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W.P. No. 368-87-04/05

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W. O. No.

STR. SITE No. 37-1324/1325

HWY. No. 407/427

LOCATION 407W-27N, S Ramp over
427N,S-407E Ramp

No. OF PAGES -

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

Ministry of
Transportation and
Communications

Ontario

FILE No._____ **DATE**_____

REMARKS ADJACENT Structure WP 150-87-01/02

Wade Young 5510

ADM-G-24 79-06 (formerly SB-OS-35A)

368-87-04

Ministry of Transportation
Ontario

SUPERCEDED

FOUNDATION DESIGN SECTION

foundation investigation and design report

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 368-87-04 DIST 6

HWY 407 STR SITE 37-1324

Ramp Structure 407 W to 27 N/S
(over Ramp 427 N/S to 407 E)

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GEOCRES 30M13-101

DATE MAY 09 1990

FOUNDATION INVESTIGATION REPORT
For
Ramp Structure 407 W to 27 N/S
(over Ramp 427 N/S to 407 E)
W.P. 368-87-04, Site 37-1324
District 6, Toronto

INTRODUCTION

This report summarizes the result of a foundation investigation conducted east of the proposed Highway 427/407 interchange at the above mentioned structure site. This report applies to the proposed structure, its related retaining walls and approaches.

SITE DESCRIPTION AND GEOLOGY

This site is located north of Steeles Avenue, west of Highway 27 adjacent to the proposed Highway 407 in the Township of Vaughan. The land is presently being used agriculturally. The terrain surrounding the site is level to undulating.

Physiographically, the region has been described by Chapman and Putman (1973) as the Peel Plain. The Peel Plain is basically a bevelled till plain, containing large amounts of Palaeozoic shale and limestone, and some areas are modifed by a veneer of varved clay.

FIELD INVESTIGATION

The fieldwork was carried out during the period from 89 12 14 to 90 01 10 and consisted of seven boreholes with six of the boreholes accompanied by dynamic cone penetration tests. The borings were advanced by hollow stem (95 and 83 mm I.D.), and solid stem augers using machines mounted on muskeg vehicles.

Sampled boreholes were advanced to depths ranging from 9.6 to 23.3 m below the ground surface. From the surface the cone tests advanced to depths ranging from 2.8 to 6 m below the ground surface. The cone tests advanced

from the bottom of the boreholes penetrated from 0.7 to 1.1 m. In general, subsoil sampling was conducted at 0.7 m intervals for the surficial 6.1 m and at 1.5 m intervals for the remainder of the borehole. All samples were retrieved using a split spoon sampler in accordance with Standard Penetration Test (ASTM D1586). All samples were identified in the field and again in the laboratory where they were taken for applicable testing.

Groundwater levels were obtained in the open boreholes and monitored until they were backfilled. The boreholes were backfilled either following their completion or at the completion of the investigation. Survey information for the location and elevation of the boreholes was provided by Central Region Surveys and Plans.

LABORATORY ANALYSES

To identify the behaviour, gradation and property of the soil, the following laboratory tests have been conducted:

1) Atterberg Limits
2) Grain Size Distributions
3) Natural Moisture Contents

SUBSURFACE CONDITIONS

General

The elevation of ground level at the site ranged from 174.8 to 173.1 m. The subsurface conditions at the site consist mainly of 8 to 11.6 m clayey silt, with sand, trace of gravel with layers of silty sand and silt found occasionally in the deposit. Below this material at elevation 166.4/161.9 m a till consisting of a heterogeneous mixture of gravel, sand, silt and clay was encountered. This mixture was found to be cohesive for the upper 4.6+ to 7.5 m, below which the till became non-cohesive.

The plan, location of borings and the subsoil stratigraphical profile are shown on Drawing 3688704-A in the attached Appendix. The boundaries between various soil types, field and laboratory test results, as well as ground water levels are plotted on the Record of Borehole sheets also in the Appendix of this report. A description of the soil types encountered are given below:

Clayey Silt, with Sand, trace of Gravel

This material was found from the surface (elevation 174.8 to 173.1 m) to the top of the Heterogeneous Mixture. The material ranged in depth from 8 to 11.6 m. The upper half of the material appeared to be a glacial till, whereas the lower half which contained layers of silty sand was lacustrine.

This soil layer consisted mainly of a clayey silt, with to trace of sand, trace of gravel. A grain size distribution envelope for the material as determined by mechanical analyses is given in Figure 1.

Atterberg Limits were also obtained to evaluate the behaviour of the fine grained portion of the material which are plotted in Figure 2. A summary of the physical properties of the fine grained portion is provided below:

	Range
Natural Moisture Content (w)	8-20%
Liquid Limit (w_L)	21-35%
Plastic Limit (wp)	12-16%

The test results indicate a clayey silt of low plasticity.

The 'N' values obtained from the standard penetration tests ranged from 6 to 103. Typical 'N' values ranged however from 10 to 50. The high values may have resulted from large aggregates such as boulders and cobbles which are characteristic of till deposits and consequently may be assumed to

exist in this deposit. The consistency of the material was found to be firm to hard with depth.

A 1 to 2 m layer of silty sand exists at elevations ranging from 169.5 to 164.5 m within the deposit. This layer is a lacustrine deposit ranging in denseness from compact to very dense. Grain size distribution curves illustrating the gradation of the layer is provided in Figure 3.

Heterogeneous Mixture of Gravel, Sand, Silt, and Clay; Cohesive

This deposit was found underlying the clayey silt at elevation 161.9/166.4. Some of the boreholes terminated within the cohesive heterogeneous mixture. However from the other boreholes which extended beyond the cohesive till, the deposit ranged from 4.6+ to 7.5 m in depth.

Only two grain size distribution tests were carried out. The results were 0/3% gravel, 14/22% sand, 56/86% silt and 4/20% clay. The physical properties of the fine grained portion indicated a natural moisture content (w) of 10/15%, a plastic limit (wp) of 15/17%, and a liquid limit (w_L) of 24/29%. These two test results indicated a clayey silt of low plasticity.

The 'N' values obtained from the standard penetration tests ranged from 11 to 137. Typical 'N' values ranged however from 50 to 120. The low values may be a result of a water bearing strata. The high values may result from large aggregates, which may be assumed to exist. The consistency of the deposit was hard.

Heterogeneous Mixture of Gravel, Sand , Silt, and Clay; Non-Cohesive

This deposit was found underlying the cohesive heterogeneous mixture in two of the boreholes at elevations 156.6 and 157.2. Both of these boreholes terminated within the non-cohesive heterogeneous mixture of till. The extent of this non-cohesive till deposit is therefore not known, although the boreholes indicate that it is 7 m plus deep.

The grain size distribution tests were carried out on three samples. The results indicated 0 to 3% gravel, 14 to 28% sand, 61 to 83% silt and 4 to 11% clay.

The physical properties of the fine grained portion indicated a natural moisture content (w) of 15 to 22%, plastic limit (wp) of 14 to 17% and liquid limits of 15 to 18%. These Atterberg limits indicate that the deposit could be classed as non-cohesive.

The 'N' values obtained from the Standard Penetration tests ranged from 13 to 122. The low blow counts are most likely due to softening by the groundwater, present at this elevation. The deposit is generally in a very dense state of relative density .

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water level in the open boreholes. These observations are recorded on the Record of Boreholes sheets as well as on Drawing 3688704-A in the Appendix. Measurements obtained at the time of the investigation revealed levels at elevations 160.2 and 153 m, corresponding to depths below the ground surface of approximately 13 to 20 m. The water level was not established in the other boreholes. It should be noted that groundwater levels are subject to seasonal fluctuations and may therefore vary from the values given in this report.

DISCUSSION AND RECOMMENDATIONS

It is proposed to construct a single span rigid frame parallel to the lower ramp with retaining walls at the acute corners. The proposed clear span is about 16.25 m. A grade raise of approximately 8 m is needed to reach the proposed pavement grade at elevation 181.6 m.

The following itemizes our preliminary recommendations for:

1) structure foundations
2) lateral earth pressures on abutments/retaining walls
3) approach fills
4) construction considerations

Structure Foundations

The proposed structure may be founded on spread footings in the upper clayey silt deposit on compacted Granular 'A' fill, or on steel 'H' piles driven into the heterogeneous till mixture.

1) Spread Footings

The proposed structure may be supported on spread footings placed at or below elevation 173 m, provided that the footings have a minimum earth cover of 1.2 m for frost protection. In addition for the:

i) Structure and West Retaining Wall
(Station 11+300 to 11+393)

The ground should be subexcavated about 1.5 m to 3 m below existing grade to elevation 172 m (or lower). The dimensions of the subexcavation should be large enough to allow for the surface of the granular pad to be 1.0 m longer (west end only) and 1.0 m wider than the footings as per attached Figure 4.

The excavated base should be compacted, and a minimum of 0.6 m of compacted Granular 'A' placed in 0.3 m lifts, immediately after, so as to guard against softening of the foundation material. The remainder of the pad should be constructed with Granular 'A' as illustrated in Figure 4.

ii) East Retaining Wall

A pad of lean concrete (150 mm) should be placed within 4 hours of completion of excavation so as to guard against softening of the foundation material from weathering and seepage effects.

For the purposes of the O.H.B.D.C. the following bearing capacities are recommended for the foundations as discussed above.

Bearing Capacity at S.L.S. Type II = 300 kPa
Factored Bearing Capacity at U.L.S. = 450 kPa

It is anticipated that settlements induced within the proposed footing should not exceed 25 m.

Sliding resistance between the concrete footing and the foundation soil and granular pad should be calculated in accordance with Section 6.7.3.3.2 of the O.H.B.D.C. assuming the factored coefficient of friction to be 0.45.

2) Steel H-Piles

Alternatively, the proposed structure may be founded on steel H-piles driven to end bearing in the heterogeneous till mixture. The estimated pile tip elevation ranges from 162 to 160 m. All steel H-piles should be reinforced with standard driving shoes, and driven to a minimum set of 15 blows per 25 mm for the final 75 mm of placement using a minimum rated driving energy of 48,000 joules/blow. For H.P. 310 x 110 steel 'H' piles the following design parameters are given:

Bearing Capacity at S.L.S. Type II = 1150 kN
Factored Bearing Capacity at U.L.S. = 1600 kN

Pile driving in the field should be controlled by employing the Hiley Dynamic Pile Driving Formula.

Lateral Earth Pressures on Abutments/Retaining Walls

To prevent hydrostatic pressure build-up, backfill to abutments and retaining walls should consist of Granular 'A' or Granular 'B' in accordance with Ministry of Transportation Standards.

Lateral Earth Pressures should be computed in accordance with Section 6.6.1.2.1 of the O.H.B.D.C.. The active condition (Ka) will govern earth pressure design if the structure is yielding while the at rest condition (Ko) will govern for an unyielding structure. The following parameters are provided for earth pressure computation.

	ϕ	γ	K_a	K_o
Granular 'A'	35°	22.8 kN/m^3	0.27	0.43
Granular 'B'	30°	21.2 kN/m^3	0.33	0.50

Note: The earth pressure coefficients apply to horizontal backfill only. Appropriate considerations should be given to account for sloping surface backfills.

It is considered that the retaining walls at both ends of the rigid frame structure may be replaced by reinforced earth walls, provided the load from the wall does not exceed the bearing capacities recommended earlier for spread footings.

Approach Embankments

Due to the competent nature of the natural soil, no deep-seated failures are anticipated through the foundation soils, for grade raises of 8 m, or less. Topsoil and surficial material should be removed prior to placing any fill. The fill should consist of well compacted acceptable material.

Embankments should have side and forward slopes no steeper that 2H:1V designed and constructed in accordance with the appropriate Ministry Standards. Care should be taken to ensure that no bouldery fill is placed within the approaches at locations through which piles have to be driven, and it is recommended that this portion of the fill contain no larger grain sizes than 75 mm.

Total settlement of the fill and the foundation soil should be in the order of 40 mm. Most of this will be elastic compression and will have occurred immediately after completion of construction.

Construction Concerns

No major construction problems are anticipated. Dewatering is not anticipated to be a problem at this site since excavations for the proposed footings should be above the existing groundwater level. However should dewatering be necessary, conventional sump pumping techniques may be utilized.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of P. Marks, Foundation Engineer and Bill Cung, Engineering Trainee. The equipment was owned and operated by Marathon Drill Co. Ltd., and Master Soil Investigations.

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

P. Marks, P.Eng.
Foundation Engineer

M.S. Devata, P.Eng.
Chief Founation 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

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

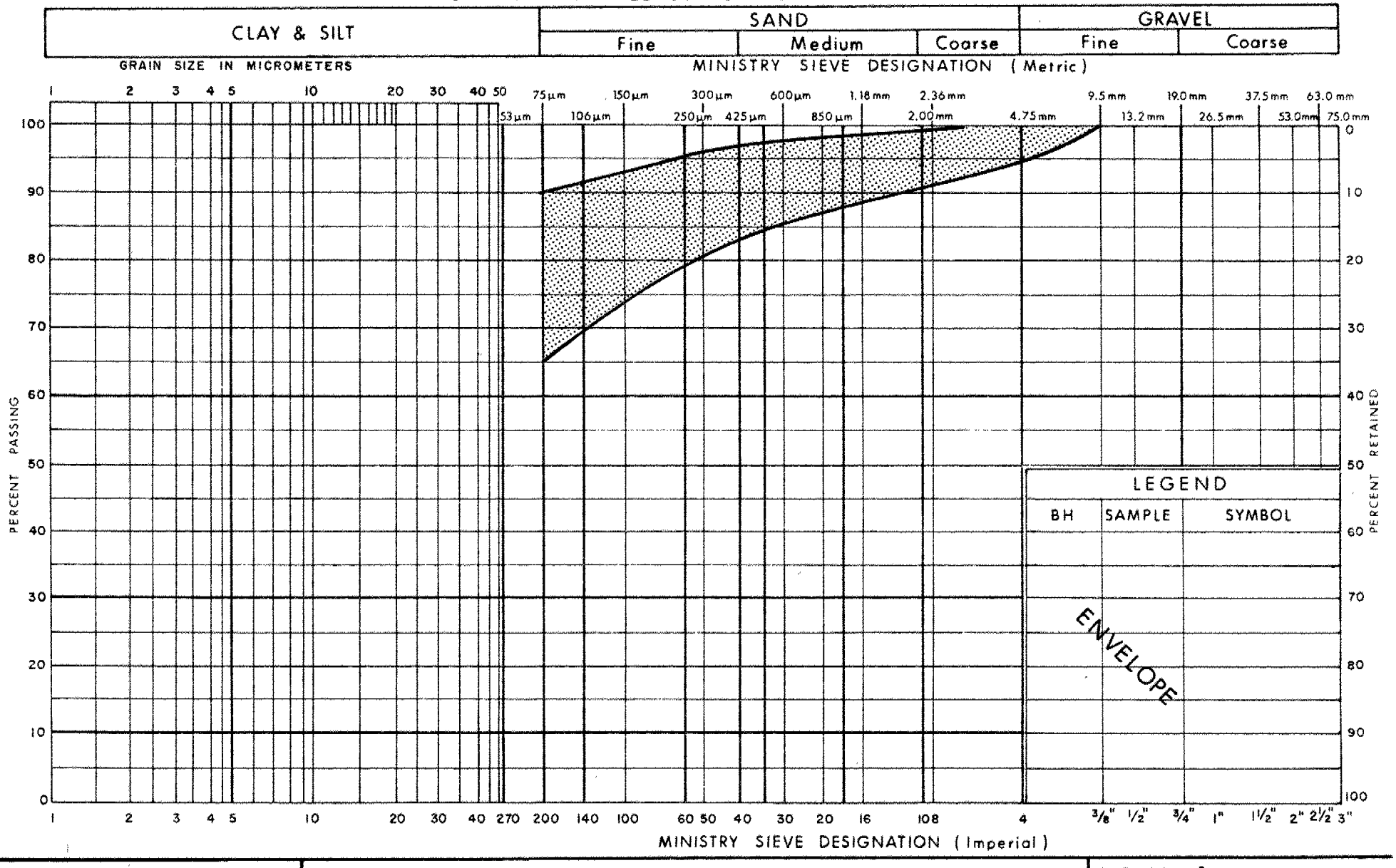
PHYSICAL PROPERTIES OF SOIL

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

UNIFIED SOIL CLASSIFICATION SYSTEM



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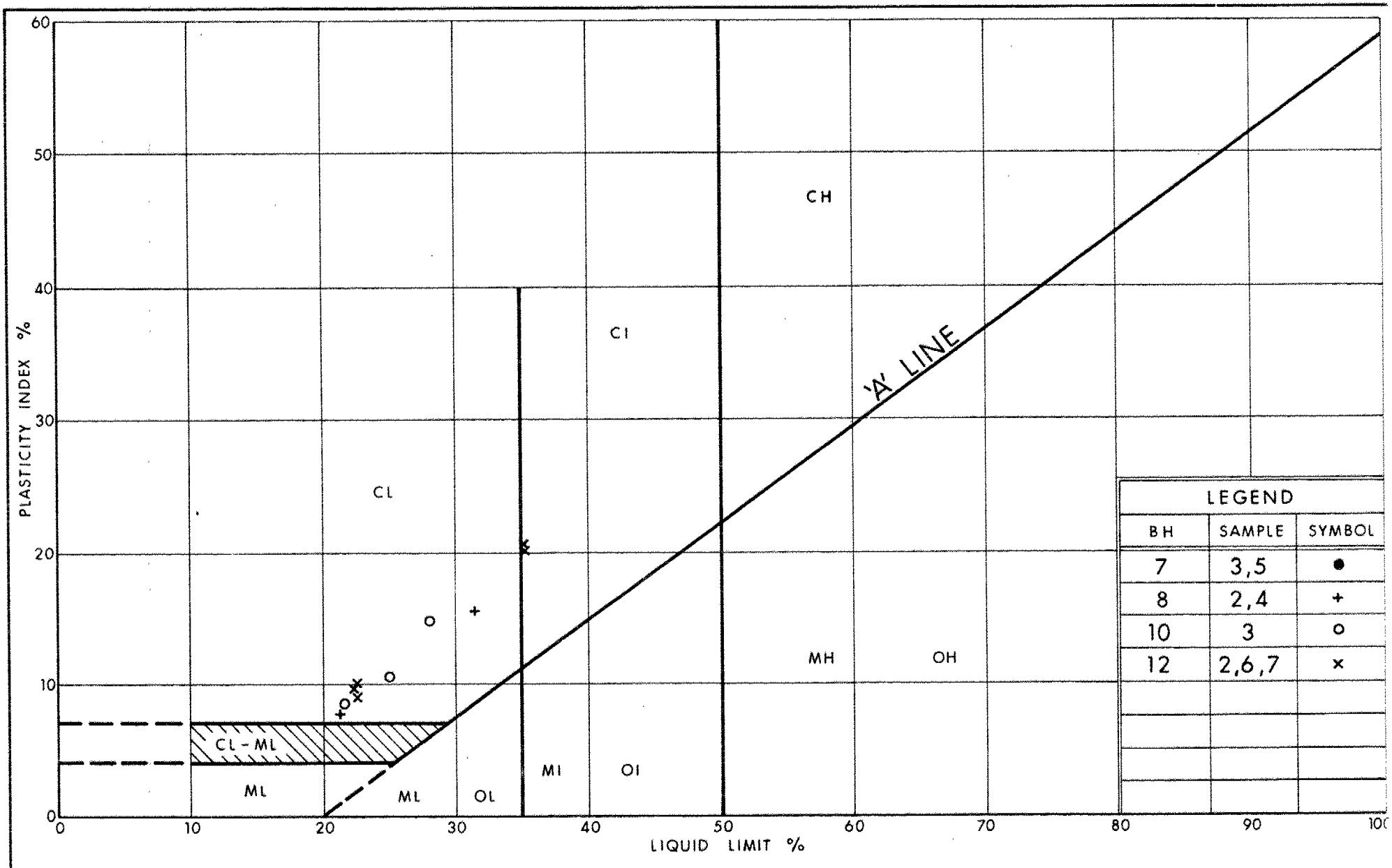
GRAIN SIZE DISTRIBUTION

CLAYEY SILT WITH SAND, TRACE GRAVEL

FIG No 1

W P 368-87-04

Oct 75, FF-S-21



LEGEND		
BH	SAMPLE	SYMBOL
7	3,5	●
8	2,4	+
10	3	o
12	2,6,7	×

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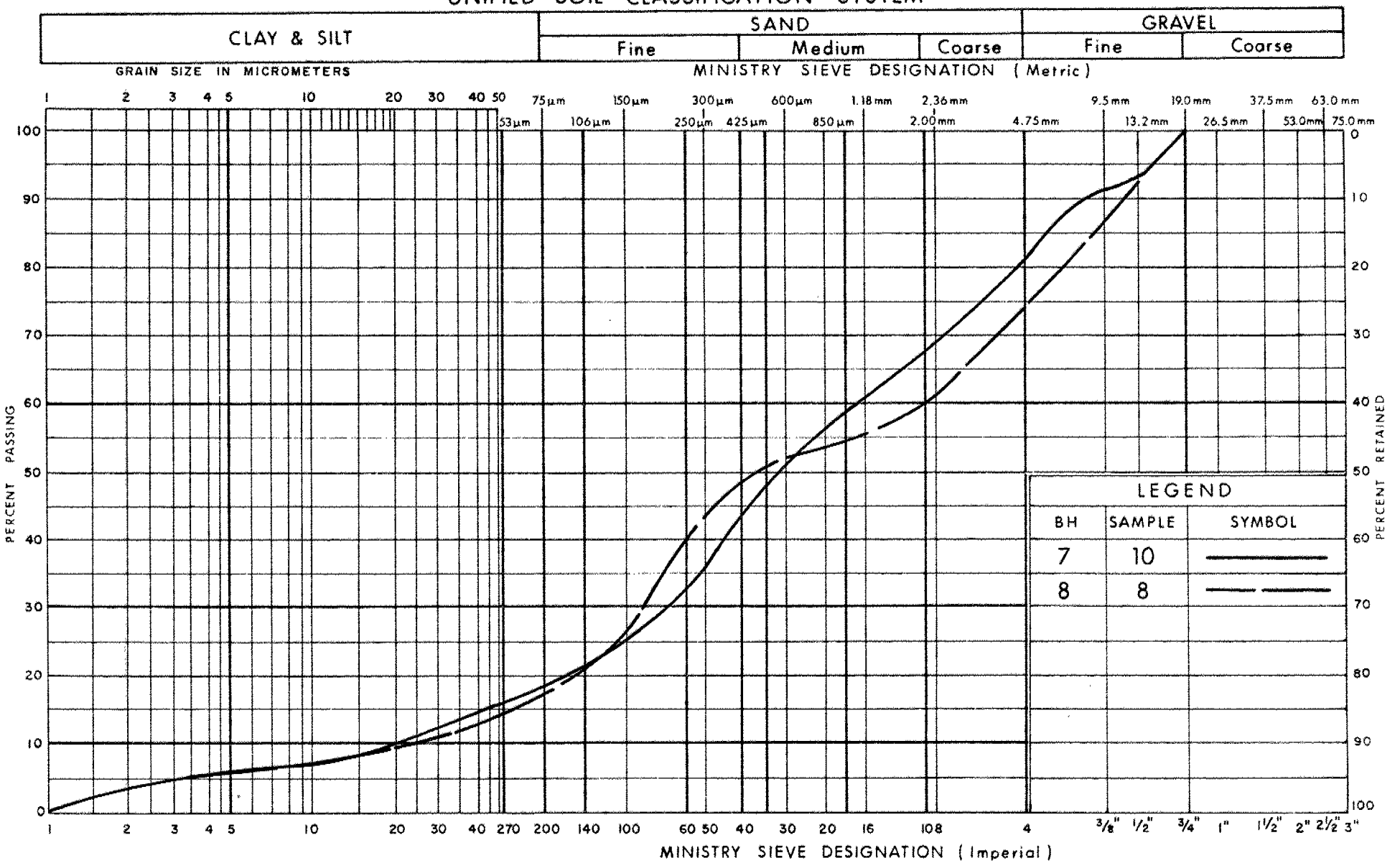
PLASTICITY CHART
CLAYEY SILT WITH SAND, TRACE GRAVEL

FIG No 2
W P 368-87-04

78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM



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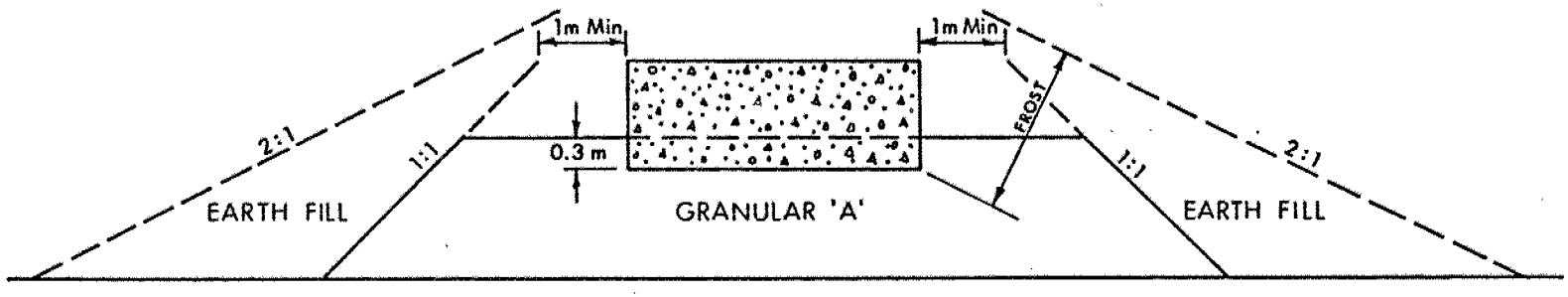
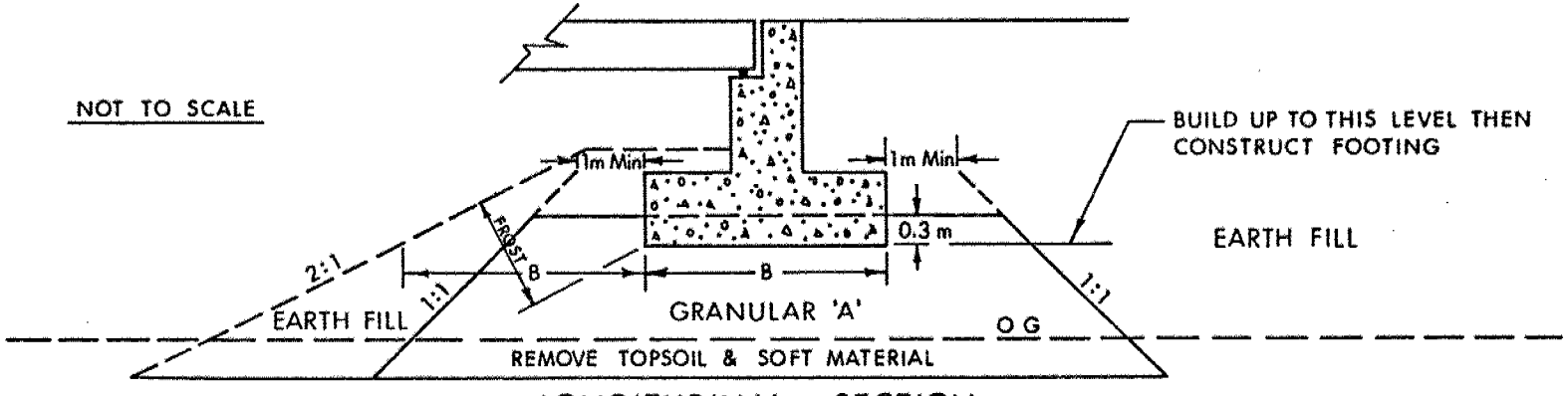
GRAIN SIZE DISTRIBUTION
LAYER OF SILTY SAND

FIG No 3
W P 368-87-04



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 368-87-04

RECORD OF BOREHOLE No 7 — 1 OF 1 — METRIC

W.P. 368-87-04 LOCATION Co-ords: N 4 845 881.3 ; E 294 526.5 ORIGINATED BY B.C.

