)

A P P E N D I X

RECORD OF BOREHOLE No 1

METRIC

W P 59-83-02 LOCATION STA. 10 + 419.0; 0/s 4.8 m Rt. C Hwy. 595 ORIGINATED BY FS
 DIST 19 HWY 595 BOREHOLE TYPE H - S Auger COMPILED BY FS
 DATUM Geodetic DATE 86 04 29 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT Wp W WL			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60				
96.5	Ground Surface													
0.0	Heterogeneous Mixture of Silt, Sand and Gravel, some Clay Shoulder Fill		1	SS	5									13 56 14 17
94.4	Loose occ. Cobbles		2	SS	8									
2.1	Silty Clay Trace Sand some organics		3	SS	4									
			4	TW	PH									
			5	SS	8									
			6	SS	3									
	Firm to Very Stiff		7	SS	23									
			8	SS	11									
			9	SS	4									
			10	SS	3									
84.9														
11.6	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 2

METRIC

W P 59-83-02 LOCATION STA. 10 + 402.9; 0/s 2.2 m Rt. Q Hwy. 595 ORIGINATED BY FS
 DIST 19 HWY 595 BOREHOLE TYPE H - S Auger and Cone Test COMPILED BY FS
 DATUM Geodetic DATE 86 04 30 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N' VALUES			20 40 60 80 100	20 40 60 80 100	Wp	W	Wl		
96.8	Ground Surface													
0.0	Heterogeneous Mixture of Silt, Sand and Gravel, some Clay Shoulder Fill occ.		1	SS	7		96							
95.1	Loose Cobbles		2	SS	16									
1.7			3	SS	12		94							
	Silty Clay		4	SS	4									0 10 45 45
	Trace Sand		5	SS	8		92							
			6	SS	14		90							0 11 44 45
	Firm to Very Stiff		7	SS	17		88							
			8	SS	9									0 1 23 76
			9	SS	6		86							
			10	TW	PH		84							
			11	SS	6		82							
			12	SS	5		80							
79.0			13	TW	PH									
17.8	End of Borehole						78							
75.5							76							
21.3	End of Cone Test													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3

METRIC

W P 59-83-02 LOCATION STA. 10 + 389.6; °/s 2.9 m LT. C Hwy. 595 ORIGINATED BY FS
 DIST 19 HWY 595 BOREHOLE TYPE H - S Auger COMPILED BY FS
 DATUM Geodetic DATE 86 04 30 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	VALUES			20	40					
96.8	Ground Surface													
0.0	Heterogeneous Mixture of Silt, Sand and Gravel, some Clay Shoulder Fill		1	SS	5									
	Occ. Cobbles		2	SS	69									5 56 27 12
93.9	Loose to Very Dense		3	SS	15									
2.9	Occasional Fine to Coarse Wood Fibres		4	SS	7									2 12 36 50
	Silty Clay		5	SS	9									
	Trace Sand		6	TW	PR									
	Firm to Very Stiff		7	SS	21									20.0 0 3 57 40
	Occasional Silt Pockets		8	SS	23									
			9	SS	14									
85.2														
11.6	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

Fine

Medium

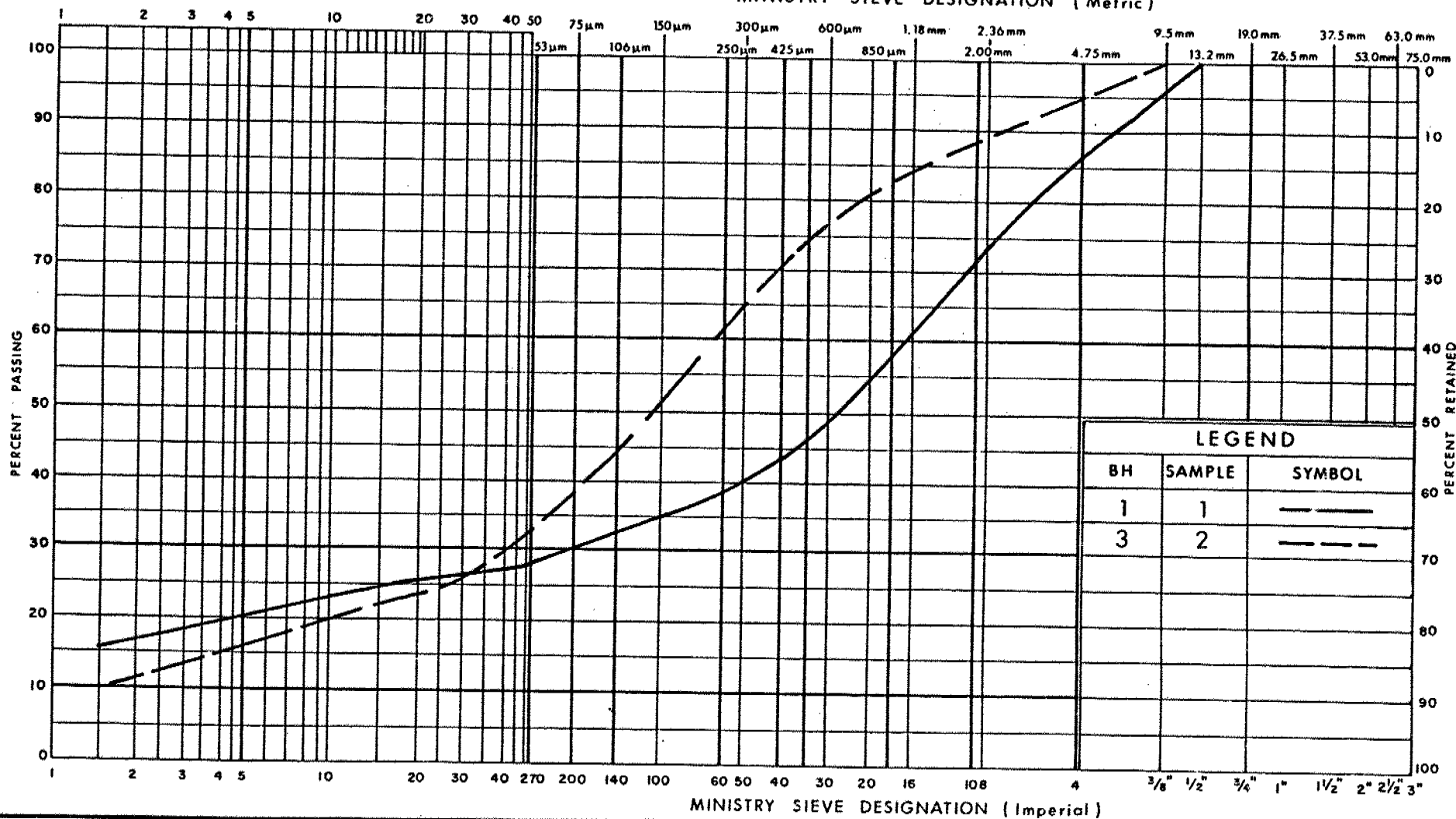
Coarse

Fine

Coarse

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)



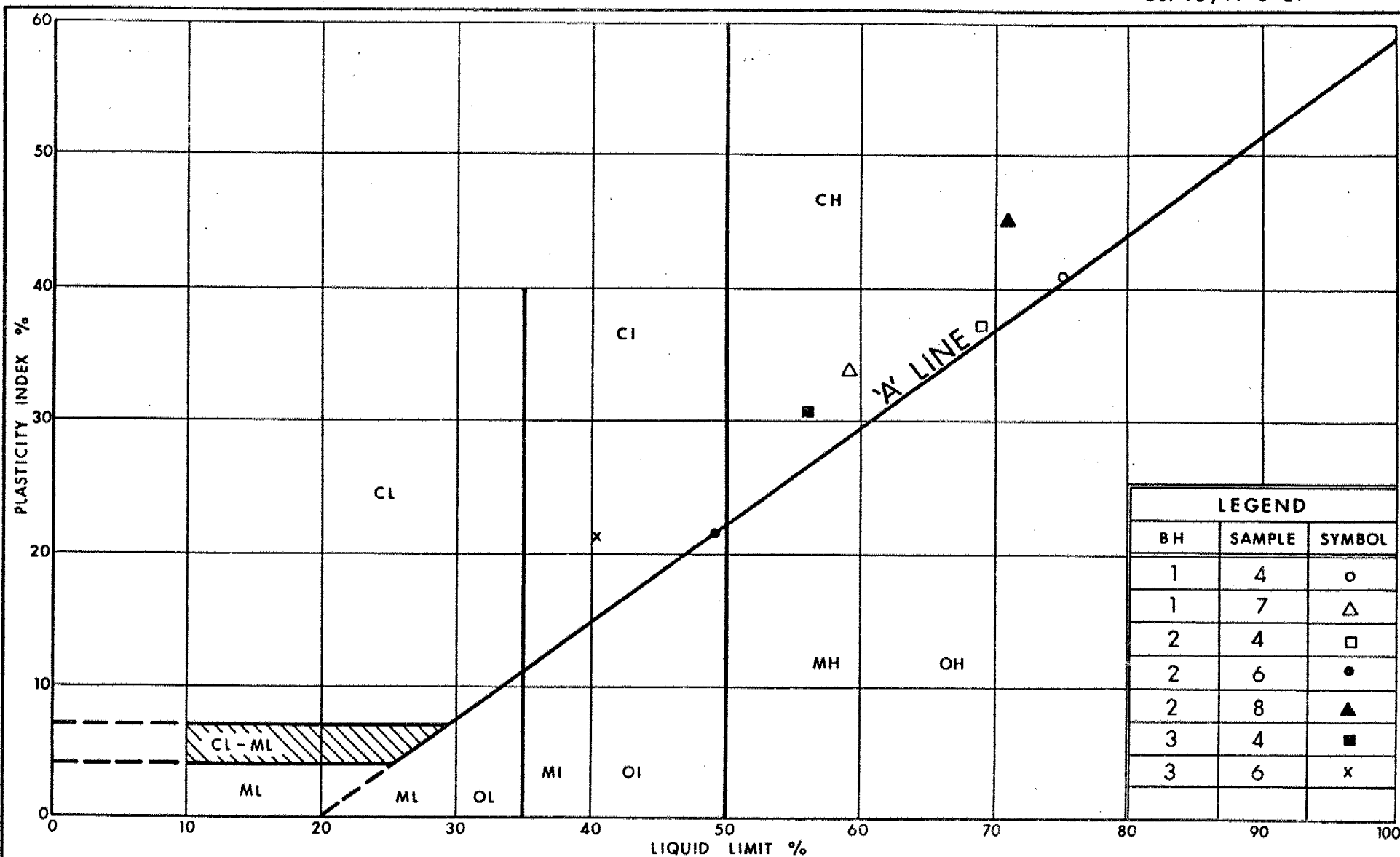
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GRAIN SIZE DISTRIBUTION
GRANULAR BASE COURSE
SHOULDER FILL

