

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 30M13-66

DIST. 6 REGION

W.P. No. 132-79-02

CONT. No. 93-52

W. O. No.

STR. SITE No. 24-211

HWY. No. 50

LOCATION C.P.R. & Hwy 50  
Bolton

No of PAGES -

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

G.I.-30 SEPT. 1976

# **FOUNDATION INVESTIGATION REPORT**

**CONTRACT NO. 93-52**



**Ministry of  
Transportation**

INDEX

<u>Page No:</u>	<u>DESCRIPTION</u>
1	Index
2	Abbreviations & Symbols
3 - 21	Foundation Investigation Report for:  C.P.R. Bridge Twinning W.P. 132-79-02, Site 24-211 Hwy. 50, District 6, Toronto

Note: For purposes of the contract, this report supercedes all other Foundation Reports prepared by, or for the Ministry in connection with the above mentioned 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
$C_\alpha$	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
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	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
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	$kg/m^3$	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	$kN/m^3$	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	$kg/m^3$	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	$kN/m^3$	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	$kg/m^3$	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	$kN/m^3$	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	$kg/m^3$	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	$m^3/s$	RATE OF DISCHARGE
$\gamma_d$	$kN/m^3$	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
$\rho_{sat}$	$kg/m^3$	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
$\gamma_{sat}$	$kN/m^3$	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	$kg/m^3$	DENSITY OF SUBMERGED SOIL	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE	j	$kN/m^2$	SEEPAGE FORCE
$\gamma'$	$kN/m^3$	UNIT WEIGHT OF SUBMERGED SOIL						

For  
CPR Bridge Twinning @ Hwy. 50  
WP 132-79-02; Site No. 24-211  
District 6, Toronto

### INTRODUCTION

This report summarizes the information obtained from a foundation investigation carried out at the above-mentioned site between 86 12 01 to 86 12 31. The field work consisted of seven sampled boreholes (BH 1 to BH 7).

BH 1 and 7 were advanced through the embankments, at the north and south approaches to the existing structure, and into the original ground, using a wash boring technique with NX and BX size casings. The depth of the boreholes were 21.8 and 30.9 m respectively.

The remaining boreholes (BH 2 to BH 6) were advanced by means of a continuous flight auger machine equipped with 83 mm I.D. hollow stem augers. Dynamic cone penetration tests accompanied these boreholes. The depth of these boreholes ranged between 25.6 m and 26.4 m below ground level.

### SITE DESCRIPTION AND GEOLOGY

This site is located on Hwy. 50 at the CPR crossing, approximately 2.5 km south of Bolton. At present, there is a two lane eight span structure at the site, with embankments in the order of 8.4 m. This site is located in the Town of Caledon, Regional Municipality of Peel.

The land use in this area is predominantly industrial and agricultural. At the site, there is an industrial development to the west of the existing structure. Hardwick Rd. runs north to south along the west side of the site, providing access to the buildings. To the east of the existing structure, there is a farm with a farmhouse at the north end, and an industrial building at the south end.

The site is located in the physiographic region known as the "South Slope" as described by The Physiography of Southern Ontario (Chapman and Putnam, 1984). The deposit characterizing this area consists of glacial till underlain by shale bedrock of the Georgian Bay Formation. The surface in this

region is a ground moraine of limited relief. Specifically, the site under investigation, is fairly level with visible hills in the surrounding area.

The area is drained by the Humber River. At the site, there is a drainage ditch running north to south that follows Hardwick Rd. along the west side of the site. This ditch drains the runoff south of the CPR tracks. To the north of the CPR tracks, there is a low area between the toe of the north approach fill and the tracks. This area is marshy and in some places, ponded water could be found to a depth of 50 to 100 mm. In the drainage ditch, during time of the investigation, the water was flowing and ranged in depth from 50 to 75 mm.

The existing two-lane reinforced concrete overpass is in good condition. The north and south approach fill in this area consists of two types of material. The slopes are covered with vegetation, and show some signs of minor surficial erosion.

#### SUBSURFACE CONDITIONS

##### General

The stratigraphy across the site is uniform beginning with a thin veneer of topsoil up to 50 mm thick. Underlying this thin layer of topsoil, is the predominant material across the site; a silty clay mainly of intermediate plasticity. This deposit is approximately 10 m thick and was encountered at or just below the original ground level. This deposit is underlain by a glacial till deposit consisting of a heterogeneous mixture of silty clay, sand and gravel. A 1 to 1.5 m seam of non-cohesive silty fine sand was encountered at a depth of approximately 17 m below ground level, in the glacial till stratum. The full extent of the glacial till deposit was not investigated, but was found to extend to a maximum depth of 26.4 m below ground level. Bedrock was not proven in any of the boreholes.

The embankments at the north and south approaches to the existing structure consist of a non-cohesive granular material in the upper portion, followed by a cohesive material of silty clay containing pockets of silty sand. The maximum height of the approaches in this area was found to be approximately 8.4 m.

The boundaries of the subsoil types, insitu and laboratory test results, as well as groundwater levels, are shown on the Record of Borehole Sheets in the Appendix. The location of each borehole is shown in plan on Dwg. No. 1327902-A\* together with a stratigraphical section.

The following is a detailed description of the soils encountered at the site.

#### Topsoil

The site is covered by a thin veneer of topsoil generally in the order of 50 mm thick. The thickness varies across the site.

The original topsoil layer was encountered at an elevation of 251.3 m in BH 7, after the borehole had been advanced through 7.9 m of fill at the north approach embankment.

#### Fill Material

The north and south approach fills at the existing structure are approximately 8.4 m in height.

The upper 3.3 m of the north and south approach fills consists of a granular material. At the north approach this material is a sand with a trace of gravel and fines. The 'N' value is 9 indicating the material is in a compact state. However, at the south approach, this material is a sand with a trace of fines. The 'N' value is 35 for this material indicating it is in a dense state. Grain size distributions for both these materials can be found in the Appendix (Figure 1).

In both fill areas, this sand layer is followed by a layer of silty clay with pockets of silty sand. This material is found from a depth of 3.3 m below the top of the fill area to a depth of 8.4 m (or the original ground level).

Atterberg Limits tests and grain size distribution tests were performed on samples of this material. And the results are summarized below.

\* DWG NO 2 OF THE CONTRACT DWG'S

		<u>% RANGE</u>			<u>% RANGE</u>
Moisture Content	W	14 - 18	Gravel;		0 - 4.5
Liquid Limit	W <sub>L</sub>	29.5 - 32.5	Sand		10 - 31.5
Plastic Limit	W <sub>p</sub>	15.5 - 17.5	Silt		40.5 - 61.5
Plasticity Index,	I <sub>p</sub>	14 - 16.5	Clay		21.5 - 30.5

Based on these results, this material can be described as a silty clay of low plasticity (CL-group) some sand trace gravel.

Standard Penetration Test values range from 8 to 26 in the silty clay fill material, indicating the fill has a stiff to very stiff consistency. The 'N' values, ranging from 26 to 30 blows/0.3 m in the sand pockets, indicate that they are in a dense state of compaction.

#### Silty Clay

The silty clay deposit is the predominant natural deposit and was observed in all the boreholes across the site, at or just below the original ground level. The thickness of this deposit ranges from 8.6 to 10.8 m below existing ground surface. In BH 1 and 7, this material was encountered immediately below the fill material of the embankments. The upper 2.5 to 6.0 m is somewhat oxidized and brown in colour, and below that, the material is essentially grey.

Atterberg Limits tests were conducted on this material and Figure 2 in the Appendix shows the results plotted on a Plasticity Chart. The results of the Limits Tests are summarized as follows:

		<u>AVERAGE %</u>	<u>% RANGE</u>
Moisture Content	W	19.5	16 - 24
Liquid Limit	W <sub>L</sub>	39.5	32.5 - 46
Plastic Limit	W <sub>p</sub>	20.1	17 - 23
Plasticity Index,	I <sub>p</sub>	19.4	15.5 - 24

Grain size distribution tests were conducted, and Figure 3 in the Appendix illustrates the results in envelope form, on a grain size distribution plot. The results are summarized as follows:



	<u>RANGE %</u>
Gravel	0.5 - 11
Sand	0.5 - 16
Silt	32.5 - 69.5
Clay	17.5 - 57.5

This deposit can be described as a silty clay of low to intermediate plasticity (CL-CI group) with a trace of sand and gravel.

The Standard Penetration 'N' values range from 5 to 94 throughout this layer, indicating it has a firm to hard consistency.

#### Glacial Till - Heterogeneous Mixture of Silty Clay, Sand and Gravel

The silty clay deposit is underlain by a grey glacial till deposit of a heterogeneous mixture of all grain sizes. The material was encountered in all boreholes, at a depth ranging from 8.6 to 10.8 m below the ground level. Within the glacial till stratum, a granular layer up to 1.5 m thick was observed in all the boreholes, except BH 1, at a depth ranging from 16 to 17.2 m below the ground level. The full extent of the glacial till deposit was not investigated.

Atterberg Limits tests were performed on this material, and the results are plotted on Figure 4 in the Appendix, and summarized below.

		<u>AVERAGE %</u>	<u>% RANGE</u>
Moisture Content	W	12.0	9 - 19
Liquid Limit	W <sub>L</sub>	24.1	17.5 - 31.5
Plastic Limit	W <sub>p</sub>	15.3	12.5 - 19.5
Plasticity Index,	I <sub>p</sub>	8.8	3.5 - 16

Grain size distribution tests were also carried out on this material. Figure 5 in the Appendix shows the results, in envelope form, on a grain size distribution plot. The results are summarized as follows:

	<u>RANGE %</u>
Gravel	0 - 14.5
Sand	8 - 23
Silt	40 - 70.5
Clay	12 - 38

With depth, the content of silt increases while the clay decreases.

As mentioned previously, a silty fine sand seam was encountered in the glacial till stratum. The 'N' values within the granular zone were in excess of 120 blows/0.3 m indicating the zones are very densely packed.

In the glacial till stratum, the SPT 'N' values ranged from 23 blows/0.3 m to 153 blows/0.3 m, indicating a consistency described as very stiff to hard.

#### GROUNDWATER CONDITIONS

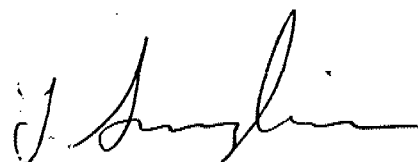
Water levels were measured during the time of investigation in the open boreholes at BH 2, 3, 4, 6 and also by installing standpipes in BH 2, 4, 5 and 7. The stabilized water level in the open boreholes was found to vary between elevation 250.5 and elevation 250 m. However, BH 4 was caved in at an approximate elevation of 241.0 m. The water levels in standpipes located at BH 4 and 7 were found to be at about elevation 245.9 m and 250.5 m respectively. However, the standpipes in BH 2 and 5 did not respond during the time of investigation up to April 10, 1987. In our opinion, for design purposes, the water level is assumed to be at an elevation of 250.5 m.

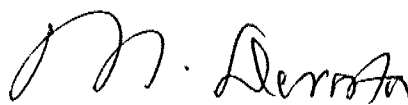
#### MISCELLANEOUS

The fieldwork for this investigation was carried out during the period from 86-12-01 to 86-12-31 under the supervision of M. Devata (Chief Foundations Engineer), M. L. Pauly (Project Foundations Engineer), and J. Petruzzello (Foundations Technician). The equipment used was owned and operated by Atcost Soil Drilling Inc. and Malones Soil Samples of Toronto.

The report was written by M. L. Pauly and reviewed by M. Devata, Chief Foundations Engineer (East).

