

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 30M13-78

DIST. 6 REGION

W.P. No. 138-87-02

CONT. No. 90-60

W. O. No.

STR. SITE No. 37-1169

HWY. No. 400

LOCATION Ramp 407E-W to 400 S  
over Steeles Ave (Bridge #1)

No. of PAGES -

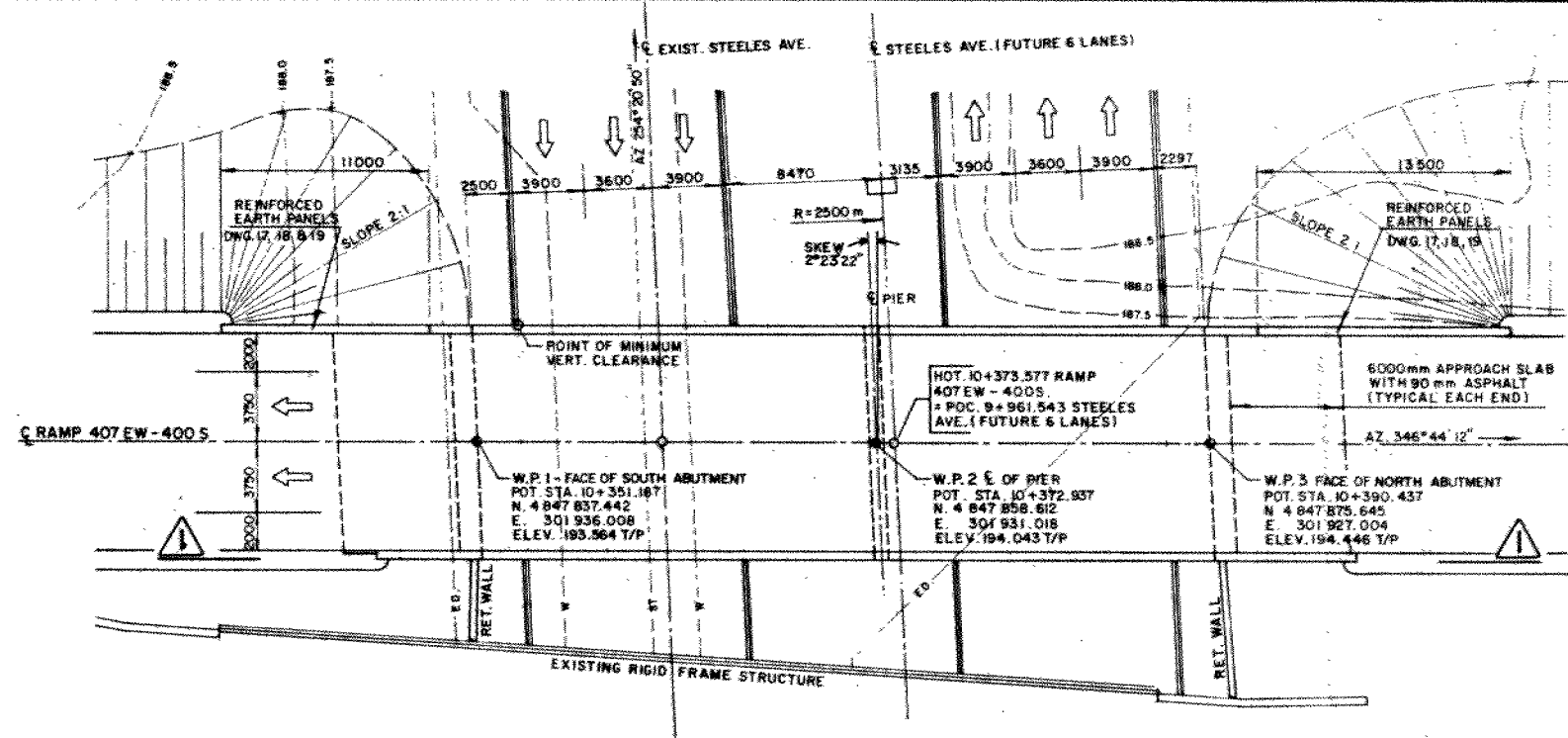
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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

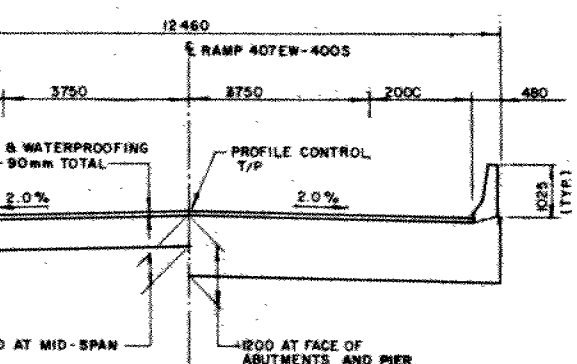
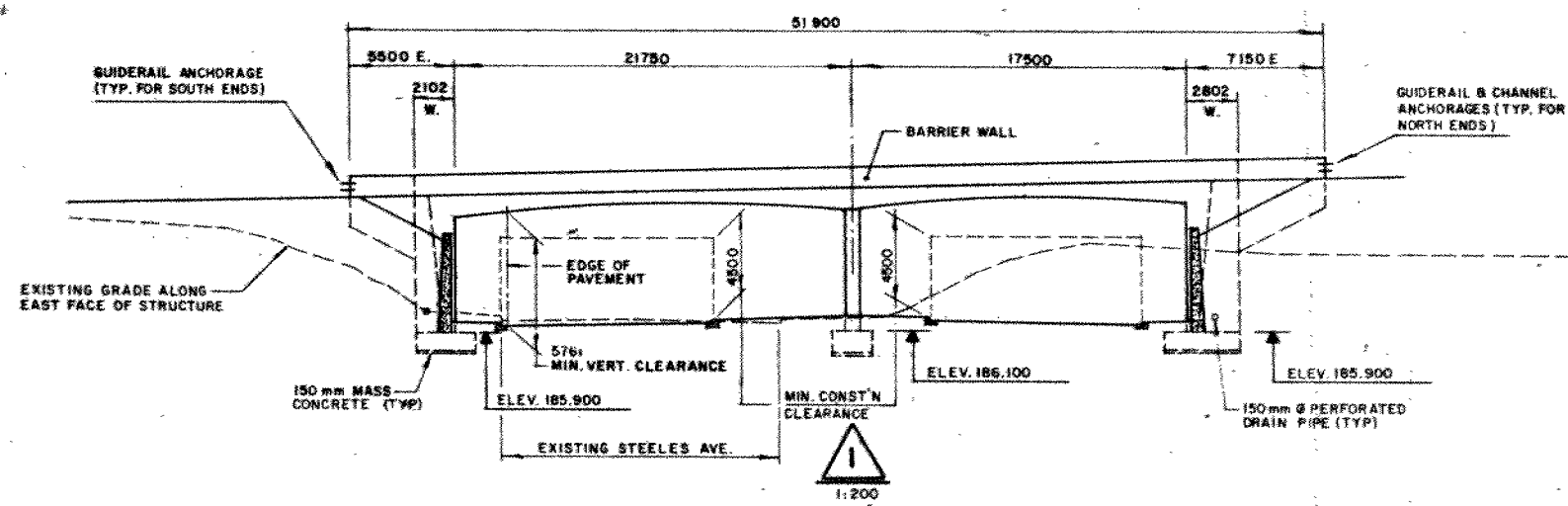
G.I.-30 SEPT. 1976

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS ONTARIO



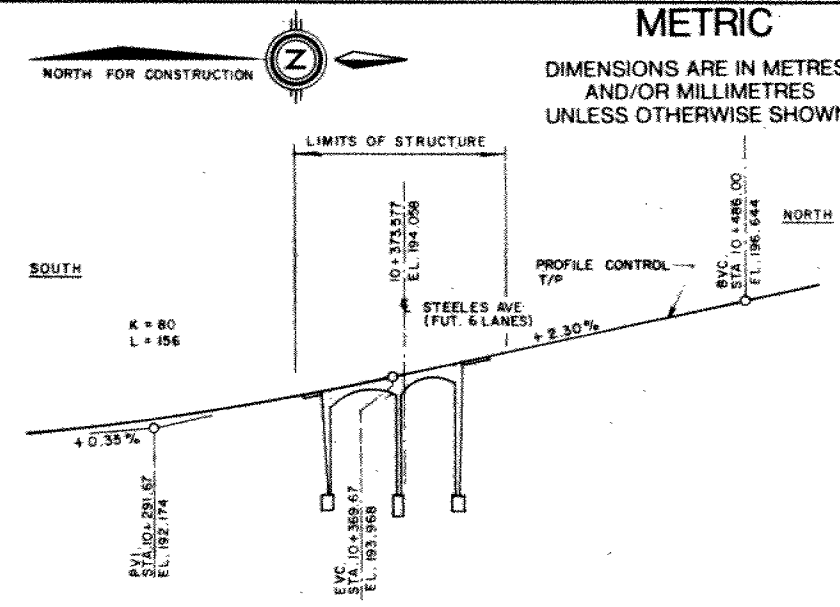
PLAN  
1:200

NOTE - W.P. DENOTES WORKING POINT  
T/P = TOP OF PAVEMENT

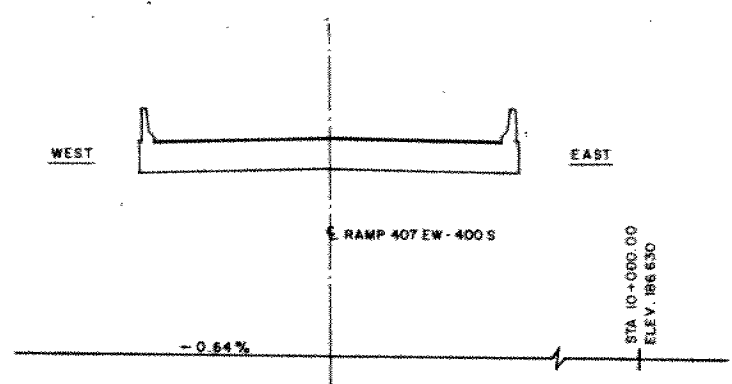


TYPICAL DECK SECTION  
1:75

BM 192.842  
GEODETIC DATUM  
CC ON 'SE' CORNER OF BRIDGE  
17.0 RT 19+446.9 HWY 400



PROFILE RAMP 407 EW - 400 S



PROFILE CONTROL - STEELES AVE.

