

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 30M13-51  
30M13-56

DIST. 6 REGION                     

W.P. No. 363-87-01/08

*see also 88-78-25*

CONT. No. ~~68-8~~ 89-62

W. O. No.                     

STR. SITE No. 37-73

HWY. No. 427/407

LOCATION Retaining Wall at Ramp 427N-407E

No of PAGES -                     

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.                     

REMARKS:

# memorandum



To: Mr. G.C.E. Burkhardt  
Head, Structural Office  
Central (5000 Yonge St.) Region

Date: 82 04 20

From: Pavement & Foundation Design Section  
Room 315, Central Bldg.  
Downsview

Re: Foundation Investigation  
Proposed Crossing at Hwy. 407 and Hwy. 27  
Site 37-1121, W.P. 88-78-08  
District #6, Toronto

Geocon Inc. has been retained by the Ministry under Agreement No. 4242-9081-226 to carry out a foundation investigation at the site of a proposed bridge to carry Hwy. 27 over the new Hwy. 407 in the Township of Vaughan, Ontario. The purpose of the investigation was to obtain subsurface information for the design and construction of foundations and the related earth works for the proposed bridge structure. This section reviewed the report for the technical content and format. Our comments are as follows.

The footings for the piers and the abutments must be provided with a minimum frost protection depth of 1.25 m from the underside of the footing. The suggested footing base elevations for the piers and abutments should be as follows:

North Abutment	elev. 171.0 or below
North Pier	elev. 171.0 or below
South Pier	elev. 171.0 or below
South Abutment	elev. 170.5 or below

The bearing capacity at Serviceability Limit states Type II should be limited to 300 kPa, whereas the factored bearing capacity at Ultimate Limit states should be 500 kPa for the pier and abutment footing design at the above-mentioned elevations.

With regard to computation of earth pressure, if the backfill is approximately level and consists of free draining granular material, the following equivalent fluid pressures may be used for design purposes:

	<u>at U.L.S.</u>	<u>at S.L.S. Type II</u>
active state:	8.0 kPa/m	6.5 kPa/m
at-rest condition:	12.0 kPa/m	10.0 kPa/m
passive state:	45.0 kPa/m	60.0 kPa/m

.../2

We believe the data provided in the foundation report, together with our comments, is adequate for your requirements. Should you require further clarification or additional information, please feel free to contact us.

  
M. Devata, P. Eng.  
Senior Foundations Engineer

MD/syc

Att.

cc: R.D. Gunter  
F. Norman  
J. Smrcka (2)  
K. Bassi  
B.J. Giroux  
R. Hore

R. Fitzgibbon (memo only)  
T.J. Kovich (memo only)

Files

REPORT TO  
MINISTRY OF  
TRANSPORTATION AND COMMUNICATIONS  
ONTARIO  
FOUNDATION INVESTIGATION  
PROPOSED CROSSING AT HWY. 407  
AND KINGS HIGHWAY 27, DISTRICT 6, TORONTO  
(WP 88-78-08)

Distribution:

12 copies - The Ministry of Transportation  
and Communications, Ontario,  
Pavement and Foundation Design Section.

2 copies - Geocon Inc.

April 6th, 1982.

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30M13-51

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887808-A

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## 1.0 INTRODUCTION

Geocon Inc. has been retained by the Ministry of Transportation and Communications, Ontario (M.T.C.) to carry out a foundation investigation at the site of a proposed Bridge to carry Highway 27 over the proposed Highway 407 in the Township of Vaughan, Ontario. The work for this project was authorized under M.T.C. Agreement Number 4242-9081-226 of March 23rd, 1982, following submission of our proposal of March 12th, 1982.

The purpose of the investigation was to obtain subsurface information for use in design and construction of foundations for the proposed Bridge structure.

## 2.0 SITE AND GEOLOGY

The site of the proposed Bridge construction is on Highway 27 between Steeles Avenue and Highway 7, where it is planned that Highway 27 will cross over the proposed Highway 407. The project limit is contained within Highway 27 chainage of 10 + 300 to 10 + 450.

The site is generally flat with a fill embankment of approximately 1.2 m supporting the paved surface of Highway 27. Shallow drainage ditches exist on either side of the Highway providing drainage in a southward direction.

Available geological information <sup>(1)</sup>, shows the area is underlain by clayey silt tills namely the Wildfield and Halton. The Woodbridge Railway Cut which is within 4 kilometres of this site shows a soil stratigraphy of the Wildfield Till overlying the Halton Till which in turn overlies a sandy silt till of the Wentworth Till formation.

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(1) Sharpe, D.R.: 1980: "Quaternary Geology of Toronto and Surrounding Area", Ontario Geological Survey Preliminary Map p 2204, Geological Series.

### 3.0 SUMMARIZED SUBSURFACE CONDITIONS

The stratigraphy encountered at the boreholes of this investigation is shown on the individual Records of Boreholes in Appendix II of this report, together with details of sampling and drilling and results of field and laboratory tests. A plan of the site showing borehole locations and stratigraphic sections is presented on the enclosed Drawing 887808-A.

The field boring program comprised six boreholes, three on either side of Highway 27, offset approximately 11 m from the centreline of Highway 27. The boreholes were located on the embankment of Highway 27.

A surficial layer of sand fill was encountered in all boreholes to a depth of approximately 1.2 m. Underlying the sand fill a stratum of silty clay till is present which extends to a depth of approximately 12 m. A sandy silt till was encountered in the two deepest boreholes from a depth of approximately 12 m to the termination of the boreholes at about 15 m.

The consistency of the silty clay till is very stiff to hard, and generally hard. The relative density of the sandy silt till is generally very dense.

The majority of the recovered samples had low moisture contents which were normally less than the Plastic Limit of the material. Groundwater levels were recorded in Boreholes 1, 3 and 4 when the most recent observations were taken on March 30th, 1982. These are shown on the Records of Boreholes and Drawing 887808-A. No groundwater was recorded on March 30th, 1982 in Borehole 6 in which a standpipe was also installed. Considering the relatively short time between installation and observations, it is not certain whether the water levels as shown represent stabilized levels.

### 4.0 DETAILED SUBSURFACE INFORMATION

The individual strata encountered at the boreholes are described in the following sections. Unified Soil Classification

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#### 4.0 DETAILED SUBSURFACE INFORMATION (continued)

symbols have been applied to the soils where applicable.

##### 4.1 Fill

A surficial stratum of fill from Highway 27 embankment was encountered in all the boreholes put down. This stratum extended down to about 1.2 m depth in all the boreholes.

Tests for grain size distribution were performed on selected auger samples of the fill and the results are shown on Figure 1 in Appendix II. The fill material varies in composition from a silty sand to a sandy silt.

##### 4.2 Silty Clay of Low Plasticity, Some Sand, Trace Gravel (Till) (CL)

Underlying the fill, a stratum of silty clay till was encountered in all the boreholes. The sand and gravel sizes are dispersed through a finer matrix of silt and clay, thus, the soil has a typical glacial till texture. Where fully penetrated in Boreholes 1 and 6 the stratum was about 11.0 m thick. The soil has a high content of silt and is slightly cohesive.

The silty clay is brown in colour in the upper level of the stratum and changes to grey for the remainder of the stratum depth. This change from brown to grey occurs at a depth of about 4 m in Boreholes 1, 2, 4, 5 and at a depth of about 5.5 m in Boreholes 3 and 6.

Atterberg Limit tests carried out on four selected samples gave Liquid Limits ranging from 26 to 34 percent, and Plastic Limits ranging from 16 to 18 percent. The Plasticity Indices for these samples ranged from 9 to 16 percent. Results of a number of tests carried out for moisture contents are plotted on individual records of the respective boreholes. Within the upper two metres or so depth of this stratum the moisture contents were close to the Plastic Limit; further down the moisture contents were distinctly less than the Plastic Limit. The results of tests for Atterberg Limits are plotted on the Plasticity Chart of Figure 3 in Appendix II. From the Plasticity Chart the material

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#### 4.0 DETAILED SUBSURFACE INFORMATION (continued)

##### 4.2 Silty Clay of Low Plasticity, Some Sand, Trace Gravel (Till) (CL) (continued)

of this stratum is described as a silty clay of low plasticity.

Four grain size distribution tests were carried out on the silty clay till obtained from the standard split spoon samples and the resultant envelope is shown on Figure 2, Appendix II. The samples as tested contained 0 to 4 percent gravel, 12 to 27 percent sand, 47 to 58 percent silt and 22 to 28 percent clay sized particles. The two samples taken from the upper level of this stratum contained slightly more sand and slightly less silt than the two samples obtained from greater depths in the stratum.

Five unconfined compressive strength tests were performed on disturbed split spoon samples from various elevations within the silty clay till stratum. The undrained shear strengths (taken as one half of the compressive strength), ranged from 180 to 534 kPa with an average of 269 kPa, indicating a very stiff to hard (and generally hard), consistency.

Wet unit weights of the samples tested for unconfined compressive strength tests ranged from 19.9 to 22.1 kN/m<sup>3</sup>.

Standard Penetration Tests carried out within the silty clay till stratum gave "N" values ranging from 27 to 89. These values are compatible with the consistencies indicated by the unconfined compressive strength tests.

##### 4.3 Sandy Silt, Trace Clay and Gravel (Till) (ML)

Underlying the silty clay till a stratum of sandy silt till was encountered in the two deepest Boreholes 1 and 6. The recovered samples consisted mainly of fine sand and silt sized particles which were green-grey in colour. The sandy silt till was penetrated for 3.6 m in Borehole 1, and 3.2 m in Borehole 6.

Two grain size distribution tests were carried out on standard split spoon samples from this sandy silt till stratum

#### 4.0 DETAILED SUBSURFACE INFORMATION (continued)

##### 4.3 Sandy Silt, Trace Clay and Gravel (Till) (ML) (continued)

and are presented on Figure 4 in Appendix II. The samples as tested contained 0 to 4 percent gravel, 17 to 42 percent sand, 65 to 74 percent silt and 3 to 5 percent clay sized particles.

Standard Penetration Tests carried out within the sandy silt till stratum gave "N" values ranging from 45 to 170 inferring a dense to very dense, generally very dense relative density.

##### 4.4 Groundwater Conditions

At the time of the field work all the boreholes were dry to the depths penetrated. Groundwater levels were subsequently recorded in Boreholes 1, 3 and 4 whereas no groundwater was encountered in Borehole 6 when the most recent levels were monitored. The observed water levels are shown on the Records of Boreholes in Appendix II and the enclosed Drawing 887808-A. Considering the relatively short time between installation and observations it is not certain whether the water levels as shown represent stabilized levels.

#### 5.0 DISCUSSION

##### 5.1 General

It is our understanding that the proposed Bridge, which is a Grade Separation Structure for Highways 407 and 27, would consist of a continuous three span reinforced concrete structure with a post tensioned deck. The spans would be of unequal lengths, these being governed by the geometric requirements of the proposed structure. The eastbound and westbound through lanes of Highway 407 would be located within the south and middle spans of the overpass, whereas the deck of the overpass would accommodate Highway 27. It is understood that the two piers of the Grade Separation Structure would each consist of a bent comprised of a number of columns. These piers would therefore probably best

## 5.0 DISCUSSION (continued)

### 5.1 General (continued)

be supported each on a continuous footing carried in intact clay. The abutments and wing walls would be reinforced concrete retaining walls.

It is our understanding that the deck elevation of the proposed structure would be about 177m and that the crown elevation of Highway 407 underneath the Bridge Structure would be about 170m.

### 5.2 Foundations

The soil investigation has indicated the existence of a surficial stratum of fill of limited depth underlain by a stiff to hard stratum of till comprised of silty clay of low plasticity with some sand and gravel traces. This till extends from about elevation 171m down to about elevation 160m.

The elevation of the footings for the piers would be governed by the pavement elevation of 170m of Highway 407 underneath the proposed structure. From the preliminary information available with us we understand that the footings of the abutments would be about two metres higher than those of the piers.

A number of foundation alternatives would be suitable for the pier and abutment footings of the proposed structure. From a purely geotechnical standpoint, the most suitable type would be spread footings within the competent till stratum which extends down to a considerable depth from the excavated ground level. Actual selection of foundation type is, however, beyond the scope of this report, since such a selection has to take into account other factors in addition to those related to geotechnics. The use of a suitably reinforced continuous footing for supporting each pier bent, should limit differential settlements of the superstructure to within tolerable limits.

A maximum allowable bearing value of 300 kilopascals may be used for design of the footings of the abutments and the piers. This is based on the bearing capacity at Serviceability Limit. The Factored bearing capacity at Ultimate Limit State was computed to be 500 kPa for the founding stratum.

## 5.0 DISCUSSION (cont'd)

5.2 Foundations (cont'd)

The founding stratum of till is silty clay of low plasticity. The Plasticity Index of the samples tested ranged between 16 and 18 percent and the Liquid Limit ranged between 26 and 34 percent. The clay fraction in the samples tested was less than 30 percent. In view of the above and the fact that almost all of the samples below elevation 170 tested for moisture content had values less than the Plastic Limit, it is concluded that the long term settlements of footings located within this stratum would be small. It is estimated that the magnitude of the combined elastic and long term settlements, both total and differential, would be less than 25 mm; the bulk of these would occur during the construction period.

The footings for the piers as well as for the abutments must be provided with a minimum frost protection depth of 1.25 m from the adjoining exposed ground surface. This suggests that the base elevations of footings for the piers and abutments should be no higher than about elevations 168m and 170m respectively.

5.3 Excavation for Footings

The present pavement elevation of about 173m of Highway 27 at the site is about 1.2 metres above the adjoining ground level. The depth of excavation for the base of pavement of Highway 407 would be about 3 metres below existing Highway 27 level. The pier footings for the Proposed Structure would be another two metres further down. Temporary excavation slopes of no steeper than 1 Horizontal to 1 Vertical may be provided for excavation for the full width of Highway 407 pavement and shoulders.

The excavation for pier footings below the general excavation level of about 170m down to about elevation 168m, if unsupported, should also be no steeper than 1 Horizontal to 1 Vertical.

Available information on groundwater levels indicate that it is at about elevation 170. However the nature of the silty clay till material (generally hard) indicates relatively low permeability of the stratum. As such no serious seepage problems are anticipated to arise during the construction. Any water flowing into the excavated construction area could be led into suitably located sumps

## 5.0 DISCUSSION (cont'd)

### 5.3 Excavation for Footings (cont'd)

from where it could be pumped out...

On the basis of present evidence, it is anticipated that any inflow of seepage or surface water into footing excavations, could be handled by the procedure of pumping from sumps.

### 5.4 Bases of Footings

It is important to clean the till surface properly down to intact till and protect it from disturbance by construction activities before pouring concrete for footings. It is recommended that a 70 mm thick mud mat of lean concrete be provided for protection at the base of each excavation before pouring the main concrete footings.

### 5.5 Approach Embankments

The approach embankments to the proposed Bridge deck will require fill of the order of 4 metres above the existing ground level and the existing Highway 27 pavement at the location of the proposed abutments. It is recommended that before placement of fill all organics and topsoil be removed. Granular fill of minimum Type B gradation, as specified in the Standards of the Ontario Ministry of Communications and Transportation, compacted in layers to minimum 95 percent Modified Proctor dry density, could be used for the embankments. The long term settlement of the fill relative to the bridge deck is estimated to be about 20 mm, the bulk of which should occur in a few months after the fill has reached grade.

The side slopes for the new approach embankments should be the same as those for the existing embankments.

### 5.6 Lateral Earth Pressures

The abutments will be subjected to lateral earth pressures from the embankment fill and as such will have to be designed as cantilever walls subjected to lateral earth pressures and to vertical loads from the bridge deck. Since the footings are to be within the very stiff to hard till stratum, they may be assumed to be on any unyielding base. For this case, the coefficient of lateral earth pressure would approach the "at rest" condition, and may be taken as 0.5. Passive

5.0 DISCUSSION (cont'd)

5.6 Lateral Earth Pressures (cont'd)

earth pressures assumed in front of the toes of the abutments should be reviewed in the light of applicability in this instance if a founding elevation is used which is above the elevation of the adjoining roadway as shown on Drawing Plan E provided to us. A coefficient of friction between the abutment footing and a special granular base placed on the underlying till may be taken as 0.5. A minimum computed Factor of Safety against sliding of 1.5, should be provided. Clean, free-draining granular fill should be used as backfill behind the abutments. It should be compacted to at least 95 percent Modified Proctor dry density. In order to avoid build up of hydrostatic pressure behind the abutments, a positive drainage system should be provided.


6.0 CLOSURE

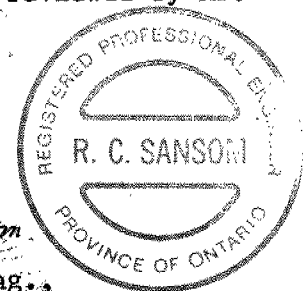
We trust this report is sufficient for your purposes. Should you have any questions in regard to this report we should be pleased to respond.

The field work for this investigation was carried out under the direction of Mr. J. Zoras. This report was written by Mr. R. C. Sansom, P. Eng., and Dr. A. S. Gill, P. Eng., and reviewed by Mr. M. A. J. Matich, P. Eng.

Yours very truly,

GEOCON INC.,

  
R. C. Sansom, P. Eng.,  
Assistant District Manager.



RCS:pw  
T10545  
34450-61

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APPENDIX I

PROCEDURE AND FIELD EQUIPMENT

## PROCEDURE AND FIELD EQUIPMENT

The field work for this investigation was carried out between March 17th and March 19th, 1982. Atcost Drilling Ltd, supplied all the field equipment together with a 2-man drilling crew. A truck-mounted CME 75 power auger drill equipped with hollow stem and continuous flight augers was used to put down a total of 6 Boreholes ranging in depth from 9.6 to 15.7 metres.

Boreholes were advanced with the auger drill and sampled using 51 mm O.D. split-spoon samplers at an interval not exceeding 1.5 metres. Standard Penetration Tests were carried out in conjunction with the use of these samplers. A 63.5 kg hammer dropping free-fall for 762 mm was used to drive the sampler.

Uncased dynamic cone penetration tests (pentests) were performed adjacent to each borehole to depths ranging from 2.4 to 2.7 metres. Each pentest was driven to refusal (greater than 100 blows per 0.3 m). A standard 51 mm diameter, 60 degree sloped cone tip was used for the pentest.

A 13 mm diameter rigid plastic standpipe was installed in Boreholes 1, 3, 4, and 6. Depth of standpipes ranged from 9.4 to 15.7 metres. The bottom 1.5 metres of each standpipe was perforated and backfilled with pea gravel. A bentonite seal was placed below the surficial fill layer to a depth of 1.5 to 1.8 metres for each borehole containing a standpipe.

The location of all boreholes of the investigation are shown on Drawing 887808-A which accompanies this report. Locations were obtained by tape measurements referenced to existing Chainage Stations marked on the centre line of Highway 27. Borehole elevations were obtained by levelling referenced to a Geodetic Benchmark located on Highway 27 bridge over the C.N.R., a short distance to the south of the project site. The elevation of this Geodetic Benchmark No. 234-66 is 177.479 m. The location of the boreholes and the elevation of the ground surface were determined in the field by Geocon personnel.

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PROCEDURE AND FIELD EQUIPMENT (cont'd)

Soil samples were transported to our Rexdale laboratory for testing. Details of field and laboratory tests and stratigraphy are presented on the Records of Boreholes and Figures in Appendix II. The soil samples will be stored until April, 1983, at which time you will be contacted for instructions regarding their disposal.

