

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 30M13-80

DIST. 6 REGION

W.P. No. 138-87-09

CONT. No. 90-60

W. O. No.

STR. SITE No. 37-1183

HWY. No. 400

LOCATION Ramp 407 EW to 400 South  
over Ramp EW to S (Bridge #20)

No of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

ENGINEERING MATERIALS OFFICE  
FOUNDATION DESIGN SECTION

*CONT 90-60*

WP 138-87-09

DIST 6

HWY 407

STR SITE 37-1183

Bridge #20  
Hwy. 407 EW - 400 S.B.L.

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FOUNDATION INVESTIGATION REPORT  
for  
BRIDGE #20  
HWY. 407 EW - 400 S.B.L.  
W.P. 138-87-09, Site 37-1183  
District #6, Toronto

INTRODUCTION

This report summarizes the foundation investigation for the proposed new bridge that will carry ramp 407 E.W. over existing ramp Steeles Ave. E.W. to highway 400 S.B..

The field work was carried out from 88 01 11 to 88 01 23, utilizing a continuous flight auger machine, equipped with 82 mm I.D. hollow stem augers and B casing. The investigation consisted of 5 sampled boreholes and 5 dynamic cone penetration tests. The boreholes ranged from 14.2 m to 30.9 m in depth.

Groundwater levels were measured in open holes at each borehole location.

Site Description

The site is located in the northwest quadrant of the existing Steeles Ave/Highway 400 interchange. It is bordered to the north by the CNR railway line, to the east by Highway 400, to the south by Steeles Ave. and by private property to the west.

Both Highway 400 and Ramp Steeles Ave. E-W 400 S are built on 4 to 7 metre high fills.

Subsurface Conditions

The subsurface conditions generally consist of 6 m of Sand (Fill) which represents the existing ramp EW 400 S. Underlying the fill material is a deposit of Clayey Silt (Glacial Till) averaging 12 m in thickness. The glacial till overlies a thick deposit of sand. The limits of the sand layer were not established during the investigation.

The boundaries of the subsoil types, laboratory test results, and groundwater levels are shown on the Record of Borehole log sheets contained in the Appendix. The locations and elevations of the boreholes, along with the stratigraphical profile are shown on Drawing 1388709-A.

The various soils encountered at this site are described as follows:

Sand (Fill)

The existing ramp E-W 400 S is composed mainly of non-cohesive granular fill material. The top layer consists of granular road bed material, while the remaining consists primarily of sand.

The thickness of the fill material corresponds to the height of the ramp above original ground, ranging between 5.5 to 7.0 m.

From the 'N' values of the Standard Penetration Test, the material can be described as moderately to well compacted.

Clayey Silt and Sand Mixture (Fill)

The side slopes of ramp EW 400 S are covered with a mixture of non-cohesive sand and cohesive clayey silt (BH #5 and #6). The sand is the same material as described above.

The presence of the clayey silt can be attributed to the fact that the side slopes were covered with native material to protect the embankment from erosion.

The thickness of this layer is approximately 2.5 m, and based on the 'N' values from the SPT test, can be described as in a very loose to loose state.

Heterogeneous Mixture Clayey Silt (Glacial Till)

This material was encountered in all boreholes and represents the original ground level for the area.

It is a deposit of cohesive, low plasticity material, ranging in thickness from 12.2 to 13.8 m. Silt and sand seams occur intermittently, and cobbles were encountered in borehole #4.

Based on 'N' values the material can be classified as firm to hard.

Typical laboratory values are as follows:

	<u>Range (%)</u>	<u>Average (%)</u>
Water Content (w)	8.5-21.0	14.8
Liquid Limit (W <sub>L</sub> )	13.0-34.5	22.4
Plastic Limit (W <sub>p</sub> )	10.0-22.0	13.9

Figure 1 illustrates a typical plasticity chart for this material based on representative samples from the entire site.

Figure 2 represents a typical grain size distribution for the material, based on representative samples obtained from the site.

Sand Some Silt

This deposit underlies the clayey silt till in all areas. The vertical extent of the deposit was not established during the investigation.

It can generally be categorized as silty sand with occasional sandy silt pockets (Borehole #3).

This layer is non-cohesive and water bearing. Boiling conditions were noted as the sand layer was penetrated in boreholes #3, 4, and 6.

The material is in a loose to very dense state based on SPT 'N' values.

#### Groundwater

The groundwater levels were measured in open boreholes, with elevations ranging from 185.4 m to 187.9 m.

Due to the short period of time that boreholes #3 and 6 were open, their water levels are not considered to be stabilized.

Boreholes number 1, 4 and 5 offer a more representative stabilized ground water level. From the information available, the groundwater level is estimated to be at elevation 186.0 m.

### Discussion

The proposed bridge is a single-span rigid frame structure with retaining walls on both sides of each abutment. This structure will carry ramp 407 EW over existing ramp Steeles Ave E-W to Hwy 400 Southbound.

The original ground in the area is approximately 4 to 7 metres below the profile grade of highway 400 and the existing ramp E-W 400 S. Both highway 400 and ramp E-W S are built on fill material.

The proposed profile grade of highway 407 is approximately 7 m above the existing ramp E-W 400 S and 12 m above original ground. This presents potential difficulties for founding the structure on original ground due the height of the abutment walls which would be required to reach profile grade.

The height of the proposed Hwy. 407 fills also present potential slope stability problems.

### Structure Recommendations

#### Abutment Foundations - Option I - End Bearing Steel H-Piles

The abutments may be founded on end-bearing steel H-piles, 310 HP 110.

Piles are to be driven in accordance with MTO standards SS103-10 or SS103-11. It is recommended to control pile driving by the Hiley Formula, utilizing an ultimate capacity of 1900 kN. Recommended minimum hammer energy is 50,000 joules per blow.

Pile driving is to be controlled from an elevation of 174.0 onward. It is possible to attain refusal in the stratum between elevation 174.0 and 170.0, due to the irregular nature of the subsoil condition. However for estimating purposes, pile lengths are to be calculated based on a final pile tip elevation of 170.0 m.

The following O.H.B.D.C. design loads are recommended for piles driven in accordance with the above recommendations:

<u>Pile Type</u>	<u>Factored Capacity at U.L.S.</u>	<u>S.L.S. Type II</u>
310 HP 110	950 kN	625 kN

Option II - Spread Footings on Compacted Fill

The abutments may be founded on compacted granular 'A' fill. The fill is to be constructed in accordance with figure 3, with side slopes at a minimum of 1H to 1V in all directions, and compacted in accordance with OPSS 501.

The following O.H.B.D.C. bearing capacity values may be utilized for design:

<u>Factored Capacity at U.L.S.</u>	<u>S.L.S. Type II</u>
900 kPa	350 kPa

Before construction of the fill begins, excavation of the existing overburden to an elevation of 184.0 m is recommended.

Settlement of the fill should be negligible if properly constructed.

Option III - Spread Footings

Spread footings can be founded on native soil (Clayey silt - glacial till) at an elevation of 182.0 m.

The following O.H.B.D.C. values for bearing capacity may be used for footing designs:

<u>Factored Capacity at U.L.S.</u>	<u>S.L.S. Type II</u>
670 kPa	450 kPa

## Retaining Walls

### Option I - Spread Footings on Compacted Fill

Retaining walls may be founded on compacted granular 'A' fill as described under abutment foundations.

Design loads and construction standards previously described may also be used for retaining wall design.

The granular 'A' fill is to be constructed from original ground to the footing elevation.

### Option II - End Bearing Steel H-Piles

Alternatively the retaining walls may be founded on steel 310 HP 110 piles. The design values given for the abutments may also be used for the retaining walls.

### Option III - Non-conventional Retaining Wall

Alternatives such as Geogrid Reinforced Earth Embankments with 1:1 slopes or reinforced earth wall systems may be considered instead of a conventional retaining wall.

However it should be noted that the system should ensure overall stability within the fill. Once the final geometries of the wall are available, this section will analyse the requirements and provide appropriate recommendations.

## Earth Pressure

Backfill to structures should consist of free-draining granular materials, in accordance with MTO special provision #121.

Computation of earth pressures should be in accordance with section 6.6.1.2 of the O.H.B.D.C..

For retaining walls, the active case should be considered for design. For the rigid frame abutment walls, the 'at-rest' case should be used for design.

The following unfactored values can be used for calculating lateral earth pressures:

	<u><math>\gamma</math></u>	<u><math>\phi</math></u>	<u><math>K_A</math></u>	<u><math>K_0</math></u>
Granular 'A'	22.0 kN/m <sup>3</sup>	35°	0.33	0.50
Granular 'B'	21.2 kN/m <sup>3</sup>	30°	0.27	0.43

Compaction of granular backfill in the vicinity of the structure walls and retaining walls shall be in accordance with OPSS 501 and MTO directive B-131.

#### Lateral Resistance

For footings placed on compacted granular 'A' fill, the sliding resistance between the concrete base and the fill material can be computed in accordance with section 6.7.3.3.2 of the O.H.B.D.C., assuming an unfactored  $\phi$  value of 35°.

For footings placed on the clayey silt till, adhesion between the soil-footing interface may be computed using an unfactored adhesion value of 75 kPa.

#### Roadway Protection

To protect the slopes of existing ramp E-W 400 S, a shoring system is required for any excavation deeper than 1.2 m, where 1:1 slopes cannot be maintained.

### Dewatering

Dewatering of excavations can be accomplished by using a sump system.

In order to facilitate the placement of structural steel and to protect the excavation base from softening by water ponding, it is recommended that a 75 mm lean concrete working slab be placed at the base of the excavation.