LIST OF DRAWINGS:

1. GENERAL ARRANGEMENT
2. BORE HOLE LOCATION & SOIL STRATA
3. FOOTING LAYOUT & DETAILS
4. SOUTH ABUTMENT & SOUTH RETAINING WALL FOOTINGS
5. NORTH ABUTMENT & NORTH RETAINING WALL FOOTINGS
6. SOUTH ABUTMENT DETAILS
7. SOUTH ABUTMENT WINGWALL DETAILS
8. NORTH ABUTMENT DETAILS
9. NORTH ABUTMENT WINGWALL DETAILS
10. PIER FOOTING & PIER STEM DETAILS
11. RETAINING WALLS
12. DECK LAYOUT AND SCREED ELEVATIONS
13. DECK REINFORCING I
14. DECK REINFORCING II
15. DECK REINFORCING III
16. BARRIER WALL
17. REINFORCED EARTH RETAINING WALLS: PLAN AND TYPICAL DETAILS
18. REINFORCED EARTH RETAINING WALLS: ELEVATION AND SECTION
19. BARRIER WALLS ON REINFORCED EARTH PANELS
20. 6000 mm APPROACH SLAB
21. BRIDGE DATA & SITE NUMBER DATA
22. AS CONSTRUCTED ELEVATION & DIM.
23. QUANTITIES

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

DIST No 6  
CONT No  
WP No 138-87-02

NORTH FOR CONSTRUCTION

NORTH

RAMP 407 EW to 400 S  
OVER STEELES AVENUE  
GENERAL ARRANGEMENT

Wyllie & Ufnal  
consulting engineers

GENERAL NOTES:

CLASS OF CONCRETE  
FOOTINGS & MASS CONCRETE..... 20 MPa  
REMAINDER..... 30 MPa

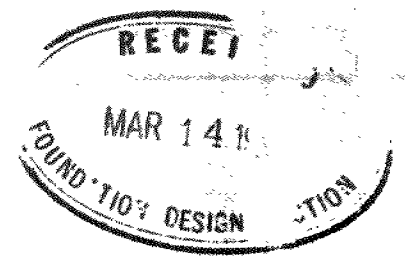
CLEAR COVER TO REINFORCING STEEL  
FOOTINGS..... 100 ± 25  
ABUTMENTS, WINGWALLS, RETAINING WALLS  
OUTSIDE FACE..... 80 ± 20  
INSIDE FACE..... 70 ± 20  
PIER..... 80 ± 20  
DECK  
TOP..... 70 ± 20  
BOTTOM..... 50 ± 10  
REMAINDER..... 70 ± 20  
UNLESS OTHERWISE NOTED

REINFORCING STEEL  
REINFORCING STEEL SHALL BE GRADE 400 UNLESS OTHERWISE  
SPECIFIED. BAR MARKS WITH SUFFIX 'C' DENOTE COATED  
BARS.

CONSTRUCTION NOTES  
NORTH EAST RETAINING WALL AND NORTH ABUTMENT TO BE BUILT  
WITH STAGE 1 OF BRIDGE #2. SEE DWG. 2 OF WP 138-87-03.  
SOUTH EAST RETAINING WALL, SOUTH ABUTMENT AND CENTRE  
PIER TO BE BUILT WITH STAGE 3 OF BRIDGE #2. WP  
138-87-03.  
BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH  
ABUTMENTS KEEPING THE HEIGHT OF THE BACKFILL  
APPROXIMATELY THE SAME. AT NO TIME SHALL THE  
DIFFERENCE IN ELEVATIONS BE GREATER THAN 40 MM.



APPLICABLE STANDARD DRAWINGS:  
DD-3502  
DD-3504  
DD-4604  
OPSD 508-02



DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION
DESIGN J.C.S.	CHK T.Z.	CODE OHBDC-83	LOAD CL. A
DRAWN G.S.	CHK J.C.S.	SITE 37-1169	STRUCT SCHEME
			DATE JULY 4 1988
			DWG 1

METRIC

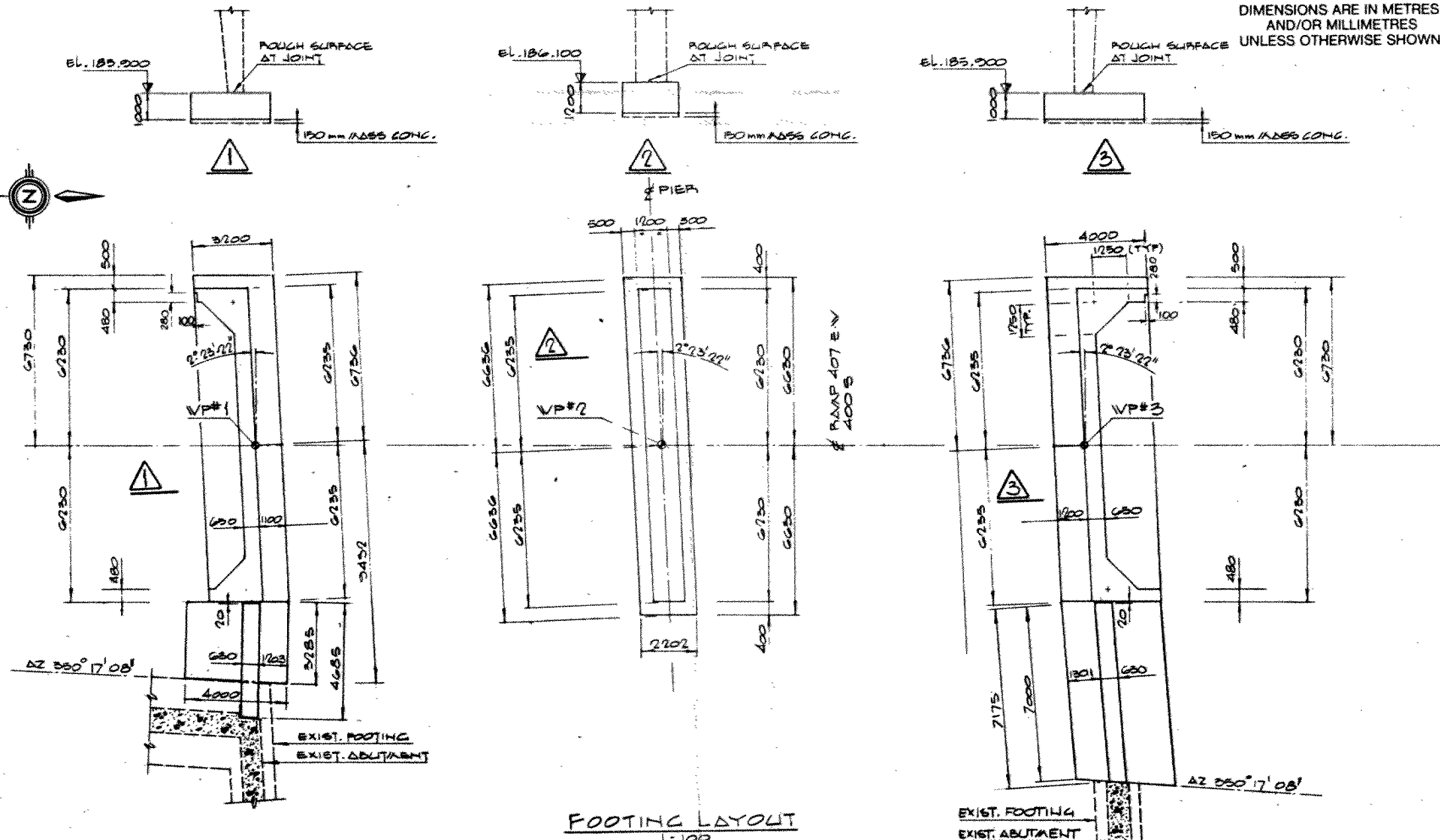
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No  
WP No 138-87-02