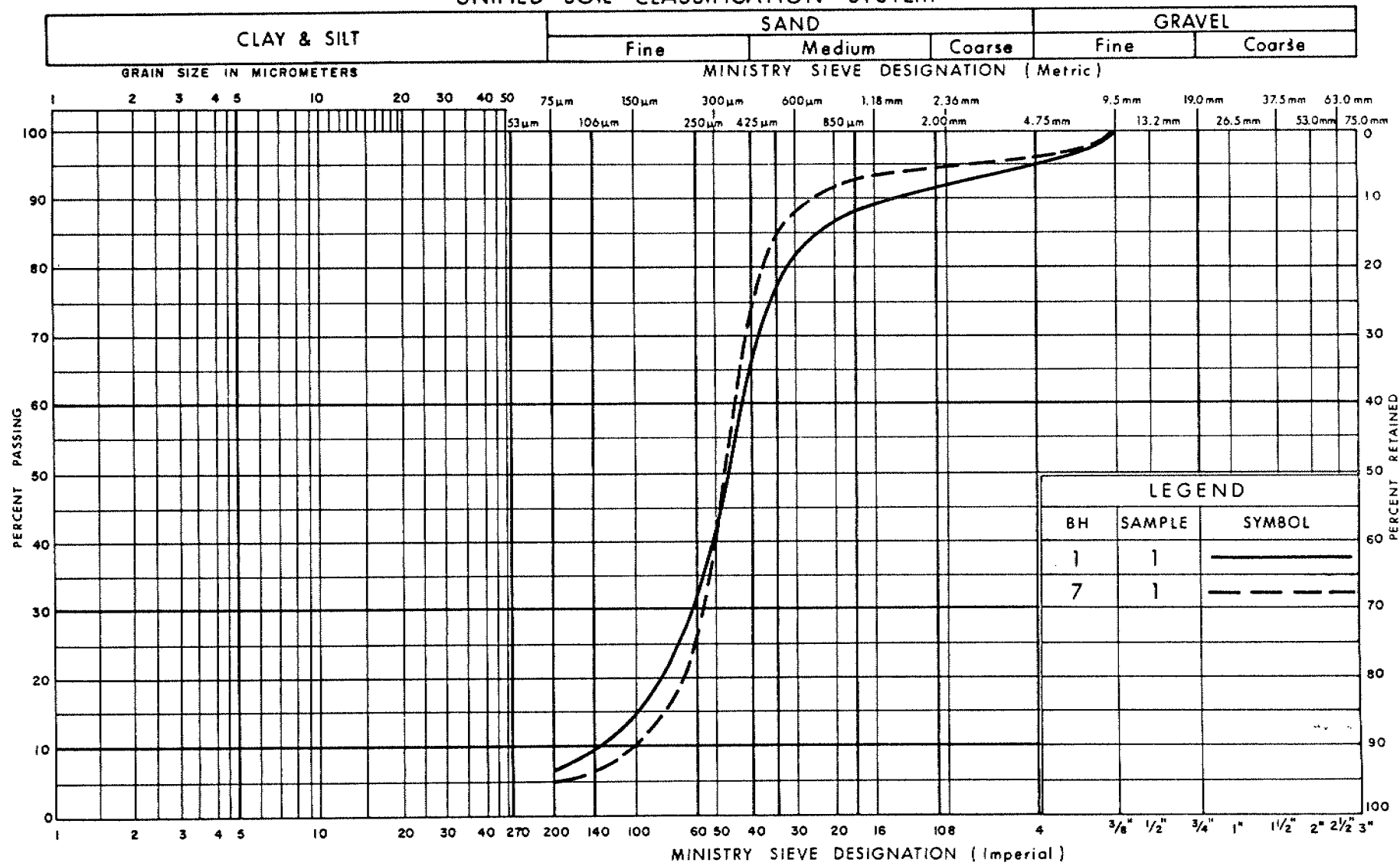


  
T. Sangiuliano, P. Eng.  
Foundation Engineer

  
M. Devata, P. Eng.  
Chief Foundation Engineer

## A P P E N D I X

## UNIFIED SOIL CLASSIFICATION SYSTEM

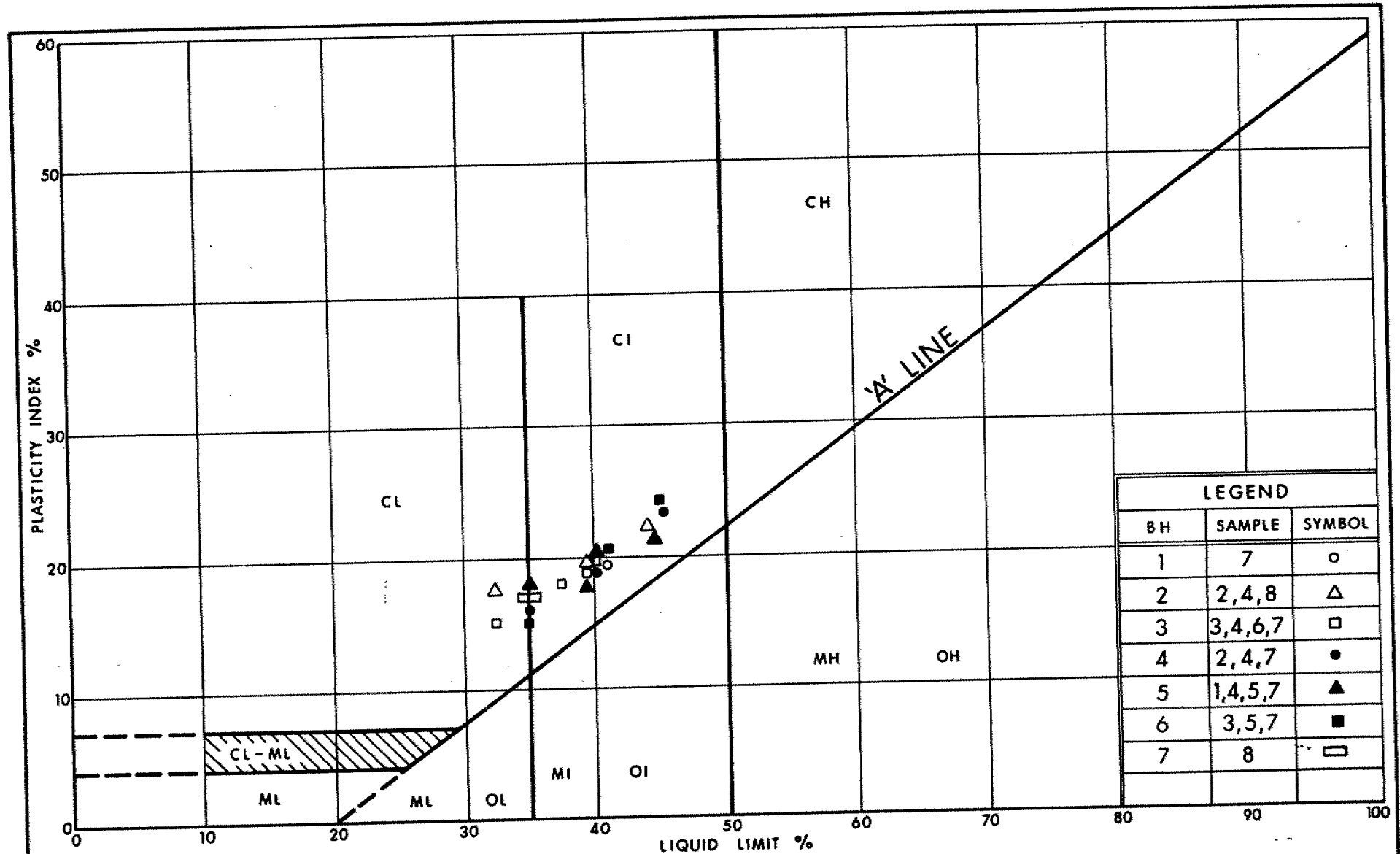


Ministry of  
Transportation and  
Communications

## GRAIN SIZE DISTRIBUTION SAND TRACE OF GRAVEL, SILT (Fill)

FIG No 1

W P 132-79-02



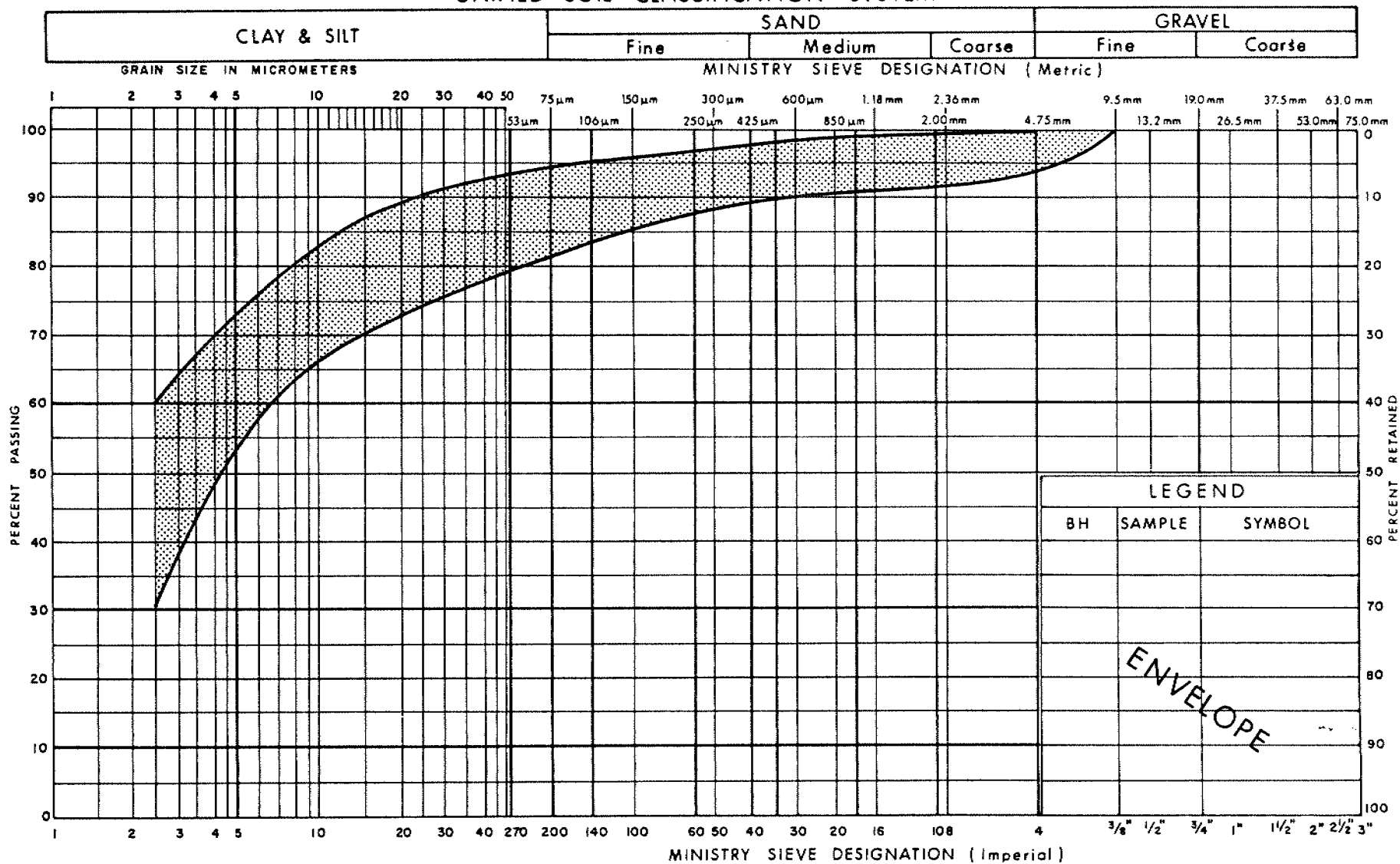
Ministry of  
Transportation and  
Communications

# PLASTICITY CHART SILTY CLAY TRACE OF SAND, GRAVEL

FIG No 2

W P 132-79-02

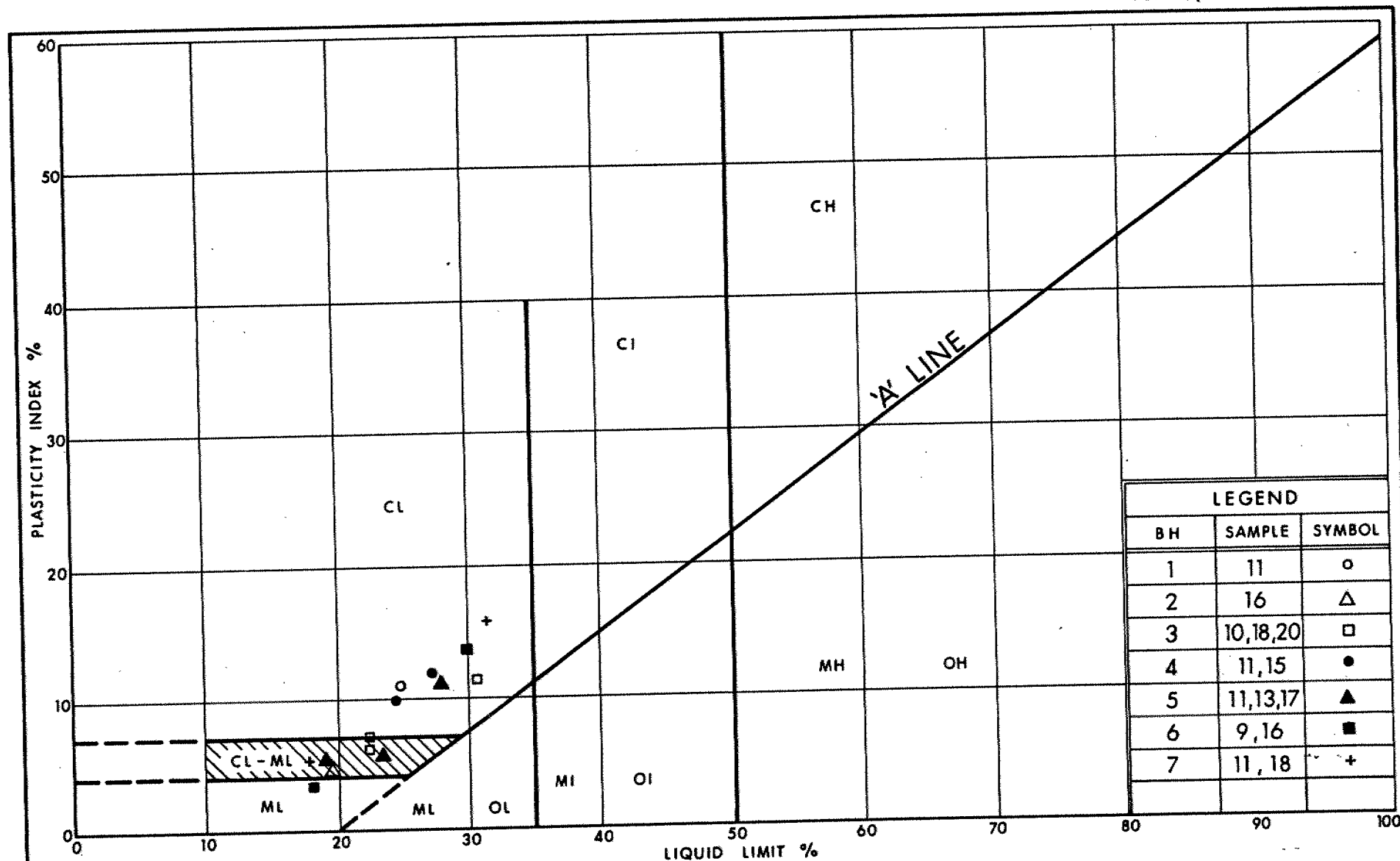
==

Ministry of  
Transportation and  
Communications

GRAIN SIZE DISTRIBUTION  
SILTY CLAY TRACE OF SAND, GRAVEL

FIG No 3

W P 132-79-02



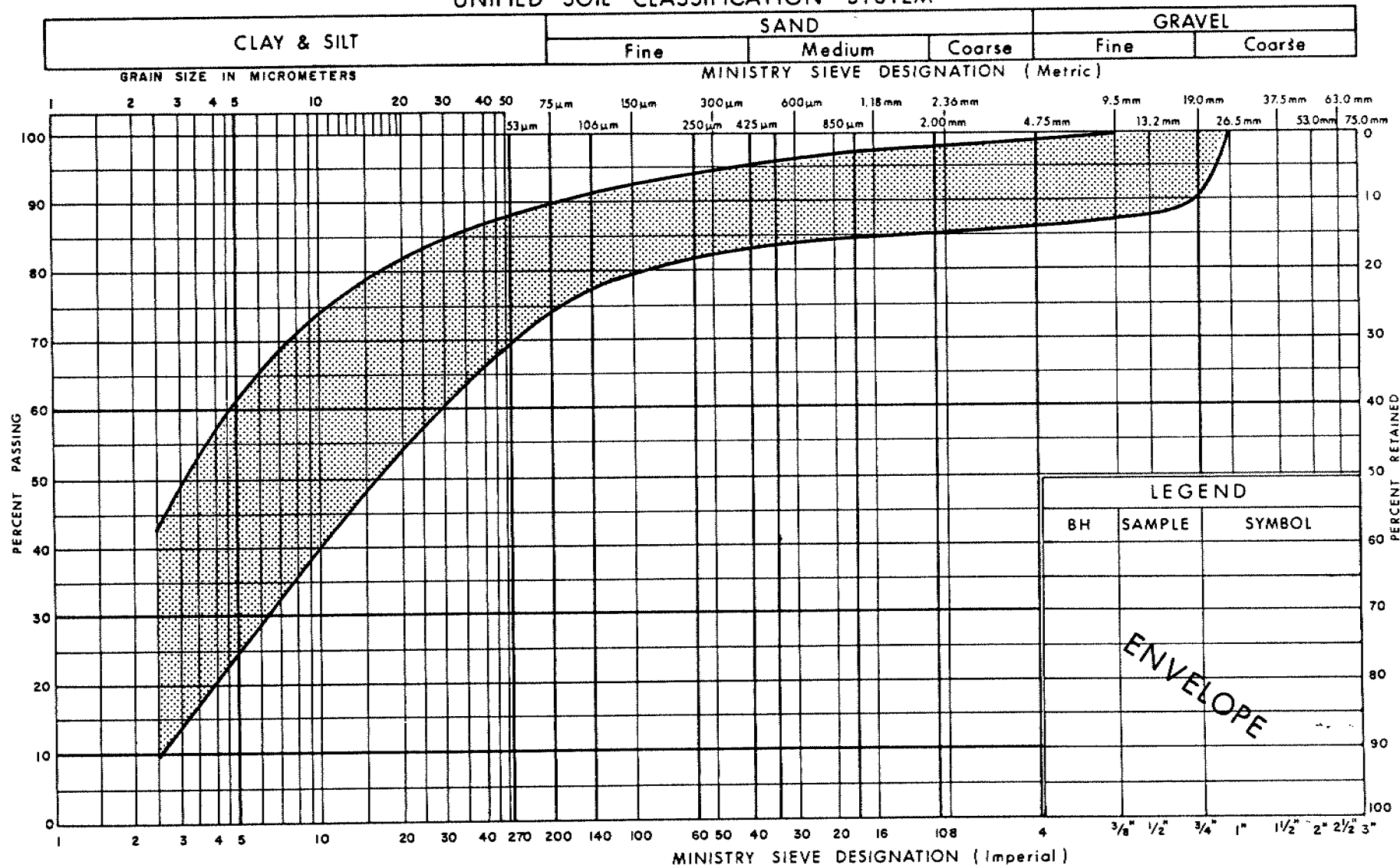
Ministry of  
Transportation and  
Communications

# PLASTICITY CHART HET MIXTURE OF SILTY CLAY, SAND, GRAVEL (Glacial Till)

FIG No 4

W P 132-79-02

## UNIFIED SOIL CLASSIFICATION SYSTEM

Ministry of  
Transportation and  
Communications

GRAIN SIZE DISTRIBUTION  
HET MIXTURE OF  
SILTY CLAY, SAND, GRAVEL (Glacial Till)

FIG No 5

W P 132-79-02



# RECORD OF BOREHOLE No 1

METRIC

W P 132-79-02 LOCATION Co-ords. N 4 858 276.3; E 287 123.2 ORIGINATED BY MLP  
DIST 6 HWY 50 BOREHOLE TYPE Washboring, NX & BX Casing COMPILED BY GP  
DATUM Geodetic DATE 86 12 01 to 86 12 05 CHECKED BY SP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100						
258.9	Ground Surface												
0.0	Sand trace of gravel silt Brown (Fill) Dense		1	SS	35	*							6 86 (8)
255.5			2	SS	26								2 10 58 30
3.4	Silty Clay trace of sand, gravel Brown/Grey (Fill) Stiff to Very Stiff		3	SS	13								
			4	SS	19							21.0	
250.5			5	SS	15								3 31 41 25
8.4			6	SS	10								5 16 52 27
	Silty Clay trace of sand, gravel Grey/Brown Stiff to Hard		7	SS	72								1 7 46 46
			8	SS	94								
			9	SS	40								
			10	SS	50								
239.7													
19.2	Het. Mixture of Silty Clay, Sand, Gravel Grey (Glacial Till) Hard												
237.1			11	SS	55								
21.8	End of Borehole												
	* Water Level Not Established												