DIST 6 HWY 407 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY P.M.

DATUM Geodetic DATE 89-12-14 to 89-12-15 CHECKED BY

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
173.5	Ground Level							20 40 60 80 100	10 20 30		
0.0	CLAYEY SILT, With Sand, Trace of Gravel (Till) Stiff to Hard		1	SS	9	*	172		o		2 31 (67)
			2	SS	20						
			3	SS	20						
			4	SS	20		170		o		4 24 (72)
			5	SS	18						
			6	SS	19						
			7	SS	20		168				
			8	SS	36						
	(Lacustrine)		9	SS	18		166				
	Silty Sand Layer		10	SS	21		164		o		18 64 15 3
161.9			11	SS	29						
11.6	Heterogeneous Mixture of Gravel, Sand, Silt and Clay (Till) Very Stiff to Hard		12	SS	35		162				
			13	SS	70		160				
			14	SS	28		158				
156.3			15	SS	31				o		0 14 66 20
17.2	End of Borehole								123		
155.2	**							80/ 8cm			
18.3	End of Cone Test										

* Water Level Not Established

** Presumed Heterogeneous Mixture of Gravel, Sand, Silt and Clay

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

$15 \overset{20}{\underset{10}{\diamond}} 5$ (%) STRAIN AT FAILURE

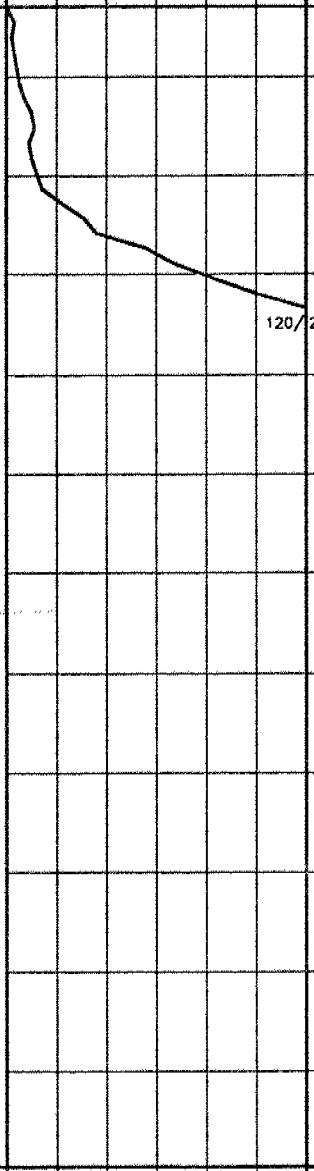
RECORD OF BOREHOLE No 8 1 OF 1 METRIC

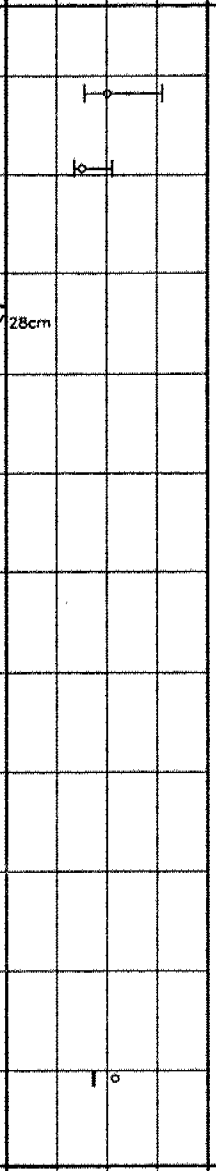
W.P. 368-87-04 LOCATION Co-ords: N 4 845 908.5 ; E 294 559.0 ORIGINATED BY BC

DIST 6 HWY 407 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY BC

DATUM Geodetic DATE 89-12-19 CHECKED BY

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
173.4	Ground Level					
0.0	CLAYEY SILT, With Sand, Trace of Gravel (Till)	1	SS	6		
		2	SS	11		2 16 (82)
		3	SS	7		
		4	SS	7	▼	5 24 (71)
	(Lacustrine)	5	SS	15		
		6	SS	20		
		7	SS	21		
	Silty Sand Some Gravel	8	SS	90		25 59 12 4
	Firm to Hard	9	SS	37		
164.7						
8.7		10	SS	53		
		11	SS	58		
	Heterogeneous Mixture of Gravel, Sand, Silt and Clay (Till) Hard to Stiff	12	SS	120 /28cm		
		13	SS	130		
		14	SS	11		
157.2						
16.2		15	SS	121		13 39 (48)
		16	SS	122		
	Heterogeneous Mixture of Gravel, Sand, Silt and Clay (Till) Very Dense	17	SS	67		
		18	SS	53		0 14 82 4
150.1		19	SS	117		
23.3	End of Borehole					





UNIT WEIGHT γ kN/m^3

+^{3}, ×^{5} : Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 9 1 OF 1 METRIC

W.P. 368-87-04 LOCATION Co-ords: N 4 845 934 ; E 294 594 ORIGINATED BY P.M.

DIST 6 HWY 407 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY P.M.

DATUM Geodetic DATE 90-01-09 CHECKED BY

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, + 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
173.9	Ground Level										
0.0	CLAYEY SILT With Sand, Trace of Gravel (Till)		1	SS	27		172				
			2	SS	34						
			3	SS	44						
			4	SS	32		170				
			5	SS	44						
			6	SS	30						
	(Locustrine)		7	SS	77		168				
	Very Stiff to Hard		8	SS	88						
165.2			9	SS	55		166				
8.7	Heterogeneous Mixture of Gravel, Sand, Silt, and Clay (Till) Hard		10	SS	88		164				
			11	SS	130						
161.5			12	SS	117		162				
12.4	End of Borehole										

▸ Water Level Not Established

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

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 10 1 OF 1 METRIC

W.P. 368-87-04 LOCATION Co-ords: N 4 845 888.5 ; E 294 561.0 ORIGINATED BY B.C.

DIST 6 HWY 407 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY P.M.

DATUM Geodetic DATE 89-12-18 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'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
173.1	Ground Level							20 40 60 80 100	10 20 30		
0.0			1	SS	7		172	FROZEN			
			2	SS	16						
	CLAYEY SILT, With Sand, Trace of Gravel (Till)		3	SS	6						3 28 (69)
			4	SS	15		170				
			5	SS	20			122			
			6	SS	60	/8cm	168				
	(Lacustrine) Occasional Layers of Silty Sand		7	SS	19						0 9 (91)
			8	SS	37		166				
			9	SS	45						
	Firm to Hard						164		51.5		
163.0			10	SS	36						2 7 (91)
10.1			11	SS	27		162				
	Heterogeneous Mixture of Gravel, Sand, Silt and Clay (Till) Very Stiff to Hard		12	SS	115						3 22 56 19
			13	SS	80		160				
			14	SS	49						
158.6							158				
16.5			15	SS	48						3 23 65 9
	Heterogeneous Mixture of Gravel, Sand, Silt and Clay (Till) Compact to Dense		16	SS	13		156				
			17	SS	49	▼					0 28 61 11
151.3			18	SS	18		154				
							152				
21.8 150.5	End of Borehole *							150			
22.6	End of Cone Test										

* Presumed Heterogeneous Mixture of Gravel, Sand, Silt and Clay

+3, ×5 : Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 11 1 OF 1 METRIC

W.P. 368-87-04 LOCATION Co-ords: N 4 845 915 ; E 294 596.5 ORIGINATED BY P.M.

DIST 6 HWY 407 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY P.M.

DATUM Geodetic DATE 90-01-10 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	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
173.4	Ground Level										
0.0	CLAYEY SILT With Sand, Trace of Gravel (Till)		1	SS	10	*					
			2	SS	25		172				
	(Locustrine)		3	SS	8						
			4	SS	16		170				
			5	SS	33						
	Stiff to Hard		6	SS	33						
			7	SS	72		168				
			8	SS	53						
165.5							166				
7.9			9	SS	56						
	Heterogeneous Mixture of Gravel, Sand, Silt and Clay (Till)		10	SS	99		164				
	Hard		11	SS	122						
							162				
160.8			12	SS	120	/23cm					
12.6	End of Borehole										

• Water Level Not Established

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

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 12 1 OF 1 METRIC

W.P. 388-87-04 LOCATION Co-ords: N 4 845 942.5 ; E 294 638.5 ORIGINATED BY B.C.

DIST 6 HWY 407 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY P.M.

DATUM Geodetic DATE 89-12-21 CHECKED BY

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, + FIELD VANE, • QUICK TRIAXIAL, x LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
174.8	Ground Level										
0.0	CLAYEY SILT, With Sand, Trace of Gravel (Till)		1	SS	27	*	172	120/15cm			1 15 (84)
			2	SS	48						
			3	SS	32						
			4	SS	33						
			5	SS	35						
			6	SS	29		170				4 30 (66)
	(Lacustrine)		7	SS	68						3 32 43 22
			8	SS	103						
	(Till)						168				
	Very Stiff to Hard		9	SS	52						
166.4											
8.4	Heterogeneous Mixture of Gravel, Sand, Silt and Clay (Till) Hard						166				
165.2			10	SS	50						
9.6	End of Borehole										

* Water Level Not Established

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

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 13 1 OF 1 METRIC

W.P. 368-87-04 LOCATION Co-ords: N 4 845 894.9 ; E 294 542.7 ORIGINATED BY P.M.

DIST 6 HWY 407 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY P.M.

DATUM Geodetic DATE 90-01-10 CHECKED BY

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 x 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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
173.4	Ground Level										
0.0	CLAYEY SILT, With Sand, Trace of Gravel (Till) Hard		1	SS	33	*	172				
	(Lacustrine)		2	SS	72		170				
163.6			3	SS	70		168				
9.8	Heterogeneous Mixture of Gravel, Sand, Silt and Clay (Till) Hard		4	SS	137		166				
			5	SS	130	/23cm	164				
159.3			6	SS	126	/19cm	162				
14.1	End of Borehole						160				

• Water Level Not Established

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

$\frac{20}{15}\text{-}\frac{5}{10}$ (%) STRAIN AT FAILURE

MINISTRY OF TRANSPORTATION, ONTARIO PH:0-207 8810

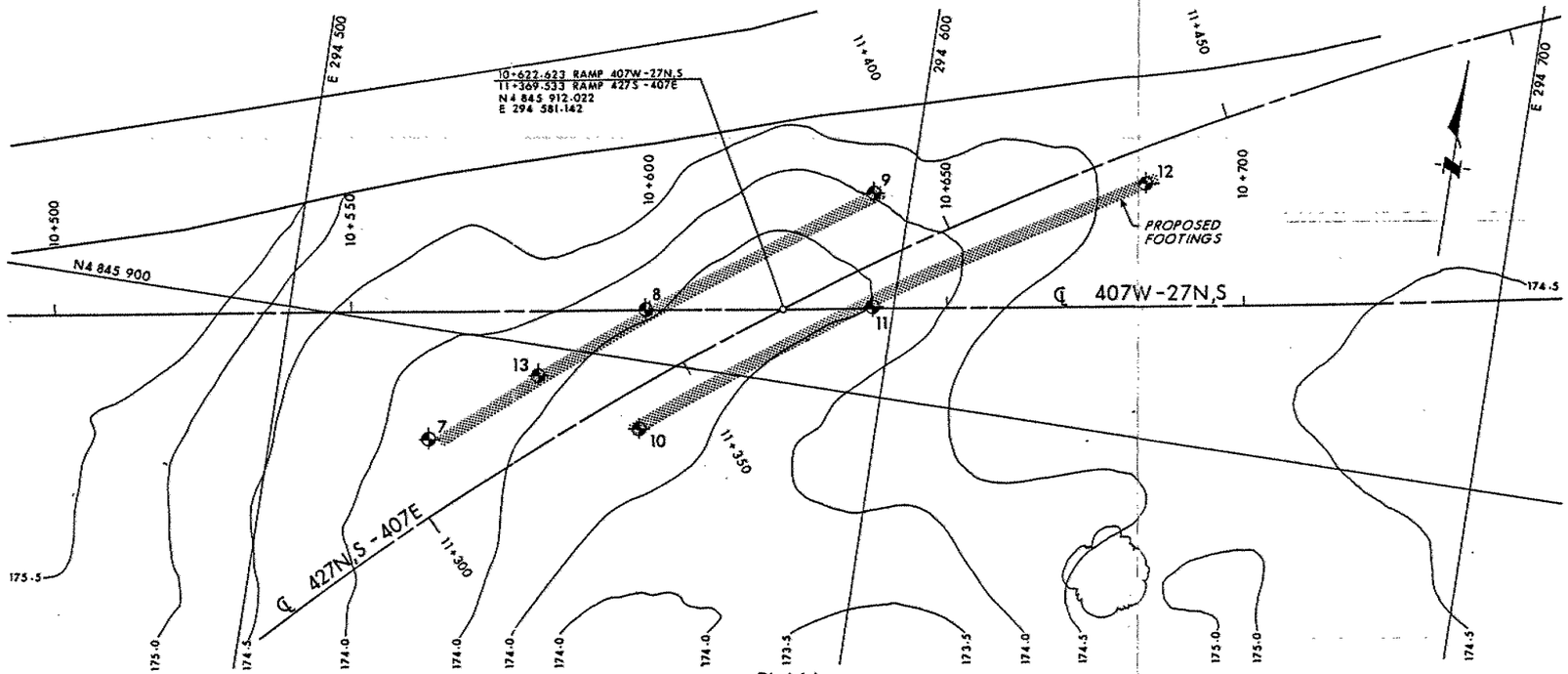
METRIC

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

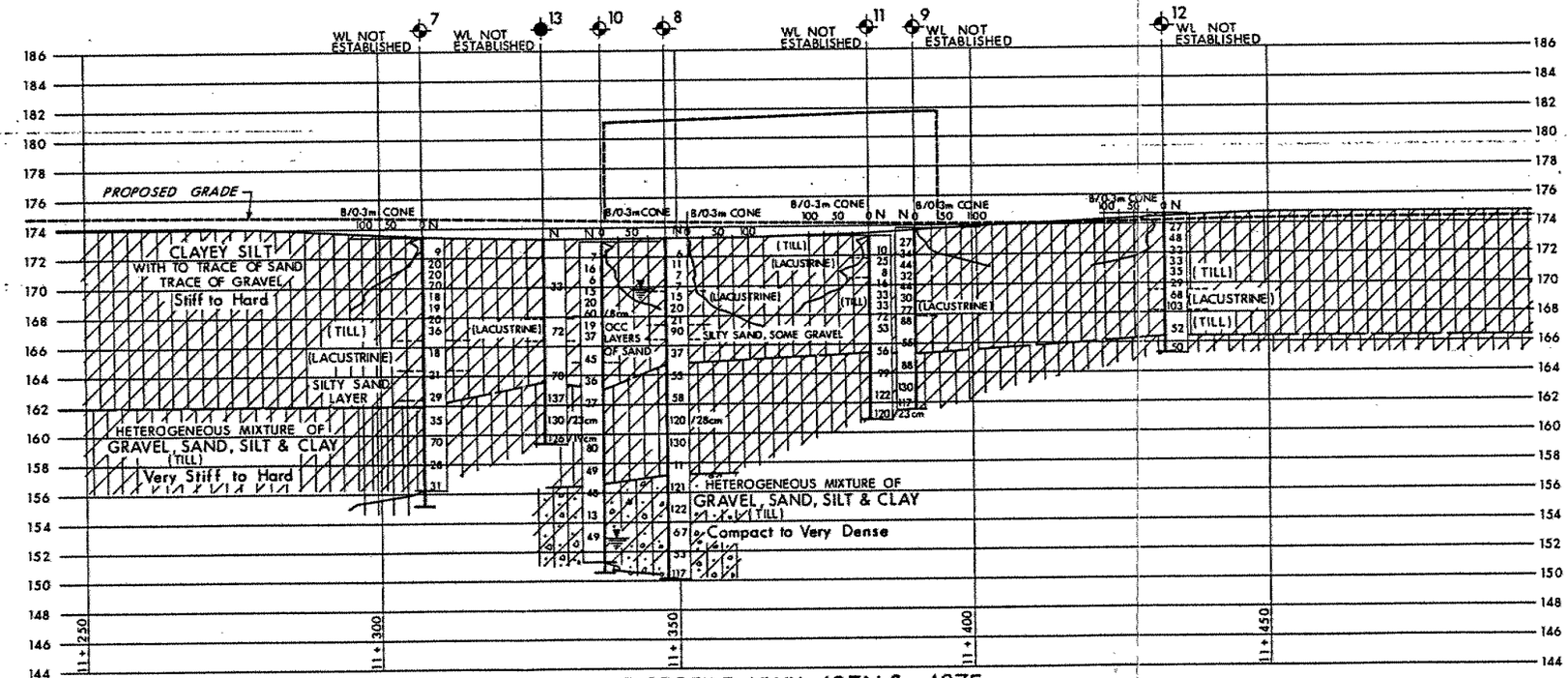
CONT No
WP No 368-87-04

HWY 407W-27N,S RAMP OVER 427N,S-407E RAMP
BORE HOLE LOCATIONS & SOIL STRATA

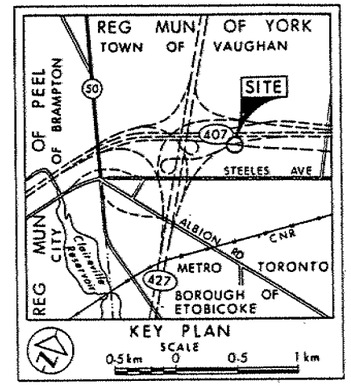
SHEET



PLAN
SCALE 10m 0 10m



℄ PROFILE HWY 427N,S - 407E
SCALE 10m 0 10m Hor
4m 0 4m Vert



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 89 12 and 90 01

No	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
7	173.5	4 845 881.3	294 526.5
8	173.4	4 845 908.5	294 559.0
9	173.9	4 845 934.0	294 594.0
10	173.1	4 845 888.5	294 561.0
11	173.4	4 845 915.0	294 596.5
12	174.8	4 845 942.5	294 638.5
13	173.4	4 845 894.9	294 542.7

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 30M13-101

HWY No 407		DIST 6
SUBM'D PM	CHECKED	DATE 90 03 30 SITE 37-1324
DRAWN DT	CHECKED APPROVED	DWG 3688704-A

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 368-87-05 DIST 6

HWY 407 STR SITE 37-1325

Ramp Structure 27 N/S to 407 W
(over Ramp 407 E to 427 N/S)

DISTRIBUTION

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B. Steeves (Cover Only)
C. Rogers (Cover Only)
File

GEOCRES 30M13-99

DATE MAY 09 1990

FOUNDATION INVESTIGATION REPORT
For
Ramp Structure 27 N/S to 407 W
(over Ramp 407 E to 427 N/S)
W.P. 368-87-05, Site 37-1325
District 6, Toronto

INTRODUCTION

This report summarizes the results of a foundation investigation conducted east of the proposed Highway 427/407 interchange at the above mentioned structure site. This report applies to the proposed structure, its related retaining walls and approaches.

SITE DESCRIPTION AND GEOLOGY

The site is located north of Steeles Avenue, west of Highway 27 adjacent to the proposed Highway 407 in the Township of Vaughan. The land is presently being used agriculturally. The terrain surrounding the site is level to undulating.

Physiographically, the region has been described by Chapman and Putnam (1973) as the Peel Plain. The Pleel Plain is basically a bevelled till plain, containing large amounts of Palaeozoic shale and limestone, and some areas are modified by a veneer of varved clay.

FIELD INVESTIGATION

The fieldwork was carried out during the period from 89 12 07 to 89 12 14 and consisted of six boreholes accompanied by dynamic cone penetration tests, with extra cone tests carried out at the bottom of two boreholes. The borings were advanced by hollow stem augers (95 mm I.D.), using a machine mounted on a muskeg vehicle.

Sampled boreholes were advanced to depths ranging from 11.1 to 20.2 m below the ground surface. From the surface the cone tests advanced to depths ranging from 2.7 to 5.8 m below the ground surface. The cone tests advanced from the bottom of the boreholes penetrated from 0.15 to 1 m. In

general, subsoil sampling was conducted at 0.7 m intervals for the surficial 6.1 m and at 1.5 m intervals for the remainder of the borehole. All samples were retrieved using a split spoon sampler in accordance with Standard Penetration Test (ASTM D1586). All samples were identified in the field and again in the laboratory where they were taken for applicable testing.

Groundwater levels were obtained in the open boreholes and monitored until they were backfilled. The boreholes were backfilled either following their completion, or at the completion of the investigation. Survey information for the location and elevation of boreholes was provided by Central Region Surveys and Plans.

LABORATORY ANALYSES

To identify the behaviour, gradation and property of the soil, the following laboratory tests have been conducted:

1) Atterberg Limits
2) Grain Size Distribution
3) Natural Moisture Contents

SUBSOIL CONDITIONS

General

The elevation of the ground level at the site ranged from 173.5 to 174.4 m. The subsurface conditions at the site consist mainly of 8.5 to 16.2 m of clayey silt, with sand, trace of gravel, with some layers of silty sand and silt found occasionally in the deposit. Below this material at elevation 165.1/158.2 m a till consisting of a heterogeneous mixture of gravel, sand, silt and clay was encountered. This mixture was found to be cohesive for the upper 1.1+ to 4.7 m, below which the percentage of clay diminishes. Therefore at elevation 162.3/154.9, 11.3 to 19.5 m below the ground level is a non-cohesive heterogeneous mixture of gravel, sand, silt and clay in which the boreholes terminated.

The plan, location of borings and the subsoil stratigraphic profile are shown on Drawing 3688705-A in the attached Appendix. The boundaries between various soil types, field and laboratory test results as well as ground water levels are plotted on the Record of Borehole sheets, also in the Appendix of this report. A description of the soil types encountered are given below.

Clayey Silt, with Sand, trace of Gravel

This material was found from beneath the 0.5 m of topsoil at the surface (elevation 174.4 to 173.6 m) to the top of the heterogeneous mixture. The deposit extended down to a depth of 8.5 to 16.2 m. The upper half of the deposit is a glacial till whereas the lower half which contained layers of silty sand was partially lacustrine.

This soil layer consisted mainly of a clayey silt, with to traces of sand, trace of gravel. A grain size distribution envelope for the material as determined by mechanical analyses is given in Figure 1. Atterberg Limits were also obtained to evaluate the behaviour of the fine grained portion of the material which are plotted in Figure 2. A summary of the physical properties of the fine grained portion is provided below:

	Range
Natural Moisture Content (w)	7-21%
Liquid Limit (w_L)	18-37%
Plastic Limit (w_P)	12-23%

The test results indicate a clayey silt of low plasticity.

The 'N' values obtained from the standard penetration tests ranged from 7 to 100. Typical 'N' values ranged however from 20 to 55. The high values may have resulted from large aggregates such as boulders and cobbles which are characteristic of till deposits and consequently may be assumed to exist in this deposit. The consistency of the material was found to be stiff to hard.

A one to 1.5 m thick layer of silty sand to sandy silt, was found in some of the boreholes at elevations 172.9 and 172.6 m within the deposit. Other occasional layers of silt and silty sand were found deeper at elevations 170.4/166.1 within a lacustrine material. Three grain size distribution curves illustrating the gradation of the non-cohesive layers is provided in Figure 3.

Heterogeneous Mixture of Gravel, Sand, Silt and Clay; Cohesive

This deposit was found underlying the clayey silt at elevation 165.1/158.2 m. One of the boreholes terminated within this deposit. The cohesive till deposit ranged in the other boreholes from 1.6 to 4.7 m in depth.

The grain size distribution test results are shown in envelope form in Figure 4. The physical properties of the fine grained portion indicate a natural moisture content (w) of 12 to 15%, a liquid limit (w_L) of 26 to 29% and a plastic limit (wp) of 16 to 17%. The few test results indicated the fines to be a clayey silt of low plasticity.

The 'N' values obtained from the standard penetration tests ranged from 32 to 75. The consistency of the deposit is therefore hard.

Heterogeneous Mixture of Gravel, Sand, Silt and Clay; Non-Cohesive

This deposit was found underlying the cohesive heterogeneous mixture at elevation 162.3/154.9 m, 11.3 to 19.5 m below ground level. None of the boreholes extended below this non-cohesive till. The deposit was found therefore to be 4 m plus thick.

The grain size distribution tests are shown in envelope form in Figure 5. The 'N' values obtained from the standard penetration tests ranged from 92 to 120/15 cm. The denseness of the deposit is therefore very dense.

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water level in the open boreholes. These observations are recorded on the Record of Borehole sheets as well as on Drawing 3688705-A in the Appendix. Measurements obtained at the time of the investigation revealed levels at elevations ranging form 170 m to 166.2 m, corresponding to depths below the ground surface of approximately 4 to 7.9 m.

It should be noted that groundwater levels are subject to seasonal fluctuations and may therefore vary from the values given in this report.

DISCUSSION AND RECOMMENDATIONS

It is proposed to construct single span rigid frames parallel to the lower ramp with retaining walls at the acute corners. The proposed clear span is about 16 to 17 m. A grade raise of approximately 8 m is required to reach the proposed pavement grade at elevation 181.5 m.

The following itemizes our preliminary recommendations for:

1) structure foundations
2) lateral earth pressures on abutments/retaining walls
3) approach fills
4) construction considerations

Structure Foundations

The proposed structure may be founded on spread footings in the upper clayey silt deposit or alternatively on steel H-piles driven into the heterogeneous till mixture. However shallow foundations are most desirable at this site.

1) Spread Footings on Clayey Silt

The proposed structure may be supported on spread footings.

For the purposes of the O.H.B.D.C. the following design values are recommended for elevation 171.7 m.

Bearing Capacity at S.L.S. Type II	300 kPa
Factored Bearing Capacity at U.L.S.	450 kPa

The underside of all footings should be provided with a minimum of 1.2 m earth cover for frost protection.

It is anticipated that settlements induced within the proposed footing should not exceed 25 mm.

Sliding resistance between the concrete footing and the foundation soil should be calculated in accordance with Section 6.7.3.3.2 of the O.H.B.D.C. assuming the coefficient of friction to be 0.45.

It is recommended that a working slab consisting of 150 mm of lean concrete be poured at the bottom of the footing excavation within 4 hours of exposure so as to guard against softening of the foundation material from the effects of weathering, seepage and surface water.

Steel 'H' Piles

The proposed structure may be founded on steel H-piles driven to end bearing in the heterogeneous till mixture. The estimated pile tip elevation ranges from 154 to 160 m. All steel H-piles should be reinforced with standard driving shoes, driven to a minimum set of 15 blows per 25 mm for the final 75 mm of placement using a minimum rated driving energy of 48,000 joules/blow.

For the purposes of the O.H.B.D.C. the following design parameters are suggested for H.P. 310 x 110 steel 'H' piles:

Bearing Capacity at S.L.S. Type II	1150 kN
Factored Capacity at U.L.S.	1600 kN

Pile driving in the field should be controlled by employing the Hiley Dynamic Pile Driving Formula.

Reinforced Earth Retaining Wall

The proposed retaining walls at the acute corners may be constructed as reinforced earth type walls. As long as the load applied by the wall does not exceed the recommended bearing capacities provided under the recommendations for spread footings.

Lateral Earth Pressure on Abutments/Retaining Walls

To prevent hydrostatic pressure build-up, backfill to abutments and retaining walls should consist of Granular 'A' or Granular 'B' in accordance with Ministry of Transportation Standards.

Lateral Earth Pressures should be computed in accordance with Section 6.6.1.2.1 of the O.H.B.D.C.. The active condition (Ka) will govern earth pressure design if the structure is yielding while the at rest condition (Ko) will govern for an unyielding structure. The following parameters are provided for earth pressure computation.