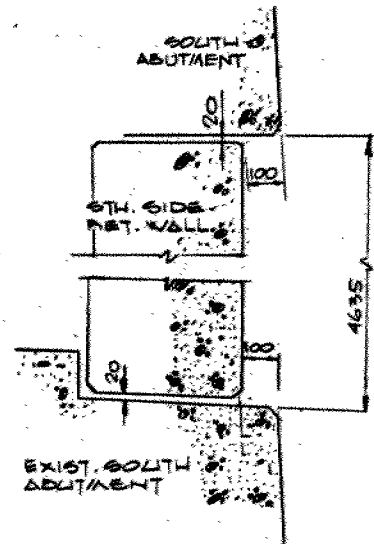
RAMP 407 EW to 400 S  
OVER STEELES AVENUE  
FOOTING LAYOUT & DTLS

SHEET

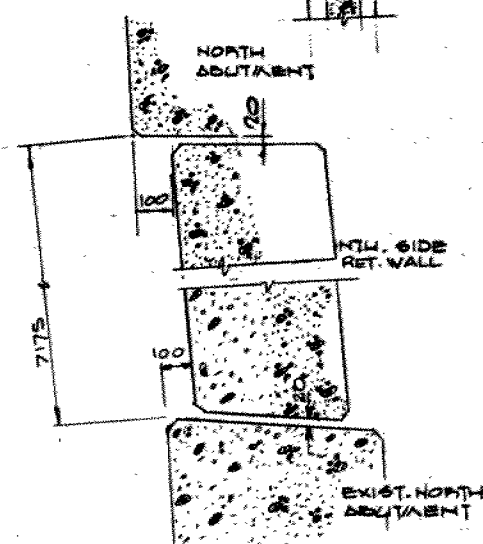
**Wyllie & Ufnal**  
consulting engineers



FOOTING LAYOUT  
1:100



S-E RETAINING WALL DETAIL



N-E RETAINING WALL DETAIL

NOTE:  
150 mm 1A855 CONCRETE TO BE PLACED  
WITHIN 5 HOURS OF EXCAVATION

APPLICABLE STANDARD DRAWINGS:  
00-4670



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	J.C.S.	CHECK	T.Z.
DRAWING	G.S.	CHECK	J.C.S.
DATE	NOV 1988		
SITE No	37-1169		
DWG	3		

DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

*CONT 90-60*  
ENGINEERING MATERIALS OFFICE  
FOUNDATION DESIGN SECTION

WP 138-87-02

DIST 6

HWY 400/407

STR SITE 37-1169

Ramp 407 EW to Hwy. 400 S  
Over Steeles Avenue  
Structure #1

DISTRIBUTION

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File

# FOUNDATION INVESTIGATION REPORT

For

Ramp 407 EW to Hwy. 400 S

Over Steeles Avenue

Structure #1

W.P. 138-87-02, Site 37-1169

District 6, Toronto

## INTRODUCTION

This report summarizes the information obtained from a foundation investigation carried out at the above mentioned site during the periods of December 14 to December 17, 1987.

As described in our previous Foundation Investigation Report (W.P. 138-87-03 & 05, April 1988), ten boreholes (Boreholes 1 to 8 and Boreholes #2-1 and #2-2) were advanced and sampled during the various time as part of the foundation investigation for the Hwy. 400 over the Steeles Avenue. These boreholes extended to depths between 8.1 and 18.6 metres below the ground surface. The results obtained from these boreholes are utilized in this report (Boreholes 1, 5 and 7).

During the December of 1987, three boreholes (Boreholes #1-1, #1-2 and #1-3) were advanced and sampled as part of this project by means of hollow stem augers and washboring techniques. These boreholes extended down to depths between 9.6 and 18.8 metres below the ground surface.

This report contains factual information together with recommendations pertaining to the foundation of a new 2-span structure shown on Drawing No. 1388702-A.

## SITE DESCRIPTION AND GEOLOGY

The site is located immediately west of existing bridge for Highway 400 where it crosses Steeles Avenue. The existing structure will be lengthened easterly and a new rigid frame structure will be constructed north and parallel to the existing structure. At this location, Steeles Avenue and Highway 400 have elevations between 186.5 and 193.0 m respectively. The existing bridge over the

Steeles Avenue is a 21.3 x 43.5 metres single span frame bridge constructed with earth embankments up to 6.5 metres in height.

This site is located in the physiographic region known as the "Peel Plain" as described by the physiography of South Ontario (Chapman and Putnam, 1984). This region is characterized by a level to gently undulating topography sloping gradually towards the south. The underlying soil consists of a hard layer of glacial till overlying very dense sandy silt to silty sand. Land use is mainly for industrial purposes.

### SUBSURFACE CONDITIONS

#### General

The subsoil conditions encountered across the site were generally uniform consisting primarily of two distinct deposits. The upper layer consists of clayey silt to silt with sand and a trace of gravel which extends down to the elevations between 179.8 m at BH #1-2 and 182.0 m at BH #1-1 as shown on the section in Drawing No. 1388702-A. The thickness of this layer varies between 5.7 m at BH #1-2 location and 6.4 m at BH #1 location. Underneath this clayey silt to silt, very dense sandy silt to silty sand with occasional sand layers is present. Approximately 11.0 metres of this very dense material was proven. These deposits are glacial origin. The fill material was encountered at two borehole locations (BH #1, #1-2 and #1-3). This material is composed of silty clay with a depth up to 2.1 metres.

More detailed description of the two distinct subsoil deposits and the fill material will be presented.

#### 1) Clayey Silt to Silt

A layer of clayey silt to silt with sand and a trace of gravel extends from the ground surface to depths between 6.1 and 8.2 metres. The material changes in colour from brown to grey at approximately elevation 184.0 on the north side of Steeles Avenue and 179.0 m on the south side of the road.

The results from laboratory tests performed on this material are summarized as follows:

<u>Properties</u>	<u>Range (%)</u>
Moisture Content (w)	8.5-19.5
Liquid Limit ( $w_L$ )	15.5-31.0
Plastic Limit ( $w_p$ )	10.0-13.0
Plasticity Index ( $I_p$ )	4-17.5

The Atterberg Limit Test results are illustrated on the plasticity chart (See Figure 1). From the chart it is evident that the layer can be classified as an inorganic clayey silt to silt with low plasticity (CL or CL-ML).

Grain size distribution tests were carried out on these materials. Figure 3 in the Appendix shows that the result in envelope form.

Standard Penetration Test 'N' values between 11 and over 100 indicated that soil can be interpreted as being stiff to hard.

## 2) Sandy Silt to Silty Sand

Silty sand to sandy silt was encountered below the clayey silt layer. All samples recovered from the north side of Steeles Avenue had a grey colour whereas samples recovered above elevation about 186.0 meters on the south side were brown in colour. Samples taken below elevation about 180.0 metres on the south side were grey in colour.

Grain size distribution analysis indicates that the soil varies between a silty sand and sandy silt. Trace of clay and gravel are also present. This layer is basically non-plastic. The Atterberg Limit Test results are shown on the plasticity chart (See Figure 2). From the chart it is evident that the layer can be classified as sandy silt to silty sand (ML). Figure 4 in the Appendix shows the results of grain size distribution tests in envelope form.

In this stratum, the 'N' values ranged from 23 to over 100 blows/0.3 m indicating a state of compaction described as dense to very dense.

### 3) Fill Material

The fill material was encountered on the north side of Steeles Avenue at two borehole locations (BH #1, #1-2 and #1-3). This fill consists of a brown silty clay or clay silt with some sand and trace of gravel. The thickness of this layer varies from 1.4 metres at BH #1 and to 2.1 metres at BH #1-3 as shown on borehole logs. No Atterberg Limit Tests and grain size distribution analysis were carried out. However, through visual observation, it is apparent that the fill material is similar to the embankment fill for Hwy. 400 which is classified to silty clay to clayey silt.

Standard Penetration Test 'N' values between 8 and 42 indicate that the fill material is in a stiff to hard state.

The results of all field and laboratory testing, along with a summary of the subsoil conditions encountered in each borehole are shown on the Record of Borehole Sheets (See Appendix). Stratigraphical profiles are shown on Drawing No. 1388702-A. Also shown on this drawing is a generalized plan of the site area showing the locations of the boreholes with respect to the relevant structures.

### GROUNDWATER CONDITIONS

Groundwater conditions were observed through the measurements of water levels in the open boreholes.

Groundwater level in the borings was found to range between elevation 182.2 m at BH #1-1 and elevation 183.8 at BH #1-3 about 4.5 metres below the original ground surface.

There are pockets of silt and sand within overburden which are water bearing and exhibit a tendency to boil under conditions of unbalanced hydrostatic head.



## DISCUSSION AND RECOMMENDATIONS

The recommendations in this report apply to the bridge structure, the retaining walls and related approaches.

Bridge #1 is from Ramp Hwy. 407 E.W. to Hwy. 400 S over Steeles Avenue. A 2-span structure with related retaining walls is proposed and this will be located parallel to the existing Hwy. 400 and some 5 m west of the highway.

