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STR. SITE No. 37-1334

HWY. No. 407

LOCATION Hwy 407 & Hwy 50
Underpass

No of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:



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**foundation
investigation and
design report**

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WP ^{369-87-09/10}
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HWY 407 STR SITE 37-1334

CONT 93-100

Hwy. 407 and Hwy. 50 Underpass

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FOUNDATION INVESTIGATION REPORT

For

Hwy. 407 and Hwy. 50 Underpass
W.P. ^{369-87-09/10} ~~367-87-02~~, Site No. 37-1334
Hwy. 407, District 6, Toronto

INTRODUCTION

This report summarizes the results of a foundation investigation conducted at the aforementioned site. It is proposed to construct a two span structure which will carry Hwy. 50 over the proposed Hwy. 407. This report contains factual information obtained from this investigation pertaining to structural foundations and related earthworks.

SITE DESCRIPTION

The site is located just north of Steeles Avenue west, along the existing four lane Hwy. 50 in the City of Brampton/Town of Vaughan, Regional Municipality of Peel. The site is characterized by a 5 m to 7 m high embankment fill with Hwy. 50 at an elevation of 181 metres and having approach slopes of +2.40% and -1.50%.

The topography of the area consists of rolling grassland with abandoned farmland to the west and east. To the east a large barn and farmhouse which is enclosed by a wire fence exists. Runoff from both fields is carried by a steel corrugated culvert which runs underneath Hwy. 50. The natural ground is at an elevation of 174.2 metres.

Physiographically, the site is located in the geological domain known as the "Peel Plain". The Peel Plain is the product of the advance and retreat of the wisconsinan ice sheet which covered the area during the pleistocene epoch. It consists of a bevelled till plain with a gently undulating rolling surface and limited relief. At some locations, the till is overlain by thin deposits of varved clay.

Till sheets of varying composition comprise the "Peel Plain". Generally, the surficial till sheets exhibit a cohesive behaviour whilst the lower till sheets are cohesionless. As characteristics of till material, these deposits contain a wide range of grain size ranging from boulders to clay.

The till sheets are usually separated from one another by interbeds of stratified silt or sand of variable thickness. Bedrock in the area has been found at depths ranging from 25 to 30 m below ground surface and consists of interbedded shale and limestone of the Dundas-Meaford Formation, Ordovician period.

INVESTIGATION PROCEDURES

Soil data and inherent properties were obtained by in situ and laboratory testing. The procedures employed are discussed below.

FIELD INVESTIGATION

The fieldwork for the investigation was carried out between 90 09 17 to 90 09 27 and consisted of six sampled boreholes which were advanced to a maximum depth of 20.3 m below the ground surface. Three boreholes were located on the west shoulder and three boulders on the east shoulder. Boreholes were placed to correspond to abutment and pier locations for the Hwy. 50 underpass.

The elevations of the boreholes advanced at the site at the embankment crest varied from 178.9 m to 180.6 m. One borehole located at the toe of the embankment was at an elevation of 174.2 metres.

In general, subsoil samples were retrieved at 0.7 m intervals for the top 6 m and at 1.5 m intervals thereafter. Disturbed subsoil samples were retrieved by a split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586). Relatively undisturbed samples were also randomly retrieved using a shelby tube sampler in accordance with Standard Practice (ASTM D1587). In situ vane tests were also conducted between the aforementioned sampling intervals to determine the undisturbed and remolded undrained shear strengths of the cohesive deposits. The vane shear test was conducted employing the standard MTO 'N' value in accordance with ASTM D2573.

All subsoil samples were identified in the field and returned to the laboratory for further examination and applicable testing.

Water levels were monitored throughout the duration of the investigation in open boreholes. All boreholes were backfilled upon completion of the fieldwork.

Survey information related to the location and elevation of boreholes was provided by Giffels Engineering Consultants under contract with Central Region Surveys and Plans.

LABORATORY ANALYSIS

The following laboratory tests were carried out on select soil samples.

- 1) Atterberg Limit Tests
- 2) Grain Size Distribution
- 3) Unit Weights
- 4) Natural Moisture Contents

Laboratory test results are given in the following section of this report and are illustrated on Figures and Borehole Logs included in the Appendix.

SUBSURFACE CONDITIONS

General

The subsoil stratigraphy consisted of various layers of cohesive and non-cohesive materials overlain by the existing fill embankment which extends approximately 5-7 metres deep. The fill can be classified as containing random mixtures of clay, silt, sand and gravel. A trace of organics was encountered at the surface of the native soils. The native soils underlying the above fill material consisted of a 0-4.5 m layer of cohesive heterogeneous mixture of clayey silt, sand and gravel (Glacial Till), 0.7 m to 4.6 m of a sandy silt to silt, another underlying layer of a 3 to 11.7 m Glacial Till but consisting of a non-cohesive heterogeneous mixture of sandy silt, clay and gravel and a layer of silt, some clay, trace sand. While the fill material remained basically uniform throughout the site the natural stratigraphy towards the north contained less of the cohesive till and the silt layers until neither was encountered at the most

northern boreholes. These boreholes had predominantly more of the non-cohesive Glacial Till. Occasional boulders and cobbles were encountered at lower depths.

The plan and location of borings and the stratigraphical profile are shown on Drawing No. 3678702-A in the attached Appendix. The field and laboratory test results are plotted on the Record of Borehole sheets also included in the Appendix of this report. A brief description of the different soil types is given below.

Random Mixture of Clay, Silt, Sand and Gravel (Fill)

The surficial material at the site consists of approximately 4-7.0 m of a random mixture of clay, silt, sand and gravel (Fill) in all boreholes within the fill embankment, primarily down to an elevation of 174.5 m.

Grain Size Distribution Test results are shown on Figure 1 in the Appendix, in an envelope form. The above figure confirms the presence of a varying mixture of clay, silt, sand and gravel. The deposit is comprised of 4-54% gravel, 20-37% sand, 16-67% silt and 6-27% clay.

The results from the Atterberg Limit Tests performed on the fine fraction of this report is summarized as follows:

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	6-14.5	9
Liquid Limit (w_L)	17-42	8
Plastic Limit (w_p)	12-26	8
Plastic Index (I_p)	5-16	8

From the Plasticity Chart (Figure 2), the layer can be classified as being non-plastic. Unit weight measurements carried out on samples from this stratum yielded dry unit weights of 17.7 kN/m³ to 21.6 kN/m³.

In this stratum the 'N' values ranged from 8 blows/0.3 m to 44 blows/0.3 m indicating the material ranged from stiff to hard.

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

Underlying the above fill is a 0-4.5 m layer of cohesive heterogeneous mixture of clayey silt, sand and gravel (Glacial Till) extending down to approximately an elevation of 172 m at south abutment and pier locations. This layer was not encountered in the most northern boreholes.

Results of Grain Size Distribution Tests on this deposit are shown on Figure 3 in the Appendix, in an envelope form. From the above figure it is evident that the layer can be classified as a well-graded mixture of sands, gravels, clays and silts. The deposit is comprised primarily of 3-9% gravel, 24-34% sand, 39-53% silt, and 15-28% clay.

The results from the Atterberg Limit Tests performed on the fine fraction of this report is summarized as follows:

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	10.5-14	4
Liquid Limit (w_L)	23-34	4
Plastic Limit (w_p)	13-19	4
Plastic Index (I_p)	10-15	4

From the plasticity chart (Figure 4), the layer can be classified as having medium plasticity. Unit weight measurements carried out on samples from this strata yielded dry unit weights of 21.3 kN/m³ to 21.9 kN/m³.

Standard Penetration Tests carried out in this deposit revealed 'N' values ranging from 19 blows/0.3 m to 55 blows/0.3. Based on these 'N' values, the material can be described as having very stiff to hard consistency.

Sandy Silt to Silt

Throughout the site underlying the two deposits described above is a 0.7 m to 4.6 m layer of non-cohesive sandy silt to silt.

Results of Grain Size Distribution tests carried out on select samples are shown on Figure 5 in the Appendix, in an envelope form. From the above figure the layer can be classified as containing a great proportion of silt and some sand. The deposit is comprised primarily of 0-5% gravel, 3-39% sand, 49-87% silt, and 9-14% clay.

The results from the Atterberg Limit Test performed on the fine fraction of this material is summarized as follows:

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	7-22.5	3
Liquid Limit (w_L)	16-22	3
Plastic Limit (w_p)	13-16	3
Plastic Index (I_p)	3-6	3

From the plasticity chart (Figure 4), the layer can be classified as inorganic silts with fine sands with no plasticity. Unit weight was found to be 20 kN/m³.

Standard Penetration Tests carried out in this deposit revealed 'N' values ranging from 20 blows/0.3 m to 105 blows/0.3 m. Based on these 'N' values, the material can be described as having a compact to very dense relative density.

Heterogeneous Mixture of Sandy Silt, Clay and Gravel

Underlying all the above materials is a layer of non-cohesive heterogeneous mixture of sandy silt, clay and gravel. This layer remains 3-11.7 m thick throughout the south abutment and pier locations but expands significantly down to the limits of our investigation at the north abutment locations. Interbedded at the north boreholes are seams of silt and gravel.

Results of Grain Size Distribution Tests carried out on select samples from this layer are shown in Figure 7 in the Appendix, in an envelope form. From the above Figure it is evident that the layer can be classified as a well-graded mixture of sand, gravel and silt. This deposit contained 1-15% Gravel, 18-52% sand, 36-52% silt, and 5-28% clay.

The results from the Atterberg Limit Tests performed on cohesive material are summarized as follows:

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	7-16	10
Liquid Limit (w_L)	21-32	10
Plastic Limit (w_p)	12-19	10
Plastic Index (I_p)	9-21	10

The plasticity chart is plotted in Figure 8. Unit weight measurements from this strata yielded dry unit weights of 15.7 to 23.5 kN/m³.

Standard Penetration Tests carried out in this deposit revealed 'N' values ranging from 40 blows/0.3 m to 140 blows/0.3 m indicating a dense to very dense state of relative density.

Silt, Some Clay, Trace Sand

The final layer extends from a depth of 11.7 m to 16.2 m down to the subsoil investigation limits of 15.7 m to 20.3 m and is a non-cohesive silt, some clay, trace sand which was encountered only at south abutment and pier locations.

Results of Grain Size Distribution Tests carried out on select samples are shown on Figure 9 in the Appendix, in an envelope form. From the above Figure it is evident that the layer contains a large percentage of silt. The material consisted of 0-67% Gravel, 1-8% Sand, 78-84% silt and 10-15% Clay.

The results from the Atterberg Limit Tests are summarized below:

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	14-19	4
Liquid Limit (w_L)	17-23	4
Plastic Limit (w_p)	14-16	4
Plastic Index (I_p)	3-7	4

The plasticity chart is plotted in Figure 10. Unit weights were found to be 20.8 to 23.3 kN/m³.

Standard Penetrations Tests carried out in this deposit revealed 'N' values of High values >100 blows/0.3 m, indicating a very dense state of relative density.

GROUNDWATER CONDITIONS

Observations of the groundwater level were carried out by measuring the water levels in the open boreholes. Groundwater levels determined at the time of the investigation were approximately at an elevation ranging from 170 m (11 m depth) to 167.5 m (12 m depth) in all borehole, excluding BH 1 which had a watertable level of 158.7 m (14.7 m). Groundwater levels in general, are subject to seasonal fluctuations and hence can vary from the values given in this report.

DISCUSSION AND RECOMMENDATIONS

It is proposed to construct a two span structure which will carry Hwy. 50 over the proposed Hwy. 407. Cuts in the order of magnitude of 8 m will be required at the pier locations as the EBL and WBL will be excavated beneath the existing Hwy. 50. The proposed elevation of Hwy. 407 is approximately 172 m. A plan illustrating the proposed structure is shown on Drawing No. 3678702-A in the Appendix of this report.

The natural ground surface ranged from 179 m to 181 m sloping downward from the north to the south. The centreline elevation of the proposed Hwy. 407 and the modified Hwy. 50 are approximately 172.6 m and 180 m with Hwy. 50 sloping down towards the south.

To facilitate the design and construction of the proposed structure foundations and related earthworks for the approach ramps over Hwy. 407, the following foundation and geotechnical recommendations are provided in the scope of this Report.

- 1) Structure Foundations
- 2) Lateral Earth Pressure
- 3) Slope Stability
- 4) Construction Considerations

- 1) Structure Foundations

Piers - Spread Footings on Native Soil for Pier Structures

Pier foundations shall be designed using shallow spread footings located at or below an elevation of 170 m. The excavation cut for Hwy. 407 and the need for 1.2 m of frost cover places the footing at this elevation. Competent soil conditions were encountered at the above elevation.

Spread footings located on competent native soil shall be designed using design parameters given below.

Table 1 - Spread Footings on Native Soil

	Factored Capacity <u>at U.L.S. (kPa)</u>	Allowable Capacity <u>at S.L.S. Type II (kPa)</u>
Spread Footings	600	400

Capacities based on 3 m footing width at all spread footing locations bearing capacity reductions to account for inclination of loads acting on shallow foundations shall be carried out in accordance with Section 6-7.3.3.5 of the O.H.B.D.C.

Abutments - Pile Foundations with Reinforced Earth

1) Abutment Pile Foundation

A reinforced earth-abutment structure design can be used at the abutment structure locations, with forward slopes.

For this option, it is understood that the bases of the abutment structures would be located at elevations 178.5 to 179.0 m. These structures would be supported on steel H-piles driven to elevations given below:

	<u>Elevation</u>
North Abutment	169 m*
South Abutment	161 m

(*Due to the denseness of the silt layer encountered in the north abutment area, some piles may get impeded at higher elevations)

For purposes of the O.H.B.D.C., the design axial capacity for vertical piles are summarized in table form below:

Table 2 - Axial Capacities - Driven Steel H-Piles

<u>Pile Type</u>	Factored Capacity <u>at U.L.S. (kN)</u>	Bearing Capacity <u>at S.L.S. Type II</u>
HP310x110	1600	1150

The installations of the piles shall be controlled and monitored employing the Hiley Dynamic Driving Formula, driven in accordance with MTO Standards. Assuming an ultimate capacity as tabulated in table below:

Table 3 - Ultimate Capacity Employing
Hiley Dynamic Formula

<u>Pile Type</u>	<u>Ultimate Capacity (kN)</u>
HP310x110	3450

Pile Spacing shall conform with Section 6.8.3.10 of the O.H.B.D.C. Advancement piles should be checked for heaving during pile installation. Lateral loads shall be supported by batter piles. All piles should be provided with standard MTO pile tip reinforcement (DD-3301).

