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W.P. No. 368-87-02

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STR. SITE No. 37-1336

HWY. No. 407/427

LOCATION Ramp 427S - 407W over Steles Ave

No of PAGES -

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

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FOUNDATION DESIGN SECTION

WP 368-87-02 DIST 6

HWY 427/407 STR SITE 37-1336

Ramp 427S-407W Over Steeles Avenue

CONT 93-93

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GEOCRES 30M13-114

DATE OCT 10 1990

FOUNDATION INVESTIGATION REPORT
For
Ramp 427S-407W Over Steeles Avenue
W.P. 368-87-02, Site 37-1336
District 6, Toronto

INTRODUCTION

This report summarizes the results of a foundation investigation conducted at the aforementioned site. A single span steel box girder structure is proposed to carry the 427S-407W ramp over Steeles Avenue. The report describes the subsurface conditions at the site and provides detailed recommendations pertaining to the structure foundations and related earthworks.

SITE DESCRIPTION AND GEOLOGY

The site is located between the Hwy. 427 overpass structures and the 427 S-407 E ramp structure that carries traffic over Steeles Avenue. Construction of these adjacent structures was in progress at the time of the investigation. The proposed realigned Hwy. 427 is situated approximately mid-distance between the existing Hwy. 50 and Hwy. 27. The southern half of the site is located within the City of Etobicoke whilst the northern half of the site is located within the Town of Vaughan, Regional Municipality of York. The existing Steeles Avenue is presently a 4 lane roadway.

The natural terrain at the site is generally flat but construction of the aforementioned structures has accentuated the flat terrain with approach fill contours. Construction activity also dominated the area immediately north of the site, in conjunction with the construction of the Hwy. 427/407 interchange complex.

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 (over 12,000 years ago). 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 characteristic of till material, these deposits contain a wide range of grain sizes 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, Ordivician period.

INVESTIGATION PROCEDURES

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

Field Investigation

The fieldwork for the investigation was carried out between 90 06 18 and 90 06 20 and consisted of 4 sampled boreholes advanced to depths ranging from 6.6 m to 12.6 m below the natural ground surface. One of the boreholes (BH 10) was advanced so that information could be obtained to evaluate the stability and settlement of the approach embankments spanning between the north abutment of this structure and the south abutment of the proposed 427S-407N ramp structure (W.P. 368-87-01). The elevation of the ground surface at the borehole locations ranged from 174.7 to 175.1.

Track mounted CME 55 equipment employing hollow stem augering and washboring techniques was used to advance the boreholes in the overburden. In general, disturbed subsoil samples were retrieved at 0.7 m intervals for the surficial 6 m and 1.5 m intervals thereafter at the structure foundation locations and at 1.5 m intervals throughout at the approaches. Sample retrieval was conducted in accordance with the Standard Penetration Test (ASTM D1586). All samples were identified in the field and then returned to the laboratory for applicable testing.

Groundwater levels were obtained by monitoring the levels in the open boreholes throughout the duration of the field investigation. All open boreholes were backfilled at the completion of the fieldwork.

Survey information related to the location and elevation of boreholes was provided by Central Region Surveys and Plans.

Laboratory Analyses

To identify the behaviour, gradation and pertinent properties and characteristics of the soil, various laboratory tests were performed. These tests included:

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

Laboratory test results have been summarized in the subsequent section of this report entitled "Subsurface Conditions", and are illustrated on corresponding figures and boreholes included in the attached Appendix.

SUBSURFACE CONDITIONS

In general, competent and uniform subsurface conditions were encountered across the site. The soil stratigraphy consists of a surficial deposit that contains a heterogeneous mixture of clayey silt, sand and gravel that extends to a maximum depth of 5.6 m. This cohesive deposit has a very stiff to hard consistency.

Underlying the surficial deposit and explored for a maximum thickness of 7.0 m exists a cohesionless deposit that ranges in composition from a silty sand to a gravelly sand. Random interbeds of silt and sand are also present within this deposit.

The boundaries between the various soil types, in situ and laboratory test results as well as groundwater levels established at the time of investigation, are shown on the attached Record of Borehole sheets in the Appendix. A plan of the site illustrating the locations and elevations of the boreholes and subsoil stratigraphical sections are provided on Dwg. 3688702-A.

A detailed description of the subsurface conditions encountered is given below.

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

The native surficial deposit at the site consists of heterogeneous mixture of clayey silt, sand and gravel and extends for a depth approximately 5.3 to 5.6 m. Occasional boulders and cobbles as inferred during the field investigation by auger grinding are also present within the deposit. A grain size distribution envelope as determined by mechanical sieve and hydrometer analysis, that illustrates the gradation of this material is provided in Figure 1 in the Appendix. The boulder and cobble sizes are not illustrated on the indicated figure, as the figure illustrates a maximum grain size of 75 mm.

The deposit has experienced varying degrees of oxidation and hence varies in colour with depth from a mottled brown and grey to grey.

Atterberg Limit tests were carried out to define the behaviour and plasticity of the fine grained portion of the soil and the results are plotted in Figure 2 in the Appendix. A summary of the indices is provided in Table 1 below.

Table 1 - Clayey Silt

	Range	# of Tests
Natural Moisture Content (w%)	9-16	4
Liquid Limit (w_L%)	21-33	4
Plasticity Index (Ip%)	7-17	4
Unit Weight (kN/m^3)	21.5-22.1	2

The results reveal that the fine grained portion of the deposit is primarily of low plasticity and hence can be classified as clayey silt.

Standard Penetration Tests carried out in this deposit revealed 'N' values ranging from 12 blows/0.3 m to 100 blows/0.15 m. Based on these 'N' values, the material can be described as having a very stiff to hard consistency, but generally is of hard consistency.

Silty Sand to Gravelly Sand

The surficial cohesive deposit is underlain by a granular stratum ranging from a sandy silt to silty sand with random interbedded silt/sand layers to a gravelly sand. Grain size distribution curves as determined by mechanical sieve analysis illustrate the range in gradation of the deposit (<75 mm) and are shown on Figure 3 in the Appendix. The thickness of the stratum was not determined during the investigation, but based on information obtained from this investigation, this stratum has a minimum thickness of 7.0 m.

Interpretation of Standard Penetration Test 'N' values ranging from 18 blows/0.3 m to 121 blows/0.25 m, indicates a denseness ranging from compact to very dense. In general, the deposit can be categorized as dense to very dense.

Groundwater Conditions

Observation of the groundwater level was carried out by measuring the water level in the open boreholes. Groundwater levels determined at the time of investigation ranged from 2.4 to 4.4 m below the ground surface (El. 172.4 to 170.6 m). The rapid rise in the water level in the borehole at the time of the investigation upon penetration of the lower silty sand to gravelly sand stratum, reflects the subartesian water condition in the lower cohesionless stratum.

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 single span steel box girder structure that will carry the proposed two lane ramp 427S-407W over the existing Steeles Avenue. The ramp structure is approximately 32 m in length and 12.5 m in width and is a component of the Hwy. 427-407 interchange complex. The ramp is a two lane roadway with adjoining shoulders. Abutments for the single span structure have been proposed immediately north and south of the existing Steeles Avenue which is a four (4) lane roadway with a future lane proposed in either direction. A plan illustrating the proposed structure is shown on Dwg. 3688702-A attached in the Appendix of this report.

The existing ground surface at the site is at approximate El. 175 m. At the south abutment, the proposed profile grade of the 427S-407W ramp is approximately at El. 186 m and the grade ascends at a 2.82% gradient in the northerly direction. Hence, at the north abutment location, the proposed profile grade is at an elevation of 189 m. Consequently, approach fills in the order of magnitude of 9 m and 14 m for the south and north approach embankments will be required.

The Hwy. 427 structure over Steeles Avenue (W.P. 153-80-04) and the ramp 427 S-407 E over Steeles Avenue immediately west and east of the proposed 427 S-407 W ramp are founded on conventional spread footings within the native surficial soil.

To facilitate the design and construction of the proposed structure foundations and related earthworks for the 427S-407W ramp over Steeles Ave., the following foundation and geotechnical recommendations are provided in the scope of this report.