The existing bridge for Hwy. 400 at Steeles Avenue crossing is founded on spread footings approximately 1.0 metre thick. The base of the footings are located at about elevation 184.9 m. There is approximately 1.2 metres of soil cover over the top of the footings.

Associated retaining walls for the existing structure are founded on stepped spread footings. Similar retaining walls will be required for the new structure.

### 1. Abutments and Pier Foundations for New Structure and Related Retaining Walls between Two Structures

The proposed new bridge structure may be supported on spread footings in a manner similar to the existing bridge on Hwy. 400. The following measures should be taken into consideration for the abutment, pier and related retaining walls construction:

- footings for abutments and pier should be at the existing foundation level of 184.9 metres;
- during excavation, care must be taken to prevent undermining of the existing foundation;
- if, during excavation, the material at the footing level adjacent to the existing foundation appears to soften and/or be disturbed, it should be carefully excavated and replaced with mass concrete;
- normal construction joints with dowels should be used to fasten together the footings;
- footings must have a minimum earth cover of 1.2 m for frost protection.

For purposes of the O.H.B.D.C. the following design values are recommended:

Factored Bearing Capacity at U.L.S. 1000 kPa

Bearing Capacity at S.L.S. Type II will not be governed since the subsoil is an unyielding type.

2. Retaining Walls Foundations for the Approaches on the West Side

The retaining walls for the new structure #1 should be founded on spread footings constructed within the very stiff to hard clayey silt deposit at or below the elevation of 186.0 metres. Normal construction joints with dowels should be used to fastened together the footings. A minimum of 1.2 metres of soil should be placed over the footings to serve as frost protection.

For the purposes of the O.H.B.D.C., the following design values are recommended:

Factored Bearing Capacity at U.L.S. 450 kPa

Bearing Capacity at S.L.S. Type II 300 kPa

3. Other Construction Considerations

Backfill to abutments and retaining walls should consist of Granular 'A' or Granular 'B' for which the following properties are recommended:

Granular 'A'  $\gamma = 22.8 \text{ kN/m}^3$   $\phi = 35^\circ$   $K_A = 0.27$

Granular 'B'  $\gamma = 21.2 \text{ kN/m}^3$   $\phi = 30^\circ$   $K_A = 0.33$

Lateral pressures should be computed in accordance with Section 6.6.1.2.1 of the code. A yielding foundation condition may be assumed. Sliding resistance may be computed by assuming an adhesion of 75 kPa to apply between the underside of footings and the soil.

Since the water level is approximately 1.5 metres below the proposed foundation level and the foundation soil is of low permeability, dewatering problems are not anticipated. If surface water does accumulate in the excavation, it should

be removed by means of a sump pump.

Approach fills and cuts should be constructed with standard 2:1 side and forward slopes in which even in general no major stability problems are anticipated. The new fill should be keyed into the existing fill as per MTO Standards. The new fill will be added to the existing fill on the west side of approaches. Some differential settlement can be anticipated between the consolidated portion of existing fill and new fill. In view of this, it is suggested that the new fill should be left in place as long as possible in order to minimize differential movement prior to paving operations. The settled portion of the embankment should be brought up to grade with fill material prior to commencement of paving.

#### MISCELLANEOUS

The fieldwork for this investigation was carried out during the period of 87-12-14 to 87-12-17 under the supervision of Tae C. Kim. The equipment was owned and operated by Master Soil Investigation Toronto.

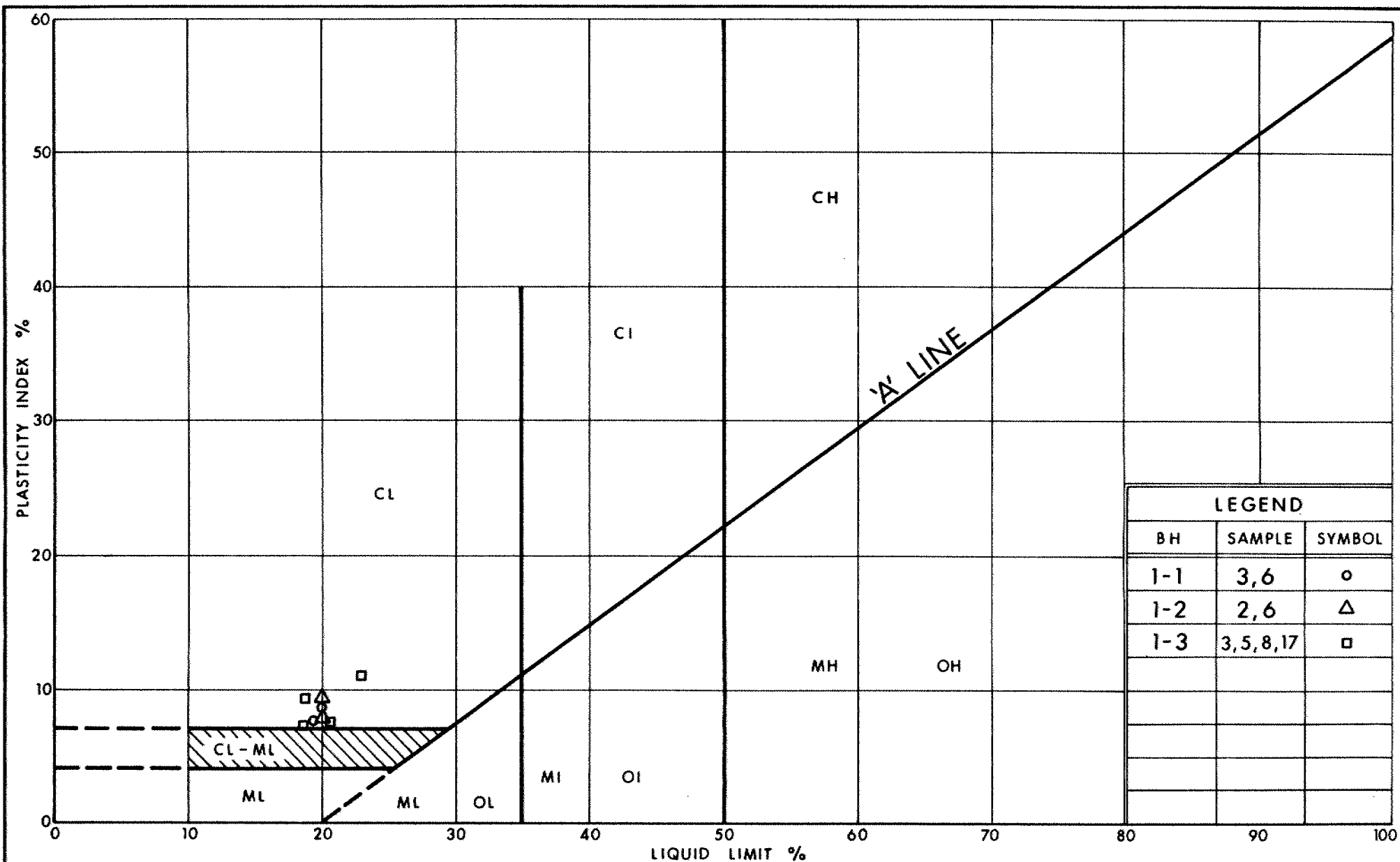
This report was written by T.C. Kim, Foundation Engineer and reviewed by M. Devata, Chief Foundation Engineer (East).



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

*Murty Devata*  
Murty Devata, P.Eng.  
Chief Foundation Engineer  
(East)