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APPENDIX II

RECORDS OF BOREHOLES

FIGURES - LABORATORY TESTING

## EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### MECHANICAL PROPERTIES OF SOIL

$m_v$	$\text{kPa}^{-1}$	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	$\text{m}^2/\text{s}$	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{VO}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_l$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### STRESS AND STRAIN

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

### PHYSICAL PROPERTIES OF SOIL

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

# RECORD OF BOREHOLE No 1

METRIC

W P 88-78-08 LOCATION Co-ords 4,846,237.60 N; 295,475.70E ORIGINATED BY JZ  
DIST 6 HWY 407 & 27 BOREHOLE TYPE Hollow Stem Augers & Cone Test COMPILED BY PAD  
DATUM Geodetic DATE 1982 03 17-18 CHECKED BY WJB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
172.09	Ground Level																GR SA SI CL
0.00	Fill		1	CS			172						0				
170.87			2	SS	32		170						0			19.9	1 25 48 26
1.22	Silty clay of low plasticity, some sand, trace gravel. (Till)		3	SS	40								0				
	Hard		4	SS	59								0				
	Brown Grey		5	SS	46		168						0				
			6	SS	51		166										
			7	SS	49		164						0				
			8	SS	61		162						0				
			9	SS	88		WL	82	03	30			0				
159.90			10	SS	93		160						0				4 17 75 4
12.19	Sandy silt, trace clay, trace gravel. (Till)		11	SS	92		158						0				
	Dense to Very Dense																
156.35	Green-Grey		12	SS	45												
15.70	End of Borehole																

+3, x5: Numbers refer to  
Sensitivity

20  
15-5 (%) STRAIN AT FAILURE  
10



# RECORD OF BOREHOLE No 2

METRIC

W P 88-78-08 LOCATION Co-ords 4,846,228.80N; 295,454.60E ORIGINATED BY JZ  
DIST 6 HWY 407 & 27 BOREHOLE TYPE Continuous Flight Augers & Cone Test COMPILED BY PAD  
DATUM Geodetic DATE 1982 03 18 CHECKED BY WJB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
								SHEAR STRENGTH kPa						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						
172.06	Ground Level													
0.00	Fill		1	CS			172							
170.84			2	SS	29		170							
1.22	Silty clay of low plasticity, some sand, trace gravel. (Till) Very Stiff to Hard		3	SS	39									
	Brown Grey		4	SS	42		168							
			5	SS	48		166							
			6	SS	33		164							
162.61			7	SS	130/300									
9.45	End of Borehole													
	Note: WL Not Established.													

+3, x5 : Numbers refer to  
Sensitivity

20  
15  5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 3

METRIC

W P 88-78-08 LOCATION Co-ords, 4,846,275.00N; 295,457,90E ORIGINATED BY JZ  
DIST 6 HWY 407 & 27 BOREHOLE TYPE Continuous Flight Augers & Cone Test COMPILED BY PAD  
DATUM Geodetic DATE 1982 03 18 CHECKED BY WJB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	W VALUES			20	40	60	80	100					
172.42	Ground Level																
0.00	Fill		1	CS			172										7 53 37 3
171.20			2	SS	27												
1.22	Silty clay of low plasticity, some sand, trace gravel. (Till)		3	SS	37		170 WL	82	03	30							
	Very Stiff to Hard		4	SS	28												
			5	SS	44		168										
	Brown Grey		6	SS	30												2 12 58 28
			7	SS	33		166										
			8	SS	87		164									22.0	
162.82																	
9.60	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 4

METRIC

W P 88-78-08 LOCATION Co-ords. 4,846,300.00N; 295,422.10E ORIGINATED BY JZ  
DIST 6 HWY 407 & 27 BOREHOLE TYPE Continuous Flight Augers & Cone Test COMPILED BY PAD  
DATUM Geodetic DATE 1982 03 18 CHECKED BY WJB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
172.64	Ground Level																
0.00	Fill																
171.42			1	CS			172										
1.22	Silty clay of low plasticity, some sand, trace gravel. (Till) Very Stiff to Hard		2	SS	32		WL	82	03	30							
			3	SS	36		170				117	300					
			4	SS	40												
			5	SS	33		168										
			6	SS	53		166										
			7	SS	41		164										
			8	SS	50												
163.04																	
9.60	End of Borehole																

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

20  
15-0.5 (%) STRAIN AT FAILURE  
10



# RECORD OF BOREHOLE No 5

METRIC

W P 88-78-08

LOCATION Co-ords. 4,846,327.00N; 295,435.00E

ORIGINATED BY JZ

DIST 6 HWY 407 & 27

BOREHOLE TYPE Continuous Flight Augers & Cone Test

COMPILED BY PAD

DATUM Geodetic

DATE 1982 03 18

CHECKED BY WJB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100						WATER CONTENT (%)	20	40
SHEAR STRENGTH kPa																				
○ UNCONFINED + FIELD VANE																				
● QUICK TRIAXIAL x LAB VANE																				
200 400 600 800 1000																				
172.65	Ground Level																			
0.00	Fill																			
171.43			1	CS																
1.22	Silty clay of low plasticity, some sand, trace gravel. (Till)		2	SS	33								0							
	Hard		3	SS	49								0							
	Brown Grey		4	SS	55								0							
			5	SS	51															
			6	SS	79								0							
163.05			7	SS	51								0							
9.60	End of Borehole																			
	Note: WL Not Established.																			





# RECORD OF BOREHOLE No 6

METRIC

W P 88-78-08

LOCATION Co-ords. 4,846,320.50N; 295,412.60E

ORIGINATED BY JZ

DIST 6 HWY 407 & 27

BOREHOLE TYPE Continuous Flight Augers & Core Test

COMPILED BY PAD

DATUM Geodetic

DATE 1982 03 19

CHECKED BY WJB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
172.76	Ground Level																
0.00	Fill		1	CS			172										1 80
171.54			2	SS	29											20.9	3 28 48 21
1.22	Silty clay of low plasticity, some sand, trace gravel. (Till)		3	SS	35		170										
	Very Stiff to Hard		4	SS	40												
			5	SS	66		168										
	Brown Grey		6	SS	58		166										
			7	SS	33		164										
			8	SS	50		162										
			9	SS	89		160										
160.57			10	SS	66		158										
12.19	Sandy silt, trace clay, trace gravel (Till)		11	SS	170/200												0 42 55 3
	Very Dense		12	SS	140/160												
157.37	Green-Grey																
15.39	End of Borehole																
	Note: Groundwater Not Encountered																

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10



# RECORD OF BOREHOLE No 12

METRIC

W P 88-78-00

LOCATION Hwy 407 & Hwy 27, Co-ords. N 4,846,271.20;E295,436.54

ORIGINATED BY

DIST 6 HWY 407

BOREHOLE TYPE Solid Stem Augers

COMPILED BY

DATUM Geodetic

DATE 1978 10 23

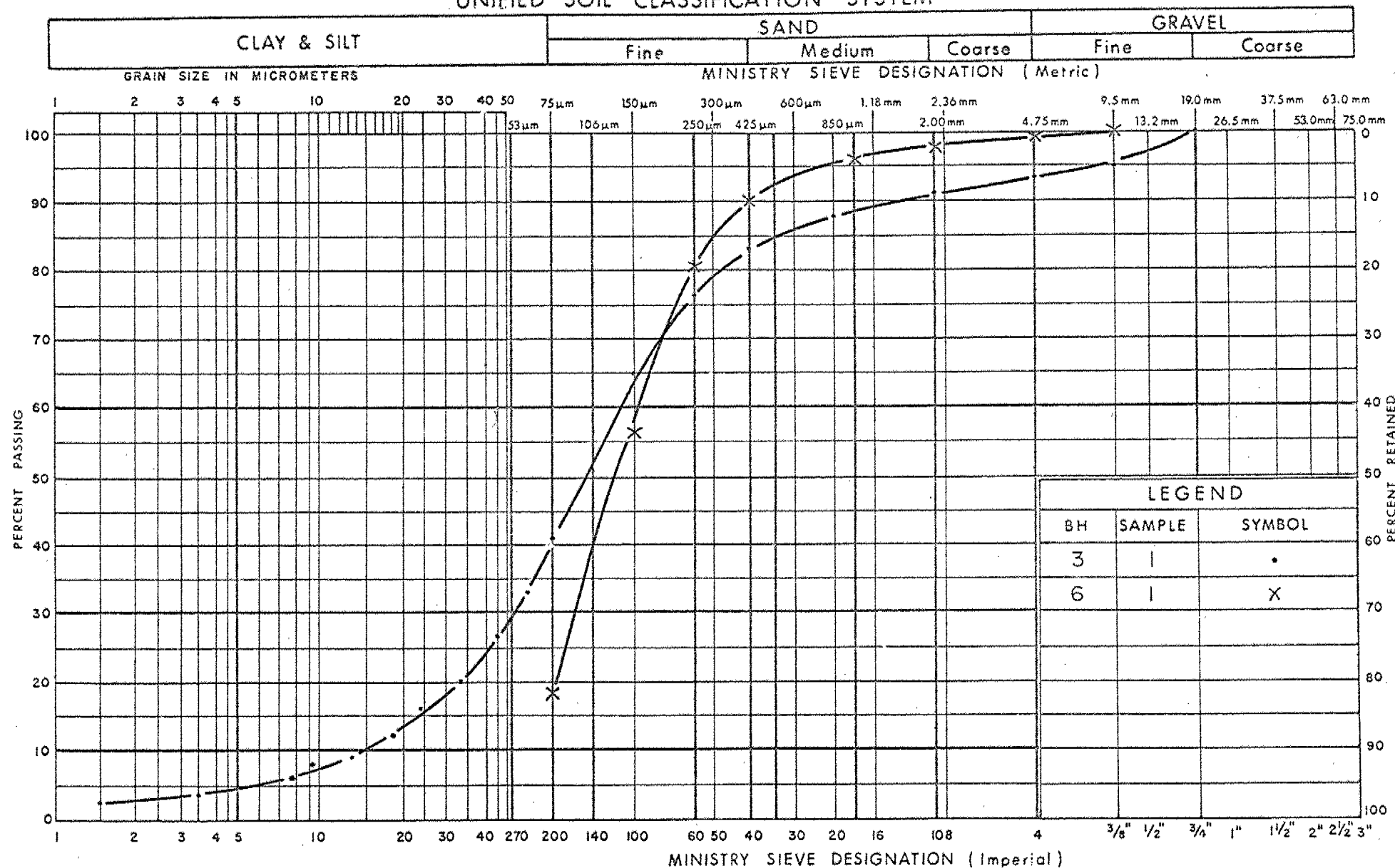
CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100					
171.45	Ground Level															
0.00	Heterogeneous mixture clayey silt sand and gravel (Glacial Till) Hard		1	SS	58											
			2	SS	55											
			3	SS	46											
			4	SS	56											
			5	SS	58											
			6	SS	80											
163.37			7	SS	78											
8.08	End of Borehole															
	Note: Groundwater Not Encountered															

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

20  
15 5 (%) STRAIN AT FAILURE  
10

## UNIFIED SOIL CLASSIFICATION SYSTEM



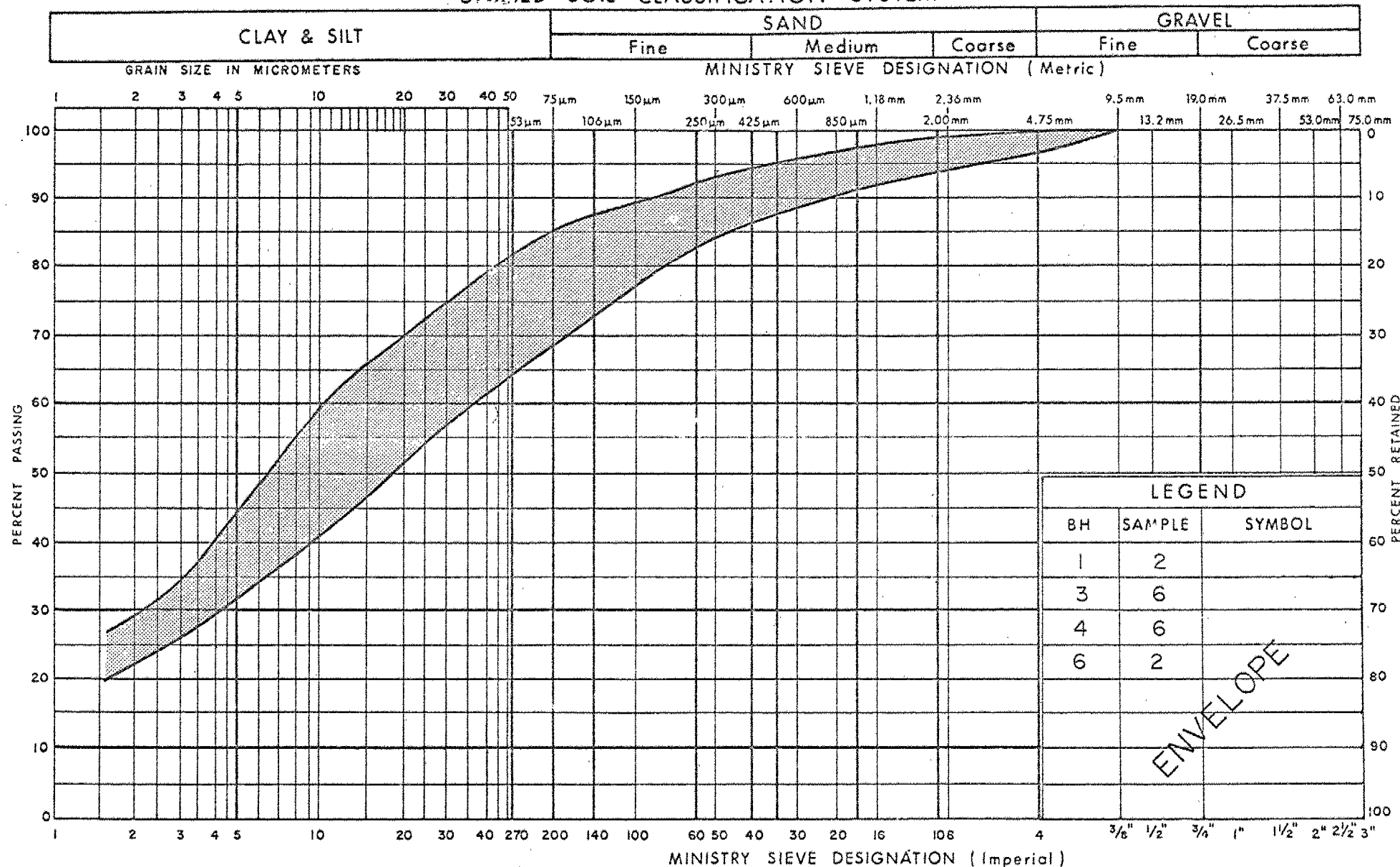
Ministry of  
Transportation and  
Communications

GRAIN SIZE DISTRIBUTION  
FILL

FIG No 1

W P 88-78-08

## UNIFIED SOIL CLASSIFICATION SYSTEM



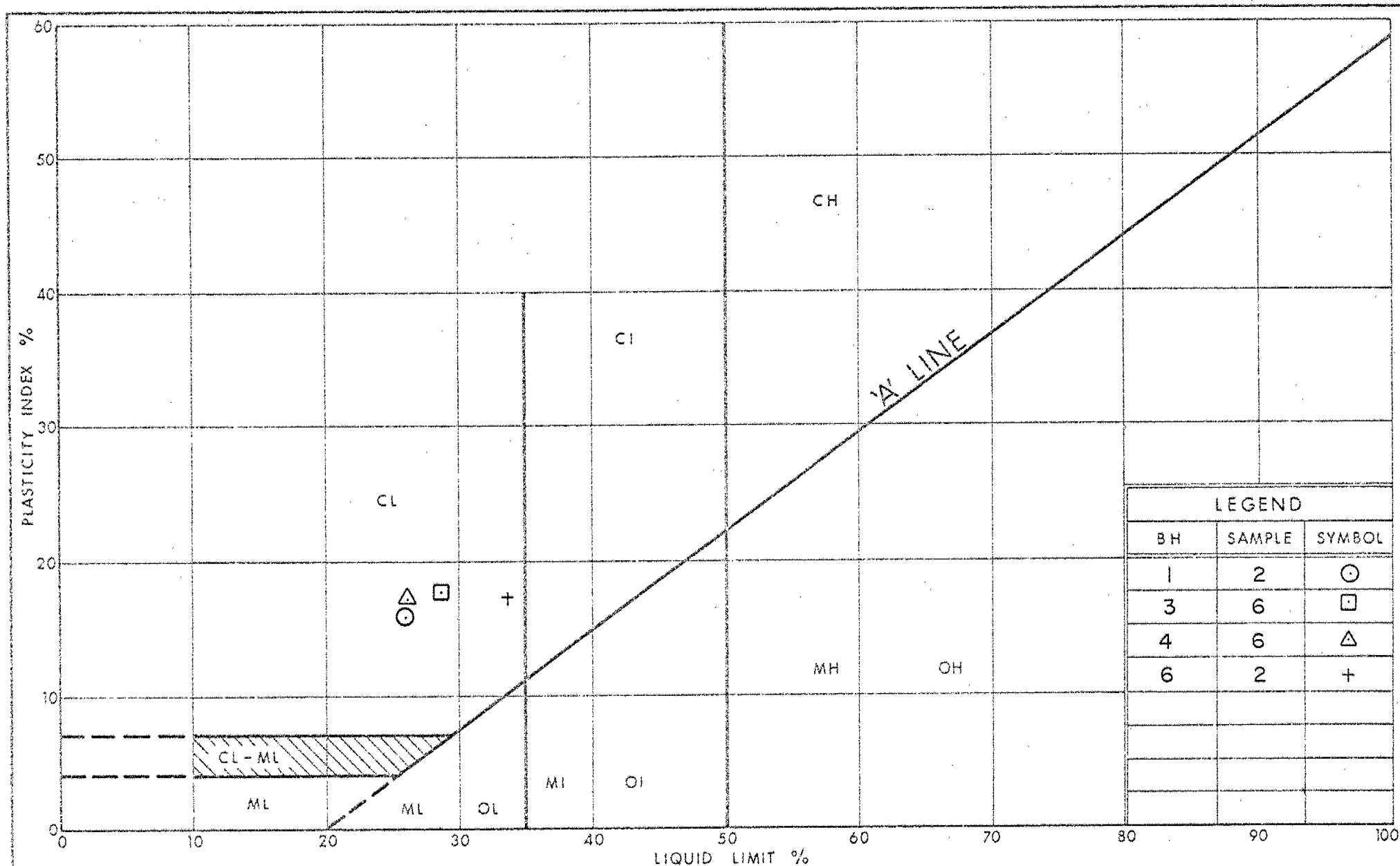
Ministry of  
Transportation and  
Communications

# GRAIN SIZE DISTRIBUTION TILL

SILTY CLAY OF LOW PLASTICITY, SOME SAND, TRACE GRAVEL

FIG No 2

W P 88-78-08



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Transportation and  
Communications