	ϕ	γ	K_a	K_o
Granular 'A'	35°	22.8 kN/m^3	0.27	0.43
Granular 'B'	30°	21.2 kN/m^3	0.33	0.50

Note: The Earth Pressure coefficients apply to horizontal backfill only. Appropriate considerations should be given to account for sloping surface backfill.

Approach Embankments

Due to the competent nature of the natural soil, no deep-seated failures are anticipated through the foundation soils, for grade raises of 8 m. Topsoil and surficial material should be removed prior to placing any fill. The fill should consist of well compacted acceptable material. Embankments should have side and forward slopes no steeper than 2H:1V designed and constructed in accordance with the appropriate Ministry Standards. Care should be taken to ensure that no bouldery fill is placed within the approaches at locations through which piles may have to be driven, and it is recommended that this portion of the fill contain no larger grain sizes than 75 mm.

Total settlement of the fill and the foundation soil should be in the order of 40 mm. Most of this will be elastic compression and will have occured immediately after completion of construction.

Construction Concerns

No major construction problems are anticipated. Dewatering is not anticipated to be a problem at this site since excavations for the proposed footings should be above the existing groundwater level. However should dewatering be necessary, conventional sump pumping techniques may be utilized.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of P. Marks, Foundation Engineer. The equipment was owned and operated by Marathon Drilling Co. Ltd.

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

P. Marks, P.Eng.
Foundation Engineer

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:

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
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 = $\frac{c_u}{\tau_r}$

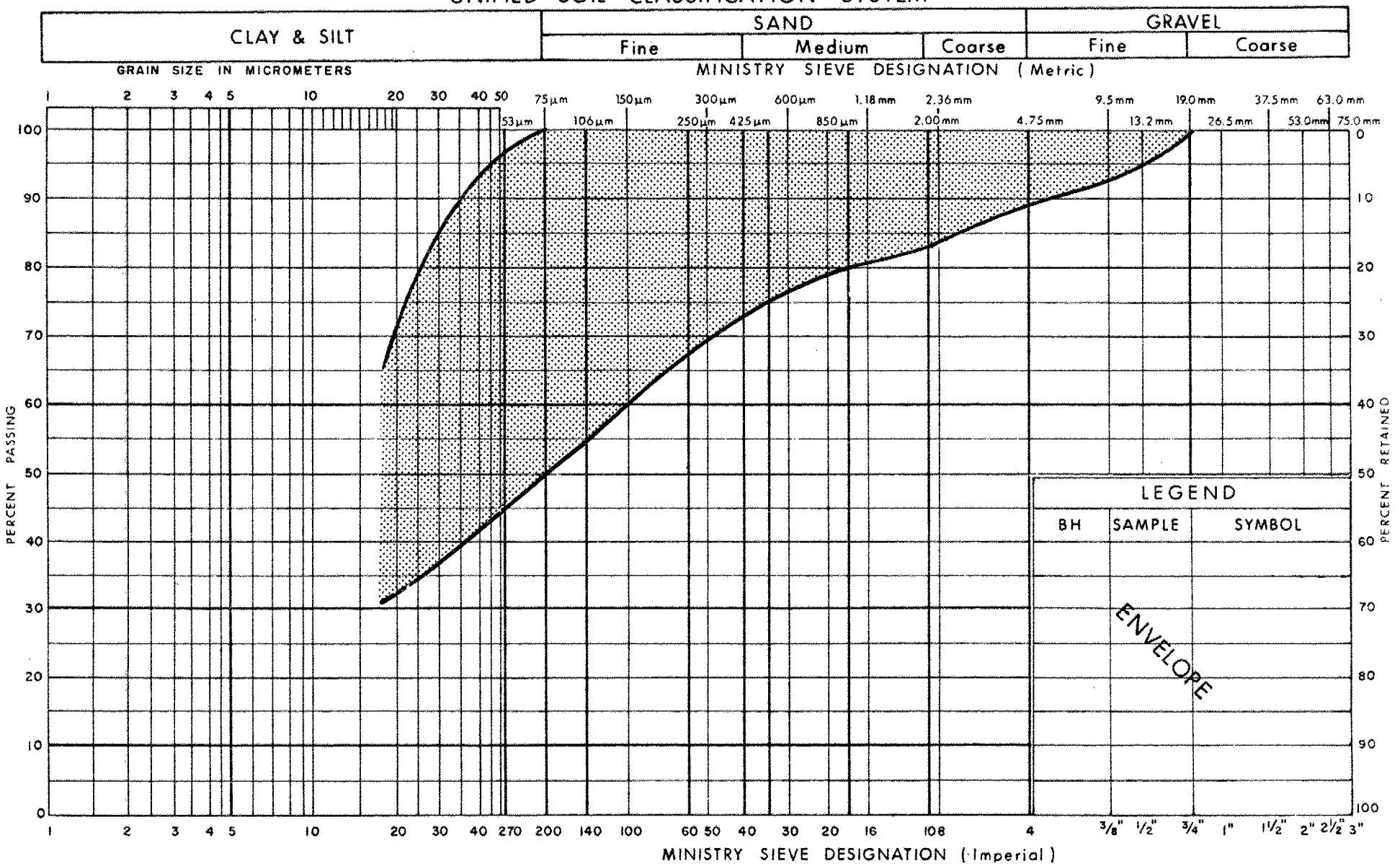
PHYSICAL PROPERTIES OF SOIL

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

UNIFIED SOIL CLASSIFICATION SYSTEM



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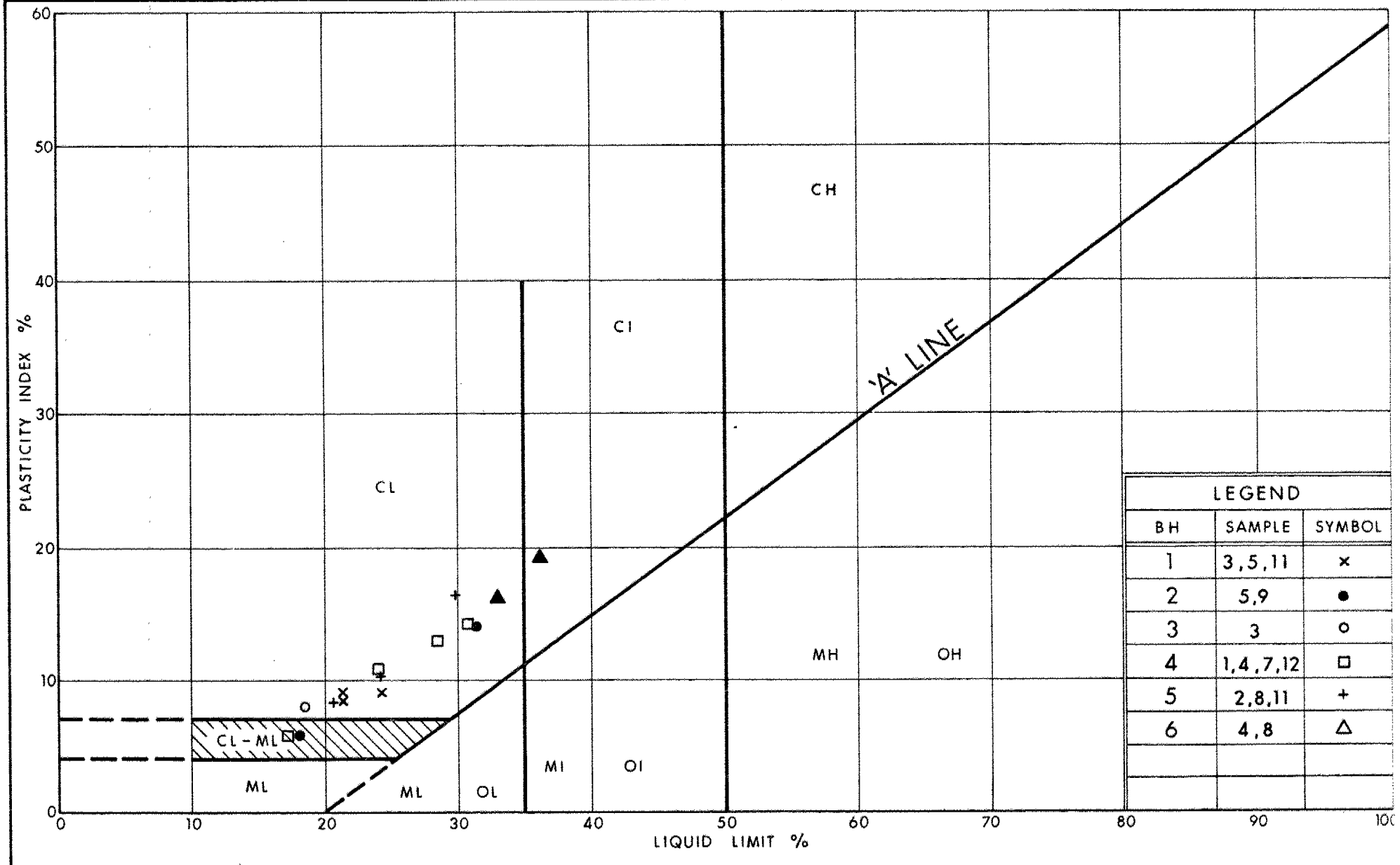
GRAIN SIZE DISTRIBUTION

CLAYEY SILT, WITH SAND, TRACE GRAVEL

FIG No 1

W P 368-87-05

Oct 75, FF-S-21



LEGEND		
BH	SAMPLE	SYMBOL
1	3,5,11	×
2	5,9	●
3	3	o
4	1,4,7,12	□
5	2,8,11	+
6	4,8	△

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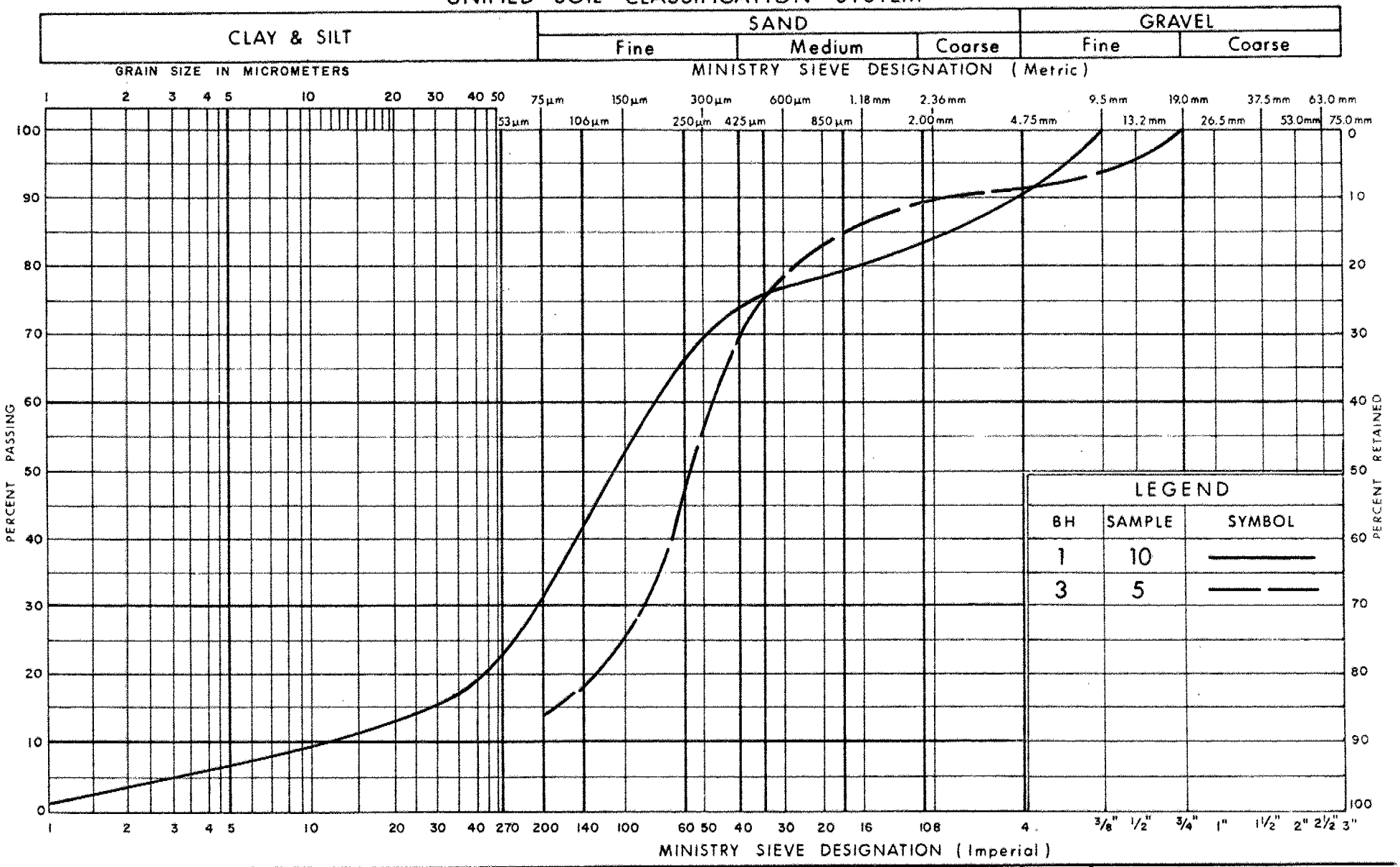
PLASTICITY CHART
CLAYEY SILT WITH SAND, TRACE GRAVEL

FIG No 2
W P 368-87-05

UNIFIED SOIL CLASSIFICATION SYSTEM



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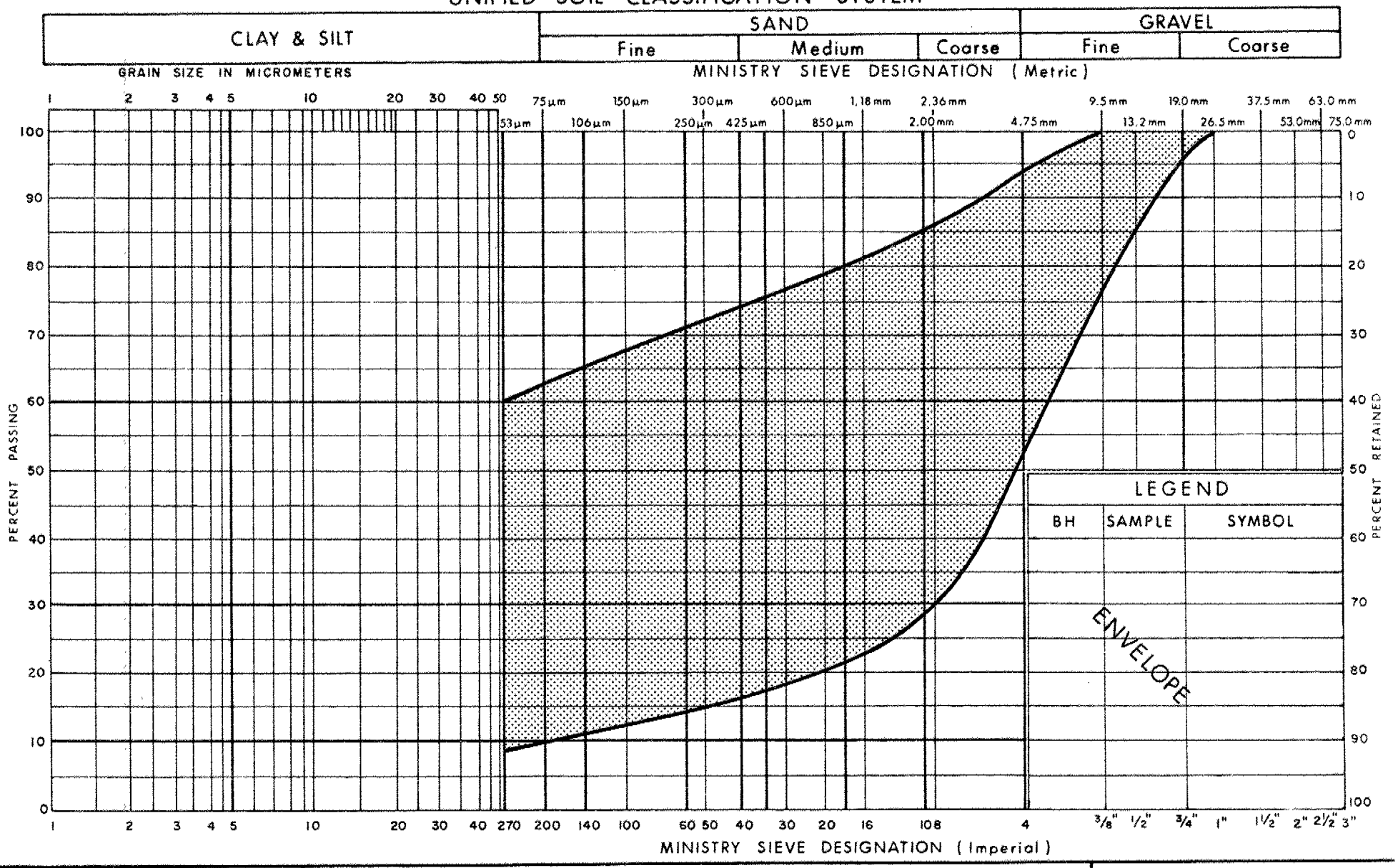
GRAIN SIZE DISTRIBUTION
OCCASIONAL SILTY SAND TO SANDY SILT LAYERS

FIG No 3

W P 368-87-05

UNIFIED SOIL CLASSIFICATION SYSTEM



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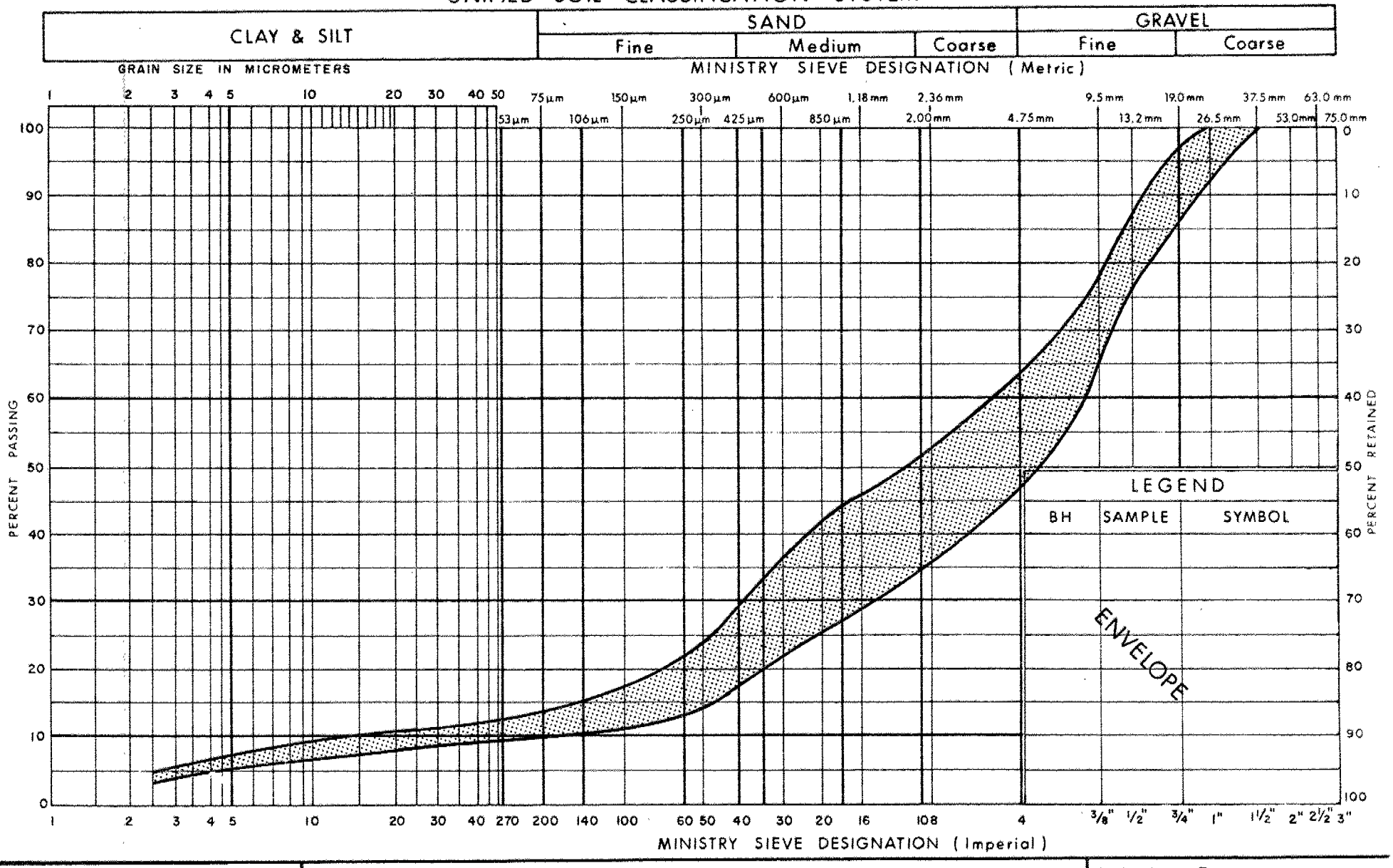
GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF GRAVEL, SAND, SILT & CLAY
COHESIVE

FIG No 4
W P 368-87-05

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF GRAVEL, SAND, SILT & CLAY
NON-COHESIVE

FIG No 5
W P 368-87-05

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OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 1

METRIC

W P 368-87-05 LOCATION Co-ords: N 4 846 166.6; E 294 866.0 ORIGINATED BY PM

DIST 6 HWY 407 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY PM

DATUM Geodetic DATE 89 12 08 to 89 12 11 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
174.4	Ground Level										
0.0	Topsoil						174				
	Clayey Silt, With to Trace of Sand Trace of Gravel		1	SS	32						
			2	SS	41		172				22 28 (50)
	Occ. Layers of Gravelly Sand		3	SS	35						
			4	SS	51				20cm		
			5	SS	66						10 31 (59)
	Hard to Very Stiff		6	SS	82		170				
			7	SS	27						
			8	SS	25		168				
	(Till) (Lacustrine)		9	SS	36						
			10	SS	33		166				9 75 (16)
	Occasional Layers of Silt, and Silty Sand		11	SS	30		164				0 4 (96)
			12	SS	28	▼					
	(Till)		13	SS	33		162				
159.8											
14.6	Heterogeneous Mixture of Gravel, Sand Silt and Clay		14	SS	40		160				
158.2	(Till) Hard										
16.2	Heterogeneous Mixture of Gravel, Sand, Silt and Clay Occasional Cobbles		15	SS	120/ 27cm		158				
			16	SS	95		156				
	(Till)										
154.2	Very Dense		17	SS	120/ 20cm						34 51 11 4
20.2	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 2

METRIC

W P 368-87-05 LOCATION Co-ords; N 4 846 178.5, E 294 917.2 ORIGINATED BY PM

DIST 6 HWY 407 BOREHOLE TYPE Continuous Flight Auger COMPILED BY PM

DATUM Geodetic DATE 89 12 08 CHECKED BY

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
174.1	Ground Level										
0.0	Topsoil						174				
	Clayey Silt With to Trace of Sand Trace of Gravel (Till) (Lacustrine)		1	SS	17						
	Sandy Silt Layer		2	SS	37		172				
			3	SS	37						
			4	SS	55						
			5	SS	34		170				0 0 (100)
	Occasional Silty Sand Layers		6	SS	27						
			7	SS	35						
			8	SS	20		168				
						▼					
	(Till)		9	SS	12		166				0 35 44 21
	Hard/Very Stiff		10	SS	29						
164.0											
10.1	Het. Mix. of Gravel, Sand, Silt & Clay (Till) Hard		11	SS	32		164				7 31 (62)
163.0											
11.1	*										
162.0											
12.1	End of Cone										

*Presumed Heterogeneous Mixture of Gravel, Sand, Silt & Clay

+3, ×5 : Numbers refer to Sensitivity

20
15 ⊹ 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 3

METRIC

W P 368-87-05 LOCATION Co-ords; N 4 846 193.7 E 294 978.0 ORIGINATED BY PM

DIST 6 HWY 407 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY PM

DATUM Geodetic DATE 89 12 07 to 89 12 08 CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPo ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
174.0	Ground Level										
0.0	Topsoil										
	Clayey Silt, With to Trace of Sand Trace of Gravel		1	SS	8						
			2	SS	7		172				
			3	SS	33						9 30 (61)
	(Till)		4	SS	45						
	Firm to Very Stiff (Lacustrine)		5	SS	44	▼	170		20cm		10 59 27 4
	Occasional Layers of Silty Sand and Silt		6	SS	55						1 37 (62)
			7	SS	66						
			8	SS	65		168				
	(Till)		9	SS	21						
164.7							166				2 17 (81)
9.3	Heterogeneous Mixture of Gravel Sand, Silt & Clay		10	SS	29						
			11	SS	44		164				
	(Till)		12	SS	65		162				8 31 (61)
160.0	Hard										
14.0	Heterogeneous Mixture of Gravel Sand, Silt & Clay		13	SS	105/ 10cm		160				46 44 7 3
	(Till)										
157.3	Very Dense		14	SS	100/ 5cm		158				
16.7	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4 — METRIC

W P 368-87-05 LOCATION Co-ords; N 4 846 139.0; E 294 826.5 ORIGINATED BY PM

DIST 6 HWY 407 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY PM

DATUM Geodetic DATE 89 12 11 to 89 12 13 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
174.4	Ground Level										
0.0	Topsoil						174				
			1	SS	22						4 26 (70)
	Sandy Silt Layer		2	SS	29						
			3	SS	47		172		13cm		
			4	SS	100						10 40 (50)
	Clayey Silt, With to Trace of Sand Trace of Gravel		5	SS	63						
			6	SS	35		170				
	(Till)		7	SS	32						5 28 (72)
	(Lacustrine)		8	SS	14		168				
			9	SS	59	▼					
	Occasional Layers of Silt Sand, Thin Layers of Silt		10	SS	34		166				
			11	SS	23		164				
			12	SS	20		162				0 4 (96)
	Very Stiff/Hard		13	SS	24		160				
158.2			14	SS	12						
16.2	Heterogeneous Mixture of Gravel, Sand, Silt and Clay (Till)		15	SS	75		158				
			16	SS	75		156				52 37 8 3
154.9	Hard										
19.5 / 154.2	*		17	SS	120/	25cm			15cm		36 53 (11)
20.2	End of Borehole										

* Heterogeneous Mixture of Gravel, Sand, Silt and Clay
Till
Very Dense

+3, ×5 : Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 5

METRIC

W P 368-87-05 LOCATION Co-ords; N 4 846 152.0, E 294 879.5 ORIGINATED BY PM

DIST 6 HWY 407 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY PM

DATUM Geodetic DATE 89 12 13 CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
174.1	Ground Level						
0.0	Topsoil						174
	Clayey Silt With to Trace of Sand Trace of Gravel Occasional Silty Sand Layers		1	SS	81		
			2	SS	55		172
			3	SS	44		
			4	SS	48		
			5	SS	47		170
			6	SS	77		
			7	SS	48		
	Occasional Cobbles		8	SS	18		168
	(Till) (Lacustrine)		9	SS	27	▼	
			10	SS	23		166
162.8	Hard/Very Stiff		11	SS	33		
11.3	Heterogeneous Mixture of Gravel, Sand, Silt and Clay (Till) Hard		12	SS	60/ 9cm		164
160.9							
13.2	Heterogeneous Mixture of Gravel, Sand, Silt and Clay (Till) Very Dense		13	SS	75/ 15cm		162
15.5	End of Borehole						160