### Frost Protection

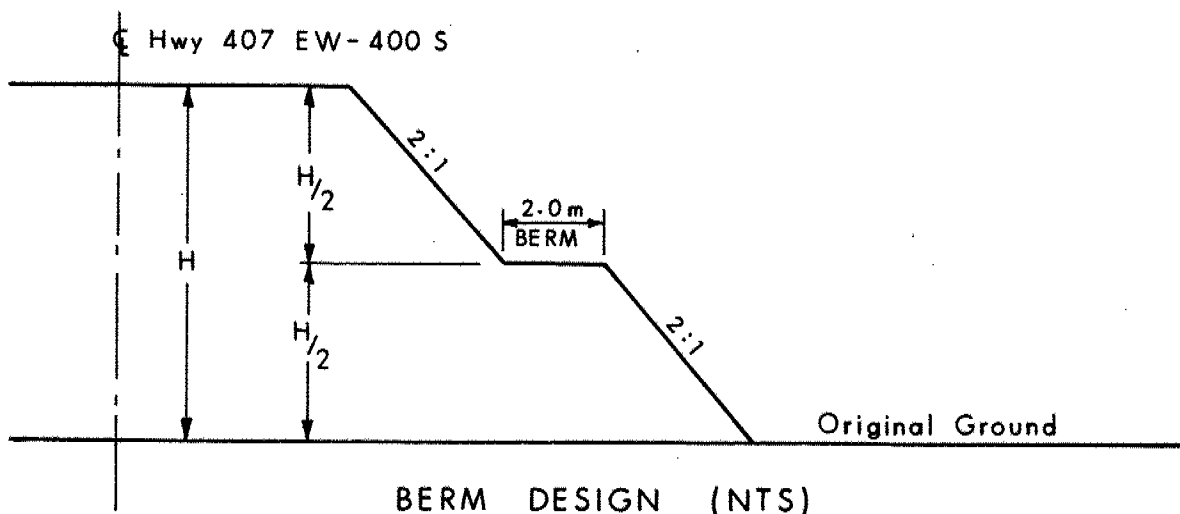
A minimum of 1.2 m of earth cover, or equivalent, to the base of the footing or pile cap, is required for frost protection.

### Approach Fills: Slope Stability

Due to the fill heights ( $\pm 13$  m) in this location of highway 407, a slope stability analysis was implemented. A total stress analysis was performed assuming that the fill is granular and non-cohesive.

Results of this analysis indicate a problem with proposed slopes on the west side of Highway 407, south and north of structure #20 and the east side of Highway 407 north of structure #20.

It is recommended that slopes in the above mentioned areas be constructed with a 2.0 m wide berm to the midheight of the slope. All slopes are to be built 2H:1V (see detail below).



Berms are to be constructed in conjunction with the highway fill as a complete unit up to the height of the berm, at which point the remainder of the fill may be constructed.

The slope on the east side of Highway 407 south of structure #20 will be stable at 2H:1V and does not require a berm.

All areas mentioned begin from the ends of the proposed retaining walls to the limits of this project.

#### Approach Fills: Settlement

Due to the magnitude of the fills involved in this area, settlement of the approach fills under their own weight can be expected.

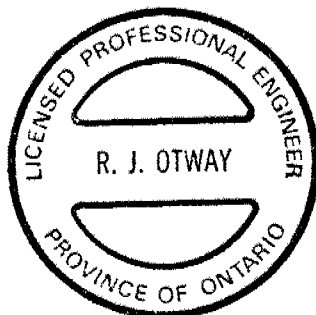
If the fill material is cohesive, settlement will occur over time, therefore the approach fills should be allowed to settle for a minimum 3 month period prior to paving. The anticipated settlement is approximately 130 mm.

If the fill material is granular, settlements will be elastic in nature and will occur during construction.

#### MISCELLANEOUS

The fieldwork was carried out under the supervision of R. Otway, Foundation Engineer, using equipment rented from Malones Soil Samples.

The report was written by R. Otway and reviewed by M. Devata, Chief Foundations Engineer (East).



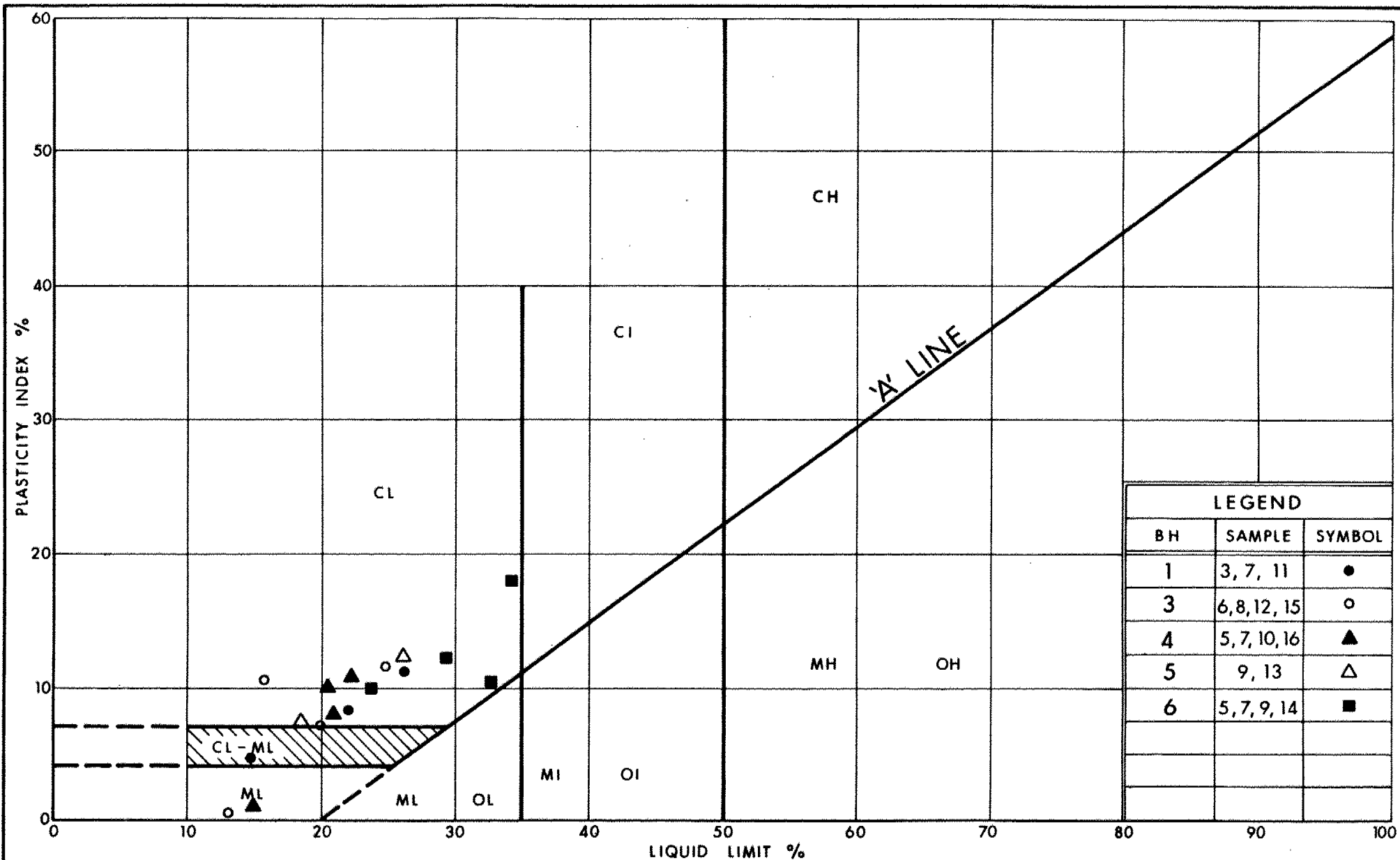
A handwritten signature in cursive script, appearing to read 'R. J. Otway'.

R.J. Otway, P.Eng.  
Foundation Engineer

A handwritten signature in cursive script, appearing to read 'M. S. Devata'.