1) Structure Foundations
2) Approach Embankments

1) Structure Foundations

In view of the competent nature of the native surficial soils at the site, the abutments can be founded on a shallow foundation. The conventional spread footings can be designed and constructed as discussed below. The design that proves to be most economical and practically feasible shall be selected.

a) Compacted Granular 'A' Pad

Structure foundations can be "perched" on a compacted Granular 'A' pad placed on the existing native soil. For purposes of the O.H.B.D.C., the following bearing capacities are recommended.

Table 2 - Perched Abutment on Granular 'A'

Bearing Capacity at S.L.S. Type II	350 kPa
Factored Bearing Capacity at U.L.S.	900 kPa

The settlements induced as a result of the applied footing pressure will be elastic in nature and consequently is expected to take place during or immediately following the construction period. The magnitude of this settlement is anticipated to be within 25 mm total or differential, provided the subsoil/granular material is not softened/loosened by construction or related activities and the granular pad is constructed to the specifications described below.

Figure 4 in the Appendix illustrates the recommended geometry for the design of the perched abutment foundation. The thickness of the pad shall be a minimum 2 m above the existing natural ground surface and a minimum edge distance of 1 m from the edge of the footing to the crest of the granular 'A' pad shall be provided. The figure also illustrates that frost protection is required to protect the founding soil. All footings must have 1.2 m of earth cover.

The Granular 'A' material must be placed and compacted to achieve 100% of the Proctor maximum dry density as outlined in OPSS 501.08.02 (Method A). Quality control in the form of material inspection and field density measurements shall be conducted. Any softened and/or organic material present within the natural subgrade must be removed prior to the placement of the granular pad.

The computation of the sliding resistance of the foundation shall be computed in accordance with Section 6-7.3.3.2 of the O.H.B.D.C. An unfactored friction

angle of 35° can be used between the concrete footing and the Granular 'A' material. If additional sliding resistance is required, consideration can be given to employing shear keys beneath the footing. The passive resistance developed by the shear key can be computed using the parameters of the granular material tabulated in Table 4 (see "Lateral Earth Pressures on Structures" in subsequent section of the report).

Bearing capacity reduction 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. The capacities tabulated in Table 2 must therefore be modified accordingly.

b) Spread Footings on Native Soil

Alternatively, abutment structure foundations can be founded on the native clayey silt till deposit at or below the elevations tabulated in Table 3. For purposes of the O.H.B.D.C., the bearing capacities tabulated in Table 3 are recommended.

Table 3 - Spread Footings on Native Soil

Structure	Bearing Capacity at S.L.S. Type II (kPa)	Factored Capacity at U.L.S. (kPa)	Founding Elevation (m)
N. Abutment	400	600	172.4
S. Abutment	400	600	173.5

Settlement of the foundation subsoil as a result of the applied footing pressure will be elastic in nature and hence will develop during or immediately following construction. The total and differential settlement is expected to be within 25 mm.

Bearing capacity reduction 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. The capacities tabulated in Table 3 must therefore be modified accordingly.

An unfactored friction angle of 30° can be used between the concrete footing and the native soil in the computation of the sliding resistance of the foundation. Additional sliding resistance can be provided by employing shear keys in the native soil. The passive resistance developed by the shear key can be computed using an angle of internal friction of 30° and a natural unit weight of 20 kN/m^3 above the prevailing groundwater table. Below the groundwater table, buoyant unit weights are to be applied.

All softened and/or organic material present at the footing founding elevation shall be removed and replaced with a granular material and/or mass concrete. In addition, to preserve the founding soil during construction, it is recommended that a concrete working slab be placed in advance of the concrete footing construction.

All footings must be provided with adequate frost protection. Hence, the foundation must be designed with 1.2 m earth cover or equivalent frost protection.

No dewatering difficulties are anticipated during foundation construction because of the relatively impervious nature of the founding subsoil. Conventional sump pumping techniques will suffice in discharging any 'perched' or surface runoff water. Temporary slopes to facilitate the footing construction shall be constructed no steeper than 1½H:1V.

2) Approach Embankments

Approach fills in the order of magnitude of 9 m at the south approach and 14 m at the north approach will be required for the structure approach embankments. Discussion of the lateral earth pressures on the structure, stability, settlement and construction of the approach embankments are provided below.

Lateral Earth Pressure on Structure

Free draining material such as Granular 'A' or Granular 'B' shall be used within a wedge behind the abutments and retaining walls bounded by a plane rising at 60° to the horizontal as shown in Figure 6-9.6.1 in the O.H.B.D.C. The

application of granular material combined with weep holes in the abutment walls to drain any accumulation of water in the backfill will prevent hydrostatic pressure build-up. Design parameters of the soil are given in Table 5 below.

Table 4 - Backfill Properties

	Granular 'A'	Granular 'B'
Angle of Internal Friction (0) (unfactored)	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

*These earth pressure coefficients apply to horizontal backfill surfaces only. The appropriate consideration shall be given to account for sloping backfill.

The earth pressure coefficient at rest is to be used in design if the abutment/ retaining walls are rigid and unyielding.

Stability/Settlement

In view of the competent nature of the subsoil, no deep-seated stability problems are anticipated for the proposed embankment fill heights for slopes constructed at 2H:1V, both in the forward and transverse directions. However to preserve the internal (surficial) stability of the embankment fill, it is recommended that for embankment fill heights exceeding 8 metres, the approach embankment be constructed with a stabilizing midheight berm of 2 m width. The berm should be constructed at a nominal 2% gradient to facilitate surface runoff and 2H:1V slopes are to be maintained. In addition, an effective erosion control protection scheme, such as sodding, should be provided to protect the exposed slopes.

Settlements in the order of magnitude of 50 mm and 75 mm at the south and north approach respectively are expected due to the elastic recompression of the

native subsoil and settlement within the fills under its own weight. It is predicted that the majority of the settlements will be realized during or immediately following the construction of the embankment. To accelerate these anticipated settlements and to minimize post construction maintenance, it is recommended that the approach fills be placed as far in advance of final paving as the construction schedule permits.

Embankment Construction

In the construction of the embankment fills, all softened and/or organic material should be excavated for their full depth within the plan limits prior to fill placement.

Any new fill placement shall be connected to existing fills by "benching" the earth slopes in accordance with MTO Standards (OPSD 208.01).

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.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano and M. Michalek, Foundation Engineers, and M. Iampietro, Engineering Student, utilizing equipment owned and operated by Malone's Soil Samples Ltd. and Master Soils Investigation.

The project was carried out by T. Sangiuliano under the general supervision of Dr. B. Iyer, Senior Foundation Engineer. The report was written by T. Sangiuliano and reviewed and approved by Dr. B. Iyer.

T. Sangiuliano, P.Eng.
Foundation Engineer

for 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 (R Q D), FOR MODIFIED RECOVERY, IS:

R Q D (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

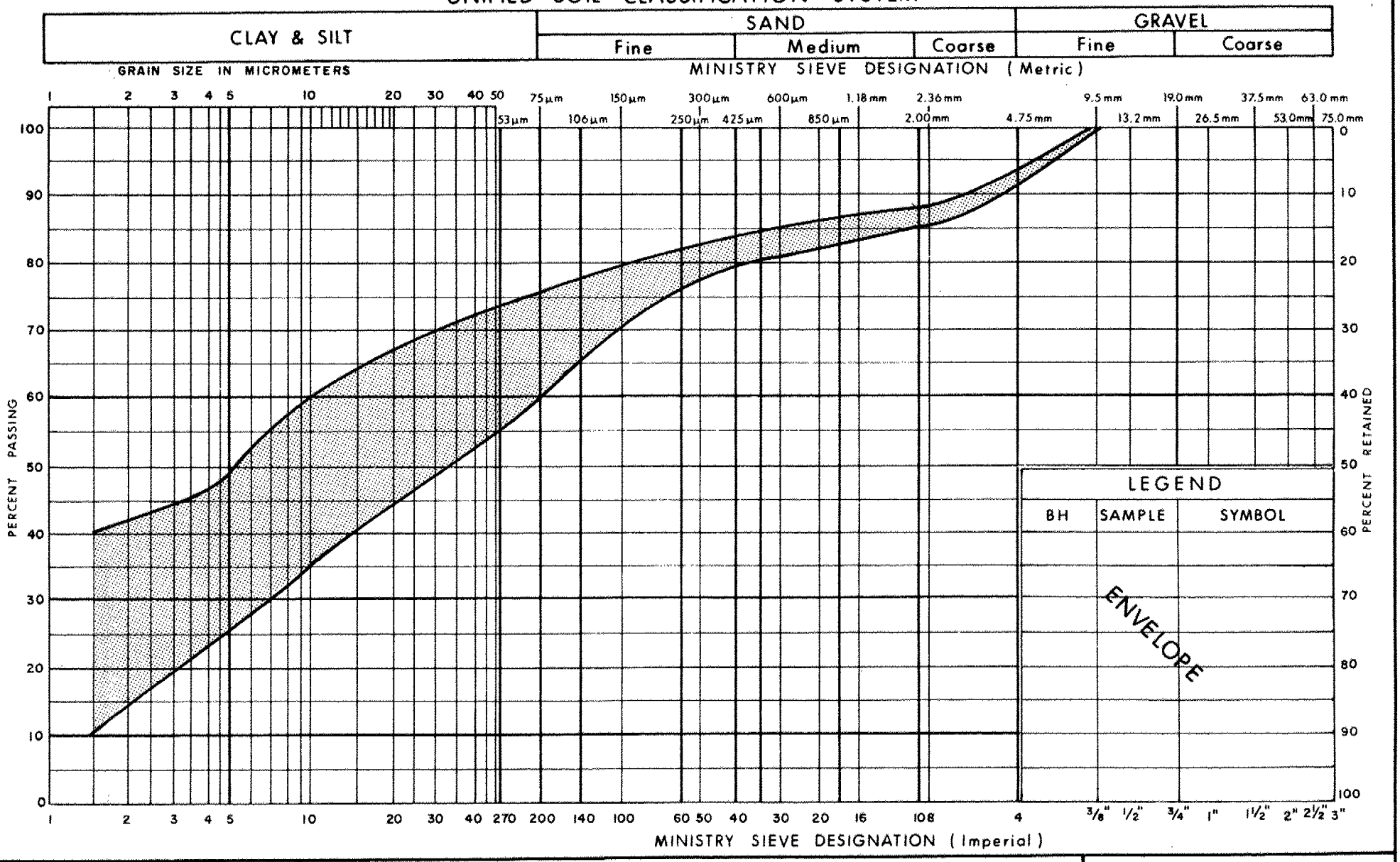
PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL

e	1,%	VOID RATIO
n	1,%	POROSITY
w	1,%	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_p	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_p	%	PLASTICITY INDEX = $w_L - w_P$
I_L	1	LIQUIDITY INDEX = $\frac{w - w_P}{I_p}$
I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
e_{max}	1,%	VOID RATIO IN LOOSEST STATE
e_{min}	1,%	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM