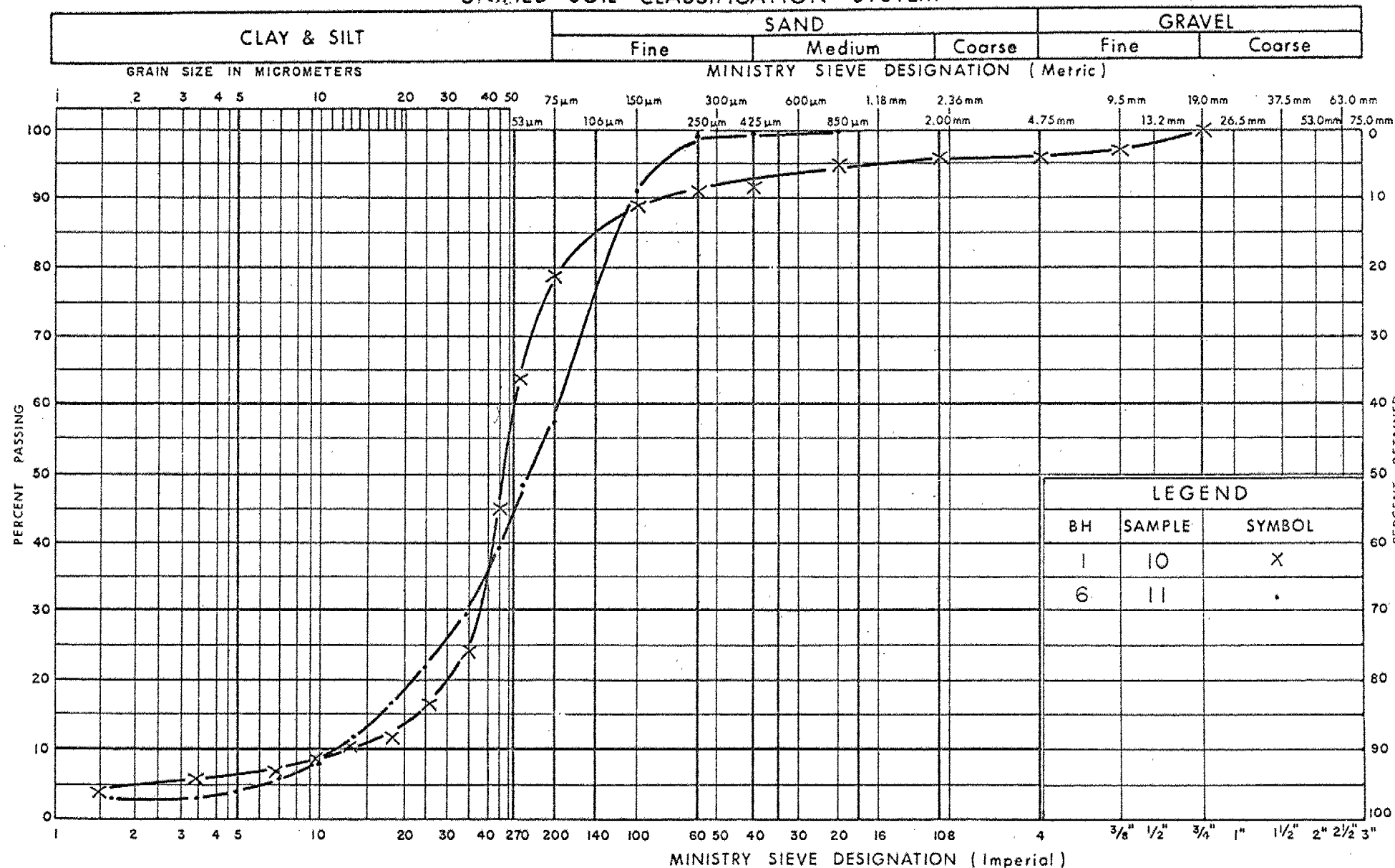
## PLASTICITY CHART TILL

SILTY CLAY OF LOW PLASTICITY, SOME SAND, TRACE GRAVEL

FIG No 3

W P 88-78-08

## UNIFIED SOIL CLASSIFICATION SYSTEM



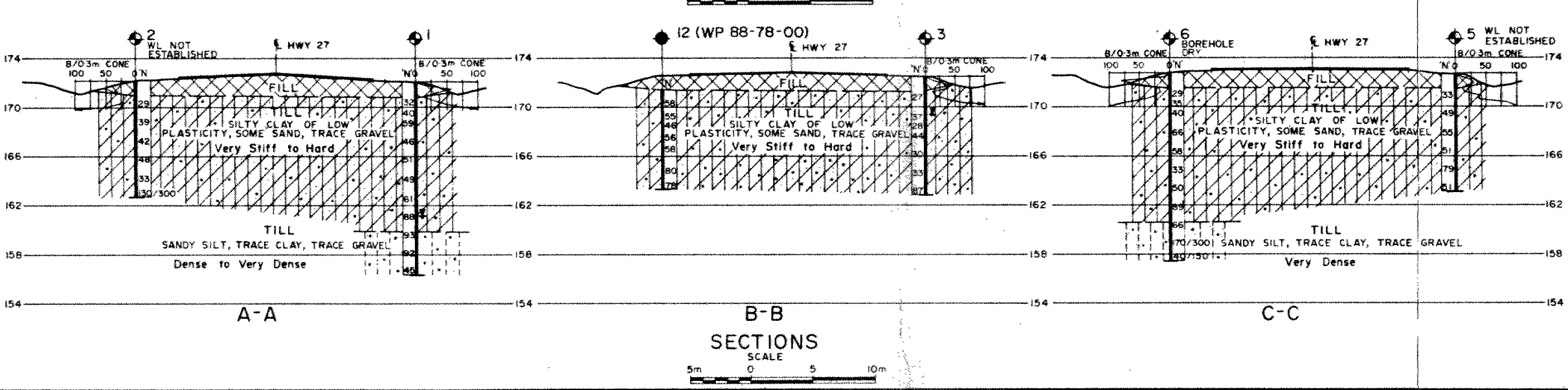
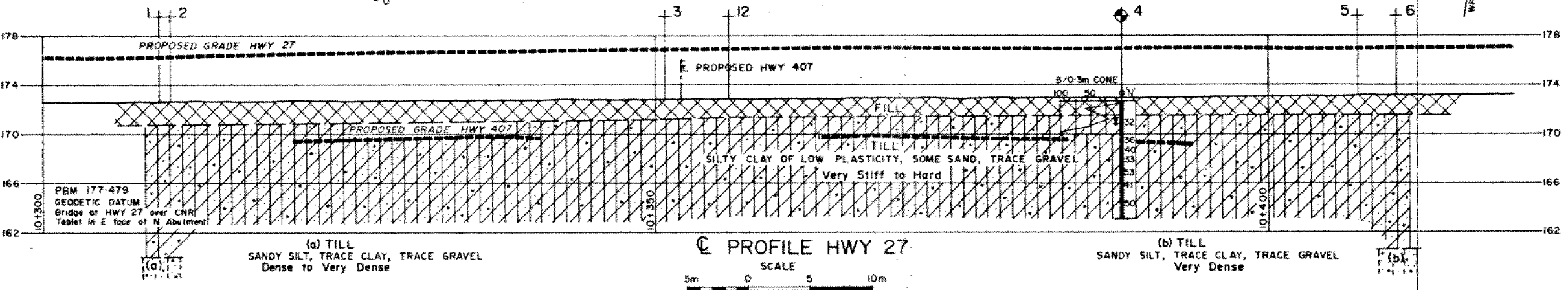
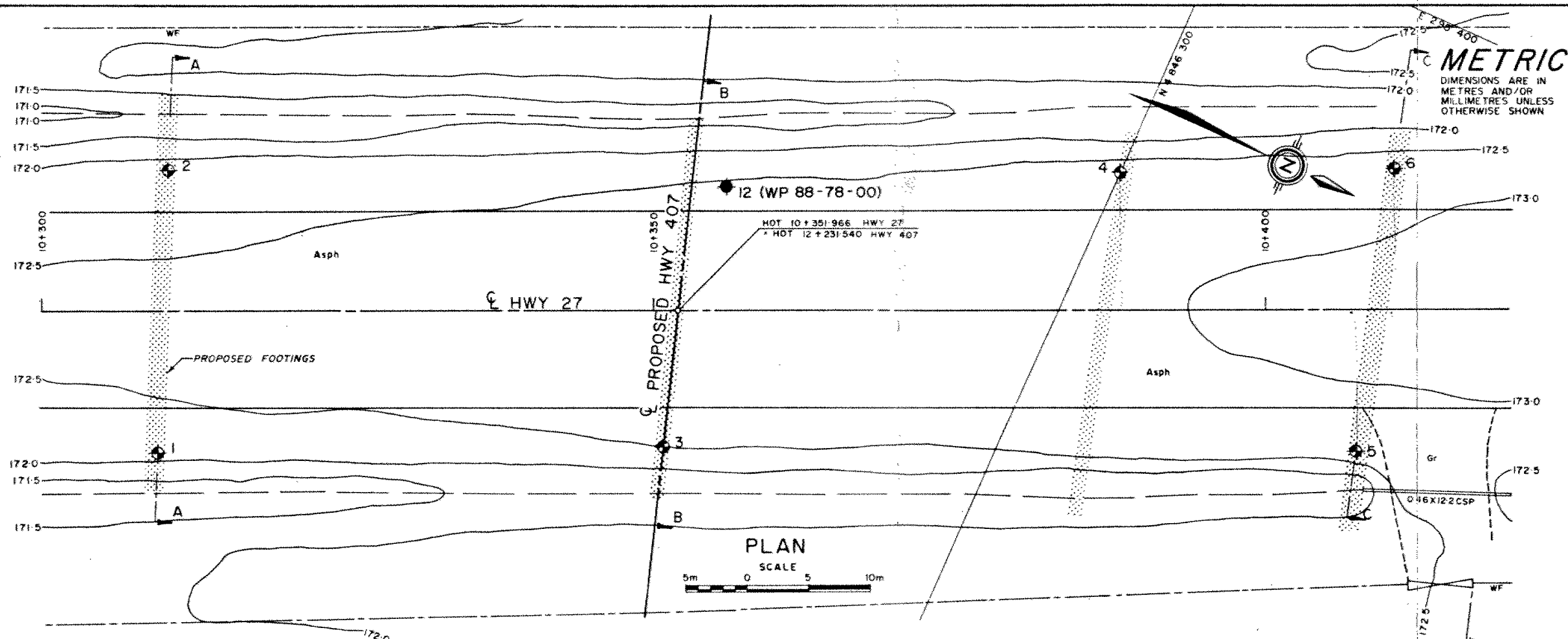
Ministry of  
Transportation and  
Communications

# GRAIN SIZE DISTRIBUTION TILL

SANDY SILT, TRACE CLAY, TRACE GRAVEL

FIG No 4

W P 88-78-08

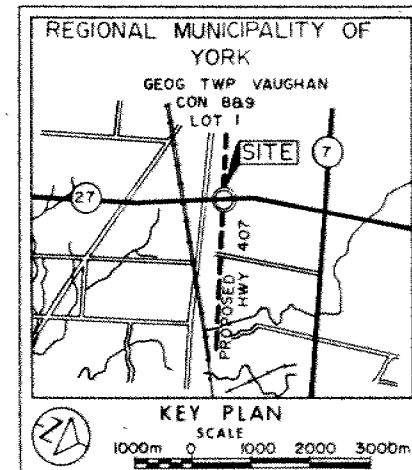


CONT No  
WP No 88-78-08

PROPOSED BRIDGE  
HWY 407 & 27  
BORE HOLE LOCATIONS & SOIL STRATA

SHEET

GEOCON INC.



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 1982 03

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	172.09	4 846 237.60	295 475.70
2	172.06	4 846 228.80	295 454.60
3	172.42	4 846 275.00	295 457.90
4	172.64	4 846 300.00	295 422.10
5	172.65	4 846 327.00	295 435.00
6	172.76	4 846 320.50	295 412.60
12	171.45	4 846 271.20	295 436.54

NOTE

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

REVISIONS

DATE	BY	DESCRIPTION

Geacres No

HWY No 407 & 27

SUBM'D RCS/CHECKED DATE 1982 03 30 SITE 37-1121

DRAWN PAD/CHECKED APPROVED RCS DWG 887808-A

37-73-1128

ENGINEERING MATERIALS OFFICE  
PAVEMENT & FOUNDATION DESIGN SECTION

WP 88-78-25  
263-87-01

DIST 6

HWY 427/407

STR SITE 37-73-1118  
37

Ramp Structure 407E - 427S (88-78-25)  
Retaining Wall - Ramp 427N - 407E (263-87-01)

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R. Hore

R. Fitzgibbon (Cover Only)  
T.J. Kovich (Cover Only)

Files



# FOUNDATION INVESTIGATION REPORT

For

Ramp Structure 407E - 427S

W.P. 88-78-25 Site: 37-73-1118

and

Retaining Wall - Ramp 427N - 407E

W.P. 88-78-25 Site: 37

Hwy. 427/407 Interchange

District 6, Toronto.

## INTRODUCTION:

This report summarizes the factual information obtained from a foundation investigation program performed at the two above-mentioned structural sites and provides detailed recommendations pertaining to the structure foundations and related earthworks. The fieldwork was carried out between 82 07 12 and 82 07 15 consisting of 9 sampled boreholes, 4 accompanied by dynamic cone penetration tests, advanced by means of hollow and solid stem continuous flight augers. Borings were advanced for depths ranging from 7.8 metres to 15.9 metres.

## SITE DESCRIPTION AND GEOLOGY

The site is located at the crossing of the proposed Hwy. 427/407 interchange complex, in the Town of Vaughan, Regional Municipality of York.

The existing topography around the site is flat and level. The land is clear of vegetation and is currently in use as farm land.

Physiographically, the site is located in the Halton-Peel till plain which was spread over the area by the advance and retreat of the Wisconsin ice sheet during the Pleistocene epoch (over 5,000 years ago). The till plain occupies the area east of the Niagara Escarpment and north of the Lake Iroquois shoreline. It consists of a bevelled till plain with a gently undulating rolling surface and limited relief. In places the till is overlain by thin deposits of varved clay.

Indications are that there are four till sheets present. The uppermost material is described as a stony clay. The till sheets are usually separated from one another by a bed of stratified silt or sand of variable thickness. The middle till is a grey to brown, dense sandy till which appears sandier than the surficial till. Bedrock has been found in the area at depths of 25 to 30 metres below ground surface, and consists of interbedded shale and limestone of the Dundas Formation, Ordovician Period.

#### SUBSURFACE CONDITIONS

In general, reasonably competent and uniform subsurface conditions were encountered across both the structure sites. The surficial deposit extending to a maximum depth of 3.5 metres is a stiff to hard cohesive deposit consisting of silty clay with sand and a trace of gravel.

Underlying the surficial deposit and explored for a maximum thickness of 11.7 metres is a dense to very dense silty sand interbedded with silt layers and occasional cobbles and boulders. A hard cohesive glacial till was encountered below this granular deposit.

The boundaries between the various soil types, insitu and laboratory test results, as well as stabilized ground water levels, are shown on the attached Record of Borehole Sheets. The locations and elevations of the borings, along with a profile showing a simplified stratigraphical summary for each of the structure sites are shown on Drawing No. 887825-A and B.

The various soil types encountered are briefly described in the following paragraphs.

#### Silty Clay With Sand

The surficial deposit encountered across the site for depths ranging from 1.4 metres to 3.5 metres is composed of silty clay with sand and a trace of gravel, probably of glacial origins. Towards this deposit's base, a higher proportion of sand was encountered. Typical grain size distribution curves for representative samples from this deposit are plotted in envelope form on Figure 1 of the appendix.

The results of Atterberg Limit and water content testing are plotted on the Plasticity Chart, Figure 2, and summarized as follows:

	<u>Range</u>	<u>Average</u>
Water Content (w) %	9-20	15
Liquid Limit ( $w_L$ ) %	25-34	29
Plastic Limit ( $w_p$ ) %	13-16	15
Plasticity Index ( $I_p$ ) %	11-18	14

These results indicate the fine grained matrix of this deposit to consist of an inorganic silty clay of low plasticity (CL).

Based on interpretation of Standard Penetration Test 'N' values and augering operations, the consistency of this silty clay deposit is assessed as ranging from stiff to hard.

#### Silty Sand

The surficial cohesive deposit is underlain by a granular stratum composed of a silty sand with interbedded silt layers in the upper portion changing to some cobbles and occasional boulders towards the lower portion of the deposit. In addition, alternating layers of silt clay were encountered at the transition between the surficial cohesive deposit and this stratum. Typical grain size distribution curves for representative samples from this deposit are shown in envelope form on Figure 3. Grain size distribution curves illustrating the finer gradation of the silt layers of this deposit are shown in envelope form on Figure 4. Thicknesses encountered for this deposit range from 3.8 to 11.7 metres.

Interpretation of Standard Penetration Test 'N' values ranging from 16 to in excess of 100 blows/0.3 metres, indicates a denseness for this deposit ranging from compact to very dense but generally very dense throughout.

#### Silty Clay, Sand and Gravel (Glacial Till)

Underlying the granular deposit and explored for a maximum thickness of 2.8 metres is a glacial till deposit composed of a silty clay matrix with high percentages of sand and gravel.

Based on interpretation of 'N' values in excess of 100 blows per foot and very difficult augering operations, the consistency for this deposit is assessed as hard.

#### Groundwater Condition

Overnight stabilized borehole water level readings taken at the time of investigation indicate the water table should approximate elevation 171±, some 7 to 9 metres below ground surface across both sites. This agrees with additional subsurface data obtained from previous investigations in the immediate area. Seasonal fluctuations of the groundwater level are anticipated.

## DISCUSSION AND RECOMMENDATIONS

As part of the planned Hwy. 427/407 interchange complex, it is proposed to construct a fourth level ramp structure to accommodate movements from 407 W.B. to Hwy. 427 S.B. A contemplated cast-in-place post-tension type of concrete deck some 13 metres in width will have five spans of 30-43-52-52-40 metres length (from south to north). A maximum ramp approach fill elevation of 195.3 and profile elevation of 173 for Hwy. 407 will necessitate fills in the order of 16 metres and cuts of 7 metres for the south forward slope and fills up to 16 metres for the northeast forward slope.

In addition, a 50 metre long retaining wall varying in height from 0.8 to 4.2 metres is required to retain the embankment fill for Ramps 407E-427S from Ramp 427N-407E. Profile control for the retaining wall ranges from elev. 180.6 to 179.1 corresponding to respective heights of 3.2 to 1.0 metres above existing ground surface. Proposed minimum top of retaining walls elevations requires wall faces up to 4.2 metres in height.

In consideration of the reasonably competent subsoils encountered across the site, recommendations pertaining to the foundations of the ramp structure, retaining wall, and related earthworks are summarized as follows:

### Approach Embankment Stability and Settlement

No deep seated rotational or translational types of instability are anticipated for the approach embankments considering the competent nature of the subsoils and provided good construction practice is exercised. However, due to the high fill heights and Hwy. 407 cuts contemplated, stability of the embankment material itself and cut slope geometry is of concern. Preliminary assessment of the approach geometries based on past stability analysis of high fills utilizing total and effective stresses indicate fills in excess of 11 metres in height will be stable with a 3:1 slope geometry in both the longitudinal and transverse direction. In order to avoid uninterrupted 3:1 slopes up to 70± metres in length and the drainage/runoff problems associated with them, it is recommended that 2:1 slope geometries with berms of sufficient length so that the overall

slope is not steeper than 3:1 be used. For preliminary estimating purposes, the following approach slope geometries are suggested (refer to attached sketch for details), however a complete stability analysis in terms of total and effective stresses will be required upon finalization of ramp geometries, grades, and fill material properties.

i) South Approach Embankment

A 2:1 geometry from the toe of the Hwy. 407 cut to the top of the fill with a minimum setback of 11.5 metres between the top of cut and toe of fill plus an additional 11.5 metre wide midheight berm for the fill itself. This effectively interrupts the 2:1 slope with 11.5 metre wide berms located at ground surface and at elevation 187.5±, plus lengthens the ramp structure by some 23 metres on the south end.

ii) Northeast Approach Embankment

A 2:1 slope geometry interrupted with an 11.5 metre wide mid-height berm at an approximate elevation of 184.5 which will effectively lengthen the ramp by 11.5 metres to the north end.

These berms are also required in the transverse direction, being tapered proportionally to a safe "non-bermed" fill height of 11.0 metres.

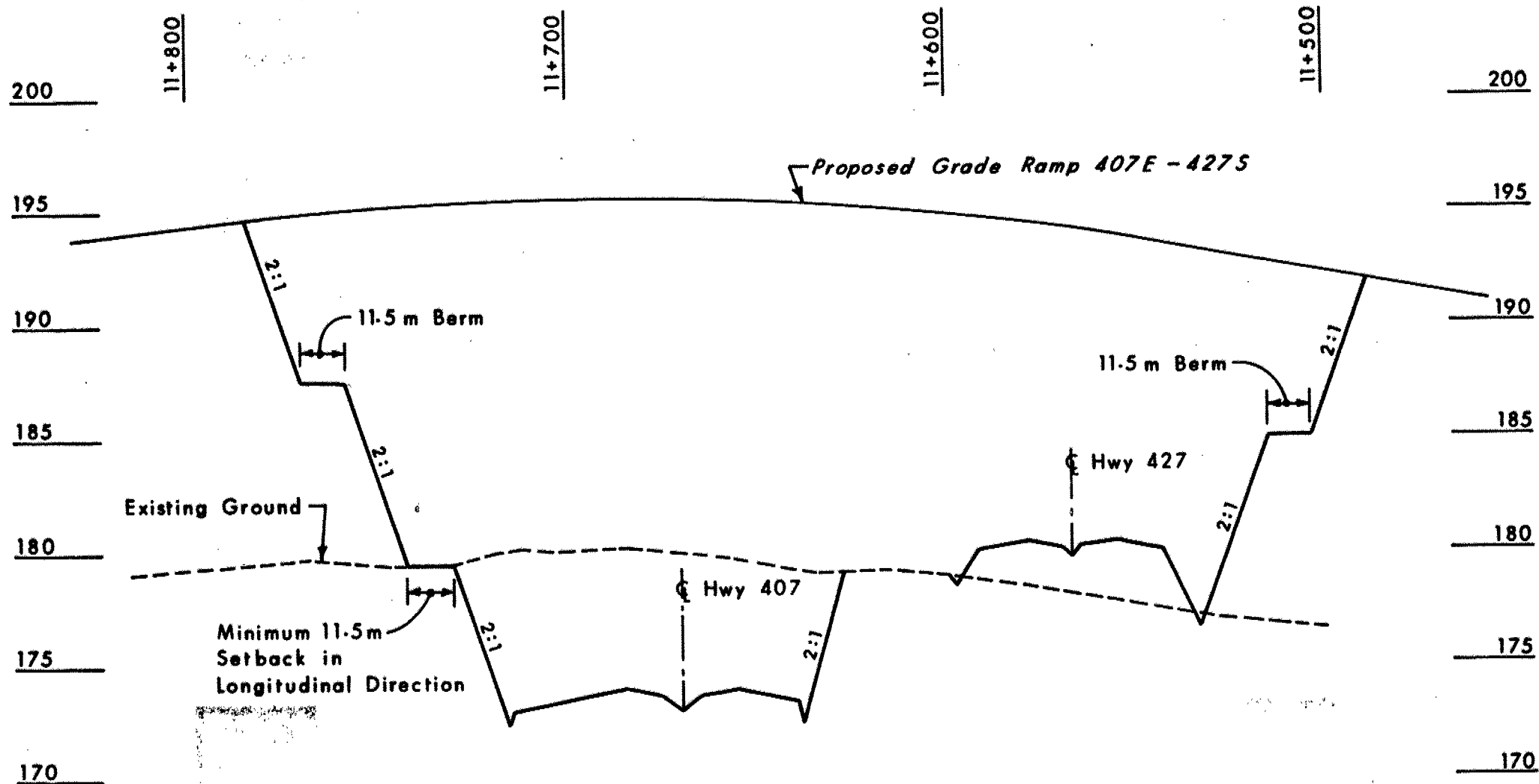
All organic and softened material should be stripped from within the planned limits of the approach embankment prior to placement of any fill.