2) Reinforced Earth Walls

Vertical loads from reinforced earth walls shall be supported on shallow spread foundations located to the south in the sandy silt to silt deposit and to the north in a heterogeneous mixture of sandy silt, clay and gravel. Bearing pressures from the design of shallow spread footings are given in the following table:

Table 4 - Bearing Capacities

Bearing Capacity at S.L.S. Type II	Factored Capacity at U.L.S.	Elevation
<u>(kPa)</u>	<u>(kPa)</u>	<u>(m)</u>
200	300	171 m±

Deep piles shall comply with Section 6.8.3.4.2 of the O.H.B.D.C.

The lateral resistance for both vertical and batter piles shall be computed in accordance with Section 6.8.3.8 of the O.H.B.D.C.

The soil used as the fill material for the reinforced earth should be predominantly coarse grained. The fill should be adequately drained to prevent it from becoming saturated.

Lateral Earth Pressures on Structure

Free draining material such as Granular 'A' or Granular 'B' is recommended as appropriate backfill to the abutments to prevent hydrostatic pressure build-up. Design parameters of the soil are given below:

Table 5 - Backfill Properties

	<u>Granular 'A'</u>	<u>Granular 'B'</u>
Angle of Internal Friction (ϕ)	35°	30°
Unit Weight (kN/m ³)	22.8	21.2
*Coefficient of Active Earth		
Pressure (Ka) - S.L.S.	0.27	0.33
- U.L.S.	0.33	0.4
*Coefficient of Earth Pressure		
at Rest (Ko) - S.L.S.	0.43	0.5
- U.L.S.	0.5	0.58

*Horizontal surface backfill only. Appropriate consideration must be given to sloping surface backfill.

The earth pressure coefficient at Rest is to be used in design if the abutment walls are rigid and unyielding. The tabulated earth pressure coefficients are applicable to horizontal surfaces only. The values must be modified to represent sloping surfaces. Weep holes in the abutment walls should be designed to drain any accumulation of water in the backfill.

3) Slope Stability

Cuts in the order of 9 m +/- 1 m would be involved in the area of the proposed Hwy. 407 at Hwy. 50. Temporary excavation at the Hwy. 407/Hwy. 50 crossing

shall be carried out using 2H:1V side slopes. Outside the limits of the Hwy. 50 embankment, the cuts will be approximately 3.2 metres deep. Permanent cuts in connection with the Hwy. 407 construction shall be 2H:1V or flatter.

4) Construction Consideration

All pile caps and footings shall be protected against frost by providing a minimum 1.2 m of earth cover.

While currently no dewatering problems are anticipated for the construction of pile caps or footings, a high water table and the presence of non-cohesive silts and sand could make it necessary to apply dewatering techniques.

Within the limits of any approach fills, if soft soil is encountered, this should be excavated and replaced by compacted granular fill. Carry out excavation for Hwy. 407 prior to construction of footing.

The excavated base is susceptible to disturbance due to construction traffic and ponded water. It is therefore recommended that the excavated base should be protected using compacted granular fill or lean concrete.

Heavy compaction equipment should not be used behind the abutment/retaining walls within a lateral distance equal to the current height of fill above the wall footing in order to avoid imposing damage or deflection to the wall during the fill placement.

Even though boulders were not encountered in the boreholes carried out at this site, based on geological evidence cobbles and boulders should be expected in the upper and lower till deposits.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of M. Michalek, Jr. Foundation Engineer, utilizing equipment owned and operated by Archer Drilling and Master Soil Investigation.

The project was carried out under the general supervision of Dr. B. Iyer, Sr. Foundation Engineer. The report was written by M. Michalek, reviewed by Dr. B. Iyer and approved by Mr. M.S. Devata, Chief Foundation Engineer.

M. Michalek

M. Michalek, P.Eng.
Jr. Foundation Engineer



M.S. Devata

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

APPENDIX

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

STRESS AND STRAIN

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

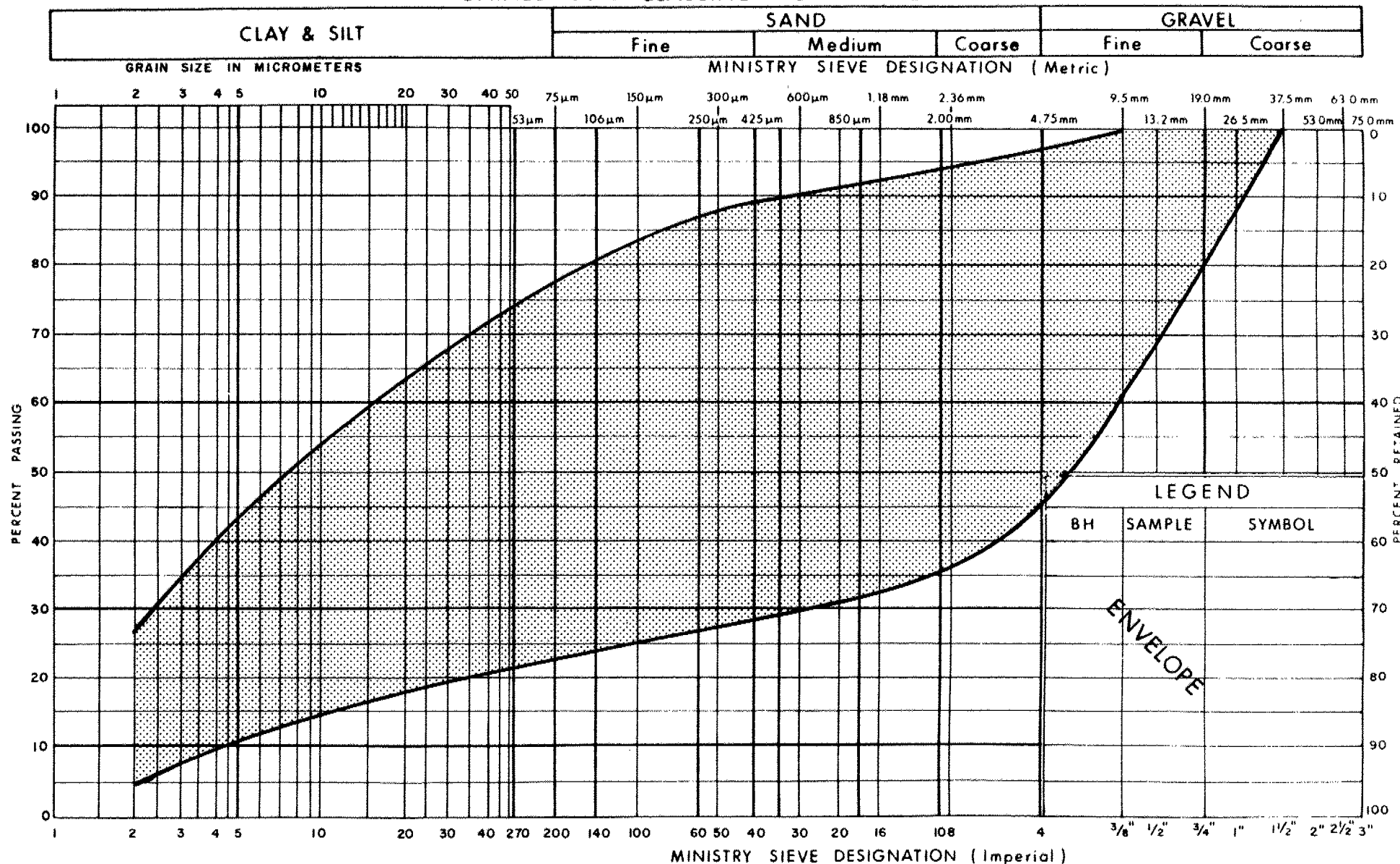
MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

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

UNIFIED SOIL CLASSIFICATION SYSTEM



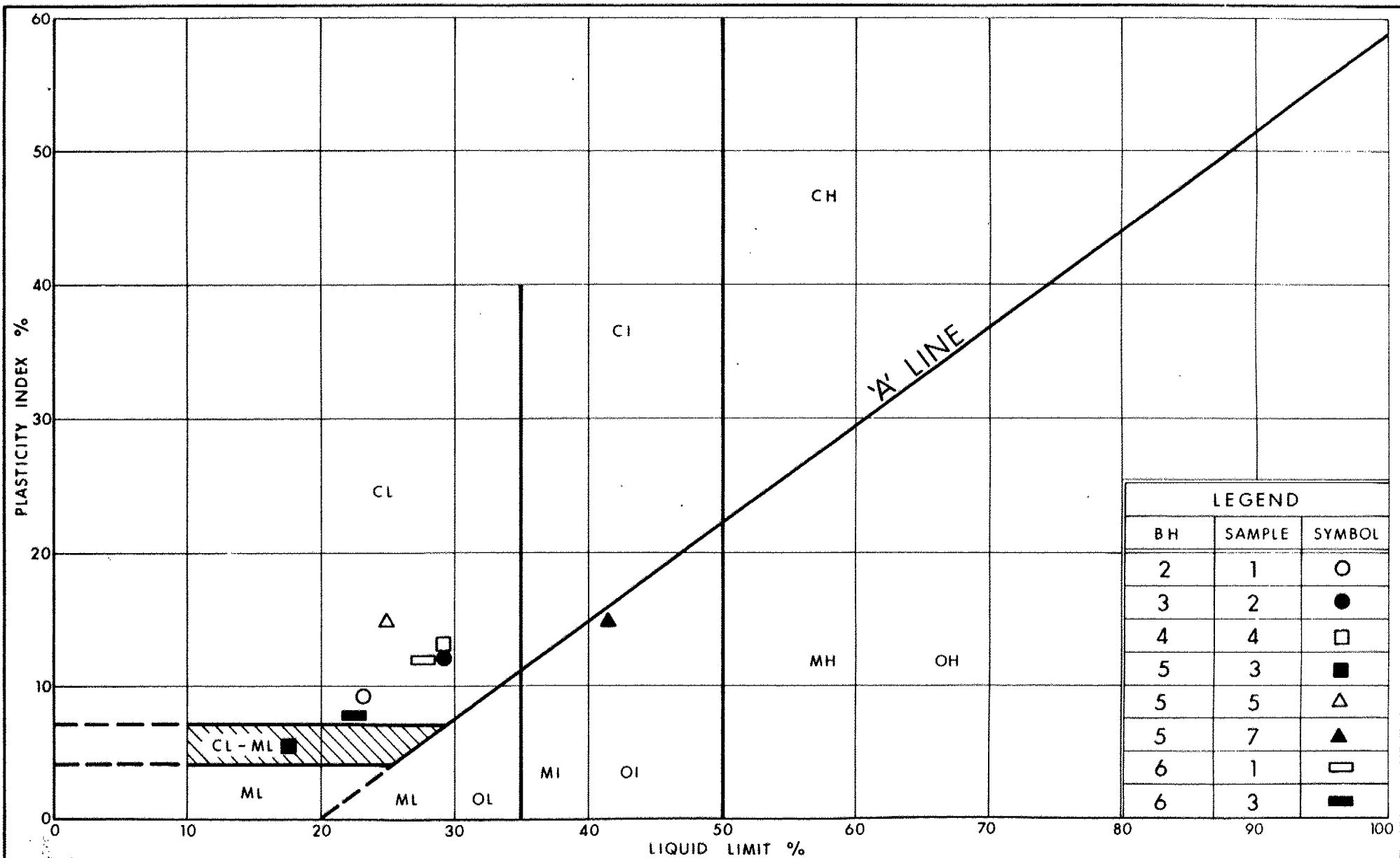
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Transportation

GRAIN SIZE DISTRIBUTION
RANDOM MIXTURE OF CLAY, SILT, SAND & GRAVEL
(FILL)

FIG No 1

W P 367-87-02

369-87-09/10



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Ontario

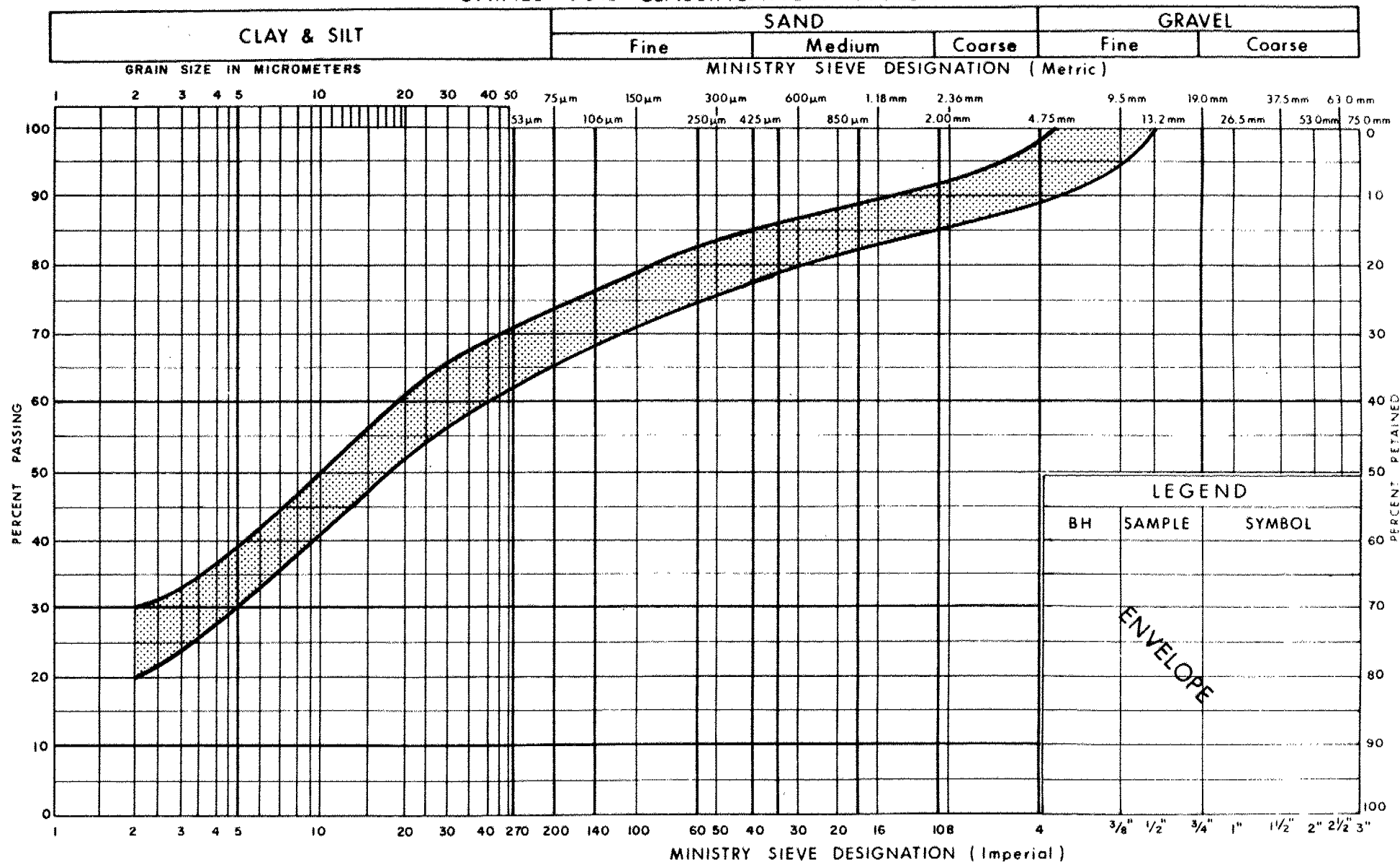
PLASTICITY CHART RANDOM MIXTURE OF CLAY, SILT, SAND & GRAVEL (FILL)