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

## APPENDIX



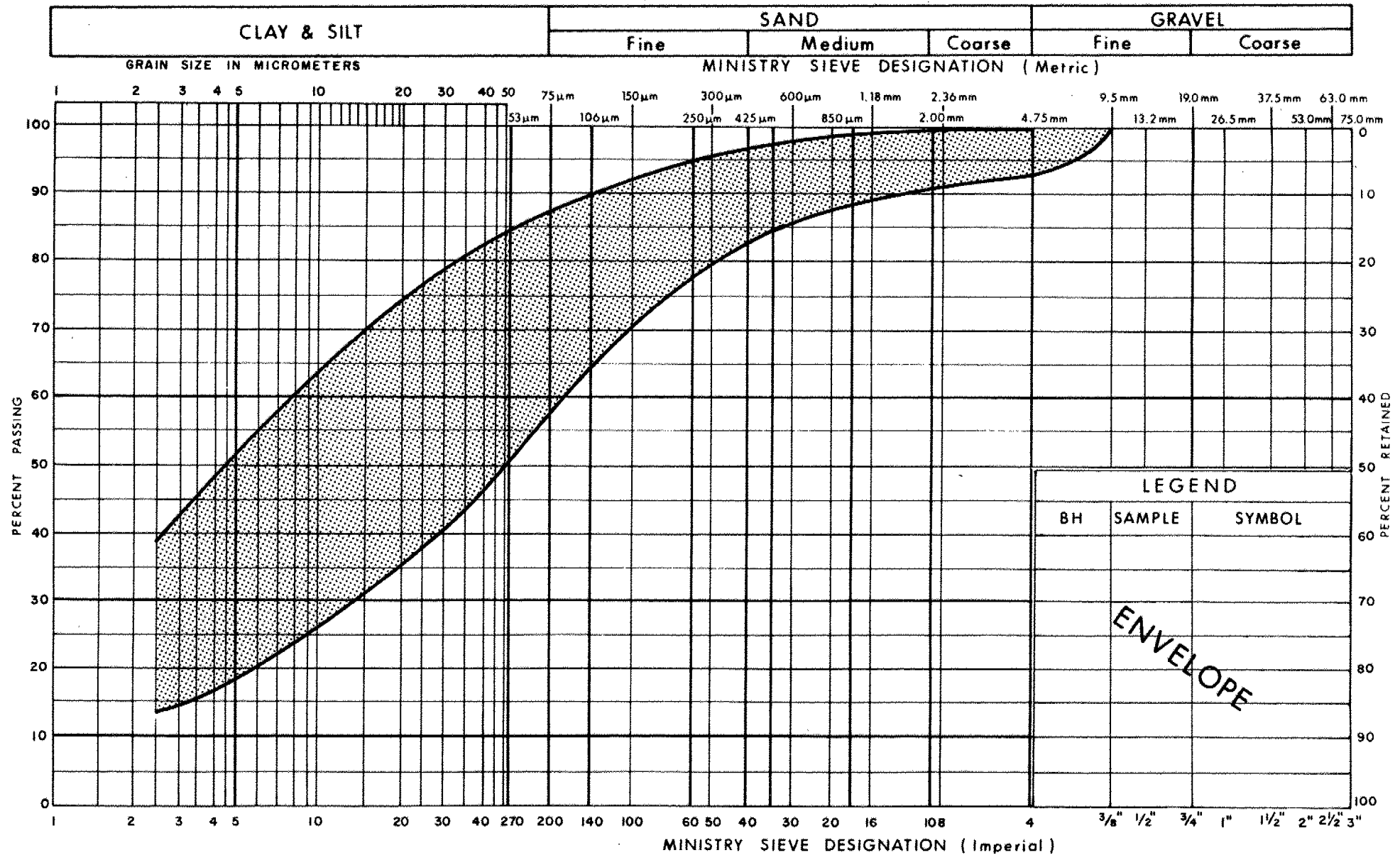
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**PLASTICITY CHART**  
 HET MIXTURE OF  
 CLAYEY SILT, SOME SAND TRACE GRAVEL (Glacial Till)

FIG No 1

W P 138-87-09

## UNIFIED SOIL CLASSIFICATION SYSTEM

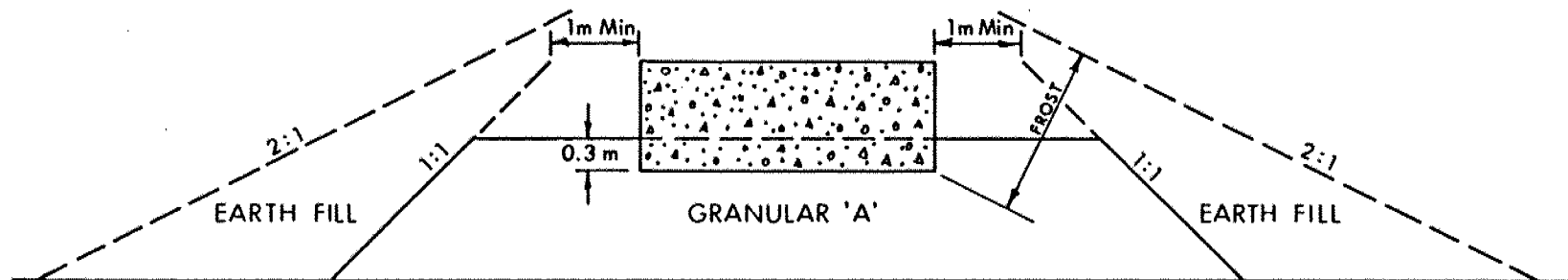


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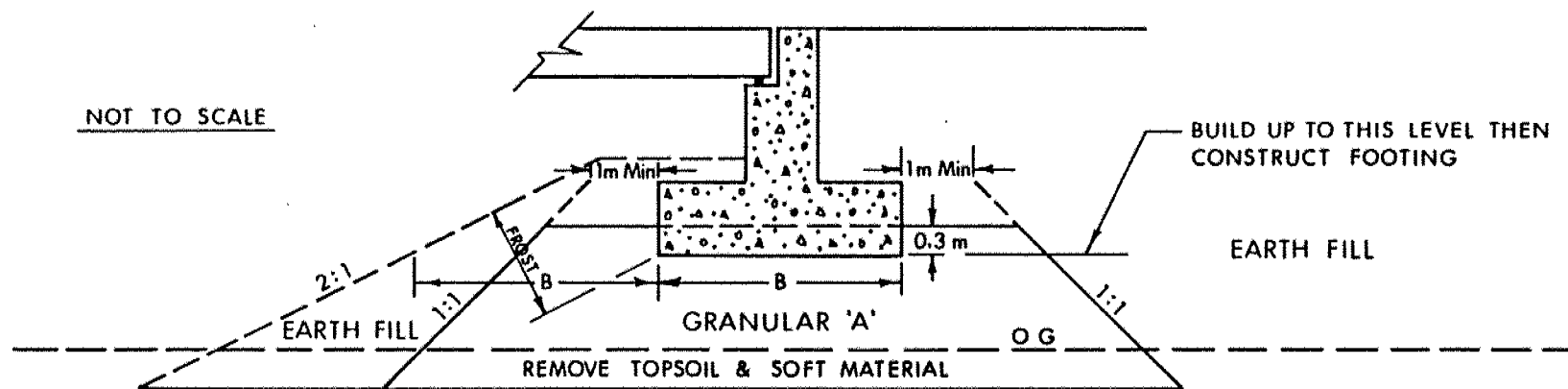
**GRAIN SIZE DISTRIBUTION**  
HET MIXTURE OF  
**CLAYEY SILT, SOME SAND TRACE GRAVEL (Glacial Till)**

FIG No 2

W P 138-87-09



X SECTION



LONGITUDINAL SECTION

NOTES:

- 1 - REMOVE TOPSOIL &/OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' & EARTH FILL.
- 2 - PLACE GRANULAR 'A' & EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO CURRENT M T C STANDARDS.
- 3 - CONSTRUCT CONCRETE FOOTING.
- 4 - PLACE REMAINDER OF GRANULAR 'A' & EARTH FILL AS REQUIRED.



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ABUTMENT ON COMPACTED FILL  
SHOWING GRANULAR 'A' CORE

FIG No 3

W P 138-87-09

## EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	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
$\sigma'_{v0}$	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						

# RECORD OF BOREHOLE No 1

METRIC

W P 138-87-09 LOCATION Co-ords. N 4 848 144.9 E 301 867.2 ORIGINATED BY RO  
DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Auger - Cone Test COMPILED BY RO  
DATUM Geodetic DATE 88 01 18 CHECKED BY DD

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	WATER CONTENT (%) 10 20 30					
186.7	Ground Surface													
0.0	Sand		1	SS	40		186							
185.2	Some Silt Dense (Fill)		2	SS	14									
1.5			3	SS	16		184							2 30 42 26
			4	SS	18									
	Brown Grey		5	SS	13									
			6	SS	32		182							
	Heterogeneous Mixture		7	SS	48									3 22 53 22
	Clayey Silt		8	SS	46		180							
	Some Sand													
	Trace Gravel		9	SS	43		178							
	Occ. Boulders													
	Occ. Silt Seams		10	SS	39		176							5 25 64 6
	Stiff to Hard													
	(Glacial Till)		11	SS	119/23 cm		174							
			12	SS	109									
172.5														
14.2	End of Borehole		13	SS	100									

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 3

METRIC

W P 138-87-09 LOCATION Co-ords. N 4 848 182.0 E 301 860.0 ORIGINATED BY RO  
 DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Auger - Cone Test COMPILED BY RO  
 DATUM Geodetic DATE 88 01 11 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ	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>			
191.6	Top of Asphalt												GR SA SI CL
0.0	Sand Some Silt Dense (Fill)		1	SS	42		190	Augered					
			2	SS	46		188						
			3	SS	43		186						
184.6			4	SS	33		184						
7.0			5	SS	18		182						
			6	SS	18		180						
	Brown Grey		7	SS	12		178						
			8	SS	28		176						
			9	SS	38		174						
	Heterogeneous Mixture		10	SS	49		172						
	Clayey Silt		11	SS	37								
			12	SS	28								
	Some Sand		13	SS	35								
	Trace Gravel		14	SS	74								
	Occ. Boulders		15	SS	63/15 cm								
	Occ. Silt Seams		16	SS	90								
	Stiff to Hard (Glacial Till)		17	SS	N/A								
171.9	Silt with Sand												
19.7													
171.3													
20.3	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 4

METRIC

W P 138-87-09 LOCATION Co-ords. N 4 848 194.5 E 301 841.3 ORIGINATED BY RO  
DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Auger - Cone Test COMPILED BY RO  
DATUM Geodetic DATE 88 01 12 CHECKED BY DD