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 2

METRIC

W P 132-79-02 LOCATION Co-ords. N 4 858 284.0; E 287 101.4 ORIGINATED BY MLP/GP  
DIST 6 HWY 50 BOREHOLE TYPE Hollow Stem Augers & Cone Test COMPILED BY GP  
DATUM Geodetic DATE 1986 12 03, 04 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	WATER CONTENT (%)						10 20 30
250.4	Ground Surface													GR SA SI CL	
0.0	Silty Clay trace of sand gravel Stiff to Hard		1	SS	18								2 9 32 57		
			2	SS	23										2 6 51 41
			3	SS	32										
			4	SS	34										
			5	SS	22										
			6	SS	18										
			7	SS	16										
			8	SS	13										2 2 38 58
			9	SS	22										
240.3	Het. Mixture of Silty Clay Sand, Gravel Grey (Glacial Till)  Silty Fine Sand  Very Stiff to Hard		10	SS	23										
10.1			11	SS	26										
			12	SS	33										1 23 48 28
			13	SS	40										
			14	SS	119										4 52 38 6
			15	SS	94										
			16	SS	87										7 20 60 13
			17	SS	72										
			18	SS	115										
224.0															
26.4	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 3

METRIC

W P 132-79-02 LOCATION Co-ords. N 4 858 297.1; E 287 095.3 ORIGINATED BY MLP/GP  
 DIST 6 HWY 50 BOREHOLE TYPE Hollow Stem Augers & Cone Test COMPILED BY GP  
 DATUM Geodetic DATE 1986 12 02 and 03 CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100					
250.5	Ground Surface												
0.0	Silty Clay (Topsoil) Dark Brown		1	SS	9	W.T. in 250 open H.H. 87 04 10							
			2	SS	16								
			3	SS	34								2 8 44 46
	Silty Clay trace of sand, gravel Light Brown - Grey		4	SS	28							20.0	4 5 52 39
			5	SS	20								
	Stiff to Hard		6	SS	20								7 7 49 37
			7	SS	10								1 12 70 17
			8	SS	9								
241.7			9	SS	23								
8.8			10	SS	26							21.4	2 16 45 37
	Het. Mixture of Silty Clay, Sand, Gravel Grey (Glacial Till)		11	SS	35								
			12	SS	27								
			13	SS	73								
	Very Stiff to Hard		14	SS	95	15 cm							
		Silty Fine Sand	15	SS	100	20 cm							
			16	SS	120	15 cm							
			17	SS	129								
			18	SS	115								2 16 68 14
			19	SS	100	15 cm							
224.2			20	SS	135	23 cm							0 16 70 14
26.3	End of Borehole												

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 4

METRIC

W P 132-79-02 LOCATION Co-ords. N 4 858 310.2; E 287 081.7 ORIGINATED BY GP  
DIST 6 HWY 50 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY GP  
DATUM Geodetic DATE 1986 12 01 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH		WATER CONTENT (%)				
250.9	Ground Surface							20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>		GR SA SI CL	
0.0	Silty Clay trace of sand gravel  Brown Grey  Stiff to Very Stiff		1	SS	11		250						1 6 52 41	
			2	SS	19		248					46	1 5 53 41	
			3	SS	19									
			4	SS	21									
			5	SS	22									
			6	SS	16									
			7	SS	14								3 7 53 37	
			8	SS	15									
			9	SS	19									
240.8	Het. Mixture of Silty Clay Sand, Gravel (Glacial Till) Grey Hard  Silty Fine Sand  Sandy Silt		10	SS	33		240					2 17 46 35		
10.1			11	SS	33		238							
			12	SS	34		236							
			13	SS	50		234							
			14	SS	132		232					1 18 55 26		
			15	SS	38		230							
			16	SS	120		228					5 35 51 9		
			17	SS	113		226							
			18	SS	86									
			19	SS	153									
			20	SS	94									
224.5	End of Borehole													
26.4														

+3, x5: Numbers refer to Sensitivity 20  
15 5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 5

METRIC

W P 132-79-02 LOCATION Co-ords. N 4 858 331.5; E 287 061.2 ORIGINATED BY GP/NLP  
DIST 6 HWY 50 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY GP  
DATUM Geodetic DATE 1986 12 08 to 12 CHECKED BY GP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH					
251.1	Ground Surface							○ UNCONFINED	+ FIELD VANE					
0.0			1	SS	10		250	● QUICK TRIAXIAL	× LAB VANE	10 20 30				3 12 48 37
			2	SS	37									
			3	SS	34									
			4	SS	27		248						22.1	1 8 52 39
	Brown/ Grey		5	SS	26									2 7 59 32
	Silty Clay		6	SS	15		246							
	trace of sand, gravel		7	SS	12									1 8 50 41
	Stiff to Hard		8	SS	12		244							
			9	SS	12		242							
241.0			10	SS	27		240							
10.1			11	SS	29									5 18 44 33
	Het. Mixture of Silty Clay Sand, Gravel Grey (Glacial Till)		12	SS	43		238							
	Very Stiff to Hard		13	SS	114		236							
	Silty Fine Sand		14	SS	72		234							7 5 83 5
			15	SS	78		232							
			16	SS	84		230							
			17	SS	105		228							3 20 65 12
			18	SS	85		226							
225.5			19	SS	123									
25.6	End of Borehole													

+3, x<sup>5</sup>: Numbers refer to  
Sensitivity

20

15

10

5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 6

METRIC

W P 132-79-02 LOCATION Co-ords. N 4 858 337.9; E 287 048.7 ORIGINATED BY NLP  
 DIST 6 HWY 50 BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY GP  
 DATUM Geodetic DATE 1986 12 05 to 08 CHECKED BY GP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	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	SHEAR STRENGTH					
251.0	Ground Surface													
0.0	With Organic inclusions Firm		1	SS	5	W.L. in Open BH 10	250							
			2	SS	8		248							1 10 50 39
	Silty Clay		3	SS	9									
	trace of sand		4	SS	34									
	gravel		5	SS	29									11 9 47 33
	Stiff		6	SS	24									
	to Hard													
	Brown/Grey		7	SS	12									2 8 48 42
	Grey		8	SS	14									
242.2			9	SS	24									2 13 47 38
8.8														
	Het. Mixture of Silty Clay													
	Sand, Gravel													
	Grey		10	SS	40									
	(Glacial Till)													
	Very Stiff		11	SS	45									
	to Hard													
			12	SS	140	22 cm	234							8 40 46 6
	Silty Fine Sand		13	SS	50									
			14	SS	75									
			15	SS	76									
			16	SS	111									1 23 64 12
			17	SS	120									
224.6			18	SS	105									
26.4	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 7

METRIC

W P 132-79-02 LOCATION Co-ords. N 4 858 360.1; E 287 040.5 ORIGINATED BY GP/NLP  
DIST 6 HWY 50 BOREHOLE TYPE Washboring, NX & BX Casing COMPILED BY GP  
DATUM Geodetic DATE 1986 12 08 to 31 CHECKED BY GP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100				
259.2	Ground Surface															
0.0	Sand, trace of gravel trace of silt Brown (Fill) Compact		1	SS	9		258									5 89 (6)
255.9			2	SS	8		256									
3.3	Silty Clay trace of sand, gravel Brown/Grey (Fill) Stiff to Very Stiff		3	SS	26		254								21.2	4 13 61 22
			4	SS	30		252									
251.3			5	SS	32		250									0 15 55 30
7.9	Silty Clay trace of sand, gravel Hard		6	SS	43		248									2 10 48 40
			7	SS	49		246									
	Brown Grey		8	SS	38		244									1 11 51 37
242.7			9	SS	170	8 cm	242									
16.5	Het. Mixture of Silty Clay Sand, Gravel (Glacial Till) Grey Hard		10	SS	34		240									
			11	SS	73		238									14 9 40 37
			12	SS	100	23 cm	236									
	Silty Fine Sand		13	SS	95		234									
			14	SS	95		232									
			15	SS	150	8 cm	230									
228.3			16	SS	150	8 cm										15 43 32 10
30.9	End of Borehole															

3, x 5: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

FILE COPY



Ministry  
of  
Transportation

---

## **FOUNDATION DESIGN SECTION**

**foundation  
investigation and  
design report**



*CONT 93-52*  
ENGINEERING MATERIALS OFFICE  
FOUNDATION DESIGN SECTION

WP 132-79-02

DIST 6

HWY 50

STR SITE 24-211

CPR Bridge Twinning

DISTRIBUTION

G.C.E. Burkhardt (3)  
R.D. Gunter  
A. Wittenberg  
J. Smrcka (2)  
K. Bassi  
J.H. Peer  
T. Yakutchuk  
G. Szekreny  
B. Steeves (Cover Only)  
M. MacLean (Cover Only)  
File

FOUNDATION INVESTIGATION REPORT  
For  
CPR Bridge Twinning @ Hwy. 50  
WP 132-79-02; Site No. 24-211  
District 6, Toronto

INTRODUCTION

This report summarizes the information obtained from a foundation investigation carried out at the above-mentioned site between 86 12 01 to 86 12 31. The field work consisted of seven sampled boreholes (BH 1 to BH 7).

BH 1 and 7 were advanced through the embankments, at the north and south approaches to the existing structure, and into the original ground, using a wash boring technique with NX and BX size casings. The depth of the boreholes were 21.8 and 30.9 m respectively.

The remaining boreholes (BH 2 to BH 6) were advanced by means of a continuous flight auger machine equipped with 83 mm I.D. hollow stem augers. Dynamic cone penetration tests accompanied these boreholes. The depth of these boreholes ranged between 25.6 m and 26.4 m below ground level.

SITE DESCRIPTION AND GEOLOGY

This site is located on Hwy. 50 at the CPR crossing, approximately 2.5 km south of Bolton. At present, there is a two lane eight span structure at the site, with embankments in the order of 8.4 m. This site is located in the Town of Caledon, Regional Municipality of Peel.

The land use in this area is predominantly industrial and agricultural. At the site, there is an industrial development to the west of the existing structure. Hardwick Rd. runs north to south along the west side of the site, providing access to the buildings. To the east of the existing structure, there is a farm with a farmhouse at the north end, and an industrial building at the south end.

The site is located in the physiographic region known as the "South Slope" as described by The Physiography of Southern Ontario (Chapman and Putnam, 1984). The deposit characterizing this area consists of glacial till underlain by shale bedrock of the Georgian Bay Formation. The surface in this

region is a ground moraine of limited relief. Specifically, the site under investigation, is fairly level with visible hills in the surrounding area.

The area is drained by the Humber River. At the site, there is a drainage ditch running north to south that follows Hardwick Rd. along the west side of the site. This ditch drains the runoff south of the CPR tracks. To the north of the CPR tracks, there is a low area between the toe of the north approach fill and the tracks. This area is marshy and in some places, ponded water could be found to a depth of 50 to 100 mm. In the drainage ditch, during time of the investigation, the water was flowing and ranged in depth from 50 to 75 mm.

The existing two-lane reinforced concrete overpass is in good condition. The north and south approach fill in this area consists of two types of material. The slopes are covered with vegetation, and show some signs of minor surficial erosion.

#### SUBSURFACE CONDITIONS

##### General

The stratigraphy across the site is uniform beginning with a thin veneer of topsoil up to 50 mm thick. Underlying this thin layer of topsoil, is the predominant material across the site; a silty clay mainly of intermediate plasticity. This deposit is approximately 10 m thick and was encountered at or just below the original ground level. This deposit is underlain by a glacial till deposit consisting of a heterogeneous mixture of silty clay, sand and gravel. A 1 to 1.5 m seam of non-cohesive silty fine sand was encountered at a depth of approximately 17 m below ground level, in the glacial till stratum. The full extent of the glacial till deposit was not investigated, but was found to extend to a maximum depth of 26.4 m below ground level. Bedrock was not proven in any of the boreholes.

The embankments at the north and south approaches to the existing structure consist of a non-cohesive granular material in the upper portion, followed by a cohesive material of silty clay containing pockets of silty sand. The maximum height of the approaches in this area was found to be approximately 8.4 m.

The boundaries of the subsoil types, insitu and laboratory test results, as well as groundwater levels, are shown on the Record of Borehole Sheets in the Appendix. The location of each borehole is shown in plan on Dwg. No. 1327902-A together with a stratigraphical section.

The following is a detailed description of the soils encountered at the site.

#### Topsoil

The site is covered by a thin veneer of topsoil generally in the order of 50 mm thick. The thickness varies across the site.

The original topsoil layer was encountered at an elevation of 251.3 m in BH 7, after the borehole had been advanced through 7.9 m of fill at the north approach embankment.

#### Fill Material

The north and south approach fills at the existing structure are approximately 8.4 m in height.

The upper 3.3 m of the north and south approach fills consists of a granular material. At the north approach this material is a sand with a trace of gravel and fines. The 'N' value is 9 indicating the material is in a compact state. However, at the south approach, this material is a sand with a trace of fines. The 'N' value is 35 for this material indicating it is in a dense state. Grain size distributions for both these materials can be found in the Appendix (Figure 1).

In both fill areas, this sand layer is followed by a layer of silty clay with pockets of silty sand. This material is found from a depth of 3.3 m below the top of the fill area to a depth of 8.4 m (or the original ground level).

Atterberg Limits tests and grain size distribution tests were performed on samples of this material. And the results are summarized below.

		<u>% RANGE</u>			<u>% RANGE</u>
Moisture Content	W	14 - 18	Gravel	0	- 4.5
Liquid Limit	W <sub>L</sub>	29.5 - 32.5	Sand	10	- 31.5
Plastic Limit	W <sub>p</sub>	15.5 - 17.5	Silt	40.5	- 61.5
Plasticity Index,	I <sub>p</sub>	14 - 16.5	Clay	21.5	- 30.5

Based on these results, this material can be described as a silty clay of low plasticity (CL-group) some sand trace gravel.

Standard Penetration Test values range from 8 to 26 in the silty clay fill material, indicating the fill has a stiff to very stiff consistency. The 'N' values, ranging from 26 to 30 blows/0.3 m in the sand pockets, indicate that they are in a dense state of compaction.

#### Silty Clay

The silty clay deposit is the predominant natural deposit and was observed in all the boreholes across the site, at or just below the original ground level. The thickness of this deposit ranges from 8.6 to 10.8 m below existing ground surface. In BH 1 and 7, this material was encountered immediately below the fill material of the embankments. The upper 2.5 to 6.0 m is somewhat oxidized and brown in colour, and below that, the material is essentially grey.

Atterberg Limits tests were conducted on this material and Figure 2 in the Appendix shows the results plotted on a Plasticity Chart. The results of the Limits Tests are summarized as follows:

		<u>AVERAGE %</u>	<u>% RANGE</u>
Moisture Content	W	19.5	16 - 24
Liquid Limit	W <sub>L</sub>	39.5	32.5 - 46
Plastic Limit	W <sub>p</sub>	20.1	17 - 23
Plasticity Index,	I <sub>p</sub>	19.4	15.5 - 24

Grain size distribution tests were conducted, and Figure 3 in the Appendix illustrates the results in envelope form, on a grain size distribution plot. The results are summarized as follows:

	<u>RANGE %</u>
Gravel	0.5 - 11
Sand	0.5 - 16
Silt	32.5 - 69.5
Clay	17.5 - 57.5

This deposit can be described as a silty clay of low to intermediate plasticity (CL-CI group) with a trace of sand and gravel.

The Standard Penetration 'N' values range from 5 to 94 throughout this layer, indicating it has a firm to hard consistency.