* Presumed Heterogeneous Mixture of Gravel, Sand, Silt and Clay Hard

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

PLASTIC LIMIT Wp | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W_L

WATER CONTENT (%) 10 20 30

23cm

UNIT WEIGHT γ

REMARKS & GRAIN SIZE DISTRIBUTION (%)	GR	SA	SI	CL
	18	31		(51)
	2	23		(75)
	6	23		(71)
	8	36	43	17
	51	38	8	3

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

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 6

METRIC

W P 368-87-05 LOCATION Co-ords; N 4 846 166.5, E 294 938.0 ORIGINATED BY PM

DIST 6 HWY 407 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY PM

DATUM Geodetic DATE 89 12 13 to 89 12 14 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
173.6	Ground Level										
0.0	Topsoil										
	Sandy Silt Layer		1	SS	26						0 1 88 11
			2	SS	30		172				
	Clayey Silt, With to Trace of Sand Trace of Gravel		3	SS	40						
			4	SS	46						0 0 (100)
			5	SS	37		170				
			6	SS	27						
			7	SS	17		168				
			8	SS	19	▼					0 0 (100)
	(Lacustrine) (Till)										
	Hard/Very Stiff		9	SS	46		166				
165.1											
8.5	Heterogeneous Mixture of Gravel, Sand, Silt and Clay (Till)		10	SS	35		164				
162.3	Hard		11	SS	60						
11.3	Heterogeneous Mixture of Gravel, Sand, Silt and Clay (Till)		12	SS	120/ 15cm		162				
159.9	Very Dense		13	SS	377/ 30cm		160				
13.7	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

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

20 15 ◇ 5 10 (%) STRAIN AT FAILURE

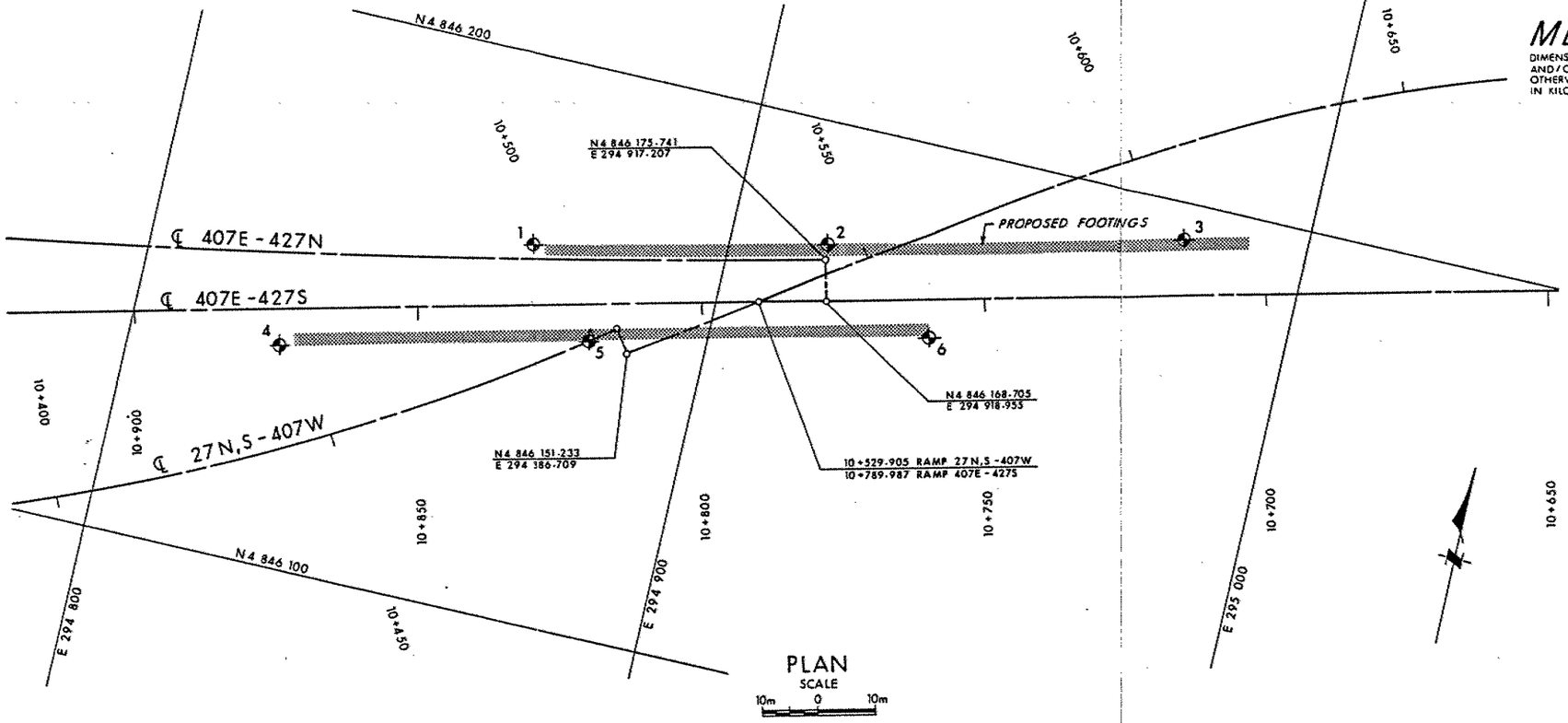
MINISTRY OF TRANSPORTATION, ONTARIO PH-0-207 88 10

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

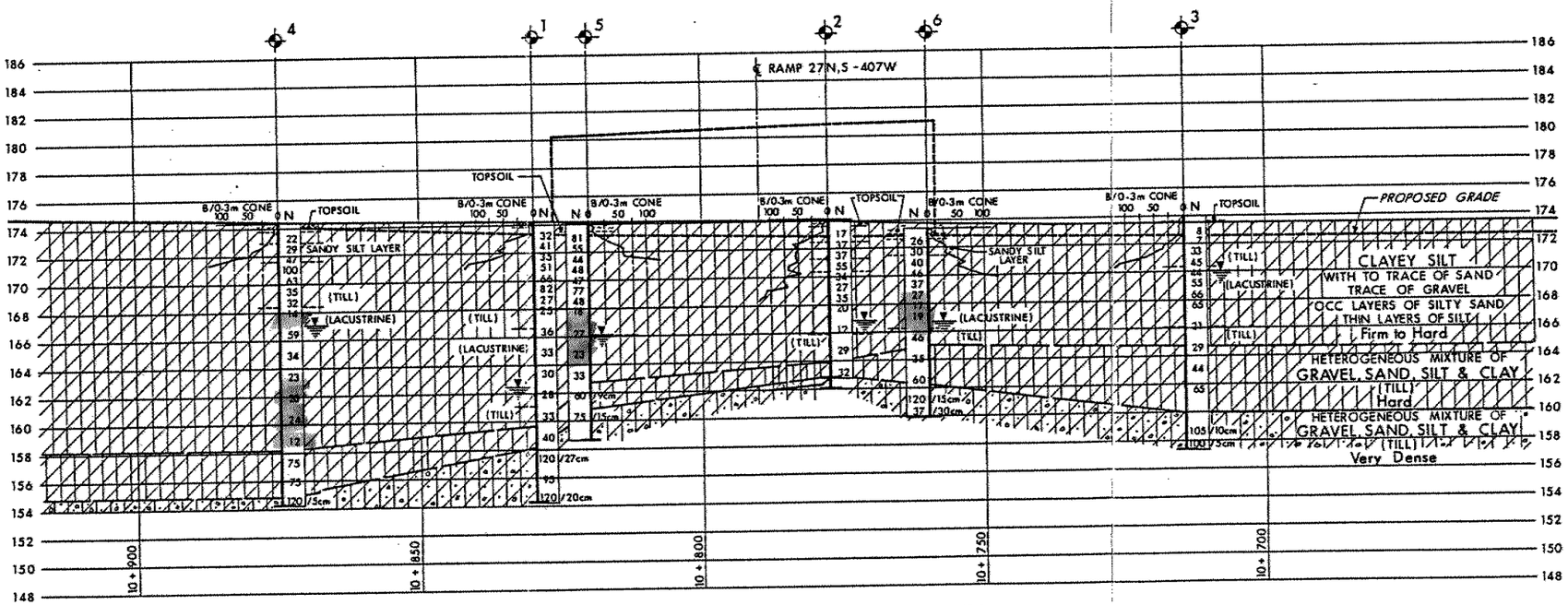
CONT No
WP No 368-87-05

27NS-407W RAMP OVER 407E-427N,S RAMP
BORE HOLE LOCATIONS & SOIL STRATA

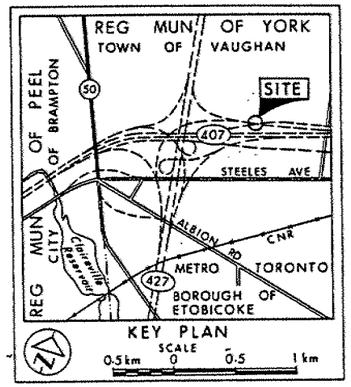
SHEET



PLAN
SCALE
10m 0 10m



℄ PROFILE HWY 407E-427S
SCALE
10m 0 10m Hor
4m 0 4m Vert



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 89 12

No	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
1	174.4	4 846 166.6	294 866.0
2	174.1	4 846 178.5	294 917.2
3	174.0	4 846 193.7	294 978.0
4	174.4	4 846 139.0	294 826.5
5	174.1	4 846 152.0	294 879.5
6	173.6	4 846 166.5	294 938.0

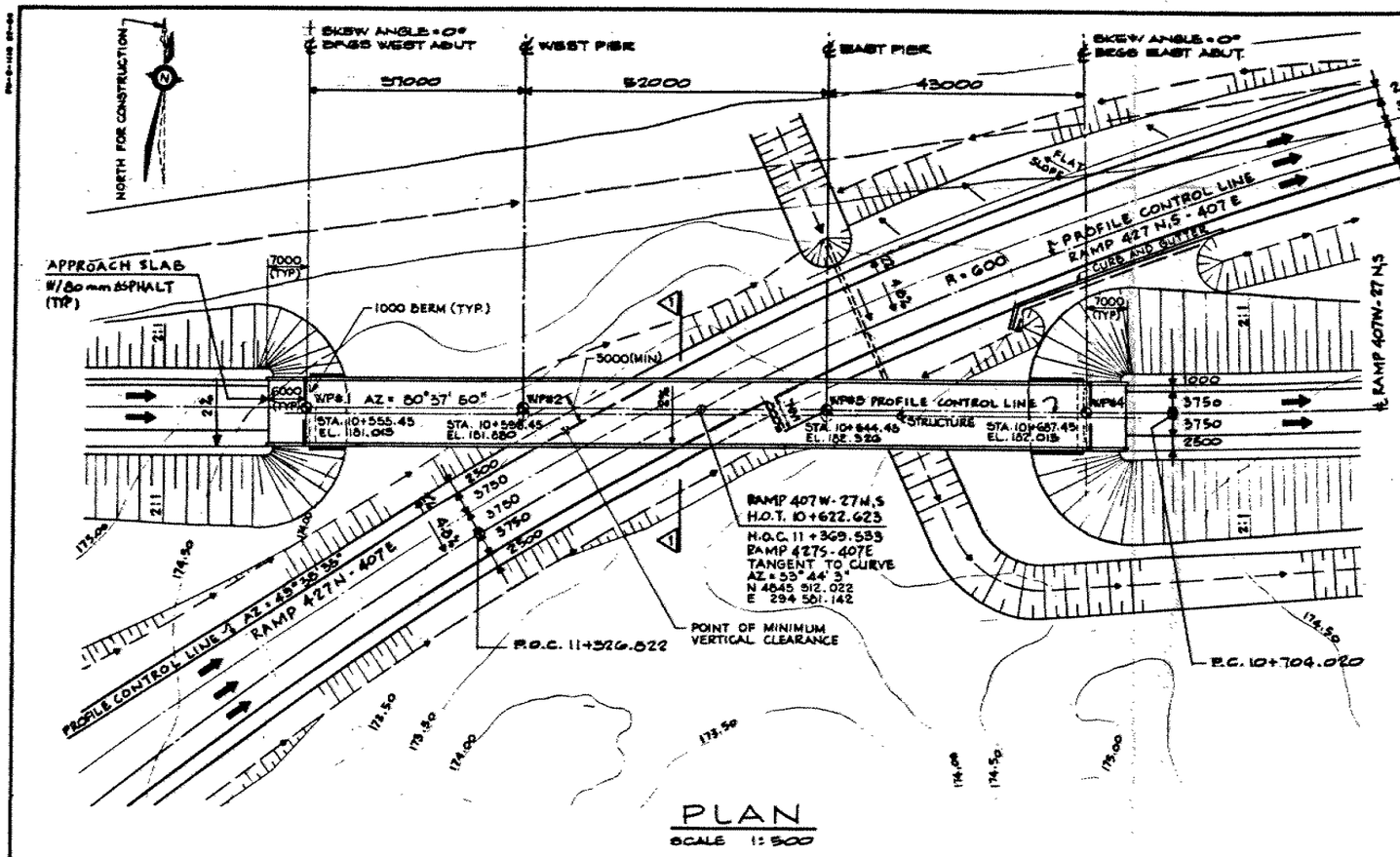
NOTE
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

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 30M13-101

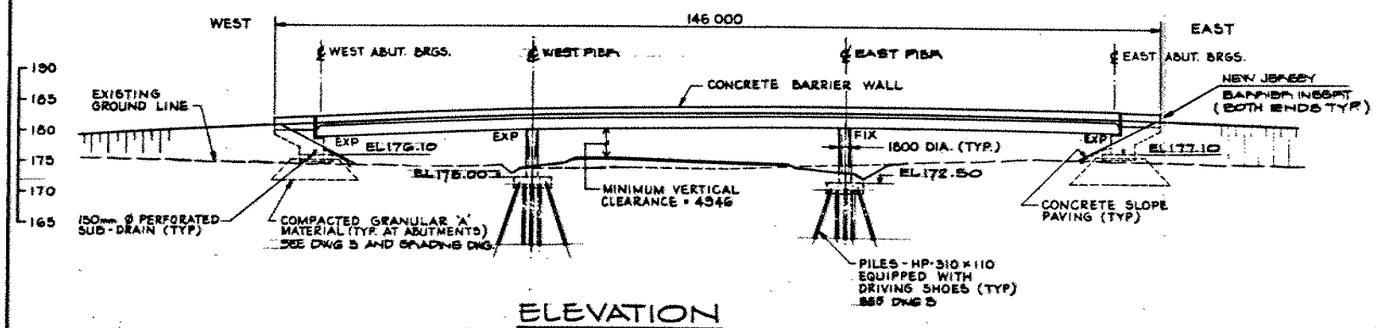
HWY No 407			DIST 6
SUBM'D PM	CHECKED	DATE 90 03 21	SITE 37-1325
DRAWN DT	CHECKED	APPROVED	DWG 3688705-A



PLAN
SCALE 1:500

NOTES

1. WATERPROOFING - ASPHALT PAVING AND APPROACH SLABS ARE NOT PART OF THIS CONTRACT
2. T/P DENOTES TOP OF PAVEMENT
3. W/P DENOTES WORKING POINTS



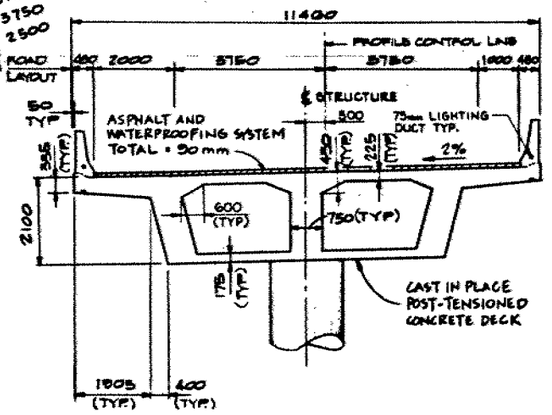
ELEVATION
SCALE 1:500

BENCH MARK ELEV. 173.207

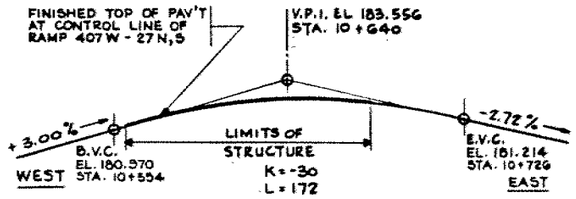
TABLET IN CENTRE AT NORTH END OF WEST CONCRETE PIER OF BRIDGE OVER C.N.R. TRACKS ON ALBION ROAD 1.16 M ABOVE GROUND LEVEL

METRIC

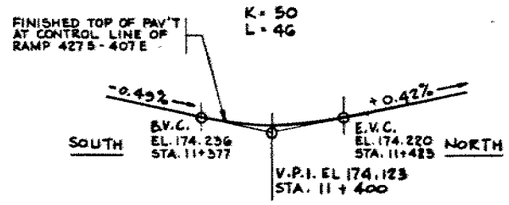
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN



1
SCALE 1:75



PROFILE RAMP 407W-27 N.S.
N. T. S.



PROFILE RAMP 427S-407E
N. T. S.

DIST	No 6
CONT	No
WP	No 368-87-04

RAMP 407W-27N,S OVER RAMP 427N,S-407E
GENERAL ARRANGEMENT

SHEET 1

Sandwell Sandwell Inc.
Sandwell Swan Wooster Division

GENERAL NOTES

CLASS OF CONCRETE
DECK AND PIER COLUMNS 35 MPa
REMAINDER 30 MPa

CLEAR COVER TO REINFORCING STEEL
FOOTINGS 100 ± 25
ABUTMENTS AND WINGWALLS:
FRONT FACE 80 ± 20
BACK FACE 70 ± 20
PIERS 80 ± 20
DECK - TOP SLAB: TOP 70 ± 20
BOT. 40 ± 10
- BOT. SLAB: TOP 40 ± 10
BOT. 50 ± 10
- WEBS 60 ± 10
REMAINDER 70 ± 20
UNLESS OTHERWISE NOTED

REINFORCING STEEL
REINFORCING STEEL SHALL BE GRADE 400 UNLESS NOTED OTHERWISE. BAR MARKS WITH SUFFIX "C" DENOTES COATED BARS.

CONSTRUCTION NOTES
IF THE ACTUAL BEARING THICKNESSES ARE DIFFERENT FROM THOSE GIVEN IN THE BEARING DESIGN DATA, THE CONTRACTOR SHALL ADJUST THE BEARING SEAT ELEVATIONS AND THE REINFORCING STEEL TO SUIT.

LIST OF DRAWINGS

1. GENERAL ARRANGEMENT
2. BOREHOLE LOCATIONS AND SOIL STRATA
3. FOUNDATION LAYOUT
4. ABUTMENT FOUNDATIONS
5. PIER - PIER FOUNDATIONS
6. WEST ABUTMENT
7. WEST ABUTMENT WINGWALLS
8. EAST ABUTMENT
9. EAST ABUTMENT WINGWALLS
10. BEARING DETAILS
11. DECK DETAILS
12. LONGITUDINAL TENDONS
13. TRANSVERSE TENDONS I
14. TRANSVERSE TENDONS II
15. DECK REINFORCING I
16. DECK REINFORCING II
17. DECK REINFORCING III
18. DECK REINFORCING IV
19. DECK REINFORCING V
20. DECK REINFORCING VI
21. JOINT ANCHORAGE AND ARMOURING - WEST ABUT.
22. JOINT ANCHORAGE AND ARMOURING - EAST ABUT.
23. NORTH AND SOUTH BARRIER WALLS
24. 6000 MM APPROACH SLAB
25. DETAILS OF CONCRETE SLOPE PAVING
26. PILE DRIVING STEAM AND DIESEL HAMMERS
27. AS CONSTRUCTED ELEVATIONS - DIMENSIONS
28. STANDARD DETAILS
29. ELECTRICAL EMBEDDED WORK
30. QUANTITIES - STRUCTURES I
31. QUANTITIES - STRUCTURES II

APPLICABLE STANDARD DRAWING

OD-3503 MINIMUM GRANULAR BACKFILL REQUIREMENTS

R.J.J. ELLIS — APPROVED FOR GENERAL CONFORMANCE — PROVINCE OF ONTARIO — JAN 29/91

D. J. REED — REGISTERED PROFESSIONAL ENGINEER — PROVINCE OF ONTARIO — JAN 29/91

DRAWING NOT TO BE SCALED
102 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

DESIGN D.J.R.	CHK EE	CODE OHBDC-85	LOAD CLASS A	DATE JAN. 1991	
DRAWN ABG	CHK D.J.R.	SITE 37-1524	STRUCT	SCHEME	DWG. 1

memorandum

Ontario

Fax. No: 235-5240
Tel. No: 235-3731

Date: 1990 07 23

To: Mr. K. G. Bassi
Head, Structural Section
Design Section

Attn: Mr. G. Al-Bazi
Design Engineer (Central)

From: Foundation Design Section
Room 315, Central Building

Subject: General Arrangement Drawing Review
Ramp 407 W-27 NS over Ramp 427 N, S-407 E
W.P. 368-87-04, Site 37-1324
District 6, Toronto

Attached please find recommendations pertaining to the aforementioned structure, summarized in a separate memo dated 90 07 23. The memo has been issued in response to changes proposed with the structure.

The general arrangement drawing does not comply with the recommendations outlined in the letter mentioned above. The piers must be supported on deep foundation units as discussed in the letter. In addition, the depths of subexcavation for the perched abutments will require confirmation once the additional soils data at the site is collected.

Please refer to the attached letter for information that will assist in the foundation design of the aforementioned structure.

T. Sangiuliano, P.Eng.
Foundation Engineer

for

M. Devata, P.Eng.
Chief Foundation Engineer

TS/ms

Attachment

memorandum

Fax. No: 235-5240
Tel. No: 235-3731

Ontario

To: Mr. V. Boehnke
Area Engineer
Structural Section
Central Region

Date: 1990 07 23

Attn: W. Young
Senior Structural Engineer

From: Foundation Design Section
Room 315, Central Building

Subject: Preliminary Foundation Report
Hwy. 407-27 N, S Ramp over 427 N, S-407 E Ramp
W.P. 368-87-04, Site 37-1324
District 6, Toronto

In response to your memoranda dated June 12, 1990 and June 19, 1990, this office acknowledges that the revised post tensioned concrete structure is a more economical design than the original proposed rigid frame structure at the aforementioned site for the reasons discussed in your letters. Consequently, recommendations to facilitate the structure foundation design and related earthworks for the revised structure are hereby provided. It is important to emphasize that recommendations provided at the proposed abutments and approaches are subject to confirmation that will be derived from additional fieldwork proposed at the site. This fieldwork will be executed as soon as possible so that compliance to pertinent schedules are met.

Structure Foundations

1) Abutments

It is recommended that the abutments be founded on a compacted Granular 'A' pad placed and compacted in accordance with OPSS 501 series and designed in accordance with Figure 4 included in the original foundation report. At the west abutment, where extrapolation of existing soils data reveals sowewhat weaker conditions, subexcavation shall be extended to El. 172 m, or approximately 1.5 m below existing ground surface. The granular pads shall be a minimum 2 m thickness above the original ground surface elevation at either abutment location. For the conditions specified above, the following bearing capacities for purposes of the O.H.B.D.C. are provided.

Table 1 - Abutments on Granular 'A'

Structure	Bearing Capacity at S.L.S. Type II (kPa) (25 mm)*	(37.5 mm)*	Factored Capacity at U.L.S. (kPa)
W. Abutment	350	400	800
E. Abutment	350	450	900

.../2

*The values tabulated in Table 1 above reveal two alternate bearing capacities at the serviceability limit state. The values of 25 mm and 37.5 mm represent the anticipated settlements for the corresponding capacities provided. These settlements will be the result of the recompression of the native soil and hence should take place during and immediately after construction.

The sliding resistance of the Foundation can be computed using an unfactored friction angle of 35° between the concrete footing and the Granular 'A' material.

Alternatively, the east abutment can be founded on spread footings within the surficial clayey silt till deposit at an elevation of 173.6 m or lower. For purposes of the O.H.B.D.C., the following capacities are provided.

Table 2 - East Abutment on Native Soil

Bearing Capacity at S.L.S. Type II	=	350 kPa
Factored Capacity at U.L.S.	=	525 kPa

The sliding resistance of the foundation can be computed using an unfactored friction angle of 30° between the concrete footing and the native soil.

2) Piers

The surficial material at the proposed pier foundation locations is of a weaker nature and hence conventional spread footings are unsuitable at these locations. Consequently, it is recommended that the pier foundations be founded on end-bearing deep foundations. Two types of deep foundation alternatives are provided.

a) Driven Steel H-piles
b) Bored caissons

The alternatives that proves to be the most economical shall be selected for design.

a) Driven Steel H-piles

Pier foundations can be supported on steel H-piles founded within the glacial till deposit consisting of a hetergeneous mixture of gravel, sand, silt and clay. For purposes of the O.H.B.D.C., the following capacities are provided.

Table 3 - Driven Steel H-piles

Pile Type	Structure	Bearing Capacity at S.L.S. Type II (kN)	Factored Capacity at U.L.S. (kN)	Founding El. (m)
HP310x110	W. Pier	1150	1600	161.5±
	E. Pier	1150	1600	163

It is recommended that in view of the fact that boulders and cobbles are characteristic componets of glacial till deposits, which are present at the site, all piles be equipped with reinforced tips to facilitate the pile driving process. In addition, it is recommended that the installation be carefully controlled and monitored by employing the MTO Hiley Dynamic formula in accordance with SS 103-11.

Settlements induced by the tabulated loadings are expected to be within 25 mm and anticipated to be realized during and immediately after construction.

b) Bored Concrete Caissons

Alternatively, pier foundations can be supported on concrete caissons drilled and cast in-situ and end bearing within the till deposit consisting of a heterogeneous mixture of gravel, sand, silt and clay.

For purposes of the O.H.B.D.C., the following capacities are provided.

Table 4 - Bored Concrete Caissons

Caisson Diameter (m)	Structure	Bearing Capacity at S.L.S. Type II (kN)	Factored Capacity at U.L.S. (kN)	Founding El. (m)
0.76	W. Pier	1500	2250	161.5
	E. Pier	1500	2250	163

Other caisson diameters can be considered and capacities can be obtained by the ratio of end bearing areas.

Settlements induced by the tabulated loadings are expected to be within 25 mm and anticipated to be realized during and immediately after construction.

Foundation Construction

No major dewatering difficulty is anticipated in the footing construction for any of the alternatives provided because of the relative impervious nature of the foundation material. Conventional sump pumping techniques will suffice in discharging

...4

any localized seepage that may result from random interbedded cohesionless layers and any surface runoff during spread footing and pile cap construction.

In the installation of the caissons, some soil sloughing can be anticipated at the sand and silt layers submerged beneath the prevailing groundwater table. It is therefore recommended that mud drilling techniques or a steel liner be employed to facilitate the penetration through these layers.

Approach Embankments

Approach embankments in the order of magnitude of 5 m and 7.5 m have been proposed in advance of the structure at the west and east approach respectively. There are no deep seated nor internal slope instabilities anticipated for fills constructed at a slope of 2H:1V as identified on the drawing.

Settlements in the order of magnitude of 50 mm attributable to the elastic recompression of the native subsoil and settlement within the fills under its own weight are anticipated. It is predicted that the majority of the settlements will be realized during or immediately following the construction of the embankment.

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 Design Section

for

M. Devata, P.Eng.
Chief Foundation Engineer

TS/ms

c.c.: K. Bassi, Head-Structural Office
Attn: G. Al Bazi

memorandum

Ontario

To: V. Boehnke
Head, Structural Section
Central Region

Date: 1990 05 31

Attn: W.F. Young
Sr. Structural Engineer

From: Foundation Design Section
Room 315, Central Bldg.

Re: General Arrangement Drawing Review
Ramp 407W - 27N,S over
Ramp 427 N,S - 407E
W.P. 368-87-04
District 6, Toronto

The General Arrangement drawing for the aforementioned structure has been reviewed by this office and the following comments are provided.

Basketweave Structure Foundations

A founding elevation for the end-bearing deep foundation steel H-piles has not been provided on the drawing. The founding elevation certainly must be included in the final design and shall conform to the elevations recommended in the original foundation report (El. 160 to 162).