FIG No 1

W P 59-83-02



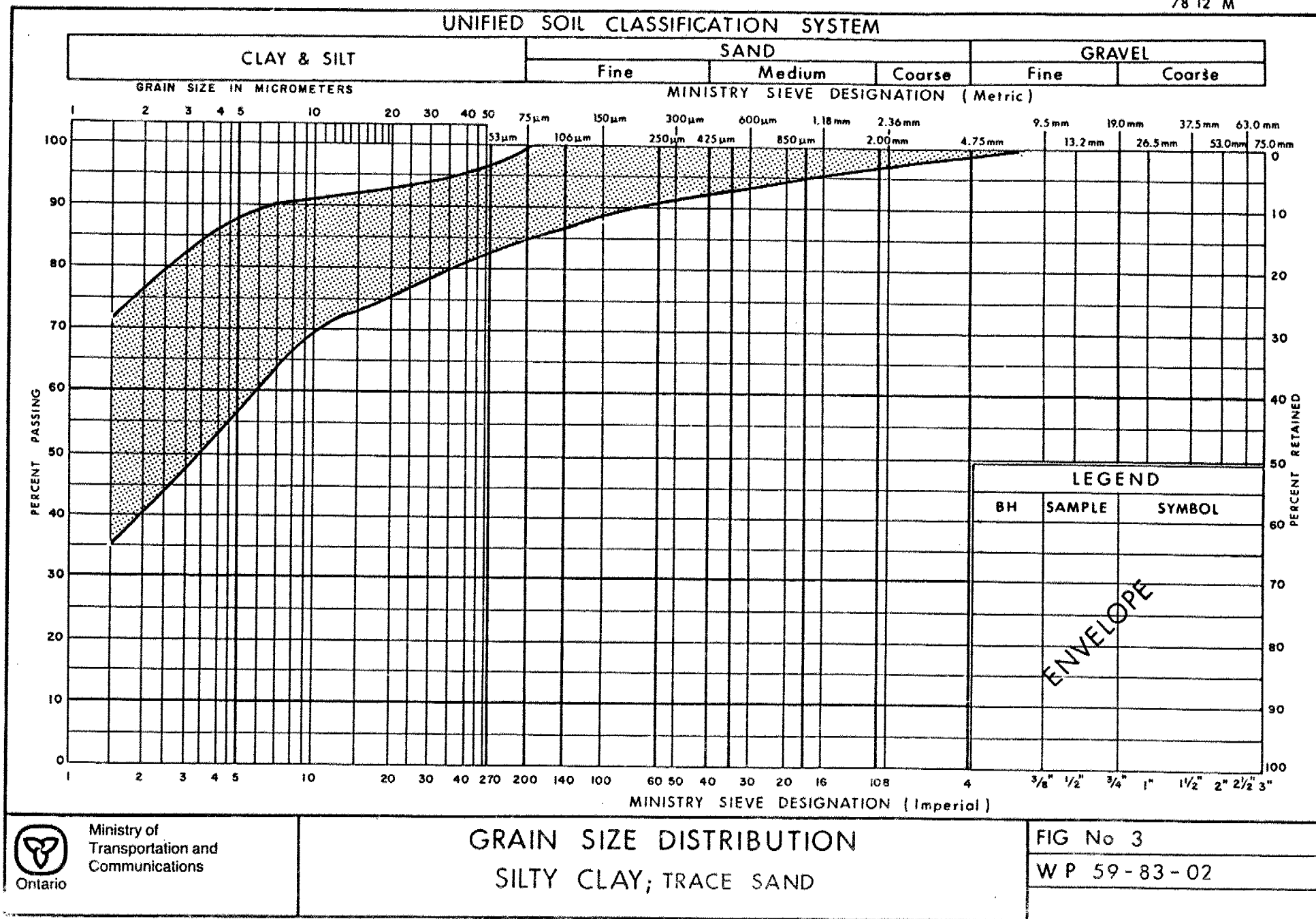
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PLASTICITY CHART SILTY CLAY, TRACE SAND

FIG No 2

W P 59-83-02





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FILE
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FOUNDATION DESIGN SECTION

foundation investigation and design report

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 129-83-02

DIST 19

HWY 593

STR SITE 48W-99

Arrow River Bridge (Revised)

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FOUNDATION INVESTIGATION REPORT

For

W.P. 129-83-02; Site 48W-99

Arrow River Bridge (Revised)

Hwy. 593, District 19, Thunder Bay

INTRODUCTION

This report summarizes the foundation investigation for the proposed bridge replacement at this site.

Two alignments were investigated; the original alignment and Line 'B'. This report is applicable to the area under the plan limits of the proposed Line 'B' alignment and its immediate approaches, extending from Sta. 10+300 to Sta. 10+350 (Line 'B') over which the proposed grade is 352 to 353 m, and the required fill heights are up to 5.4 m.

SITE DESCRIPTION

The site is located near the existing river crossing of Sec. Hwy. #593 and the Arrow River. It lies approximately 29.5 km northwest of Hwy. #61 and 22 km south of Hwy. #588, within the Township of Devon, Concession 3, District of Thunder Bay. At this location the Arrow River flows towards the east.

The revised alignment is 13 to 14 m left (west) of the existing Hwy. 593 ϕ .

FIELD INVESTIGATION

The field work for the original alignment was carried out between 86 05 12 and 86 05 15 utilizing a continuous flight auger machine equipped with 82 mm I.D. hollow-stem augers, B-casing and B-core barrel. The investigation consisted of 4 sampled boreholes, 2 of which were supplemented with cone penetration tests. The boreholes ranged from 12.6 m to 25.7 m in depth.

The field work for the revised alignment (Line 'B') was conducted between 87 01 20 and 87 01 23 utilizing a continuous flight auger machine equipped with 82 mm I.D. hollow-stem augers. This additional investigation consisted of 3 boreholes supplemented with cone penetration tests. The boreholes ranged from 14.2 m to 18.3 m in depth.

Groundwater elevations were measured in open holes at each borehole location.

LABORATORY ANALYSES

Laboratory testing was carried out on representative samples to determine undrained shear strengths, unit weight, Atterberg Limits and grain size characteristics of the overburden material.

The results of the laboratory analyses are illustrated on the Record of Borehole Sheets.

SUBSURFACE CONDITIONS

The Record of Borehole Sheets in the Appendix illustrate the subsurface conditions at the borehole locations. The boreholes are referenced as BH 1-4, and 10-12. The locations and elevations of the boreholes along with the stratigraphical profile based on the borehole data are shown on Dwg. 1298302-1. The subsurface conditions generally consist of the following materials, commencing with the uppermost layer:

<u>Material</u>	<u>Thickness of Layer</u>
Granular Embankment Fill (at the original alignment)	1.1 m - 1.4 m
Silty Clay (with organic zones)	1.0 m - 2.3 m
Silty sand	4.6 m - 6.1 m
Sandy silt	5.2 m - 7.0 m
Silty sand	0 m - 8.5 m
Heterogeneous Mixture of silt, sand, and gravel; occasional cobbles and boulders	> 6.3 m

At BH 2, which was commenced from the timber bridge deck the silty clay layer was not encountered. Here, the river bottom is immediately underlain by the upper silty sand layer. The following describes the subsurface soil conditions in greater detail.

The main deposits are the upper silty sand, the sandy silt and the lower silty sand which together extend for a total thickness of 11.5 m to 18.3 m. All of these deposits are interlayered and could be described as a unit as silty sand to sandy silt. In addition, the deposits contain occasional slightly cohesive silt layers.

Embankment Fill

Fill material was encountered immediately beneath the roadway shoulder. The depth of fill varies from 1.1 m in BH 3 to 1.4 m in BH 1 and overlies a silty clay stratum. The material consists of a non-cohesive mixture of varying amounts of silt, sand, and gravel. The moisture content of this material, as determined from a laboratory test performed on a typical sample of this material is 7%.

A typical grain size distribution curve for the fill material is shown on Figure 1.

Based on 'N' values ranging from 5 to 14 blows per 0.3 m, the material is in a loose to compact state.

Silty Clay (CI-CH); trace/with sand
occasional organic (OH) zones _ _ _

This material is the natural surficial deposit across the site except at BH #2, in the river channel, where it was not encountered. It varies in thickness from 0 to 2.1 m.

Occasional organics were present within this deposit especially on the north side of the river channel where they influence the soil properties making it extremely soft and compressible. Within the river channel the upper 1.0± m contains silty sand, gravel and cobbles typical of river bottoms.

Properties of the material, as determined by field and laboratory tests, are summarized as follows:

		<u>Range</u>	<u>Average</u>	<u>Median</u>
Natural Moisture Content	(w)	24.5 - 93.0%	49.0%	41.8%
Liquid Limit	(w _L)	31.5 - 77.5%	55.8%	56.8%
Plastic Limit	(w _p)	19.0 - 38.0%	27.3%	25.8%
Shear Strength	(C _u)			
- field vane (undisturbed)		50 - 88 kPa	N/A	N/A
- unconfined compression		46 kPa (one test)		
Unit Weight	γ	19.0 kN/m ³ (one test)		

Based on 'N' values generally ranging from 3 to 17 and shear strength values ranging from 46 to 86 kPa, the consistency of this deposit is soft to very stiff. Remolded shear strengths indicate a sensitivity of 2 to 4.

The results of the Atterberg Limit tests indicate that the material generally exhibits intermediate plasticity. The organic content tends to increase the plastic behaviour.

Figure 2 illustrates a typical grain size distribution for this material.

Upper Silty Sand; trace gravel, trace clay

This non-cohesive deposit underlies the 'Silty Clay' across most of the site, except at some locations within the river channel where it is at the ground surface. The thickness of the deposit ranges from 4.6 to 6.1 m.

Occasional gravel zones and slightly cohesive silty pockets were encountered in the upper few metres of this deposit on the north side of the river at BH #1 and #10. Occasional sandy silt layers are present throughout the deposit.

Figure 3 illustrates a typical grain size distribution for this material.

Based on 'N' values ranging from 3 to 22, the state of compaction of the material is very loose to compact, but generally compact since the lower 'N' values may have resulted from soil disturbance during sampling.

Sandy Silt; trace clay

This non-cohesive material underlies the 'Upper Silty Sand' where it extends for thicknesses ranging from 4.6 to 7.0 m.

The deposit is interlayered with occasional silty sand layers and contains occasional slightly cohesive silt zones.

The results of natural moisture content tests indicate a range of 18% to 26%.

Based on the results of Standard Penetration Tests ranging from 2 to 39, the state of compaction of this deposit ranges from very loose to dense. However,

unbalanced hydrostatic head problems encountered in a number of boreholes led to artificially low 'N' values and it is anticipated that the deposit is generally in a compact to very dense state.

Figure 4 illustrates a representative grain size distribution for this deposit.

Lower Silty Sand; trace clay

This non-cohesive deposit underlies the 'Sandy Silt' except at the north side of the river where it is discontinuous (BH #1, BH #10). It's thickness increases towards the south where it reaches a maximum of 8.5 m at BH #3.