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	20 40 60 80 100					
191.3	Top of Asphalt													GR SA SI CL
0.0	Granular (Fill)													
190.4														
0.9	Sand		1	SS	18		190							
	Some Silt													
	Occ. Clayey Zones		2	SS	39		188							
	Compact to Dense (Fill)													
185.8			3	SS	18		186							
5.5														
			4	SS	23									
			5	SS	14									
			6	SS	17		184							2 38 40 20
	Brown Grey		7	SS	8									
	Heterogeneous Mixture		8	SS	55		182							
	Cobbles		9	SS	52									1 25 50 24
	Clayey Silt		10	SS	41		180							0 18 65 17
	Some Sand		11	SS	38									
	Trace Gravel													
	Occ. Boulders		12	SS	41		178							0 19 75 6
	Occ. Silt Seams													
	Stiff to Hard (Glacial Till)		13	SS	100	8 cm	176							
			14	SS	55	8 cm								
			15	SS	50	10 cm	174							
			16	SS	50	8 cm								1 14 81 4
172.0							172							
19.3			17	SS	7									
	Sand		18	SS	89		170							0 10 87 3
	Some Silt		19	SS	63		168							
	Loose to Very Dense													
			20	SS	55	15 cm	166							
			21	SS	63		164							
			22	SS	114		162							
160.4			23	SS	100	20 cm								
30.9	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

+<sup>3</sup>, x<sup>5</sup>: Numbers refer to Sensitivity  
20  
15 5 (%) STRAIN AT FAILURE  
10



# RECORD OF BOREHOLE No 5

METRIC

W P 138-87-09 LOCATION Co-ords. N 4 848 216.0 E 301 836.0 ORIGINATED BY RO  
DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Auger - Cone Test COMPILED BY RO  
DATUM Geodetic DATE 88 01 18 CHECKED BY DD

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	10 20 30					
187.7	Ground Surface													
0.0	Clayey Silt and Sand Mixture Very Loose (Fill)		1	SS	3		186							
185.3			2	SS	11		184							5 34 41 20
2.4			3	SS	15									
			4	SS	17									
			5	SS	9		182							
			6	SS	62									
			7	SS	43		180							
			8	SS	69									
			9	SS	41		178							3 13 52 32
			10	SS	42									
			11	SS	26		176							0 51 46 3
			12	SS	100	15 cm								
			13	SS	100	8 cm	174							5 37 44 14
173.1			14	SS	42		172							
14.6			15	SS	100	18 cm	170							
169.0			16	SS	88									
18.7	End of Borehole													

# RECORD OF BOREHOLE No 6

METRIC

W P 138-87-09 LOCATION Co-ords. N 4 848 203.0 E 301 855.5 ORIGINATED BY RO  
DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Auger - Cone Test COMPILED BY RO  
DATUM Geodetic DATE 88 01 20 CHECKED BY DD

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 kP <sub>o</sub> ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					
189.1	Ground Surface													GR SA SI CL
0.0	Clayey Silt and Sand Mixture Loose (Fill)		1	SS	7	*	188							
186.6			2	SS	11		186							
2.5			3	SS	23									
			4	SS	23		184							
			5	SS	14									
			6	SS	12		182							1 25 43 31
	Brown Grey Heterogeneous Mix.		7	SS	29									2 20 62 16
	Clayey Silt		8	SS	97		180							7 18 58 17
	Some Sand Trace Gravel Occ. Boulders Occ. Silt Seams Stiff to Hard (Glacial Till)		9	SS	100									
			10	SS	82		178							
			11	SS	34									
			12	SS	16		176							0 11 84 5
	Silt Some Sand Compact		13	SS	100	10 cm								
			14	SS	94		174							0 1 65 34
172.9			15	SS	9		172							
16.2			16	SS	53		170							
	Sand		17	SS	47		168							
	Some Silt		18/19	SS	13		166							
	Loose to Very Dense		20	SS	83		164							
			21	SS	87		162							
			22	SS	56									
161.2			23	SS	59									
27.9	End of Borehole													
	* Water Level Not Established													

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

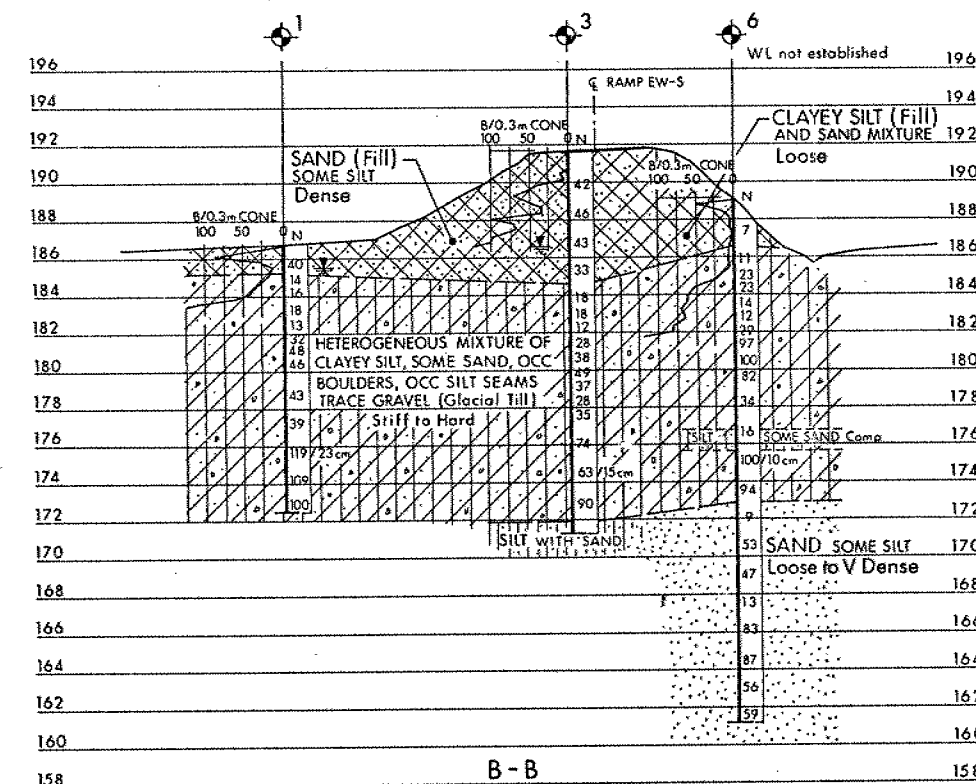
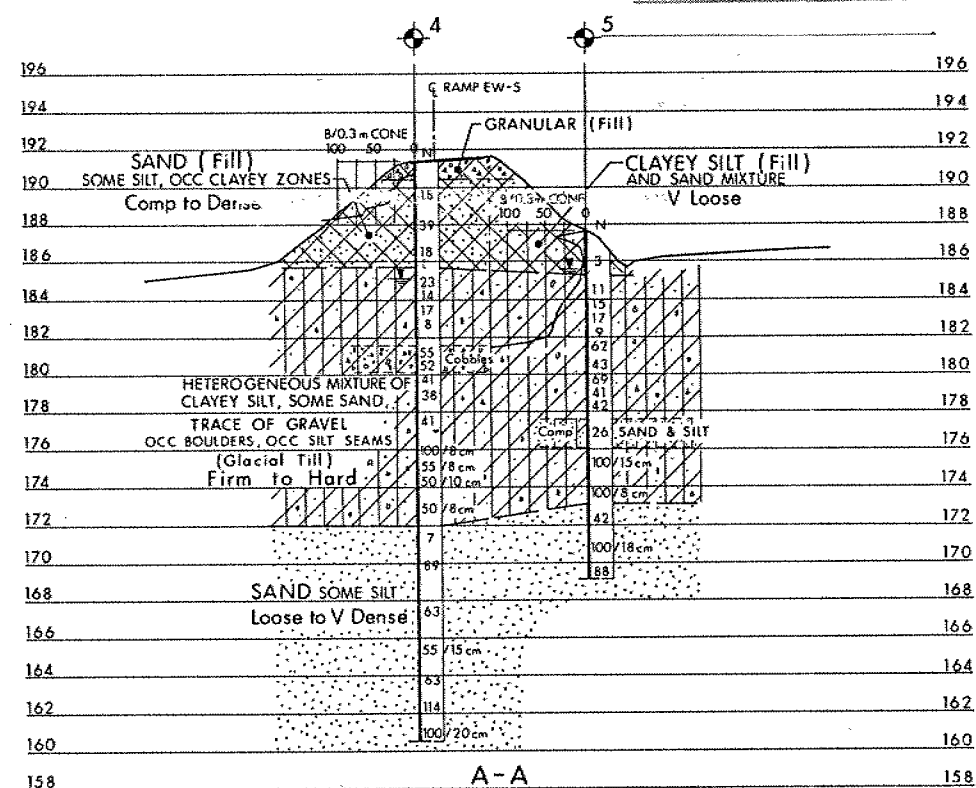
OFFICE REPORT ON SOIL EXPLORATION