In order to minimize post construction maintenance problems as a result of settlements within the embankment fill material ranging up to 1% of the total fill height (ie. 16 centimetres), it is recommended that fills be constructed and left in place for as long a period as possible (minimum 6 months) prior to final grading and paving operations.

Ramp Structure Foundations

Abutments

Considering the height of the approach embankment, abutments elements should be perched within the approach fills and supported on end-bearing piles driven into the competent silty sand stratum. Assuming a 110HP310 steel 'H' section pile equipped with the standard M.T.C. reinforced tips (welded flange plates) and driven to a minimum set of 15



NOTE: All berms in both longitudinal and transverse directions.  
Transverse berms to taper to nil at safe fill height of 12 metres.

Sketch showing Preliminary Approach Slope Geometry for  
Ramp 407 E - 427 S Embankment.

Sketch No 1

WP 88-78-25

blows/25mm for the last 75 mm with a hammer capable of delivering a minimum energy of 48,000 joules/blow, the following design parameters are recommended

Factored Capacity at U.L.S.	1650 kN
Capacity at S.L.S. Type II	1000 kN
Ultimate Capacity	3000 kN

Upon finalization of abutment locations as a result of structure lengthening and completion of any supplementary fieldwork, estimated tip elevation for piles advanced using the above mentioned driving criteria will be forwarded.

For preliminary estimating purposes based on boreholes advanced at the present abutment locations, the following minimum tip elevations are given:

South Abutment	Elev. 171.0
Northeast Abutment	Elev. 172.0

Gradation of all fill placed in the zone of pile penetration should be restricted to a maximum size of 75 mm.

### Piers

Piers #5 and #4 (corresponding to BH 5 & 6, respectively), located within the depressed Hwy. 407 cut section, can be supported on spread footings located within the very dense silty sand, at or below elevation 172.0, and designed to the following O.H.B.D.C. parameters.

Factored Capacity at U.L.S.	950 kPa
Capacity at the S.L.S. Type II	450 kPa

The remaining piers can be designed as follows:

	<u>Minimum Founding Elevation</u>	<u>Factored Capacity at U.L.S.</u>	<u>Capacity at S.L.S. Type II</u>
Pier #3			
(BH #7 location)	178	800 kPa	350 kPa
Pier #2			
(BH #8 location)	177	800 kPa	350 kPa



A minimum of 1.3 metres of earth cover is required for frost protection purposes for all footings and abutment pile caps.

#### Retaining Wall Foundations

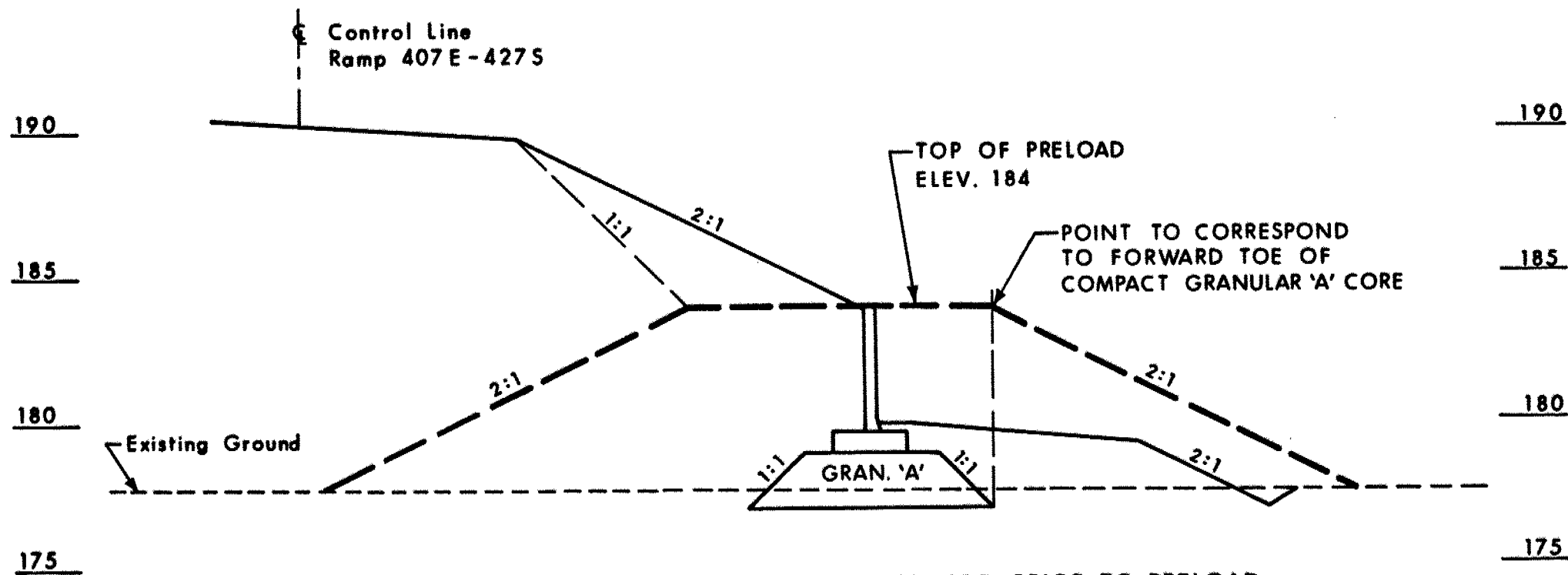
Excessive settlements resulting from the increased vertical stresses imposed by the high ramp 407E-427S embankment and the localized stiff, moderately compressible, condition of the surficial silty clay deposit may result in detrimental movements to a standard concrete cantilever retaining wall design. In order to minimize these movements, it is recommended to preload the area of the retaining wall to a height of elevation 184 for a minimum period of 6 months prior to construction of the retaining wall. The actual limits of preloading treatment are shown on the attached sketch. The retaining wall can then be supported on spread footings located on a well compacted core of granular 'A', constructed as per current MTC specifications. All softened and/or organic material within the planned area of the compacted core must be subexcavated prior to placement of any granular material. For retaining wall footings so constructed the following O.H.B.D.C. parameters are applicable:

Factored Capacity at U.L.S.	800 kPa
Capacity at S.L.S. Type II	300 kPa

The compacted granular 'A' core should be installed prior to placement of any preload material.

In order to eliminate the need for preloading and double handling of fill material, serious consideration should be given to selecting a flexible reinforced earth-type of retaining wall system which can accommodate the minor vertical movements anticipated. This system can be founded on a compacted core of granular 'A' as previously mentioned.

Alternatively, the need for a retaining wall can be eliminated completely provided the Ramp embankment side slopes are steepened to a 1:1 geometry utilizing slope reinforcement design concepts similar to the designed slopes on Hwy. 410. Design details for this concept can be forwarded upon request.



Sketch showing Details of Retaining Wall Preload Arrangement

### Other Considerations

Provided backfill to the abutments and retaining walls consists of free draining granular material and adequate provisions are made for an appropriate drainage scheme, the following equivalent fluid pressures may be assumed for computation of earth pressures.

a) At ultimate limit state

- |                     |            |
|---------------------|------------|
| - active condition  | 8.0 kPa/m  |
| - at rest condition | 12.0 kPa/m |

b) At serviceability limit state

- |                     |            |
|---------------------|------------|
| - active condition  | 6.5 kPa/m  |
| - at rest condition | 10.0 kPa/m |

No unwatering difficulties are anticipated for footing excavations into the silty sand deposit provided groundwater levels are below the founding elevation. For higher water levels an appropriate unwatering scheme will be necessary to insure the integrity of the base of the excavation. In order to minimize unwatering concerns, it is recommended to advance Hwy. 407 cuts and install the permanent slope drainage scheme prior to footing excavations.

Vibratory compaction equipment for use behind abutment walls must be restricted in size as per current MTC specifications.

The underside of all footings and pile caps should be provided with a minimum 1.3 metres of earth cover for frost protection purposes.

Resistance to sliding of the retaining wall and abutment footings can be calculated assuming a coefficient of friction of 0.7 between the underside of the concrete footing and the Granular 'A' core and 0.6 with the silty sand deposit at piers #4 and #5. An adhesional value of 95 kPa may be used in calculating sliding resistance for piers #2 and #3 founded in the silty clay deposit.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of Mr. Dave Wismath, Student Technician, utilizing equipment owned and operated by Master Soil Drilling, Toronto. This report was written by Mr. T. J. Kazmierowski, Foundations Engineer and reviewed by Mr. M. Devata, Senior Foundations Engineer.



A handwritten signature in black ink, appearing to read "T. J. Kazmierowski".

T. J. Kazmierowski, P. Eng.,  
Foundations Engineer

A handwritten signature in black ink, appearing to read "M. Devata".

M. Devata, P. Eng.,  
Senior Foundations Engineer

## APPENDIX



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# RECORD OF BOREHOLE No 1

METRIC

W P 88-78-25 LOCATION Co-ords. N 4 845 593.6; E 294 101.2 ORIGINATED BY D.W.  
DIST 6 HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY T.J.K.  
DATUM Geodetic DATE 82 07 12 CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100				
177.6	Ground Surface														
0.0	Brown Mottled Silty Clay, Some Sand Trace Gravel V. Stiff		1	SS	21										2-13 ( 85 )
176.2			2	SS	28										1 53 40 6
1.4			3	SS	80/28 cm										
			4/5	SS	89										
	Silt Layer		6	SS	71										1 5 89 5
			7/8	SS	71										1 50 43 6
	Silty Sand Trace of Clay and Gravel		9	SS	99										
			10	SS	91										5 53 41 1
	Brown Grey with Gravel		11	SS	100/23 cm										24 40 ( 36 )
	occ. Cobbles and Boulders		12	SS	60										
	Very Dense		13	SS	60/15 cm										
164.5			14	SS	95										
13.1	(Glacial Till) Silty Clay, Sand and Gravel														
161.7	Hard		15	SS	100/15 cm										
15.9	End of Borehole  Note: Borehole caved @ 7.0 m														

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

20  
15  
10  
5 (%) STRAIN AT FAILURE

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## RECORD OF BOREHOLE No 2

METRIC

W P 88-78-25 LOCATION Co-ords. N 4 845 608.4; E 294 099.5 ORIGINATED BY D.W.  
DIST 6 HWY 427 BOREHOLE TYPE Solid Stem Auger & Cone Test COMPILED BY T.J.K.  
DATUM Geodetic DATE 82 07 12 CHECKED BY GP.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100		W <sub>p</sub>	W	W <sub>L</sub>		
177.7	Ground Surface													GR SA SI CL
0.0	Brown Silty Clay with Sand Trace Gravel		1	SS	17		176							8 28 46 18
175.3	Stiff		2	SS	12									1 39 50 10
2.4	Brown		3	SS	17									
	Silty Sand		4	SS	82		174							0 72 25 3
	Trace of Clay & Gravel		5	SS	96									
	Very Dense		6	SS	100/	18 cm	172							2 65 27 6
			7	SS	100/	23 cm								
			8	SS	100/	15 cm	170							
168.2	with Gravel and Cobbles		9	SS	100/	20 cm								20 67 ( 13 )
9.5	End of Borehole													
	Note: Borehole caved @ 8.0 m													

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

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Ontario

# RECORD OF BOREHOLE No 3

METRIC

W P 88-78-25 LOCATION Co-ords. N 4 845 623.0; E 294 102.0 ORIGINATED BY D.W.  
DIST 6 HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY T.J.K.  
DATUM Geodetic DATE 82 07 13 CHECKED BY *CP*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
178.0	Ground Surface																
0.0	Brown mottled Silty Clay with Sand Trace Gravel		1	SS	27												
	Very Stiff to Hard		2	SS	47		176										4 31 41 24
175.1			3	SS	86												
2.9			4	SS	107												0 68 30 2
	Silt		5	SS	75		174										
	Silty Sand		6	SS	100/	25 cm											
	Trace Clay & Gravel		7	SS	100/	18 cm	172										
			8	SS	85		170										
	Brown Grey		9	SS	65		168										
	Cobble		10	SS	39		166										
	with Gravel		11	SS	100		164										
	Occ. Cobbles and Boulders		12	SS	100/	20 cm											
	Dense to Very Dense		13	SS	100/	14 cm											
163.7	Grey (Glacial Till)																
14.3	Silty Clay, Sand & Gravel Hard																
162.5																	
15.5	End of Borehole																
	Note: Borehole caved at 9.2 m																

+3, x5: Numbers refer to  
Sensitivity

20  
15 + 5 (%) STRAIN AT FAILURE  
10

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# RECORD OF BOREHOLE No 4

METRIC

W P 88-78-25 LOCATION Co-ords. N 4 845 771.3; E 294 089.7 ORIGINATED BY DW  
DIST 6 HWY 427 BOREHOLE TYPE Solid Stem Auger & Cone Test COMPILED BY TJK  
DATUM Geodetic DATE 82 07 13 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH					
179.4	Ground Surface							○ UNCONFINED    + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE	10 20 30					GR SA SI CL
0.0	Brown Silty Clay Some Sand		1	SS	18		178							1 16 54 29
177.3	Trace Gravel Stiff to V. Stiff		2	SS	13									0 39 59 2
2.1	Brown		3	SS	31									
			4	SS	49		176							2 2 92 4
			5	SS	37									
			6	SS	71									
	Silt Layer						174							
	Silty Sand		7	SS	50/	8 cm								
	Trace Clay & Gravel													
	Occ. Cobbles		8	SS	95/	15 cm	172							6 51 38 5
			9	SS	100/	23 cm	170							
169.0	Dense to V. Dense													
10.4	Grey (Glacial Till) Silty Clay, Sand, Gravel		10	SS	125/	19 cm	168							
166.9	Hard		11	SS	112									
12.5	End of Borehole													

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE



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# RECORD OF BOREHOLE No 5

METRIC

W P 88-78-25 LOCATION Co-ords. N 4 845 801.0; E 294 100.0 ORIGINATED BY DW  
DIST 6 HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY TJK  
DATUM Geodetic DATE 82 07 14 CHECKED BY GP

SOIL PROFILE		STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION		NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
180.4	Ground Surface																
0.0	Brown Silty Clay with Sand Trace of Gravel V. Stiff to Hard		1	SS	32	*	180										2 27 50 21
178.0			2	SS	26												
2.4	Silt		3	SS	73		178										1 2 95 2
			4	SS	110												
	Brown Silty Sand Trace Clay & Gravel Very Dense		5	SS	100	23 cm	176										3 38 53 6
			6	SS	90	15 cm											
			7	SS	65	15 cm	174										
172.4	Silt		8	SS	100	13 cm											
8.0	End of Borehole * Note: Water Level not encountered																

+3, x5 : Numbers refer to  
Sensitivity

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



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# RECORD OF BOREHOLE No 6

METRIC

W P 88-78-25 LOCATION Co-ords. N 4 845 840.0; E 294 118.0 ORIGINATED BY DH  
DIST 6 HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY TJK  
DATUM Geodetic DATE 82 07 14 CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100								
								SHEAR STRENGTH								
179.9	Ground Surface															
0.0	Brown mottled Silty Clay with Sand Trace Gravel		1	SS	32	*										
			2	SS	66		178									
177.2	Hard		3	SS	100/	15 cm										
2.7	Brown Silty Sand Trace Clay & Gravel		4	SS	100/	15 cm										
			5	SS	100/	23 cm	176									
			6	SS	100/	11 cm										
							174									
	Silt		7	SS	100/	20 cm										
	Very Dense Brown		8	SS	100/	11 cm	172									
	Grey															
170.6			9	SS	100/	13 cm										
9.3	End of Borehole  * Note: Water Level not encountered															

\* 3, \* 5: Numbers refer to Sensitivity

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

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# RECORD OF BOREHOLE No 7

METRIC


W P 88-78-25 LOCATION Co-ords. N 4 845 883.2; E 294 145.0 ORIGINATED BY DW  
DIST 6 HWY 427 BOREHOLE TYPE Solid Stem Auger & Cone Test COMPILED BY TJK  
DATUM Geodetic DATE 82 07 14 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100		W <sub>p</sub>	W	W <sub>L</sub>		
179.2	Ground Surface													
0.0	Brown mottled Silty Clay Some Sand Trace Gravel V. Stiff to Hard		1	SS	22	*	178							5 19 46 30
176.5			2	SS	47									2 7 86 5
			3	SS	100/25 cm									8 17 73 2
2.7	Brown Silt to Silty Sand  Trace Clay & Gravel  V. Dense		4	SS	100/15 cm		176							
			5	SS	100/10 cm									
			6	SS	100/13 cm		174							
172.7			7/8	SS	72									
6.5	Grey (Glacial Till) Silty Clay, Sand, Gravel Hard						172							
171.2			9	SS	100/19 cm									
8.0	End of Borehole													
	* Note: Water Level not encountered													

+3, x5: Numbers refer to  
Sensitivity

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

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RECORD OF BOREHOLE No 8										METRIC				
W P 88-78-25		LOCATION Co-ords. N 4 845 923.5; E 294 178.7				ORIGINATED BY DW								
DIST 6 HWY 427		BOREHOLE TYPE Solid Stem Auger				COMPILED BY TJK								
DATUM Geodetic		DATE 82 07 15				CHECKED BY 								
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
178.1	Ground Surface													
0.0	Brown mottled Silty Clay with Sand Trace Gravel		1	SS	25	*								
			2	SS	50									
175.2	V. Stiff to Hard		3	SS	89									
2.9	Brown Silty Sand Trace Clay & Gravel		4	SS	100	10 cm								
			5	SS	130	20 cm								
	Very Dense		6	SS	100	8 cm								
			7	SS	130	15 cm								
171.1														
7.0	Grey (Glacial Till)													
170.3	Hard		8	SS	125	15 cm								
7.8	End of Borehole													
	* Note: Water Level not encountered													