The deposit is interlayered with occasional silty sand layers.

The results of natural moisture content tests indicate a range of 18% to 22%.

Based on the results of Standard Penetration Tests ranging from 19 to 60, the state of compaction of this deposit ranges from compact to very dense.

Figure 5 illustrates a representative grain size distribution for this deposit.

Heterogeneous Mixture of Silt, Sand, and Gravel
Occasional Cobbles (Till)

This non-cohesive material underlies the sandy silt layer in BH #1 and #10 and the lower silty sand layer in BH #2, #11 and #12. Sandy zones are contained within this deposit in BH 1 at elevation 333.5 m to 335 m. The full extent of this material was not investigated but is at least 6.3 m in thickness. The deposit contains an appreciable gravel content and occasional cobbles. Occasional boulders are also anticipated. Rock coring techniques were employed at times to advance the boreholes in this material.

A typical grain size distribution for this material is shown on Figure 6. The results can be summarized as follows:

	<u>Range</u>
Gravel	43 - 56%
Sand	26 - 34%
Silt	10 - 24%
Clay	1 - 4%

Based on 'N' values ranging from 61 to over 100 blows per 0.3 m, the material is in a very dense state.

Groundwater

Groundwater level observations were carried out in the open boreholes. At the time of the investigation the stabilized groundwater level was at or very near the river water level (Elevation 347±m).

Discussion and Recommendations

The existing structure is a 2-span (9± m, 9±m) timber bridge supported on rockfilled cribs.

A new structure is proposed to cross the Arrow River (North Branch) along an alignment (Line 'B') 12± m left of the existing alignment. At this location the river is 17± m wide and less than 1 m deep. Either a single-span or 2-span structure is proposed, with total bridge lengths of 22± m for a closed abutment design, or 30± m for an open abutment design. Approach embankments up to 5± m high will be required for the proposed grade of 352± m.

Two foundation alternatives for the replacement structure are provided. The most economical alternative should be adopted.

Structure Recommendations

The proposed single span replacement structure may be founded on end-bearing steel H-piles or on compacted fill.

The proposed two span replacement structure may be founded on end-bearing steel H-piles. If the structure can be designed to tolerate small differential movements, the abutments may be founded on compacted fill with the pier supported on end-bearing steel H-piles.

End-Bearing Steel H-Piles

Both structure replacement alternatives may be founded on steel H-piles, equipped with reinforced tips and driven in accordance with M.T.C. Standard SS 103 - 10 or SS 103 - 11. Friction piles were not considered to be an appropriate alternative because of the proximity of the end bearing stratum to the estimated friction pile tip elevation.

The following ultimate capacities for 310 HP 79 and 310 HP 110 are recommended for control of pile driving using M.T.C. Standard SS 103 - 10 or SS 103 - 11. Estimated pile tip elevations are also provided.

<u>Location</u>	<u>Station</u>	<i>310 HP 79 310 HP 110</i>		<u>Estimated Pile Tip Elevation</u>
		<u>Ultimate</u>	<u>Capacity</u>	
South Abutment	10 + 312.0 to 10 + 316.0	2154 kN	3000 kN	326.5 m
2-Span Pier	10 + 327.0	2154 kN	3000 kN	328 m
North Abutment	10 + 338.0 to 10 + 342.02	2154 kN	3000 kN	330 m

The following O.H.B.D.C. design loads are recommended for piles driven in accordance with the above-noted recommendations.

<u>Pile Type</u>	<u>Factored Capacity at U.L.S.</u>	<u>Capacity at S.L.S. Type II</u>
310 HP 79	1080 kN	720 kN
310 HP 110	1500 kN	1000 kN

Footings on Compacted Fill

Because of the possibility of differential settlements between abutments on spread footings and a pier on end-bearing piles, this alternative is only applicable to the single span proposal, unless the two span proposal can be designed to tolerate differential movements between the pier and the abutments.

This alternative would require subexcavation of the cohesive deposits beneath the plan limits of the compacted fill. For estimation purposes, subexcavation will be required to Elev. 345.7± m at the south abutment and Elev. 346.0± m at the north abutment. The fill should consist of either compacted Granular 'A' or rock fill. The fill should be constructed to the top of the footing elevation before excavating for the footing. The requirements for frost protection apply.

Settlements within the Granular 'A' fill will be negligible. Settlements within the rock fill are estimated at up to 2% of the rock fill height. In addition, voids within the rock fill immediately below the abutment footings will require chinking.

The following O.H.B.D.C. design values are recommended for spread footings on compacted fills constructed in accordance with Figure 7.

<u>Engineered Fill Type</u>	<u>Factored Bearing Capacity at U.L.St.</u>	<u>Bearing Capacity at S.L.S. Type II</u>
Compacted Granular 'A'	720 kPa	300 kPa
Compacted Rock Fill	600 kPa	250 kPa

General Recommendations (Applicable to Entire Site)

Earth Pressure Calculations

Backfill to structures should consist of granular material in accordance with M.T.C. Standard Special Provision #121 (83 10). Computation of earth pressures should be in accordance with Section 6.6.1.2 of the O.H.B.D.C. For design purposes, the physical properties of the backfill are as follows:

<u>Material</u>	<u>ϕ</u>	<u>γ</u>
Granular 'A'	35°	22.0 kN/m ³
Granular 'B'	30°	21.2 kN/m ³
Rock Fill	40°	19.5 kN/m ³

If sufficient movement in the structure is anticipated, the active case may be used for earth pressure calculations. Otherwise, the at-rest condition will govern earth pressure design.

Lateral Resistance

Sliding resistance between the base of concrete footings and the underlying material should be calculated in accordance with Section 6-7.3.3.2 of the O.H.B.D.C., assuming unfactored ϕ values of 35° for Granular 'A' and 40° for rock fill.

The horizontal component of battered piles may be used to resist lateral forces.

Subexcavation

Beneath the plan limits of the approach embankments, from Sta. 10 + 300 to Sta. 10 + 350, the upper 1 m of material should be subexcavated and backfilled with free-draining granular material compacted in accordance with M.T.C. standards. Beyond these limits, the subexcavation should be tapered at 5H:1V or as recommended by the Regional Geotechnical Section.

Settlement

Settlements of the structure will be negligible unless supported on rock fill. Provided that the subexcavation is carried out, settlements of the approach embankments will be primarily restricted to the fill material. The total amount of settlement will be dependent on the characteristics of the fill material, but should be less than 2% of the embankment height. Preloading the embankments would permit the majority of the settlement to occur during construction.

Stability

Provided that the subexcavation is carried out, no stability problems are anticipated for temporary slopes during construction of 1.5 H:1V.

Permanent earth fill slopes should be 2H:1V or flatter. Permanent rock fill slopes should be 1.5H:1V or flatter.

Dewatering

The noncohesive deposit found below elevation 346± m at this site is susceptible to boiling under conditions of unbalanced hydrostatic head.

If excavations are to be constructed in the dry below the prevailing groundwater elevation within this deposit, dewatering will be required to lower the groundwater level a minimum of 0.5 m below the base of the excavation.

Alternatively, excavations may be completed below the groundwater level, and backfilled with compacted free-draining granular material to 0.5 m above the groundwater level before construction of footings or pile caps.

For excavations below the water table, the footings could be partially constructed using tremie concrete. For this method a sheet pile cofferdam or prefabricated box should be sealed on the creek bottom. Enough tremie concrete should be placed to balance the hydrostatic head before proceeding with concrete construction in the dry.

Frost Protection

A minimum of 2.2 m of earth cover, or equivalent, to the base of the footing or pile cap, is required for frost protection. At the pier location for the two span proposal, the designer should ensure that adequate frost protection is provided be either flowing water conditions or earth cover.

Miscellaneous

The fieldwork for this project was carried out under the supervision of Ms. I. Steblynsky, Trainee Engineer, and Mr. D. Dundas, Senior Foundations Engineer, using equipment owned and operated by Dominion Soil Investigation Inc. The report was written by Mr. D. Dundas, Senior Foundations Engineer and reviewed by Mr. M. Devata, Chief Foundations Engineer (East).



DHD/MD/mmj

D. H. Dundas

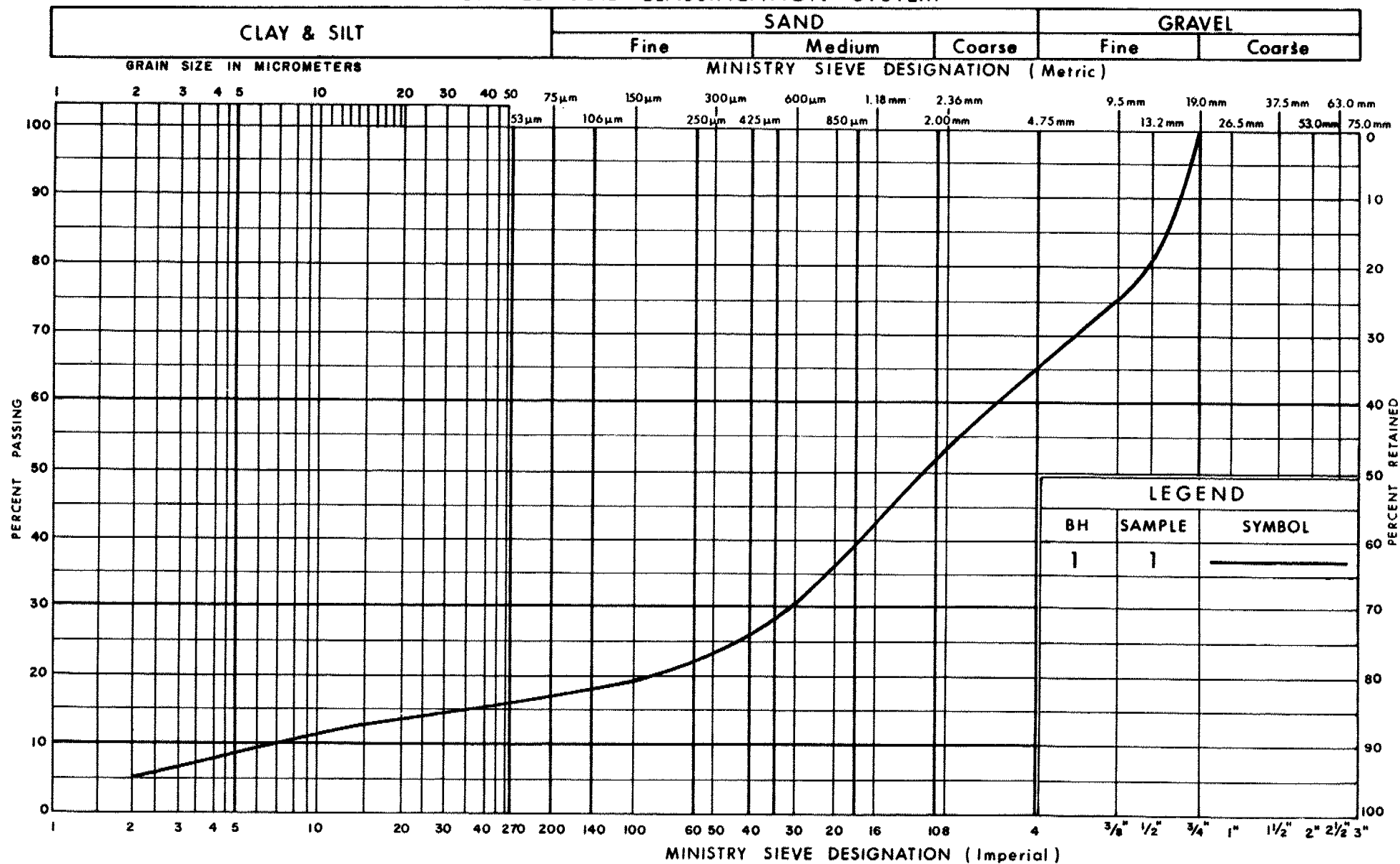
D.H. Dundas, P. Eng.
Senior Foundations Engineer