Pile driving shall be carefully controlled by employing the MTO Hiley Dynamic Formula and this requirement must be included in the contract package. The piles shall be driven in accordance with MTO Standards SS103-10 or SS103-11 assuming an ultimate capacity of 3450 kN for the HP 310 X 110 pile.

Reinforced Earth Retaining Walls

A non-standard special provision shall be prepared to address the construction of the reinforced earth retaining walls. The special provision shall include specifications on the foundation preparation, levelling pad construction, reinforcing strip installation, and backfill material and placement procedures.

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

T. Sangiuliano, P. Eng.
Foundation Engineer

for

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

PP/TS/jb

memorandum

Ontario

To: V. Boehnke
Head, Structural Section
Central Region

Date: 1990 02 15

Attn: W. F. Young, Sr. Structural Engineer

From: Foundation Design Section
Room 315, Central Building

RE: W.P. 368-87-04, Structure Site 37-1324
District 6, Toronto

As per our meeting 90 02 08, the following additional recommendations are being supplied for shallow foundations.

Spread footings can be placed at or below elevation 173 m, provided that the footings have a minimum earth cover of 1.2 m for frost protection. In addition for:

1. Structure and West Retaining Wall
(Station 11 + 300 to 11 + 393)

   The original ground should be subexcavated down an additional 1 m to elevation 172 m or lower. The dimensions of the subexcavation should be large enough to allow for the surface of the granular pad to be 1.0 m longer (west ends only) and 1.0 m wider then the footings as per attached figure.

   The ground should then be compacted and 1.0 m of compacted Granular 'A' placed immediately after, so as to guard against softening of the foundation material.

2. East Retaining Wall

   Lean concrete (150 mm) should be placed within 4 hours of completion of excavation so as to guard against softening of the foundation material from weathering and seepage effects.

For the purposes of the O.H.B.D.C. the following bearing capacities are recommended:

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

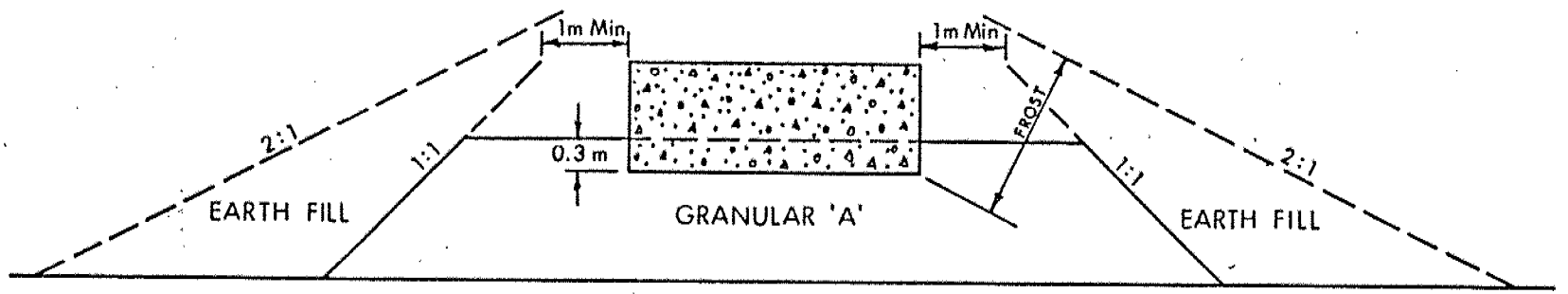
P. Marks, P. Eng.
Foundation Engineer

for

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

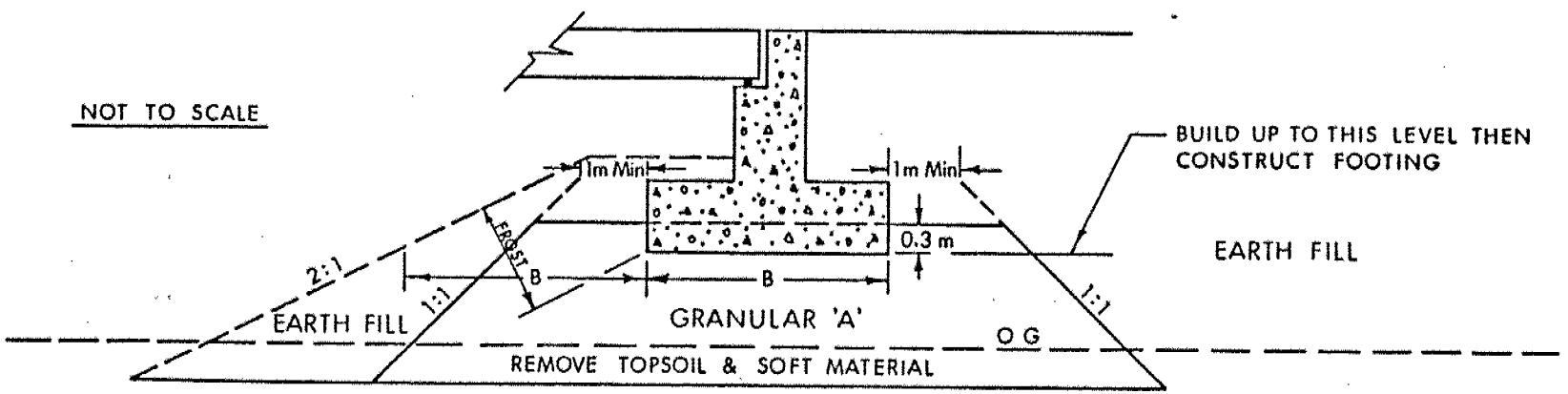
BI/PM/jb

Attach.



X SECTION

NOT TO SCALE



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 C STANDARDS.

3 - CONSTRUCT CONCRETE FOOTING.

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

Ministry of Transportation and Communications Ontario	ABUTMENT ON COMPACTED FILL SHOWING GRANULAR 'A' CORE	FIG No W P

memorandum

Ontario

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

Date: 1990 01 18

Attention: W.F. Young, Sr. Structural Engineer

From: Foundation Design Section
Room 315, Central Building

RE: W.P. 368-87-04, Structure Site 37-1324
W.P. 368-87-05, Structure Site 37-1325
District 6, Toronto

This memo accompanies two detailed memoranda giving preliminary recommendations on design and construction of foundations for the above structures. Two foundation options are given in the attached memoranda; namely, spread footings and steel H piles. Giving consideration to the presence of competent founding stratum within shallow depth, we would strongly favour spread footings for these structures. As mentioned in the attached memoranda, some localized excavation of existing material and replacement with competent granular fill might be required.

We would be pleased to elaborate on the comments given above or on items covered in the attached memoranda. Please contact this office if you need further input on this project.

B Iyer

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

BI/mmj

c.c. - K.G. Bassi
G. Al-Bazi

memorandum

Ontario

To: V. Boehnke
Head, Structural Section
Central Region

Date: 1990 01 16

Attn: W. F. Young, Sr. Structural Engineer

From: Foundation Design Section
Room 315, Central Building

RE: Highway 407 W - 27N, S Ramp over 427 N, S - 407 E Ramp
W.P. 368-87-04, Structure Site 37-1324
District 6, Toronto

This memorandum gives preliminary recommendations regarding the design and construction of foundations for the above structure. Also, included in this memo are preliminary comments regarding the design of approach embankments. This information is provided to you in advance of our final report, to facilitate your design to proceed. We will submit our final report on this project in the near future.

Subsurface Conditions

The elevation of the ground level at the site ranged from 174.8 to 173.1 m. The subsurface conditions at the site consist mainly of 8 to 11.6 m of clayey silt, some sand, trace of gravel with some layers of silty sand and silt found occasionally in the deposit. Below this material at elevation 166.4/161.9 m a till consisting of a heterogenous mixture of gravel, sand, silt and clay was encountered. This mixture was found to be cohesive for the upper 3. to 4.7 m+, below which the percentage of clay diminishes.

Measurements of the groundwater taken at the time of an investigation at structure site #37-1325 done just to the northeast, indicate that the groundwater level may be as high as elevation 170 m, 3.1 m below the ground level. It should be noted that groundwater levels are subject to seasonal fluctuations and may therefore vary from those given above.

Proposed Structure

It is proposed to construct single span rigid frames parallel to the lower ramp with retaining walls at the acute corners. The proposed clear span is about 16.25 m. A grade raise of approximately 8 m is needed to reach the proposed pavement grade at elevation 181.6 m.

Structure Foundations

The proposed structure may be founded on spread footings in the upper clayey silt deposit,on compacted Granular 'A' fill or on steel H-piles driven into the heterogenous till mixture.

.../2

1) Spread Footings

a) On the Clayey Silt:

The proposed structure may be supported on spread footings at or below elevation 169 m. For the purposes of the O.H.B.D.C., the following design values are recommended.

Factored Bearing Capacity at U.L.S. 450 kPa
Bearing Capacity at S.L.S. Type II 300 kPa

For footings located at higher elevations, a reduced bearing capacity can be recommended by this office.

It is anticipated that settlements induced within the proposed footing should not exceed 25 mm.

a) On Compacted Granular 'A'

The proposed structure may be supported on spread footings at elevation 174 m. For this alternative a section along both footings should be subexcavated to elevation 169 m and backfilled with compacted Granular 'A' as illustrated in Figure 1 attached. The following design values are recommended:

Factored Bearing Capacity at U.L.S.	450 kPa
Bearing Capacity at S.L.S. Type II	300 kPa

It is anticipated that settlements induced within the proposed footing should not exceed 25 mm.

The underside of all footings should be provided with a minimum of 1.2 m earth cover for frost protection.

2) Steel H-piles

The proposed structure may be founded on steel H-piles driven to end bearing in the heterogenous till mixture. The estimated pile tip elevation ranges from 161 to 165 m. All steel H-piles should be reinforced with standard driving shoes.

For the purposes of the O.H.B.D.C, the following design parameters are suggested for H.P. 310 X 110 steel "H" piles:

.../3

Factored Capacity at U.L.S.	1600 kN
Bearing Capacity at S.L.S. Type II	1150 kN

Pile driving in the field should be controlled by employing the Hiley Dynamic Pile Driving Formula.

Approach Embankments

Due to the competent nature of the natural soil, no deep-seated failures are anticipated through the foundation soils, for grade raises of 8 m. Topsoil and surficial material should be removed prior to placing any fill. The fill should consist of well compacted acceptable material. Embankments should have side and forward slopes no steeper than 2 horizontal to 1 vertical designed and constructed in accordance with the appropriate Ministry Standards. Care should be taken to ensure that no bouldery fill is placed within the approaches at locations through which piles have to be driven, and it is recommended that this portion of the fill contain no larger grain sizes than 75 mm.

Total settlement of the fill and the foundation soil should be in the order of 40 mm. Most of this will be elastic compression and will have occurred immediately after completion of construction.

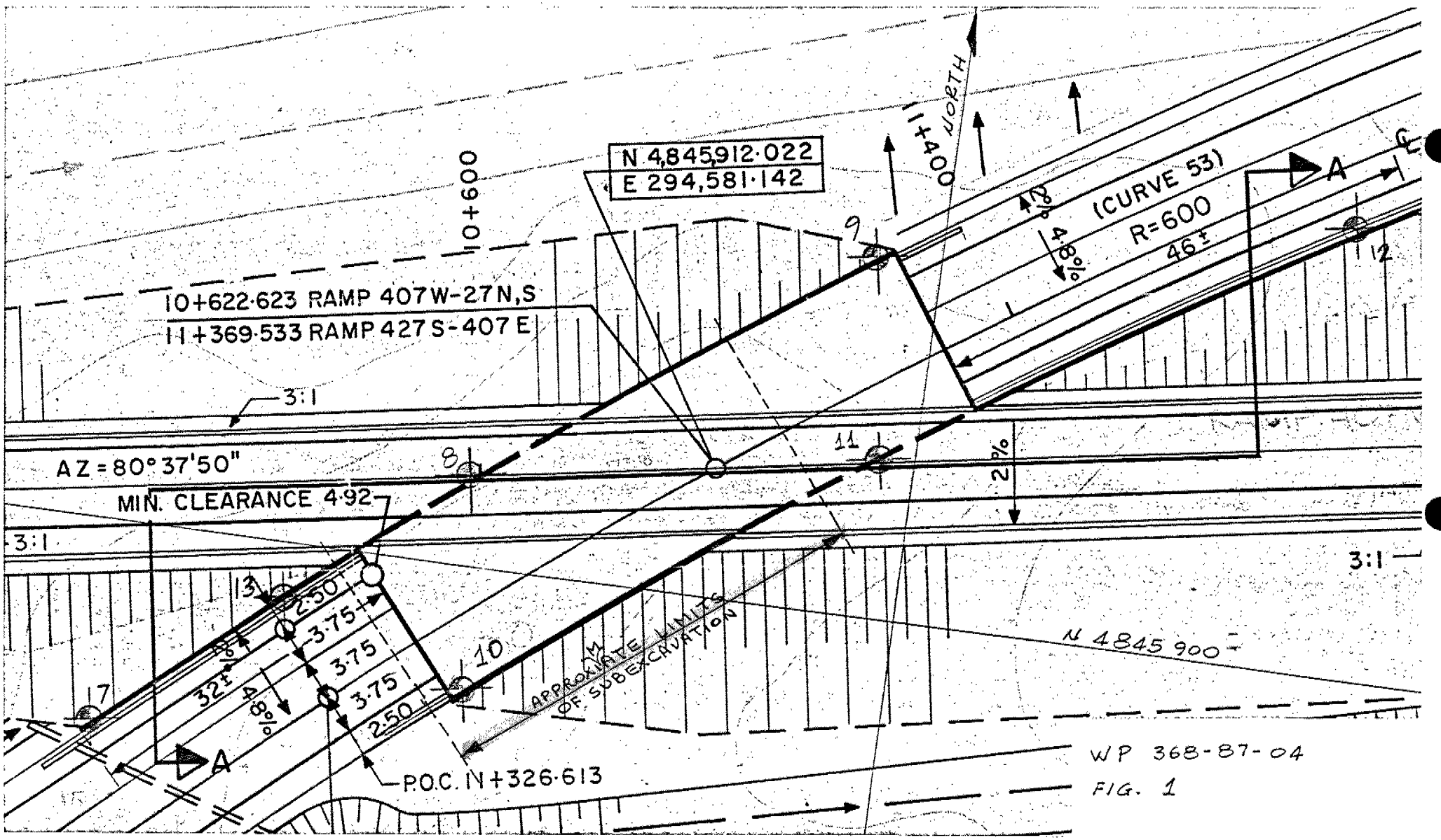
Construction Concerns

No major construction problems are anticipated.

Pamela Marks, P. Eng.
Foundation Engineer

for

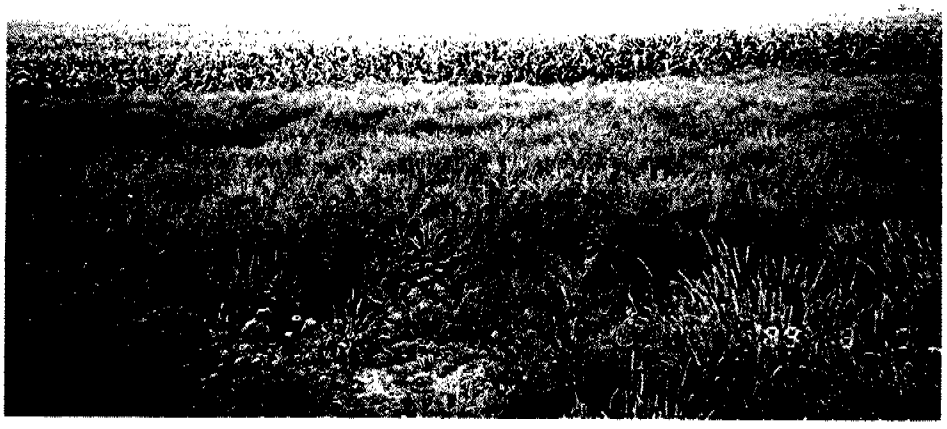
Dr. B. Iyer, P. Eng.
Sr. Foundation Engineer



WP 368-87-04

FIG. 1

LOOKING EAST AT SITE FROM HWY 427 ADVANCE FILL



LOOKING SOUTH FROM TOP OF SLOPE HWY 407, CONT. 88-30
(STEELES AVE. IN THE BACKGROUND)

RAMP 407W - 27NS OVER RAMP 427NS - 407E SITE 37-1324

LOOKING EAST AT SITE FROM FENCE LINE

LOOKING EAST AT SITE FROM STATION 10+900 ON RAMP 407E - 427NS

LOOKING SOUTH, 40 m NORTH OF SITE

RAMP 27NS - 407W OVER RAMP 407E - 427NS SITE 37-1325

LOOKING WEST AT SITE FROM STATION 10+700 ON RAMP 407E - 427NS

LOOKING NORTH, 50 m SOUTH OF SITE

DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 30M13-99

DIST. 6 REGION

W.P. No. 368-87-05

CONT. No.

W. O. No.

STR. SITE No. 37-1325

HWY. No. 407/427

LOCATION 27N,S - 407W Ramp over 407E - 427N,S Ramp

No. of PAGES - —

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
WP No368-87-05

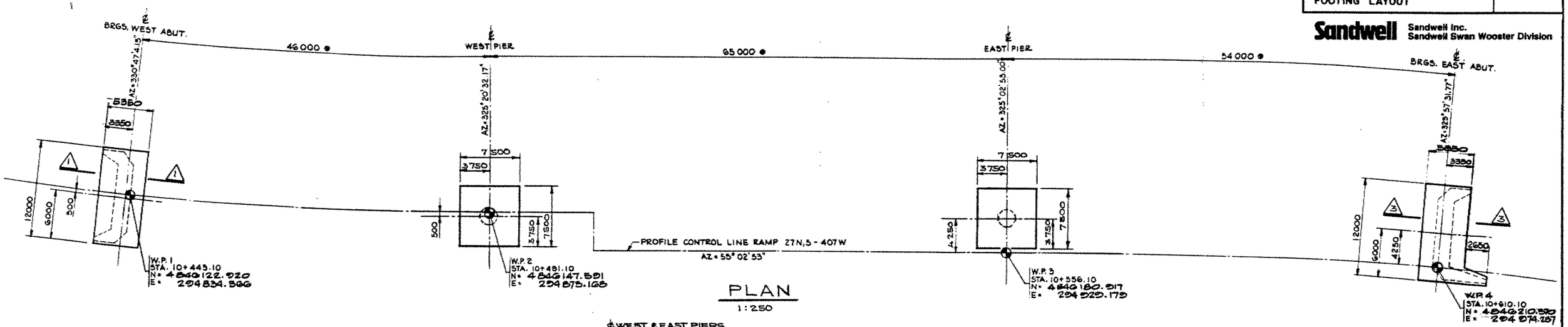
SHEET

RAMP 27N,S-407W OVER
RAMP 407E-427N,S
FOOTING LAYOUT

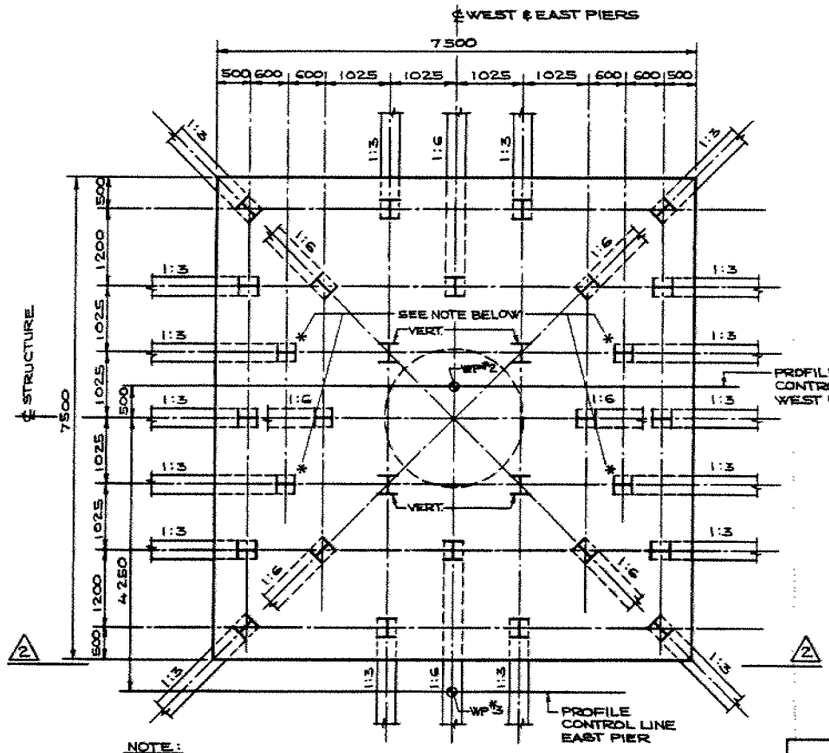
Sandwell Inc.
Sandwell Swan Wooster Division

NORTH FOR CONSTRUCTION

● DIMENSION MEASURED ALONG PROFILE CONTROL LINE

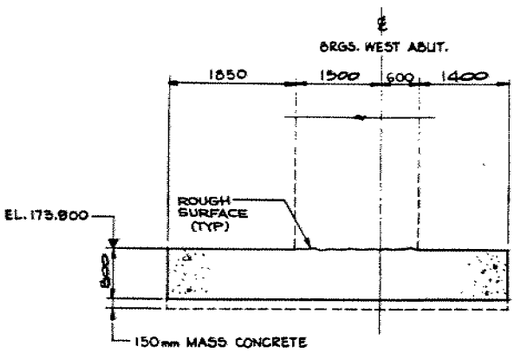


PLAN
1:250



NOTE:
PILES MARKED THUS (*) TO BE INSTALLED AT EAST PIER ONLY

PLAN
EAST PIER AS SHOWN
WEST PIER AS SHOWN AND NOTED
1:50



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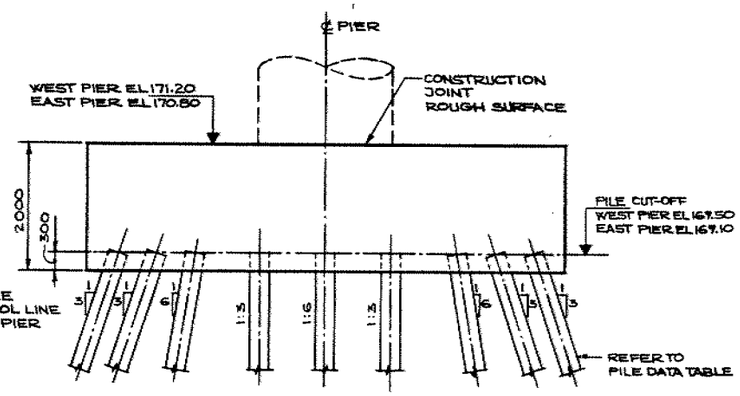
1:50



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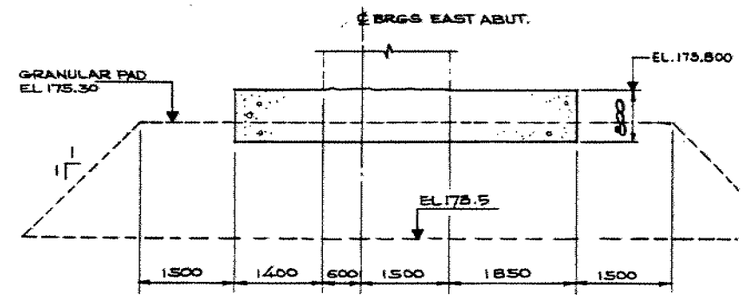


3
1:50

PILE DATA

LOCATION	BATTER	No. REQ'D	LENGTH	CUT OFF EL.
WEST PIER	1:3	14	11.5	169.50
	1:6	8	11.0	169.50
	VERT.	4	11.0	169.50
EAST PIER	1:3	18	11.0	169.10
	1:6	8	10.5	169.10
	VERT.	4	10.5	169.10

PILE CAPACITIES

FACTORED AXIAL CAPACITY @ ULS	1600 kN
AXIAL CAPACITY @ SLS TYPE II	1150 kN
FACTORED LATERAL CAPACITY @ ULS	80 kN
LATERAL CAPACITY @ SLS TYPE II	60 kN

PILING NOTES:
1. ALL PILES TO BE HP 310 × 110.
2. PILE SPACING IS MEASURED AT UNDERSIDE OF FOOTING.
3. PILE LENGTHS SHOWN IN TABLE ARE THEORETICAL LENGTHS BELOW CUT-OFF ELEVATION.
4. ALL PILES TO HAVE DRIVING SHOES.
5. PILES TO BE DRIVEN TO ELEV. 162.0 m THEN CONTROLLED IN ACCORDANCE WITH STANDARD DRAWING SS 103-11 ASSUMING AN ULTIMATE CAPACITY OF 3450 kN PER PILE. THE ESTIMATED LOWEST TIP ELEVATION IS ELEV. 159.0 m. THE PILE HAMMER SHALL HAVE A MINIMUM CAPACITY OF 50 kJ.

APPLICABLE STANDARD DRAWING - PILING

SPLICE AND DRIVING SHOE DETAILS FOR STEEL H-PILES	OPSD-3301.00
SUPPORTS FOR BOTTOM REINFORCING STEEL	OPSD-3922.00
PILE DRIVING - STEAM & DIESEL HAMMERS	SS103-11

NOTES
1. REMOVE TOPSOIL AND/OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' + EARTH FILL
2. PLACE GRANULAR 'A' AND EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED AS SPECIFIED
3. CONSTRUCT CONCRETE FOOTINGS
4. PLACE REMAINDER OF GRANULAR 'A' AND EARTH FILL AS REQUIRED.