CONT No  
WP No 138-87-09

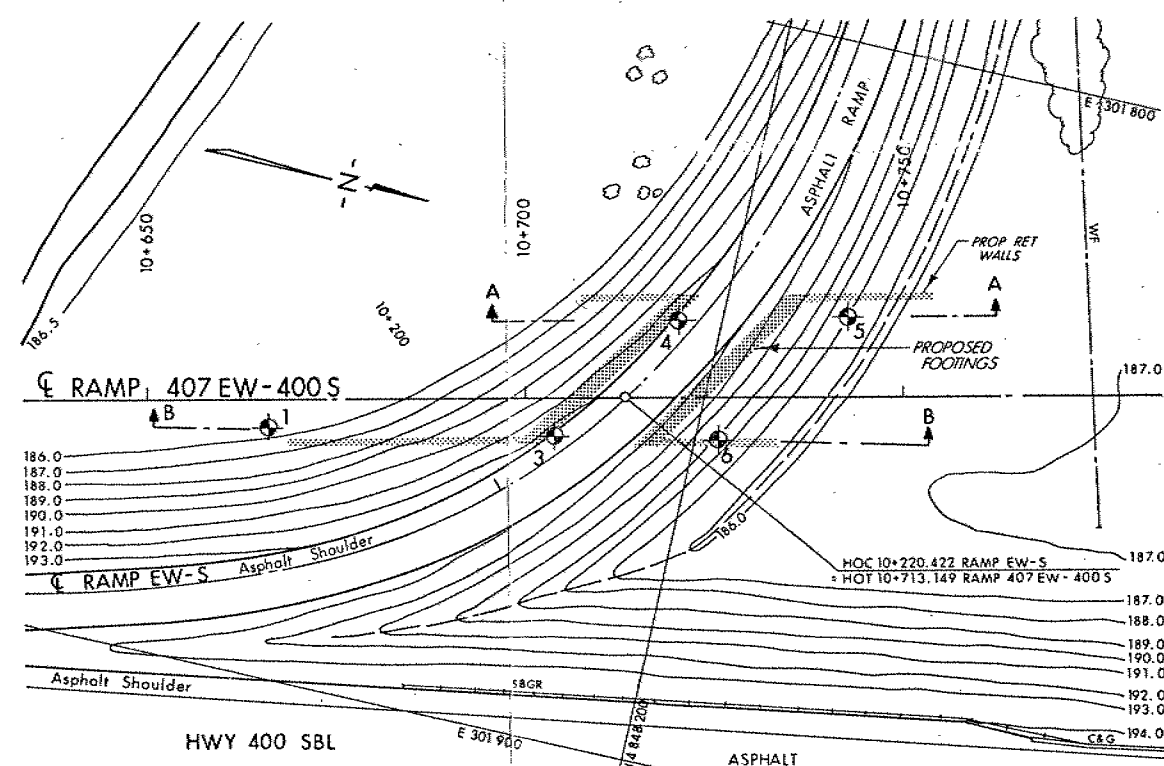
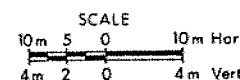


RAMP 407EW-400S  
BRIDGE-20  
BORE HOLE LOCATIONS & SOIL STRATA

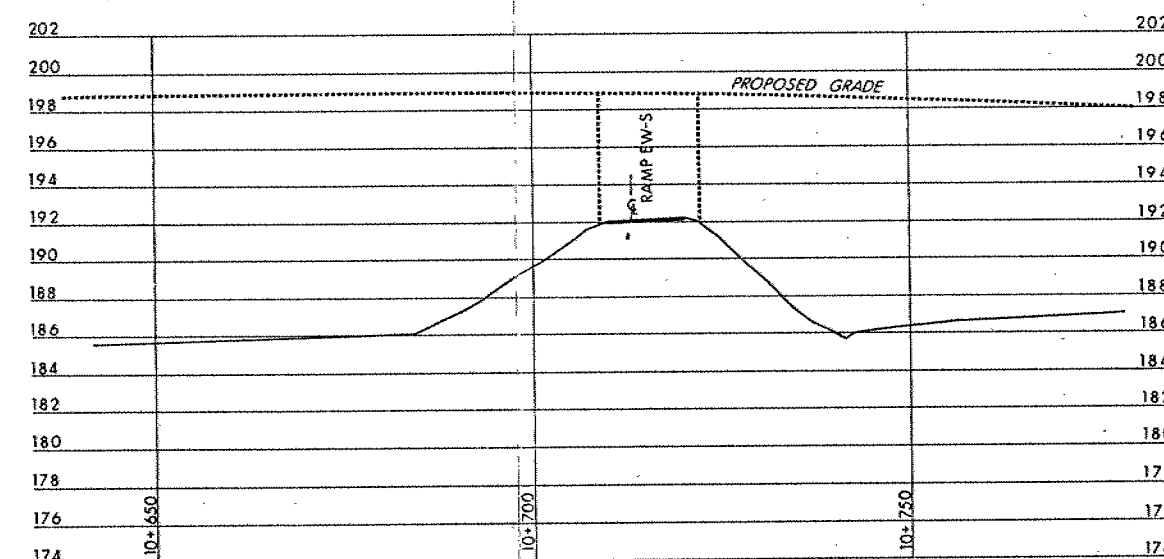
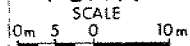
SHEET



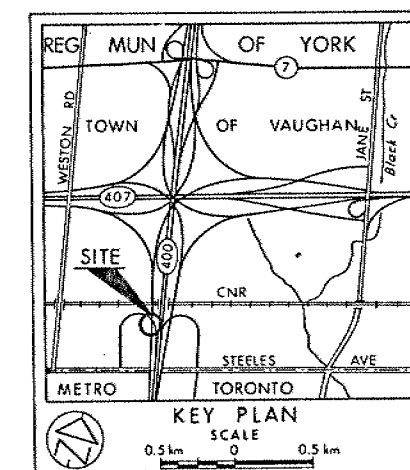
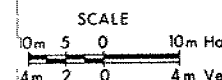
SECTIONS



PLAN



PROFILE RAMP 407EW-400S



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 88 01

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	186.7	4848144.9	301867.2
3	191.6	4848182.0	301860.0
4	191.3	4848194.5	301841.3
5	187.7	4848216.0	301836.0
6	189.1	4848203.0	301855.5

NOTE

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

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

REV	DATE	BY	DESCRIPTION
1			

Geocres No 30M13-80

HWY No RAMP EW-S	DIST 6
SUBMD RO CHECKED	DATE 1988 05 12
DRAWN SO CHECKED	SITE 37-1183
	DWG 1388709-A

REF NO E-73-400-4 88 01

# memorandum



To: L. Bowering  
Construction Office  
Central Region

~~92-02-05~~

92 02 05

FROM: Foundation Design Section  
Room 315, Central Building

RE: Armbro Pile Driving Claim  
Contract 90-60  
Bridge #13  
WP 138-87-03, Site 37-1177  
Hwy. 400, Dist. 6, Toronto

and Bridge #20  
WP 138-87-09, Site 37-1183

Further to your speedy memo of Jan. 24/92, we have reviewed the package submitted concerning pile driving at these projects.

Armbro has based their claim on compliance with the Hiley Formula at higher elevations. In our opinion, they have not submitted sufficient facts to justify their claim on the basis of the Hiley Formula. The package does not contain sufficient details on Hiley Formula measurements to evaluate Armbro's claim that the Hiley criteria were achieved at higher elevations. As we indicated in our previous memo dated Oct 4/91, we would require Hiley graphs at those higher elevations at which Armbro claims that the criteria were met in order to evaluate their claim. Their statement that 8 blow per inch represents a 3 x overdriving is irrelevant since it has not been supported by Hiley data.

But perhaps the claim can be considered from a less technical viewpoint:

For Bridges #13 and #20, Foundation Design Section requirements would be for pile tip elevations below elev. 176 m, then control pile driving by the Hiley Formula. For both projects, the contract controls pile driving solely by the Hiley formula. This created a contradiction between Foundation Design requirements and contract instructions. Obviously this lends some weight to the Armbro claim.

For Bridge #13, the contract implies 17± m lengths while actual lengths generally exceed this by a certain amount (in the order of 4 m) that could be accurately calculated. Any adjustment to payment could be based on this 'extra' pile length.

For Bridge #20, the contract implies 20± m lengths while actual lengths are mostly shorter. This implies that Armbro should not have been surprised by the actual pile lengths and that no adjustment to payment is appropriate.

To summarize, in our opinion Armbro has cause to claim for expenses related to additional pile driving at Bridge #13 but not Bridge #20. Hopefully our comments are of some use in your assessment. If there are any questions, please call.

A handwritten signature in dark ink, appearing to read "D. Dundas".  
D. Dundas, P. Eng.  
Sr. Foundation Engineer

REPLY  
COPYL. Bowering  
Construction Office, Central RegionSEND  
TO

Foundation Design Section

DATE: Oct. 4/91

SUBJECT

Pile Driving Claim, Contract 90-60 (Hwy 400 Structures 13 &amp; 20)

As requested in your memo of Oct. 2/91, we have reviewed the Armbro claim dated Mar. 7/91.

It is our understanding that they claim that the pile capacity specified in the contract was achieved at higher elevations than required by our recommendations for an equivalent blow per inch value.

In order to assess Armbro's claim, we would require penetration/rebound graphs at the higher elevations in question. It should be noted that graphs from different elevations can not be extrapolated to other elevations due to the complexity of the Hilge Formula.

REPLY

Also, another method of assessing the validity of the claim would be to compare actual pile lengths with those predicted in the contract documents.

If you wish us to assess these details, please forward the required information to us.

REPLY FROM

D. Dundas, P. Eng.

REPLY DATE

Sr. Foundation Engineer

SEND  
TO

D. Dundas  
Sr. Foundation Engineer  
Foundation Design Section



FROM

L. R. Bowersing Construction Office

DATE

91 10 02

SUBJECT

Pile Driving Claim - Cont. 90-60

As discussed, I am enclosing a copy of a letter from Ambro Construction which outlines the basis of their claim.

Please review your records and comment on the merits of their statements regarding excessive blow counts and the validity of their claim.

Since Ambro is pressing us for a decision please comment by 91 10 09.