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

20  
15  
10  
5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 9

METRIC

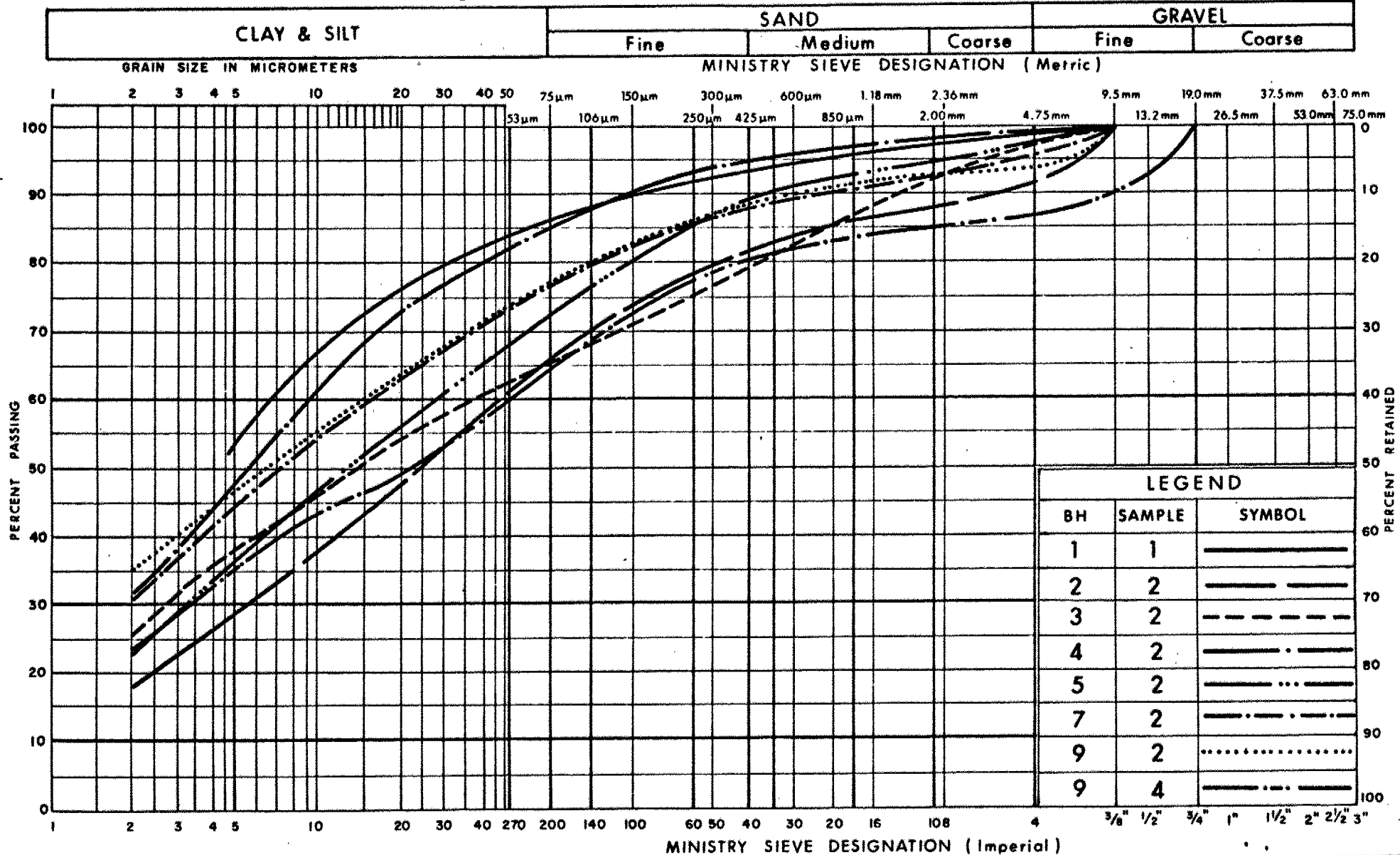
W P 88-78-25 LOCATION Co-ords. N 4 845 951.7; E 294 208.6 ORIGINATED BY DW  
DIST 6 HWY 427 BOREHOLE TYPE Solid Stem Auger & Cone Test COMPILED BY TJK  
DATUM Geodetic DATE 82 07 15 CHECKED BY 

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES									
176.9	Ground Surface													
0.0	Brown mottled Silty Clay with Sand		1	SS	25		176							
	Trace of Gravel		2	SS	38									6 19 43 32
	V. Stiff to Hard		3	SS	100/25	cm								
173.4			4	SS	100/18	cm	174							13 23 42 22
3.5	Silt		5	SS	100/15	cm								13 4 76 7
	Silty Sand		6	SS	100/10	cm	172							
	Trace Clay													
	and Sandy Silt		7	SS	70/15	cm								2 22 70 6
	Gravel						170							
	Occ. Cobbles		8	SS	100/28	cm								
167.8	Very Dense						168							
9.1	End of Borehole													
	Note: Borehole caved @ 7.0 m													

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

20  
15 5 (%) STRAIN AT FAILURE  
10

## UNIFIED SOIL CLASSIFICATION SYSTEM

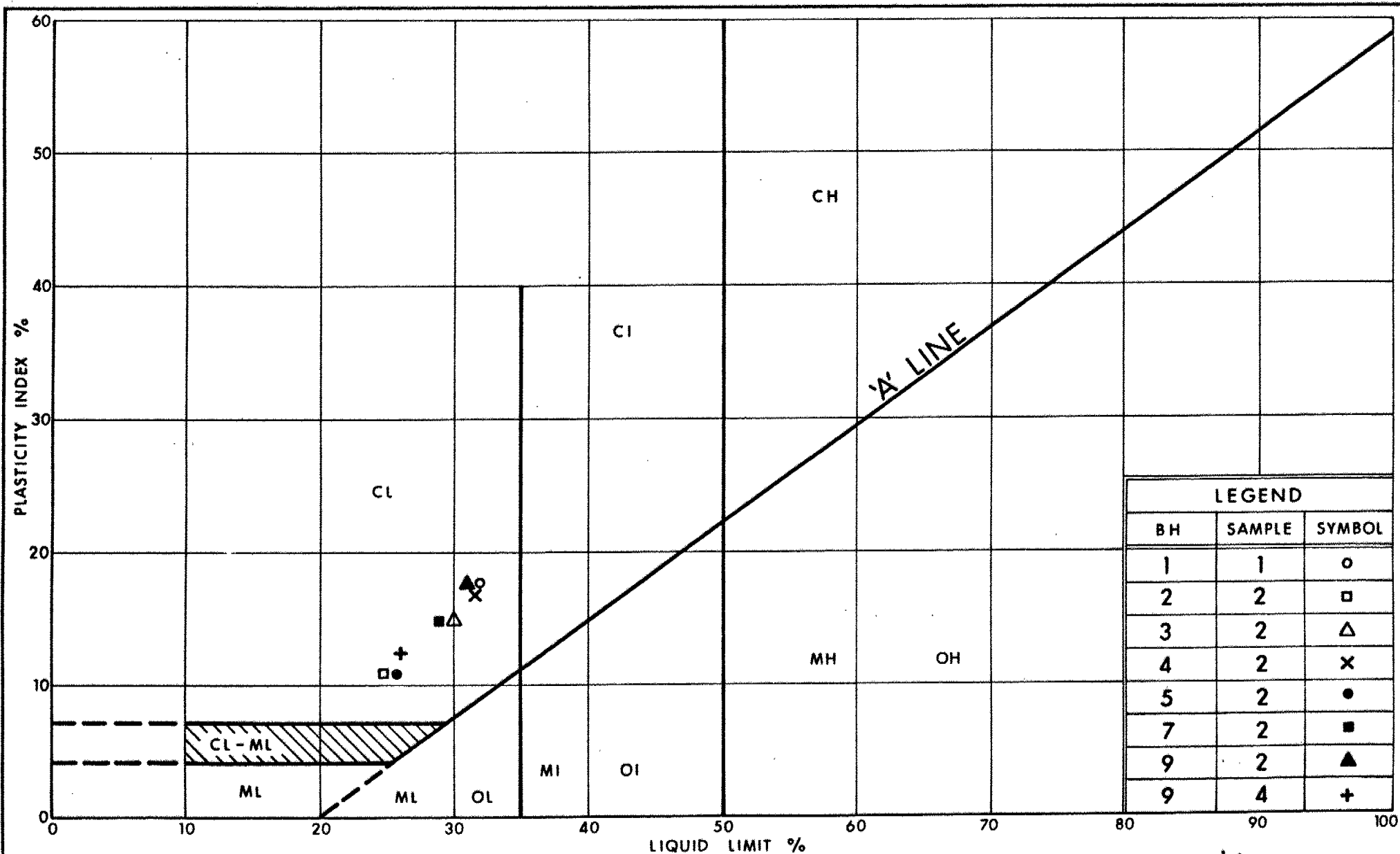


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**GRAIN SIZE DISTRIBUTION**  
**SILTY CLAY WITH SAND TRACE OF GRAVEL**

FIG No 1

W P 88-78-25



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# PLASTICITY CHART SILTY CLAY OF LOW PLASTICITY

FIG No 2

W P 88-78-25

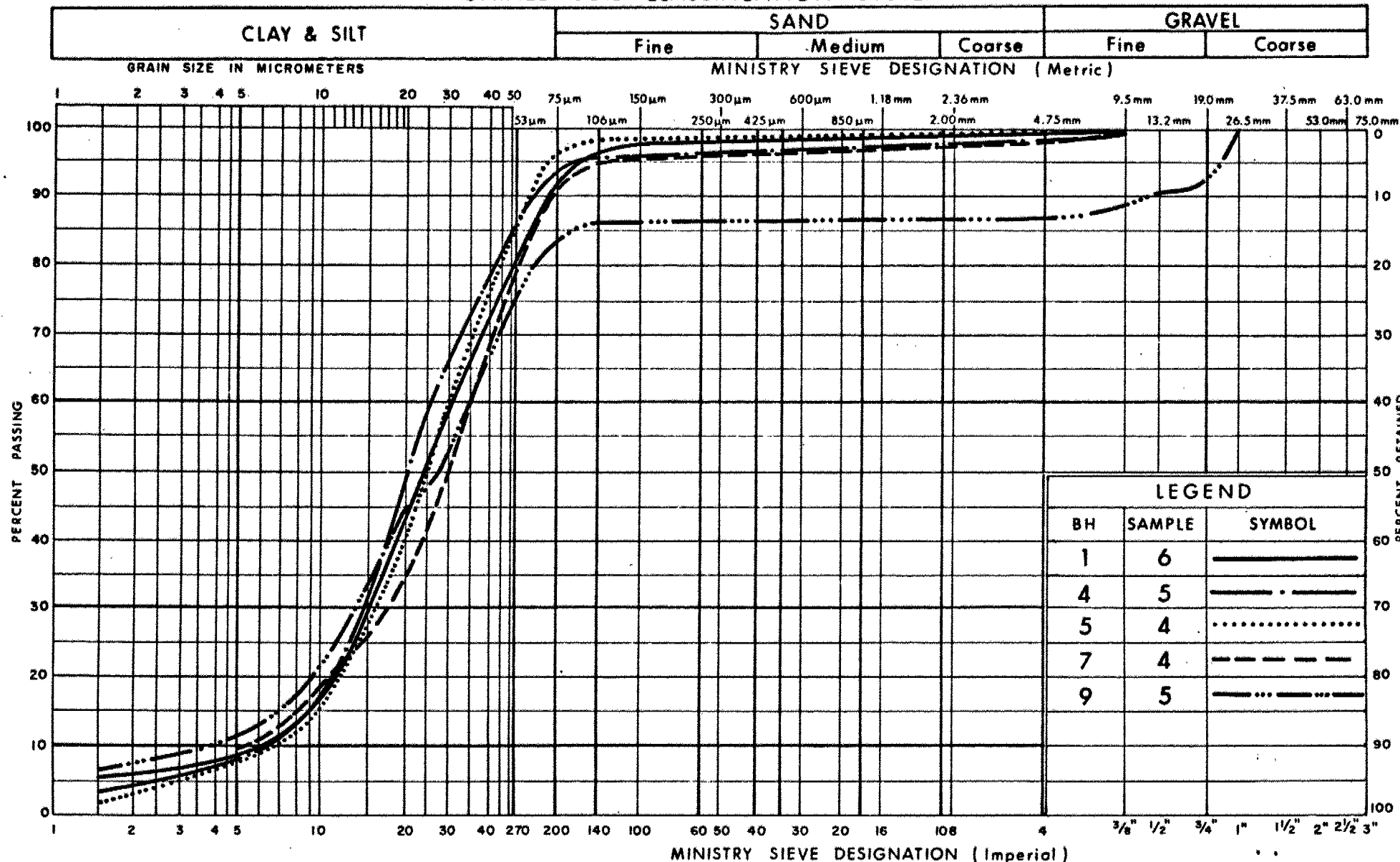




GRAIN SIZE DISTRIBUTION  
SILTY SAND, TRACE OF CLAY & GRAVEL

WP 88-78-25

## UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION  
INTERBEDDED SILT LAYERS

FIG No 4

W P 88-78-25

## 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

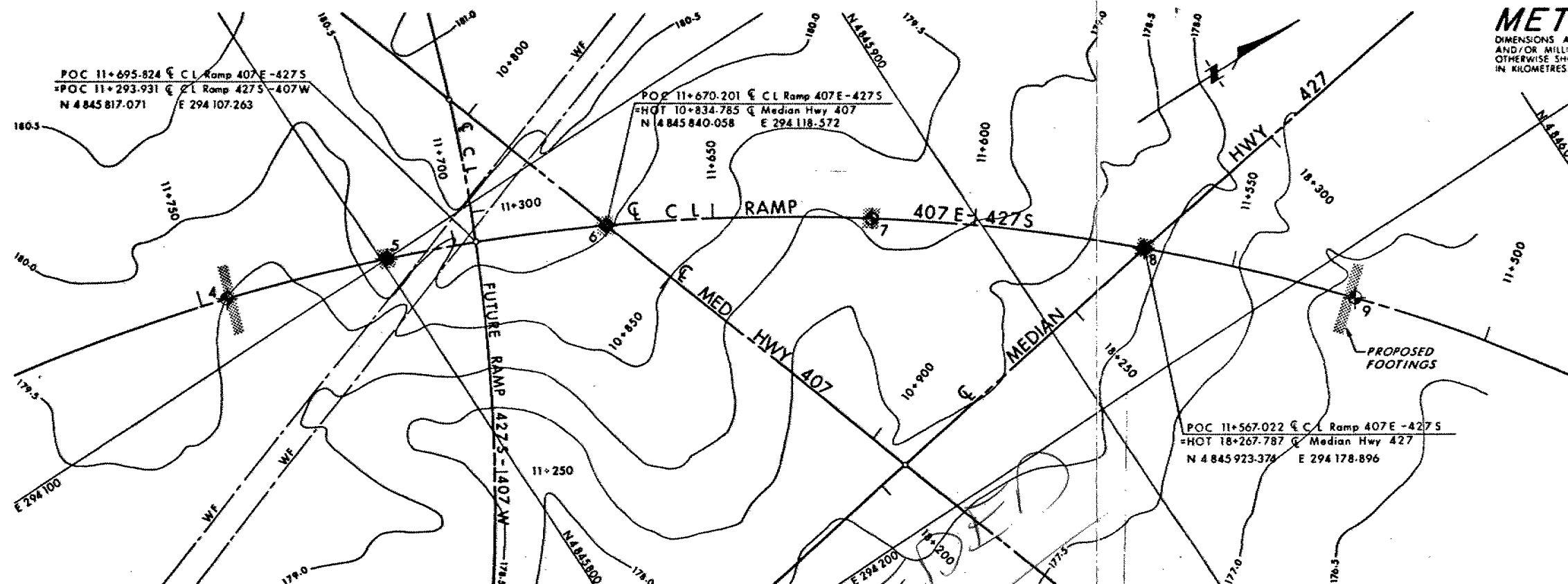
$u_w$	kPa	PORE WATER PRESSURE
$u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_t$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

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



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

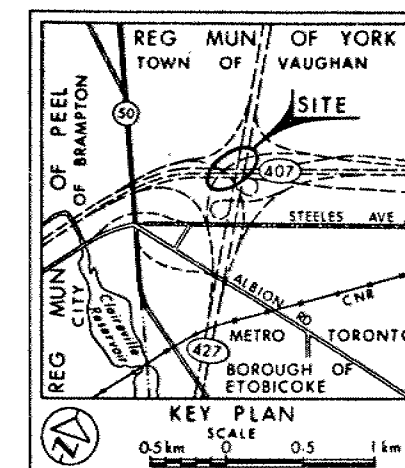
CONT No  
WP No 88-78-25

RAMP 407 E - 4275





BORE HOLE LOCATIONS &amp; SOIL STRATA



SHEET



### LEGEND

-  Bore Hole  
 Dynamic Cone Penetration Test (Cone)  
 Bore Hole & Cone  
 N Blows/0.3m [Std Pen Test, 475 J/blow]  
 CONE Blows/0.3m [60° Cone, 475 J/blow]  
 WL at time of investigation 1982 07  
 WL Not Encountered in  
 Boreholes 5, 6, 7 and 8

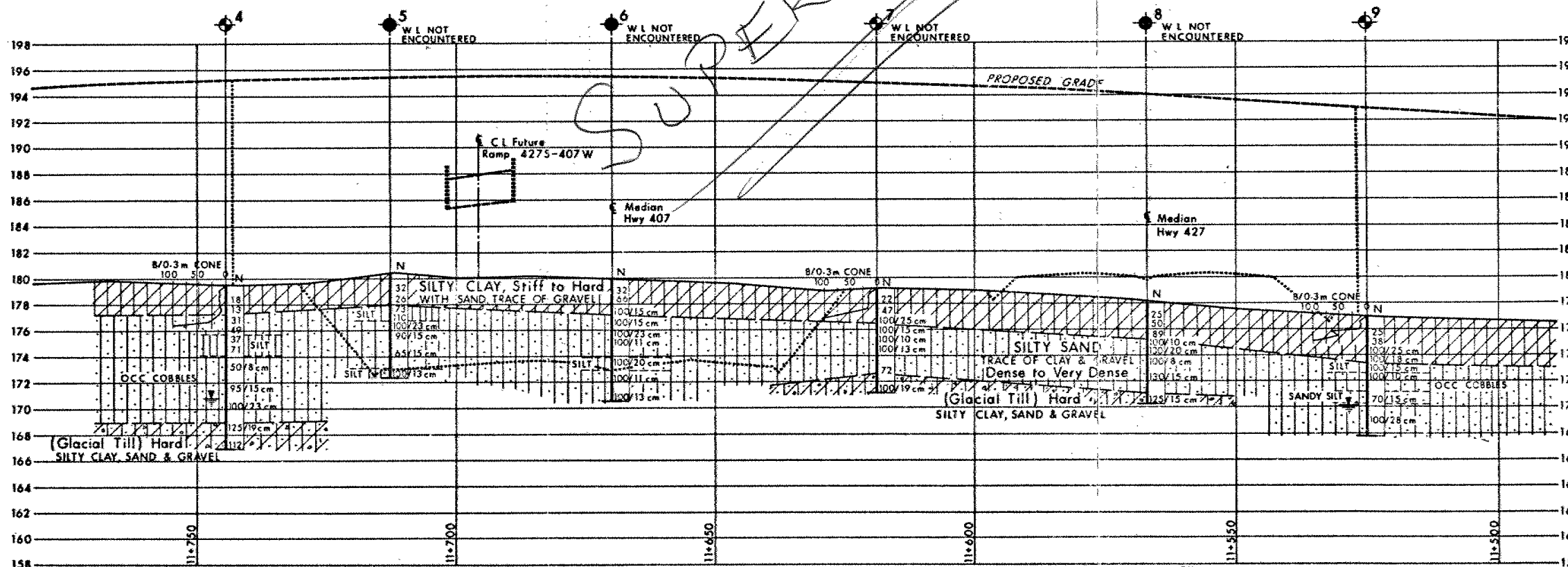
No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
4	179.4	4 845 771.3	294 089.7
5	180.4	4 845 801.0	294 100.0
6	179.9	4 845 840.0	294 118.6
7	179.2	4 845 883.2	294 145.6
8	178.1	4 845 923.5	294 178.7
9	176.9	4 845 951.7	294 208.4

**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 30M13-56			
HWY No 407 & 427			DIST 6
SUBM&DTJK	CHECKED	DATE 1982 11 10	SITE 37-23-1118
DRAWN &	CHECKED	APPROVED	DWG 887825-A