M. Devata

M. Devata, P. Eng.
Chief Foundations Engineer
(East)

A P P E N D I X

UNIFIED SOIL CLASSIFICATION SYSTEM



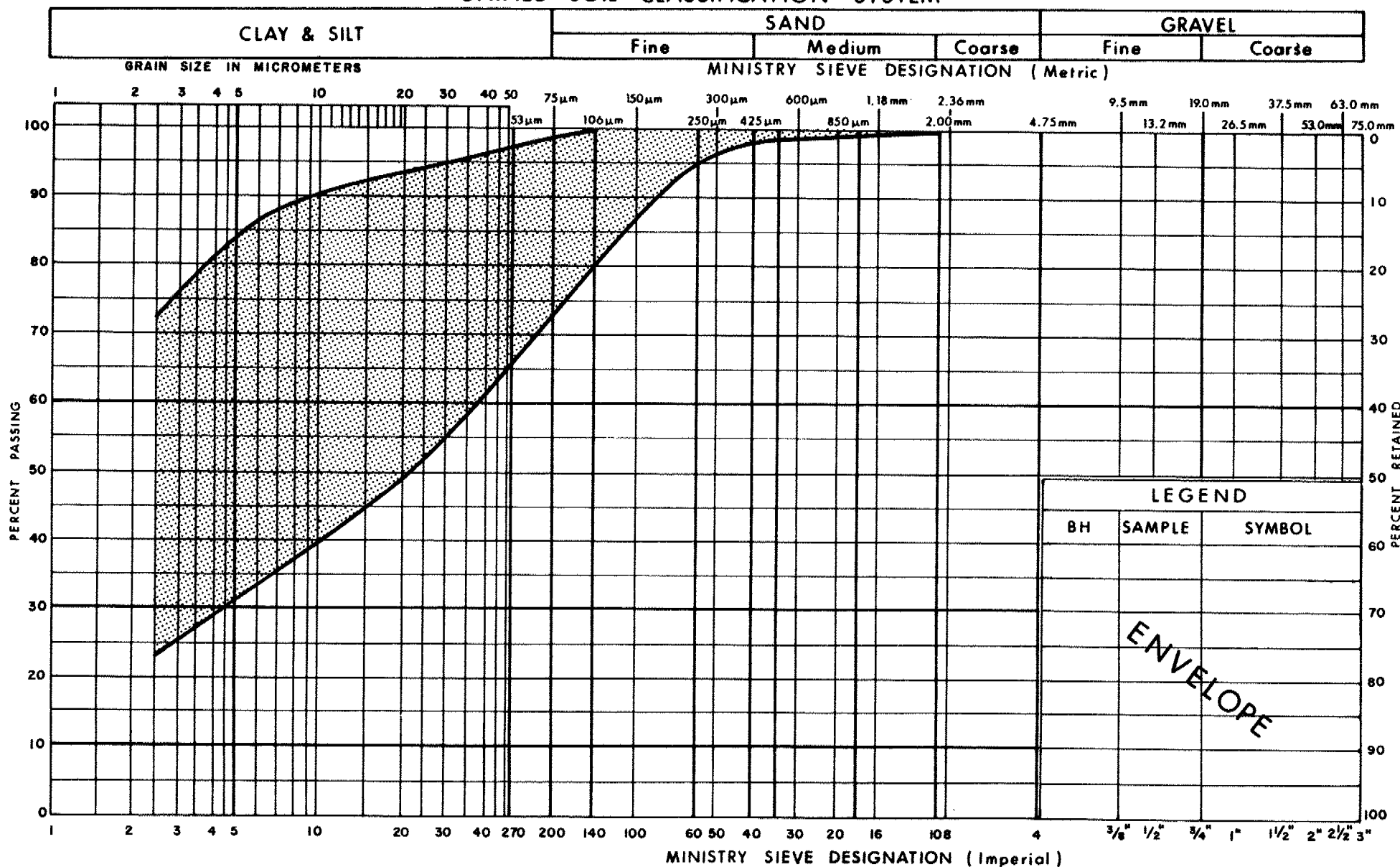
Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
GRAVEL, SAND & SILT
(EMBANKMENT FILL)

FIG No 1

W P 129-83-02

UNIFIED SOIL CLASSIFICATION SYSTEM



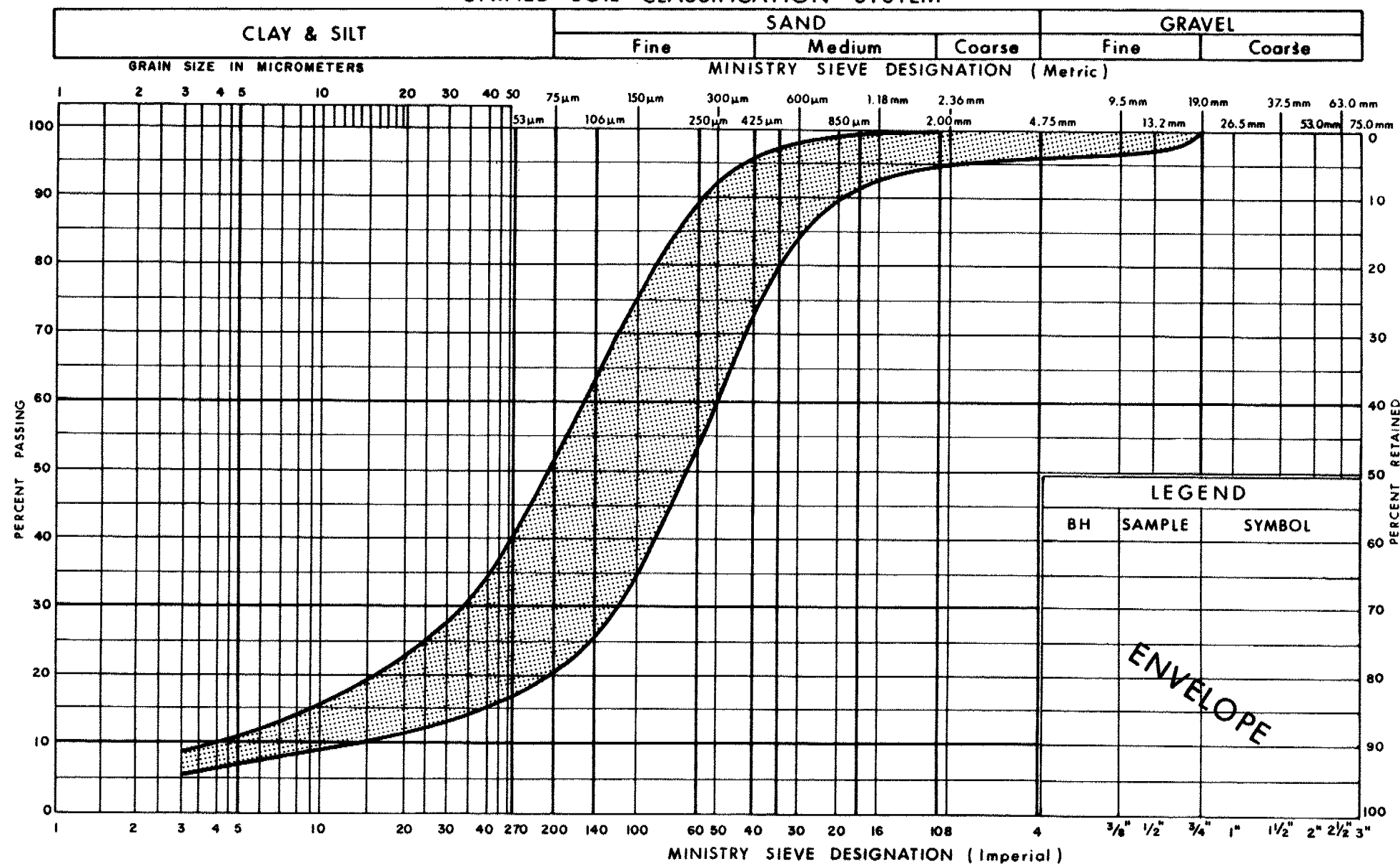
Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
SILTY CLAY (CI-CH); TRACE/WITH SAND
OCC ORGANIC (OH) ZONES