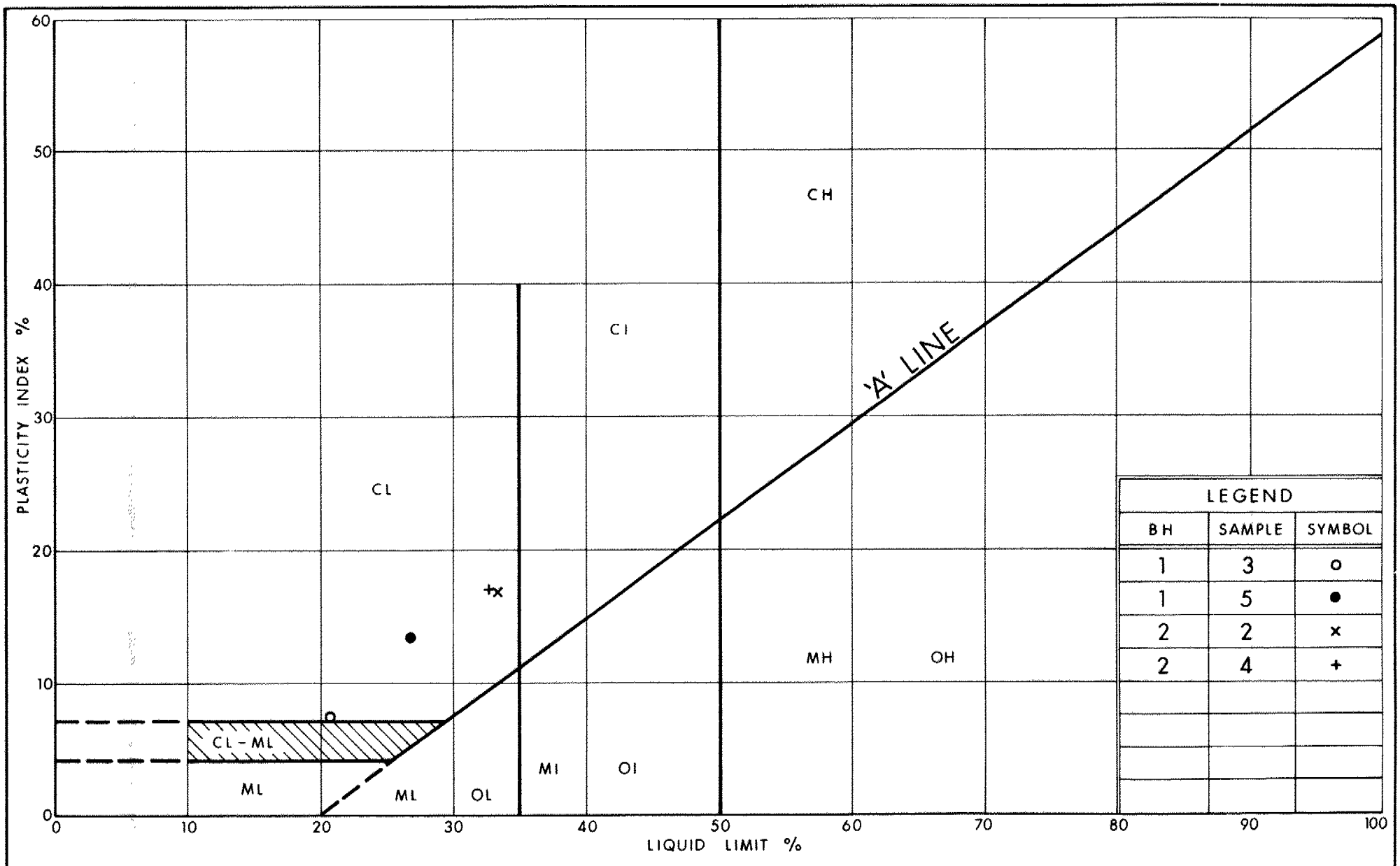


Ministry of Transportation
Ontario

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

FIG No 1
W P 368-87-02

Oct 75, FF-S-21



LEGEND		
BH	SAMPLE	SYMBOL
1	3	o
1	5	●
2	2	×
2	4	+

Ministry of Transportation
Ontario

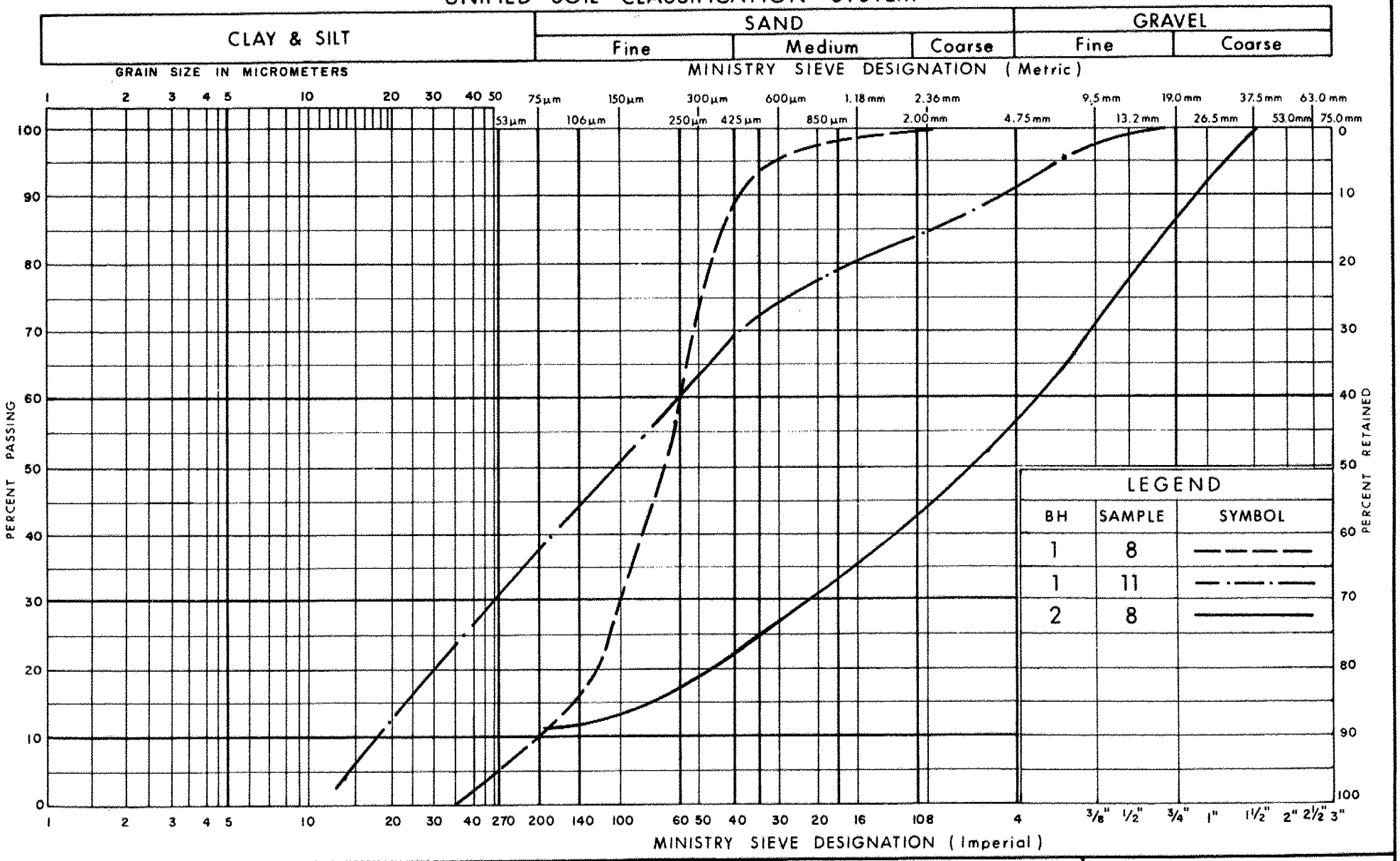
PLASTICITY CHART
HET MIXTURE OF CLAYEY SILT, SAND & GRAVEL (GLACIAL TILL) UPPER

FIG No 2

W P 368-87-02

78 12 M

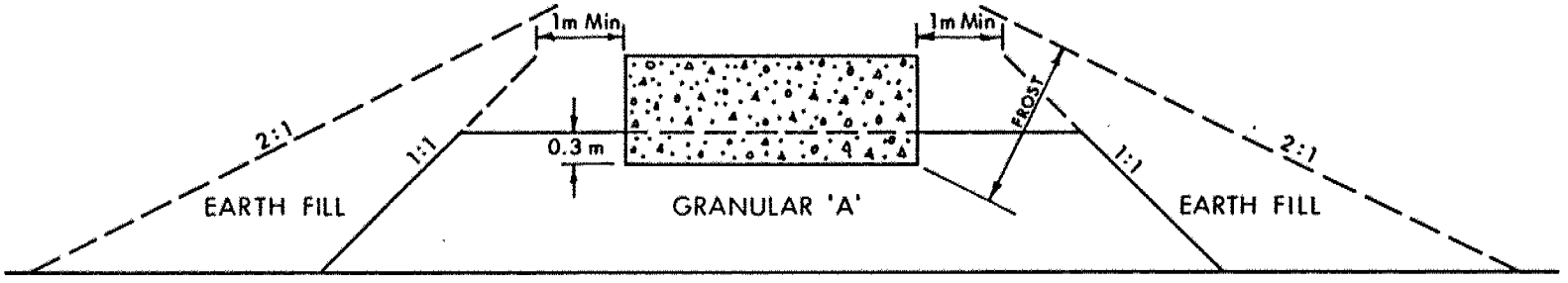
UNIFIED SOIL CLASSIFICATION SYSTEM



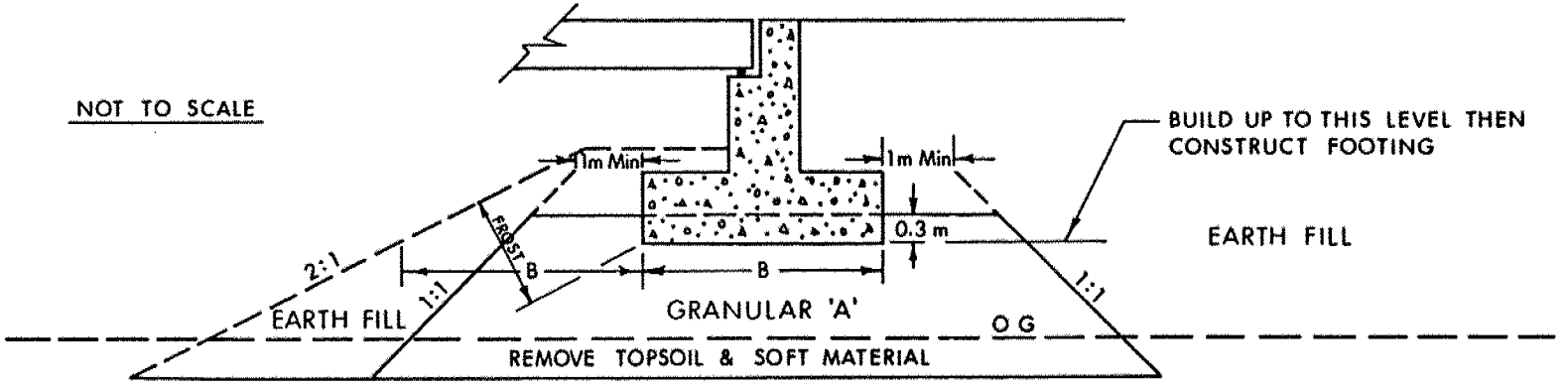
Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
SILTY SAND TO SAND

FIG No 3
W P 368-87-02



X SECTION



LONGITUDINAL SECTION

NOTES:

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

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

3 - CONSTRUCT CONCRETE FOOTING.

4 - PLACE REMAINDER OF GRANULAR 'A' & EARTH FILL AS REQUIRED.

Ministry of Transportation Ontario	ABUTMENT ON COMPACTED FILL SHOWING GRANULAR 'A' CORE	FIG No 4 W P 368-87-02

RECORD OF BOREHOLE No 1 1 OF 1 METRIC

W.P. 368-87-02 LOCATION Co-ords: N4 845 572; E294 307 ORIGINATED BY MM

DIST 6 HWY 407 BOREHOLE TYPE HS Auger/Washboring COMPILED BY TS

DATUM GEODETIC DATE 90 06 18 CHECKED BY TS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
174.8	Ground Surface							20 40 60 80 100	10 20 30		
0.0	Heterogeneous mixture of Clayey Silt, sand and gravel (Glacial Till) V. Stiff to Hard		1	SS	41						
			2	SS	19						
			3	SS	25	▼	172		o	22.1	7 32 48 13
	Brown		4	SS	37						
	Grey		5	SS	59				o	21.5	8 26 36 30
169.2			6	SS	63		170				
5.6			7	SS	39						
	sand		8	SS	32		168		o		0 88 (12)
	Silty Sand to Sand, with random interbeds of silt Grey, Compact to Dense		9	SS	29		166				
			10	SS	18		164				
	trace gravel		11	SS	48				o		10 52 (38)
162.2											
12.6	End of Borehole										

+3, ×3: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2 1 OF 1 METRIC

W.P. 368-87-02 LOCATION Co-ords: N4 845 536.5 ; E 294 302 ORIGINATED BY MM

DIST 6 HWY 407 BOREHOLE TYPE HS Auger/Washboring COMPILED BY TS

DATUM GEODETIC DATE 90 06 18 CHECKED BY TS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	WATER CONTENT (%) (PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
175.0	Ground Surface							20 40 60 80 100	10 20 30		
0.0	Heterogeneous mixture of Clayey Silt, sand and gravel (Glacial Till) V. Stiff to Hard		1	SS	12		174				
			2	SS	30				o		8 19 31 42
			3	SS	47		172				
			4	SS	38				o		8 15 43 34
	Brown		5	SS	169						
	Grey		6	SS	120	/23cm	170				
169.5											
5.5	Silty Sand to Gravelly Sand Grey, V. Dense		7	SS	87		168		o		16 75 (9)
			8	SS	107				o		44 44 (12)
165.4			9	SS	121	/25cm	166				
9.6	End of Borehole										