Thank you

REPLY

REPLY FROM

REPLY DATE



## ARMBRO CONSTRUCTION

25 VAN KIRK DRIVE, UNIT 8 BRAMPTON, ONTARIO L7A 1A6  
TELEX 06-97527 TEL. (416) 451-0690

March 7, 1991

Ministry of Transportation, Ontario  
Job - Hwy. 400/407 Interchange  
Job No. 90-60  
Attention: Mr. Carl Wride

Re: Intent to Claim No. 1 - Piles Driven Beyond  
Refusal Requirement

Further to our intent to claim no. 1 dated December 13th, 1990, we submit herewith our claim on piles that were driven beyond refusal criteria in Structure no. 13 and 20.

First of all, we want to point out that the refusal criteria were determined on basis of Hiley Formula as specified in the working drawing and full energy was engaged in the hammers while driving piles.

In structure 13, when piles were driven to the specified depth, we were instructed to drive further down to a newly required blow count as per instruction notice dated October 26th, 1990, even though the blow count at that stage was already more than 3 times as much as that required according to the computed value from the Hiley Formula.

Similarly in structure 20, we were instructed to drive piles further down when actual blow count had also reached more than 3 times as much as that required when depth of piles had reached approximately 12 meters. We were instructed to drive at least 4 meters more and the new requirement of blow count was 8 blows/20 mm.

Please note that our calculations on the required blow counts agreed with those of Mr. Bill Cung's, an M.T.O. Field Engineer.

In view of the excessiveness of blows, we envisaged that refusal would have occurred a lot earlier at the first segment of the piles. We therefore, would wish to claim for the cost on extra splices as well as time to expedite extra blows, including those from the time of refusal to the completion of driving.

# memorandum



To: Carl Wride  
Project Supervisor

From: Foundation Design Section  
Room 315, Central Building

Re: Contract 90-60  
W.P. 138-87-09, Site 37-1183  
Ramp 407 E to 400 S  
Bridge #20  
Hwy. 400/407, District 6, Toronto

Date: 1990 11 19

Further to our conversations of Nov. 14/90 and Nov. 15/90.

- We recommend that piles should be driven to elev. 176 m then controlled by the Hiley formula.

Based on the Hiley formula and pile driving records information you provided;

- piles 20 m long
- penetration = 3 mm
- rebound = 7.5 mm
- D16-32 hammer
- ultimate pile capacity = 1900 kN

We recommend that the design pile capacity has been achieved at a set of 8 blows per inch.

If there are any questions, please call.

A handwritten signature in dark ink, appearing to read "D. Dundas".

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

DD/jb

FROM

Bill Brabant Reinforced Earth Co.

DEPARTMENT

TO

Ministry of Transportation

DATE

Febr 9/89

SUBJECT

Structure 20

1201 Wilson Avenue

Downsview, Ontario M3M 1J8

MESSAGE

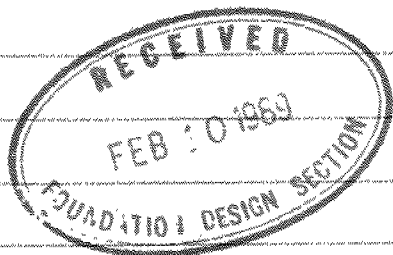
Attn. Mr. Tony Longiuliano

Foundation Design Section

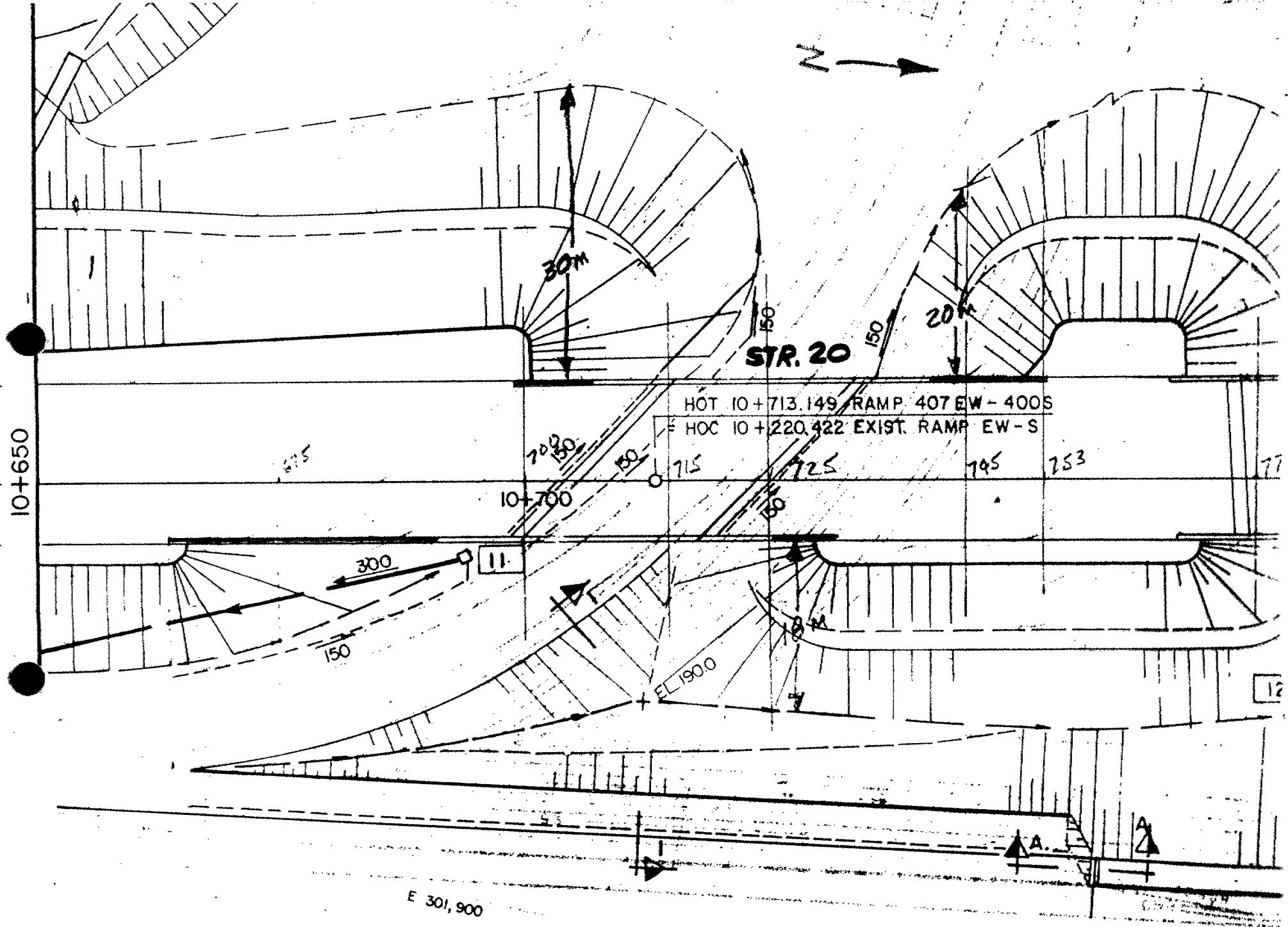
Enclosed are cross sections and a grading plan for the area around Structure 20, which I received from D. S. Lea.

Judging from this latest information it appears that the embankment slopes (at a right angle to the face of the R/E walls) are much flatter than 2:1, for all walls except the southeast wall.

Please call me to discuss.



Thanks  
Bill



North East Wing Wall

2:1 with bench @ beg. wall

2:4:1 @ end wall

INTERMEDIATE SECTION

2:10:1 to toe

AREA OF 7.5 sq ft

(0.725)

# memorandum



To: J.K. Lam  
Senior Structural Engineer  
Structural Section  
Central Region

Date: 1989 04 17

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

RE: Final Drawings  
W.P. 138-87-09  
Structure #20  
Hwy. 407 EW to 400S

We have reviewed the above drawings and offer the following comments;

The minimum energy for the pile driving hammer should be 50,000 joules per blow, instead of 5,000 as indicated under "Notes" on the footing layout page.

The remainder of the drawings appear to conform to the recommendations contained in the Foundation Design Report.

Please forward the final drawings for the Reinforced Earth Retaining Wall Design for our review.

A handwritten signature in dark ink, appearing to read "R.J. Otway".

R.J. Otway, P. Eng.  
Foundation Engineer

RJ/jb



# R.V. Anderson Associates Limited

consulting engineers and architect

Suite 401, 1210 Sheppard Ave. E., Willowdale, Ontario M2K 1E3  
Telephone (416) 497-8600 Fax (416) 497-0342

## Directors

K.A. Hyde	R.C. Hinde
D.D. Dunbar	P.J. Laughton
K.A. Morrison	V. Kald
V. Raun	H. Guttman
R.J. Andres	

## Associates

T.H. McColm	A. Berge
B.E. Buntin	K.J. Dwyer
H.A. Verbruggen	A.R. Martin
C.G. Chin	D. F. Walker
B. Chang	G.A. Farrell
I. Marshall	C. Doherty
G. Addison	V. Chin

## Consultants

R.V. Anderson	Dr. J.G. Henry
---------------	----------------

## MEMO

TO: John Lam  
Senior Structural Engineer  
MTO Central Region

FROM: Nick Garland  
R.V. ANDERSON ASSOCIATES

DATE: March 16, 1989

RE: Highway 400/407, District 6  
Bridge 20

Notes regarding preliminary submission of drawings and contract documents:

1. Possible tender items not included in structural "TAPS" -

- . Excavating and Backfilling Structures
- . Subdrains (behind abutments)
- . Clear Stone (at weepholes)
- . Salvage and Re-erect Steel Beam Guide Rail\*
- . Temporary Concrete Barrier\*

\* if not included in Roadway Protection

2. Specification for R/E retaining to be provided by MTO

3. Estimated quantity for Reinforced Earth Retaining Wall L.S. Item to be provided by RECO.

4. MTO standard 6m approach slab is used - no special design has been done at this time. (Queensway Interchange Bridge #2, Highway 7, Site No. 26-1545-1738 drawing set dated Oct./82 shows standard 6m approach slab. This structure is very similar to Bridge 20).