FIG No 2

W P 129-83-02

UNIFIED SOIL CLASSIFICATION SYSTEM

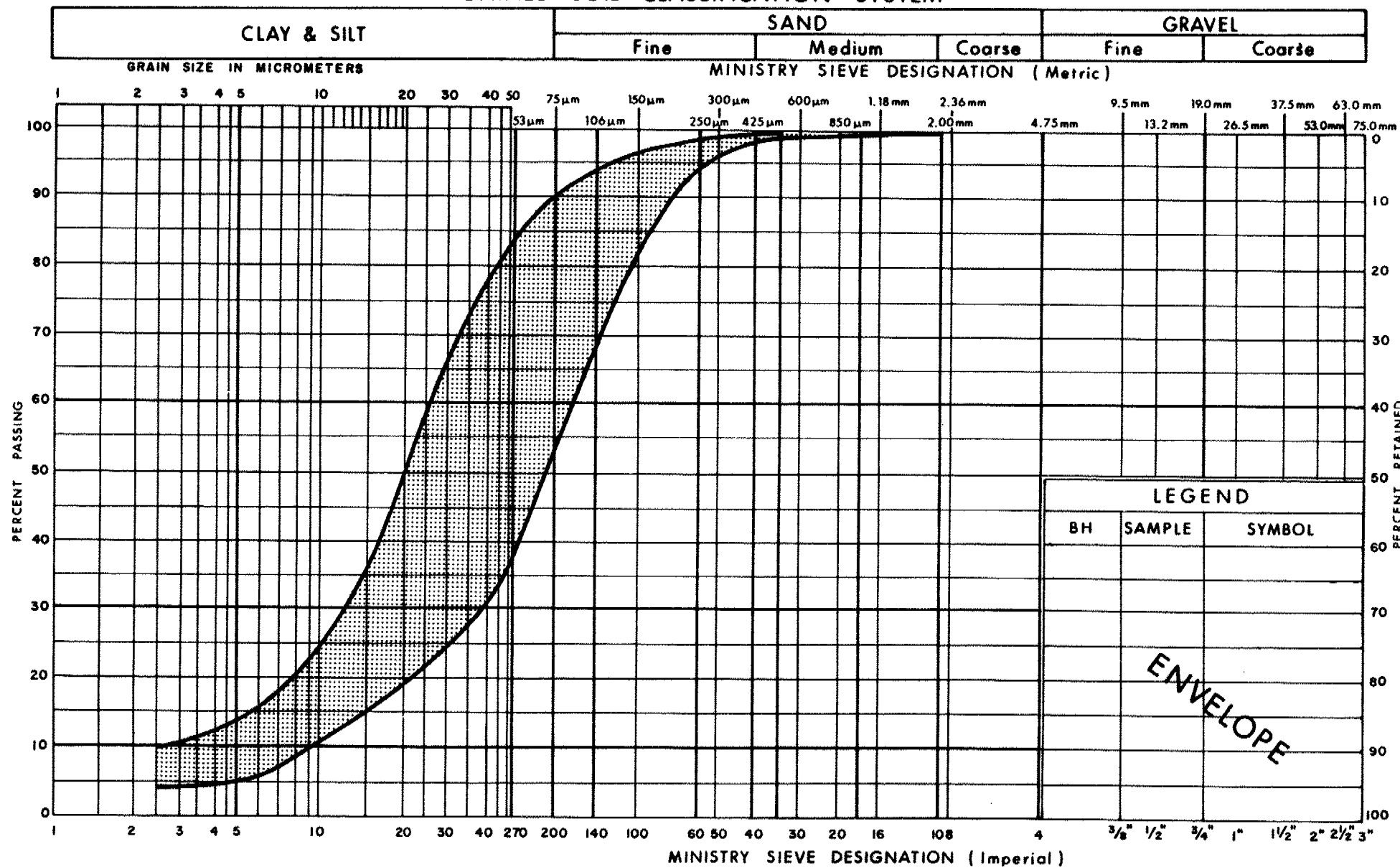
Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
Upper SILTY SAND
TRACE GRAVEL, TRACE CLAY

FIG No 3

W P 129-83-02

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

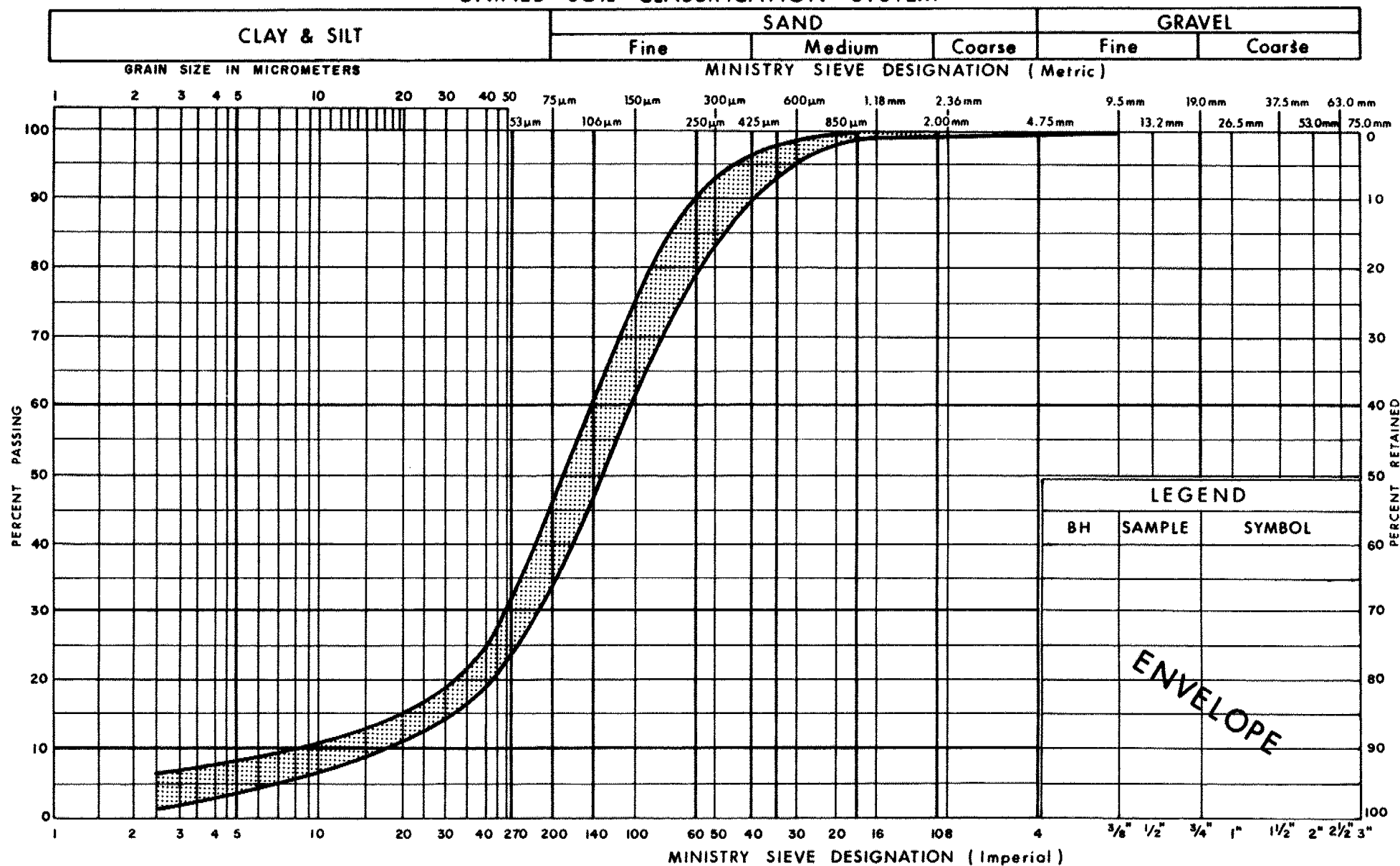
Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
SANDY SILT, TRACE CLAY

FIG No 4

W P 129-83-02

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

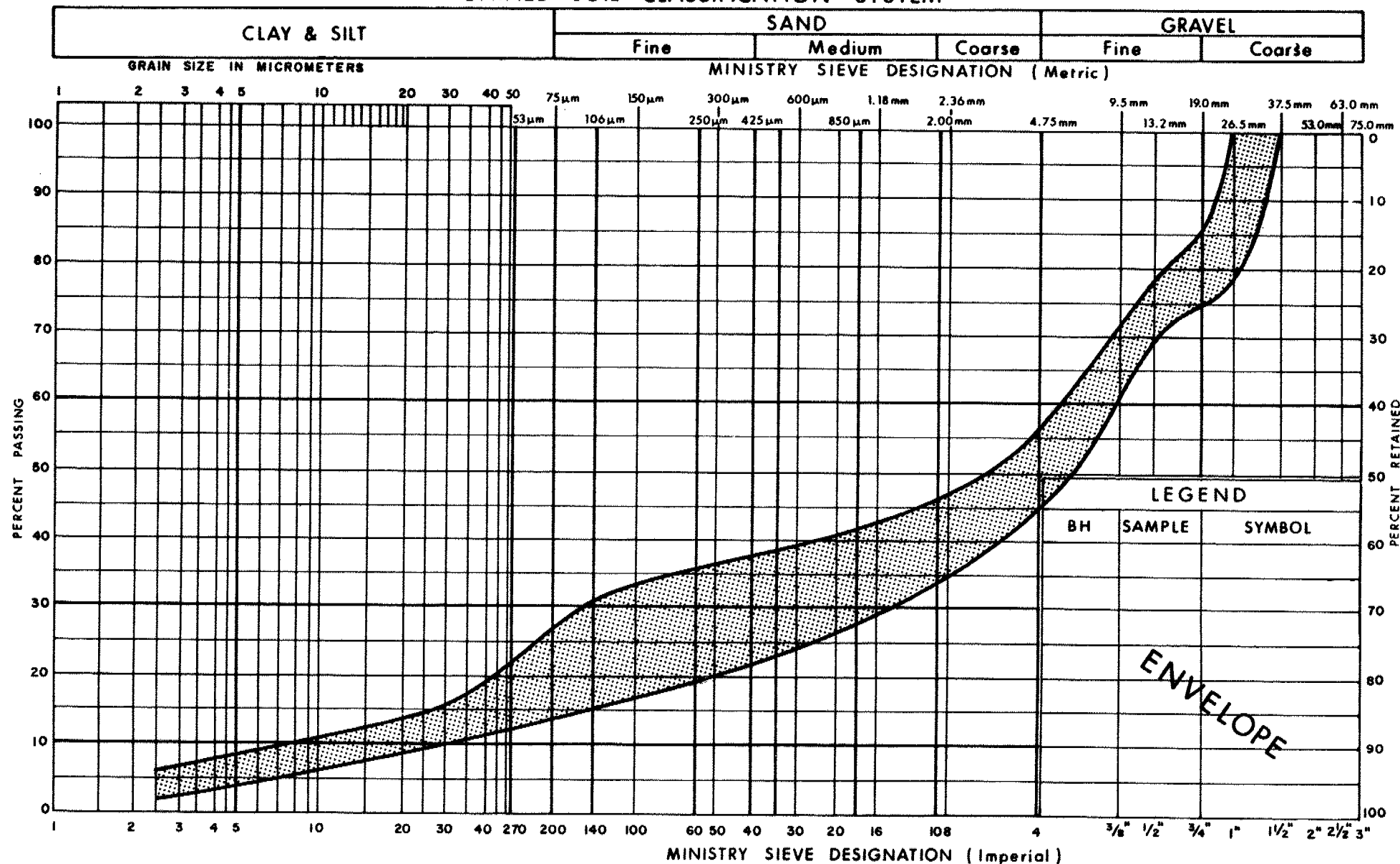
**Ministry of
Transportation and
Communications**

GRAIN SIZE DISTRIBUTION
Lower SILTY SAND, TRACE CLAY

FIG No 5

W P 129-83-02

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

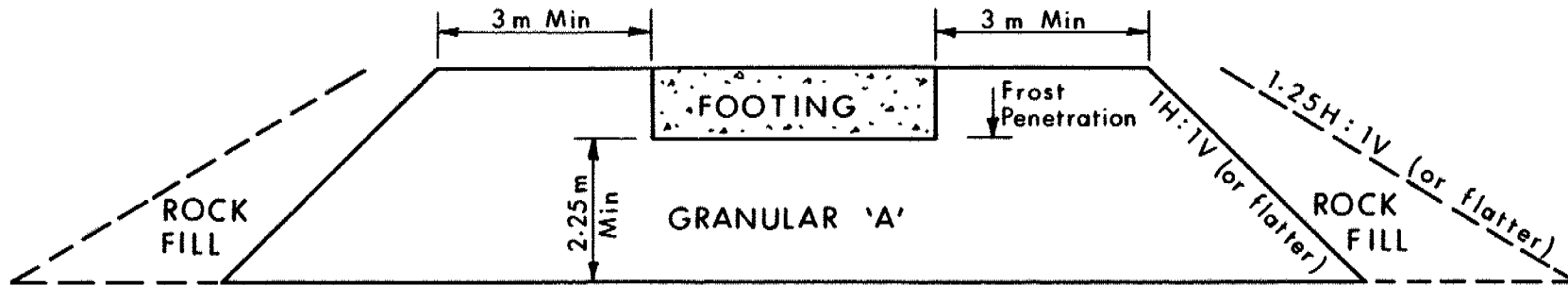
 Ministry of
Transportation and
Communications