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

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

RECORD OF BOREHOLE No 3 1 OF 1 METRIC

W.P. 368-87-02 LOCATION Co-ords: N4 845 499.3 ; E 294 316.5 ORIGINATED BY MM

DIST 6 HWY 407 BOREHOLE TYPE HS Auger/Washboring COMPILED BY TS

DATUM GEODETIC DATE 90 06 19 CHECKED BY TS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	WATER CONTENT (%) 10 20 30		GR SA SI CL
174.7	Ground Surface										
0.0	Heterogeneous mixture of Clayey Silt, sand and gravel (Glacial Till) Brown, Hard		1	SS	37		172				
			2	SS	88	▼					
169.2			3	SS	100	/15cm	170				
5.5	Gravelly Sand, Brown, V. Dense		4	SS	118						
168.1											
6.6	End of Borehole										

+³, ×⁵ : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 10 1 OF 1 METRIC

W.P. 368-87-01 LOCATION Co-ords: N 4 845 625.5 ; E 294 281.5 ORIGINATED BY MI

DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY MI

DATUM Geodetic DATE 90 06 20 CHECKED BY TS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
175.1	Ground Surface										
0.0	Heterogeneous mixture of Clayey Silt, sand and gravel (Glacial Till) Brown V. Stiff / Hard		1	SS	28		174				
			2	SS	85		172				
169.8			3	SS	105	▼	170				
5.3	Sandy Silt to Silty Sand V. Dense Brown / Grey		4	SS	55						
			5	SS	53		169				
165.5			6	SS	50		166				
9.6	End of Borehole										

+⁵, ×⁵ : Numbers refer to Sensitivity

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

MINISTRY OF TRANSPORTATION, ONTARIO FH-D-207 88 10

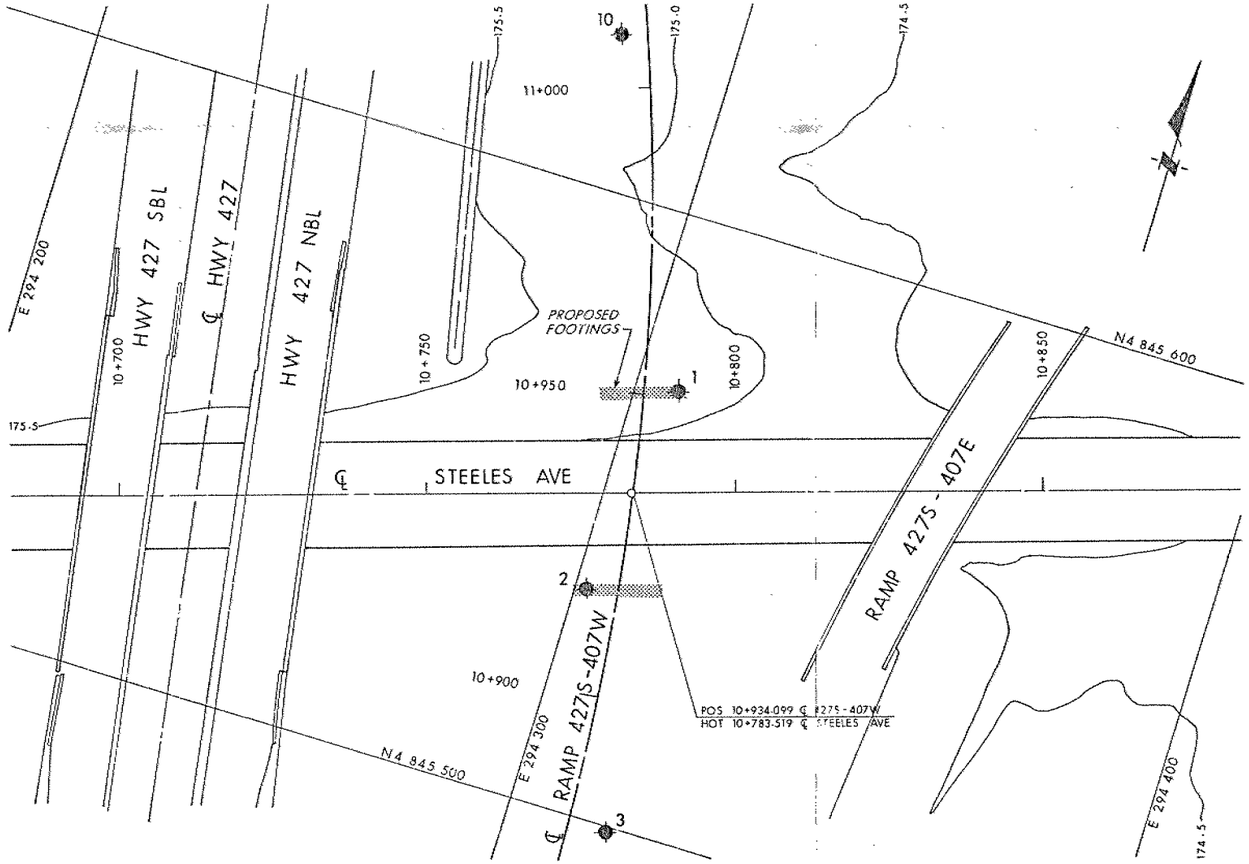
METRIC

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

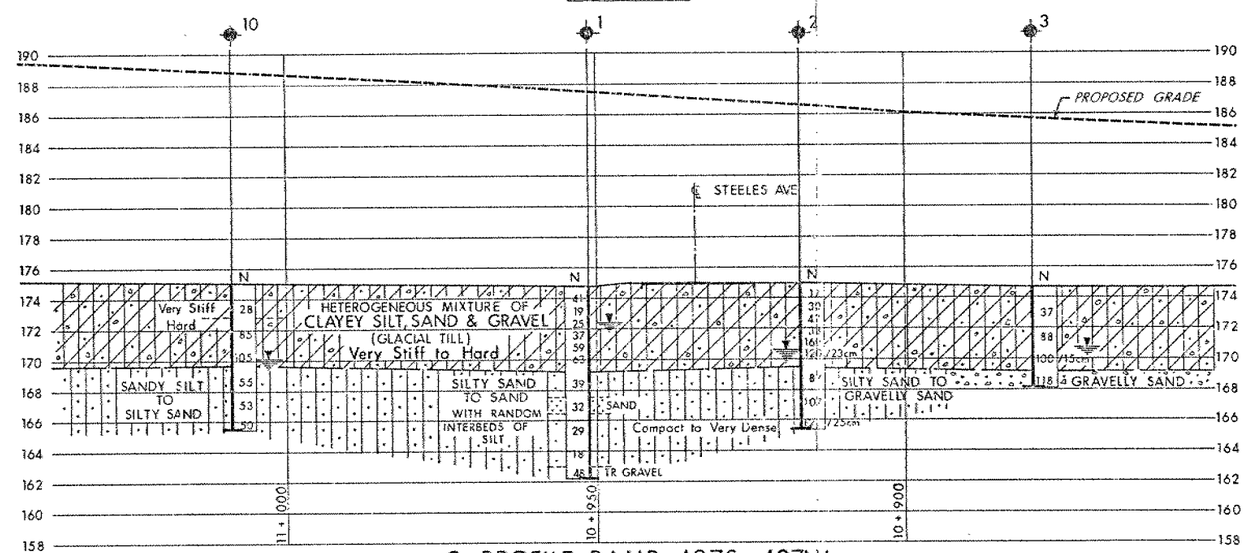
CONT No
WP No 368-87-02

RAMP 427S-407W
OVER STEELES AVE
BORE HOLE LOCATIONS & SOIL STRATA

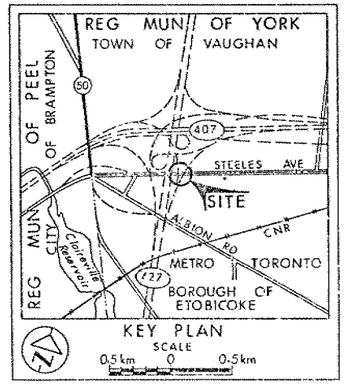
SHEET



PLAN
SCALE
10m 0 10m



℄ PROFILE RAMP 427S-407W
SCALE
10m 0 10m Hor
4m 0 4m Vert



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)
- WL at time of investigation 90 06

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	174.8	4 845 572.0	294 307.0
2	175.0	4 845 536.5	294 302.0
3	174.7	4 845 499.3	294 316.5
10	175.1	4 845 625.5	294 281.5

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 30M13-114

REF No B-73-407-19.