PLEASE TYPE

DATE 89 02 16

PAGE 1 OF 1

TO: Bill Brockbank  
Reinforced Earth Co

FROM: Tony Sangiuliano  
Ministry of Transportation

SUBJECT: R/E Prefabricated walls @ Structure 20

The preliminary drawings RECO No. 88753-1 and 88753-2 have been reviewed and observations reveal that the drawings are in conformance with applicable recommendations, provided the forward slopes are as were illustrated in the sections submitted with your memo dated 89 02 09. The prefabricated wall elevations and associated forward slopes should be integrated into one drawing with sections provided at selected intervals along the wall. This definitely would enhance the accuracy of the review.

Thanks

Tony

PLEASE TYPE

DATE 89 02 11

PAGE 1 OF 2

TO: Bill Brockbank  
Reinforced Earth Co.

FROM: Tony Sanginulano  
Ministry of Transportation

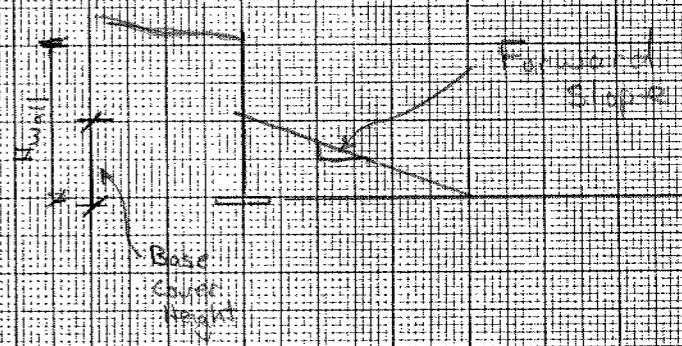
SUBJECT: R/E Prefabricated Walls @ Structure 20  
(Hwy 407/400 over Steeles Ramp)

In response to your memo dated 89/02/09, I have reviewed the sections provided and as mentioned, the slopes are indeed flatter than 2H:1V for all walls except the southeast. Consequently, prefabricated walls of shorter heights can be applied provided these heights are provided with required base covers. To clarify this intent I have provided a table that summarizes calculations for various wall heights and forward slopes. This table shall be used in coordinating the heights of your walls. Please contact me if there is any difficulty in the interpretation of the results.

Thanks  
Tony

# SUMMARY OF CALCULATIONS

H <sub>wall</sub> (m)	FORWARDS	Slopes	FS
2	2:1	(start @ levelling pad)	1.06
	2.5:1	(start @ levelling pad)	1.28
	2.5:1	(1.5m base cover)	1.48 ✓
	3:1	(start @ levelling pad)	1.47 ✓
	2:1	(1.5m base + midheight berm)	> 1.3
4	2:1	(start @ levelling pad)	< 1.3
	2:1	(1m base cover)	1.14
	3:1	(1.5m base cover)	1.26
	2:1	(2m base cover)	1.40 ✓
	3:1	(start @ levelling pad)	1.14
	3:1	(1m cover)	1.450 ✓
6	2:1	(2m base cover)	< 1.3
	2:1	(3m base cover)	1.37 ✓
	3:1	(1m base cover)	< 1.3 ✓
	3:1	(2m base cover)	1.45 ✓
	4:1	(1m base cover)	1.342