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

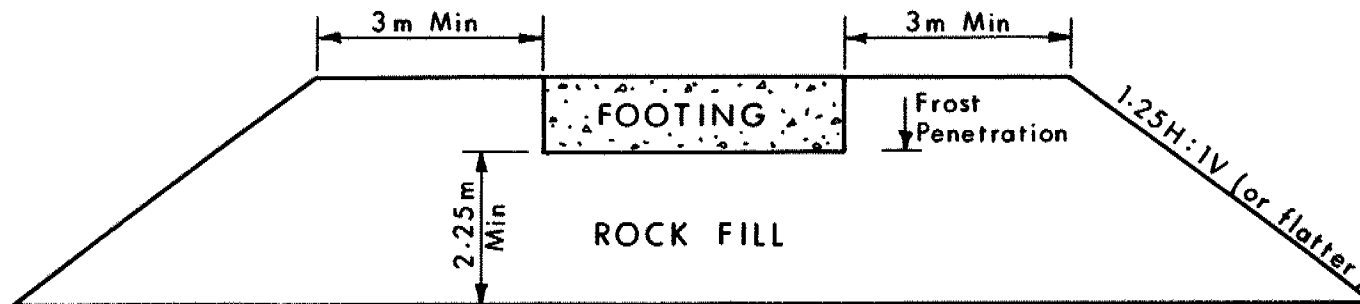
FIG No 6

W P 129-83-02

ABUTMENT ON COMPACTED FILL



X- SECTION / LONGITUDINAL SECTION



X- SECTION / LONGITUDINAL SECTION

NOT TO SCALE

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

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	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	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m ³	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m ³	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m ³	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m ³ /s	RATE OF DISCHARGE
γ_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m ³	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						



RECORD OF BOREHOLE No 1

METRIC

W P 129-83-02 LOCATION STA. 10 + 342.4 ; °/s 15.2 m Rt. 4 Line 'B' ORIGINATED BY FS
DIST 19 HWY 593 BOREHOLE TYPE H-S Auger, B-Casing, Wash Boring, B Rock Core, COMPILED BY FS
DATUM Geodetic DATE 86 05 12 - 13 Cone Test CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
349.3	Ground Surface													
0.0	Mixture of Gravel, Sand and Silt, Trace Clay (Embankment Fill)													
347.9	Compact		1	SS	14		348						34	48 13 5
1.4	Silty Clay Trace Sand		2	SS	8									
346.7	Stiff													
2.6	Gravelly Zones		3	SS	10		346						51	28 14 7
	Silty Sand Trace Clay		4	TW	PH								19.0	0 1 98 1
			5	SS	11									
			6	SS	15		344							
			7	SS	17									
			8	SS	22		342							
340.6	Compact												0	79 17 4
8.7	Sandy Silt Trace Clay		9	SS	12		340						0	22 74 4
			10	SS	14									
			11	SS	20		338							
							336							
335.2	Compact		12	SS	17									
14.1	Sandy Zones		13	SS	40		334						7	76 15 2
	Heterogeneous Mixture of Silt, Sand and Gravel		14	SS	61									
	Occasional Cobbles (Till)		15	RC			332							
	Dense to Very Dense		16	SS	100	10 cm							56	31 10 3
328.9							330							
20.4	End of Borehole		17	SS	120	18 cm								



RECORD OF BOREHOLE No 2

METRIC

W P 129-83-02 LOCATION STA. 10 + 325.8 ; °/s 11.4 m Rt. 4 Line 'B' ORIGINATED BY FS
DIST 19 HWY 593 BOREHOLE TYPE H-S Auger, Wash Boring, B Rock Core COMPILED BY FS
DATUM Geodetic DATE 86 05 15 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
349.3	Bridge Deck																
0.0	Air																
347.3	Water Level																
2.0	Water																
345.9	River Bottom																
3.4	Silty Sand Trace Clay Compact		1	SS	9												0 27 67 6
			2	SS	14												
			3	SS	15												
340.6																	
8.7	Sandy Silt Trace Clay Compact		4	SS	13												
			5	SS	17												0 20 76 4
335.1																	
14.2	Silty Sand Trace Clay Compact		6	SS	11												
			7	SS	23												
330.4																	
18.9	Heterogeneous Mixture of Silt, Sand & Gravel Occasional Cobbles (Till) Very Dense		8	SS	155	25 cm											43 34 22 1
328.3			9	RC													
21.0	End of Borehole		10	SS	96	20 cm											

+3, x5 : Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 3

METRIC

W P 129-83-02 LOCATION STA. 10 + 305.9; 0/s 11.0 m Rt. 4 Line 'B' ORIGINATED BY FS
DIST 19 HWY 593 BOREHOLE TYPE H-S Auger, Wash Boring, Cone Test COMPILED BY FS
DATUM Geodetic DATE 86 05 13 - 14 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
350.1	Ground Surface						350							
0.0	Mixture of Gravel, Sand and Silt, Trace Clay (Embankment Fill) *													
349.0			1	SS	5									
1.1	Silty Clay		2	TW	PH									
	Trace Sand													
346.7	Stiff		3	SS	8									
3.4	Silty Sand		4	SS	6									
	Trace Clay													
			5	SS	18									
	Loose to Compact													
342.1			6	SS	19									
8.0	Sandy Silt		7	SS	9									
	Trace Clay		8	SS	8									
			9	SS	21									
336.9	Loose to Compact													
13.2	Silty Sand		10	SS	19									
	Trace Clay		11	SS	29									
			12	SS	55									
			13	SS	27									
	Compact to Very Dense		14	SS	16									
328.4	Heterogeneous Mixture of Silt, Sand & Gravel		15	SS	17									
21.7	Occasional Cobbles (Till)		16	SS	100	15 cm								
	Compact to Very Dense		17	SS	100	8 cm								
324.4	End of Borehole													
25.7	* Loose to Compact													

+3, x5: Numbers refer to
Sensitivity

20
15
10

5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No 4

METRIC

W P 129-83-02 LOCATION STA. 10 + 340.5; 0/s 9.1 m Lt. 4E Line 'B' ORIGINATED BY JD
DIST 19 HWY 593 BOREHOLE TYPE H-S Auger COMPILED BY FS
DATUM Geodetic DATE 86 05 15 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100									
								SHEAR STRENGTH kPa									
								○ UNCONFINED	+ FIELD VANE								
								● QUICK TRIAXIAL	x LAB VANE								
								20 40 60 80 100									
										WATER CONTENT (%)							
										20 40 60							
347.4	Ground Surface													GR SA SI CL			
0.0	Silty Clay Topsoil		1	SS	3									0 28 52 20			
346.4	& Sand		2	SS	5												
1.0	Some Organics Firm																
	Silty Sand		3	SS	17		346										
	Trace Clay		4	SS	5												
			5	SS	11		344							3 76 17 4			
	Loose to Compact		6	SS	7												
341.7							342										
5.7																	
	Sandy Silt		7	SS	16									0 9 87 4			
	Trace Clay		8	SS	22		340										
			9	SS	29		338										
	Compact		10	SS	24		336										
334.8			11	SS	21												
12.6	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 10

METRIC

W P 129-83-02 LOCATION Sta. 10 + 338.7, E Line 'B' ORIGINATED BY I.S./D.D.
DIST 19 HWY 593 BOREHOLE TYPE Hollow Stem Auger, Cone Test COMPILED BY I.S.
DATUM Geodetic DATE 87 01 20 CHECKED BY D.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	**N* VALUES			SHEAR STRENGTH						
347.5	Ground Surface							20 40 60 80 100						
0.0	Silty Clay (CL to CI)		1	CS										GR SA SI CL
346.5	*with organic (OH) zones		2	SS	4									0 26 53 21
1.0	with gravel loose to compact (slightly cohesive)		3	SS	15									57 22 18 3
			4	SS	3									56 26 14 4
	Silty Sand trace gravel trace clay loose (LACUSTRINE)		5	SS	6									
			6	SS	6									
			7	SS	9									
			8	SS	5									
341.1			9	SS	10									
6.4	Sandy Silt trace clay very loose to compact (LACUSTRINE)		10	SS	7									0 17 74 9
			11	SS	12									1 11 80 8
			12	SS	12									
			13	SS	2									
334.1														
13.4	Heterogeneous Mixture of Silt, sand and gra-		14	SS	32									
333.3	End of Borehole		15	SS	100									
14.2	* Some sand soft (LACUSTRINE) ** trace clay occ. cobbles and boulders very dense (TILL) *** N Values reduced by an unbalanced hydrostatic head condition													

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 11

METRIC

W P 129-83-02 LOCATION Sta. 10 + 325.7, 0.8 m LT. of & Line 'B' ORIGINATED BY I.S./D.D.
DIST 19 HWY 593 BOREHOLE TYPE Hollow Stem Auger, Cone Test COMPILED BY I.S.
DATUM Geodetic DATE 87 01 21 CHECKED BY D.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH						
							○ UNCONFINED + FIELD VANE								
							● QUICK TRIAXIAL x LAB VANE								
346.9	Water Surface														GR SA SI CL
0.0	Water (ice)														
346.1	River Bottom						870121								
0.8	Silty sand, gravel and cobbles		1	SS	27		346	augered							15 51 21 13
344.8	* Silty Clay (CL to CI)		2	SS	17										
2.1	Silty Sand trace gravel trace clay loose to compact (LACUSTRINE)		3	SS	6										
			4	SS	11										
			5	SS	10										
			6	SS	14										2 55 35 8
			7	SS	8										
			8	SS	20										1 47 45 7
339.9															
7.0	Sandy Silt trace clay Compact to Dense (LACUSTRINE)		9	SS	21										0 46 49 5
			10	SS	38										
			11	SS	33										
334.1			12	SS	36										
12.8	Silty Sand trace clay dense to very dense (LACUSTRINE)		13	SS	35										
331.4			14	SS	60										0 66 30 4
311.1	**		15	SS	60										45 33 17 5
15.8	End of Borehole						12.7cm								
	*with sand some gravel very stiff														
	** Heterogeneous Mixture of Silt, Sand and Gravel trace clay occ. cobbles and boulders very dense (TILL)														