PROFILE C L RAMP 407E-427 S

SCALE

HOR 10m 5 0 10m

VERT 4m 2 0 4m



REF No COLE SHERMAN & ASSOC LTD  
Dwg No 1982-55-1F ; 1982 09 18

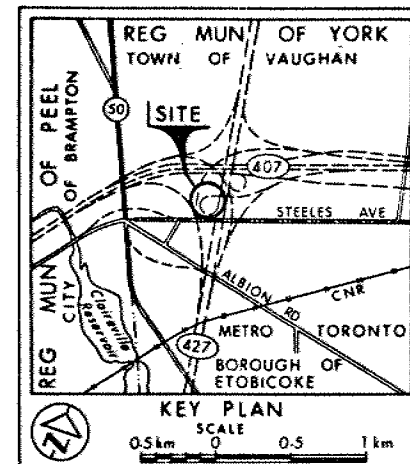
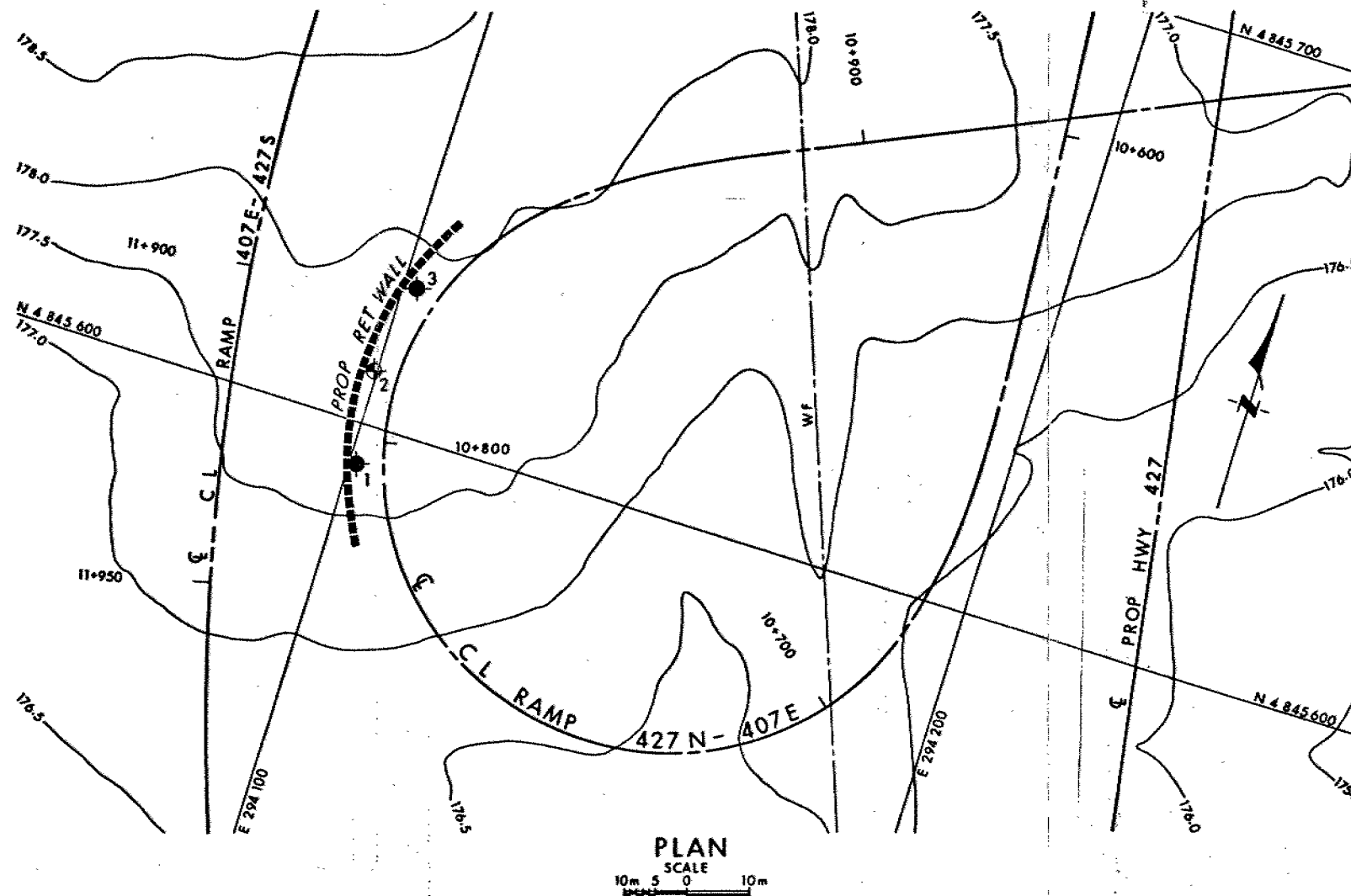
**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES UNLESS  
OTHERWISE SHOWN. STATIONS  
IN KILOMETRES + METRES.

CONT No  
WP No 88-78-25

RET WALL - RAMP 427N-407E  
ADJACENT TO RAMP 407E-427S  
BORE HOLE LOCATIONS & SOIL STRATA



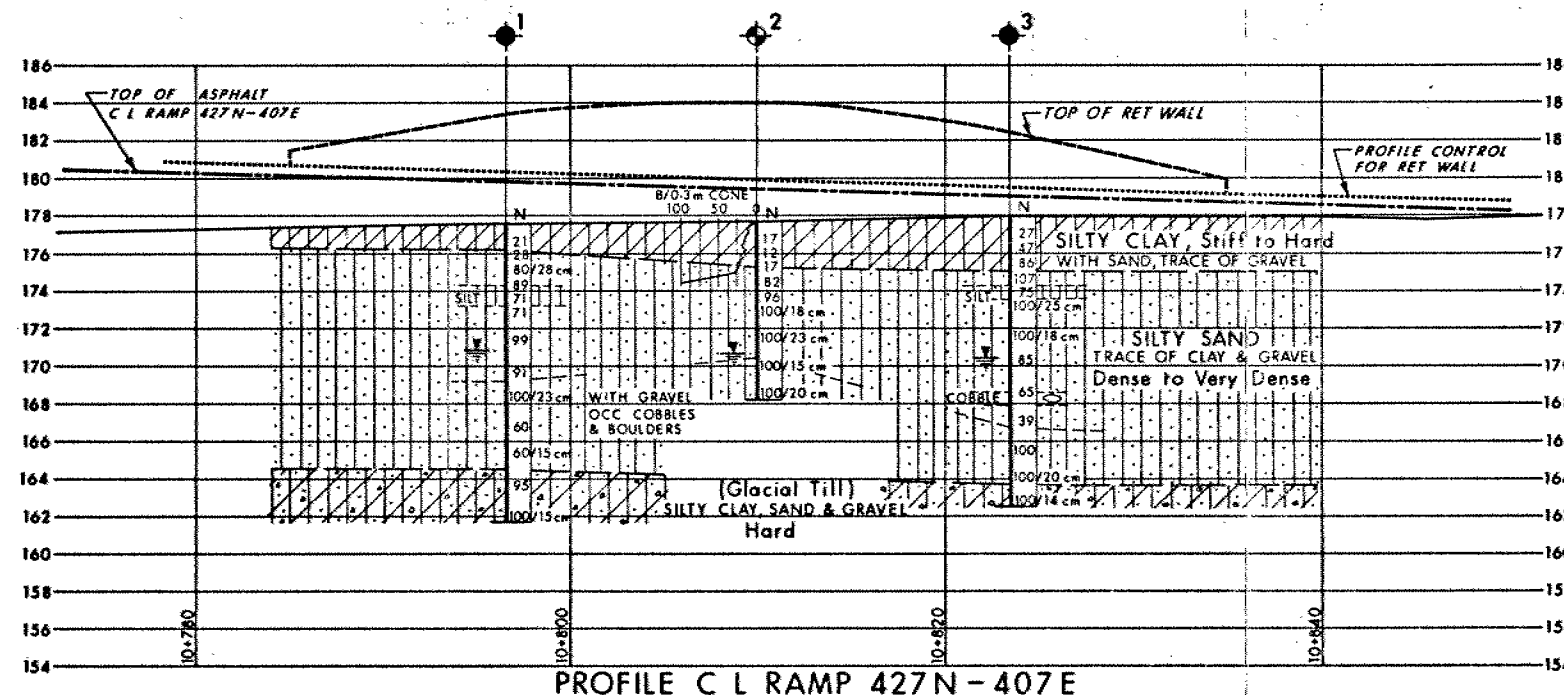
SHEET



**LEGEND**

- ◆ Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- ✚ W.L. at time of investigation 1982 07

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	177.6	4 845 593.6	294 101.2
2	177.7	4 845 608.4	294 099.5
3	178.0	4 845 623.0	294 102.0



PROFILE C L RAMP 427N-407E

**NOTE**

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

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

REV.	DATE	BY	DESCRIPTION
1			
2			
3			

Geocres No 30M13-56

HWT No 407 & 427	DIST 6
SUBMITTAL CHECKED	DATE 1982 11 09 SITE 37
DRAWN BY	DWG 887825-B

REF COLE SHERMAN & ASSOC LTD  
Dwg No 5581-52 F 1982 10 22



ADDITIONAL RECOMMENDATIONS

83 09 15

# memorandum



To: W.L. Lin  
Design Engineer  
Structural Office  
3501 Dufferin Street  
Central Region

Date: 1983 09 15

From: Pavement and Foundation  
Design Section  
Room 315, Central Building

Re: Ramp to 407E-427S Overpass  
at Hwy. 427 and 407  
W.P. 88-78-25, Site 37-73-1118  
District 6, (Toronto)

The additional foundation information for the above mentioned project has been completed. This additional work was necessitated by the lengthening of the proposed structure from 5 spans to 7 spans.

Three boreholes were completed and one piezometer was installed with borings indicating surficial deposits similar to those encountered previously. The surficial deposit in the latest boreholes is 2.8 to 4.3 m of very stiff to hard silty clay which is underlain by 6.1 to 8.1 m of very dense silty sand. In the most northeasterly section of the project a hard silty clay (glacial till) was encountered below the silty sand stratum.

The record of borehole sheets for the additional boreholes are attached along with a revised Drawing 887825-A showing the borehole locations, elevations and a profile showing a simplified stratigraphical section.

The following recommendations pertain to the design and construction of the structure foundations and related earthworks for the proposed 7 span structure.

## RECOMMENDATIONS

### Approach Embankment Stability

A more complete stability analysis in terms of total and effective stresses has been completed assuming the following soil properties:

	Unit Weight (kN/m <sup>3</sup> )	Total Stress		Effective Stress	
		Cu (kPa)	$\phi$	c' (kPa)	$\phi'$
Fill	21.2	0	30°	0	30°
Silty Clay	20.4	72	0	12	25°
Silty Sand	20.4	0	30°	0	30°

Using the above indicated soil properties it was found that the proposed 22 m fill and cut slope would have an adequate factor of safety against slope failure if the indicated 11.5 m berms are reduced to 5 m. Berms will be required between the top of the cut and toe of the fill on the south approach embankment and midheight of all fills over 11 m in both the longitudinal and transverse directions. Slopes can be constructed to a 2:1 geometry.

#### Ramp Structure Foundations

##### Abutments

The abutments should be supported on end bearing piles with bearing capacities as outlined in the foundation investigation report. Minimum pile tip elevations should be revised to 171 for the south abutment and 170 for the northeast abutment.

##### Piers

The additional piers #1 and 6 can be supported on spread footings and designed as follows:

	<u>Minimum Founding Elevation</u>	<u>Factored Bearing Capacity at U.L.S. (kPa)</u>	<u>Bearing Capacity at S.L.S. Type II (kPa)</u>
Pier #1 (Borehole #9 Location)	174.5	950	450
Pier #6 (Porehole #101 Location)	177.0	950	450

##### Dewatering

Water levels encountered in the additional boreholes and in the piezometer indicate dewatering of the footing excavations for piers #3, 4 and 5 will be required in order to prevent "boiling" of the silty sand.

This can be accomplished by using depressed perimeter ditches around the footing excavations and pumping from sumps. Completion of the Highway 407 cuts prior to footing excavation is recommended to help minimize dewatering problems as outlined in the foundation investigation report.



H. Sturm, P. Eng.  
Project Foundations Engineer

HS/mmj

Attach.

c.c. - G.C.E. Burkhardt ✓ B.J. Giroux  
R.D. Gunter ✓ R. Hore  
A. Wittenberg ✓ R. Fitzgibbon  
J. Smrcka T.J. Kovich  
K. Bassi ✓





Ministry of  
Transportation and  
Communications  
Ontario

# RECORD OF BOREHOLE No 100

METRIC

W P 88-78-25 LOCATION Co-ords N 4 845 712.2; E 294 074.5 ORIGINATED BY BER  
DIST 6 HWY 407/427 BOREHOLE TYPE Hollow Stem Auger COMPILED BY BER  
DATUM Geodetic DATE 1983 04 28 CHECKED BY CPD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
179.3	Ground Surface																
0.0																	
	Silty Clay some Sand trace Gravel Hard		1	SS	30		178										
			2	SS	41												
			3	SS	91												
175.6			4	SS	79		176										
3.7			5	SS	101	18cm											
	Silt very dense		6	SS	102		174										
			7	SS	65												
			8	SS	93		172										
	Silty Sand trace Clay trace Gravel Very Dense		9	SS	121		170										
168.2			10	SS	100	23 cm											
11.1	End of Borehole																

\*3, x5: Numbers refer to  
Sensitivity

20  
15 → 5 (%) STRAIN AT FAILURE  
10



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# RECORD OF BOREHOLE No 101

METRIC

W P 88-78-25

LOCATION Co-ords N 4 845 751.6; E 294 087.3

ORIGINATED BY BER

DIST 6 HWY 407/427

BOREHOLE TYPE Hollow Stem Auger

COMPILED BY BER

DATUM Geodetic

DATE 1983 04 28

CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
179.9	Ground Surface																
0.0	Silty Clay Some Sand Trace Gravel	very stiff	1	SS	25												1 18 44 37
			2	SS	28												
177.1		hard	3	SS	100												
2.8			4	SS	100/	20 cm											
		Silt	5	SS	100/	18 cm											1 1 94 4
			6	SS	102/	23 cm											
	Silty Sand																
	Trace Clay		7	SS	85/	15 cm											6 49 40 5
	Trace Gravel																
	Very Dense		8	SS	68/	15 cm											
			9	SS	85												
169.0			10	SS	100/	8 cm											
10.9	End of Borehole																

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

20  
15-5 (%) STRAIN AT FAILURE  
10



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# RECORD OF BOREHOLE No 102

METRIC

W P 88-78-25 LOCATION Co-ords N 4 845 974.6; E 294 234.2 ORIGINATED BY BER  
DIST 6 HWY 407/427 BOREHOLE TYPE Hollow Stem Auger COMPILED BY BER  
DATUM Geodetic DATE 1983 04 29 CHECKED BY CP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
176.5	Ground Surface																
0.0							176										
	Silty Clay very stiff		1	SS	26												
	Some Sand		2	SS	35												
	Trace Gravel		3	SS	59		174									9	22 44 25
	hard		4	SS	91												
172.2			5	SS	100/	20cm											
4.3			6	SS	100/	15cm	172										3 17 48 33
	Silt		7	SS	104/	25cm	170										5 6 86 3
	Silty Sand		8	SS	100/	18cm											
	Trace Clay		9	SS	71		168										
	Trace Gravel																
	Very Dense																
166.1							166										
10.4																	
165.4	Silty Clay (Till)		10	SS	87												
11.1	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to  
Sensitivity

20  
15 → 5 (%) STRAIN AT FAILURE  
10



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# RECORD OF PIEZOMETER No 103

METRIC

W P 88-78-25

LOCATION Co-ords N 4 845 807.5; E 294 100.5

ORIGINATED BY BER

DIST 6 HWY 407/427

BOREHOLE TYPE Piezometer

COMPILED BY BER

DATUM Geodetic

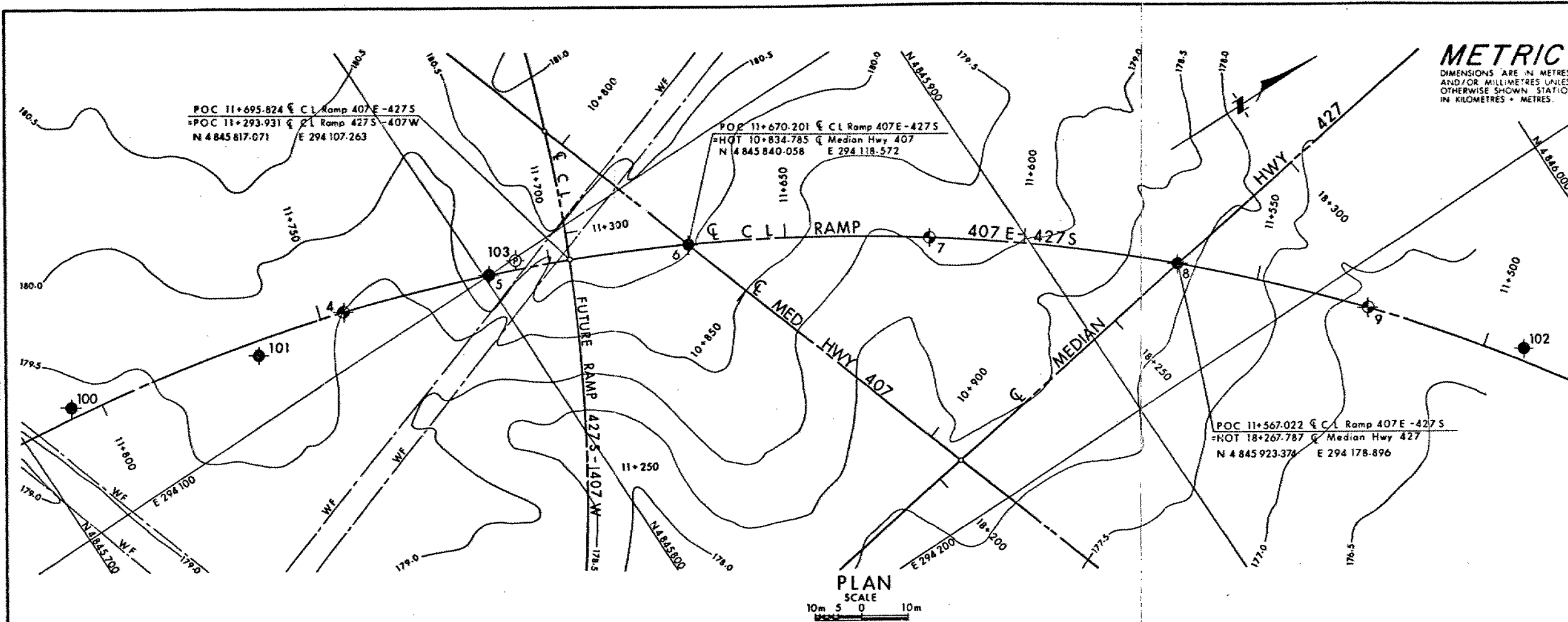
DATE 1983 04 28

CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES									
180.3 0.0	Ground Surface					180.7	180							
177.9 2.4	Probable Silty Clay				Bentonite Seal		178							
							176							
							174							
	Probable Silty Sand with Silt Seams						172							
							170							
168.1					Bentonite Seal									
12.2	Bottom of Piezometer													
	Piezometer Water Level Readings													
	Date													
	Elevation													
	83 04 28													
	83 04 29													
	83 05 06													
	83 08 19													
	83 09 14													

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10



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

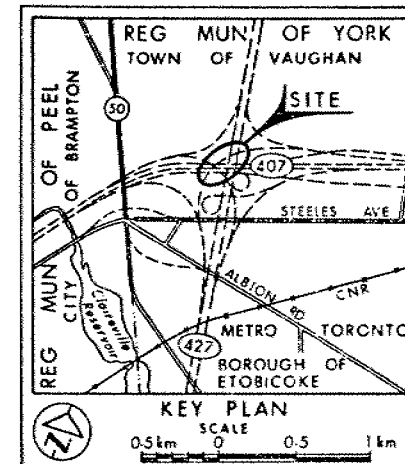
CONT No  
WP No 88-78-25

RAMP 407E - 427S

BORE HOLE LOCATIONS & SOIL STRATA



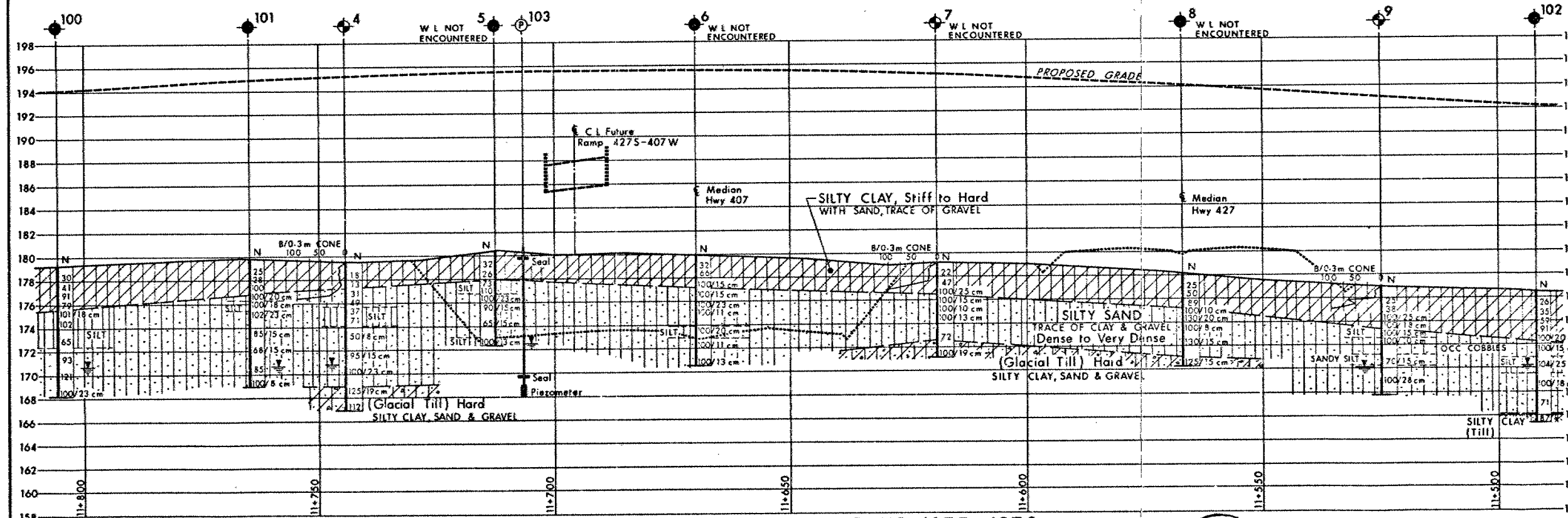
SHEET



**LEGEND**

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation 1982 07
- W.L. Not Encountered in Boreholes 5, 6, 7 and 8
- W.L. for Boreholes 100, 101 & 102; 83 04
- ⊕ Piezometer