## APPENDIX



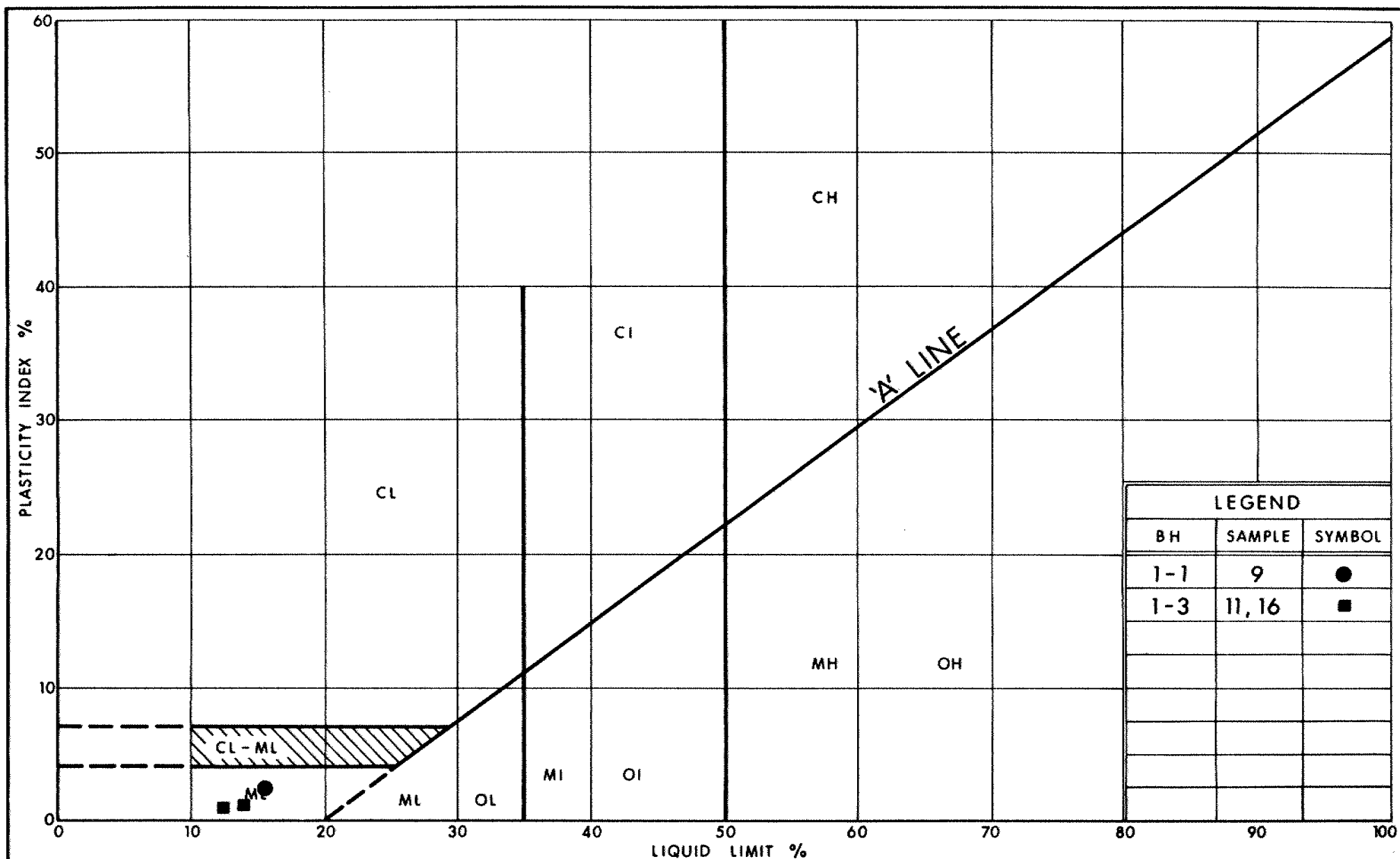
Ministry of  
Transportation

Ontario

# PLASTICITY CHART CLAYEY SILT TO SILT

FIG No 1

W P 138-87-02



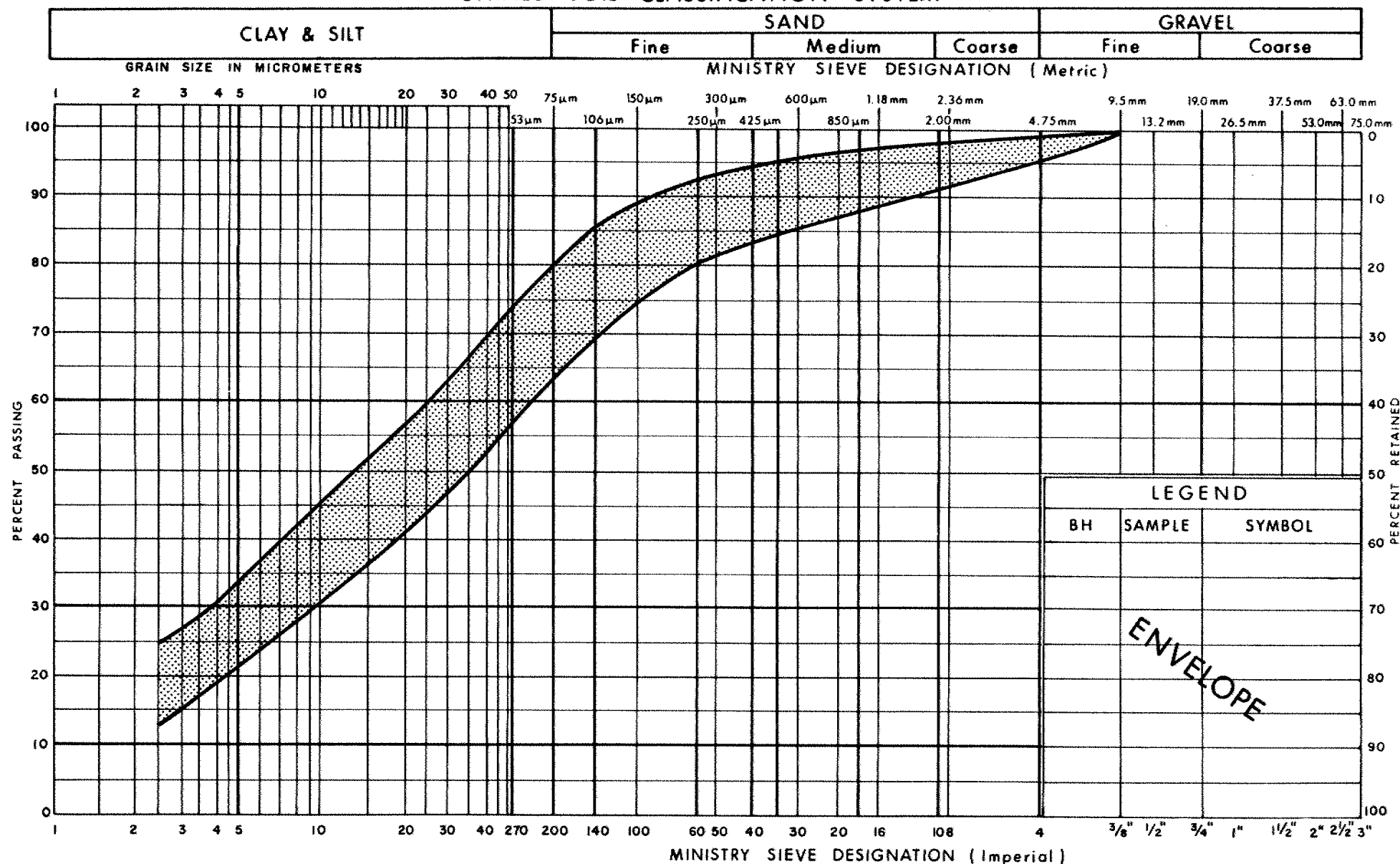
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Transportation

# PLASTICITY CHART SANDY SILT TO SILTY SAND

FIG No 2

W P 138-87-02

## UNIFIED SOIL CLASSIFICATION SYSTEM



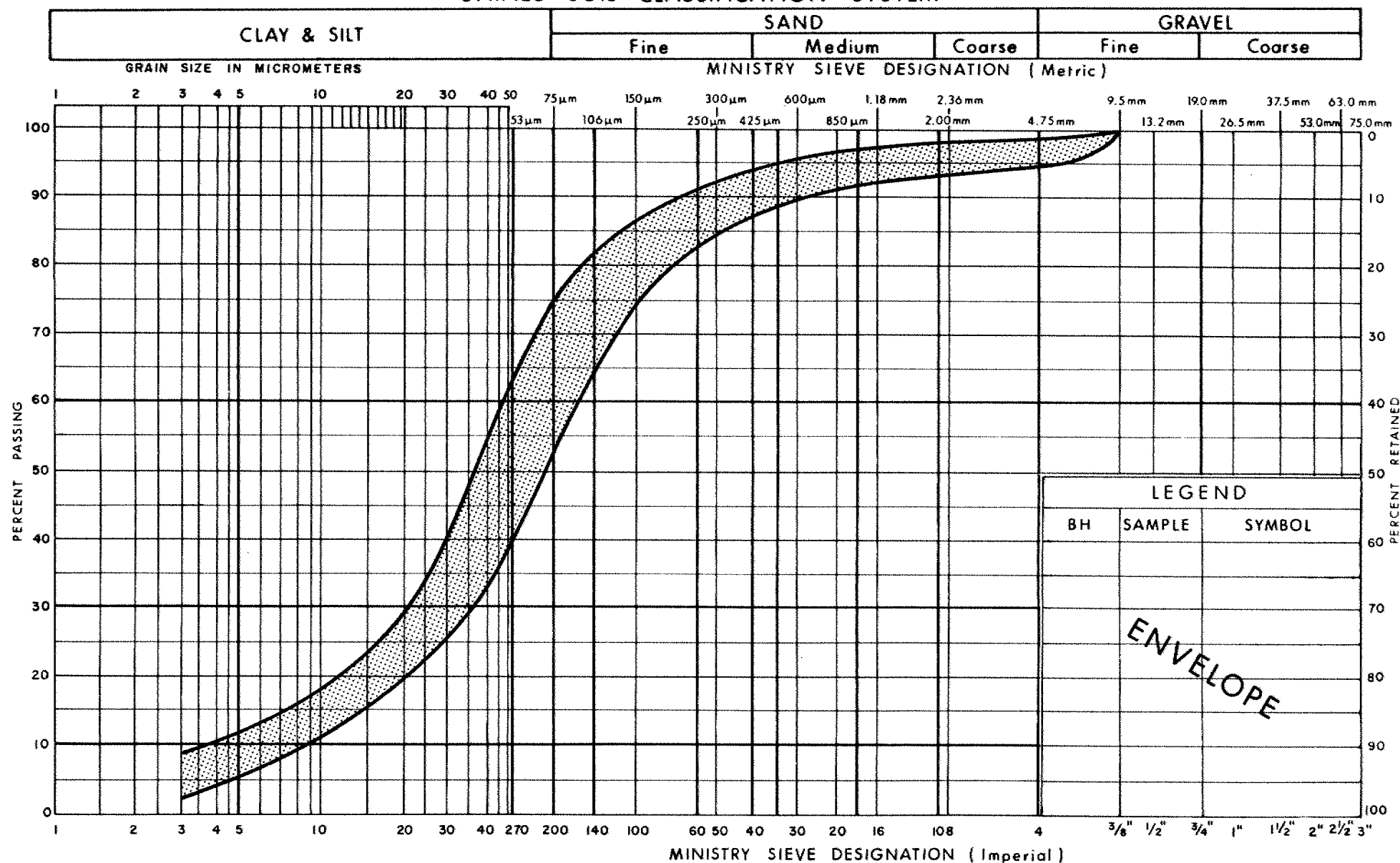
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## GRAIN SIZE DISTRIBUTION CLAYEY SILT TO SILT