FIG No 2

W P 367-87-02

369-87-09/10

UNIFIED SOIL CLASSIFICATION SYSTEM



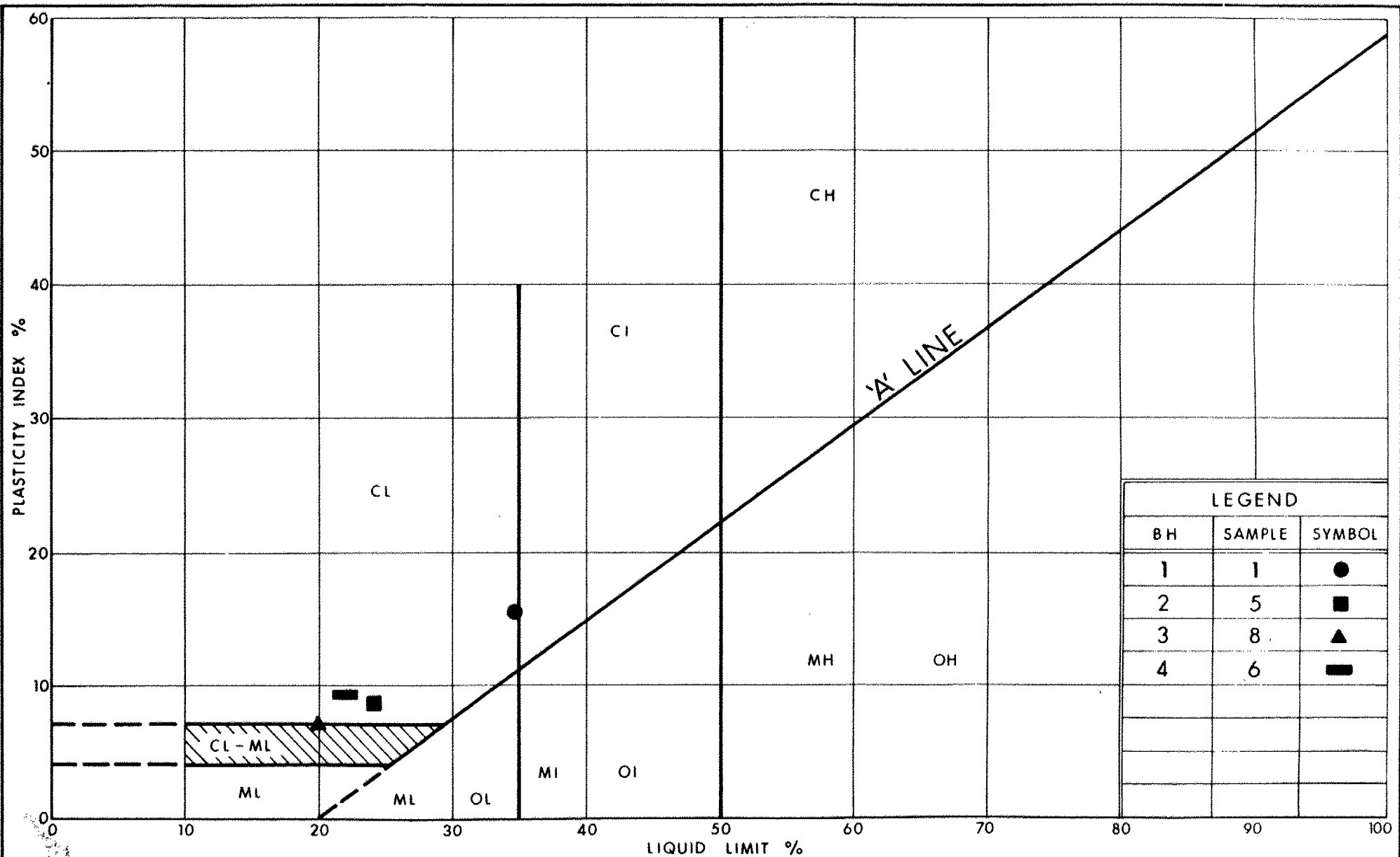
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF CLAYEY SILT, SAND & GRAVEL
 (GLACIAL TILL)