No	ELEVATION	CO-ORDINATES NORTH	EAST
4	179.4	4845771.3	294089.7
5	180.4	4845801.0	294100.0
6	179.9	4845840.0	294118.0
7	179.2	4845883.2	294145.0
8	178.1	4845923.5	294178.7
9	176.9	4845951.7	294208.6
100	179.3	4845712.2	294074.5
101	179.9	4845751.6	294087.3
102	176.5	4845974.6	294234.2
103	180.3	4845807.5	294100.5



PROFILE C L RAMP 407E-427S

HOR SCALE 10m 5 0 10m  
VERT SCALE 4m 2 0 4m



REF No COLE SHERMAN & ASSOC LTD  
Dwg No 1982-55-1F, 1982 09 18

**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. Downview information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

DATE	BY	DESCRIPTION
1982 11 10	DATE	1982 11 10
1982 09 18	DATE	1982 09 18

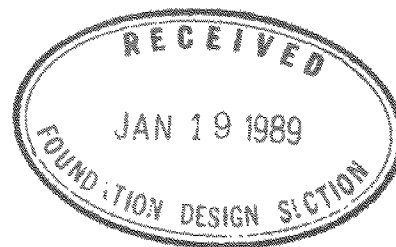
Geocres No 30M13-56  
Dwg No 407 E 427  
SITE 57-73-1118  
DWG 887825-A



Toronto Office  
January 13, 1989

WP 363-87-01

Ministry of Transportation,  
Central Region,  
5000 Yonge Street,  
Willowdale, Ontario  
M2N 6E9



Attention: Mr. G. Burkhardt, P. Eng.  
c/o Mr. Wade Young, P. Eng.

Dear Sir:

Re: Reinforced Earth Retaining Wall  
@ Ramp 427 N - 407 E  
Contract Specifications  
Our File No. T88701

Enclosed please find Section 4.9 Frictional Backfill, revised to reflect our comments on the proposed specifications. This should be read in conjunction with our comments on all other sections of the specifications which our Mr. Richard Macdonell sent to you on January 6, 1989.

Yours very truly,

REINFORCED EARTH COMPANY LTD.

Bill Brockbank, P. Eng.,  
Senior Geotechnical Engineer.

BB/jbc  
encl.

cc: Dave Dundas, MTO  
Richard Macdonell, RECO-Toronto

#### 4.9 Frictional Backfill

All backfill placed within the Reinforced Earth Volume shall be free from organic or otherwise deleterious substances and shall conform to Granular B, Type I in accordance with OPSS 1010.

Within a zone of 1200 mm immediately behind the panels, the Granular B Type 1 shall have less than 8% passing the .075 mm size.

Backfill placed within the Reinforced Earth Volume shall also meet the following electro-chemical parameters:

##### ELECTRO-CHEMICAL PARAMETER

Chlorides ( $\text{Cl}^-$ )	< 200 ppm
Sulphates ( $\text{SO}_4^{--}$ )	< 1000 ppm
Resistivity	> 1000 ohm-cm
pH	5 - 10

Backfill which conforms to Select Sub-grade Material, OPSS 1010, may be acceptable subject to approval by the Engineer.

The Contractor shall furnish the Engineer with a Certificate of Compliance, certifying that the backfill material for the Reinforced Earth wall meets the above requirements. All test results shall accompany the Certificate of Compliance.

89 01 19

Note

I called Bill Brackbank to clarify requirements for frost envelope behind wall panels & below ground surface. He will formalize this understanding.

D. Danden  
Sr. Febr Eng.

# memorandum



To: G.C.E. Burkkhardt  
Head, Structural Section  
5000 Yonge Street  
Central Region

Date: 1989 01 04

Attention: W. Younge, Structural Engineer

From: Foundation Design Section  
Room 315, Central Building

RE: Reinforced Earth Retaining Wall  
at Ramp 427N-407 E  
G.W.P. 88-78-25, W.P. 363-87-01  
Site 37-73, Hwy. 427/407 IC  
District 6, Toronto

Further to your memo dated 88 12 19, we have reviewed the proposed contract specification for the above wall.

Our comments are as follows:

- (1) The minimum requirement for backfill within the Reinforced Earth Volume is MTO Granular B Type 1.
- (2) Non frost susceptible material is specified for the frost penetration zones behind the wall face and below the surface. Fines should be restricted to less than 8%.

If there are any question, please advise.

*D. H. Dundas*

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

DHD/mmj



NOTE TO FILE

FROM: B. Brockbank

DATE: November 15, 1988

RE: Minutes of Meeting with  
MTO Foundation Design  
RECO No. 88711

PRESENT: Murty Devata (MD), MTO  
Dave Dundas (DD), MTO  
Herwig Wandschneider (HW), RECO  
Bill Brockbank (BB), RECO

-----

The purpose of the meeting was to clarify design concepts of Reinforced Earth, since the Foundation Design Section (MTO) will have to review and approve any designs that RECO gives to the Structural office (MTO).

MD stated that any concerns or questions of a geotechnical nature of RECO's should be addressed directly to the Foundation Section, as they have been asked by the Structural office to be involved.

HW explained MTO's method to set up a design contract with RECO and then RECO has a supply contract with the contractor.

R.E. Backfill

RECO stated their specifications.

MD and DD were both relieved that clay could not be used because they understood clay was acceptable.

HW stated that the Plasticity Index must be under 6. MD said he would tell the Structural office that the R.E backfill must be "noncohesive".

The depth of non-frost susceptible material shall be 4' (1.2 m), both in front and on top of R.E.

MTO stated that since the internal design was RECO's responsibility, we could use our own  $\phi$  angle (as long as it's reasonable) but should call it  $\phi_{RE}$ , so that it is not confused with the  $\phi$  which the OHBDC gives to Granular A and B (i.e. 35° and 30°). DD will send RECO the latest revision for gradation of granular material, since it has been revised from the old A, B and C.

R.E. Abutments

Although discussed very briefly, it was decided to meet again to discuss in more detail. A dated of Tuesday, December 13, 1988 at 11:00 a.m. was tentatively set. MD stated that following a very large investigation by MTO (which he will send us a copy of), it was concluded that values of 350 kPa serviceability limit state type II or 900 kPa ultimate limit state could be used for foundations on granular fill (i.e. bridge seats). These values could be used rather than the old limit of 200 kPa (unfactored) which RECO had been given for design on other projects.

R.E. Supported on Fill

RECO stated that R.E could be built directly on miscellaneous fill, provided that the fill was properly compacted to 95% standard proctor density and that MTO check the global stability.

BB/jbc

# memorandum



To: G.C.E. Burkhardt  
Head, Structural Section  
Central Region

Date: 1988 11 22

Atten: Wade Young

From: Foundation Design Section  
Room 315, Central Building

RE: Reinforced Earth Retaining Wall  
at Ramp 427N-407E  
GWP 88-78-25, W.P. 363-87-01, Site 37-73  
Hwy. 427/407 I.C., District 6, Toronto

---

Further to your memo dated 88 11 07, we have reviewed the proposal for a Reinforced Earth TM retaining wall at the above-noted site.

As part of our review, M. Devata and D. Dundas met with Herwig Wandschneider and Bill Brockbank of the Reinforced Earth Company Ltd. (R.E.) on 88 11 15 to discuss the geotechnical details of their proposal, and to develop a consensus for future R.E. projects. During this meeting it was agreed that:

- 1) The overall stability of the slope geometry resulting from the retaining wall is the responsibility of MTO. The internal stability of the reinforced earth retaining wall, its integrity within the embankment, and the performance of the wall are the responsibility of R.E.
- 2) Free-draining and non frost-susceptible materials should be used in the zone of frost penetration behind the wall face and below the ground surface behind the wall face.
- 3) R.E. will specify their requirements for backfill materials. It is understood that the backfill will be basically granular material with restrictions for grain size, plasticity index and compaction. It is also understood that R.E. assumes, on their responsibility, a  $\phi$  of  $36^\circ$  for backfill meeting their requirements. However a  $\phi$  of  $36^\circ$  is not consistent with the O.H.B.D.C. for this type of material. Consequently, any reference to a  $\phi$  requirement in the contract document will be designated as  $\phi$  RE ( $\phi$  Reinforced Earth.)
- 4) RE will include provisions for drainage of the backfill if there is concern about the drainage characteristics of the reinforced soil mass and consequently the build-up of hydrostatic pressures.

- 5) RE has indicated that the bearing pad for the wall panels may be placed on any competent material (i.e. not necessarily granular material) because the wall is flexible and any movements generated by frost action are not considered to be significant.

As previously commented on 88 10 11, we recommend that consideration be given to constructing a crest wall (founded on the slope) rather than a toe wall in order to minimize surcharge earth pressures and therefore costs.

If there are any questions, please contact this office.

*D.H. Dundas*

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

DHD/mmj

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

# OVERSIZE DRAWING

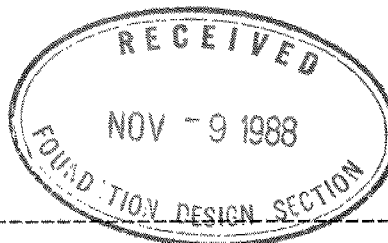
MINISTRY OF TRANSPORTATION

M E M O R A N D U M

TO: M. Devata  
Chief Foundations Engineer - East  
Foundation Design Section  
Central Bldg.  
1201 Wilson Ave.

DATE: 1988-11-07

Attention: Dave Dundas



FROM: Structural Section, Central Region

RE: Reinforced Earth Retaining Wall at Ramp 427N - 407E  
GWP 88-78-25, W.P. 363-87-01, Site 37-73  
Hwy 427/407 Interchange  
District 6, Toronto

Further to our conversation a few weeks ago, please find attached completed design drawings, numbers 88761-1 to 3 (2 sets) for the above wall.

As discussed, I wish to draw your attention to Section 1, drawing 88701-2. In the original foundation investigation carried out in 1982, reference was made to the use of a Granular 'A' pad for supporting retaining wall footings or reinforced earth retaining wall pads. The details shown on the design drawings do not comply with the recommendations of the foundation investigation. In addition, the levelling pad has not been placed low enough to provide 1.2 m of cover to the underside, although the use of a non-frost susceptible material has been indicated to a depth of 1.2 m.

During recent discussions between Mr. R. Macdonnell and the undersigned, Mr. Macdonnell suggested the following:

- (a) The placing of a Granular 'A' pad under the levelling pad only, down to competent material would result in a fairly rigid support for the levelling pad while the remainder of the R/E volume would be supported by embankment fill. This could lead to an undesirable situation where there could be differential settlement between the wall panels and the R/E volume.
- (b) The vertical loads imposed on the levelling pad are quite small. Consequently, the Granular 'A' pad need not be taken down to competent native material.
- (c) It is not necessary to place the underside of levelling pad 1.2 m below grade as long as the noted free draining material is provided to that depth. In other words, frost heave would not occur under these conditions.

We request that you review these drawings, in particular the above-noted detail, in light of Mr. Macdonnell's comments and provide us with your comments. Thank you.

For your information, we also enclose a draft construction specification and a material specification. As you may be aware, the Regional Structural Section and several other offices have been trying to formalize the above specifications such that they could be used on all future reinforced earth wall contracts.

Please call if you have any questions.



Wade F. Young  
Structural Engineer  
for:  
G.C.E. Burkhardt  
Head, Structural Section

WFY/jlk

Attach.

cc: K. Bassi\*+  
W. McFarlane\*+  
J. Klowak\*  
B. Hurd (CSA)\*+  
P. Jefford\*  
E. Heinrichs (P&R)\*+

\*Memo Only

+Drawings Sent Previously

88 10 18

memo

To: File

Re: GWP 88-78-25

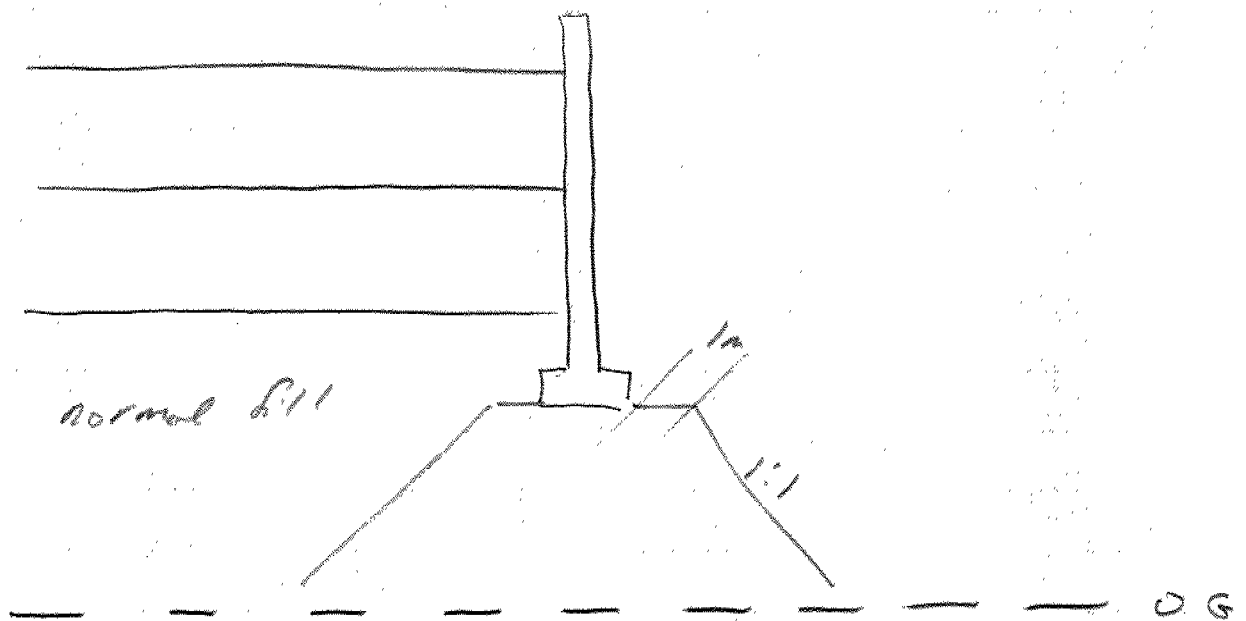
Retaining Wall (RE) at Ramp 427 N-407E

---

Wade Young indicated that RE<sup>(TM)</sup> were concerned about the use of Granular A pods for their wall.

Presently the recommendation for Gran. A pods has been interpreted to underlie only the bearing pod of the RE wall. RE is concerned that this may result in differential settlement between the reinforced zone & the facing if the zone under the reinforced zone is normal fill.





I told whole I would discuss  
with M. Quata and agreed that  
we would respond in review of drawing.

D. Denotes.  
Sr. Fda. Eng.

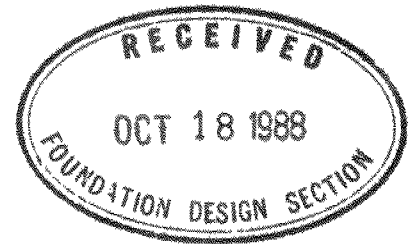
BY COURIER

Structural Section  
Central Region  
5000 Yonge Street  
Willowdale, Ontario  
M2N 6E9

Telephone: 224-7424

1988-10-14

Reinforced Earth Company Ltd.  
190 Attwell Drive, Suite 501  
Rexdale, Ontario  
M9W 6H8



ATTENTION: Mr. James Hanley

Dear Sir:

Re: Retaining Wall at Ramp 427N-407E  
GWP 88-78-25, W.P. 363-87-01, Site 37-73  
Hwy 427/407 Interchange  
District 6, Toronto  
Your File No. T88701

---

We are returning one set of RECO Drawings Nos 88701-1, 2 and 3, which you submitted on 1988-09-22, with our comments marked in red. The significant points are as follows:

- (a) The reinforcing in the wall panels should be epoxy coated.
- (b) All drawings will require two Professional Engineers' stamps, representing the designer and the checker.
- (c) The horizontal offset of the face of retaining wall to centreline control line Ramp 427N-407E has been increased by 0.025 m to 6.150 m to allow for expansion joint filler material between the wall and the future barrier wall.
- (d) The majority of the levelling pad will be placed at an elevation which is higher than existing ground. This will necessitate the removal of surficial organic material and the placement of compacted Granular 'A' up to the underside of the levelling pad. This was noted in our previous letter of 1988-09-09 with an attached sketch. We have also sketched this on Dwg 88701-2.

Associated with the above, please show the existing ground elevations on Dwg 88701-3.

- (e) The upper and lower limits of the Reinforced Earth Volume needs to be clarified.
- (f) The elevations shown for the top of the levelling pad do not appear to provide a minimum 1.2 m frost cover to the underside.
- (g) There seems to be some discrepancies in the top of coping elevations. Please see comments on drawings.


Please call when you have received our comments so that we may discuss these matters in order to expedite the work. Thank you.

During our conversation earlier this week, you suggested that if you receive our comments by 1988-10-14, your present workload would permit you to provide us with completed drawings and documents before 1988-10-28. We would appreciate your efforts to accomplish this.

With regard to your letter request to have "the maximum applied bearing pressures and overall global stability reviewed by the Geotechnical Engineer", we reply as follows.

- i) The maximum allowable pressures were shown on the attachment with our letter of 1988-09-09 (300 kpa at SLS II).
- ii) Deep seated failure has been checked by our Foundation Section and we have been advised verbally that there is no problem in this regard. This will be confirmed to us later in writing.

Yours truly,

  
W.F. Young  
Structural Engineer  
G.C.E. Burkhardt  
Head, Structural Section

WY/jlk  
attachment

cc: K. Bassi  
D. Dundas  
J. Klowak  
P. Jefford  
E. Heinrichs (Proctor & Redfern)  
B. Hurd (Cole Sherman)

REPLY  
COPYSEND  
TO

Dave Dundas, Sr. Fdt. Eng.  
Foundation Design Section

WP 88-88-25

SUBJECT

Central Bldg.  
Structural Section - Central Region  
427/407 I.C. - Reinforced Earth Retaining Wall

88-09-27

Enclosed, please find 2 sets of Dwg. 88701-  
1, 2 + 3 for your review & comments by Oct. 7/88

V.F. Boehnke

REPLY

To: V.F. Boehnke  
Sr. Structural Eng.  
Structural Section  
Central Reg.

88 10 11

D.H. Dundas  
Sr. Fdt. Eng.

Further to my telephone conversation with your Wade Young, (488 10 11) we have reviewed the noted drawings and offer the following comments.