FIG No 3

W P 138-87-02

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation

GRAIN SIZE DISTRIBUTION  
SANDY SILT TO SILTY SAND

FIG No 4

W P 138-87-02



## 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

### MECHANICAL PROPERTIES OF SOIL

$m_v$	$\text{kPa}^{-1}$	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	$\text{m}^2/\text{s}$	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
$S_f$	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

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



# RECORD OF BOREHOLE No 1

METRIC

W P 138-87-02 LOCATION Coordinates N 4 847 842.0; E 301 951.0 ORIGINATED BY MD  
DIST 6 HWY 400 BOREHOLE TYPE Washbore & Cone Test COMPILED BY  
DATUM Geodetic DATE 1959 06 11 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					
189.4	Ground Level																
0.0	Clayey Silt (Fill)																
188.2																	
1.2	Clayey Silt to Silt With Sand, Trace of Gravel Occasional Silty Sand Layers Hard (Glacial Till)		1	SS	48		188									23.6	
			2	SS	60		186									24.6	
			3	SS	155											24.4	
			4	SS	110		184									22.9	
			5	SS	151												
181.8			6	SS	160		182										
7.6			7	SS	167		180										
			8	SS	160												
			9	SS	160		178										
			10	SS	170											25.5	
			11	SS	-		176										
			12	SS	160		174										
173.5																	
15.9	Sand with Gravel Very Dense						172										
170.8			13	SS	135												
18.6	End of Borehole																
	<p><u>NOTE:</u> This borehole was done prior to construction of existing bridge. Therefore soil information above Elev. 185± does not apply.</p>																

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

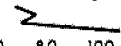
20  
15 5 (%) STRAIN AT FAILURE  
10



# RECORD OF BOREHOLE No 5

METRIC

W P 138-87-02 LOCATION Co-Ords N 4 847 874.0; E 301 932.0 ORIGINATED BY KM  
DIST 6 HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY KM  
DATUM Geodetic DATE 81 02 10 CHECKED BY \_\_\_\_\_

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 					UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
186.3	Ground Level													
0.0							186							
	Clayey Silt to Silt		1	SS	70	*								
			2	SS	100/	28 cm								
	Some to <u>Brown</u>		3	SS	100/	20 cm	184							
	Trace of Sand <u>Grey</u>		4	SS	49									
	Trace of Gravel		5	SS	97		182							
	Occ. Silty Sand Layers		6	SS	59									
	Hard (Glacial Till)													
180.1			7	SS	100/	20 cm	180							
6.2	Sandy Silt													
178.2	Very Dense		8	SS	100/	20 cm								
8.1	End of Borehole													2 40 50 8
	* W.L. Not Established													

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

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



# RECORD OF BOREHOLE No 7

METRIC

W P 138-87-02 LOCATION Co-ords N 4 847 825.0; E 301 945.0 ORIGINATED BY KM  
DIST 6 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY KM  
DATUM Geodetic DATE 81 02 10-11 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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
188.4	Ground Level																
0.0	Clayey Silt to Silt With Sand and Gravel Occ. Silty Sand Layers Very Stiff to Hard (Glacial Till)		1	SS	19	*	188										
			2	SS	34												
			3	SS	52		186										
			4	SS	100/	15 cm											
			5	SS	100/	25 cm											
			6	SS	44		184										
			7	SS	100/	13 cm											
182.3			8	SS	100/	20 cm	182										
6.1	Sandy Silt to Silty Sand Very Dense		9	SS	100/	15 cm											1 60 36 3
			10	SS	100/	10 cm											2 35 59 4
							180										1 42 52 5
178.8	Brown Grey		11	SS	100/	28 cm											9 35 56 0
9.6	End of Borehole																
	* W.L. Not Established																

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 1-1

METRIC

W P 138-87-02 LOCATION Co-ords. N 4 847 820.5; E 301 932.7 ORIGINATED BY TCK  
 DIST 6 HWY 400 BOREHOLE TYPE HS Auger and Cone Test COMPILED BY TCK  
 DATUM Geodetic DATE 1987 12 17 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						
188.2	Ground Level													GR SA SI CL
0.0	Silty Clay		1	SS	12		188							
	Clayey Silt to Silt with Sand		2	SS	11									
	Trace of Gravel		3	SS	30									4 29 51 16
	Occ. Silty Clay and Silty Sand Layers		4	SS	55									
	Brown Grey		5	SS	25									
	Stiff to Hard (Glacial Till)		6	SS	44									5 20 57 18
			7	SS	46									
182.0	Sandy Silt to Silty Sand		8	SS	107		182							
6.2	Trace of Clay and Gravel		9	SS	125									
	Brown Grey													
	Very Dense													2 23 70 5
178.6	End of Borehole		10	SS	128		180							
9.6														

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 1-2

METRIC

W P 138-87-02 LOCATION Co-ords. N 4 847 859.0; E 301 930.0 ORIGINATED BY TCK  
 DIST 6 HWY 400 BOREHOLE TYPE HS Auger and BX Casing and Cone Test COMPILED BY TCK  
 DATUM Geodetic DATE 1987 12 16 & 17 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					
186.9	Ground Level																GR SA SI CL
0.0	Silty Clay (Fill)		1	SS	8		186										
185.5			2	SS	34												5 33 48 14
1.4	Brown Silty Sand		3	SS	200	10 cm											
	Grey Clayey Silt to Silt with Sand		4	SS	67		184										
	Trace of Gravel		5	SS	87												
	Occ. Silty Sand Layers		6	SS	70	87 12 17	182										2 16 63 19
	Hard (Glacial Till)		7	SS	74												
179.8			8	SS	100		180										
7.1	Sandy Silt to Silty Sand		9	SS	86		178										2 46 51 1
			10	SS	119												
	Brown Sand with Some Gravel		11	SS	43		176										10 81 8 1
	Trace of Clay and Gravel		12	SS	108		174										
172.7	Very Dense		13	SS	127												
14.2	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

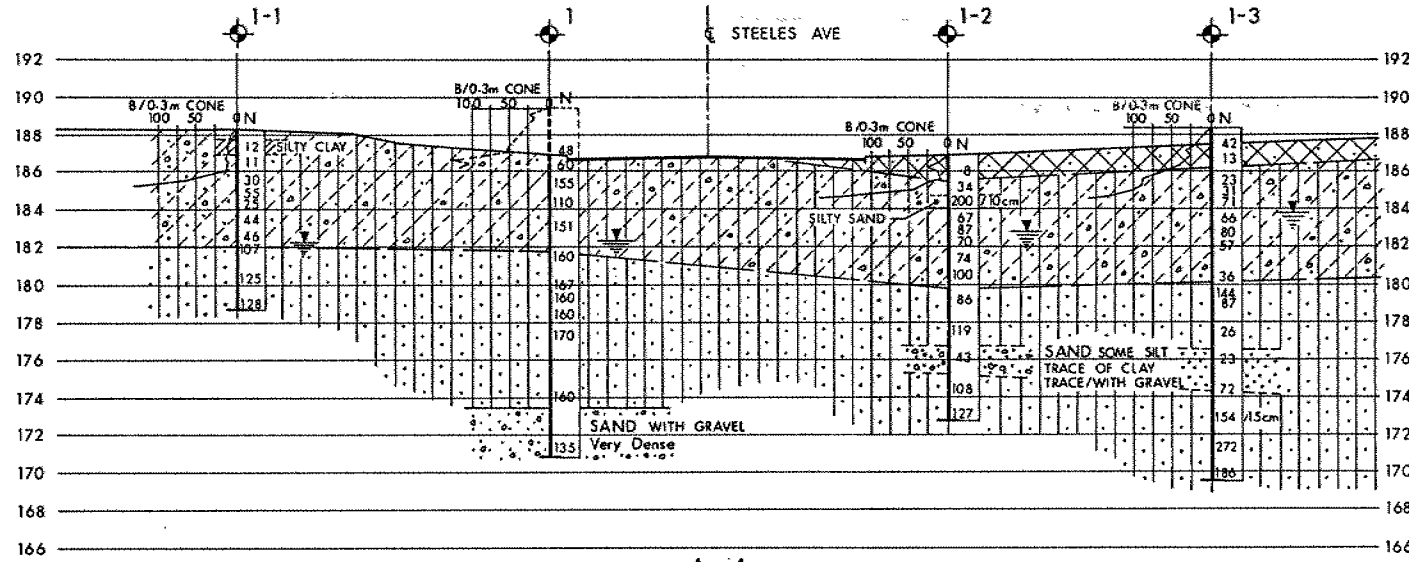
# RECORD OF BOREHOLE No 1-3

METRIC

W P 138-87-02 LOCATION Co-ords N 4847 870.5; E 301 918.5 ORIGINATED BY TCK  
 DIST 6 HWY 400 BOREHOLE TYPE HS Auger and Cone Test COMPILED BY TCK  
 DATUM Geodetic DATE 1987 12 14 and 16 CHECKED BY \_\_\_\_\_