Glacial Till - Heterogeneous Mixture of Silty Clay, Sand and Gravel

The silty clay deposit is underlain by a grey glacial till deposit of a heterogeneous mixture of all grain sizes. The material was encountered in all boreholes, at a depth ranging from 8.6 to 10.8 m below the ground level. Within the glacial till stratum, a granular layer up to 1.5 m thick was observed in all the boreholes, except BH 1, at a depth ranging from 16 to 17.2 m below the ground level. The full extent of the glacial till deposit was not investigated.

Atterberg Limits tests were performed on this material, and the results are plotted on Figure 4 in the Appendix, and summarized below.

		<u>AVERAGE %</u>	<u>% RANGE</u>
Moisture Content	W	12.0	9 - 19
Liquid Limit	W <sub>L</sub>	24.1	17.5 - 31.5
Plastic Limit	W <sub>p</sub>	15.3	12.5 - 19.5
Plasticity Index,	I <sub>p</sub>	8.8	3.5 - 16

Grain size distribution tests were also carried out on this material. Figure 5 in the Appendix shows the results, in envelope form, on a grain size distribution plot. The results are summarized as follows:

	<u>RANGE %</u>
Gravel	0 - 14.5
Sand	8 - 23
Silt	40 - 70.5
Clay	12 - 38

With depth, the content of silt increases while the clay decreases.

As mentioned previously, a silty fine sand seam was encountered in the glacial till stratum. The 'N' values within the granular zone were in excess of 120 blows/0.3 m indicating the zones are very densely packed.

In the glacial till stratum, the SPT 'N' values ranged from 23 blows/0.3 m to 153 blows/0.3 m, indicating a consistency described as very stiff to hard.

#### GROUNDWATER CONDITIONS

Water levels were measured during the time of investigation in the open boreholes at BH 2, 3, 4, 6 and also by installing standpipes in BH 2, 4, 5 and 7. The stabilized water level in the open boreholes was found to vary between elevation 250.5 and elevation 250 m. However, BH 4 was caved in at an approximate elevation of 241.0 m. The water levels in standpipes located at BH 4 and 7 were found to be at about elevation 245.9 m and 250.5 m respectively. However, the standpipes in BH 2 and 5 did not respond during the time of investigation up to April 10, 1987. In our opinion, for design purposes, the water level is assumed to be at an elevation of 250.5 m.

#### DISCUSSION AND RECOMMENDATIONS

It is proposed to twin the existing structure, providing two lanes northbound and two lanes southbound, to facilitate the increasing volume of traffic on Hwy. 50. The proposed 5 span (16-21-28-21-16) bridge will be 11.2 m wide and will consist of 4 piers and 2 abutments.

The approach fills for the new structure will be similar to the existing approach fills and will be approximately 9 m above the original ground level.

The soil conditions at this location are consistent across the site. Underneath a thin layer of topsoil, a stiff to hard silty clay of mainly intermediate plasticity is encountered. Below this deposit is a glacial till of silty clay, sand and gravel. Within this glacial till layer is a seam of silty fine sand located approximately 16 to 17.2 m below the original ground level.

The natural groundwater table is believed to be at an elevation of 250.5 m. The static head in several boreholes was just below ground level after drilling was completed.

The following are our foundation recommendations for the design and construction of the structure and the approach fills from approximately Sta. 12+830 to Sta. 12+950 on Hwy. 50.

#### APPROACHES

The approach fills, located at Sta. 12+830 and Sta. 12+950 on Hwy. 50, will have a height of approximately 8.4 m above the original ground level.

Subsurface conditions are competent, and no stability problems are anticipated provided the approaches are constructed with a 2:1 slope. The new slopes should be keyed into the existing slope and compacted in accordance with MTC standards.

Since the existing fills will be widened to accommodate the construction of the new structure, some differential settlement can be expected. The new fill will settle, according to its own weight, approximately 0.75% of the total fill height for a fill between 7 and 10 m high, and 0.5% of its total fill height for a fill up to 7 m high. However, no major settlements are expected in the underlying soil.



## STRUCTURE FOUNDATIONS

### Piers

The piers should be located at an approximate elevation of 249 metres on spread footings. The following table gives the details for the design of the spread footings.

<u>Structural Element</u>	<u>Reference Borehole</u>	<u>Factored Bearing Capacity @ U.L.S.</u>	<u>Bearing Capacity @ S.L.S. II</u>
Pier #1	3	500 kPa	250 kPa
2	4	500	250
3	5	600	300
4	6	600	300

In the vicinity of pier #4 (Sta. 12+930 metres), there is a localized weak material down to an elevation of 248 metres. This material should be sub-excavated and well compacted with Granular 'A', or mass concrete so that this footing can be located at the same elevation.

### Abutments

The abutments can be founded on end bearing piles driven into the hard glacial till stratum. This alternative can also be used for the piers. For example, 310x110 steel H piles should be driven to an approximate tip elevation of 225 metres. The following table gives the details for the design of the abutment foundations.

<u>Structural Element</u>	<u>Reference Borehole</u>	<u>Factored Bearing Capacity @ U.L.S.</u>	<u>Bearing Capacity @ S.L.S. II</u>
S. Abutment	2	1650 kN	1050 kN
N. Abutment	7	1650	1050

Pile driving should be controlled as per MTC current standards. If the design capacity is achieved at a depth higher than specified the Foundation Design Section should be contacted to provide specific recommendations.

The abutments should be perched within the fill, as per MTC standards. The material used to construct the approach fills should be restricted to a maximum particle size of 75 mm to facilitate pile driving.

### Earth Pressures

Backfill to structures should consist of granular material in accordance with MTC Standard Special Provision #121 (83-10). For design purposes, the following physical properties can be assumed for backfill:

<u>Material</u>	<u><math>\phi</math></u>	<u><math>\gamma</math></u>
Granular 'A'	35°	22.0 kN/m <sup>3</sup>
Granular 'B'	30°	21.2 kN/m <sup>3</sup>

Computation of earth pressures should be in accordance with Section 6-6.1.2 of the O.H.B.D.C.

### Sliding Resistance

The adhesive value between the rough concrete and the cohesive foundation soil may be assumed to be 100 kPa in computing sliding at the bearing surface. Since sliding resistance is computed at U.L.S., the factored cohesion should be computed from the above mentioned value. With regard to detailed calculations, please refer to article C6-7.3.3.2 of the O.H.B.D.C.

### GENERAL CONSIDERATIONS

Since excavation will be carried out below the prevailing groundwater level in cohesive material, no major dewatering problems are anticipated. However, any minor seepage or surface runoffs into the excavation can be handled by ordinary sump pump methods.

To prevent softening of the foundation base due to surface runoff, it is desirable to place a thin granular mat or working slab to protect the foundation base.

A roadway protection scheme may be necessary for the construction of the south and north abutments as well as Pier No. 4. In order to design a temporary retaining structure scheme, pertinent soil parameters should be obtained from this office once the details of the scheme are chosen.

Some measures may also be required for the construction of Piers #2 and #3 in view of the close proximity of the CP tracks.

MISCELLANEOUS

The fieldwork for this investigation was carried out during the period from 86-12-01 to 86-12-31 under the supervision of M. Devata (Chief Foundations Engineer), M. L. Pauly (Project Foundations Engineer), and J. Petruzzello (Foundations Technician). The equipment used was owned and operated by Atcost Soil Drilling Inc. and Malones Soil Samples of Toronto.

The report was written by M. L. Pauly and reviewed by M. Devata, Chief Foundations Engineer (East).