- No deep-seated stability problems are anticipated for this proposal

- Consideration could be given to constructing the wall up the slope rather than at the toe in order to minimize surcharge earth pressures

REPLY FROM

REPLY DATE

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 30M13-051

DIST. \_\_\_\_\_ REGION \_\_\_\_\_

W.P. No. 88-78-08

CONT. No. 89-62

W. O. No. \_\_\_\_\_

STR. SITE No. 37-73-1128

HWY. No. 407

LOCATION Proposed <sup>Hwy</sup> ~~4~~ 27 Crossing

No of PAGES -

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. \_\_\_\_\_

REMARKS: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

DIST #6

CONT NO

WP NO 00-10-08

2A

SHEET

HIGHWAY 27 4 PAGES

AT HIGHWAY 407

GENERAL ARRANGEMENT

Wyllie & Umlal

consulting engineers

METRIC

19.0

PAVED SHOULDER

DIMENSIONS ARE IN METRES

UNLESS OTHERWISE SPECIFIED

ELEVATIONS, COORDINATES, CURVE

AND ALIGNMENT DATA ARE IN METRES

STATIONS ARE IN KILOMETRES + METRES

- GENERAL NOTES:
1. CLASS OF CONCRETE

DECK & PIER COLUMNS 35 MPa

ABUTMENTS & WING WALLS 30 MPa

REINFORCING 30 MPa
2. CLEAR COVER TO REINF. STEEL

FOOTINGS 100 mm

DECK TOP 50 mm

DECK BOTTOM 50 mm

PIERS, ABUTMENTS & WING WALLS 50 mm

PROTECT FACES 100 mm

REINFORCING 100 mm

UNLESS OTHERWISE NOTED
3. REINFORCING STEEL

REINFORCING STEEL SHALL BE GRADE 400

UNLESS OTHERWISE SPECIFIED

BAR MARKS WITH SUFFIX 'C' DENOTE

COATED BARS
- CONSTRUCTION NOTES:
- BEARING SEATS SHALL BE FINISHED

LEVEL TO THE SPECIFIED ELEVATIONS

- LIST OF DRAWINGS:
1. GENERAL ARRANGEMENT

2. SOIL STRATA & BOREHOLE LOCATIONS

3. FOOTING DETAILS

4. SOUTH ABUTMENT - I

5. NORTH ABUTMENT - I

6. BEARING DETAILS

7. PIER DETAILS

8. DECK LAYOUT

9. LONG/CABLE DETAILS

10. TRANSV. CABLE DETAILS

11. DECK REINFORCING - I

12. JOINT ANCHORAGE & ARMOURING

13. BARRIER WALL ON SIDEWALK

14. RAILING FOR BARRIER WALL

15. 6000 mm APPROACH SLAB

16. DETAIL OF CONC. SLOPE PAVING

17. STANDARD DETAIL

18. BRIDGE DATA & SITE NUMBER DATA

19. AS CONSTRUCTED ELEV'S & DIM'S

20. ELECTRICAL EMBEDDED WORK - I

21. QUANTITY STRUCTURE - I

STANDARD DRAWINGS

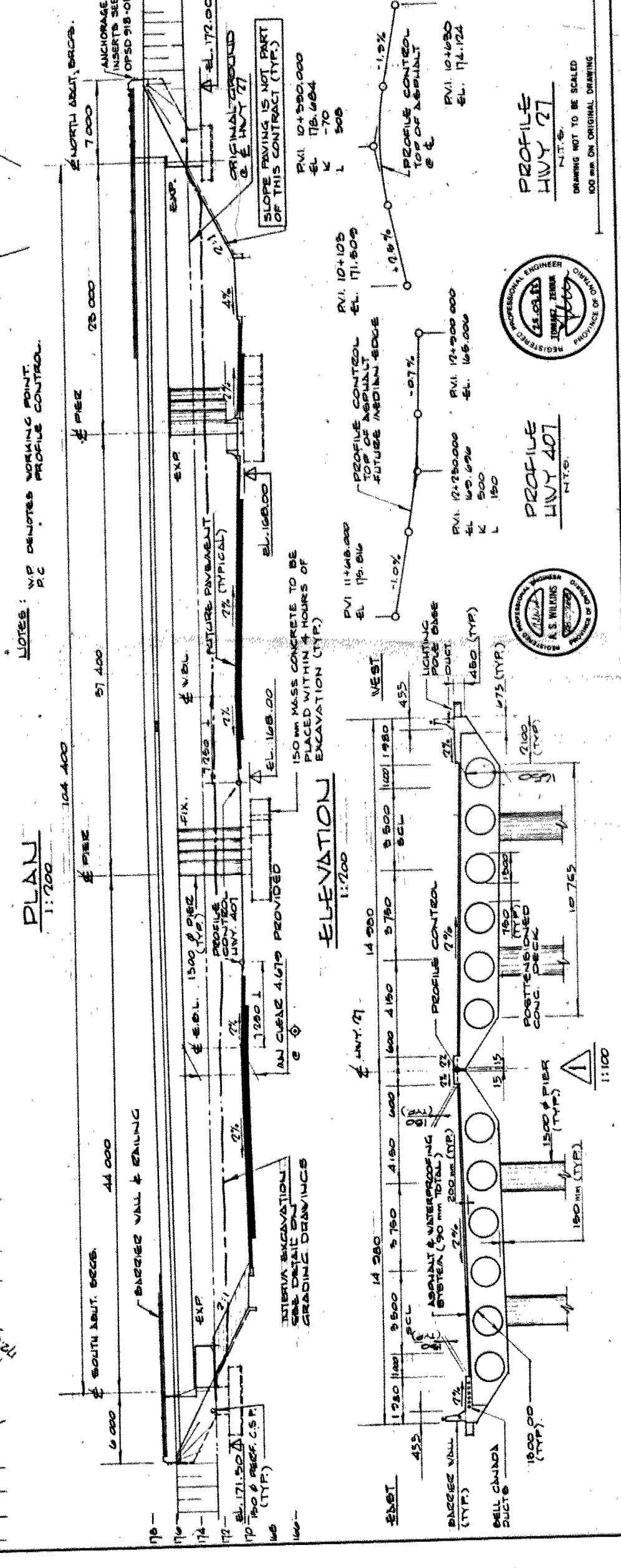
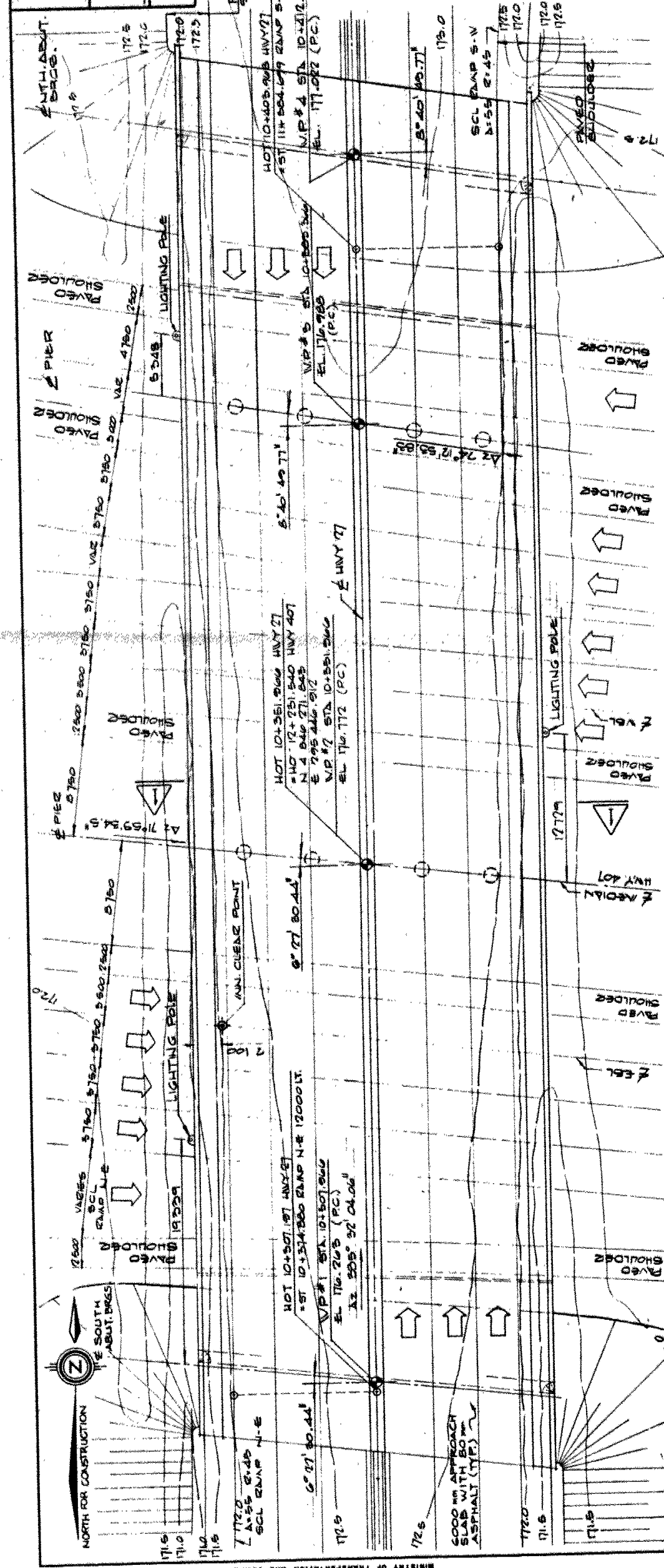
DD-3503 - MIN. GRANULAR BACKFILL REQ'D

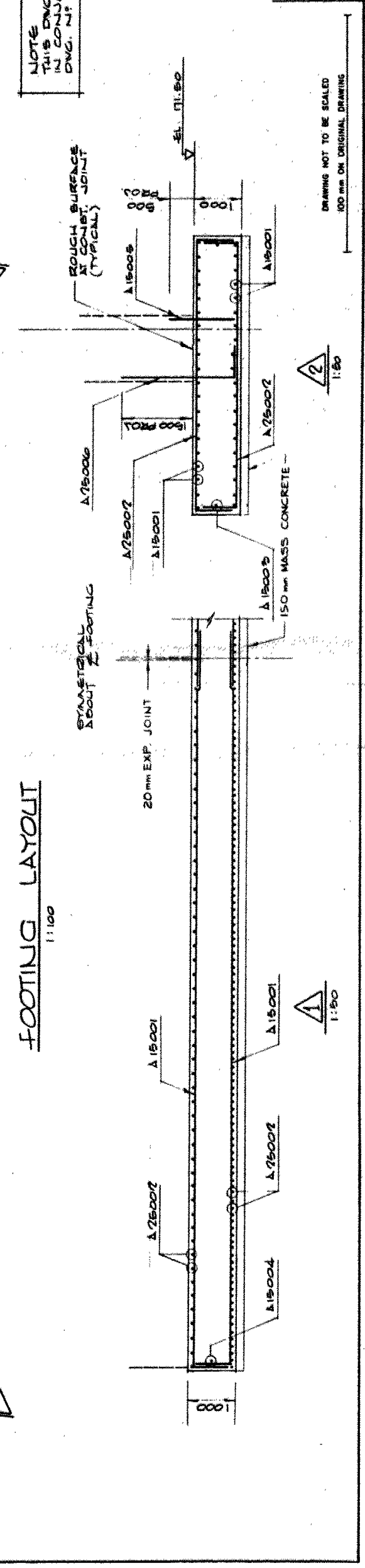
OPSD 508-2 BRIDGE DECK WATERPROOFING TO

OPSD 918-0 DOWEL DETAIL CONNECTION TO

NEW STRUCTURES

NO.	DATE	BY	DESCRIPTION
1			DESIGN
2			CHECK
3			REVISION





# memorandum



To: G. Al-Bazi  
Design Engineer  
Structural Office  
3501 Dufferin Street

Date: 88 11 07

Attention: I. Husain

From: Foundation Design Section  
Room 315, Central Building

RE: Final Review  
Hwy. 27 Underpass  
W.P. 88-78-08, Site 37-73-1128  
Hwy. 407, District 6, Toronto

---

Further to your memo date 88 08 03, we have reviewed the final design package for this project. The final design was originally reviewed by this office on 83 03 15 and we have no further comment.

A handwritten signature in cursive script that reads "D.H. Dundas".

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

for

M. Devata, P. Eng.  
Chief Foundation Engineer

DHD/MD/mmj



# memorandum



To: Mr. W.L. Lin  
Design Engineer (Central)  
Structural Office  
3501 Dufferin St., 4th Floor

Date: 83 03 15

From: Pavement & Foundation Design Section  
Room 315, Central Bldg.  
Downsview

Re: Highway 27 Underpass at Highway 407  
W.P. 88-78-08, Site 37-73-1128  
District 6, Toronto

---

We have reviewed the final bridge drawings for the above-mentioned site and provide the following comment:

In our memo of 82 04 20 which was attached to the foundation report, we recommended a founding elevation of 171.0 or lower for the north abutment. However, we note that the specified founding elevation is 171.25. We suggest lowering this to elevation 171.0 in order to ensure that any soil disturbed during construction of Hwy. 27 is removed.

A handwritten signature in cursive script that reads "Brian Ruck".

Brian Ruck  
Trainee Engineer

For: M. Devata, P. Eng.  
Senior Foundations Engineer

BR:syc

# memorandum



To: Mr. W.L. Lin  
Design Engineer  
Operating Section  
Central (5000 Yonge St.) Reg.

Date: 82 08 25

From: Pavement & Foundation Design Section  
Room 315, Central Bldg.  
Downsview

Re: Hwy. 27 U/P at Hwy. 407  
W.P. 88-7808, Site 37-73-1121  
District 6, Toronto

We have reviewed the preliminary drawing (P-1) for the above-mentioned structure and provide the following comment:

- 1) The site should be properly graded and drained to prevent ponding of water and possible softening of founding subsoil, provided an interim grade is required.

A handwritten signature in black ink, appearing to read "Tom Kazmierowski".

Tom Kazmierowski, P. Eng.  
Foundations Engineer

TK:syc

SEND  
TO

MR. M. L. VATA

FOUNDATION DESIGN SECTION  
3RD FLOOR, CENTRAL BUILDING.

ATTN

MR. D. DUNDAS.

FEB : C 1989

FOUND. TIO. DESIGN

DATE 89-02-07

FROM

P. K. ROY, STRUCTURAL SECTION

SUBJECT

CULVERT AT HWY. 27, W.P. 88-78-07  
DISTRICT 6, TORONTO.

ENCLOSED PLEASE FIND 3 DRAWINGS SHOWING THE  
LOCATION ~~OF~~ ~~THE~~ AND DETAILS OF ABOVE  
MENTIONED CULVERT.

PLEASE ADVISE US WHETHER WE HAVE TO  
PROVIDE WORKING SLAB FOR THE CULVERT.

Pky

REPLY RE: WP 88-78-07 CULVERT @ HWY 27

The drawings provided have been reviewed and, as  
was discussed between yourself and D. Dundas on  
89-02-01 and reconfirmed in our telephone conversation  
of 89-02-14, a working slab is recommended  
at this culvert location.

REPLY FROM

B. Bennett

REPLY DATE

89-02-14

HIGHWAY 407 AND HIGHWAY 27  
W.P. 88-78-08, SITE 37-1121,  
DISTRICT 6, TORONTO

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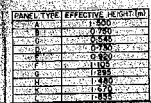


VIEW OF HIGHWAY 27 (LOOKING NORTH)

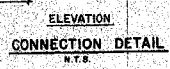


VIEW OF HIGHWAY 27 (LOOKING SOUTH)

and also Little River  
dated R. N. 22



**TYPICAL ELEVATION (FRONT FACE)**  
1.75



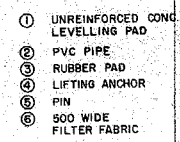
1-1      SECTION 2-2



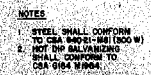
1-1      SECTION 2-2



### SECTION 3-3



TYPICAL GENERAL ARRANGEMENT




TIE STRIP - TYPE 'T'

DIMENSIONS ARE IN MILLIMETRES  
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ELEVATIONS, COORDINATES, CURVE  
AND ALIGNMENT DATA ARE IN METRES.  
STATIONS ARE IN KILOMETRES + METRES.

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**Reinforced Earth Company Ltd.**  
190 Astwell Drive, Suite 501 (416) 674-1818  
Rexdale, Ontario M9W 6H8

CONT No WP No	
HWY 427-407 INTERCHANGE	SHEET

- [illegible]

REVISIONS				
	DATE	BY	DESCRIPTION	
DESIGN	CHECK	LOADING	DATE	
DRAWING	CHECK	SITE	CWS	

DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

27

85701-2

SECTION 10

SECTION 10

SECTION 10

SECTION 10

# METRIC

DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No  
WP No

HWY 427-407 INTERCHANGE

SHEET

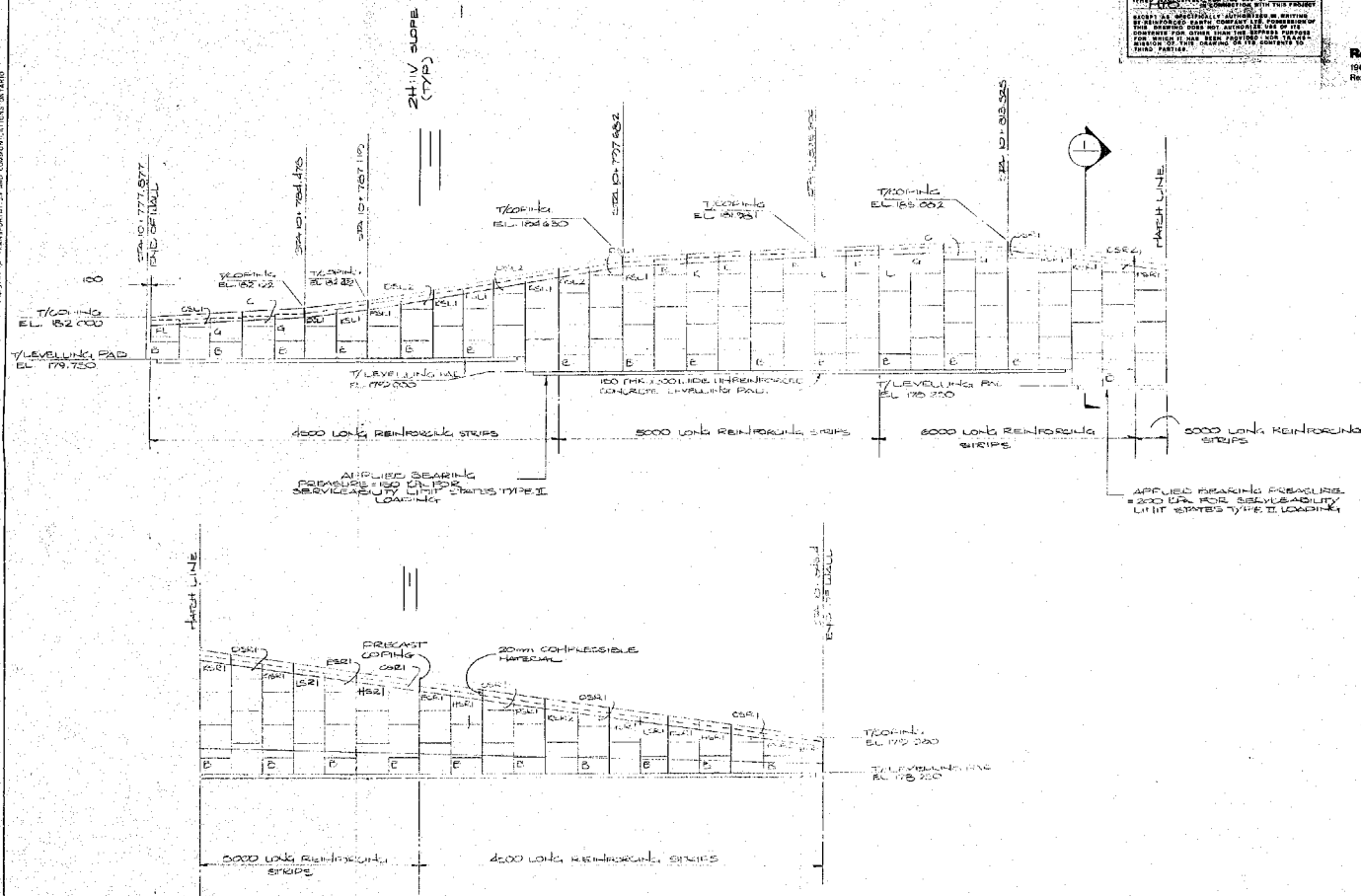
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(416) 674-1818

REINFORCED EARTH



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DATE	BY	DESCRIPTION	DATE
DESIGN	CHK	CODE	LEAD
DRAWN	CHK	SITE	STRUCT
			SCHEME
			DWG

88701-5