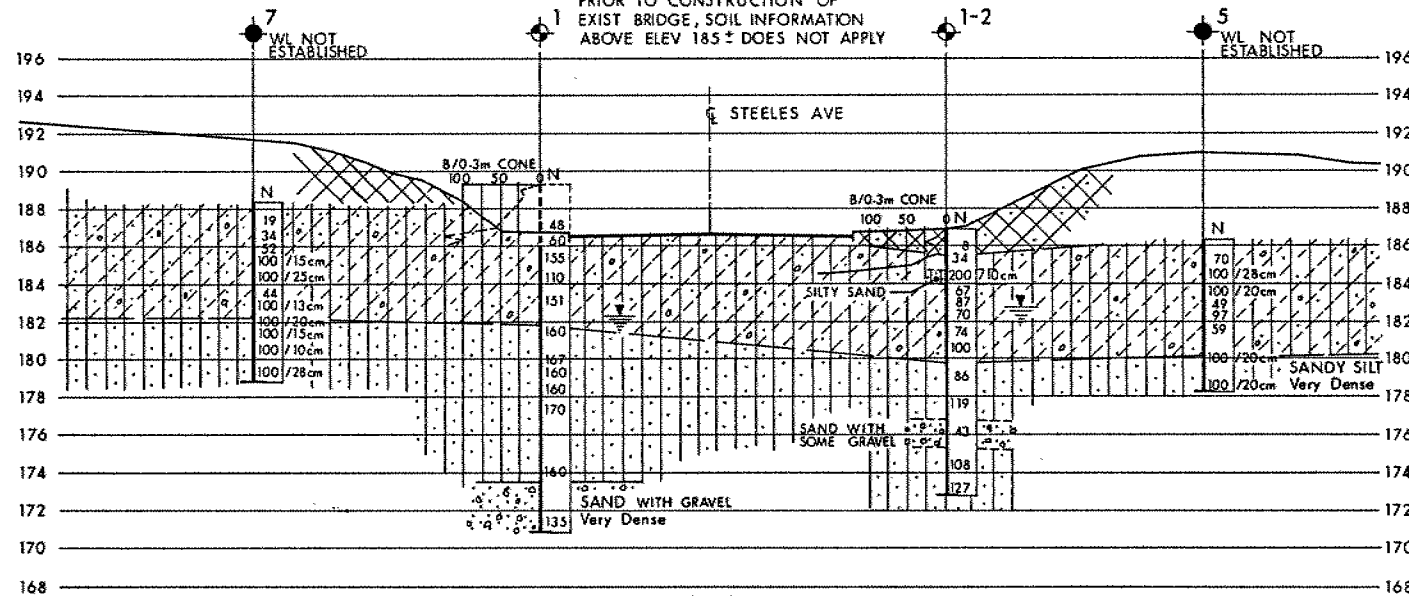
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa						WATER CONTENT (%)		
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE						10 20 30		
188.3	Ground Level													GR SA SI CL			
0.0	Silty Clay (Fill)		1	SS	42		188										
186.2			2	SS	13		186										
2.1	Clayey Silt to Silt With Sand Trace of Gravel Occ. Silty Sand Layers Very Stiff to Hard (Glacial Till)		3	SS	23		184							4 28 48 20			
			4	SS	31												
			5	SS	71									2 29 55 14			
			6	SS	66												
			7	SS	80												
			8	SS	57									4 24 62 10			
180.1	Brown		9	SS	36		180										
8.2	Grey		10	SS	144												
			11	SS	87									3 43 53 1			
			12	SS	26												
	Grey Brown Sand Some Silt Trace of clay and Gravel		13	SS	23												
	Grey		14	SS	72									3 83 13 1			
	Sandy Silt to Silty Sand Trace of Gravel and Clay		15	SS	154/	15 cm											
	Compact to Very Dense		16	SS	272									6 36 49 9			
169.5			17	SS	186		170							4 23 52 24			
18.8	End of Borehole																

NOTE  
BH 1 WAS DONE IN 1959  
PRIOR TO CONSTRUCTION OF  
EXIST BRIDGE, SOIL INFORMATION  
ABOVE ELEV 185+ DOES NOT APPLY



A-A

NOTE  
BH 1 WAS DONE IN 1959  
PRIOR TO CONSTRUCTION OF  
EXIST BRIDGE, SOIL INFORMATION  
ABOVE ELEV 185+ DOES NOT APPLY



B-B

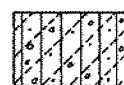
SECTIONS

SCALE  
4m 2 0 4m

SOIL STRATIGRAPHY LEGEND



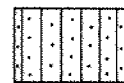
CLAYEY SILT  
(FILL)



CLAYEY SILT TO SILT  
TRACE TO WITH SAND  
TRACE OF GRAVEL  
OCC SILTY CLAY & SILTY SAND LAYERS  
Very Stiff to Hard  
(GLACIAL TILL)



SILTY CLAY  
(FILL)



SANDY SILT TO SILTY SAND  
TRACE OF GRAVEL & CLAY  
Compact to Very Dense

**METRIC**

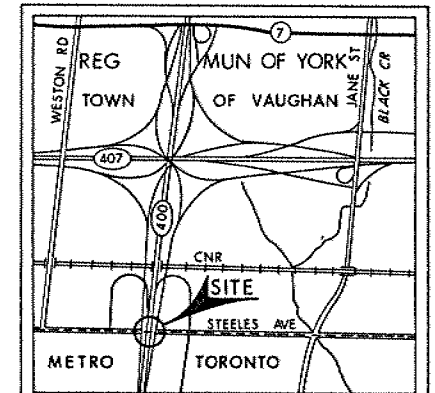
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES UNLESS  
OTHERWISE SHOWN. STATIONS  
IN KILOMETRES + METRES.

CONT No  
WP No 138-87-02

RAMP 407EW TO 400S  
OVER STEELES AVE (BRIDGE-1)  
BORE HOLE LOCATIONS & SOIL STRATA



SHEET



KEY PLAN  
SCALE  
0.5km 0 0.5km

LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation  
59 06, 81 02 and 87 12

		No	ELEVATION	CO - ORDINATES	
				NORTH	EAST
59 06	{	1	189.4	4 847 842.0	301 951.0
81 02		5	186.3	4 847 874.0	301 932.0
	{	7	188.4	4 847 825.0	301 945.0
		1-1	188.2	4 847 820.5	301 932.7
87 12	{	1-2	186.9	4 847 859.0	301 930.0
		1-3	188.3	4 847 870.5	301 918.5

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

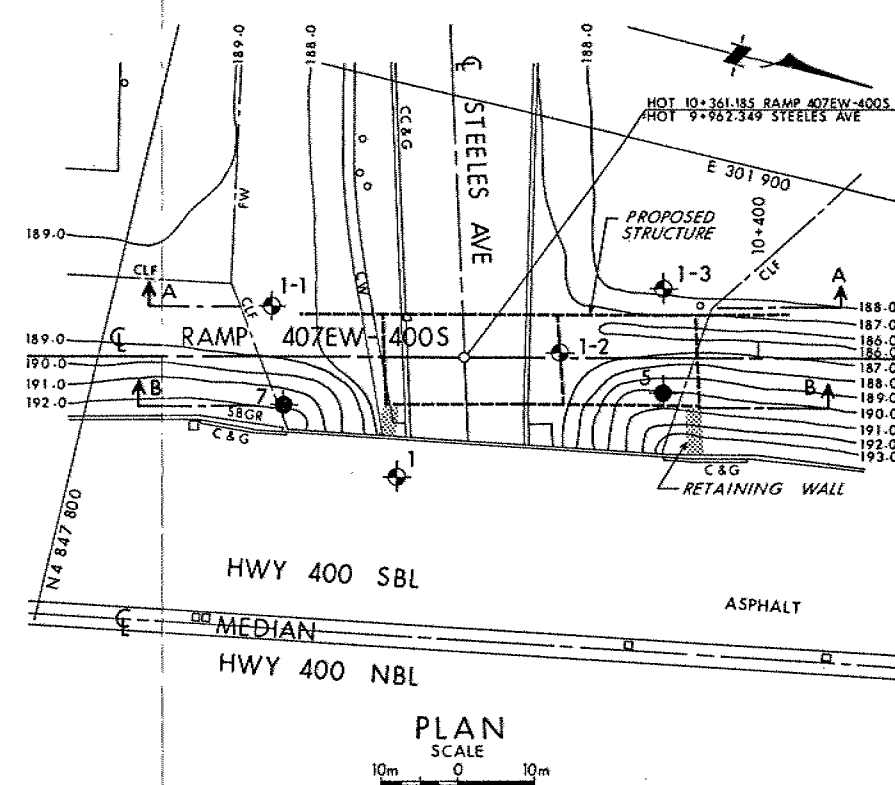
NOTE: The complete foundation investigation and design report for  
this project and other related documents may be examined at the  
Engineering Materials Office, Downsview. Information contained in  
this report and related documents is specifically excluded in  
accordance with the conditions of Section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