FIG No 3

W P ~~367-87-02~~

369-87-09/10



Ministry of
Transportation

Ontario

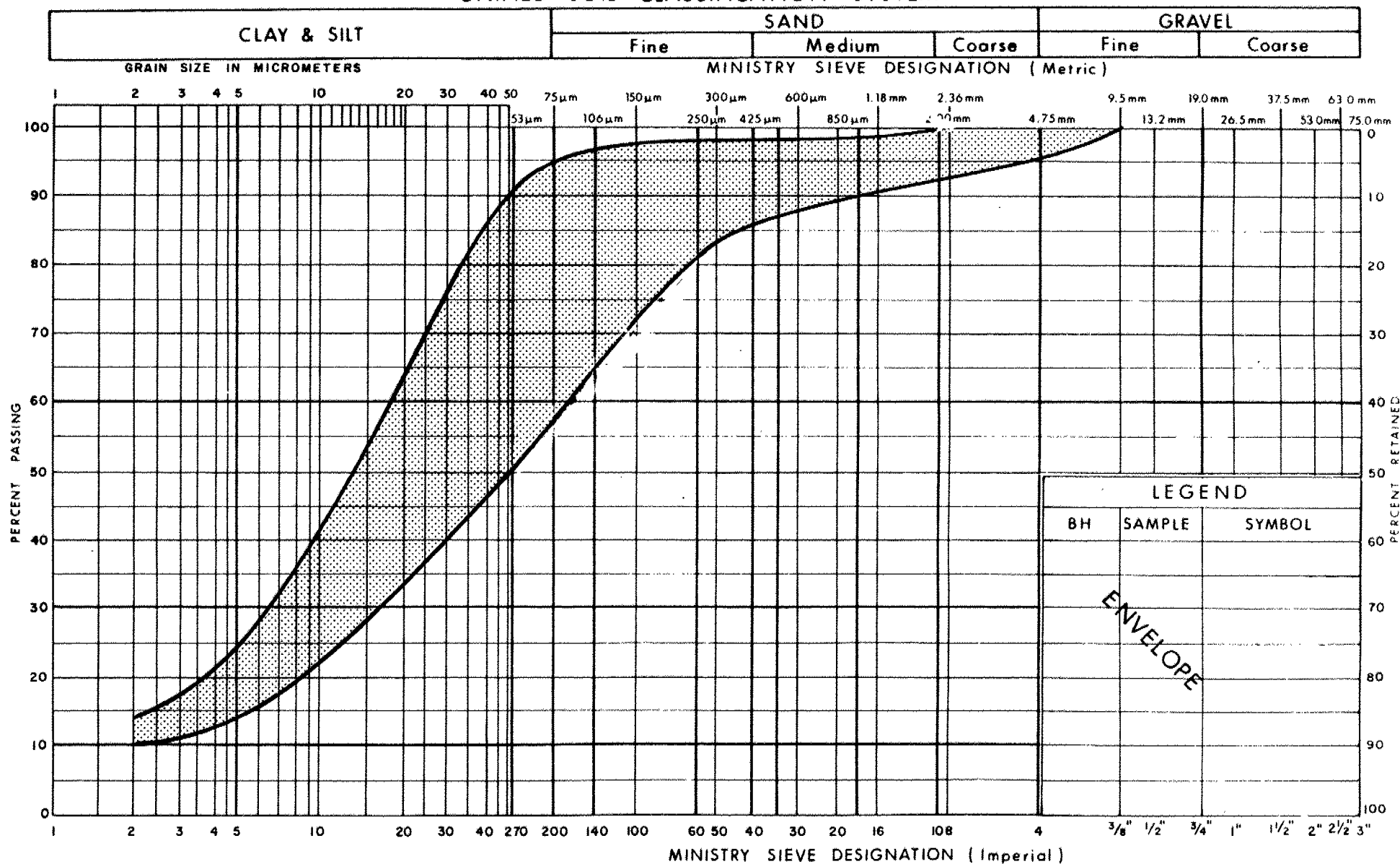
PLASTICITY CHART HETEROGENEOUS MIXTURE OF CLAYEY, SILT, SAND & GRAVEL

FIG No 4

W P ~~367-87-02~~

369-87-09/10

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

Ministry of
Transportation

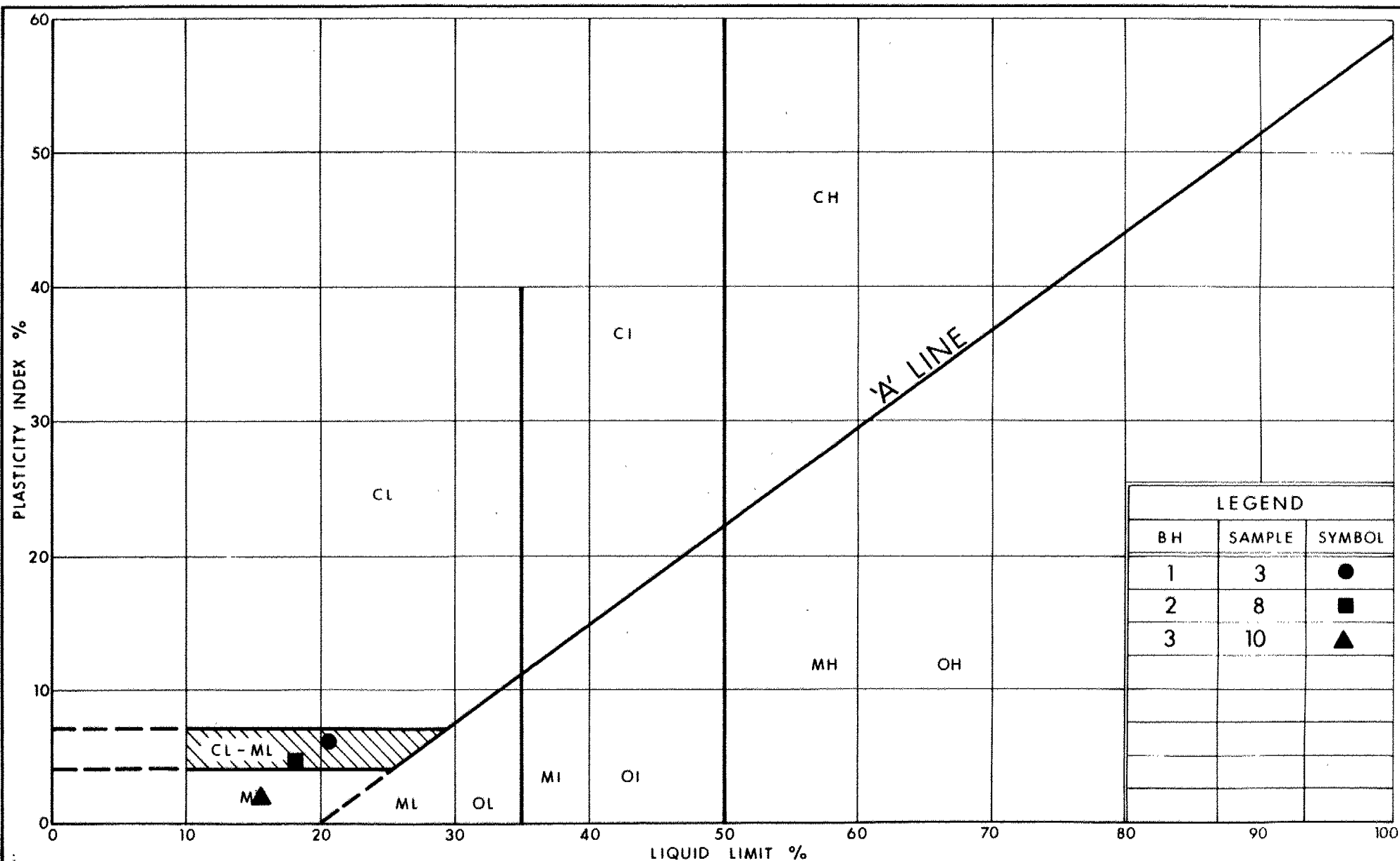
GRAIN SIZE DISTRIBUTION

SANDY SILT TO SILT

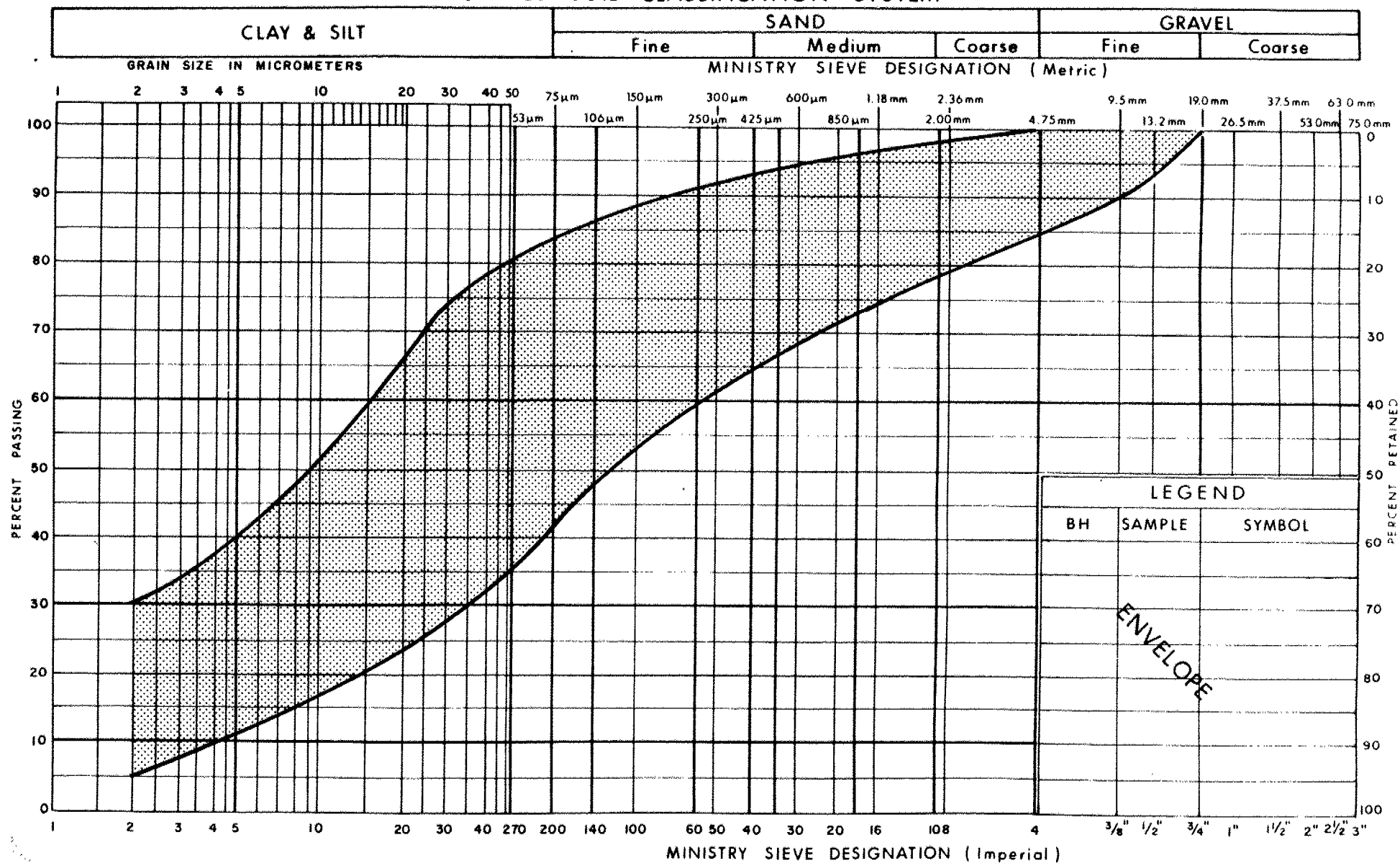
FIG No 5

W P 367-87-02

367-87-09/10



UNIFIED SOIL CLASSIFICATION SYSTEM



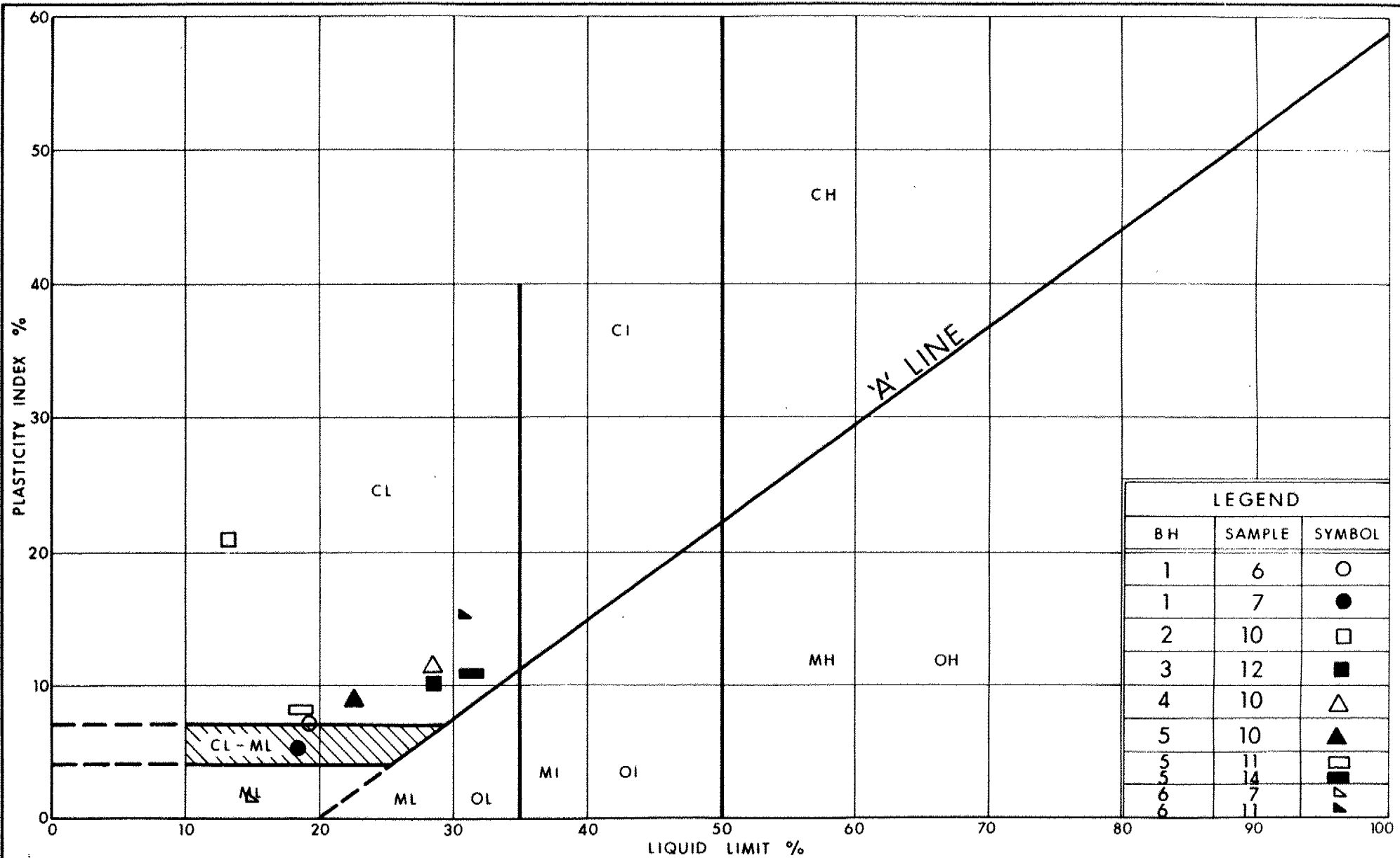
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF SANDY SILT, CLAY & GRAVEL
 (GLACIAL TILL)

FIG No 7

W P 367-87-02

367-87-09/10



Ministry of
Transportation

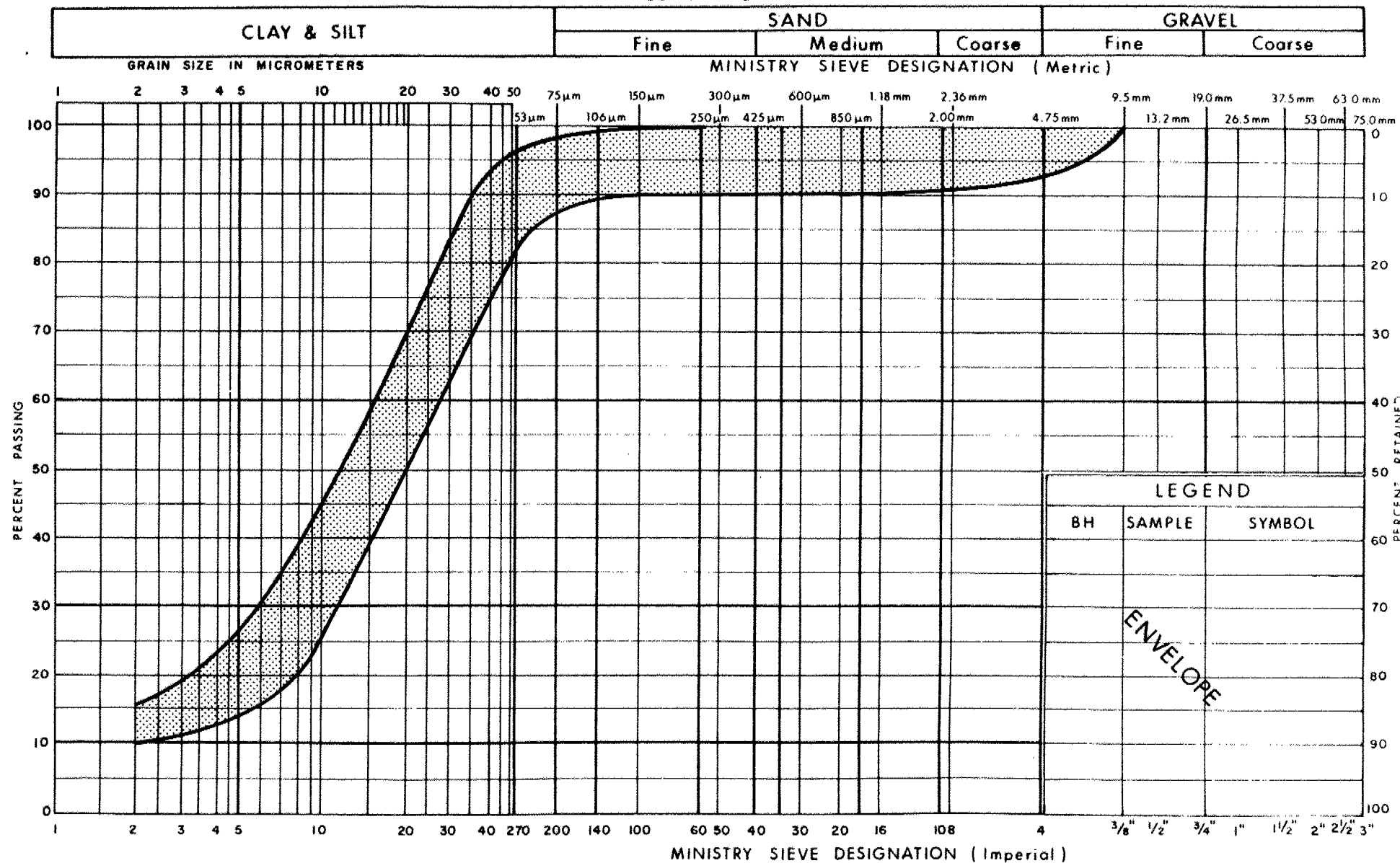
PLASTICITY CHART HETEROGENEOUS MIXTURE OF SANDY SILT, CLAY & GRAVEL (GLACIAL TILL)

FIG No 8

W P 367-87-02

367-87-09/10

UNIFIED SOIL CLASSIFICATION SYSTEM



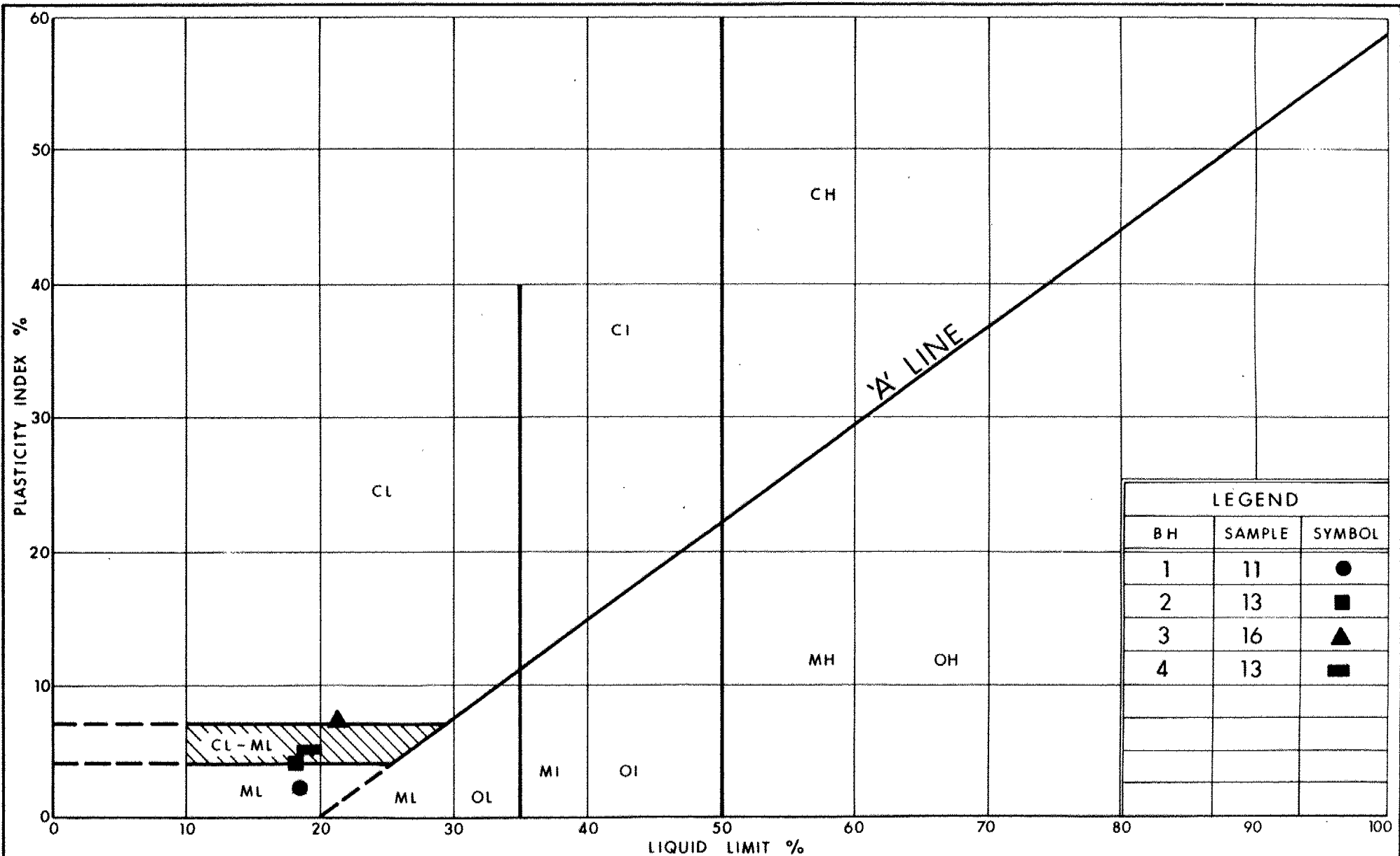
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILT, SOME CLAY, TRACE SAND

FIG No 9

W P 367-87-02

367-87-09/10



Ministry of
Transportation
Ontario

PLASTICITY CHART SILT, SOME CLAY, TRACE SAND

FIG No 10

W P 367-87-02

369-87-09/10

RECORD OF BOREHOLE No 1

1 OF 2

METRIC

W.P. 389-87-09/10 LOCATION Coords: N 4 845 382.0, E 293 491.0 ORIGINATED BY M.M.
DIST 5 HWY 407 BOREHOLE TYPE SOLID STEM AUGER COMPILED BY M.M.
DATUM GEODETIC DATE 80/10/01 CHECKED BY B.I.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
175.4	Ground Surface													
0.0														
	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Very Stiff to Hard		1	SS	19		175							5 28 39 28
			2	SS	48		174							
173.2														
2.1			3	SS	44		173						20.1	0 3 87 10
	Sandy Silt to Silt Compact to Dense		4	SS	24		172							
	Brown Grey		5	SS	39		171							
170.8			6	SS	43		170						22.4	5 35 40 20
4.4			7	SS	125		169						22.5	13 35 37 15
	Heterogeneous mixture of Sandy Silt, Clay and Gravel (Glacial Till) Dense to Very Dense		8	SS	76		168							
			9	SS	82		167							
			10	SS	60	/5cm	166							
163.7			11	SS	125	/13cm	163						20.9	1 8 79 12
11.7	Silt, some Clay, trace Sand Very Dense						162							
							161							
160.1														