R.J.J. ELLIS Feb. 8, 91 REGISTERED PROFESSIONAL ENGINEER PROVINCE OF ONTARIO

D. J. REED Feb. 8, 91 REGISTERED PROFESSIONAL ENGINEER PROVINCE OF ONTARIO

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS		
DATE	BY	DESCRIPTION
91 08 12	GT	E-€W-PIER FOOTINGS REVISED TO DEEP FOUNDATIONS

DESIGN D.J.R.	CHK B.E.	CODE OHBDC-83	LOAD CLASS A	DATE FEB 1991	
DRAWN A.VACCA	CHK D.J.R.	SITE 37-1325	STRUCT	SCHEME	DWG. 3

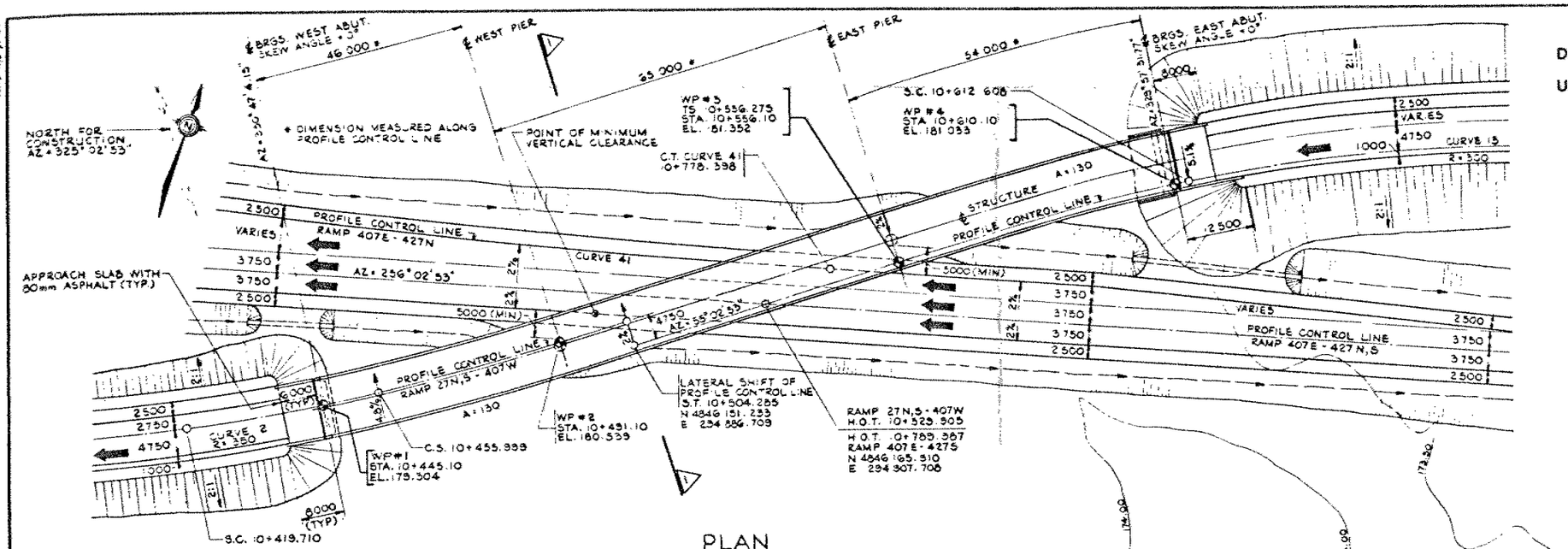
METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

DIST No 6
CONT No
WP No 368-87-05

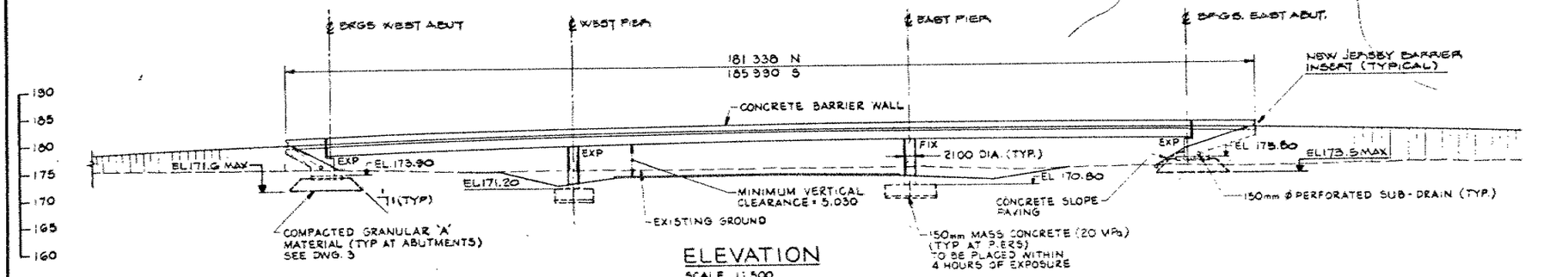
SHEET

RAMP 27 N,S - 407 W OVER RAMP 407 E - 427 N,S
GENERAL ARRANGEMENT



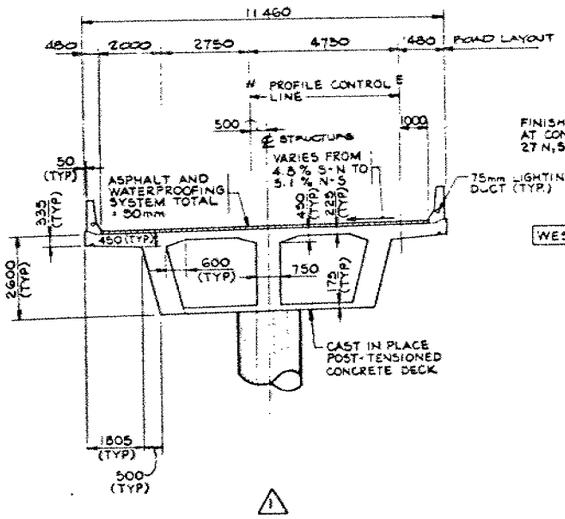
PLAN

SCALE 1:500



ELEVATION

SCALE 1:500



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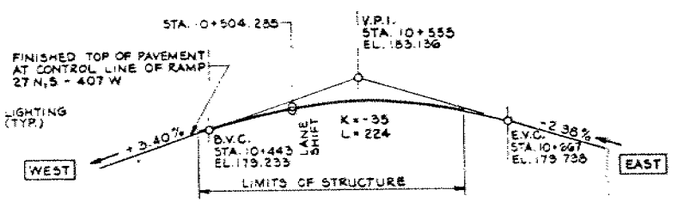
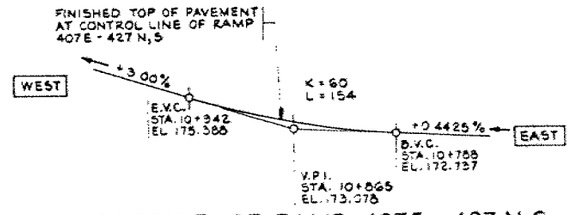


PROFILE OF RAMP 27N,S - 407W

N.T.S.



PROFILE OF RAMP 407E - 427 N,S

N.T.S.

BENCH MARK ELEV. 173.207

TABLET IN CENTRE AT NORTH END OF WEST CONCRETE PIER OF BRIDGE OVER C.N.R. TRACKS ON ALBION ROAD 1.16 M ABOVE GROUND LEVEL

Sandwell Sandwell Inc. Sandwell Swan Wooster Division

GENERAL NOTES

CLASS OF CONCRETE

DECK AND PIER COLUMNS	35 MPa
REMAINDER	30 MPa

CLEAR COVER TO REINFORCING STEEL

FOOTINGS		100 ± 25
ABUTMENTS AND WINGWALLS:		
FRONT FACE		80 ± 20
BACK FACE		70 ± 20
PIERS		80 ± 20
DECK - TOP SLAB:	TOP	70 ± 20
	BOT.	40 ± 10
- BOT. SLAB:	TOP	40 ± 10
	BOT.	50 ± 10
- WEBS		60 ± 10
REMAINDER UNLESS OTHERWISE NOTED		70 ± 20

REINFORCING STEEL
REINFORCING STEEL SHALL BE GRADE 400 UNLESS NOTED OTHERWISE. BAR MARKS WITH SUFFIX "C" DENOTES COATED BARS.

CONSTRUCTION NOTES
IF THE ACTUAL BEARING THICKNESSES ARE DIFFERENT FROM THOSE GIVEN IN THE BEARING DESIGN DATA, THE CONTRACTOR SHALL ADJUST THE BEARING SEAT ELEVATIONS AND THE REINFORCING STEEL TO SUIT.

LIST OF DRAWINGS

NOTES:

1. WATERPROOFING, ASPHALT PAVING AND APPROACH SLABS ARE NOT PART OF THIS CONTRACT
2. T/P DENOTES TOP OF PAVEMENT
3. WP DENOTES WORKING POINTS
4. BRIDGE DECK SPAN DIMENSIONS ARE MEASURED ALONG PROFILE CONTROL LINE. LATERAL DIMENSIONS ARE MEASURED AT RIGHT ANGLES TO PROFILE CONTROL LINE.
5. BARRIER WALLS AND WING WALLS ARE PARALLEL TO PROFILE CONTROL LINE AND ARE MEASURED ALONG THE INSIDE FACES OF THE WALLS.

APPLICABLE STANDARD DRAWINGS

SD-350S MINIMUM GRANULAR BACKFILL REQUIREMENTS

REGISTERED PROFESSIONAL ENGINEER B.J.J. ELLIS Feb. 8, 91 PROVINCE OF ONTARIO

Feb. 8, 91

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

DESIGNED J. [illegible] K B.E	CODE OHBDC - 83	LOAD CLASS A	DATE FEB 1991	
DRAWN A[illegible] K D.R	SITE 37-1325	STRUCT	SCHEME	DWG.

METRIC

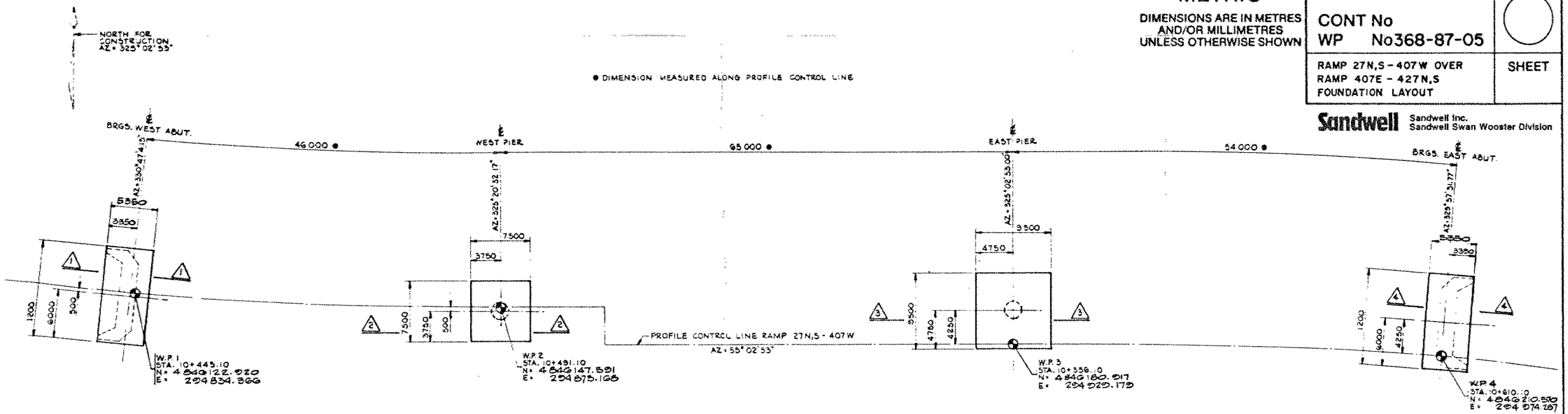
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No368-87-05

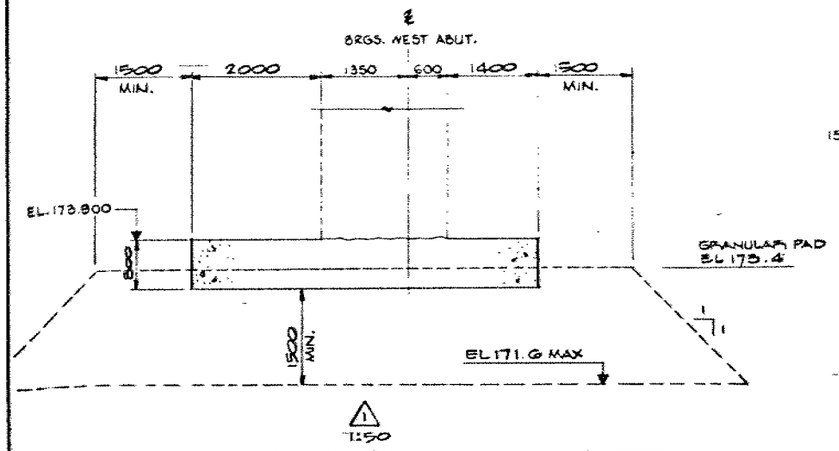
SHEET

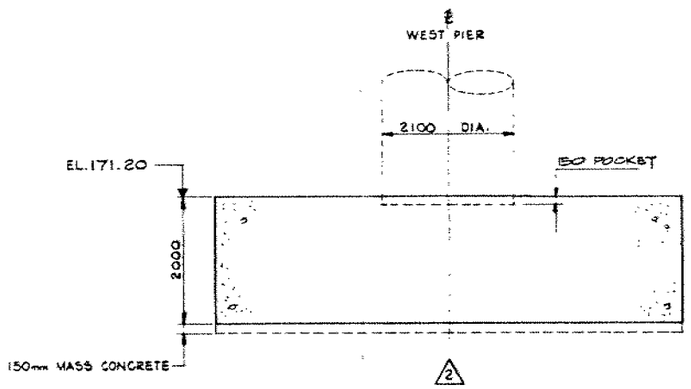
RAMP 27N,S - 407W OVER
RAMP 407E - 427N,S
FOUNDATION LAYOUT

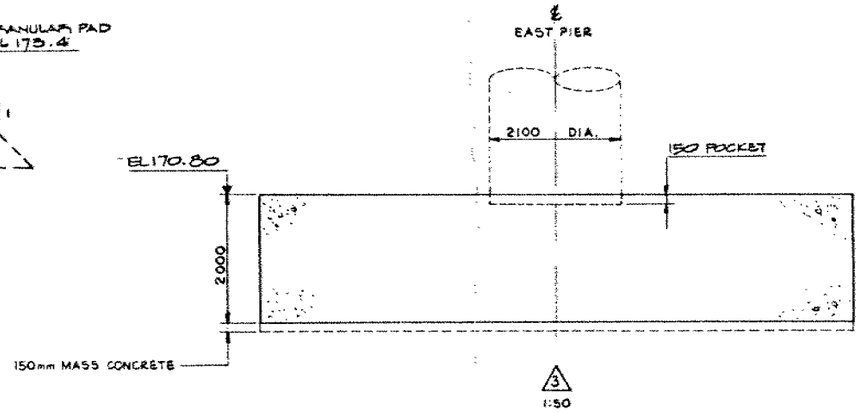
Sandwell Inc.
Sandwell Swan Wooster Division

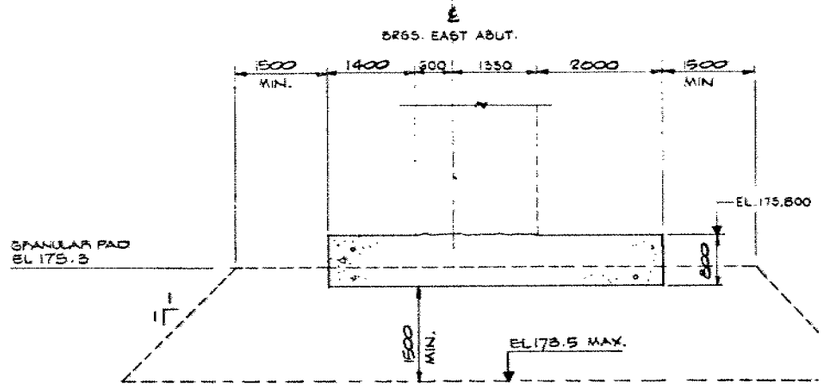


PLAN
1:250









NOTES

1. REMOVE TOPSOIL AND/OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' + EARTH FILL
2. PLACE GRANULAR 'A' AND EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED AS SPECIFIED
3. CONSTRUCT CONCRETE FOOTING
4. PLACE REMAINDER OF GRANULAR 'A' AND EARTH FILL AS REQUIRED.

REGISTERED PROFESSIONAL ENGINEER B.J.J. ELLIS Feb. 8, 91 PROVINCE OF ONTARIO

D. J. REED Feb. 8, 91

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

DESIGN DJ	BE	CODE OHBDC - 83	LOAD CLASS A	DATE FEB 1991	
DRAWN AS	DJR	SITE 37-325	STRUCT	SCHEME	DWG. 3

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
WP No368-87-05

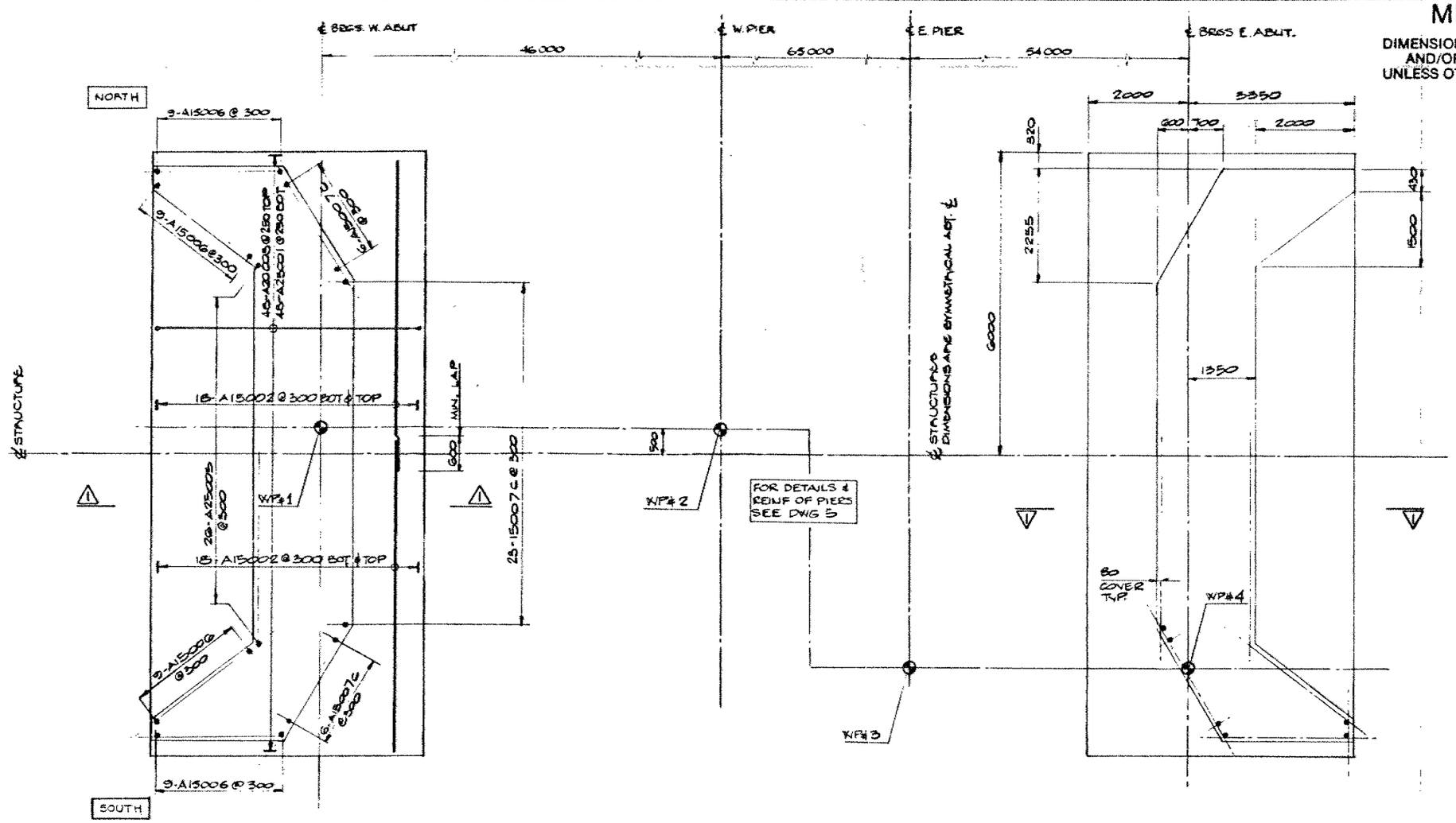
RAMP 27N,S - 407W OVER
RAMP 407E - 427N,S
ABUTMENT FOUNDATIONS

SHEET

Sandwell Inc.
Sandwell Swan Wooster Division

NOTES :-

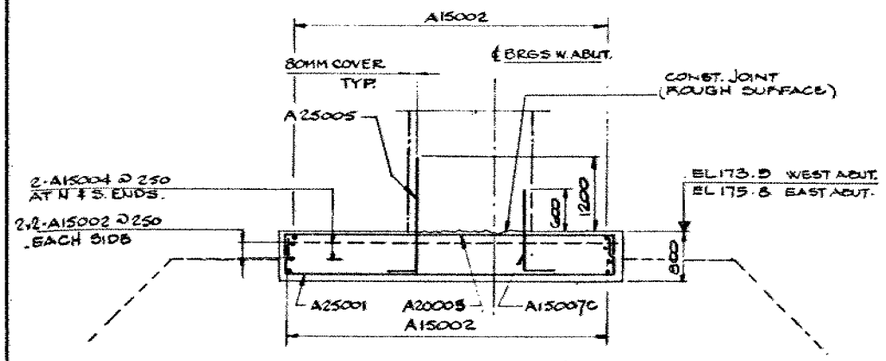
1 APPLICABLE STANDARD DRAWING :-
DD3922 SUPPORTS FOR BOTTOM REINFORCING



WEST ABUTMENT

NOTE : REINFORCING FOR EAST ABUTMENT SIMILAR TO WEST ABUTMENT BUT OPPOSITE HAND

EAST ABUTMENT



⚠ 1:50

B.J.J. ELLIS
FEB. 8, 91
PROVINCE OF ONTARIO

D. J. REED
FEB. 8, 91

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

DESIGN O.T.R.	BE	CODE OHBDC-83	LOAD CLASS A	DATE FEB. 1991	
DRAWN NC	CHK'D	SITE 37-15/25	STRUCT	SCHEME	DWG 4

FILE

Ministry
of
Transportation
Ontario

FOUNDATION DESIGN SECTION

foundation investigation and design report

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 368-87-05 (R) DIST 6

HWY 27N STR SITE 37-1325

Ramp Structure Hwy. 27N, S to Hwy 407W
(over Ramp Hwy. 407E to Hwy. 427N)

DISTRIBUTION

V.F. Boehnke (3)
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E.A. Joseph
B. Steeves (Cover Only)
I. Bullen (Cover Only)
File

GEOCRES 30M13-99 DATE NOV 27 1990

FOUNDATION INVESTIGATION REPORT

For

Ramp Structure Hwy. 27N,S to Hwy. 407W

(over Ramp Hwy. 407E to Hwy. 427N)

W.P. 368-87-05 (R), Site No. 37-1325

District 6, Toronto

INTRODUCTION

This report summarizes the results of a foundation investigation conducted at the aforementioned site. It is proposed to construct a three span structure that will carry the Hwy.27N,S-Hwy.407W ramp structure over the Hwy.407E-Hwy.427N ramp structure. This report describes the subsurface conditions at the site and provides detailed recommendations regarding the structure foundations and related earthworks.

SITE DESCRIPTION AND GEOLOGY

The site is located approximately 0.5 km east of the new Hwy. 427-Hwy. 407 intersection and 0.25 km north of Steeles Avenue in the Town of Vaughan, Regional Municipality of York. The structure is a component of the Hwy. 427-Hwy. 407 interchange complex that features numerous other structures. Many of these structures were under construction at the time of the investigation and consequently, construction equipment, materials and personnel were present at the site at the time of the investigation. A haul route for transportation of fill material colinear with the proposed Hwy. 407WB lanes was located immediately south of the site.

The natural terrain at the site is generally flat but construction of the Hwy. 427/407 interchange has accentuated the flat terrain with approach fills and cuts. A corn field was present immediately beyond the northern limits of the site at the time of the investigation. Grassland was present elsewhere at the specific site location.

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 characteristics 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 conducted within two different time periods. Initially, six sampled boreholes (BH's 1-6 inclusive) accompanied by six dynamic cone penetration tests were advanced during the period from 89 12 17 to 90 12 14. The sampled boreholes were advanced to depths ranging from 11.1 m to 20.2 m below the ground surface whereas the dynamic cone tests were advanced to depths ranging from 2.7 m to 5.8 m below the ground surface. A subsequent second field investigation was conducted on 90 08 01 to retrieve additional subsurface data and information. The fieldwork consisted of two sampled boreholes advanced to depths ranging from 5 m to 13.8 m.

Track mounted CME 55 equipment employing hollow stem augering and washboring/ casing 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. 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 peformed. 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

General

The elevation of the ground surface at the site ranged from 173.6 m to 174.5 m. The subsurface conditions at the site are generally uniform and consists of two distinct glacial till deposits. The surficial deposit consists of a cohesive heterogeneous mixture of clayey silt, sand and gravel. This deposit contains layers of cohesionless silty sand to sandy silt and also interbeds of cohesive

clayey silt to silty clay of glaciolacustrine origin. Boulders and cobbles are also present within the deposit. This deposit extends to depths ranging from 10.1 m to at least 16.2 m.

The surficial cohesive till deposit is underlain by a cohesionless till deposit consisting of a heterogeneous mixture of gravel, sand, silt and clay. The extent of the deposit was not determined within the scope of the investigation.

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 stratigraphic sections are provided on Dwg. 3688705R-A. The subsoil descriptions for BH's 1 to 6 inclusive have been editted for this report. These boreholes are the same boreholes advanced in conjunction with W.P. 368-87-04.

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

Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) - Cohesive

The natural glacial deposit at the site consists of a heterogeneous mixture of clayey silt, sand and gravel and extends for depths ranging from 10.1 m to 16.2 below ground surface. The deposit contains layers of cohesionless silty sand to sandy silt ranging in thickness from 0.5 m to 1.5 m located randomly throughout the deposit. In addition, layers of clayey silt to silty clay of glaciolacustrine origin in thicknesses ranging from 0.5 m to 5.3 m are also present within the deposit. Boulders and cobbles, inferred throughout the deposit during borehole advancement in this deposit, are also present within this deposit.

Figure 1 in the Appendix illustrates the gradation, in envelope form, of the heterogeneous mixture of the clayey silt, sand and gravel that comprises the deposit. The envelope was created by integrating individual sample grain size distribution curves produced by mechanical sieve and hydrometer analysis. The envelope does not include the larger boulder and cobble sizes.

The results reveals a wide range of grain sizes with the fine grained portion of the deposit (clay and silt) consistently exceeding 50%. Figure 2 in the Appendix illustrates the gradation of the typical silty sand to sandy silt layers interbedded in the deposit.

The fine grained portion of the till deposit was examined for its plasticity and behaviour by conducting Atterberg Limits tests. The results are plotted in Figure 3 in the Appendix and the indices are summarized in Table 1 below.

Table 1 - Clayey Silt (Glacial Till)

	Range	# of Tests
Natural Moisture Content (w%)	7-20	12
Liquid Limit (w_L%)	17-33	12
Plasticity Index (Ip%)	6-16	12
Unit Weight (kN/m^3)	20-22.6	4

The results reveal that the fine grained portion of the deposit is primarily of low plasticity and hence can be classified as clayey silt. Natural moisture contents are generally less than the plastic limit of the soil.

Atterberg Limit tests were also carried out to examine the behaviour and plasticity of the interbedded glaciolacustrine deposits. The results are illustrated on Figure 3 in the Appendix and are summarized in Table 1a below.

Table 1a - Clayey Silt to Silty Clay
(Glaciolacustrine)

	Range	# of Tests
Natural Moisture Content (w%)	15-20	7
Liquid Limit (w_L%)	23-41	7
Plasticity Index (Ip%)	9-20	7

The results reveal that the interbedded glaciolacustrine layers has a low to intermediate plasticity and hence can be categorized as a clayey silt to silty clay.

Standard Penetration tests carried out in this deposit revealed 'N' values ranging from 7 blows/0.3 m to 121 blows/0.15 m. Based on these 'N' values, the material can be described as having a consistency ranging from firm to hard. In general, the upper 6 metres or so is of hard consistency and the deposit below this depth is very stiff to hard. The presence of the interbedded glaciolacustrine clayey silt explains the lower consistency at the lower depths of the deposit.

Heterogeneous mixture of Gravel, Sand, Silt and Clay (Glacial Till) - Non-Cohesive

Underlying the cohesive heterogeneous mixture of clayey silt, sand and gravel, a second till deposit consisting of a heterogeneous mixture of gravel, sand, silt and clay exists. This deposit is cohesionless in nature and was found to exist at depths ranging from 10.1 m to 16.2 m. The extent of this deposit was not determined during the investigation and the maximum thickness explored was 4 m. Boulders and cobbles, although not encountered during the invesigation, are characteristic components of these types of deposits and hence can exist in the deposit.

Grain size distribution curves as determined by mechanical sieve and hydrometer analysis for this deposit are shown in Figure 4 in the Appendix.

Results of the Standard Penetration Test performed within this deposit reveal 'N' values ranging from 92 blows/0.3 m to 120 blows/0.15 m. Hence, the deposit can be categorized as having a very dense state of denseness.

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water level in the open boreholes. Water levels measured at the time of investigation revealed levels ranging from El. 170 m to 166.2 m corresponding to depths of approximately 4 m to 7.9 m below the ground surface. Observations of the groundwater levels are recorded on the Record of Borehole sheets as well as on Drawing 3688705(R)-A in the appendix.