+³, x⁵: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 12

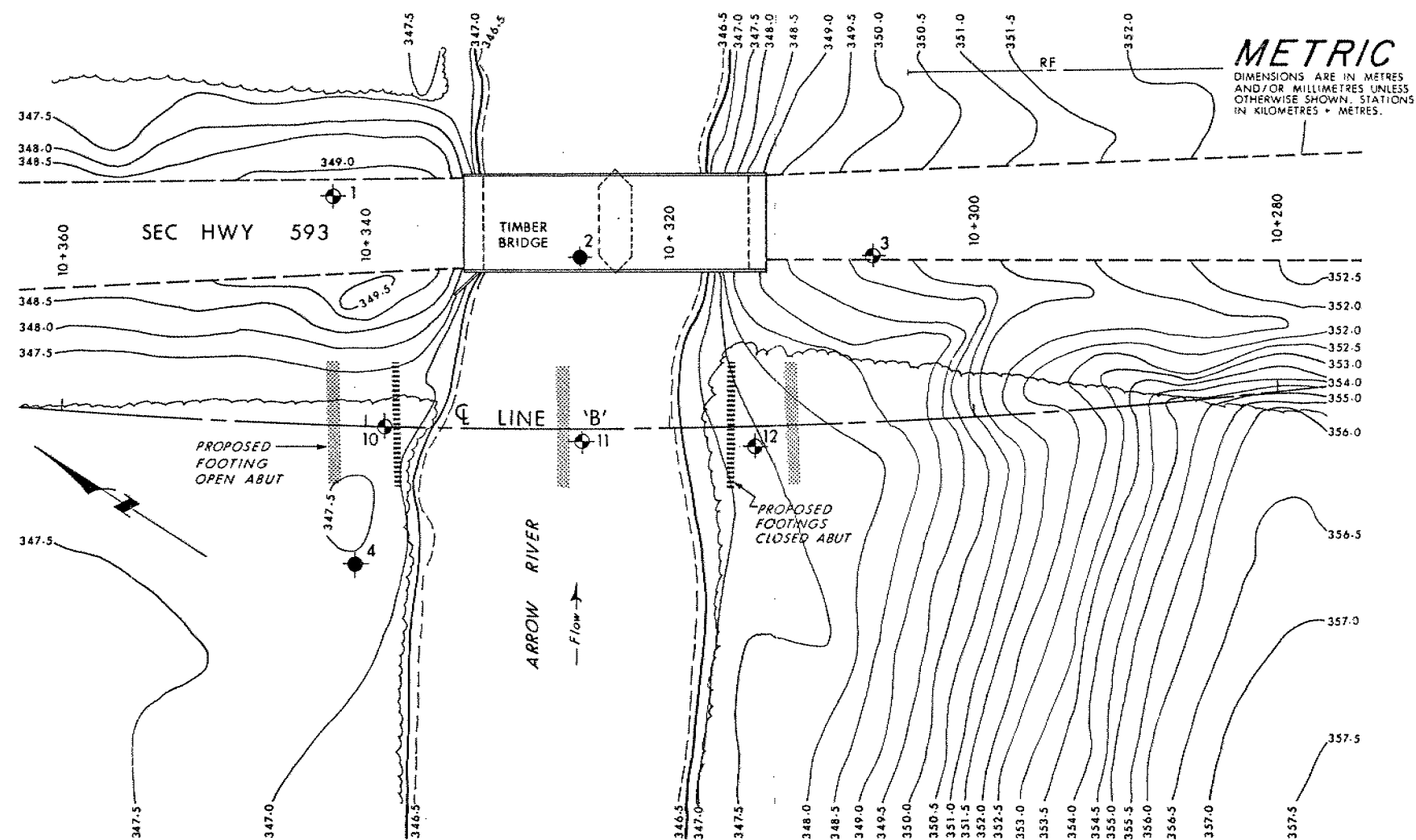
METRIC

W P 129-83-02 LOCATION Sta. 10+314.4, 1.2 m LT of Line 'B' ORIGINATED BY IS
DIST 19 HWY 593 BOREHOLE TYPE HOLLOW STEM AUGER, CONE TEST COMPILED BY IS
DATUM Geodetic DATE 87 01 22 CHECKED BY DD

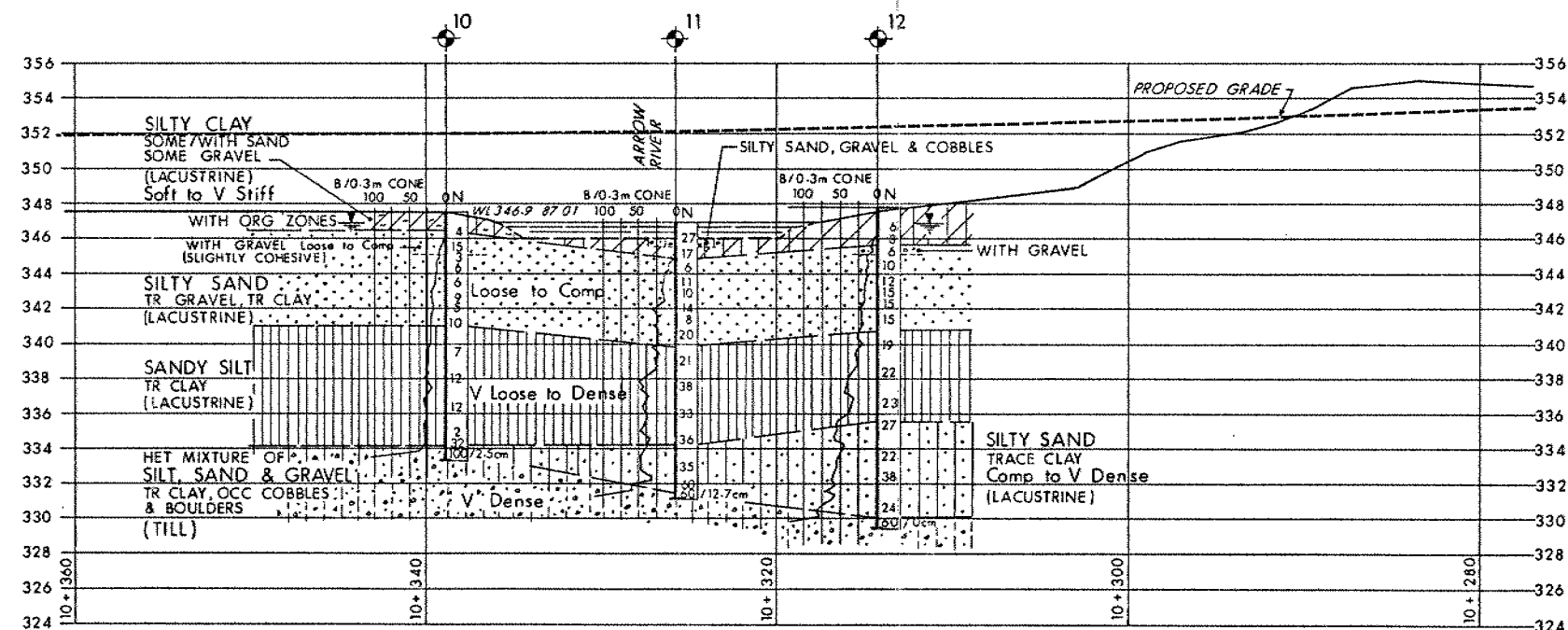
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
347.8	GROUND SURFACE													
0.0	Silty Clay (CL to CI) some sand firm (LACUSTRINE)		1	CS		↓ assumed	346	augered						0 11 55 34
345.7			2	SS	6									
2.1			3	SS	8									
	with gravel		4	SS	6									
	Silty Sand		5	SS	10									
	trace gravel		6	SS	12									
	trace clay		7	SS	15									
	loose to compact (LACUSTRINE)		8	SS	15									
340.8			9	SS	15									
7.0			10	SS	19		340							
	Sandy Silt		11	SS	22		338							
	trace clay		12	SS	23		336							
335.6			13	SS	27		334							0 67 28 5
12.2			14	SS	22		332							0 50 45 5
	Silt Sand		15	SS	38		330							
	trace clay		16	SS	24									
	compact to dense (LACUSTRINE)													
330.1														
17.2														
329.5 *														
18.3	End of Borehole		17	SS	60	10 cm								
	* Heterogeneous Mixture of Silt, Sand and Gravel trace clay occ. cobbles and boulders very dense (TILL)													

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



PLAN
SCALE
4m 2 0 4m

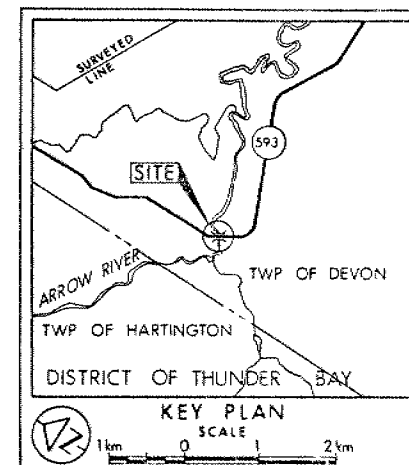


CONT No
WP No 129-83-02

ARROW RIVER
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 1/blow)
- CONE Blows/0.3m (60° Cone, 475 1/blow)
- W.L. at time of investigation 87 01

No	ELEVATION	STATION	OFFSET
1	349.3	10+342.4	15.2m Rt
2	349.3	10+325.8	11.4m Rt
3	350.1	10+305.9	11.0m Rt
4	347.4	10+340.5	9.1m Lt
10	347.5	10+338.7	℄
11	346.9	10+325.7	0.8m Lt
12	347.8	10+314.4	1.2m Lt

NOTE:
BOREHOLES 1 TO 4 FOR INFORMATION ONLY. REFER TO RECORD OF BOREHOLE FOR SUBSOIL INFORMATION.