REV	DATE	BY	DESCRIPTION

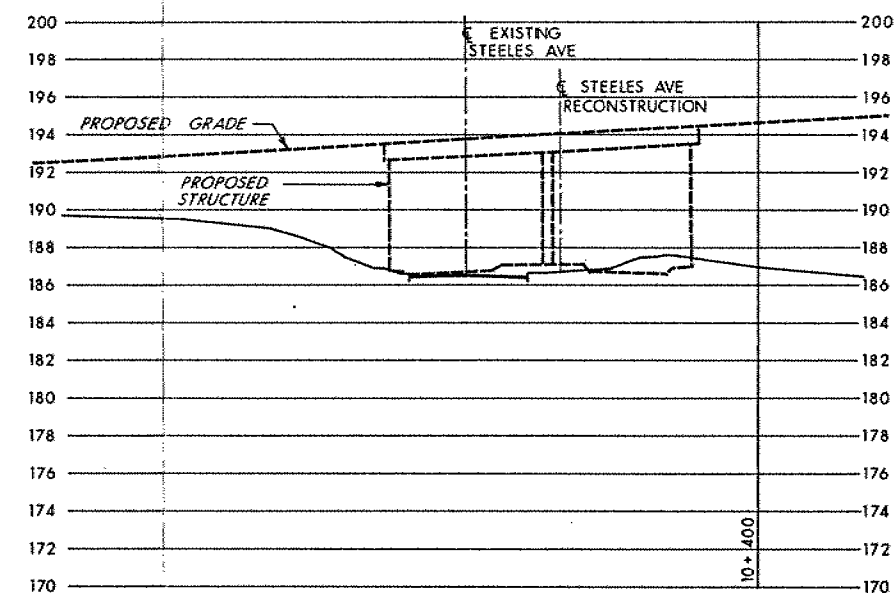
Geocres No 30M13-78

HWY No 400	DIST 6
SUBMITTAL CHECKED	DATE 88 05 05
DRAWN DT CHECKED	APPROVED
	SITE 37-1169
	DWG 1388702-A

REF No E-73-400-3, 88 01



PLAN  
SCALE  
10m 0 10m



PROFILE RAMP 407EW-400S

SCALE  
10m 5 0 10m Hor  
4m 2 0 4m Vert



# memorandum



To: G. Al-Bazi  
Design Engineer  
Structural Office

Date: 1989 03 30

From: Foundation Design Section  
Room 315, Central Building

Re: Steeles Ave. Ramp 407EW - 400S  
W.P. 138-87-02, Site 37-1169  
District 6, Toronto

Further to your memo on 1989 03 13, this letter summarizes our review on the submitted final drawings and provisions.

Based on our review, it is concluded that the designer generally complied with our recommendations. However, it should be noted Section 4.9 Frictional Backfill be revised to reflect the recent agreement between the Ministry and the Reinforced Earth Company of Canada Ltd.

We have no further comments. If you have any questions, please contact us.

A handwritten signature in cursive script, reading "Tae C. Kim".

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

For:

M. S. Devata, P. Eng.  
Chief Foundation Engineer

MSD/TCK:jb

# memorandum



Tel: 3731

To: G.C.E. Burkhardt  
Head, Structural Section  
5000 Yonge Street

Date: 1988 03 14

Atten: J.K. Lam, Sr. Structural Engineer

From: Foundation Design Section  
Room 315, Central Building

RE: Foundation Investigation for  
Ramp 407 EW to Highway 400 S  
Over Steeles Avenue  
Structure #1  
W.P. 138-87-02, Site 37-1169  
District 6, Toronto

The fieldwork for the foundation investigation for the above-noted project has been completed.

As you have requested, this memo provides a summary of subsurface conditions and recommendations which will permit this project to proceed. The complete foundation investigation and design report will be forwarded to you at a later date. However, if additional information is required, please contact this office immediately.

## Site Description

The site is located immediately west of Highway 400 where it crosses Steeles Avenue. The existing structure will be lengthened easterly and a new rigid frame structure will be constructed north and parallel to the existing structure. At this location Steeles Avenue and Highway 400 have elevations between 186.5 and 193.0 m respectively. The existing bridge over the Steeles Avenue (Structure #2) is a 21.3 x 43.5 metre single span rigid frame bridge constructed with earth embankments up to 6.5 metres in height. Topography is moderately level ground. Land use is mainly for industrial purposes.

## Subsurface Conditions

The subsoil conditions encountered across the site were generally uniform consisting primarily of two distinct deposits. The upper layer consists of clayey silt to silt with sand and a trace of gravel which extends down to the elevations between 179.8 m at B.H. # 1-2 and 182.0 m at B.H. #1-1 as shown on the sections attached. The thickness of this layer varies between 4.0 m at B.H. #1-1 location and 7.2 m at B.H. #1-2 location. Underneath this clayey silt to silt, very dense silty sand to sandy silt with occasional sand layers is present. Approximately 11.0 metres of this very dense material was proven. These deposits are of glacial origin. The embankments of the existing Hwy. 400 are composed of approximately 6.5 metres of sand and clayey silt fill materials.

.....2

Groundwater level in the borings was found to range between elevation 182.2 m at B.H. #1-1 and elevation 183.8 at B.H. #1-3 about 4.5 metres below the original ground surface.

There are pockets of silt and sand within overburden which are water bearing and exhibit a tendency to boil under conditions of unbalanced hydrostatic head.

#### Recommendations

The recommendations in this report apply to the bridge structure, the retaining walls and related approaches.

Bridge #1 is from Ramp Hwy. 407 E.W. to Hwy. 400 S over Steeles Avenue. A 2-span structure with related retaining walls is proposed and this will be located parallel to the existing Hwy. 400 and some 5 m west of the highway.

The existing bridge for Hwy. 400 at Steeles Avenue crossing is founded on spread footings approximately 1.0 metre thick. The base of the footings are located at about elevation 184.9 m. There is approximately 1.2 metres of soil cover over the top of the footings.

Associated retaining walls for the existing structure are founded on stepped spread footings. Similar retaining walls will be required for the new structure.

#### 1. Foundations for New Structure and Related Retaining Walls between Two Structures

The proposed new bridge structure may be supported on spread footings in a manner similar to the existing bridge on Hwy. 400. The following measures should be taken into consideration for the abutment, pier and related retaining wall construction:

- footings should be at the existing foundation level of 184.9 metres
- during excavation, care must be taken to prevent undermining of the existing foundation
- if, during excavation, the material at the footing level adjacent to the existing foundation appears to soften and/or be disturbed, it should be carefully excavated and replaced with mass concrete.
- footings must have a minimum earth cover of 1.2 m for frost protection.

For purposes of the O.H.B.D.C. the following design values are recommended:

Factored Bearing Capacity at U.L.S.: 1000 kPa

Bearing Capacity at S.L.S. Type II will not be governed since the subsoil is an unyielding type.

2. Retaining Wall Foundations for the  
Approaches on the West Side

The retaining walls for the new structure #1 should be founded on spread footings constructed within the very stiff to hard clayey silt deposit at or below the elevation of 186.0 metres. Normal construction joints with dowels should be used to fastened together the footings. A minimum of 1.2 metres of soil should be placed over the footings to serve as frost protection.

For purposes of the O.H.B.D.C., the following design values are recommended:

Factored Bearing Capacity at U.L.S.: 450 kPa

Bearing Capacity at S.L.S. Type II: 300 kPa

Backfill to abutments and retaining walls should consist of Granular 'A' or Granular 'B' for which the following properties are recommended:

Granular 'A' = 22.8 kN/m<sup>3</sup> / = 35° KA = 0.27

Granular 'B' = 21.2 kN/m<sup>3</sup> / = 30° KA = 0.33

Lateral pressures should be computed in accordance with Section 6.6.1.2.1 of the code. A yielding foundation condition may be assumed. Sliding resistance may be computed by assuming an adhesion of 75 kPa to apply between the underside of footings and the soil.

Since the water level is approximately 1.5 metres below the proposed foundation level and the foundation soil is of low permeability, dewatering problems are not anticipated. If surface water does accumulate in the excavation, it should be removed by means of a sump pump.

Approach fills and cuts should be constructed with standard 2:1 side and forward slopes in which even in general no major stability problems are anticipated.

We believe that this memorandum meets with your present requirements. If you have any questions, please contact us.

  
T.C. Kim, P. Eng.  
Project Foundation Engineer

for

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

TCK/mmj

c.c. - T. Miles (D.S. Lea)  
J. Klowak  
B. Lankinen