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 three span post-tensioned concrete deck structure that will carry the Hwy.27N,S-Hwy.407W ramp over the Hwy.407E-Hwy.427N ramp. The three span structure has proposed spans of 46, 68 and 54 m and has a width of approximately 10.5 m. The overpass structure has been planned to facilitate two lane traffic. The roadway for the proposed Hwy.407E-Hwy.427N ramp under the structure is 16 m in width and is to facilitate three lanes of traffic.

A minimum vertical clearance of 4.782 m between the Hwy.27N,S-Hwy.407W structure and the Hwy.407E-Hwy.427N has been proposed. The proposed profile grade of the Hwy.27N,S-Hwy.407W ramp is at approximate El. 179 and 181 m at the west and east approach respectively. The existing ground surface at the site is generally between El. 173.6 m to 174.5 m. Consequently, approach fills in the order of magnitude of 5 m to 7 m will be required at the site. In addition, a retaining wall has been proposed at the south end of the east approach.

The Hwy.407E-Hwy.427N ramp is proposed at a profile grade of approximately 172.5 m to 173 m at the overpass structure location. Consequently, shallow elevation cuts up to 2 m will be required for the construction of this ramp.

A plan and profiles illustrating the proposed ramp structure and roadways are included on Dwg. 3688705(R)-A in the Appendix.

To facilitate the design and the construction of the proposed structure foundations and related earthworks at the aforementioned site, the following foundation and geotechnical recommendations are provided in the scope of this report.

1) Structure Foundations
2) Reinforced Earth Retaining Walls
3) Approach Fill/Cuts
4) Construction Considerations

1) STRUCTURE FOUNDATIONS

In view of the competent nature of the surficial deposit consisting of a heterogeneous mixture of clayey silt, sand and gravel, structure foundations can be founded on conventional spread footings. All structure foundations can be founded on spread footings within the surficial native deposit with major consideration given to perched abutments founded on a well compacted Granular 'A' pad.

Discussion and recommendations to facilitate the design of the shallow foundations are given below. The alternative or combination of alternatives that proves to be most economical and technically feasible shall be selected.

'Perched' Abutments/Retaining Walls on Granular 'A' Pad

The abutment structure foundations and any associated retaining walls can be designed as open-type structures by supporting the foundations on spread footings founded on a well compacted Granuar 'A' pad. The granular pad shall be constructed according to the geometry shown in Figure 5 in the Appendix. As illustrated, the Granluar 'A' pad shall be constructed to a minimum 1 m edge distance from the top of the footing to the crest of the pad and with 1H:1V slopes. The granular pad shall have a minimum thickness of 1.5 m and the footings must have a minimum 1.2 m earth cover. For purposes of the O.H.B.D.C. and for the conditions described above, the following bearing capacities are given.

Table 2 - Perched Abutment on Granular Pad

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

Settlement of the foundation granular pad 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, provided the granular material is

not loosened by construction or related activities. The settlement prediction includes any settlement anticipated within the Granular 'A' pad itself. This settlement is contingent on proper fill placement and compaction.

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 measurments 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.

Reduction for inclination of loading on the shallow foundation shall be carried out in accordance with Section 6.7.3.3.5 of the O.H.B.D.C.

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 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 of Structures" in subsequent section of the report.

Spread Footings on Native Soil

Alternatively, the proposed structure can be designed as a closed-type structure with the abutments and associated retaining walls founded in the surficial native deposit consisting of the heterogeneous mixture of clayey silt, sand and gravel. The pier foundations can also be supported on spread footings in the surficial native deposit. For purposes of the O.H.B.D.C., the following bearing capacities are provided at or below the tabulated founding elevations.

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)
W. Abutment	500	750	173
E.Abutment/Retaining Wall	500	750	172
W. Pier	500	750	172.6
E. Pier	350	525	172.6

The magnitude of settlement as a result of the applied pressures tabulated in Table 3 is expected to be within 25 mm provided that the founding soil is not softened by construction or related activities. Any softened soil at the founding depth shall be removed and replaced with compacted granular material or mass concrete. To preserve the founding soil against construction disturbances and also against the elements of weathering, it is recommended that a working slab comprised of granular material or mass concrete be placed on the soil.

The reduction for inclination of loading on the shallow foundation shall be carried out in accordance with Section 6-7.3.3.5 of the O.H.B.D.C.

The computation of the sliding resistance of the foundation soil shall be computed in accordance with Section 6-7.3.3.2 of the O.H.B.D.C. An unfactored friction angle of 32° can be used between the concrete footing and the native soil. 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 aforementioned unfactored friction angle of 32° and a unit weight of 21 kN/m^3.

2) REINFORCED EARTH RETAINING WALLS

Reinforced earth retaining walls are considered a technically feasible alternative at the site. Should this method be chosen, a non-standard special provision shall be included in the contract documents that addresses the construction of these walls. The reinforced earth retaining walls can be founded on the native soil or compacted Granular 'A' pads as discussed previously in this report.

3) APPROACH FILLS/CUTS

Approach fills in the order of magnitude of 5 to 7 m will be required for the approaches to the 27N,S-407W structure and excavation cuts up to 2 m will be required for the 407E-427N ramp roadway. Discussion pertaining to the design and construction considerations for the fill/cut scenarios is given below.

APPROACH FILLS - 27N,S-407W Ramp

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 direction. To preserve the internal stability of the embankment fills, an effective erosion control protection scheme, such as sodding, should be provided on the exposed slopes.

Settlements in the order of magnitude of 50 mm 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.

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 of 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 4 below.

Table 4 - Backfill Properties

	Granular 'A'	Granular 'B'
Angle of Internal Friction (ϕ) (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.

Embankment Construction

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

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.

4) CONSTRUCTION CONSIDERATIONS

Foundation Excavation

In view of the cohesive nature of the surficial heterogeneous mixture of clayey silt, sand and gravel, no dewatering problems are anticipated for the construction of spread footings. Any localized groundwater seepage that may result from random interbedded submerged cohesionless layers and any surface runoff that occurs can be easily discharged using conventional sump pumping techniques.

Temporary slopes to facilitate the excavation for the spread footings shall be no steeper than 1.5H:1V.

MISCELLANEOUS

The initial fieldwork conducted during the period from 89 12 07 to 90 12 14 was carried out under the supervision of P. Marks, Foundation Engineer. The subsequent fieldwork conducted on 90 08 01 was conducted under the supervision

of M. Iampietro, Engineering Student. The initial fieldwork was carried out utilizing equipment owned and operated by Marathon Drilling Co. Ltd. The subsequent fieldwork was carried out utilizing equipment owned and operated by Master Soils Investigations Ltd.

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

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
$\mathcal{E}$	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

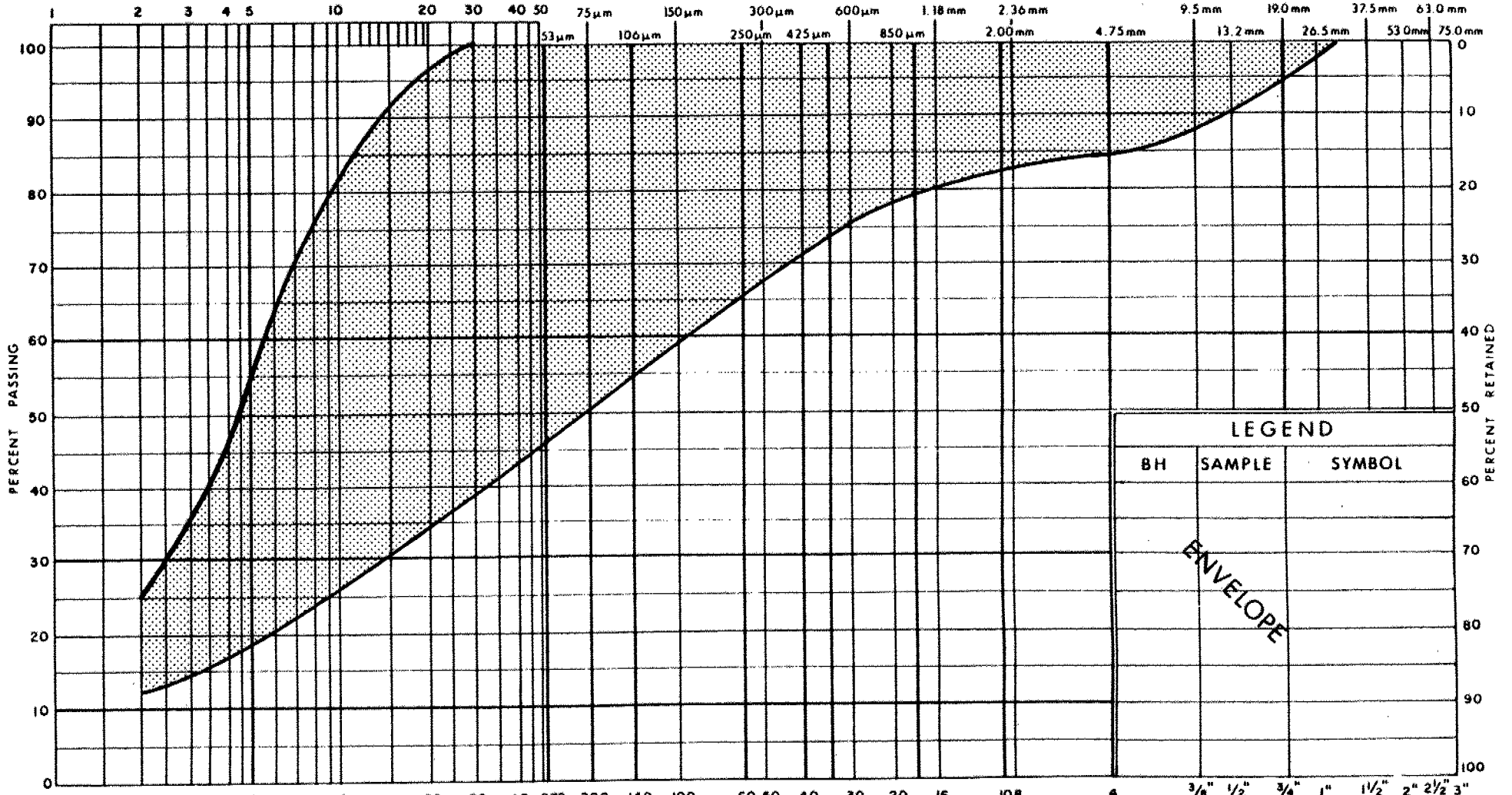
ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL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

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



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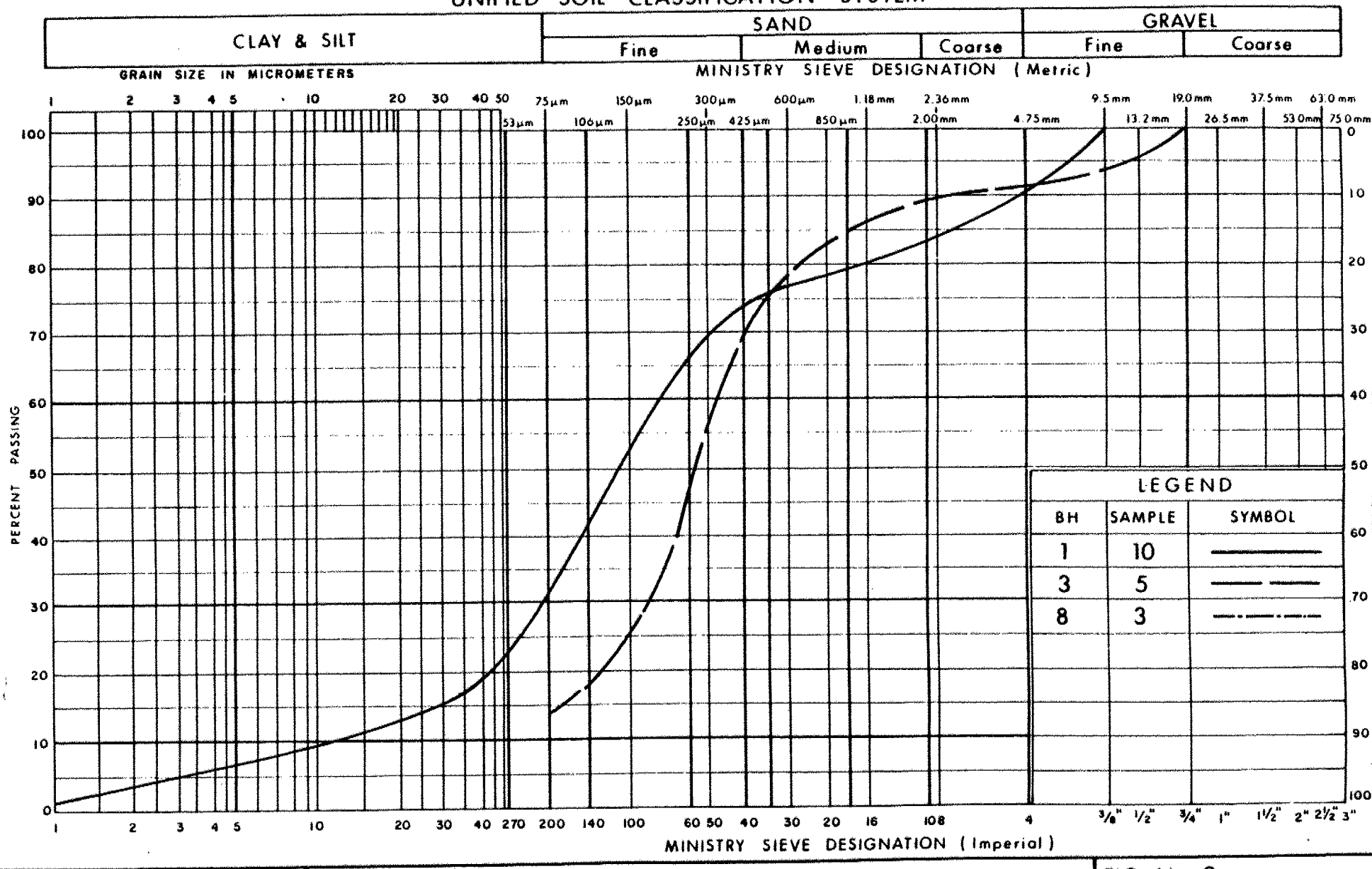
GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF CLAYEY SILT, SAND & GRAVEL (GLACIAL TILL)

FIG No 1
W P 368-87-05 R

UNIFIED SOIL CLASSIFICATION SYSTEM



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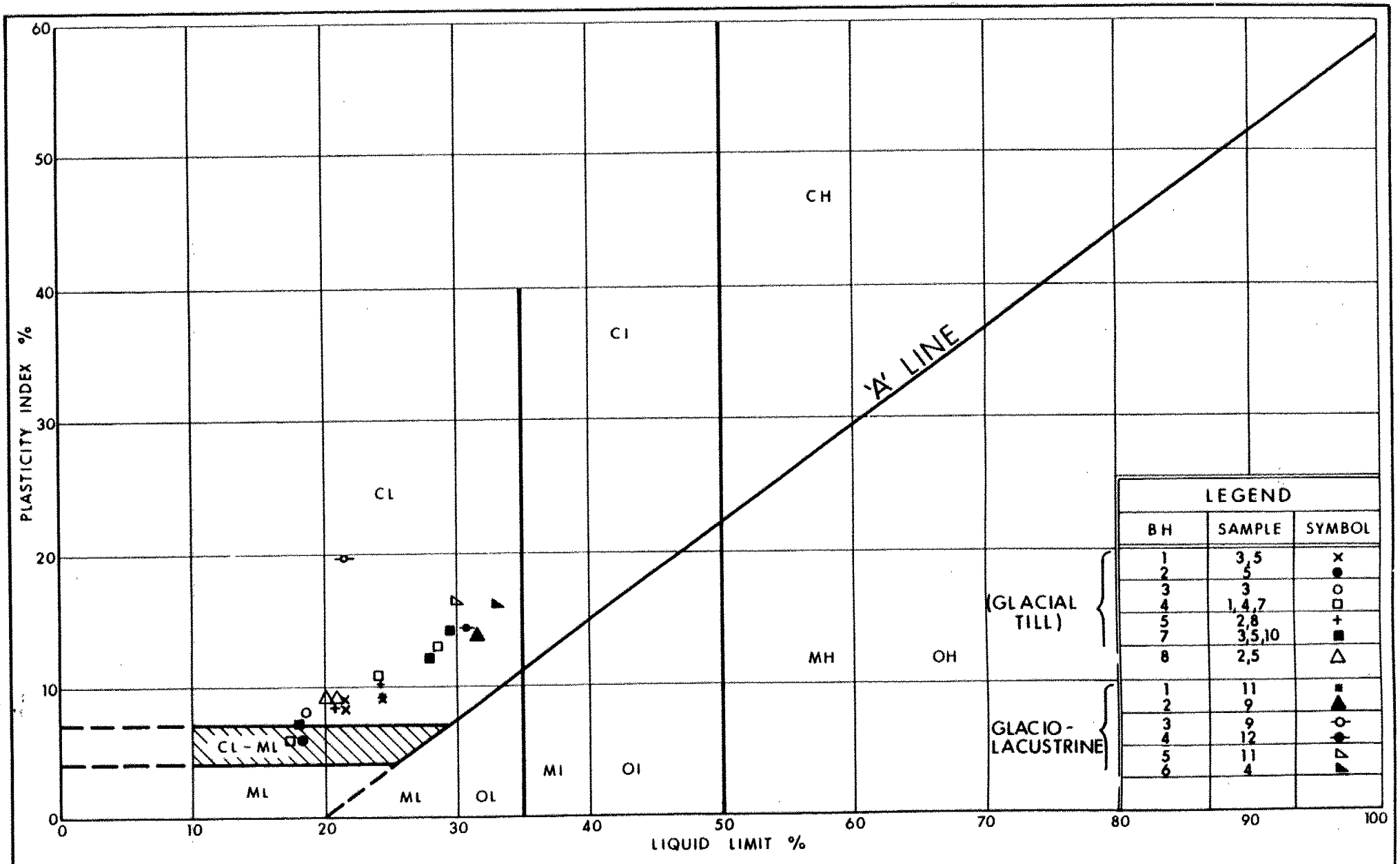
GRAIN SIZE DISTRIBUTION
OCCASIONAL SILTY SAND TO SANDY SILT LAYERS

FIG No 2
W P 368-87-05R

Oct 75, FF-5-21



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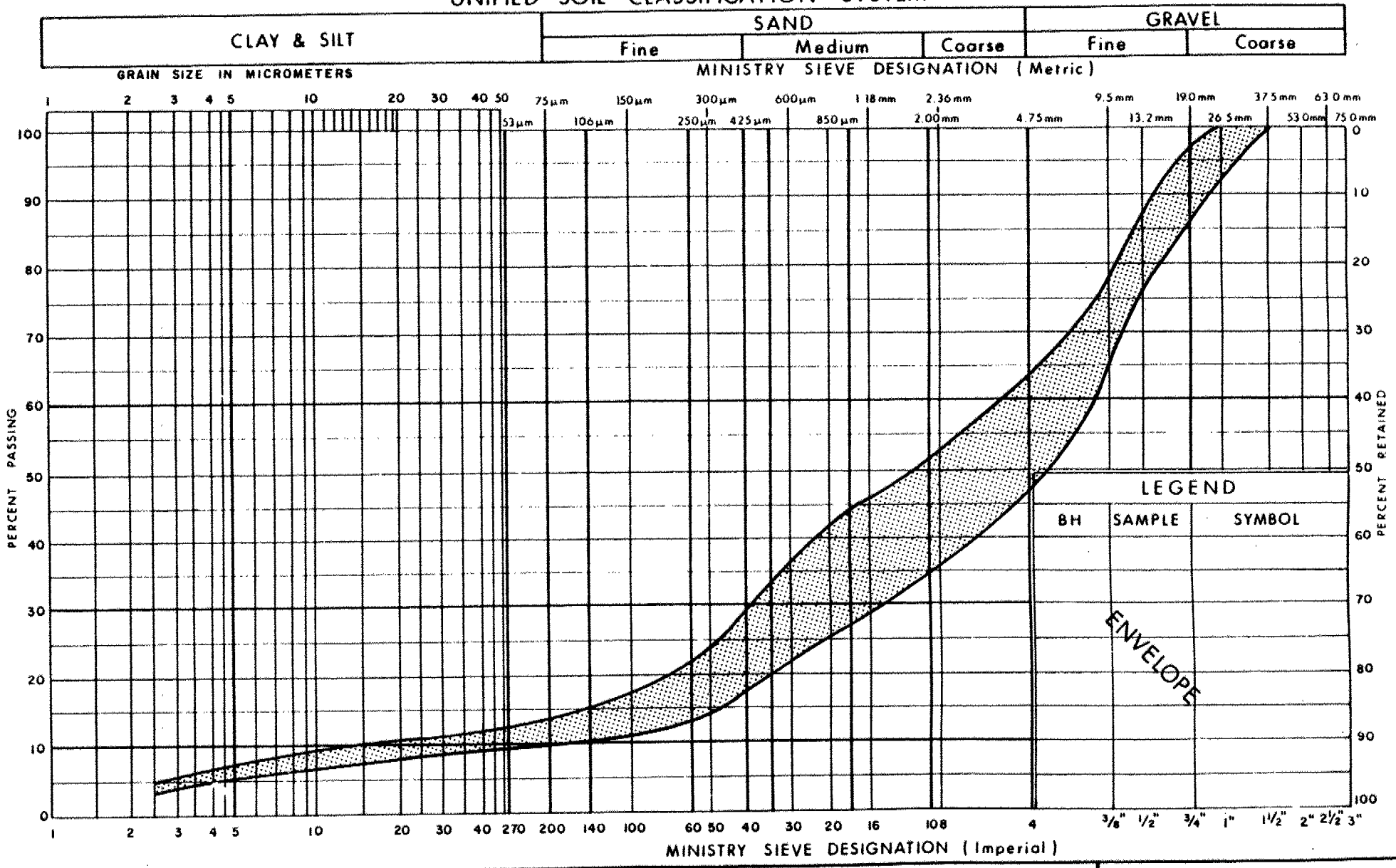
PLASTICITY CHART
HETEROGENEOUS MIXTURE OF CLAYEY SILT, SAND & GRAVEL (GLACIAL TILL)

FIG No 3
W P 368-87-05 R

UNIFIED SOIL CLASSIFICATION SYSTEM



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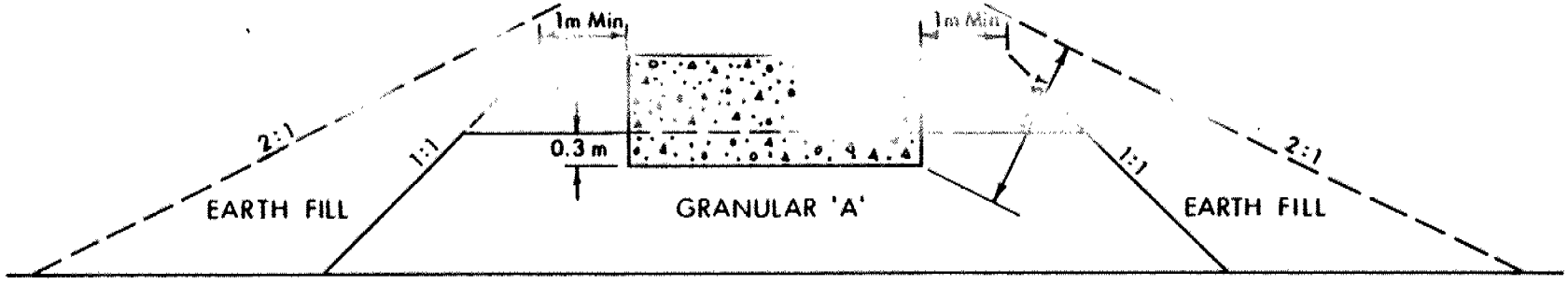
GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF GRAVEL, SAND, SILT & CLAY
(GLACIAL TILL) NON-COHESIVE

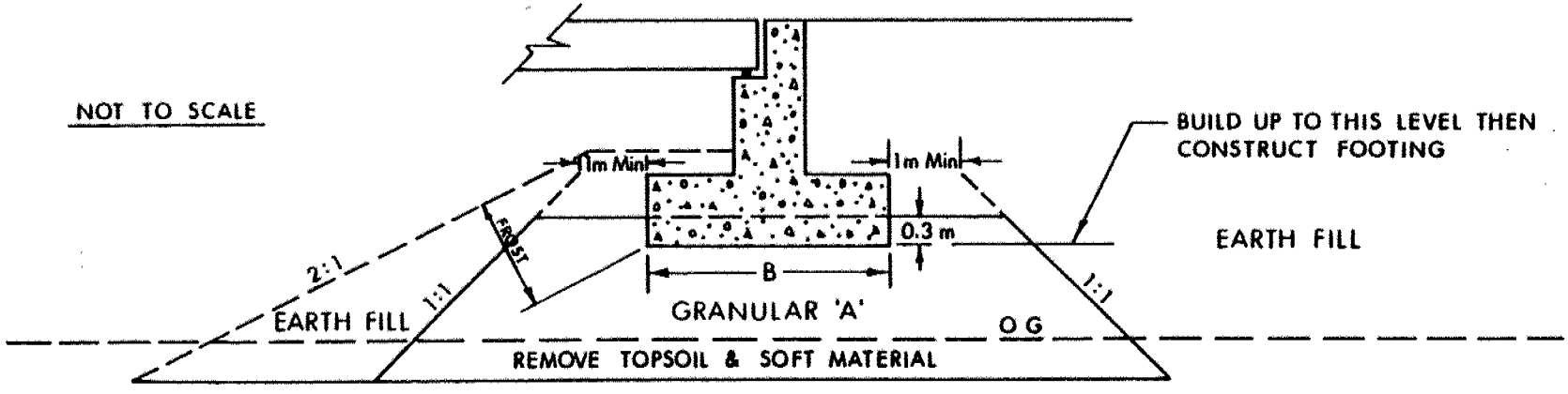
FIG No 4

W P 368-87-05 R



X SECTION

NOT TO SCALE



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.