15.2 Continued

+3, x.5: Numbers refer to
Sensitivity

20
15-5 (x) STRAIN AT FAILURE
10

Continued

RECORD OF BOREHOLE No 1

2 OF 2

METRIC

W.P. 369-87-09/10 LOCATION Coords: N 4 845 382.0, E 293 491.0 ORIGINATED BY M.M.
 DIST 6 HWY 407 BOREHOLE TYPE SOLID STEM AUGER COMPILED BY M.M.
 DATUM GEODETIC DATE 90/10/01 CHECKED BY B.I.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20					
15.2	Continued		12	SA	120	/15cm	160						
159.7													
15.7	End of Borehole												

RECORD OF BOREHOLE No 2

1 OF 2

METRIC

W.P. 369-87-09\10 LOCATION Coords: N 4 845 418.0, E 293.516.0 ORIGINATED BY M.M.
DIST 6 HWY 407 BOREHOLE TYPE SOLID STEM AUGER COMPILED BY M.M.
DATUM GEODETIC DATE 90/10/01 CHECKED BY B.I.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa					
								WATER CONTENT (%)					
178.9	Ground Surface												
0.0	Random mixture of Clay, Silt, Sand and Gravel (Fill) Firm to Very Stiff		1	SS	17	178						21.2	24 32 29 15
			2	SS	8	177							
			3	SS	16	176							
	trace Organics		4	SS	12	175							
174.9						174						21.9	9 24 46 21
4.0	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Very Stiff		5	SS	23	173							
			6	SS	25	172							
171.8	Brown					171							
7.1	Gray		7	SS	20	170							
	Sandy Silt to Silt Compact to Very Dense		8	SS	105	169							5 30 51 14
			9	SS	31	168							
167.2						167							
11.7	Heterogeneous mixture of Sandy Silt, Clay and Gravel (Glacial Till) Dense to Very Dense		10	SS	40	166							8 48 36 8
			11	SS	60	165							
163.7						164							

15.2

Continued

+3, x³: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

Continued

RECORD OF BOREHOLE No 2

2 OF 2

METRIC

W.P. 369-87-09\10 LOCATION Coords: N 4 845 418.0, E 293.516.0 ORIGINATED BY M.M.
 DIST 6 HWY 407 BOREHOLE TYPE SOLID STEM AUGER COMPILED BY M.M.
 DATUM GEODETIC DATE 90/10/01 CHECKED BY B.I.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
	Continued															
15.2		12	SS	100	/10cm	163										
162.7																
16.2	Silt, some Clay trace Sand Very Dense	13	SS	100	/10cm	162										0 8 82 10
						161										
						160										
		14	SS	100	/15cm											
158.6		15	SS	120	/15cm	159										
20.3	End of Borehole															

RECORD OF BOREHOLE No 3

1 OF 2 METRIC

W.P. 369-87-09/10 LOCATION Coords: N 4 845 446.0, E 293 472.0 ORIGINATED BY M.M.
 DIST 6 HWY 407 BOREHOLE TYPE SOLID STEM AUGER COMPILED BY M.M.
 DATUM GEODETIC DATE 90/10/01 CHECKED BY B.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								20 40 60 80 100	20 40 60 80 100						
180.6	Ground Surface														
0.0	Random mixture of Clay, Silt, Sand, and Gravel (FTH) Stiff to Very Stiff ----- trace of Organics -----		1	SS	17										
			2	SS	18								21.4	28 27 26 19	
			3	SS	14										
			4	SS	28										
			5	SS	24										
			6	SS	12										
175.0															
5.6	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Very Stiff to Hard		7	SS	33										
			8	SS	21								21.3	3 26 52 19	
			9	SS	125										
170.5															
10.1	Sandy Silt Very Dense		10	SS	114									4 39 48 9	
			11	SS	17										
168.9															
11.7	Heterogeneous mixture of Sandy Silt, Clay and Gravel (Glacial Till) Compact to Very Dense		12	SS	88										
													22.4	8 23 44 25	
165.4															

15.2

Continued

+3, x3 Numbers refer to
Sensitivity

20
15 5 (x) STRAIN AT FAILURE
10

Continued

RECORD OF BOREHOLE No 3

2 OF 2

METRIC

W.P. 367-89-09/10

LOCATION Coords: N 4 845 446.0, E 293 472.0

ORIGINATED BY M.M.

DIST 6 HWY 407

BOREHOLE TYPE SOLID STEM AUGER

COMPILED BY M.M.

DATUM GEODETTIC

DATE 90/10/01

CHECKED BY B.I.

SOIL PROFILE		STRAT PLOT	SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION		NUMBER	TYPE			'N' VALUES	SHEAR STRENGTH kPa • UNCONFINED + FIELD VANE • QUICK TRIAXIAL x LAB VANE						WATER CONTENT (%)
15.2	Silt, some Clay trace Sand trace Gravel Very Dense		13	SS	160									
154.4														
15.2			14	SS	113	/10cm								
			15	SS	120	/8cm								
			6	SS	120	/15cm								
160.3												23.3	6 5 78 10	
20.3	End of Borehole													

RECORD OF BOREHOLE No 4

1 OF 2

METRIC

W.P. 369-87-09/10

LOCATION Co-ords: N 4 845 483.5, E 293 487.5

ORIGINATED BY M.M.

DIST 8 HWY 407

BOREHOLE TYPE Hollow Stem Auger

COMPILED BY M.M.

DATUM Geodetic

DATE 90 10 01

CHECKED BY B.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100					
179.8	Ground Surface														
0.0	Random mixture of Clay, Silt Sand and Gravel (FII)														
	Stiff to Hard		1	SS	33										
			2	SS	14										
			3	SS	31										
			4	SS	44										
173.9			5	SS	52										
5.9	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		6	SS	55										
			7	SS	49										
			8	SS	41										
169.7			9	SS	14										
10.1	Silt, some Sand Compact		10	SS	103										
168.1			11	SS	101										
11.7	Heterogeneous mixture of Sandy Silt, Clay and Gravel (Glacial Till) Very Dense														
165.1															
14.7															
154.6															
15.2															

Continued

Continued

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4

2 OF 2

METRIC

W.P. 369-87-09/10 LOCATION Co-ords: N 4 845 483.5, E 293 487.5 ORIGINATED BY M.M.
 DIST 5 HWY 407 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.
 DATUM Geodetic DATE 90 10 01 CHECKED BY B.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
164.8	Continued																
15.2	Silt, some Clay Very Dense		12	SS	100	/15cm	164										
162.8			13	SS	80	/10cm	163										0 1 84 15
17.2	End of Borehole																

RECORD OF BOREHOLE No 5

1 OF 2

METRIC

W.P. 369-87-09/10 LOCATION Coords: N 4 845 495.0, E 293 445.0 ORIGINATED BY M.M.
DIST 5 HWY 407 BOREHOLE TYPE HOLLOW STEM AUGER, SPLIT SPOON COMPILED BY M.M.
DATUM GEODETTIC DATE 90/10/03 CHECKED BY B.I.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
181.1	Ground Surface																
0.0	Random mixture of Clay, Silt Sand and Gravel (FH) Stiff to Hard		1	SS	22	Dry	180									21.6	7 37 44 12
			2	SS	17		178										
			3	SS	18		178										
			4	SS	21		177										
			5	SS	11		176										
			6	SS	42		175										
			7	SS	14		174										
174.0							173										
7.1	Silt, trace Sand Dense		8	SS	33		172										
172.5							171										
8.6			9	SS	132	/28cm	170										
							169										
			10	SS	129	/28cm	168										
							167										
			11	SS	120	/15cm	166										
			12	SS	59												
165.8																	
15.2																	

Continued

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

Continued

RECORD OF BOREHOLE No 5

2 OF 2

METRIC

W.P. 389-87-09/10 LOCATION Coords: N 4 845 495.0, E 293 445.0 ORIGINATED BY M.M.
 DIST 6 HWY 407 BOREHOLE TYPE HOLLOW STEM AUGER, SPLIT SPOON COMPILED BY M.M.
 DATUM GEODETIC DATE 90/10/03 CHECKED BY B.I.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
15.2	Continued		13	SS	117											
			14	SS	137	/28cm									23.6	8 28 42 22
			15	SS	60	/8cm										
			16	SS	100	/15cm										
160.8																
20.3	End of Borehole															

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 6

1 OF 1

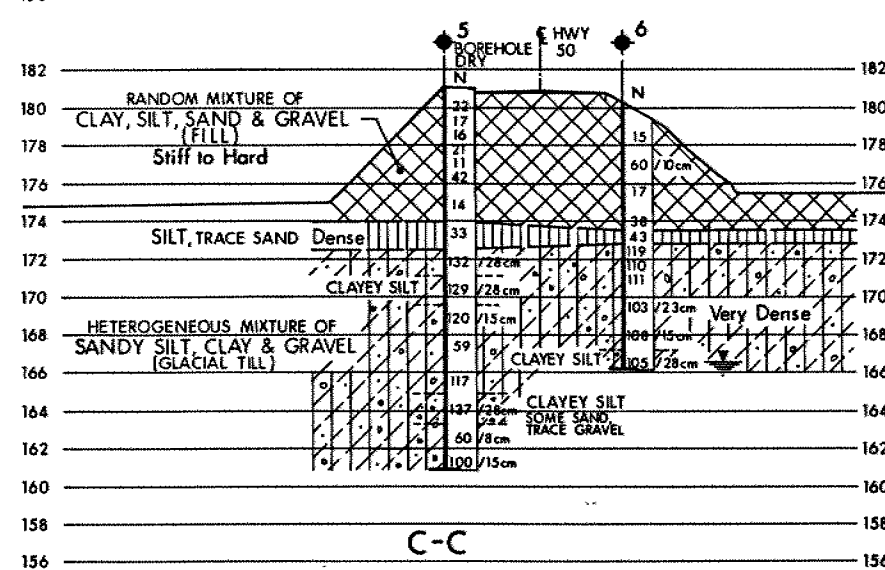
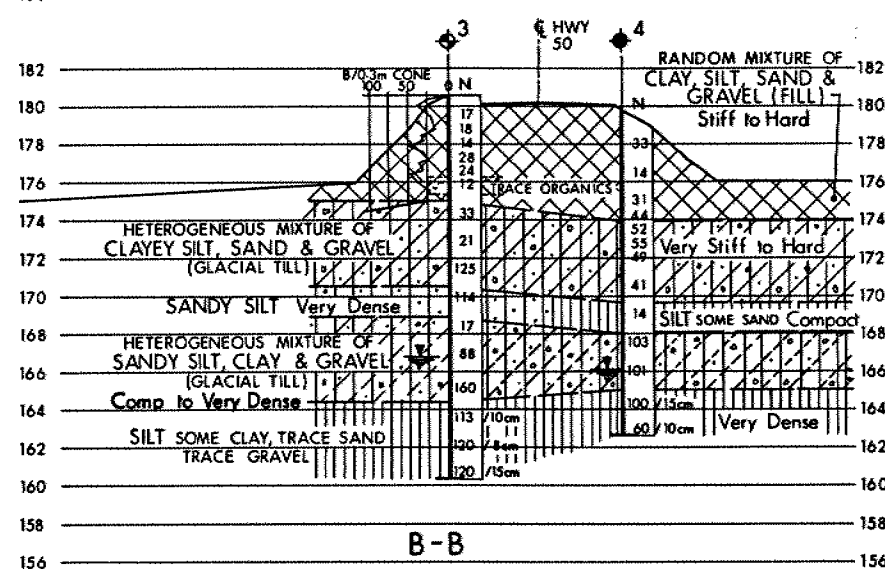
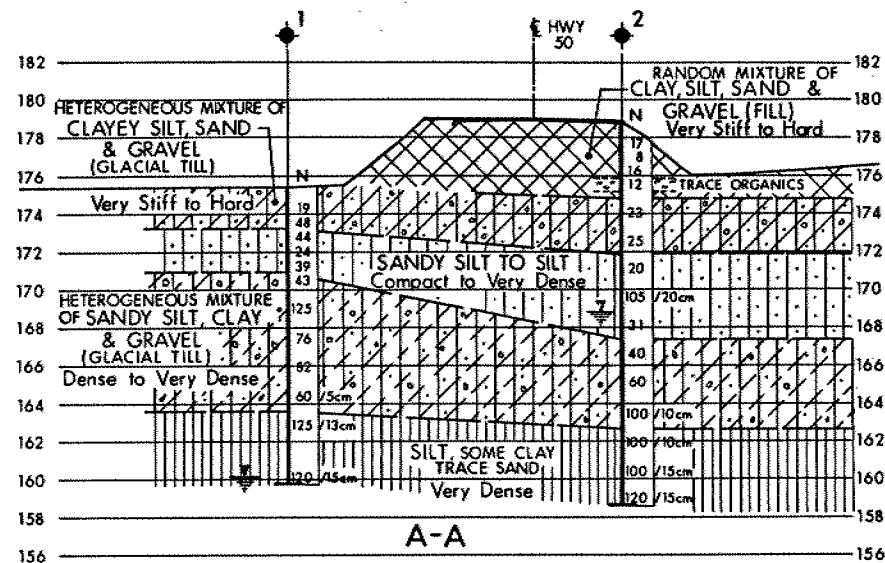
METRIC

W.P. 389-89-09/10 LOCATION Coor'ds: N 4 845 510.0, E 293 463.5 ORIGINATED BY M.M.
 DIST 6 HWY 407 BOREHOLE TYPE HOLLOW STEM AUGER, SPLIT SPOON COMPILED BY M.M.
 DATUM GEODETIC DATE 90/10/03 CHECKED BY B.J.