HWY No 407/427			DIST 6
SUBM'D TS	CHECKED	DATE 90 09 19	SITE 37-1336
DRAWN DT	CHECKED	APPROVED	DWG 368702-A

memorandum

Ontario

To: V.F. Boehnke
Head, Structural Section
Central Region
4th Floor, Atrium Tower

Date: 1991 08 15

Attn: D. Wong
Sr. Structural Engineer

From: Foundation Design Section
Room 315, Central Bldg.

Re: Final Design Drawing Review
Hwy. 407/427 Interchange Advance Structures
Ramp 427S - 407W Overpass at Steeles Avenue, W.P. 368-87-02
Ramp 407W - 427S Overpass at Steeles Avenue, W.P. 368-87-03
G.W.P. 368-87-00, District 6

The final design drawings and special provisions pertaining to the aforementioned proposed structures have been reviewed for their foundation and geotechnical content. Pertinent comments are provided below.

RAMP 427S - 407W OVERPASS AT STEELES AVENUE, W.P. 368-87-02

The drawings and provisions are in accordance with our previously submitted recommendations and the design is in compliance with foundation and geotechnical standards. Therefore, we have no further comments as far as the design and construction of this structure is concerned.

RAMP 407W - 427S OVERPASS AT STEELES AVENUE, W.P. 368-87-03

Temporary Shoring

a) Reinforced Earth Retaining Wall Between New and Existing Structures

A temporary roadway protection scheme has been designed to facilitate the installation of the reinforced earth module between the existing 407E - 427S ramp structure and the proposed 407W - 427S ramp structure. The shoring scheme and layout in general is deemed acceptable from a geotechnical point of view. However, the following issues should be reviewed to verify and also possibly to enhance the design.

1) It is understood that the retained embankment is to be resisted by the L100x100x10 tie-back anchored into the existing structure concrete wall with a square plate and adhesive epoxy anchors. The additional loads introduced on the existing concrete wall should be taken into consideration to verify that the wall remains stable from an overturning and sliding point of view.

2) Soldier pile embedment lengths range up to 6 metres with the two northerly soldier piles embedded with a toe elevation of approximately 170.0 metres. In view of the fact that a toe elevation of 170.0 m will encroach into the submerged cohesionless sandy silt to silty sand stratum present at the site and hence create soldier pile installation difficulty as a result of unbalanced hydrostatic conditions, it is recommended that the soldier pile embeddments be decreased and terminated at or above elevation 172.0 m.

3) The timber lagging illustrated on the drawings reveals 100 x 100 members spanning the soldier piles. Although, these members may be structurally capable of supporting the applied loads, in practice, 100 x 200 lagging boards are generally employed.

b) North-East Reinforced Earth Retaining Wall

The levelling pad elevations proposed at the north-east reinforced retaining wall are stepped-up and range from El. 174.868 to El. 182.368. The existing contour elevations are not clearly defined on the plan on drawing 1, but it is interpreted that the contours range up to approximately 183 metres. Consequently, it appears that excavation of the existing approach embankment will be required to facilitate the installation of the reinforced earth module and the proprietary facing. In order to ensure the stability of the existing approach embankment, the construction method should be evaluated to determine if a temporary shoring scheme is required.

Reinforced Earth Walls

At the south abutment, section 3 on drawing 5 illustrates the reinforced earth levelling pad unsupported. It is believed that the levelling pad should be positioned on the pier abutment concrete foundation and consequently, the section should be revised to reflect this levelling pad-foundation contact.

Approach Embankments Slope Geometry

The slopes of the proposed approach embankments are not labelled on the drawings. As revealed in the original Foundation report, forward and traverse slopes can be constructed at 2H:1V or flatter for fill heights up to 8 metres. For fill height magnitudes exceeding 8 metres, embankment slopes shall be constructed with 2H:1V slopes and a midheight berm of 2 metres width or alternatively 2.5H:1V or flatter slopes.

Slope Benching

The plan or drawing 1 clearly depicts that new approach fills will be superimposed on existing approach fills. It is hereby reiterated that any new fill placement shall be connected to existing fills by 'benching' the earth slopes in accordance with M.T.O standards (see Pg. 11 of foundation report 'Embankment Construction') The applicable standard drawing (OPSD - 208.01) should therefore be included or referenced on the contact drawings

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

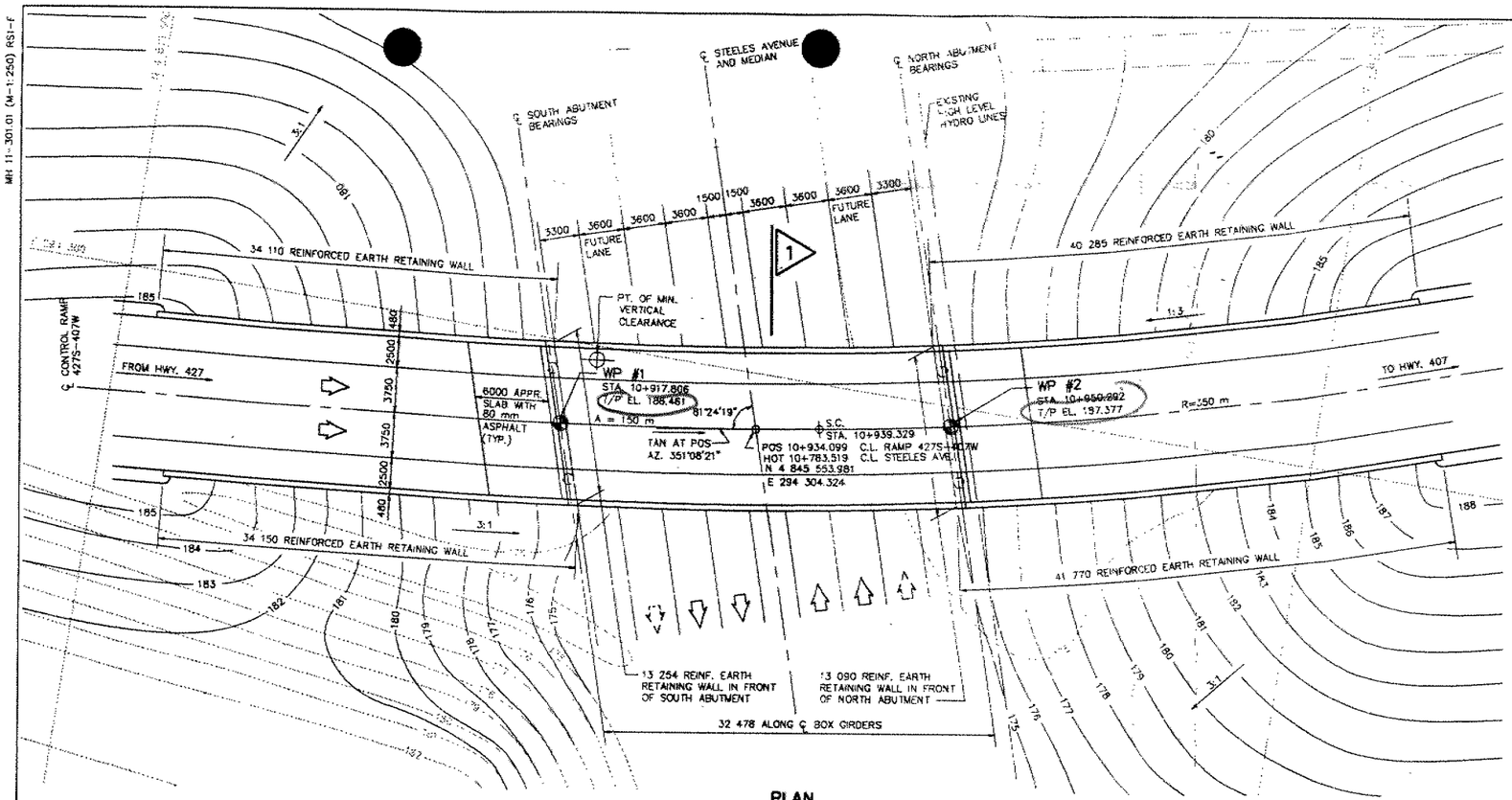
T. Sangiuliano P. Eng.
Foundation Engineer