*Mary Lou Pauly*

Mary Lou Pauly  
Project Foundations Engineer

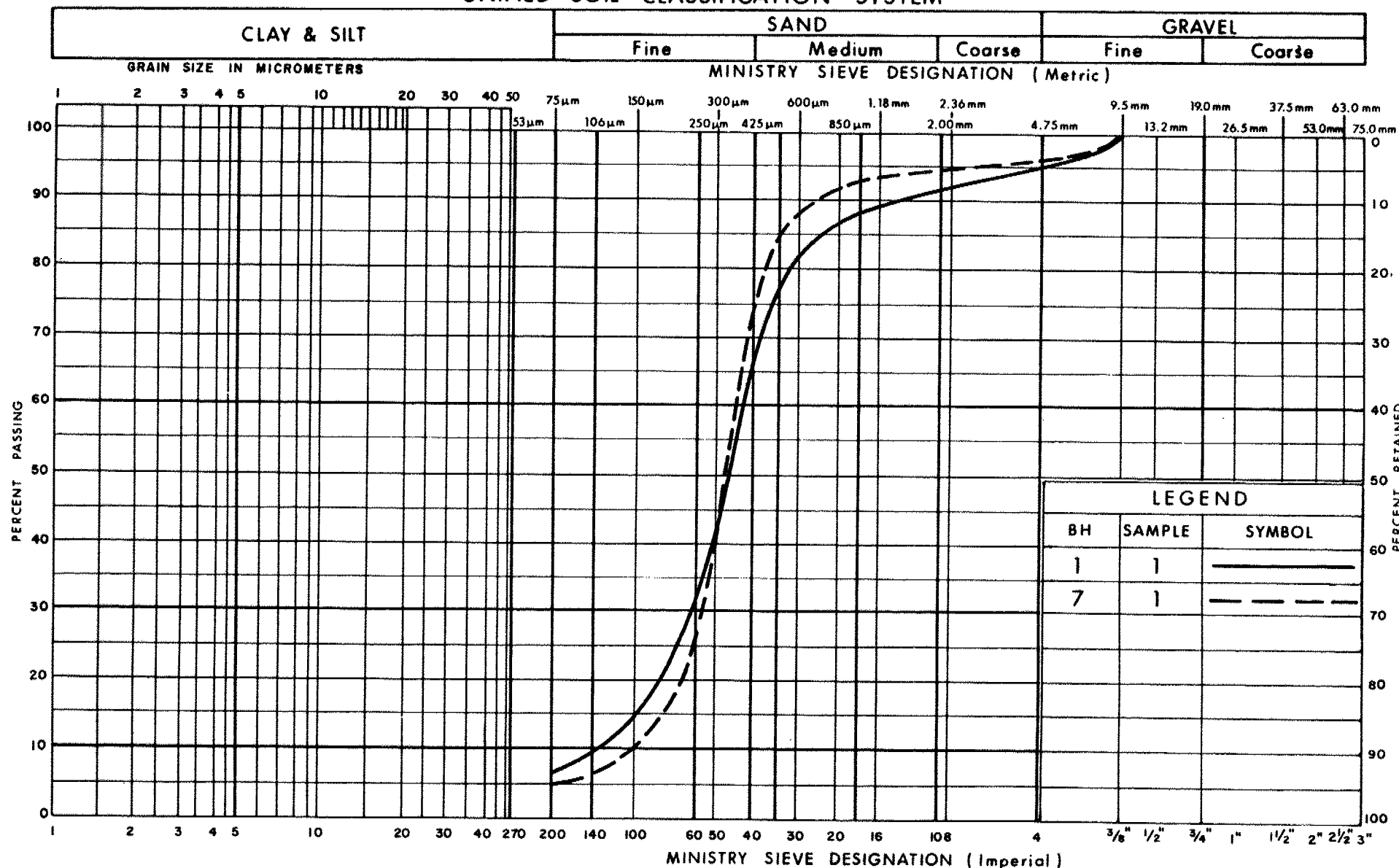


*M. Devata*

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

A P P E N D I X

## UNIFIED SOIL CLASSIFICATION SYSTEM

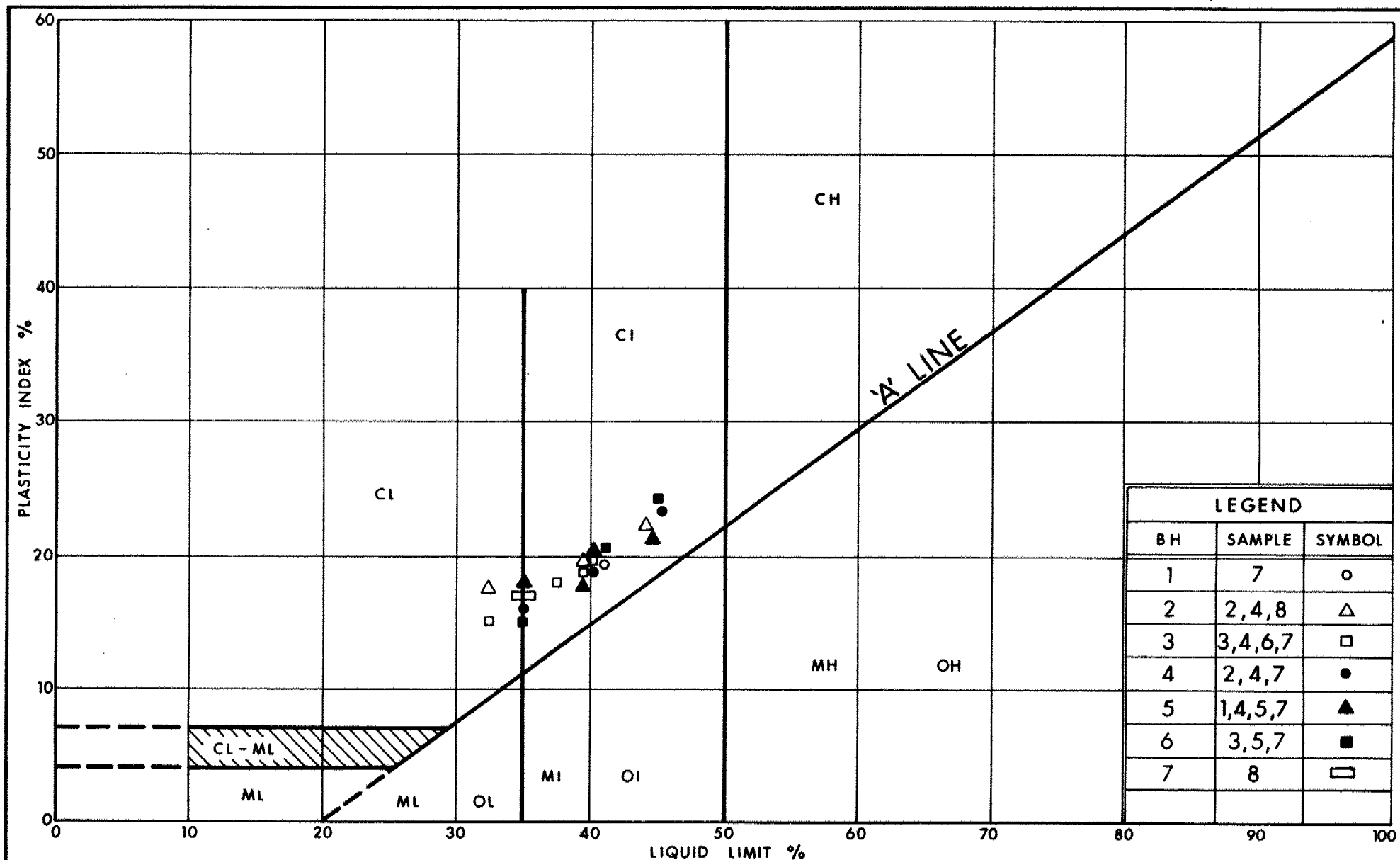


Ministry of  
Transportation and  
Communications

**GRAIN SIZE DISTRIBUTION**  
**SAND TRACE OF GRAVEL, SILT (Fill)**

FIG No 1

W P 132-79-02



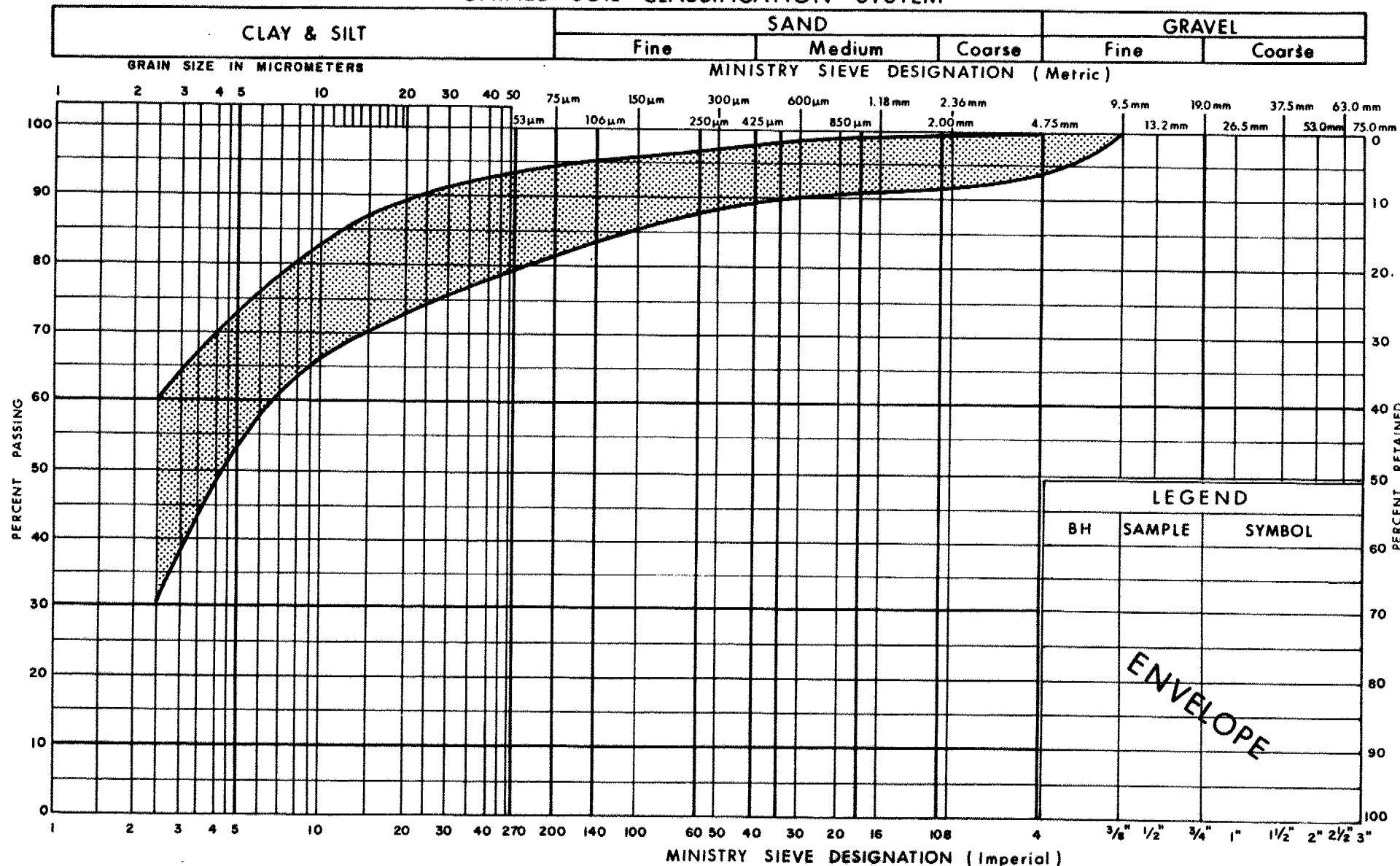
Ministry of  
Transportation and  
Communications

# PLASTICITY CHART SILTY CLAY TRACE OF SAND, GRAVEL

FIG No 2

W P 132 - 79 - 02

# UNIFIED SOIL CLASSIFICATION SYSTEM

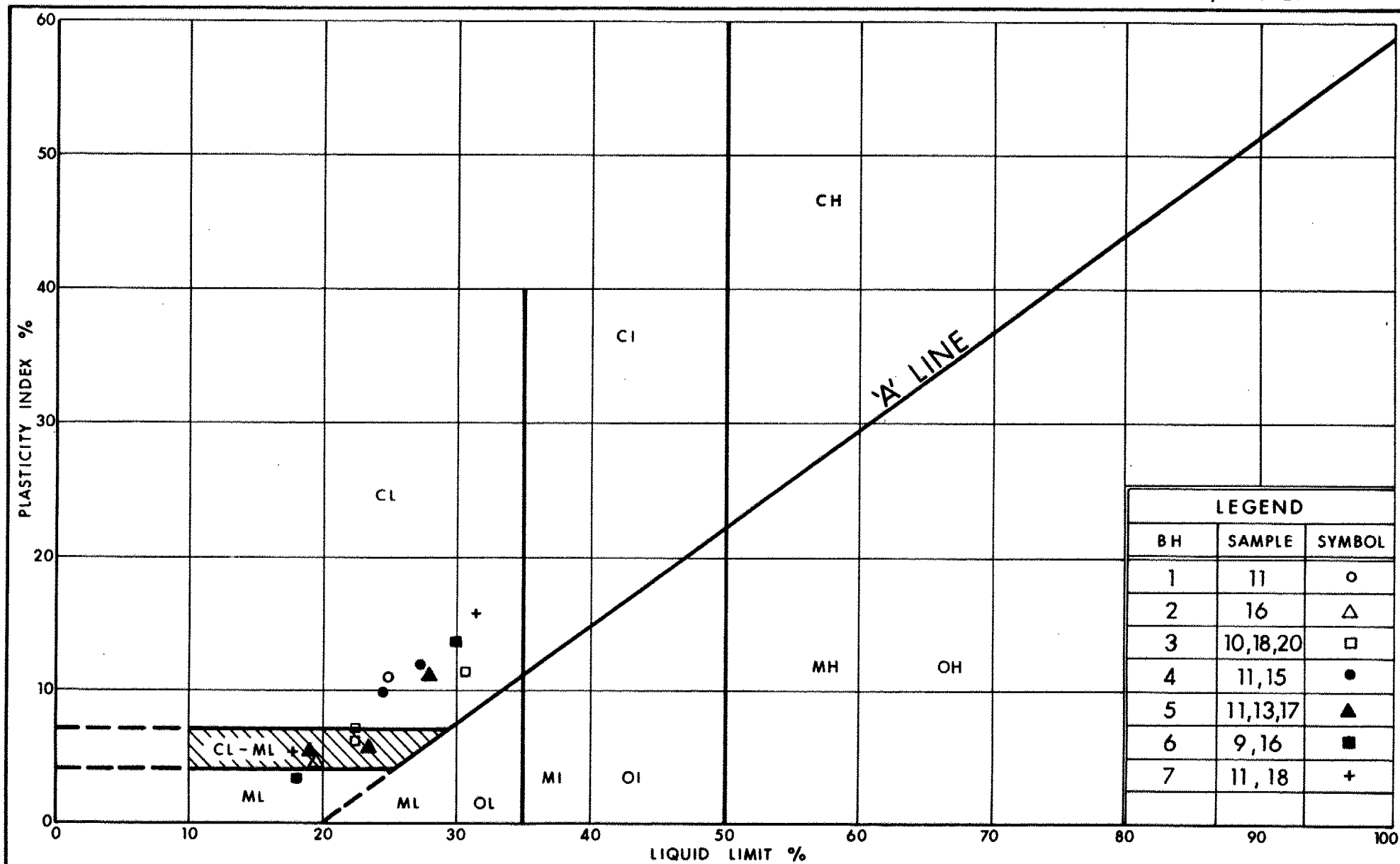


**Ministry of  
Transportation and  
Communications**

GRAIN SIZE DISTRIBUTION  
SILTY CLAY TRACE OF SAND, GRAVEL

FIG No 3

W P 132-79-02



Ministry of  
Transportation and  
Communications

# PLASTICITY CHART HET MIXTURE OF SILTY CLAY, SAND, GRAVEL (Glacial Till)

FIG No 4

W P 132-79-02





**GRAIN SIZE DISTRIBUTION**  
**HET MIXTURE OF**  
**SILTY CLAY, SAND, GRAVEL (Glacial Till)**

W P 132-79-02

## EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	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
$\alpha$	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
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_t$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

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



# RECORD OF BOREHOLE No 1

METRIC

W P 132-79-02 LOCATION Co-ords. N 4 858 276.3; E 287 123.2  
DIST 6 HWY 50 BOREHOLE TYPE Washboring, NX & BX Casing  
DATUM Geodetic DATE 86 12 01 to 86 12 05

ORIGINATED BY MLP  
COMPILED BY GP  
CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
								SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						
							W <sub>p</sub> — W — W <sub>L</sub>			WATER CONTENT (%) 10 20 30				
258.9 0.0	Ground Surface													
	Sand trace of gravel silt Brown (Fill) Dense		1	SS	35	*	258					6 86 (8)		
255.5 3.4			2	SS	26		256					2 10 58 30		
	Silty Clay trace of sand, gravel Brown/Grey (Fill) Stiff to Very Stiff		3	SS	13		254							
			4	SS	19		252					21.0		
250.5 8.4			5	SS	15		250					3 31 41 25		
			6	SS	10		248					5 16 52 27		
			7	SS	72		246					1 7 46 46		
	Silty Clay trace of sand, gravel Grey/Brown  Stiff to Hard		8	SS	94		244							
			9	SS	40		242							
			10	SS	50		240							
239.7 19.2	Het. Mixture of Silty Clay, Sand, Gravel Grey (Glacial Till) Hard		11	SS	55		238							
237.1 21.8	End of Borehole													
	* Water Level Not Established													

+<sup>3</sup>, x<sup>5</sup>: Numbers refer to 20  
Sensitivity 15  $\pm$  5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 2

METRIC

W P 132-79-02 LOCATION Co-ords. N 4 858 284.0; E 287 101.4  
DIST 6 HWY 50 BOREHOLE TYPE Hollow Stem Augers & Cone Test  
DATUM Geodetic DATE 1986 12 03, 04  
ORIGINATED BY MRP/GP  
COMPILED BY GP  
CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	WATER CONTENT (%)					
250.4 0.0	Ground Surface													GR SA SI CL
			1	SS	18		250							
			2	SS	23		248							2 9 32 57
			3	SS	32									
			4	SS	34									2 6 51 41
			5	SS	22									
			6	SS	18									
			7	SS	16									
			8	SS	13									2 2 38 58
			9	SS	22									
240.3 10.1			10	SS	23		240							
			11	SS	26									
			12	SS	33									1 23 48 28
			13	SS	40									
			14	SS	119									4 52 38 6
			15	SS	94									
			16	SS	87									7 20 60 13
			17	SS	72									
224.0 26.4			18	SS	115									
	End of Borehole													

+3, x<sup>5</sup>: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION



# RECORD OF BOREHOLE No 3

METRIC

W P 132-79-02 LOCATION Co-ords. N 4 858 297.1; E 287 095.3 ORIGINATED BY MLP/GP  
DIST 6 HWY 50 BOREHOLE TYPE Hollow Stem Augers & Cone Test COMPILED BY GP  
DATUM Geodetic DATE 1986 12 02 and 03 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	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						
250.5	Ground Surface														
0.0	Silty Clay (Topsoil) Dark Brown		1	SS	9										
			2	SS	16										
			3	SS	34										
	Silty Clay		4	SS	28										
	trace of sand, gravel		5	SS	20										
	Light Brown - Grey		6	SS	20										
	Stiff to Hard		7	SS	10										
			8	SS	9										
241.7			9	SS	23										
8.8			10	SS	26										
	Het. Mixture of Silty Clay, Sand, Gravel		11	SS	35										
	Grey		12	SS	27										
	(Glacial Till)		13	SS	73										
	Very Stiff to Hard		14	SS	95	15 cm									
	Silty Fine Sand		15	SS	100	20 cm									
			16	SS	120	15 cm									
			17	SS	129										
			18	SS	115										
			19	SS	100	15 cm									
224.2			20	SS	135	23 cm									
26.3	End of Borehole														

+<sup>3</sup>, x<sup>5</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION



# RECORD OF BOREHOLE No 4

METRIC

W P 132-79-02 LOCATION Co-ords. N 4 858 310.2; E 287 081.7 ORIGINATED BY GP  
DIST 6 HWY 50 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY GP  
DATUM Geodetic DATE 1986 12 01 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
250.9	Ground Surface													
0.0			1	SS	11		250							
			2	SS	19		248							
			3	SS	19		246							
			4	SS	21		244							
			5	SS	22		242							
			6	SS	16		240							
			7	SS	14		238							
			8	SS	15		236							
			9	SS	19		234							
240.8			10	SS	33		232							
10.1			11	SS	33		230							
			12	SS	34		228							
			13	SS	50		226							
			14	SS	132		224							
			15	SS	38		222							
			16	SS	120	15 cm	220							
			17	SS	113		218							
			18	SS	86		216							
			19	SS	153		214							
224.5			20	SS	94		212							
26.4	End of Borehole													

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10



# RECORD OF BOREHOLE No 5

METRIC

W P 132-79-02

LOCATION Co-ords. N 4 858 331.5; E 287 061.2

ORIGINATED BY GP/MLP

DIST 6 HWY 50

BOREHOLE TYPE Hollow Stem Auger and Cone Test

COMPILED BY GP

DATUM Geodetic

DATE 1986 12 08 to 12

CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100		W <sub>p</sub>	W	W <sub>L</sub>		
251.1	Ground Surface												
0.0			1	SS	10								
			2	SS	37								
			3	SS	34								
			4	SS	27								
	Brown/ Grey		5	SS	26								
	Silty Clay		6	SS	15								
	trace of sand, gravel		7	SS	12								
	Stiff to Hard		8	SS	12								
			9	SS	12								
241.0			10	SS	27								
10.1			11	SS	29								
	Het. Mixture of Silty Clay Sand, Gravel Grey (Glacial Till)		12	SS	43								
	Very Stiff to Hard		13	SS	114								
	Silty Fine Sand		14	SS	72								
			15	SS	78								
			16	SS	84								
			17	SS	105								
			18	SS	85								
225.5			19	SS	123								
25.6	End of Borehole												

+<sup>3</sup>, x<sup>5</sup>: Numbers refer to  
Sensitivity

20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10



# RECORD OF BOREHOLE No 6

METRIC

W P 132-79-02 LOCATION Co-ords. N 4 858 337.9; E 287 048.7  
DIST 6 HWY 50 BOREHOLE TYPE Hollow Stem Auger & Cone Test  
DATUM Geodetic DATE 1986 12 05 to 08

ORIGINATED BY MLP

COMPILED BY GP

CHECKED BY GP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH					
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	WATER CONTENT (%) 10 20 30						
251.0	Ground Surface												
0.0	With Organic inclusions Firm	1	SS	5									
		2	SS	8									
	Silty Clay trace of sand gravel	3	SS	9									
		4	SS	34									
	Stiff to Hard	5	SS	29									
		6	SS	24									
	Brown/Grey Grey	7	SS	12									
		8	SS	14									
242.2		9	SS	24									
8.8		10	SS	40									
	Het. Mixture of Silty Clay Sand, Gravel Grey (Glacial Till) Very Stiff to Hard	11	SS	45									
		12	SS	140	22 cm								
	Silty Fine Sand	13	SS	50									
		14	SS	75									
		15	SS	76									
		16	SS	111									
		17	SS	120									
224.6		18	SS	105									
26.4	End of Borehole												

+<sup>3</sup>, x<sup>5</sup>: Numbers refer to Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE





# RECORD OF BOREHOLE No 7

METRIC

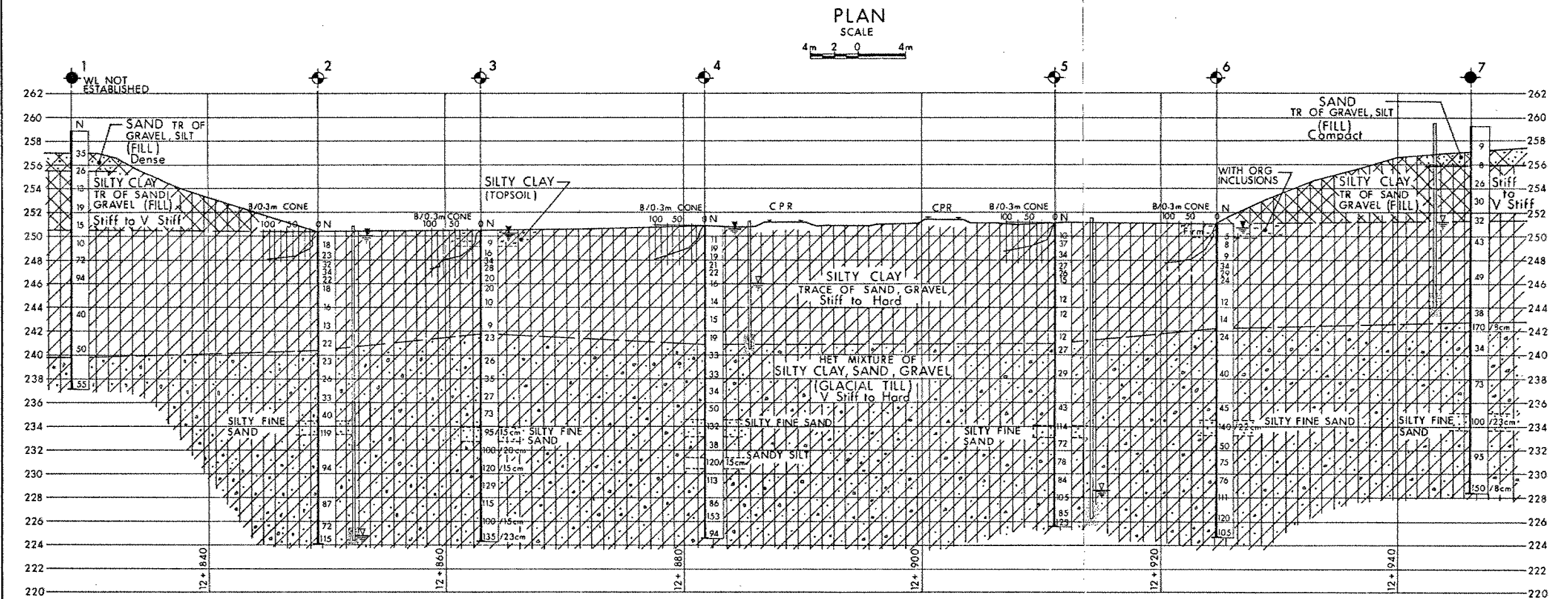
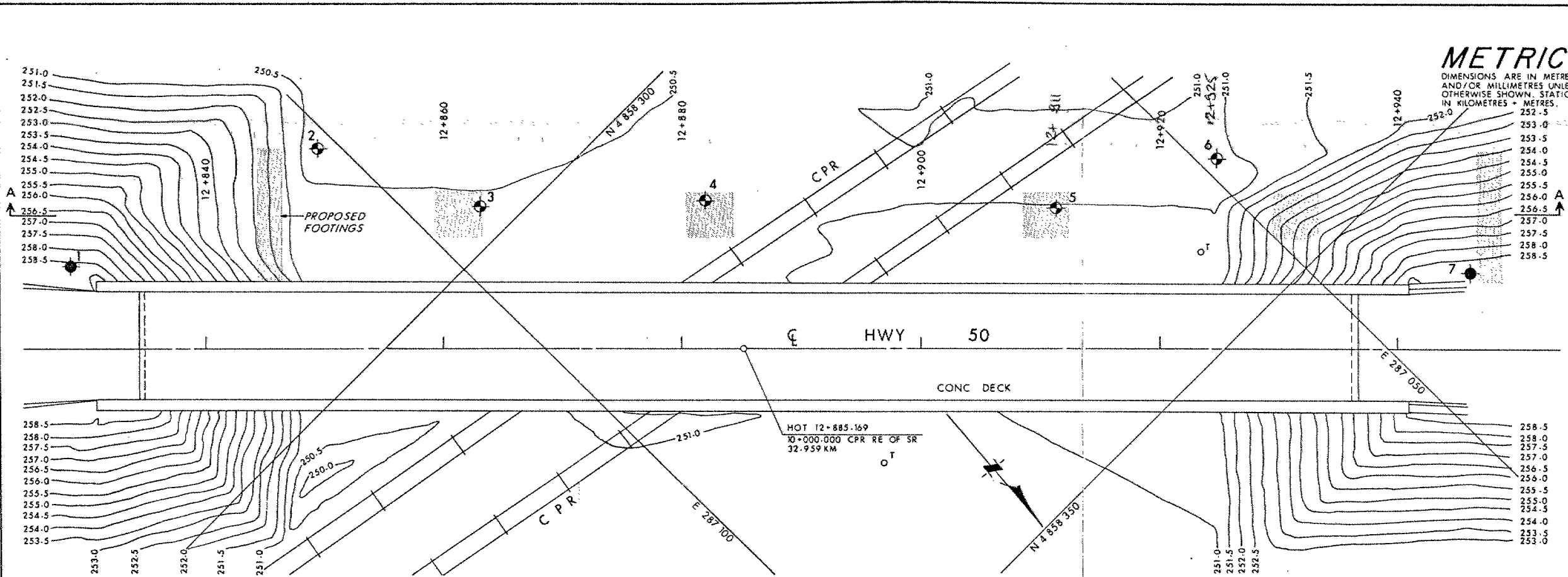
W.P. 132-79-02 LOCATION Co-ords. N 4 858 360.1; E 287 040.5  
DIST 6 HWY 50 BOREHOLE TYPE Washboring, NX & BX Casing  
DATUM Geodetic DATE 1986 12 08 to 31  
ORIGINATED BY GP/MLP  
COMPILED BY GP  
CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
								SHEAR STRENGTH						
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE	WATER CONTENT (%)				
259.2	Ground Surface									10	20	30		
0.0	Sand, trace of gravel trace of silt Brown (Fill) Compact		1	SS	9		258							5 89 (6)
255.9			2	SS	8		256							
3.3	Silty Clay trace of sand, gravel Brown/Grey (Fill) Stiff to Very Stiff		3	SS	26		254						21.2	4 13 61 22
			4	SS	30		252							
251.3			5	SS	32		250							0 15 55 30
7.9	Silty Clay trace of sand, gravel Hard		6	SS	43		248							2 10 48 40
			7	SS	49		246							
	Brown Grey		8	SS	38		244							1 11 51 37
242.7			9	SS	170	8 cm	242							
16.5	Het. Mixture of Silty Clay Sand, Gravel (Glacial Till) Grey Hard		10	SS	34		240							
			11	SS	73		238						14	9 40 37
			12	SS	100	23 cm	236							
	Silty Fine Sand		13	SS	95		234							
			14	SS	95		232							
228.3			15	SS	150	8 cm	230							
30.9	End of Borehole		16	SS	150	8 cm								15 43 32 10

+<sup>3</sup>, x<sup>5</sup>: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION



SECTION A-A

SCALE  
4m 2 0 4m

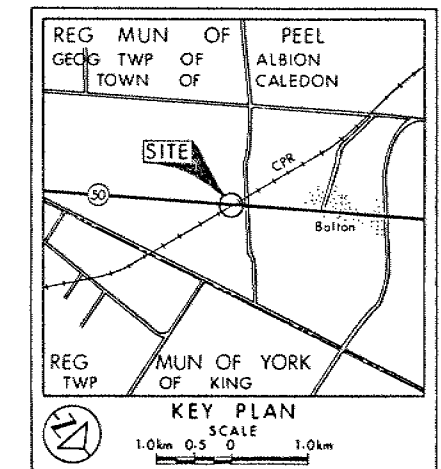
**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES UNLESS  
OTHERWISE SHOWN. STATIONS  
IN KILOMETRES - METRES.

CONT No  
WP No 132-79-02

CANADIAN PACIFIC RAILWAY

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 in open hole 1986 12 and 1987 04
- WL in Standpipe 1987 04 10

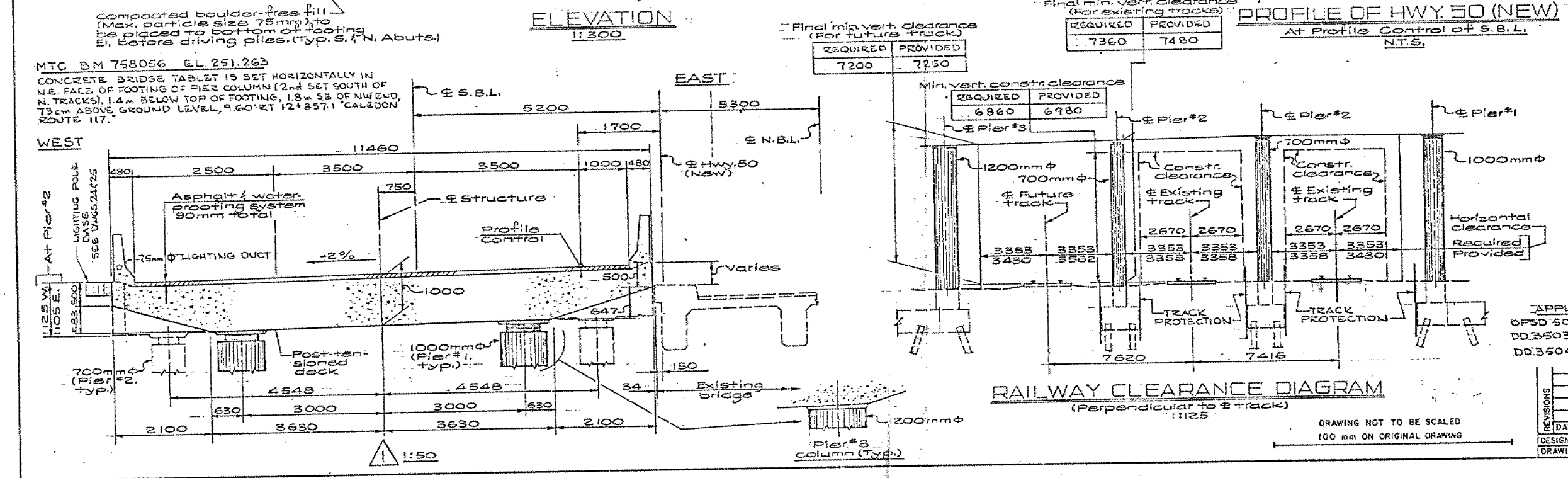
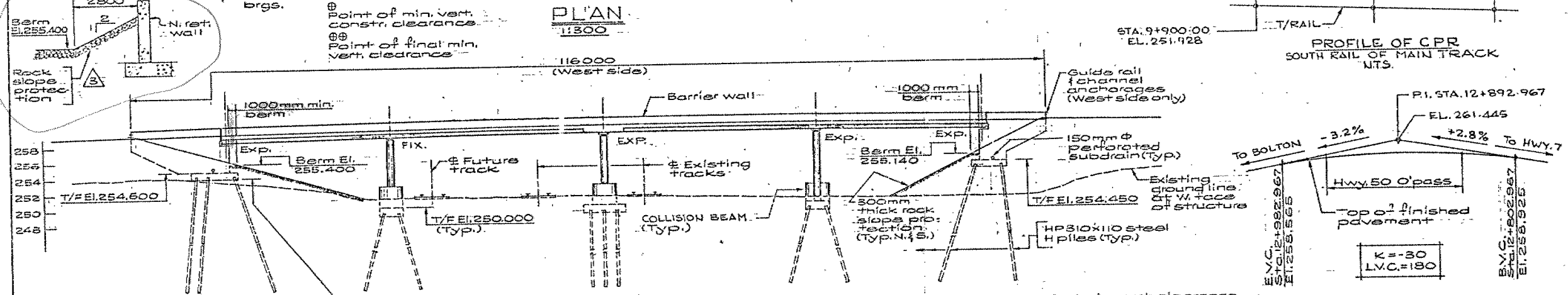
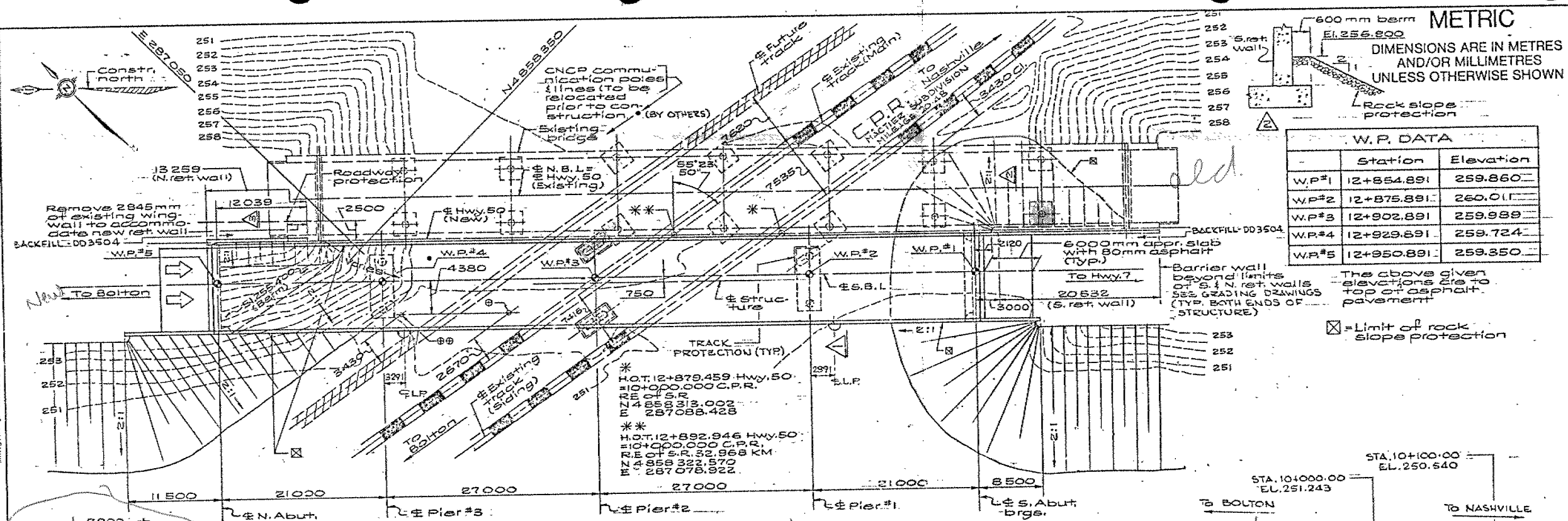
No	ELEVATION	CO-ORDINATES NORTH	EAST
1	258.9	4 858 276.3	287 123.2
2	250.4	4 858 284.0	287 101.4
3	250.5	4 858 297.1	287 095.3
4	250.9	4 858 310.2	287 081.7
5	251.1	4 858 331.5	287 061.2
6	251.0	4 858 337.9	287 048.7
7	259.2	4 858 360.1	287 040.5

**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
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			
31			
32			
33			
34			
35			
36			
37			
38			
39			
40			
41			
42			
43			
44			
45			
46			
47			
48			
49			
50			
51			
52			
53			
54			
55			
56			
57			
58			
59			
60			
61			
62			
63			
64			
65			
66			
67			
68			
69			
70			
71			
72			
73			
74			
75			
76			
77			
78			
79			
80			
81			
82			
83			
84			
85			
86			
87			
88			
89			
90			
91			
92			
93			
94			
95			
96			
97			
98			
99			
100			

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS ONTARIO



DIST. 6  
CONT No  
WP No 132-79-02  
SHEET

HWY 50 O'PASS AT C.P.R. BOLTON

GENERAL ARRANGEMENT

- NOTES**
- CLASS OF CONCRETE**
- ABUT. & RET. WALL FOOTINGS ..... 20 MPa  
PIERS AND DECK ..... 35 MPa  
REMAINDER ..... 30 MPa
- CLEAR COVER TO REINF. STEEL**
- FOOTINGS ..... 100 ± 25  
ABUTMENTS, WINGWALLS AND  
RETAINING WALLS:  
FRONT FACE ..... 80 ± 20  
BACK FACE ..... 70 ± 20  
PIERS ..... 80 ± 20  
DECK:  
TOP ..... 70 ± 20  
BOTTOM AND SIDES ..... 50 ± 10  
REMAINDER  
UNLESS OTHERWISE SPECIFIED ..... 70 ± 20
- REINFORCING STEEL**
- REINFORCING STEEL SHALL BE GRADE 400  
UNLESS OTHERWISE SPECIFIED. BAR MARKS  
WITH SUFFIX 'C' DENOTE COATED BARS.
- CONSTRUCTION NOTES**
- BEARING SEATS SHALL BE FINISHED  
LEVEL AND TO THE SPECIFIED  
ELEVATIONS.
- CONCRETE BARRIER WALLS ON RE-  
TAINING WALLS SHALL NOT BE CAST UNTIL  
RETAINING WALL BACKFILL HAS BEEN  
COMPLETED.