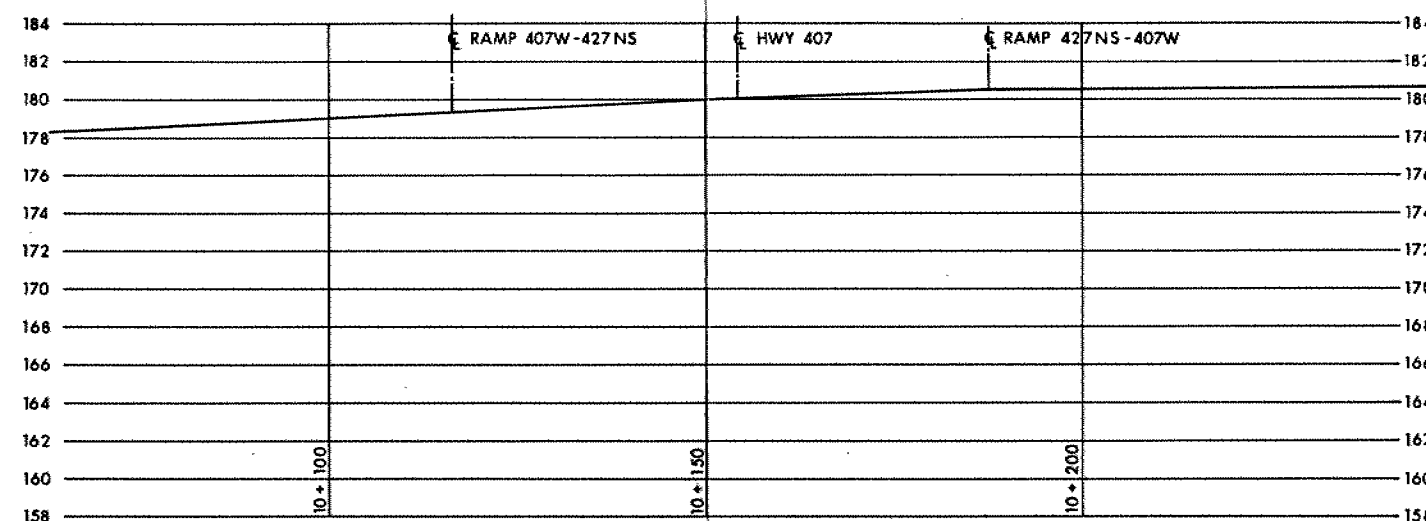
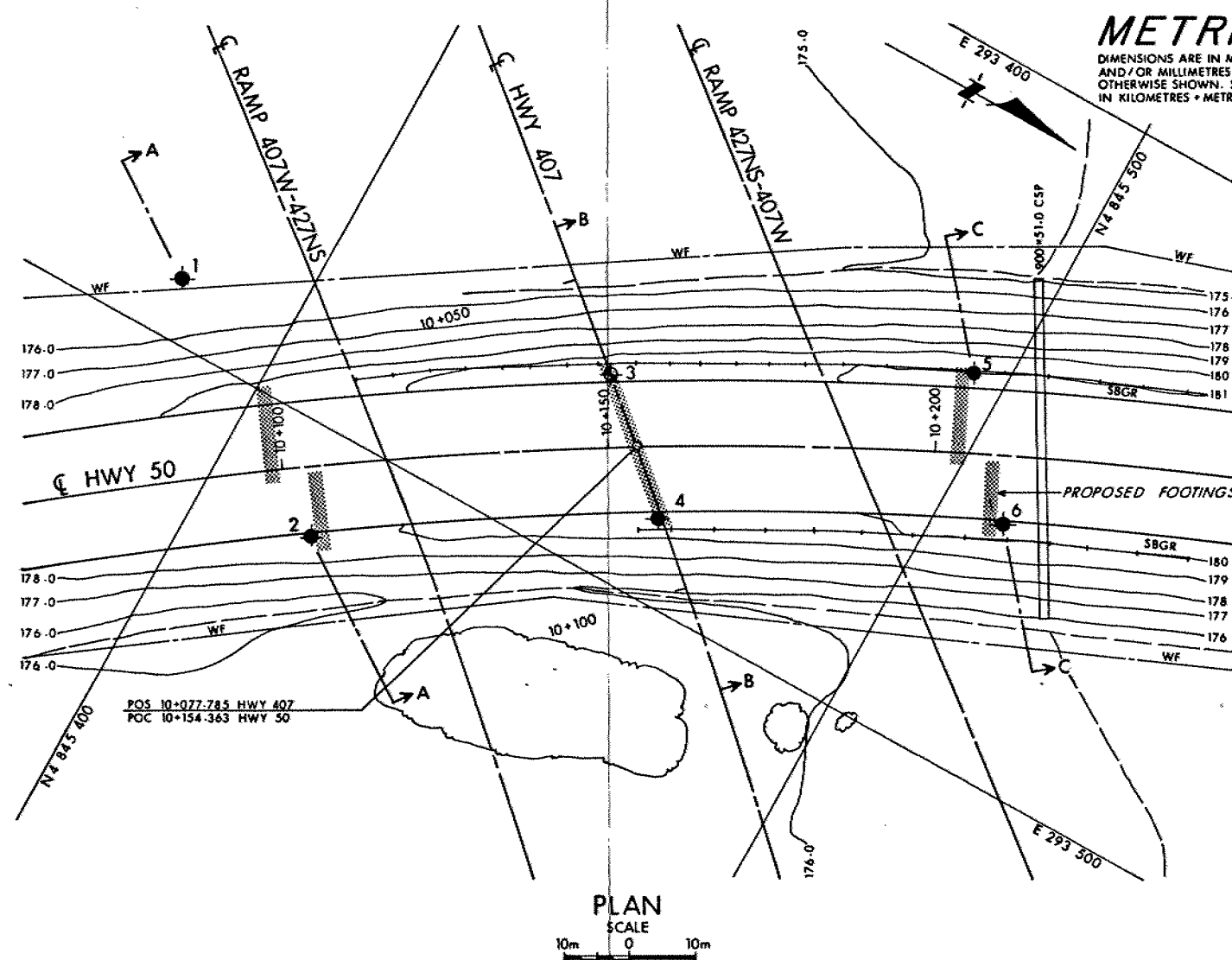
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
180.3	Ground Surface																
0.0	Random mixture of Clay, Silt Sand and Gravel (Fill) Stiff to Very Stiff		1	SS	15		180									21.5	8 27 38 27
			2	SS	60	/10cm	179										
			3	SS	17		178										
			4	SS	38		177										
173.5			5	SS	43		176										
6.7	Silt, trace Sand Dense		6	SS	119		175										
172.8			7	SS	110		174										
7.5	Heterogeneous mixture of Sandy Silt, Clay and Gravel (Glacial Till) Very Dense		8	SS	111		173										
			9	SS	103	/23cm	172										
			10	SS	108	/15cm	171										
			11	SS	105	/28cm	170										
166.1	Clayey Silt						169										
							168										
							167										
14.2	End of Borehole						166										

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10



SECTIONS



PROFILE HWY 50

METRIC

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

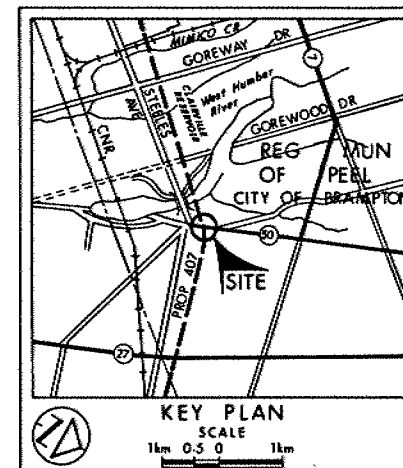
CONT No 369-87-09/10
WP No 367-87-02

HIGHWAY 50

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]
- W L at time of investigation 90 10

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	175.4	4 845 382.0	293 491.0
2	178.9	4 845 418.0	293 516.0
3	180.6	4 845 446.0	293 472.0
4	179.8	4 845 463.5	293 487.5
5	181.1	4 845 495.0	293 445.0
6	180.3	4 845 510.0	293 463.5

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.

DATE	BY	DESCRIPTION
------	----	-------------

Geocres No 30M13-118

HWY No 407	SUBMD MM	CHECKED	DATE 91 02 28	DIST 6
DRAWN DT	CHECKED	APPROVED		SITE 37-1334
				DWG 3678702-A

REF No E-199-407-5, 90 05

367870910

METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No 369-87-09 (NB)
369-87-10 (SB)

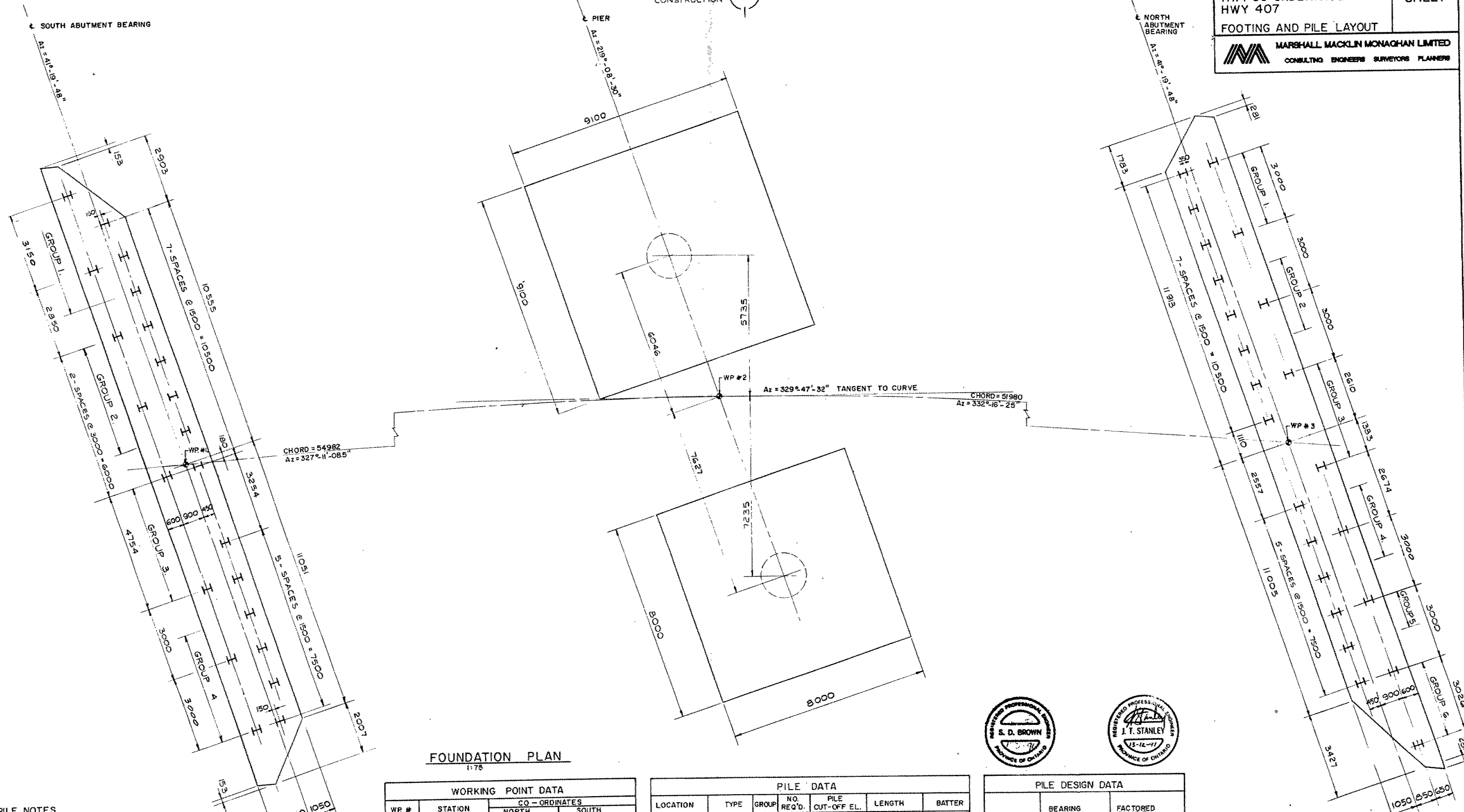


HWY 50 UNDERPASS AT
HWY 407

SHEET

FOOTING AND PILE LAYOUT

MARSHALL, MACKLIN, MONAGHAN LIMITED
CONSULTING ENGINEERS SURVEYORS PLANNERS



FOUNDATION PLAN
1:75

WORKING POINT DATA			
WP #	STATION	CO - ORDINATES	
		NORTH	SOUTH
1	10 + 099.363	845 409 098	293 509 308
2	10 + 154.363	845 455 307	293 479 512
3	10 + 206.363	845 501 319	293 455 320

PILE DATA						
LOCATION	TYPE	GROUP	NO. REQ'D.	PILE CUT-OFF EL.	LENGTH	BATTER
NORTH ABUTMENT	HP 310 x 110	1	5	177.550	13.55	VERT.
		2	4	177.350	13.35	
		3	4	177.150	13.15	
		4	4	176.900	12.9	
		5	3	176.700	12.7	
		6	3	176.550	12.55	
SOUTH ABUTMENT	HP 310 x 110	1	5	176.000	15.0	VERT.
		2	6	175.700	14.7	
		3	5	175.500	14.5	
		4	6	175.200	14.2	

PILE DESIGN DATA		
LOCATION	BEARING CAPACITY AT SLS TYPE II	FACTORED CAPACITY AT ULS
BOTH ABUT'S	1150 kN	1600 kN

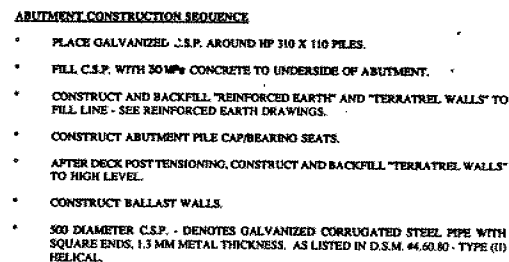
DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

PILE NOTES

- PILE SPACING IS MEASURED AT THE UNDERSIDE OF FTG'S.
- PILE LENGTHS SHOWN IN TABLE ARE THE THEORETICAL LENGTH BELOW CUT-OFF ELEV.
- ALL PILES SHALL HAVE DRIVING SHOES.
- PILES TO BE DRIVEN IN ACCORDANCE WITH STD. S3-103-10 OR S3-105-11 USING AN ULTIMATE CAPACITY OF 5450 kN PER PILE BUT NOT BELOW ELEVATION SHOWN ON DWG 1, WITHOUT APPROVAL OF THE ENGINEER.

APPLICABLE STANDARD DRAWINGS:
OPSD 3301.00 - SPLICE AND DRIVING SHOE DETAILS FOR STEEL H-PILES.