NOTE

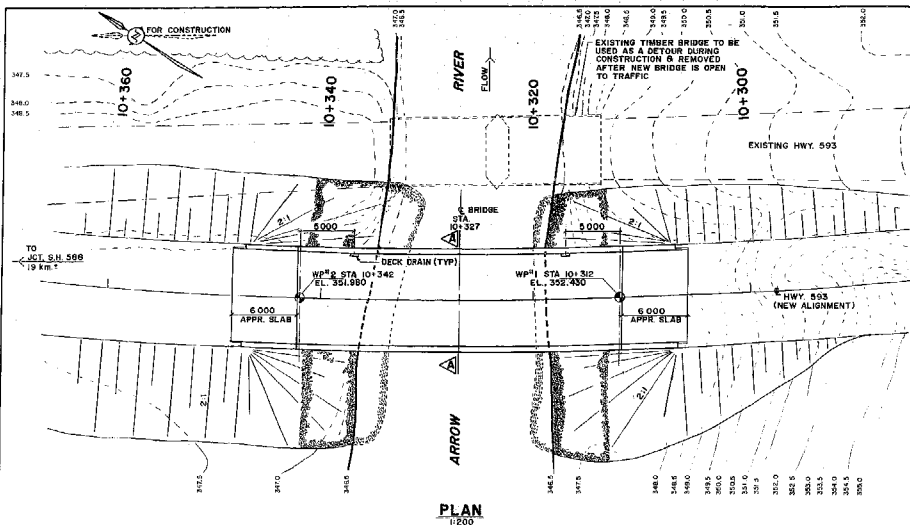
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

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

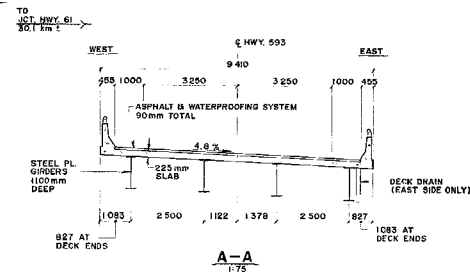
Geocres No 52A-87

HWY No 593	DATE 87 04 15	SITE 48W-99
SUBMD DD CHECKED	APPROVER	DWG 1298302-A
DRAWN DT CHECKED		

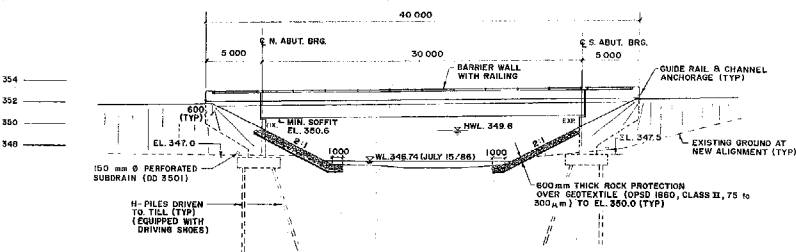


PLAN
1:200

CURVE DATA
 RADIUS — 450 m
 Δ_c — $33^\circ 32' 54''$
 Lc — 263.498 m
 A — 160.0 m

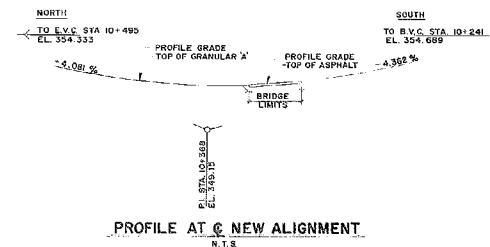


A-A
1:75



ELEVATION
1:200

BM 347.921
 GEODETIC DATUM
 N & W IN ROOT OF 0.45 x PINE
 30.2 RT. 10+372.1



PROFILE AT & NEW ALIGNMENT
N.T.S.

METRIC
 DIMENSIONS ARE IN METRES
 AND/OR MILLIMETRES
 UNLESS OTHERWISE SHOWN

DIST. 19	HWY. 593	
CONT No		
WP No	129-83-02	
ARROW RIVER BRIDGE		SHEET 12
GENERAL ARRANGEMENT		

GENERAL NOTES

- CLASS OF CONCRETE**
 DECK, BARRIER WALLS, ABUTTS. & WINGWALLS — 30 MPa
 FOOTINGS — 20 MPa
- REINFORCING STEEL**
 GRADE 400
 BAR MARKS WITH THE SUFFIX 'C' DENOTE COATED BARS
 CLEAR COVER TO REINFORCING STEEL
 FOOTINGS — 100 ± 25 mm
 ABUTMENTS & WINGWALLS:
 FRONT FACE — 80 ± 20 mm
 BACK FACE — 70 ± 20 mm
 DECK — TOP — 70 ± 20 mm
 BOTTOM — 40 ± 10 mm
 REMAINDER — 70 ± 20 mm
 (UNLESS NOTED OTHERWISE)

CONSTRUCTION NOTES

THE CONTRACTOR SHALL FINISH THE BEARING SEATS
 LEVEL TO THE SPECIFIED ELEVATIONS TO A
 TOLERANCE OF ± 3 mm.
 A NEAT CEMENT PASTE SHALL BE APPLIED TO EXISTING
 CONCRETE AT CONSTRUCTION JOINTS.

LIST OF DRAWINGS

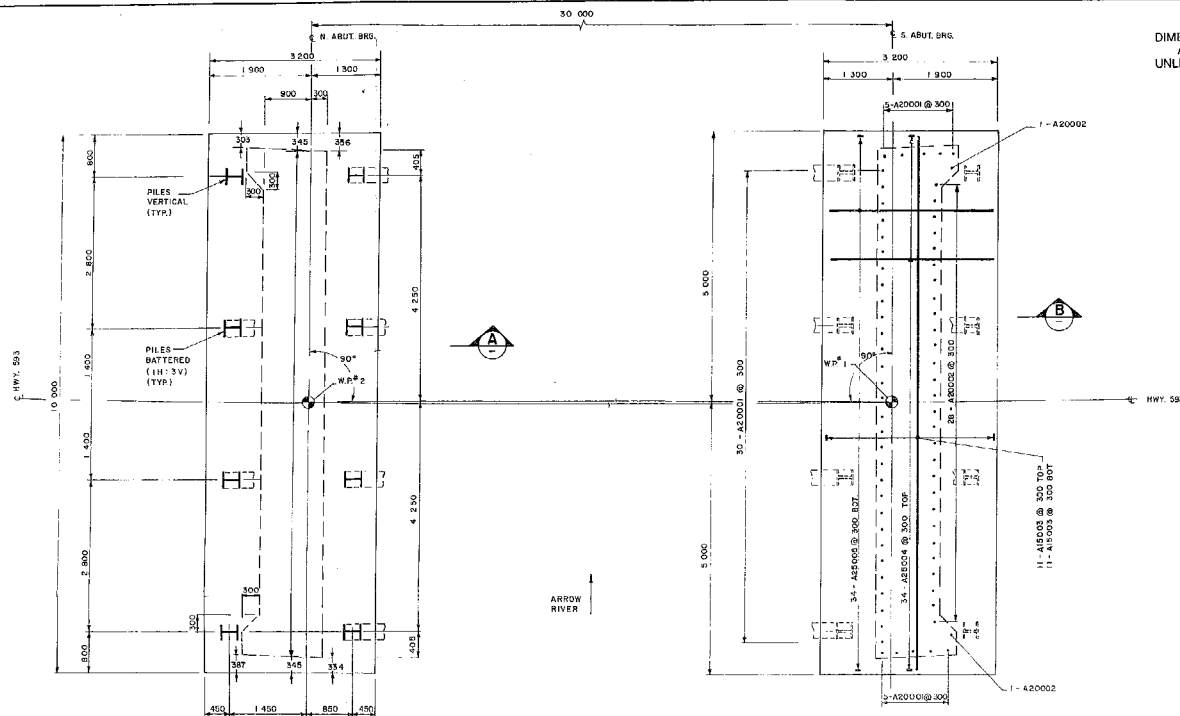
- | | |
|--------|--|
| 45W/50 | 1 - GENERAL ARRANGEMENT |
| 2 - | BOREHOLE LOCATIONS AND SOIL DATA |
| 3 - | PILES AND FOOTINGS |
| 4 - | SOUTH ABUTMENT |
| 5 - | NORTH ABUTMENT |
| 6 - | STRUCTURAL STEEL I |
| 7 - | STRUCTURAL STEEL II |
| 8 - | DECK LAYOUT AND DETAILS |
| 9 - | 6000 MM APPROACH SLAB |
| 10 - | BARRIER WALLS WITH RAILING |
| 11 - | RAILING FOR BARRIER WALLS |
| 12 - | JOINT ANCHORAGE AND ARMORING |
| 13 - | DECK DRAINAGE AND JOINT ELEVATIONS |
| 14 - | AS CONSTRUCTED ELEVATIONS AND DIMENSIONS |
| 15 - | BRIDGE DATE AND SITE NO. DATA |



DRAWING NOT TO BE SCALED
 100 mm ON ORIGINAL DRAWING

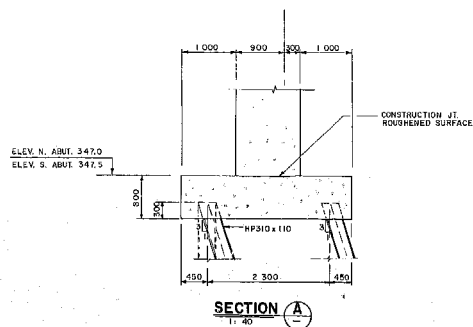
REVISIONS					
	DATE	BY	DESCRIPTION		
	DESIGN	R.J.K.	CHECK	LOADING OHBDC 55-B	DATE 02/87

REVISIONS OF THIS DRAWING ARE TO BE MADE BY THE DESIGNER'S OFFICE

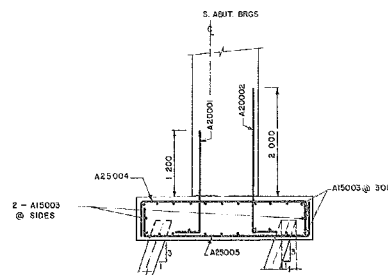


TYPICAL DIMENSIONS SHOWN

TYPICAL REINFORCEMENT SHOWN



SECTION A
1:40



SECTION B
1:40

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

DIST. 19 HWY. 593

CONT No
WP No 129-83-02

ARROW RIVER BRIDGE
PILES AND FOOTINGS



SHEET

PILE DESIGN DATA						
LOCATION	TYPE	No. REQ'D	LENGTH	REMARKS	DESIGN DATA	
					S.L.S. II LOAD	LOAD U.L.S.
SOUTH ABUT	HP 310 x 110	8	22 000mm	WITH ROCK POINTS	1000 kN/PILE	1500 kN/PILE
NORTH ABUT	HP 310 x 110	8	18 000mm	WITH ROCK POINTS	1000 kN/PILE	1500 kN/PILE

NOTES

- SPECIFIED PILE LENGTHS ARE THEORETICAL LENGTHS OF PILES BELOW CUT-OFF ELEVATION.
- PILES ARE TO BE DRIVEN IN ACCORDANCE WITH SS103-10 OR SS103-11 USING AN ULTIMATE CAPACITY OF 3000 kN PER PILE BUT MUST BE DRIVEN BELOW EL. 330 m AT NORTH FOOTING AND EL. 338 m AT SOUTH FOOTING. ALL AS DIRECTED BY THE ENGINEER.
- PILE SPACINGS MEASURED TO UNDERSIDE OF FOOTING.
- ALL STEEL FOR PILES SHALL BE IN ACCORDANCE WITH CSA G40.21M GRADE 300W.
- PILE DRIVING SHOES TO BE IN ACCORDANCE WITH M.T.C. STANDARD 100301.

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING



REVISIONS	DATE	BY	CHECK	DESCRIPTION	DATE	BY
DESIGN		R.J.K.	CHECK	LOADING CHBDC '88 - B	08/87	
DRAWING		L.M.	CHECK	R.J.K. SITE NO. 48W-89	08/87	