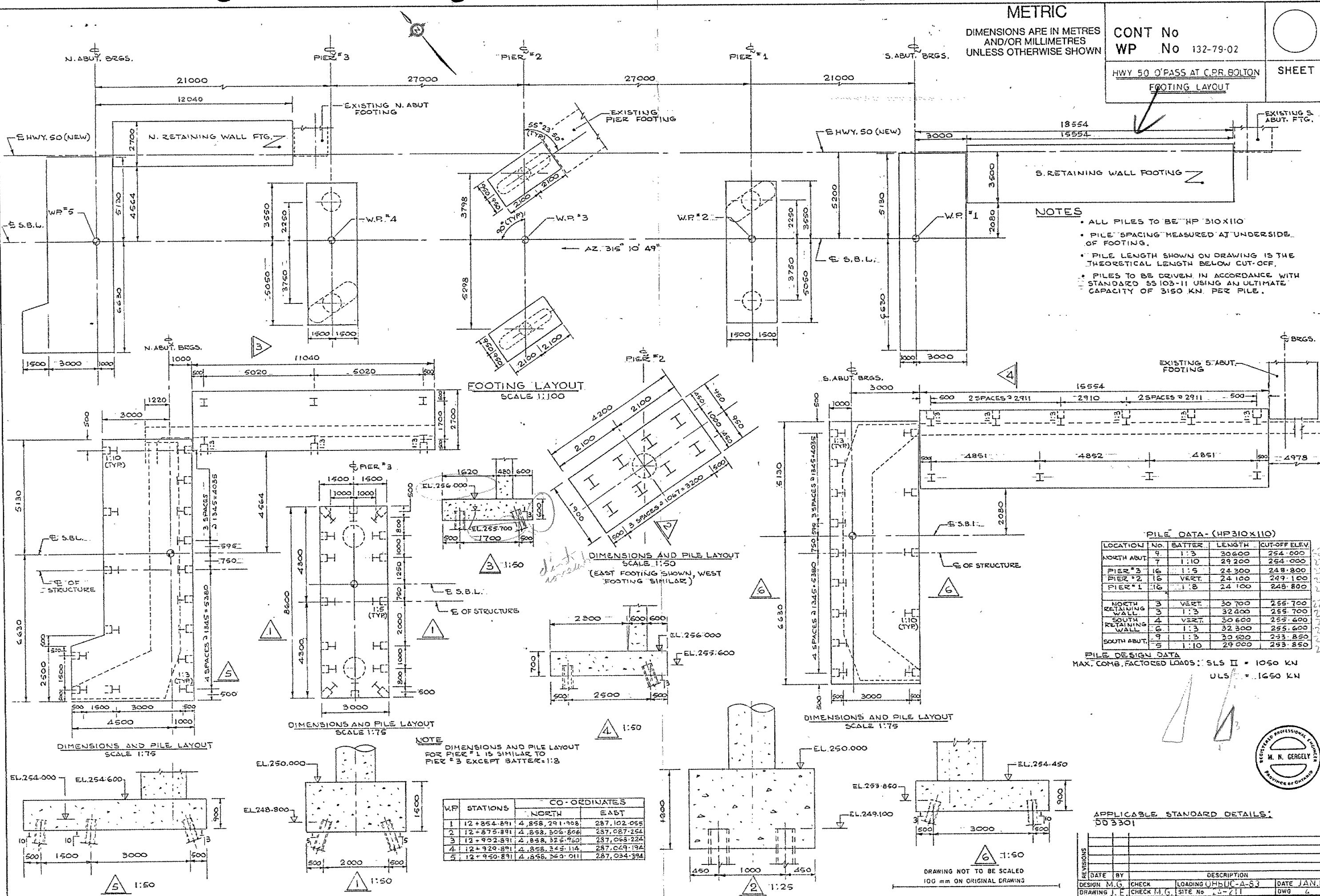
- LIST OF DRAWINGS**
- 24-211-  
1. General Arrangement  
2. Bore Hole Location & Soil Strata  
3. Roadway and Track Protection  
4. Footing Layout  
5. Footing Reinforcing  
6. South Abutment  
7. North Abutment  
8. S. & N. Abut. Wingwalls  
9. S. & N. Retaining Walls  
10. Piers & Bearing Data  
11. Deck Details  
12. Longitudinal Tendon Details  
13. Transverse Tendon Details I  
14. Transverse Tendon Details II  
15. Deck Reinforcing I  
16. Deck Reinforcing II  
17. Barrier Wall - East  
18. Barrier Wall - West  
19. 600mm Approach Slab  
20. As Constructed Elev. & Dim.  
21. Bridge Data & Site Number Data  
22. Joint Anchorage and Armouring  
23. Pile Driving Steam & Diesel  
Hammers  
24. STANDARD DETAILS  
25. ELECTRICAL EMBEDDED WORK  
26. QUANTITIES - STRUCTURE  
27. QUANTITIES - STRUCTURE

- LIST OF ABBREVIATION**
- W.P. = Working point  
T/A = Top of asphalt  
T/F = Top of footing  
F.F. = Front face  
B.F. = Back face  
E.F. = Each face  
L.P. = LIGHTING POLE

APPLICABLE STANDARD DETAILS:  
OFSD 508.02 - BRIDGE DECK WATERPROOFING  
DD3503 - MIN. GRANULAR BACKFILL  
DD3504 - RETAINING WALLS BACKFILL

REVISIONS	DATE	BY	DESCRIPTION
DESIGN M.G. CHECK			LOADING OF BOC-A-83
DRAWING D.C. CHECK M.G.			SITE No 24-211
			DATE Jan/89
			DWG. 1





FILE DATA - (HP310X110)				
LOCATION	No.	BATTER	LENGTH	CUT-OFF ELEV.
NORTH ABUT.	4	1:3	30 600	254.600
	7	1:10	29 200	254.000
PIER #3	16	1:5	24 300	248.800
PIER #2	16	VERT.	24 100	249.100
PIER #1	16	1:5	24 100	248.800
NORTH RETAINING WALL	3	VERT.	30 700	255.700
	3	1:3	32 400	255.700
SOUTH RETAINING WALL	4	VERT.	30 600	255.600
	6	1:3	32 300	255.600
SOUTH ABUT.	9	1:3	30 500	253.850
	5	1:10	29 000	253.850

FILE DESIGN DATA  
MAX. COMB. FACTORED LOADS: SLS II = 1050 KN  
ULS = 1650 KN

W.P.	STATIONS	CO-ORDINATES	
		NORTH	EAST
1	12 + 854.891	4,858, 291.958	287, 102.058
2	12 + 875.891	4,858, 306.506	287, 087.254
3	12 + 902.891	4,858, 325.960	287, 068.222
4	12 + 929.891	4,858, 345.114	287, 049.194
5	12 + 950.891	4,858, 360.011	287, 034.394

APPLICABLE STANDARD DETAILS:  
DD3301

[illegible]

SEND  
TO

B. IYER

FOUNDATION DESIGN SECTION

3rd FLOOR CENTRAL BUILDING

FROM

TYRONE LOWE

DEPT.

GEOTECHNICAL SECTION

DATE

APRIL 20,

SUBJECT

C 93-52 / WP 132-79-01 HWY 50, BOLTON S. LIMITS, S'LY 2.75 km.

DISTRICT 6, TORONTO.

Please refer to the comments under Item 15 (iii), P. 18 of the attached copy from P&P Verification Review, which requires a conversion factor for TONNES PER CUBIC METRE for lightweight structural backfill to be used on the above project.

A copy of the covering memo from KEN WONG of the Structural Section and the subject NSSP which originated from your office are attached for clarification.

C.C. KEN WONG - STRUCTURAL SECTION

P. CHACKERIS

Sd: Tyrone Lowe  
for B. IYER, HEAD, GEOTECHNICAL SECTION

REPLY

USE COMPACTED UNIT WEIGHT OF AVG.  
11.5 kN/m<sup>3</sup> FOR THE TYPE II FILL.

PLEASE USE NECESSARY CONVERSION TO  
GET EQUIVALENT TONNES / m<sup>3</sup>. PLEASE CALL  
IF YOU NEED ADDITIONAL INPUT

Ponyer

REPLY FROM

REPLY DATE

93 04 22

# memorandum



Tel: (416) 235-5650

To: V. Boehnke, P. Eng.  
Head, Structural Section  
Central Region, Downsview

Date: 92 03 02

Attn: K. Wong, P. Eng.



Re: Hwy 50 CPR O'head, at Bolton  
W.P. 132-79-02, Site 24-211  
District 6, Toronto

In response to your memo dated 92-02-27, regarding the lightweight fill for this structure, we have discussed your proposal with the Foundation Section. We are in agreement with raising the bottom elevation of this fill to EL 251.0, but would require its plan size to be 4.6 m x 4.6 m, from which it would extend upwards at a slope of 1 horizontal to 2 vertical.

Please revise our drawing 23 to reflect this change.

*Michael Gergely*

M. Gergely, P. Eng.  
Sr. Project Engineer  
for G. Al-Bazi  
Design Engineer

MG/sl

✓ c.c. T. Sangiuliano



Structural Section  
Central Region  
1201 Wilson Avenue  
Atrium Tower, 4th Floor  
Downsview, Ontario, M3M 1J8  
Telephone: 235-5507

**MINISTRY OF TRANSPORTATION**

---

**m e m o r a n d u m**

TO: Kris Bassi  
Head, Structural Design Section

DATE: February 27, 1992

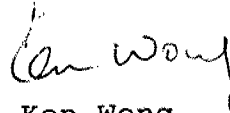
Attn: Mr. Mike Gregely

RE: WP 132-79-02: Hwy. 50 CPR O'Pass at Bolton  
Site No. 24-211, District 6, Toronto

---

We are in the midst of preparing the lightweight fill application for MOE approval. We note that the lightweight fill commences at Elev. 249.17 and the ground water elevation recommended by the Foundation Design Report is EL 250.5. As a result, a height of roughly 1.33 m of the lightweight fill will be submerged in the ground water which not be approved by MOE.

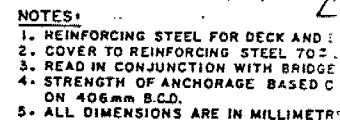
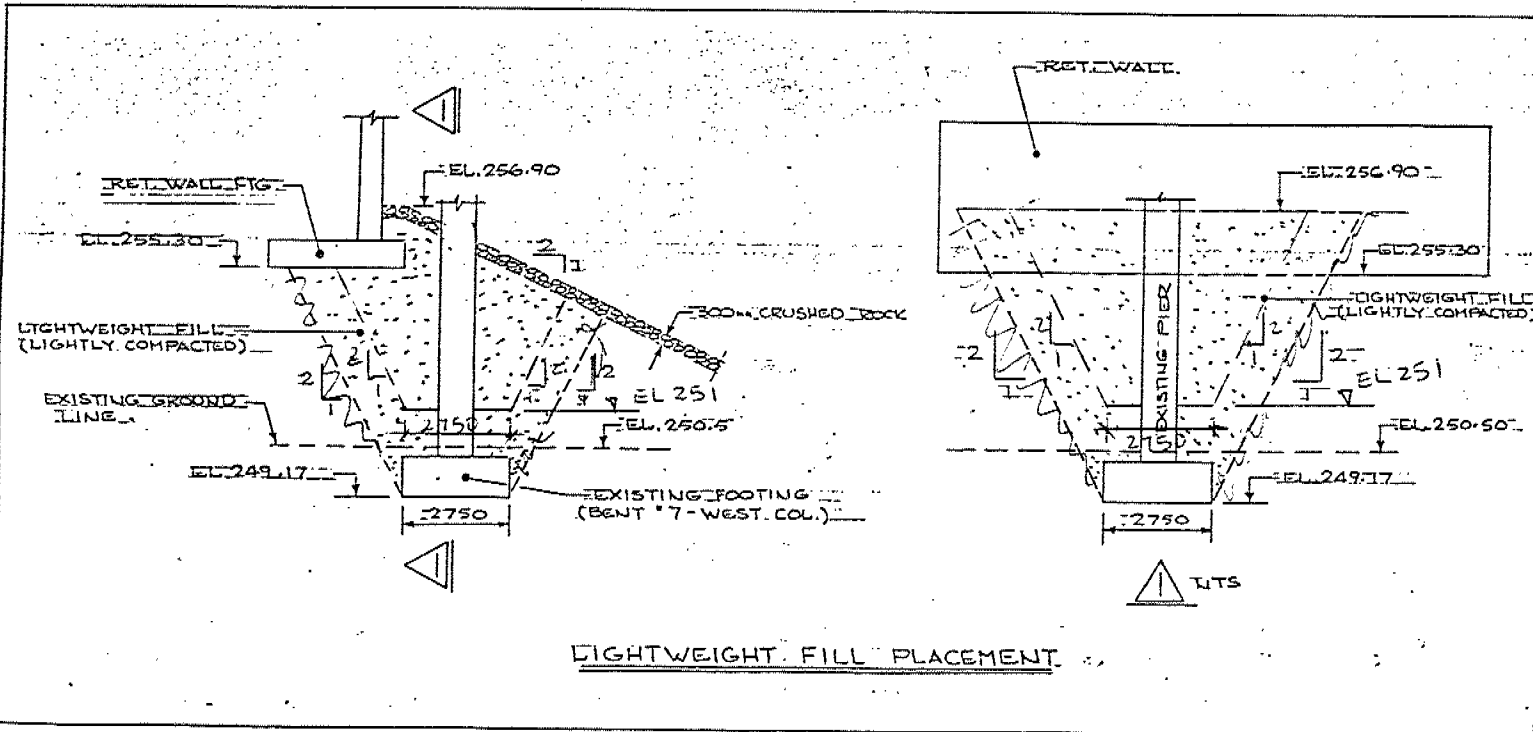
Therefore, we suggest that the lightweight fill commence at Elev. 251 which will be above the recommended ground water level. Attached is the sketch showing the above noted changes. Please confirm A.S.A.P. whether the above proposal is acceptable.



Ken Wong  
Senior Structural Engineer  
for:  
V.F. Boehnke  
Head, Structural Section

KW:vn  
attach.

cc: T. Sangiuliano - Foundation Design Section  
P. Chackeris - P. & D.





# memorandum



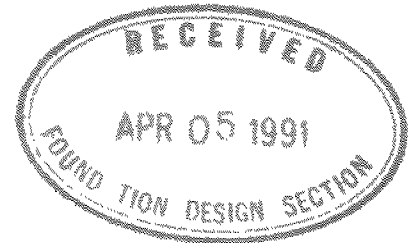
Tel: (416) 235-5650

To: M. Devata  
Head, Foundation Design Section  
Central Bldg., Room 315

Date: 91 04 04

Attn: B. Iyer

Re: Hwy 50 O'pass at C.P.R. Bolton  
W.P. 132-79-02, Site 24-211  
District 6, Toronto



This memo is to confirm a discussion between B. Iyer and D. Bhatia on 91 04 03 regarding the re-design of the Roadway Protection at the proposed N. Retaining Wall for this structure.

- although the soil is a cohesive material, because it is fill, use equivalent granular soil properties and design method:

$$K_a = 0.33$$

$$K_p = 3.0$$

$$\gamma = 20. \text{ kN/m}^3$$

- embedment depth required is then increased by 50% based on the above
- use earth - pressure distribution as for 'sheet-pile' analysis, even though soldier-piles with timber lagging is being used.
- the design is based on Serviceability Limit States.

*M. Gergely*

M. Gergely  
Sr. Project Engineer  
for G. Al-Bazi  
Design Engineer

MG/sl

c.c. A. Aly



DRAWING NOT TO BE SCALE  
100 mm ON ORIGINAL DRAWING

[illegible]

# memorandum



To: P. Chackeris  
Sr. Project Manager  
Planning & Design Section  
4th Floor, Atrium Tower

From: Foundation Design Section  
Room 315, Central Building

Re: Highway 50  
Bolton South Limit Southerly 2.7 km  
W.P. 132-79-01  
District 6, Toronto

Date: 1991 03 26

We have received the minutes of the Initial Engineering Review meeting held on March 14, 1991. We have the following comments regarding the item titled "High Fill Construction".

1. How high is the "High Fill"?
2. Was any foundation/geotechnical investigation carried out at this site?.
3. We would like to review the proposed design and construction for the "High Fill" areas.