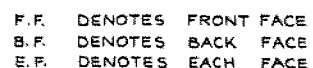
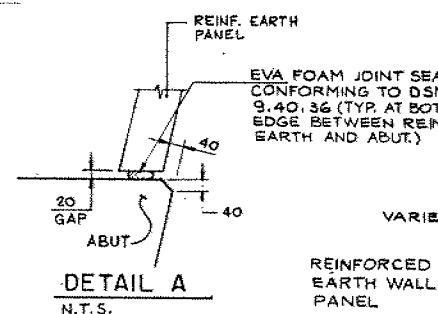
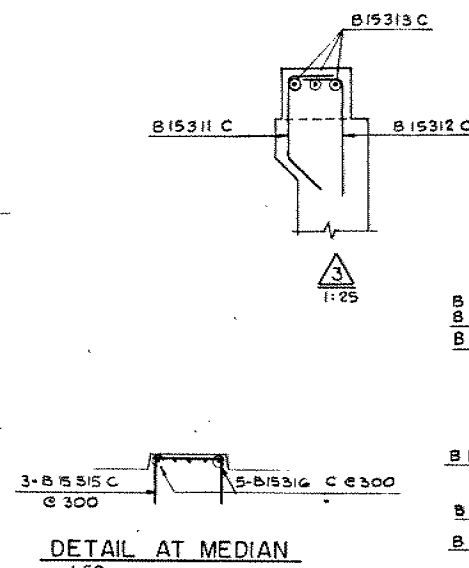
DATE	BY	DESCRIPTION
DESIGN S. B.	CHK T. S.	CODE OHBC - 83
DRAWN I. R.	CHK S. B.	SITE 37-133 4
		STRUCT
		SCHEME
		DWG. 3



CONT No	369-87-09 (NB)
WP No	369-87-10 (SB)
HWY 50 UNDERPASS AT HWY 407 SOUTH ABUTMENT	



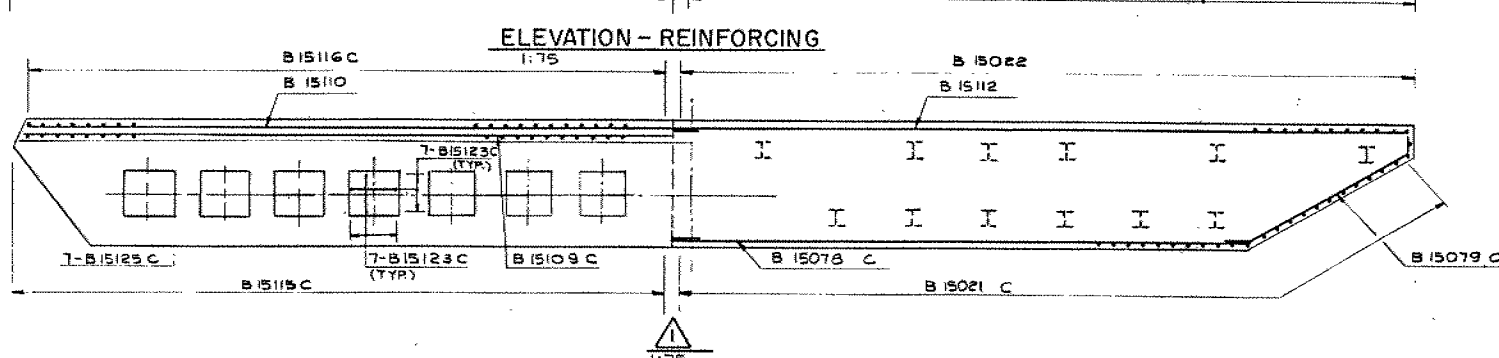
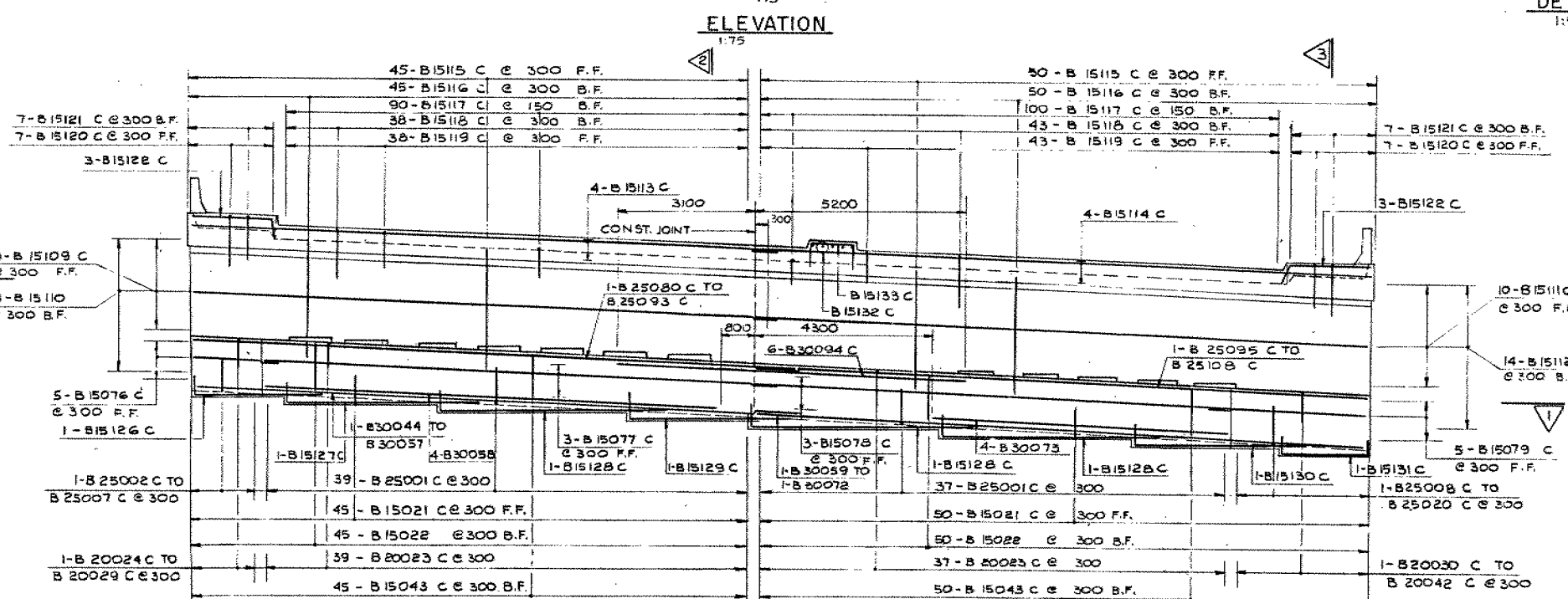
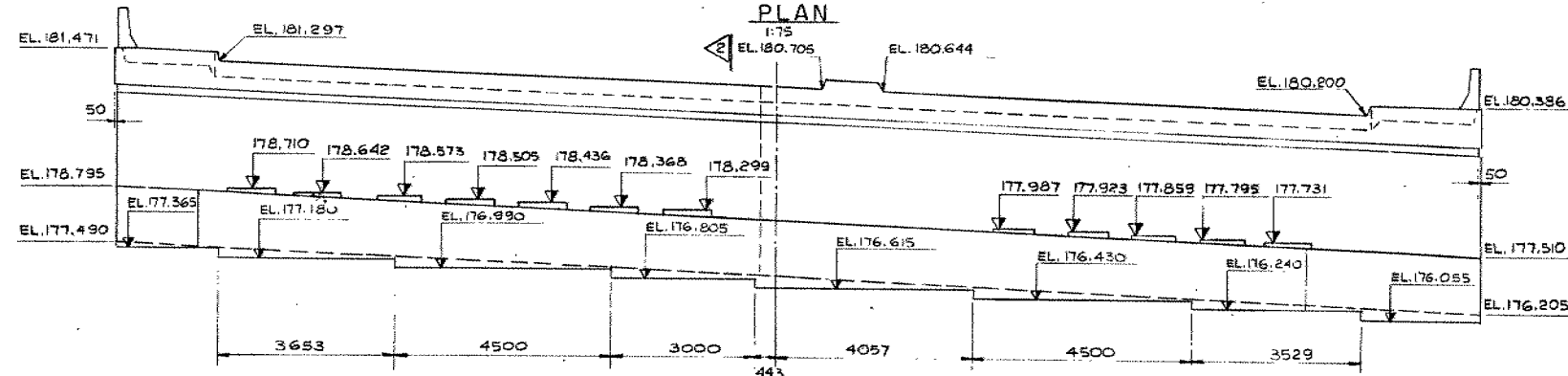
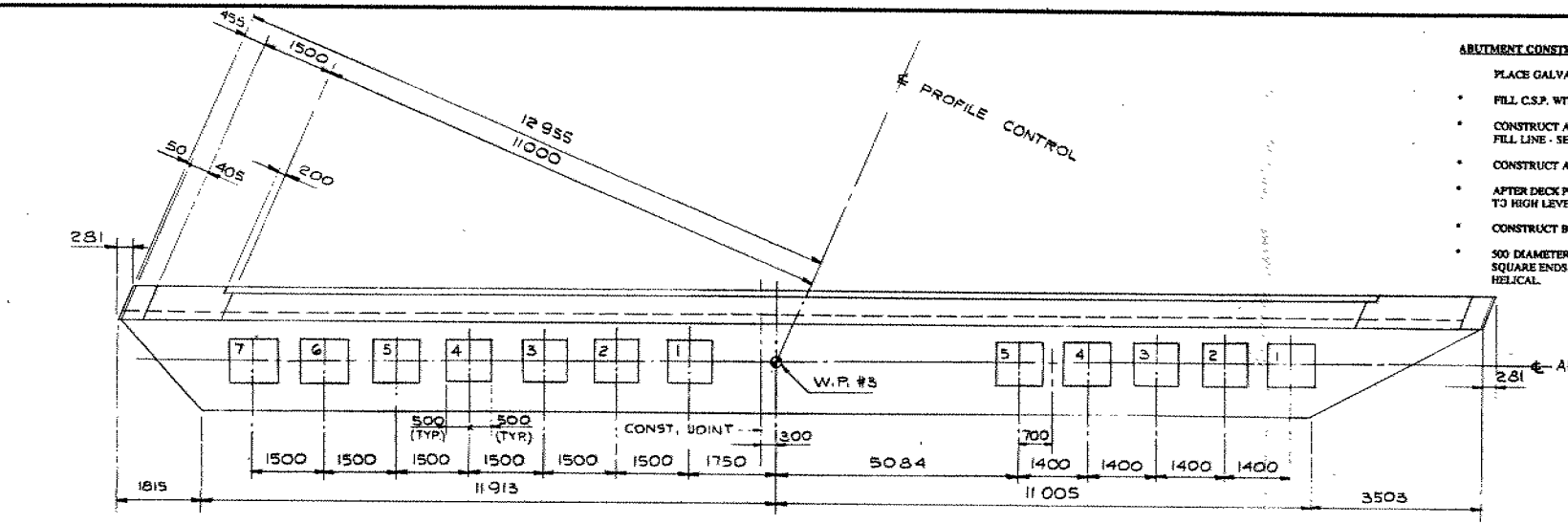
MARSHALL MACKLIN MONAGHAN LIMITED
CONSULTING ENGINEERS SURVEYORS PLANNERS



DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS			
	DATE	BY	DESCRIPTION
	DESIGN K.M.	CHK S.B.	CODE QHBDC -83 LOAD CLASS 4 DATE JUNE 92
	DRAWN I.R.	CHK K.M.	SITE 37-1334 STRUCT SCHEME DWG. 4





ABUTMENT CONSTRUCTION SEQUENCE

- PLACE GALVANIZED C.S.P. AROUND HP 310 X 110 PILES.
- FILL C.S.P. WITH 30 MPa CONCRETE TO UNDERSIDE OF ABUTMENT.
- CONSTRUCT AND BACKFILL "REINFORCED EARTH" AND "TERRAZEL WALLS" TO FILL LINE - SEE REINFORCED EARTH DRAWINGS.
- CONSTRUCT ABUTMENT PILE CAP/BEARING SEATS.
- AFTER DECK POST TENSIONING, CONSTRUCT AND BACKFILL "TERRAZEL WALLS" TO HIGH LEVEL.
- CONSTRUCT BALLAST WALLS.
- 500 DIAMETER C.S.P. - DENOTES GALVANIZED CORRUGATED STEEL PIPE WITH SQUARE ENDS, 1.3 MM METAL THICKNESS. AS LISTED IN D.S.M. 44.60.60 - TYPE (II) HELICAL.

METRIC

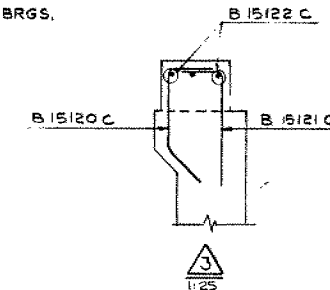
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No 369-87-09 (NB)
369-87-10 (SB)

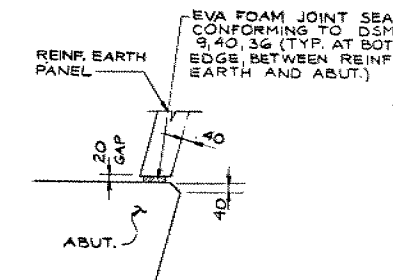
HWY 50 UNDERPASS AT
HWY 407
NORTH ABUTMENT

MARSHALL MACKLIN MONAGHAN LIMITED
CONSULTING ENGINEERS SURVEYORS PLANNERS

SHEET



DETAIL AT MEDIAN
1:50



DETAIL 'A'
N.T.S.

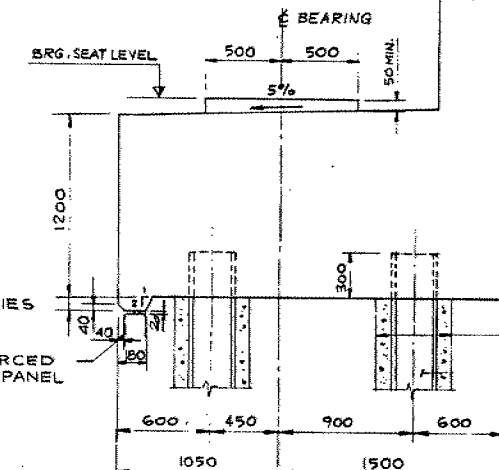
REINFORCING

1:25

335mm BLOCK OUT
TO BE CAST AFTER
EXPANSION JOINT
INSTALLATION

VARY TO ACCOMMODATE
J GAP BETWEEN DECK
& BALLAST WALL AT THE
TIME OF CASTING BALLAST
WALL, DWG. #26

TOP OF BALLAST WALL
CAST TO SUIT FIN.
PAVEMENT PROFILE



DIMENSIONS

1:25

F.F. DENOTES FRONT FACE
B.F. DENOTES BACK FACE
E.F. DENOTES EACH FACE

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION
DESIGN K.M.	CHK S.B.	CODE 04BDC-83	LOAD CLASS A DATE JUNE 92
DRAWN I.R.	CHK K.M.	SITE 37-1334	STRUCT SCHEME DWG. 5





memorandum

To: T.C. Tam
Head, Construction Reviews
Approvals Section

From: Foundation Design Section
Room 315 Central Building

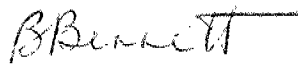
Re: Falsework Foundation Report Review
Highway 50 U'Pass
Highway 407, Contract 93-100

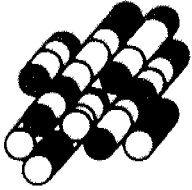
Date: 94 04 14

The falsework foundation report for the Highway 50 underpass submitted by Terraprobe Testing Ltd. has been reviewed and the following comments are provided.

1. The report should identify the bearing pressure applied by the falsework, as well as the bearing resistance assumed by the geotechnical engineer.
2. An elevation of 173.89m is mentioned. It should be supported by appropriate reference drawings in order that its relation to existing or original ground elevations may be determined.
3. We have no concern with the falsework construction on natural ground. However, the report mentions that backfill will be placed at the pier locations. More details of the extent of this backfilling is required, e.g. elevations. Again, the bearing resistance of the backfill material should be provided.
4. The report should be aware of and reference the OPSS 919 criteria on formwork and falsework, specifically the allowable settlement of 13mm.
5. Falsework foundation reports should be stamped by the geotechnical engineer.