for

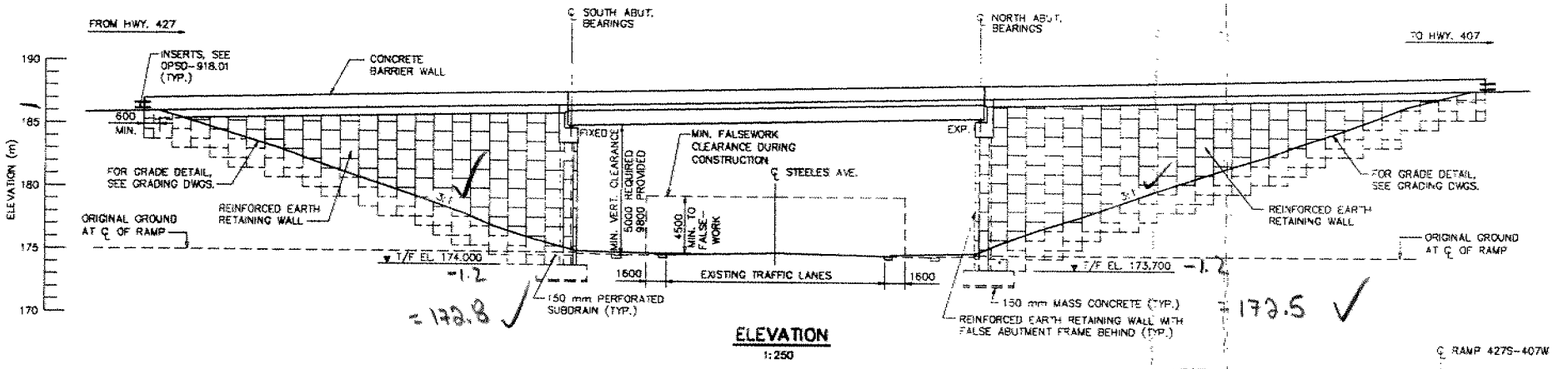
M. Devata, P. Eng.
Chief Foundation Engineer

MD/TS/me

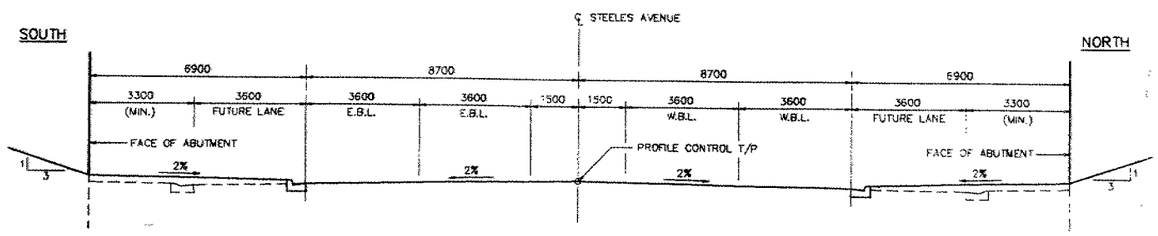
MH 11-301.01 (A-1:250) RS1-F



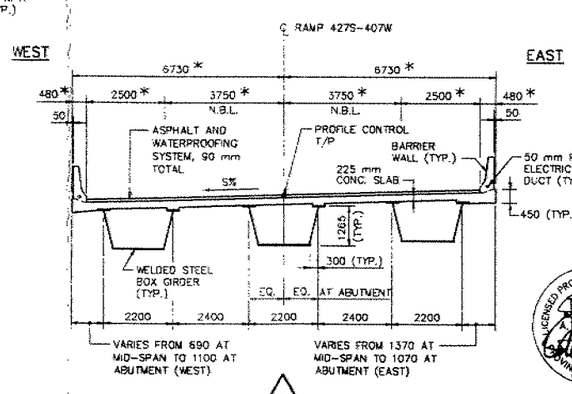
PLAN
1:250



ELEVATION
1:250



SECTION SHOWING STEELES AVE. UNDER RAMP 427S-407W
N.T.S.



1
1:100

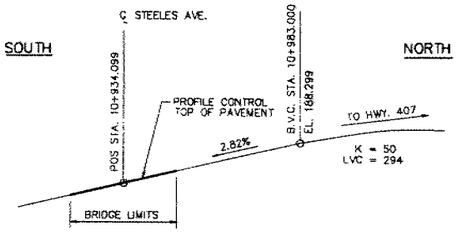
* DENOTES RADIAL DIMENSIONS

B.M. ELEVATION 173.207

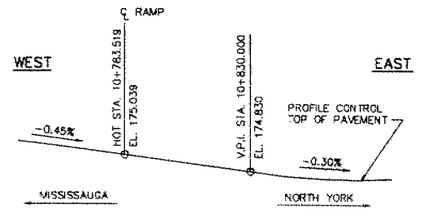
TABLET IN CENTRE AT NORTH OF WEST CONCRETE PIER OF BRIDGE OVER CNR TRACKS ON ALBION ROAD, 1.16 m ABOVE GROUND LEVEL APPROX. 200 m EAST OF HWY. 427

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

NOTE
THE APPROACH SLABS, ASPHALT AND WATERPROOFING ARE NOT PART OF THIS CONTRACT.



PROFILE OF RAMP 427S-407W
N.T.S.



PROFILE OF STEELES AVE.
N.T.S.

DIST. No. 6
CONT. No.
WP. No. 368-87-02

RAMP 427S-407W OVERPASS AT STEELES AVENUE

GENERAL ARRANGEMENT

SHEET

Morrison Hershfield Limited
Consulting Engineers

GENERAL NOTES

1. CLASS OF CONCRETE

ALL CONCRETE	30 MPa

2. CLEAR COVER TO REINFORCING STEEL

FOOTINGS	100±25
ABUTMENTS	
FRONT FACE	80±20
BACK FACE	70±20
COLUMNS (EMBEDDED)	70±20
DECK SLAB	
TOP SURFACES	70±20
BOTTOM SURFACES	40±10
REMAINDER	70±20 UNLESS OTHERWISE SPECIFIED

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

4. CONSTRUCTION NOTES
a. EXTERIOR FACES OF REINFORCED EARTH RETAINING WALLS AND THE EDGES OF DECK ARE PARALLEL TO ℄ OF CONTROL RAMP 427S-407W.
b. IF THE ACTUAL BEARING HEIGHTS ARE DIFFERENT FROM THE ASSUMED HEIGHTS GIVEN WITH THE BEARING DESIGN DATA, THE CONTRACTOR SHALL ADJUST THE BEARING SEAT ELEVATIONS AND THE REINFORCING STEEL TO SUIT THE ACTURAL HEIGHTS.
c. REINFORCED EARTH RETAINING WALLS, FALSE ABUTMENTS AND BACKFILLING SHOULD BE COMPLETED BEFORE THE STEEL GIRDER ERECTION.
d. CONCRETE BARRIER WALLS ON RETAINING WALL SHALL NOT BE CAST UNTIL THE RETAINING WALL BACKFILL HAS BEEN COMPLETED.