A handwritten signature in black ink, appearing to read "B. Iyer", written over a horizontal line.

Dr. B. Iyer, P. Eng.  
Sr. Foundation Engineer

BI/jb

cc: G. Cautillo  
Head, Geotechnical Section

# memorandum



Tel: 3731

To: H. Jagasia, P. Eng.  
Design Engineer  
Structural Office  
7th Floor, Atrium Tower

Date: 1989 09 01

Atten: Mr. Gergoly, P. Eng.  
Project Engineer

From: Foundation Design Section  
Room 315, Central Building

RE: Hwy. 50 Overpass at C.P.R. - Bolton  
W.P. 132-79-02, Site 24-211  
District 6, Hwy. 50-C.P.R.

The revisions implemented in response to the comments given by this Section for the aforementioned structure have been reviewed and reflect compliance to the recommendations given.

A handwritten signature in dark ink, appearing to read 'T. Sangiuliano'.

T. Sangiuliano, P. Eng.  
Foundation Engineer

for

Dr. B. Iyer, P. Eng.  
Sr. Foundation Engineer

TS/BI/mmj

# memorandum



To: H. Jagasia  
Design Engineer

Date: 1989 06 13

Attn: M. Gergely  
Project Engineer

From: Foundation Design Section  
Room 315, Central Building

RE: Additional Loadings on Existing Foundations  
Hwy. 50 Overpass at C.P.R. Bolton  
District 6, Highway 50

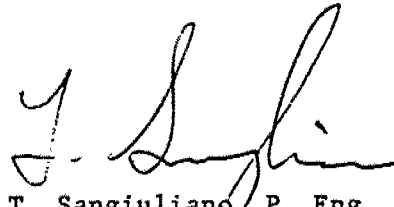
Further to our memorandum dated 88 04 19 and discussions conducted at this office on 89 06 01, the influence of the fill material adjacent to the proposed south retaining wall on the existing south pier footings has been evaluated. Based on the structural loadings and soil bearing capacities at SLS Type II and ULS summarized in the attached Table 1, the following recommendations are provided.

## LIGHTWEIGHT FILL

To avoid overstressing the footing founding soil at the serviceability and ultimate limit states, it is recommended that lightweight fill be backfilled over the existing footings in accordance with the attached Figure 1. As illustrated, the lightweight fill shall be placed at a minimum 1H:2V slopes in both the longitudinal and transverse directions. The regular fill beyond the wedge of lightweight fill shall be placed and compacted according to MTO specifications (OPSS 501). The lightweight fill shall also be placed in standard lift thickness but the "light" compaction desirable to minimize "locked-in" vertical stresses can be achieved by the travel of the placement equipment itself. It is important to emphasize that extreme caution be exercised when placing and compacting material within close proximity of the existing foundations.

...../2

If you have any queries regarding the above comments and/or require additional information, please do not hesitate to contact this office.



T. Sangiuliano, P. Eng.  
Foundation Engineer

for

Dr. Balu Iyer, P. Eng.  
Sr. Foundation Engineer

BI/TS/sp

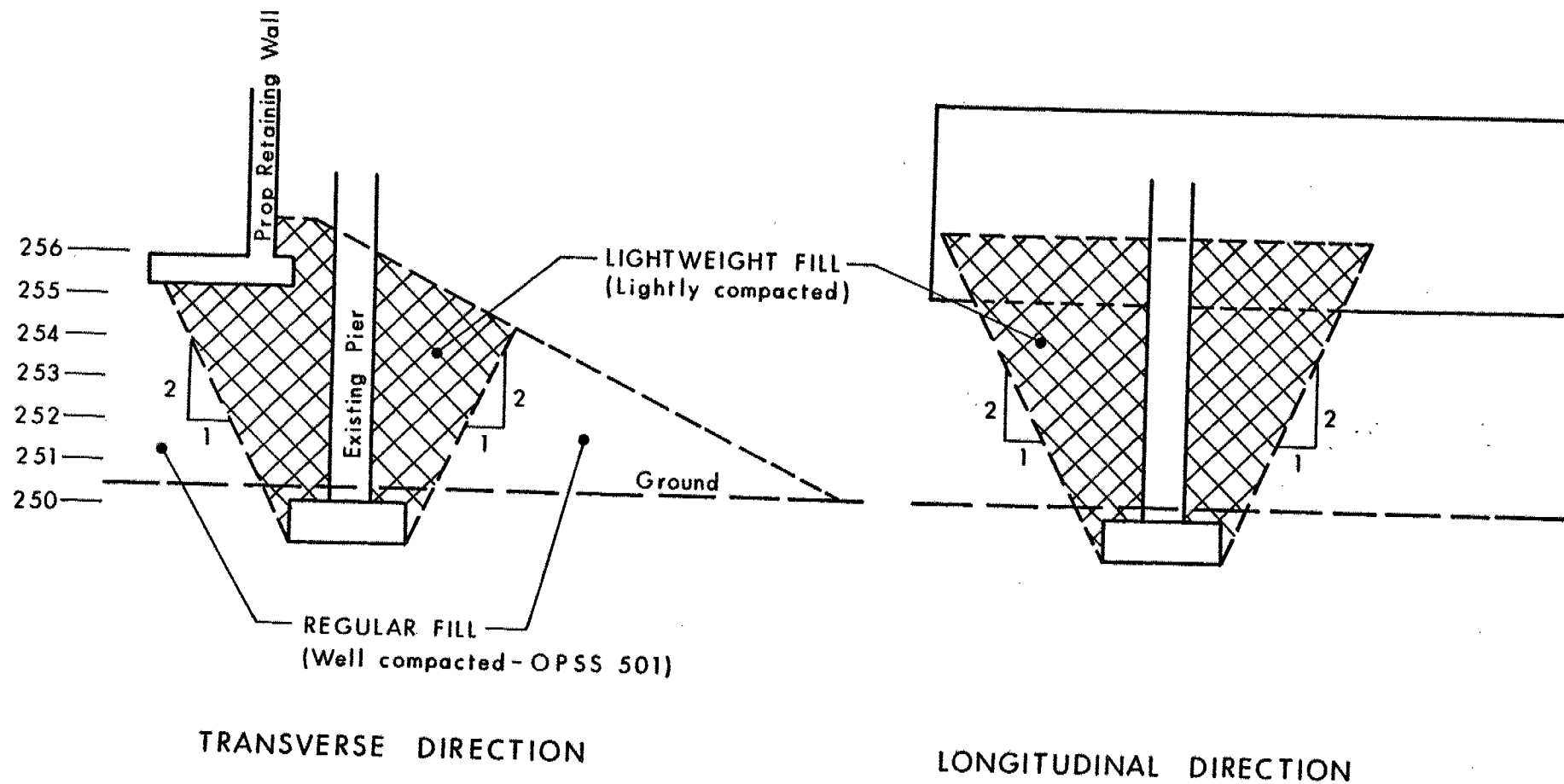
T A B L E   1

P E R T I N E N T   F O U N D A T I O N   L O A D S   /   C A P A C I T I E S

<sup>+</sup> Factored Total Load at S.L.S. Type II tons/ft <sup>2</sup> (kPa)	<sup>+</sup> Factored Total Load at U.L.S. tons/ft <sup>2</sup> (kPa)	*Bearing Capacity at S.L.S. Type II tons/ft <sup>2</sup> (kPa)	*Factored Capacity at U.L.S. tons/ft <sup>2</sup> (kPa)
2.35 (226)	3.17 (304)	3.0 (288)	4.5 (432)

+ excludes load induced by additional fill (supplied by M. Gergely, 89 06 01)

\* for existing pier shallow foundation



LIGHTWEIGHT FILL PLACEMENT

WP 132-79-02

Fig. 1



# memorandum



To: H. Jagasia  
Design Engineer

Date: 1988 04 19

Attn: M. Gergely  
Project Engineer

From: Foundation Design Section  
Room 315, Central Building

RE: Final Design Drawings Review For  
Hwy. 50 Overpass at C.P.R. Bolton  
W.P. 132-79-02, Site 24-211  
District 6, Highway 50-C.P.R.

---

The final design drawings for the aforementioned project were reviewed by this Section and the following comments are provided.

## 1) TRACK PROTECTION

The braced-sheet pile excavation at Pier #2 (columns 3 & 4) and northeast corner of Pier #1 (column 6) appear to be appropriately designed. Installation and then removal of this shoring system however, warrants careful consideration and planning. Particular emphasis should be directed at column 4 where the footing cap abuts the existing spread footing. Firstly, it is recommended that the existing footing be probed to confirm its exact location to avoid any shearing of the footing during installation of the sheet-piling. Installation is to be monitored closely to avoid excessive soil displacement and deformation by ensuring the plumbness of the sheet-pile, reducing encroachment into the existing footing zone of influence. Finally, to avoid further soil deformation at the new footing-existing footing interface, it is recommended that the sheet pile at this interface remain insitu upon completion rather than extracting it.

## 2) ROADWAY PROTECTION

The designed roadway protection will effectively resist all applicable pressures. Any pile installed within a 3.0 m radius of the existing north abutment footing, however, should be installed in preaugered holes rather than driven to avoid excessive soil deformation and displacement within the footing's zone of influence.

### 3) PILED FOUNDATIONS

An area of grave concern is the installation of the south retaining wall footing. Although there is no precise measurement provided for the distance between the existing pier footings and the new retaining wall, the close proximity clearly necessitates that a careful scheme of installation be provided. Avoidance of soil loss and excessive soil deformation and displacement within the existing footings zone of influence is essential. Similar recommendations apply at column 4 (Pier #2) and column 6 (Pier #1)

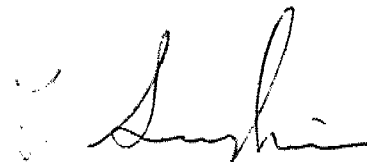
The capacities and lengths of the piled foundations adhere to the recommendations provided at all locations. The pile driving will be controlled by employing the Hiley Dynamic Pile Driving Formula.

### 4) BACKFILL

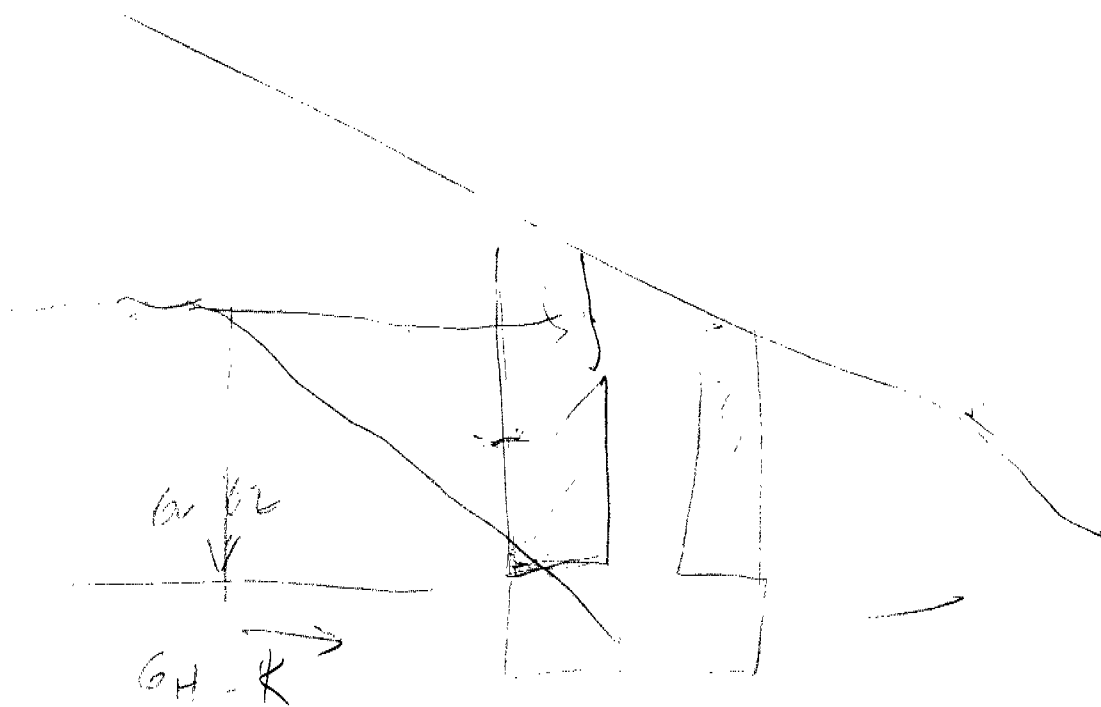
Additional vertical and horizontal loadings induced on the existing footings by the fill adjacent to the new south retaining wall should be calculated and the resistances of the existing footings be re-examined to assure appropriate safety.

The new approach fills should be "Keyed" into the existing fills. Settlements approximately 0.5% of the total fill height can be expected for new approach fills up to 7 m high and approximately 0.75% of the total fill height for a fill between 7 and 10 m high. No major settlements are expected in the underlying soil.

If you have any queries regarding the above review or require further information, please do not hesitate to contact this office.



T. Sangiuliano  
Foundations Engineer  
for  
M. Devata  
Chief Foundations Engineer  
(East)



# memorandum



To: K. Bassi  
Head, Design Section  
Structural Office  
3501 Dufferin Street

Date: 1987 09 01

Atten: G. Al-Bazi  
M. Gergely

From: Foundation Design Section  
Room 315, Central Building

RE: C.P.R. Bridge Twinning  
W.P. 132-79-02, Site 24-211  
Hwy. 50, District 6, Toronto

Further to our meeting of 87 08 27, concerning the foundation design for the centre pier (Pier #2) for the proposed new SB structure at this site:

Provisions for a third C.P.R. track has required a change in the configuration of the proposed structure. A 4-span structure is now proposed, requiring foundation elements to be constructed near existing tracks as illustrated on the enclosed plan.

It is our understanding that C.P.R. may impose clearance constraints that limit construction access to a 2 m wide area. Consequently we have investigated possible foundation alternatives that may facilitate construction of foundation elements to provide your 5400 kN± reaction.

The following alternatives are considered to be unfeasible.

- Constructing spread footings at normal depths (Elev. 248 to 249 m). This alternative would provide the following OHBDC design values:

- Factored Bearing Capacity at U.L.S. = 300 kPa
- Bearing Capacity at S.L.S. Type II = 200 kPa

As a large footing area would be required to obtain the design loading, this alternative does not appear to be feasible under the 2 m space constraint.

- Constructing spread footings at depth (Elev. 240 to 241 m). This alternative would provide higher bearing capacities, but the required excavation could not be practically constructed under the 2 m space constraint.

.....2

- . Utilizing smaller scale pile driving or caisson equipment. However there is no available pile driving or caisson equipment that is capable of installing suitable deep foundation elements within a 2 m wide area.

The following alternatives are considered to be feasible.

- . Re-routing train traffic onto one of the existing tracks to permit the operation of construction equipment over the closed track.
- . Constructing a full scale detour for train traffic.
- . Scheduling construction operations around C.P.R. requirements. It is conservatively estimated that each pile at this pier location could be installed within 5 hours and that any equipment could be moved outside the required clearance area within 1 hour. Since only 5 or 6 piles are required, this would appear to be the most reasonable solution.

In our opinion the most economical of the feasible alternatives would appear to be the most reasonable approach.

If there are any questions, please contact this office.



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

DHD/mmj

Encl.



# memorandum



To: M. Gergely  
Senior Project Engineer,  
Structural Office

Date: 1987 07 17

From: Foundation Design Section  
Room 315, Central Building

Subject: Highway 50 SBL/CPR  
W.P. 132-79-02, Site 24-211  
District 6

We have reviewed the General Arrangement Drawing 24-211-P1 for the above noted structure.

The following are our comments:

- 1) The foundation investigation was conducted assuming a 5-span configuration consisting of 4 piers and 2 abutments. The structure design has been modified to a 3-span configuration, consisting of 2 piers and 2 abutments. As a result we have reviewed the information obtained from the foundation investigation and we believe the investigation is adequate to cover the design in presented in the General Arrangement Drawing.
- 2) It appears that all our recommendations in the foundation report have been complied with by the designer.

A handwritten signature in cursive script that reads "Mary Lou Pauly".

Mary Lou Pauly  
Project Foundations Engineer  
for:

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

MD/pb