If additional clarification is required, please advise.


Betty Bennett, P.Eng.
Sr. Foundation Engineer (Acting)



Terraprobe Testing Ltd.

Construction and Materials Inspection and Testing

2565 Steeles Ave. E.
Brampton, Ontario
L6T 4L6
(905) 793-2650
FAX: 793-2655

March 25, 1994

Our File No. 949114

Graham Bros. Construction Ltd.
290 Clarence Street
Brampton, Ontario
L6W 1T4

Attention: Mr. Dave Weltz, P.Eng.

*no conc. @ natural ground
but some at filled areas (piers)
need more details.*

**RE: FALSEWORK FOUNDATION INSPECTION
HIGHWAY 50 UNDERPASS (MTO 93-100)
BRAMPTON, ONTARIO**

Dear Sir:

This letter presents the results of our review of the subsurface soil conditions in the vicinity of the proposed falsework foundations, at the above project site.

How thick are sills, their width, single or double

It is our understanding that the mudsills are to be founded at an elevation of about 173.89 m and the maximum load that is to be applied to any one leg of the scaffolding is 65 kN. In reviewing the Foundation Investigation Report for the site that was prepared by the Ministry of Transportation (Report for Contract No. 93-100), native soils were encountered in the boreholes at the proposed foundation elevation of the mudsills (i.e., Elev. 173.89 m).

The results of our site inspection indicated that the native soils exposed in the excavations at this site consist of competent native clayey to sandy silt soils, and are similar to those indicated in the borehole logs. These soils are considered to be suitable for support of the mudsills for the underpass falsework.

At the pier locations, where there has been significant excavation (up to 4 m) in order to construct the piers, the excavations should be properly backfilled. The native soils

*- need heavy pressure
used*

*we have no detail
to interpret elev
so they need profile
to top of pier
they should have
used referenced material
we shouldn't have to
search our files for.*

to what elev.

March 25, 1994

2

Our File No. 949114

encountered at the site may be utilized to backfill the excavations. If the excavations are backfilled and compacted to a minimum of 98 percent Standard Proctor Maximum Dry Density (SPMDD), then the backfill soils at the pier locations will also be able to adequately support the mudsills.

*at what
bearing capacity*

Prior to placement of the mudsills, we recommend that the foundation subgrade be thoroughly cleaned of all loose and disturbed or wet soils.

We trust the foregoing information is sufficient for your present requirements. If you have any questions, please do not hesitate to contact us.

Yours truly,

TERRAPROBE TESTING LTD.



Karl Roechner, P. Eng.



Matthew Julien, P. Eng.

*they should reference OPS criteria regarding
settlement for falsework foundations ($\frac{1}{2}$ ")*

sealed

memorandum



To: K.G. Bassi
Head, Structural Office
7th Floor, Atrium Tower

Date: 1992 07 07

Attention: G. Al-Bazi

From: Foundation Design Section
Room 315, Central Building

Re: Review of Final Drawings and Documents
Hwy 50 Overpass at Hwy 407
W.P. 369-87-09/10, Site 37-1334
District 6, Toronto

We have reviewed the final drawings and documents on the above project and find that they generally conform to the recommendations provided by this Section.

We have the following comments.

1. On the General Arrangement drawing, remove the following phrases:
 - i "..... driven to El. 161.000." (from the south abutment area)
 - ii "..... driven to El. 164.000." (from the north abutment area)
2. On drawing No. 3, make the following changes:
 - i All piles shall have standard MTO pile tip reinforcement as per DD 3301.
 - ii Change the ultimate capacity of piles to 3450 kN, from 5450 kN.
 - iii Remove the phrase "... but not below elevation shown on Drawing 1, without the approval of the engineer.
3. There are two existing CSP's, one at the north abutment area and the other at the south abutment area. We assume that protection of these existing culverts during the construction of the bridge is covered elsewhere.

4. On drawings 4 and 5, notes are given regarding filling of the 500 dia. CSP's which are installed to protect the foundation piles. Notes regarding excavation for and installation of these CSP's as well as backfilling around these CSP's should also be included on these two drawings.

We have no other comments.



Balu Iyer, P.Eng.
Sr. Foundation Engineer

for

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

cc. V. Boehnke



Ministry
of
Transportation
Ontario

Ministère
des
Transports

To: H. Sich, P. Eng.

Hatch Associates Limited
2800 Speakman Drive
Mississauga, Ontario
L5K 2R7

From: Structural Section
Central Region

(416) 235 5659
1991 08 29

Re: Highway 407/ Highway 50 Underpass Structure
G.W.P. 369-87-00, Site 37-1334
Proposed C.S.P. in Front of Abutment Walls:

Dear Mr. Sich:

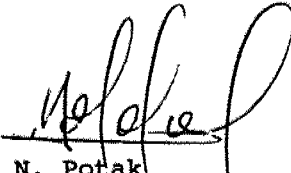
As requested, we have reviewed the proposed C.S.P. in front of the abutment walls. Our comments are as follows, assuming that the pipe diameter is not greater than 1.2 m:

- The location of the C.S.P. does not affect the piled abutment footings.
- At North Abutment the pile tip elevation (El. 169.0 m \pm) will be lowered. The revised tip elevations will vary from El. 164.0 m \pm to El. 167.0 m \pm to stabilize the piles.
- The following construction sequence will apply:
 1. Excavation for Highway 407.
 2. Excavation and installation of C.S.P.
 3. Construction of abutment piles/footings.
 4. Construction of Reinforced Earth wall in front of the abutments.

If you have any questions, please contact the undersigned.

Yours truly,

cc: M. Chan, Planning and Design
G. Al-Bazi, Structural Office
B. Iyer, Foundation Design Section
W. Lachmaniuk, Giffels Consultants


N. Potak
Sr. Structural Engineer
for:
V.F. Boehnke
Head, Structural Section



BT File

memorandum



To: K.G. BASSI
Head, Structural Section - Design Section
7 th Floor, Atrium Tower

Date: 91 05 06

Att: G. Al-Baazi

Frm: Foundation Design Section
Room 315, Central Building

Re: Hwy 50 Underpass at Hwy 407
WP 369-87-09/10, Site 37-1334A/B
District 6, Toronto

Comments concerning the preliminary General arrangement drawing 37-1334A/B-P1 are as follows:

1. The 2H to 1V slope in front of both abutments could be removed and the front face (Reinforced Earthwall) could be extended down to an elevation of 171 m +/- . However a dewatering scheme would have to be implemented for excavations below ground water levels. This option could be implemented if it were found more economical.

We have no other comments,

If you have any questions, please do not hesitate to contact this office.

A handwritten signature in dark ink, appearing to read "M. Michalek".

M. Michalek
Jr. Foundation Engineer
For:
Dr. B. Iyer, P. Eng.
Sr. Foundation Engineer

cc V. Boehnke, Head Structural Section, 4th Floor, Atrium Tower

To: V.F. Boehnke,
Head, Structural Section,
Central Region

Attn: N. Potak

From: Foundation Design Section
Room 315, Central Building

Re: Hwy 50 Underpass Structure,
W.P. 367-87-02, Site 37-1334,
Hwy 407, District 6, Toronto

1990 12 19

This is in reply to your speedy memo dated 1990 12 10.

Preliminary recommendations regarding design and construction of spread footings located at elevations 170 to 172 m have been given in our memo dated 1990 12 06. Comments are provided herein for two different structure options listed in your memo mentioned above.

1. PERCHED ABUTMENT FOUNDATION

It is understood that for this alternative, the base of the abutment footings would be at elevations 175.5 m and 174.5 m at the north and south abutments respectively.

At the north abutment, the existing overburden should be excavated to elevation 173.5 m, and at the south abutment to elevation 172.5 m, about 2 m below the underside of the proposed footings. Footings located on granular fill, placed and compacted from the excavated levels as mentioned above, may be designed using SLS and factored ULS capacities of 350 kPa and 900 kPa respectively.

2. REINFORCED EARTH - ABUTMENT STRUCTURE

The details of the reinforced earth wall and forward slopes (at 2H to 1V) are shown on a marked up drawing which accompanied your memo of 1990 12 10. From a foundation design and construction standpoint, the reinforced earth - abutment structure design as shown is considered acceptable at this site.

For this option, it is understood that the bases of the abutment structures would be located at elevations 178.5 to 179.0 m. These structures may be supported on steel H piles driven to elevations given below.

North abutment	169 m*
South abutment	161 m

(* Due to the denseness of the silt layer encountered in the north abutment area, some piles may get 'hung up' at higher elevations.)

It is recommended that 310x110 steel H piles be used with factored

ULS and SLS capacities of 1600 and 1150 kN respectively. The pile installation should be controlled in the field using the Hiley formula.

We trust that the comments given in this memo together with those contained in our memo of 1990 12 06 are sufficient for your immediate needs. Should you require further elaboration on any item covered in the two memos issued from our section, please do not hesitate to give us a call.



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

cc. G. AlBazi

MEMORANDUM

TO: V.F. BOEHNKE
STRUCTURAL SECTION
CENTRAL REGION

DATE: 90/12/06

AT: N. POTAK
STRUCTURAL ENGINEER

FR: FOUNDATION DESIGN SECTION
ROOM 315, CENTRAL BUILDING

RE: HWY 50 UNDERPASS
WP 367-87-02, SITE 37-1334
HWY 407, DISTRICT 6, TORONTO

This memorandum summarizes the results of a Foundation Investigation conducted at the aforementioned site and provides preliminary comments pertaining to the structure foundations and related earth works. These comments have been submitted in advance of the final report to assist in expediting the design so that conformance to project scheduling can be met. The final report will be submitted in the near future.

PROPOSED STRUCTURE

It is proposed to construct a two span structure which will carry HWY 50 over the proposed HWY 407. Cuts in the order of magnitude of 8 m will be required at the pier locations as the EBL and WBL will be excavated beneath the existing HWY 50. The proposed elevation of HWY 407 is approximately 172 metres.

SITE DESCRIPTION

The area is located just north of Steeles Ave. West along the existing four lane HWY 50 in the city of Brampton/Vaughan, Regional Municipality of Peel. The site is characterized by a 5 m to 7 m high embankment fill with HWY 50 at an elevation of 181 metres and having approach slopes of +2.40 % and -1.50 %.

The topography of the area consisted of rolling grassland with abandoned farmland to the west and east. To the east a large barn and farmhouse which is enclosed by a wire fence exists. Runoff from both fields is carried by a steel corrugated culvert which runs underneath Hwy 50 to provide drainage of the embankment.

FIELD INVESTIGATION

The foundation investigation consisted of 6 boreholes, 3 located on the west shoulder and 3 on the east shoulder. Boreholes were placed to correspond to abutment and pier locations for the HWY 50 underpass.

The elevation of the boreholes advanced at the site at the embankment crest varied from 178.9 m to 180.6 m. One borehole located at the toe of the embankment was at an elevation of 174.2 metres.

SUBSURFACE CONDITIONS

The subsoil stratigraphy was variable throughout the site with the existing fill embankment approximately 4 metres deep. The top 2 to 2.5 m of the fill consists of a cohesive top layer of Clayey Silt, Trace Sand, Trace Gravel. The rest of the fill is a layer of 1 to 2.2 metres of Heterogeneous Mixture of Silts, Sands, and Gravels. The native soils below the fill material consisted of various layers of Silt, Silty Sand, Sandy Silt to Clayey Silt with boreholes for the south east/west abutments and pier locations reaching very dense/hard Silt and borehole's for the north east/west abutments reaching a very dense material of Heterogeneous Mixture of Silt, Sand, Gravel and Clayey Silt, Trace Sand, Trace Gravel respectively. Occasional boulders and cobbles were encountered at lower depths.

Groundwater levels observed at the time of the investigation varied from 167.5 m to 170 m or approximately 10 metres below the existing HWY 50 grade.

DISCUSSION AND RECOMMENDATIONS

The following Foundation/Geotechnical items are hereby discussed.

- 1) Structure Foundation
- 2) Approach Embankments
- 3) Construction Considerations

STRUCTURE FOUNDATION

It is understood that the structure at this site would consist of closed abutments. The foundations would be located at or below elevation 171 m to 172 m at the abutments and about 170 m at the piers.

At the above elevations competent soil conditions are encountered. Spread footings located on competent native soil shall be designed using design parameters given below.

<u>SPREAD FOOTINGS ON NATIVE SOIL</u>		
	<u>FACTORED CAPACITY</u>	<u>ALLOWABLE CAPACITY</u>
	<u>AT U.L.S (Kpa)</u>	<u>AT S.L.S TYPE II (Kpa)</u>
spread footings	600	400

At all spread footing locations bearing capacity reductions to account for inclination of loads acting on shallow foundations shall be carried out in accordance with section 6-7.3.3.5 of the O.H.B.D.C.

APPROACH CUTS

Cuts in the order of 8 m +/- 1 m would be involved in the area of the proposed HWY 407 at HWY 50. Temporary excavations at the HWY 407/ HWY 50 crossing shall be carried out using 2 horizontal to 1 vertical side slopes. Outside the limits of the HWY 50 embankment, the cuts will be approximately 3.2 m deep. Permanent cuts in connection with the HWY 407 construction shall be at 2 horizontal to 1 vertical or flatter.

CONSTRUCTION CONSIDERATIONS

It is considered that excavations in connection with the proposed HWY 407 and the abutment and pier foundations would not extend below the groundwater level observed during the investigation. No dewatering of excavations would therefore be necessary if the spread footings are located at elevations as discussed in the previous section.

Within the limits of the approach fills, if any soft material is encountered, this should be excavated and replaced by compact granular fill.

All spread footings should be provided with a minimum of 1.2 m of cover for frost protection purposes.

No other construction problems are anticipated at this site.

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



MARTIN MICHALEK
FOUNDATION DESIGN ENGINEER

For:
DR. BALU IYER, P. Eng.
SENIOR FOUNDATION ENGINEER

BY: N. POTAK AUGUST 7, 1990
407/50 SITE 37-1334

1 OF 4



NORTH
VIEW
FROM
EAST



NORTH
VIEW
FROM
EAST



N-E
VIEW

BY: N. POTAK AUGUST 7, 1990

2 OF 4

607/50 SITE 37-1334



EAST
VIEW



S-E
VIEW



S-E
VIEW

BY: N. POTAK AUGUST 7, 1990

3 OF 4

407/50 SITE 37-1334



LOOKING
NORTH
FROM
WEST



N-W
VIEW



WEST
VIEW

BY: N. POTAK AUGUST 7, 1990

4 OF 4

407/50 SITE 37 1334



WEST
VIEW



S-W
VIEW



SOUTH
VIEW