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ABUTMENT ON COMPACTED FILL SHOWING GRANULAR 'A' CORE

FIG No 5

W P 368-87-05R

RECORD OF BOREHOLE No 1 — 1 OF 2 — METRIC

W.P. 368-87-05R — LOCATION Co-ords: N 4 846 166.6 ; E 294 866 — ORIGINATED BY PM

DIST 6 — HWY 407 — BOREHOLE TYPE HS Auger — COMPILED BY PM

DATUM Geodetic — DATE 89 12 08 to 89 12 11 — 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 (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, x 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
174.4	Ground Surface										
0.0	Topsoil										
			1	SS	32						
			2	SS	41						
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Very Stiff to Hard		3	SS	35						22 28 (50)
			4	SS	51			+20/-20cm			
	Occasional Layers of Gravelly Silty Sand		5	SS	68						10 31 (59)
	Brown / Grey		6	SS	82						
			7	SS	27						
			8	SS	25						
			9	SS	36						
			10	SS	33						9 75 (16)
	Clayey Silt (Lacustrine)		11	SS	30	▼					0 4 (96)
			12	SS	28						
			13	SS	33						

Continued

+3, x3 : Numbers refer to Sensitivity

20 / 15 / 10 (%) STRAIN AT FAILURE

Continued

RECORD OF BOREHOLE No 1 2 OF 2 METRIC

W.P. 368-87-05R LOCATION Co-ords: N 4 846 166.6 ; E 294 866 ORIGINATED BY PM

DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY PM

DATUM Geodetic DATE 89 12 08 to 89 12 11 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 (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, x 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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
15.2	Continued										
159.2			14	SS	40						
158.2							158				
16.2	Heterogeneous Mixture Gravel, Sand, Silt and (Glacial Till) Very Dense Occasional Boulders		15	SS	120	/27cm					
			16	SS	95		156				
154.2			17	SS	120	/19cm					34 51 11 4
20.2	End of Borehole										

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

$\frac{20}{15}\diamond^5_{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 2 — 1 OF 1 — METRIC

W.P. 388-87-05R — LOCATION Co-ords: N 4 846 178.5 ; E 294 917.2 — ORIGINATED BY PM

DIST 6 — HWY 407 — BOREHOLE TYPE HS Auger — COMPILED BY PM

DATUM Geodetic — DATE 89 12 08 — CHECKED BY TS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, * QUICK TRIAXIAL, + FIELD VANE, x 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
174.1	Ground Surface										
0.0	Topsoil										
	Heterogeneous Mixture Clayey Silt, Sand and (Glacial Till) Stiff to Hard; Occasional Silty Sand Layers		1	SS	17						
			2	SS	37		172				
			3	SS	37						
			4	SS	55						
			5	SS	34		170				0 0 (100)
			6	SS	27						
	Silt (Marine)		7	SS	35						
			8	SS	20	▼	168				
			9	SS	12						0 35 44 21
			10	SS	29		166				
			11	SS	32		164				7 31 (62)
163.0											
11.1	End of Borehole										
162.2											
11.9	End of Cone Test							120/20cm			

+3, x3 : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 3 1 OF 2 METRIC

W.P. 368-87-05R LOCATION Co-ords: N 4 846 193.7 ; E 294 978 ORIGINATED BY PM

DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY PM

DATUM Geodetic DATE 89 12 07 to 89 12 08 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 x 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 7 kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
174.0	Ground Surface										
0.0	Topsoil										
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Firm to Hard		1	SS	8		173				2 17 (81)
			2	SS	7		172				
	Occasional Layers of Silty Sand		3	SS	33						9 30 (61)
			4	SS	45		171	120/20cm			
			5	SS	44		170				10 58 27 4
			6	SS	55		169				1 37 (62)
	Silty Clay (Lacustrine)		7	SS	66						
			8	SS	65		168				
							167				
			9	SS	21		166				2 17 (81)
			10	SS	29		165				
							164				
			11	SS	44		163				
							162				
			12	SS	65						8 31 (61)
160.0							161				
14.0	Heterogeneous Mixture of Gravel, Sand, Silt and Clay (Glacial Till) Very Dense						160				
							159				

Continued

Continued

+³, x³ : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 3 2 OF 2 METRIC

W.P. 368-87-05R LOCATION Co-ords: N 4 846 193.7 ; E 294 978 ORIGINATED BY PM

DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY PM

DATUM Geodetic DATE 89 12 07 to 89 12 08 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						
158.8	Continued										
15.2			13	SS	105	/10cm	158				46 44 7 3
157.3			14	SS	100	/5cm					
16.7	End of Borehole										

+³, ×³: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4 1 OF 2 METRIC

W.P. 368-87-05R LOCATION Co-ords: N 4 846 138.0 ; E 294 826.5 ORIGINATED BY PM

DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY PM

DATUM Geodetic DATE 89 12 11 to 89 12 13 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 (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 7 kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
174.4											
0.0	Topsoil						174				
			1	SS	22						4 26 (70)
			2	SS	29		173				
			3	SS	47		172				
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Very Stiff to Hard Occasional Layers of Silty		4	SS	100		171	120/15cm	o		10 40 (50)
			5	SS	63		170				
			6	SS	35						
			7	SS	32		169				
	Brown / Grey		8	SS	14		168				
			9	SS	59	▼	167				
	Silt (trine)		10	SS	34		166				
			11	SS	23		165				
			12	SS	20		164				0 4 (96)
			13	SS	24		163				
							162				
							161				
							160				

Continued

Continued

+3, ×5 : Numbers refer to Sensitivity

20 15 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 4 2 OF 2 METRIC

W.P. 388-87-05R LOCATION Co-ords: N 4 846 139.0 ; E 294 826.5 ORIGINATED BY PM

DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY PM

DATUM Geodetic DATE 89 12 11 to 89 12 13 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						
159.2	Continued										
15.2			14	SS	12		159				
							158				
			15	SS	75						
							157				
			16	SS	75		156				52 37 8 3
154.9							155				
19.3	*										
154.2			17	SS	120	/25cm					
20.2	End of Borehole										

* Het. Mixt. of Gravel, Sand, Silt and Clay
(Glacial Till)
Very Dense

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

$\frac{20}{15}\diamond^5_{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 5 — 1 OF 2 — METRIC

W.P. 368-87-05R — LOCATION Co-ords: N 4 846 152.0 ; E 294 879.5 — ORIGINATED BY PM

DIST 6 — HWY 407 — BOREHOLE TYPE HS Auger — COMPILED BY PM

DATUM Geodetic — DATE 89 12 13 — CHECKED BY TS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
174.1	Ground Surface						
0.0	Topsoil						
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Very Stiff to Hard Occasional Silty Sand Layers Occasional Boulders/Cobbles		1	SS	81		
			2	SS	55		
			3	SS	44		
			4	SS	47		
			5	SS	47		
	Brown						
	Grey		6	SS	77		
			7	SS	48		
			8	SS	18		
			9	SS	27	▼	
	Clayey Silt (Lacustrine)		10	SS	23		
			11	SS	33		
			12	SS	60 /9cm		
160.9							
13.2	Heterogeneous Mixture of Gravel, Sand, Silt and Clay (Glacial Till) Very Dense		13	SS	75 /15cm		

DYNAMIC CONE PENETRATION RESISTANCE PLOT — 20 40 60 80 100

SHEAR STRENGTH kPa — ○ UNCONFINED — ● QUICK TRIAXIAL — + FIELD VANE — × 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

ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
173	
172	18 31 (51)
171	
170	
169	
168	2 23 (75)
167	
166	
165	
164	
163	6 23 (71)
162	
161	
160	
159	

120/23cm

Continued

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

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

Continued

RECORD OF BOREHOLE No 5 2 OF 2 METRIC

W.P. 368-87-05R LOCATION Co-ords: N 4 846 152.0 ; E 294 879.5 ORIGINATED BY PM

DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY PM

DATUM Geodetic DATE 89 12 13 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						
	Continued										
158.8			14	SS	50 /5cm						
15.5	End of Borehole										

+³, ×³ : Numbers refer to Sensitivity

20
15 ◇ 3 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 6 1 OF 1 METRIC

W.P. 368-87-05R LOCATION Co-ords: N 4 846 166.5 ; E 294 938 ORIGINATED BY PM

DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY PM

DATUM Geodetic DATE 89 12 13 to 89 12 14 CHECKED BY TS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	'N' VALUES	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 7 kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
173.6	Ground Surface										
0.0	Sandy Silt		1	SS	26		173				0 1 88 11
			2	SS	30		172				
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Very Stiff to Hard		3	SS	40		171				
			4	SS	46		170				0 0 (100)
	Clayey Silt (Lacustrine) Brown		5	SS	37						
	Grey		6	SS	27		169				
			7	SS	17		168				
			8	SS	19	▼					0 0 (100)
			9	SS	46		167				
			10	SS	35		166				
162.3			11	SS	60		165				
11.3	Heterogeneous Mixture of Gravel, Sand, Silt and Clay (Glacial Till) Very Dense		12	SS	120	/15cm	164				
158.8			13	SS	37	/15cm	163				
							162				
							161				
13.7	End of Borehole						160				

+³, ×³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 7 — 1 OF 1 — METRIC

W.P. 368-87-05R — LOCATION Co-ords: N 4 846 212 ; E 294 977 — ORIGINATED BY MI

DIST 6 — HWY 407 — BOREHOLE TYPE SS Auger — COMPILED BY MI

DATUM Geodetic — DATE 90 08 01 — 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, • QUICK TRIAXIAL, + FIELD VANE, × 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						
174.0	Ground Surface										
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		1	SS	46		173				
			2	SS	65		172				
			3	SS	66					22.6	6 33 42 19
			4	SS	89		171				
			5	SS	69	▼	170				
			6	SS	31		169				0 0 75 25
			7	SS	41		168				
			8	SS	27		167				
	Clayey Silt (Lacustrine)		9	SS	61		166				
			10	SS	121	/25cm	165				
			11	SS	121	/25cm	164				
160.2			12	SS	121	/13cm	163			21.6	5 26 44 25
							162				
							161				
13.8	End of Borehole										

+³, ×³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 8 1 OF 1 METRIC

W.P. 368-87-05R LOCATION Co-ords: N 4 846 125 ; E 294 832 ORIGINATED BY MI

DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY MI

DATUM Geodetic DATE 90 08 01 CHECKED BY TS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × 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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
174.5 / 0.0	Ground Surface					DRY	174				
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Brown, Hard		1	SS	33						
			2	SS	120		173		○	20.0	14 29 39 18
	Sandy		3	SS	120	/25cm	172				0 30 64 6
			4	SS	120	/28cm	171				
			5	SS	121	/28cm	170		○	23.0	10 33 43 14

of Borehole

+³, ×⁵ : Numbers refer to Sensitivity

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

MINISTRY OF TRANSPORTATION, ONTARIO PH-0-20/ 88 10

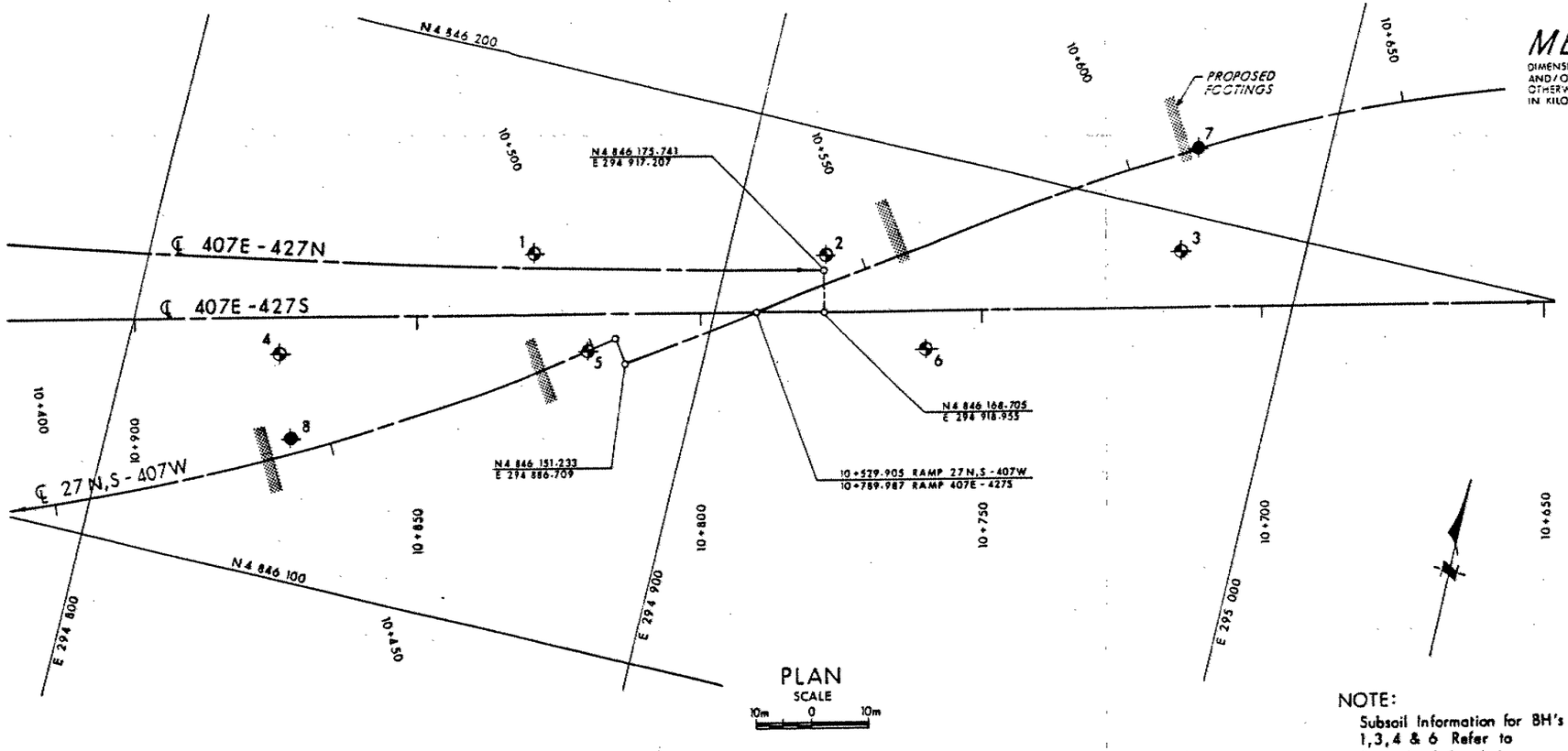
CONT No
WP No 368-87-05R

27 N,S-407W RAMP OVER 407E-427N,S RAMP
BORE HOLE LOCATIONS & SOIL STRATA

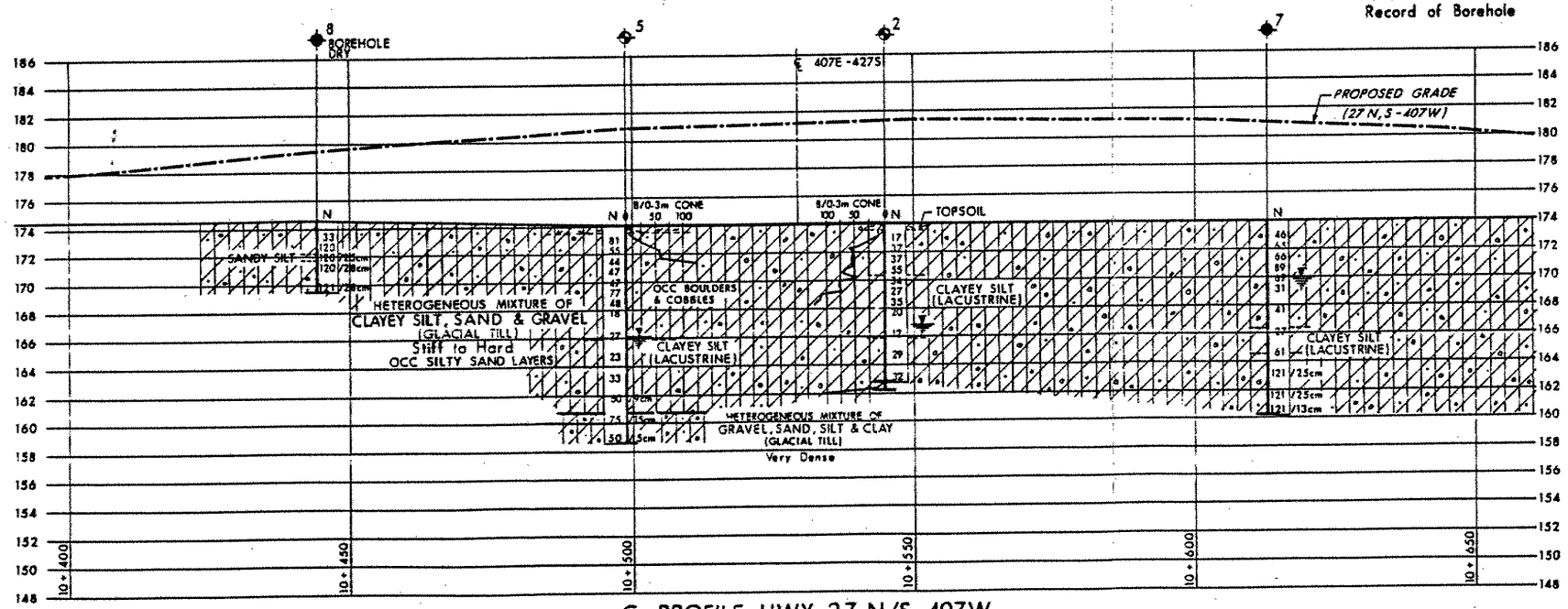
SHEET

METRIC

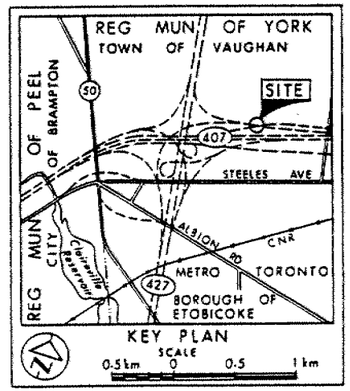
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.



NOTE:
Subsoil Information for BH's 1,3,4 & 6 Refer to Record of Borehole



℄ PROFILE HWY 27 N/S-407W
SCALE
10m 0 10m Hor
4m 0 4m Vert



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 89 12 and 90 08

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	174.4	4 846 166.6	294 866.0
2	174.1	4 846 178.5	294 917.2
3	174.0	4 846 193.7	294 978.0
4	174.4	4 846 139.0	294 826.5
5	174.1	4 846 152.0	294 879.5
6	173.6	4 846 166.5	294 938.0
7	174.0	4 846 212.0	294 977.0
8	174.5	4 846 125.0	294 832.0

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 30M13-101

HWY No 402				DIST 6
SUBM'D TS	CHECKED	DATE 90 11 16		SITE 37-132.5
DRAWN DT	CHECKED	APPROVED		DWG 3688705R-A

REF No E-73-407-21, 89 09

July 8, 1994

FINAL DRAWING REVIEW FOR WP 368-87-05

Ramp Structure Highway 27N, S to Highway 407W
(over Ramp Highway 407E to Highway 427N)

Upon re-review of the final documents submitted for this structure in February 1991, it is apparent that the bearing resistances recommended for the East and West Pier footings are too high for the subsurface conditions encountered at the proposed base of footing elevations.

The foundation design is unacceptable unless actual applied loads are 50% less than the bearing resistances recommended at Serviceability Limit States. An alternate foundation design should be used.

Betty Bennett, P.Eng.
Sr. Fdn. Eng. (Acting)
MTO, Foundation Design Section

memorandum

Fax. No: 235-5240
Tel. No: 235-3731

Ontario

To: V. Boehnke
Head, Structural Section
Central Region

Date: 1990 07 18

Attn: W. Young
Senior Structural Engineer

From: Foundation Design Section
Room 315, Central Building

Subject: Preliminary Foundation Report
Hwy. 27 N, S-407 W Ramp over 407 E-427 N, S Ramp
W.P. 368-87-05, Site 37-1325
District 6, Toronto

In response to your memoranda dated June 12, 1990 and June 19, 1990, this office acknowledges that the revised post tensioned concrete structure is a more economical design than the original proposed rigid frame structure at the aforementioned site for the reasons discussed in your letters. Consequently, recommendations to facilitate the structure foundation design and related earthworks for the revised structure are hereby provided. It is important to emphasize that the recommendations provided at the proposed abutments and approaches are subject to confirmation that will be derived from additional fieldwork proposed at the site. This fieldwork will be executed as soon as possible so that compliance to pertinent schedules are met.

Structure Foundations

1) Abutments

It is recommended that major consideration be given to "perching" the abutment foundations on a compacted Granular 'A' pad. At the proposed east abutment, the native soil shall be subexcavated to elevation 171.3 m (approximately 2.7 m in depth) and the granular material placed from this elevation. Any loosened/softened material at the surface of the proposed west abutment shall also be removed. The granular material shall be placed and compacted in accordance with OPSS 501 series and as illustrated on conventional design drawings (see Figure 4-W.P. 368-87-05). The granular pad shall be a minimum 2 m thickness.

For the conditions specified above, the following bearing capacities for purposes of the O.H.B.D.C. are provided.

Table 1 - Abutments on Granular 'A'

Structure	Bearing Capacity at S.L.S. Type II (kPa) (25 mm)*	Factored Capacity at U.L.S. (kPa)
W. Abutment	350	900
E. Abutment	350	900

.../2

*The settlements produced by the tabulated bearing pressure at S.L.S. will be the result of the recompression of the native soil and hence should take place during and immediately after construction. The magnitude of this settlement is expected to be within 25 mm differential.

The sliding resistance of the Foundation can be computed using an unfactored friction angle of 35° between the concrete footing and the Granular 'A' material.

Alternatively, a closed-type abutment design can be employed by supporting the abutment structure foundation on conventional spread footings within the native surficial deposit consisting of a clayey silt with/trace sand and a trace of gravel. The recommended founding elevations and bearing capacities at the respective abutment locations are summarized in Table 2 below.

Table 1 - Abutments on Native Soil

Structure	Founding El. (m)	Bearing Capacity at S.L.S. Type II (kPa)		Factored Capacity at U.L.S. (kPa)
		(25 mm)*	(37.5 mm)*	
W. Abutment	171.7	350	400	500
E. Abutment	171.3	350	450	550

*The values tabulated in Table 2 above reveal two alternate bearing capacities at the serviceability limit state. The values of 25 mm and 37.5 mm represent the anticipated settlements for the corresponding capacities provided. These settlements will be immediate in nature and hence should occur during or immediately following construction.

The sliding resistance of the foundation can be computed using an unfactored friction angle of 30° between the concrete footing and the native soil.

2) Piers

The piers can be founded on conventional shallow foundations as summarized in Table 3 below.

Table 3 - Piers on Spread Footings

Structure	Founding El. (m)	Bearing Capacity at S.L.S. Type II (kPa)	Factored Capacity at U.L.S. (kPa)
W. Abutment	172.6	500	750
E. Abutment	171.8	350	525

The settlements induced by the tabulated applied pressures are anticipated to be within 25 mm differential. These settlements are expected to be the result of the recompression of the native soil and hence should be realized during and immediately following construction.

.../3

At the east pier, an induced pressure of 450 kPa at the serviceability limit state will produce an anticipated settlement of 37.5 m.

Foundation Construction

No major dewatering difficulty is anticipated in the shallow foundation footing construction at the site because of the relative impervious nature of the foundation material. Conventional sump pumping techniques will suffice in discharging any localized seepage that may result from random interbedded cohesionless layers and any surface runoff.

Approach Embankments

Approach embankments in the order of magnitude of 4.5 m and 7 m have been proposed in advance of the structure at the west and east approach respectively. There are no deep seated nor internal slope instabilities anticipated for fills constructed at a slope of 2H:1V as identified on the drawing.

Settlements in the order of magnitude of 50 mm attributable to the elastic recompression of the native subsoil and settlement within the fills under its own weight are anticipated. It is predicted that the majority of the settlements will be realized during or immediately following the construction of the embankment.

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 Design Section

for

M. Devata, P.Eng.
Chief Foundation Engineer

TS/ms

c.c.: K. Bassi - Head, Structural Office
Attn: G. Al Bazi

memorandum

Ontario

To: V. Boehnke
Head, Structural Section
Central Region

Date: 1990 05 31

Attn: W.F. Young
Sr. Structural Engineer

From: Foundation Design Section
Room 315, Central Bldg.

Re: General Arrangement Drawing Review
Ramp 27N,S - 407W over
Ramp 407E - 427N,S
W.P. 368-87-05
District 6, Toronto

The General Arrangement drawing for the aforementioned structure has been reviewed by this office and the following comments are provided.

Basketweave Structure Foundations

The General Arrangement drawing reveals that deep foundation steel H-piles have been selected. As initially stated in the original foundation report and hereby reiterated, it is our opinion that shallow foundations are certainly more applicable and therefore feasible at the aforementioned site. In view of this, an explanation is certainly warranted that justifies the selection of the deep foundation alternative.

Reinforced Earth Retaining Walls

A non-standard special provision shall be prepared to address the construction of the reinforced earth retaining walls. The special provision shall include specifications on the foundation preparation, levelling pad construction, reinforcing strip installation, and backfill material and placement procedures.

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

T. Sangiuliano, P. Eng.
Foundation Engineer

for

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

PP/TS/jb

memorandum

Ontario

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

Date: 1990 01 18

Attention: W.F. Young, Sr. Structural Engineer

From: Foundation Design Section
Room 315, Central Building

RE: W.P. 368-87-04, Structure Site 37-1324
W.P. 368-87-05, Structure Site 37-1325
District 6, Toronto

This memo accompanies two detailed memoranda giving preliminary recommendations on design and construction of foundations for the above structures. Two foundation options are given in the attached memoranda; namely, spread footings and steel H piles. Giving consideration to the presence of competent founding stratum within shallow depth, we would strongly favour spread footings for these structures. As mentioned in the attached memoranda, some localized excavation of existing material and replacement with competent granular fill might be required.

We would be pleased to elaborate on the comments given above or on items covered in the attached memoranda. Please contact this office if you need further input on this project.

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

BI/mmj

c.c. - K.G. Bassi
G. Al-Bazi

memorandum

Ontario

To: V. Boehnke
Head, Structural Section
Central Region

Date: 1990 01 11

Attn: W. F. Young, Sr. Structural Engineer

From: Foundation Design Section
Room 315, Central Building

RE: Highway 27N, S-407W Ramp over 407E - 427N, S. Ramp
W.P. 368-87-05, Structure Site 37-1325
District 6, Toronto

This memorandum gives preliminary recommendations regarding the design and construction of foundations for the above structure. Also, included in this memo are preliminary comments regarding the design of approach embankments. This information is provided to you in advance of our final report, to facilitate your design to proceed. We will submit our final report on this project in the near future.

Subsurface Conditions

The elevation of the ground level at the site ranged from 173.5 to 174.4 m. The subsurface conditions at the site consist mainly of 8.5 to 16.2 m of clayey silt, some sand, trace of gravel with some layers of silty sand and silt found occasionally in the deposit. Below this material at elevation 165.1/158.2 m a till consisting of a heterogenous mixture of gravel, sand, silt and clay was encountered. This mixture was found to be cohesive for the upper 1.5+ to 4.6 m+, below which the percentage of clay diminishes.

Measurements of the groundwater level obtained at the time of the investigation revealed levels as high as elevation 170.0 corresponding to approximately 4 m below the ground surface. It should be noted that groundwater levels are subject to seasonal fluctuations and may therefore vary from those given above.

Proposed Structure

It is proposed to construct single span rigid frames parallel to the lower ramp with retaining walls at the acute corners. The proposed clear span is about 16 to 17 m. A grade raise of approximately 8 m is needed to reach the proposed pavement grade at elevation 181.3 m.

Structure Foundations

The proposed structure may be founded on spread footings in the upper clayey silt deposit, or on steel H-piles driven into the heterogenous till mixture.

.../2

1) Spread Footings

The proposed structure may be supported on spread footings at or below elevation 171.7 m. For the purposes of the O.H.B.D.C., the following design values are recommended.

Factored Bearing Capacity at U.L.S.	450 kPa
Bearing Capacity at S.L.S. Type II	300 kPa

For footings located at higher elevations, a reduced bearing capacity can be recommended by this office.

The underside of all footings should be provided with a minimum of 1.2 m earth cover for frost protection.

It is anticipated that settlements induced within the proposed footing should not exceed 25 mm.

2) Steel H-piles

The proposed structure may be founded on steel H-piles driven to end bearing in the heterogenous till mixture. The estimated pile tip elevation ranges from 157 to 162 m. All steel H-piles should be reinforced with standard driving shoes.

For the purposes of the O.H.B.D.C, the following design parameters are suggested for H.P. 310 X 110 steel "H" piles:

Factored Capacity at U.L.S.	1600 kN
Bearing Capacity at S.L.S. Type II	1150 kN

Pile driving in the field should be controlled by employing the Hiley Dynamic Pile Driving Formula.

Approach Embankments

Due to the competent nature of the natural soil, no deep-seated failures are anticipated through the foundation soils, for grade raises of 8 m. Topsoil and surficial material should be removed prior to placing any fill. The fill should consist of well compacted acceptable material. Embankments should have side and forward slopes no steeper than 2 horizontal to 1 vertical designed and constructed in accordance with the appropriate Ministry Standards. Care should be taken to ensure that no bouldery fill is placed within the approaches at locations through which piles have to be driven, and it is recommended that this portion of the fill contain no larger grain sizes than 75 mm.

.../3

Total settlement of the fill and the foundation soil should be in the order of 40 mm. Most of this will be elastic compression and will have occurred immediately after completion of construction.

Construction Concerns

No major construction problems are anticipated.

Pamela Marks, P. Eng.
Foundation Engineer

for

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