LIST OF DRAWINGS

ISSUED
JUL 29 1991
MORRISON HERSHFIELD LIMITED
DRAWING OFFICE

LEGEND

T/F	TOP OF FOOTING
T/C	TOP OF CONCRETE
T/P	TOP OF PAVEMENT (OR TOP OF CONC. DAM)
WP	WORKING POINT

APPLICABLE STANDARD DRAWINGS

OD-4603	FALSEWORK CLEARANCES
OPSD 918.01	CONNECTION TO NEW STRUCTURES

LICENSED PROFESSIONAL ENGINEER A. H. CHAN PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER C. Y. LO PROVINCE OF ONTARIO

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	DL	CHK. ATC	CODE	OHBDC-83	LOAD CLASS A	DATE	APR./91
DRAWN	DL	CHK. ATC	SITE	37-1336	STRUCT.	SCHEME	DWG. 1

MH 11-301.01 (M=1:50) RS3-B

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

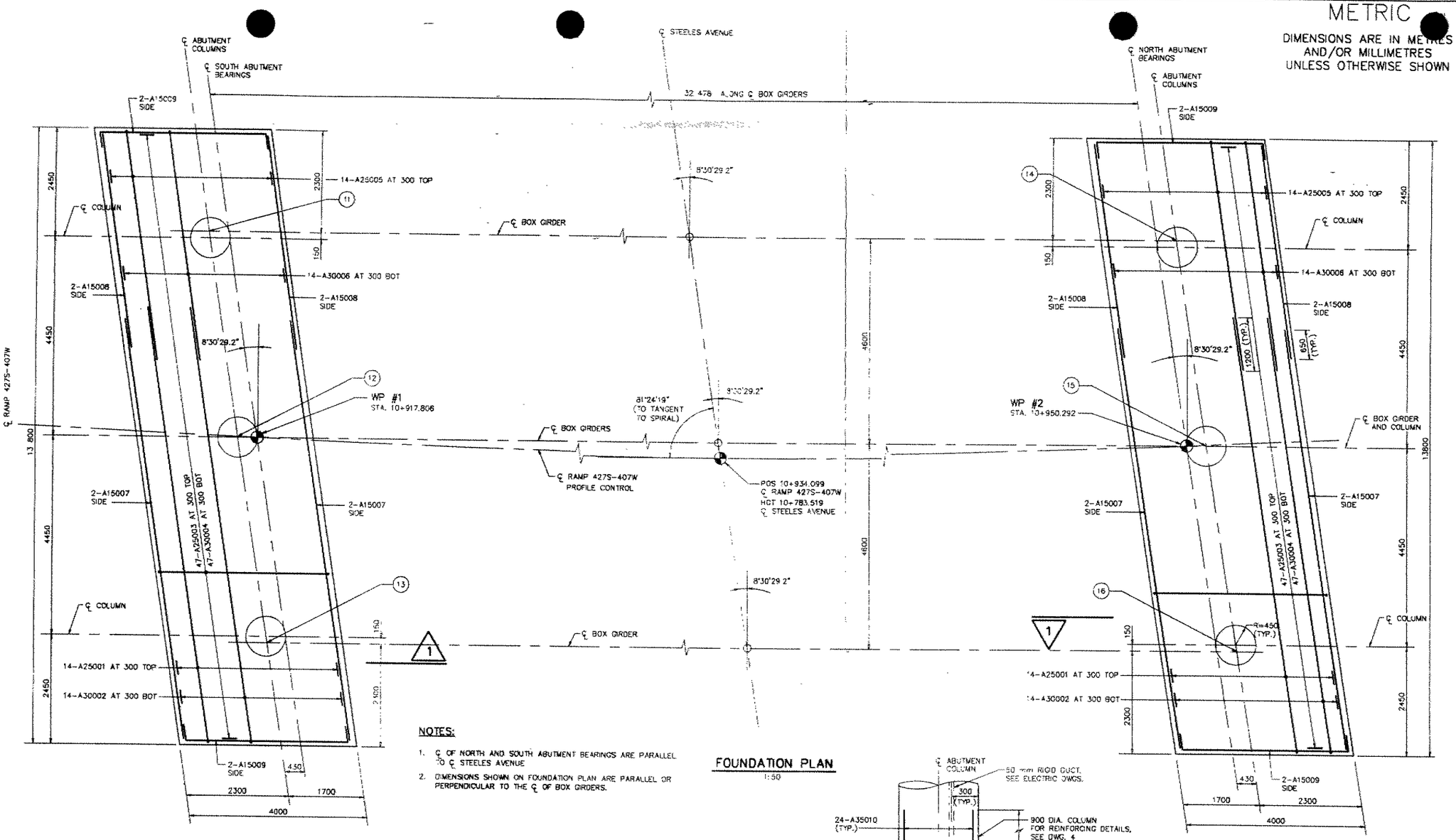
DIST. No.
CONT. No.
WP. No. 368-87-02

SHEET

RAMP 427S – 407W OVERPASS AT STEELES AVENUE

FOOTING LAYOUT AND REINFORCING

Morrison Hershfield Limited
Consulting Engineers

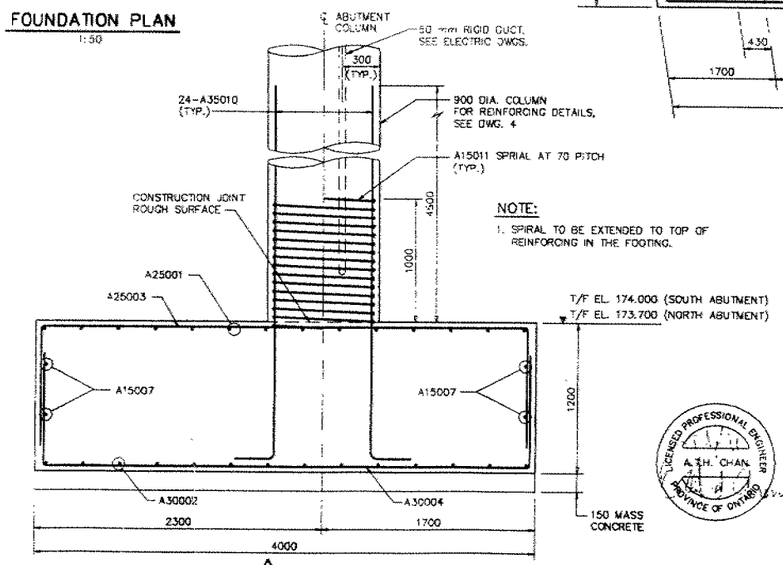


NOTES:

1. ℄ OF NORTH AND SOUTH ABUTMENT BEARINGS ARE PARALLEL TO ℄ STEELES AVENUE
2. DIMENSIONS SHOWN ON FOUNDATION PLAN ARE PARALLEL OR PERPENDICULAR TO THE ℄ OF BOX GIRDERS.

FOUNDATION PLAN

1:50



1
1:25

NOTE:

1. SPIRAL TO BE EXTENDED TO TOP OF REINFORCING IN THE FOOTING.

LEGEND:

T/F – TOP OF FOOTING
BOT – BOTTOM LAYER
(15) – DENOTES REFERENCE POINT 15

CO-ORDINATES OF WORKING POINTS

WORKING POINT	STATION	CO-ORDINATES	
		NORTH	EAST
1	10+917.806	4 845 537.835	294 306.515
2	10+950.292	4 845 569.917	294 301.463

CO-ORDINATES OF REFERENCE POINTS

REFERENCE POINT	CO-ORDINATES	
	NORTH	EAST
11	4 845 536.010	294 302.146
12	4 845 537.405	294 306.583
13	4 845 538.800	294 311.020
14	4 845 568.951	294 296.959
15	4 845 570.346	294 301.396
16	4 845 571.742	294 305.833

172.8

173.70
1.35
172.35

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS

DATE	BY	DESCRIPTION

DESIGN	ATC	CHK. ATC	CODE	OHBDC-83	LOAD CLASS A	DATE	JUNE/91		
DRAWN	TY	CHK. ATC	SITE	37-1338	STRUCT.	SCHEME		DWG.	3

memorandum

Ontario

To: V. Boehnke
Head, Structural Section
Central Region

Date: 1990 12 11

Atten: D. Wong
Structural Engineer

From: Foundation Design Section
Room 315, Central Building

Re: Highway 427/407 Interchange Advanced Structure
Ramp 427S-407W Overpass at Steeles Avenue
Site #37-1336, W.P. 368-87-02
District 6, Toronto

The General Arrangement Drawing for the afore-mentioned project has been reviewed by this office from a foundation and related earthworks point of view. The retaining walls supported on compacted granular 'A' pad are situated above the abutment spread footings and consequently the influence of the additional loading on the lower abutment foundation should be considered in the design.

All other geotechnical aspects of the drawing are in accordance with previously submitted recommendations.

T. Sangiuliano, P. Eng.
Foundation Engineer

for

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

BI/TS/mmj