Min FS = 1.3

47 1510

41.4 88.33

37.3 85.77

28 86.67

28.58 87.91

26.98 86.25

Plan shows toe flaring out  
past station +700

South West Wing Wall

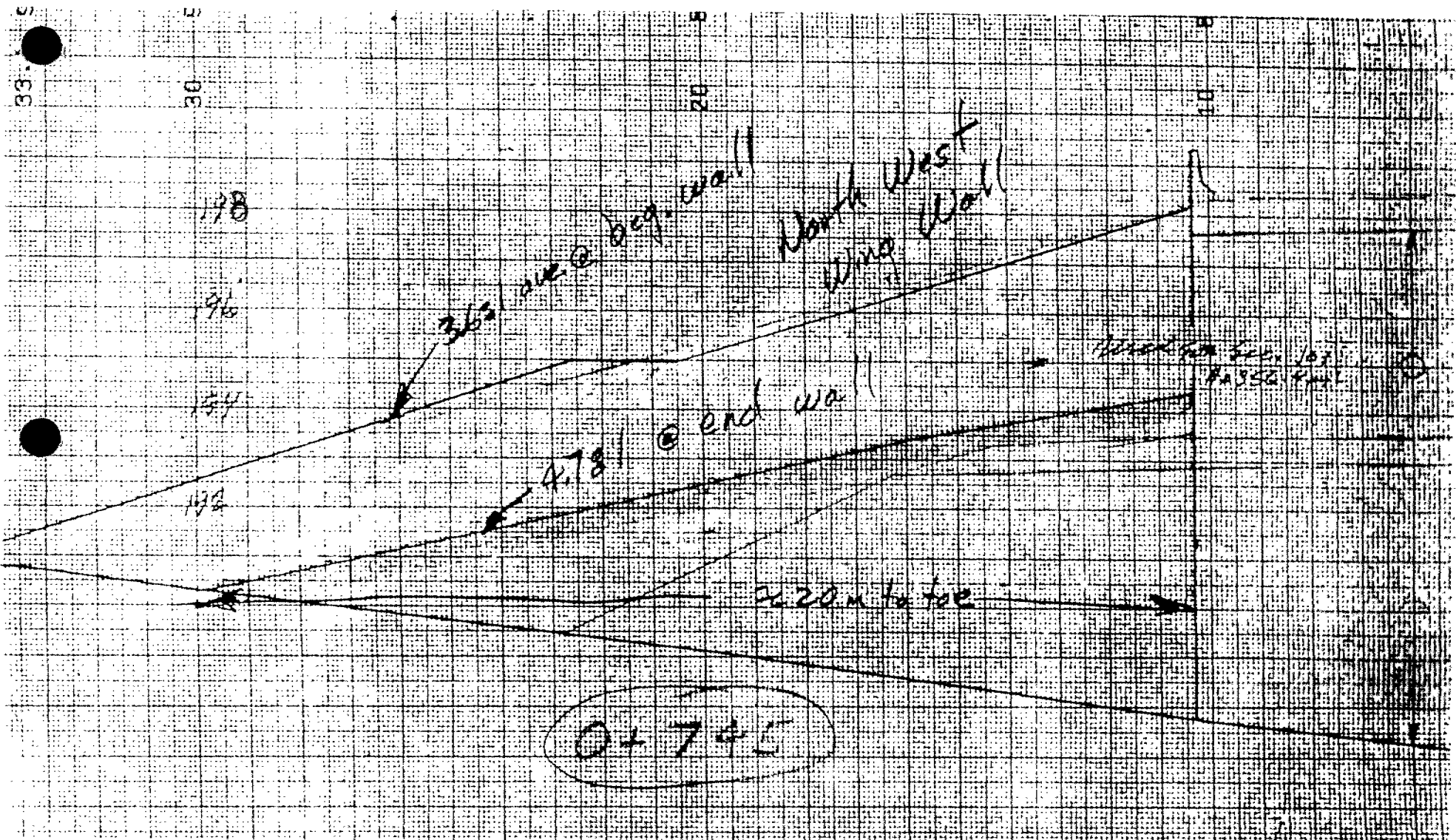
381' elev. @ beg. wall

563' @ end wall

0+700

30-30 m to toe

O.K. ✓



191 South East Wing 197 Well

@ end R/E Wall

5.3

2.1

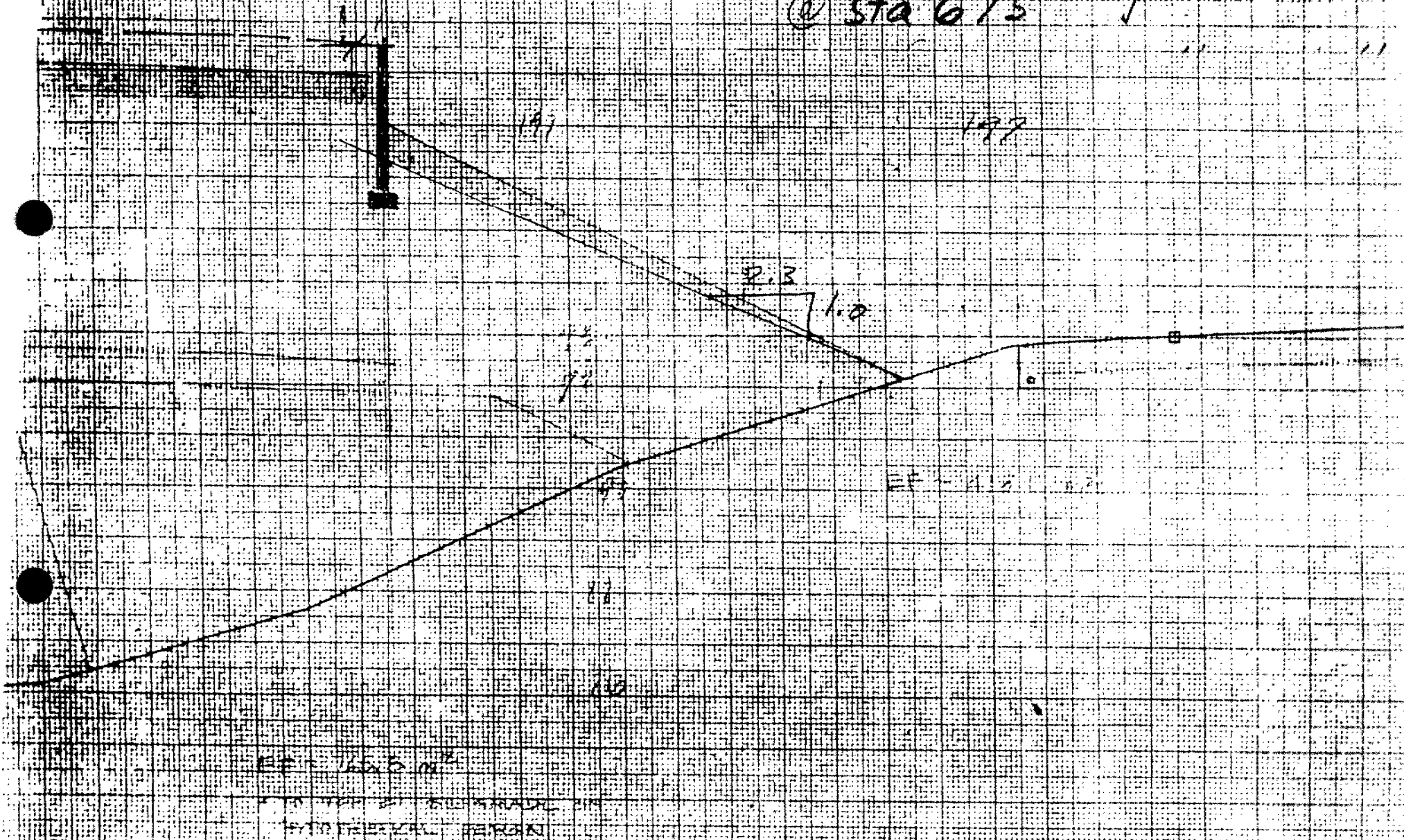
estimated  
ditch  
insert

EF - 1.5

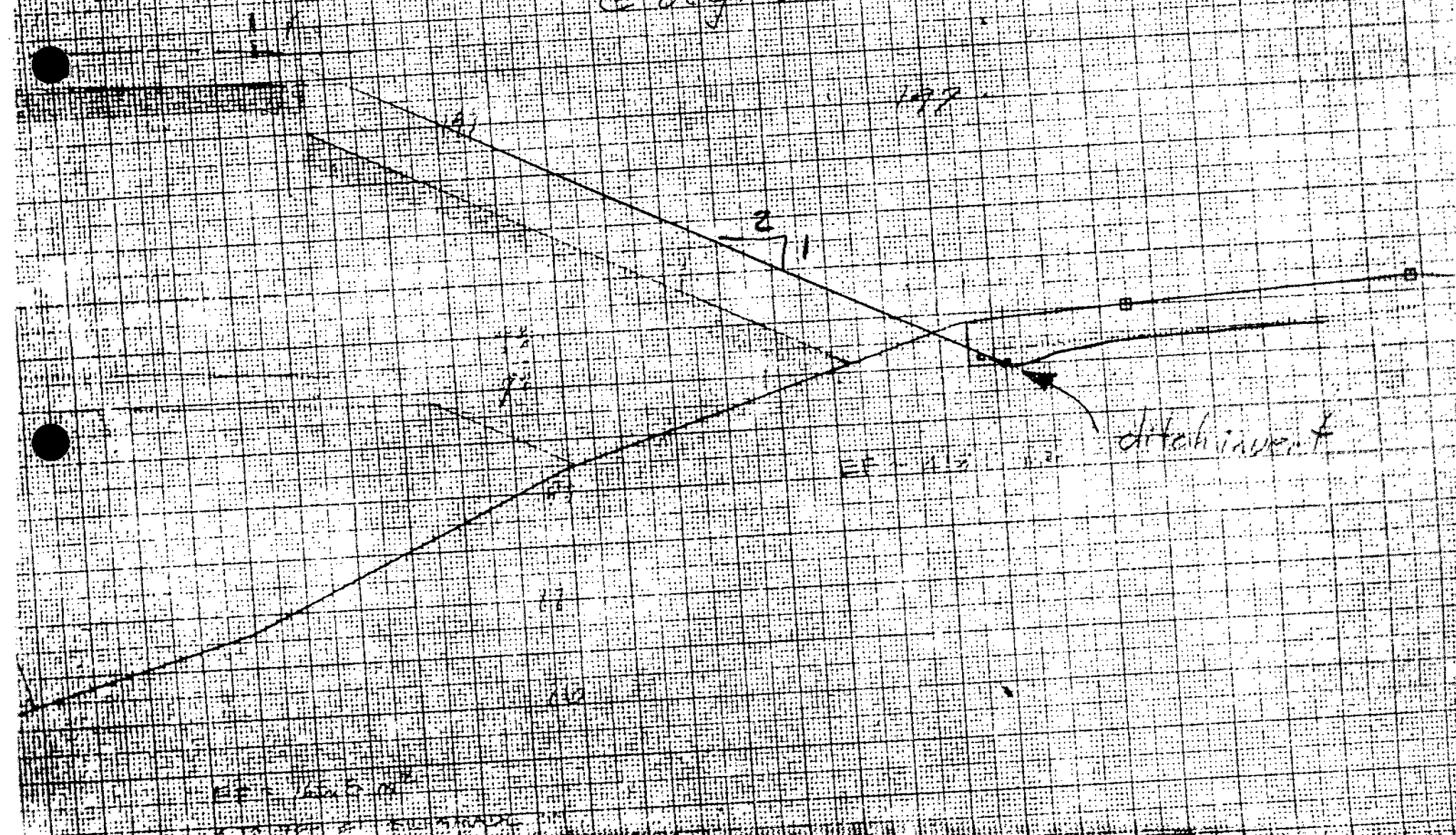
EF - 15.5 m

NOT TO SCALE IN  
HORIZONTAL PLANE

South East Wing Wall  
@ sta 675



South East Wing Wall  
@ beg. of wall



# memorandum



WP 138-87-09

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

Date: 1989 01 20

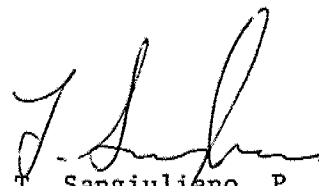
Atten: J. Lam, Sr. Structural Engineer

From: Foundation Design Section  
Room 315, Central Building

RE: W.P. 138-87-00  
Hwy. 400/407 Interchange  
Drawing Review  
Structures 4,5 and 20

The submitted construction drawings accompanying your memo dated 89 01 13 and produced by DS-Lea Associates, pertaining to the afore-mentioned structures have been reviewed by the undersigned and the general arrangement configurations appear to be in agreement with provided recommendations. As discussed, a more comprehensive review of the reinforced earth retaining walls associated with Structure 20 will be implemented when further details are submitted.

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



T. Sangiuliano, P. Eng.  
Foundation Engineer

TS/mmj



PLEASE TYPE

DATE 89/01/06

PAGE 1 OF 3

TO: Bill Brockbank

FROM: Tony Sangiuliano  
MTO

SUBJECT: R/E Retaining Walls @ Structure 20

In response to your Fax concerning the geometry and configuration of the aforementioned walls, I am returning the submitted elevation that illustrates the necessity for the forward slopes (Section A-A'). The forward slopes should be no steeper than 2.5H:1V and the design should be coordinated and integrated with the Steeles Ramp to 400 S.

The above comments pertain to the south east retaining wall. These comments are also applicable to the other retaining walls but an alternative design may also be considered in view of the greater area availability. This alternative involves a



PLEASE TYPE

DATE 89/01/06

PAGE 2 OF 3

TO:

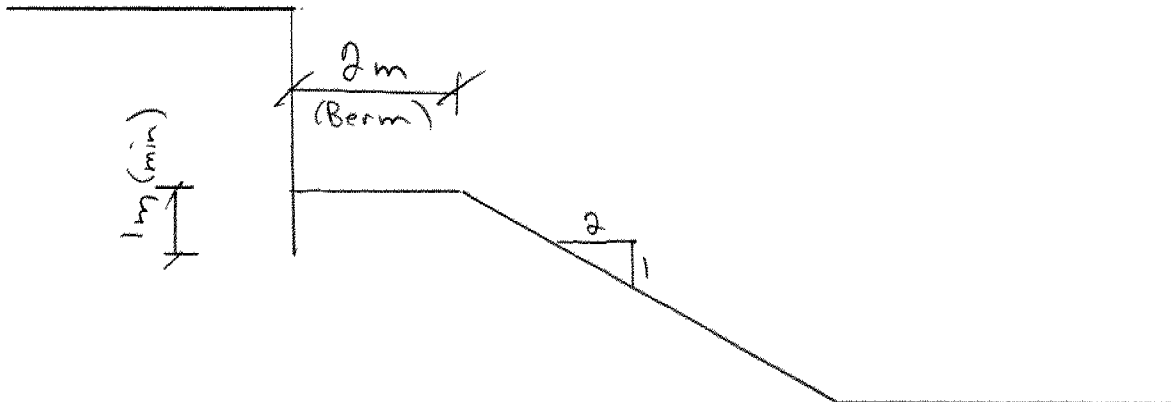
FROM:

Tony Sangiuliano  
MTO

SUBJECT:

2m nominal berm constructed a  
minimum 1m above the reinforced  
earth levelling pad. (see Fig 1 below)  
All slopes are 2H:1V.

Fig. 1

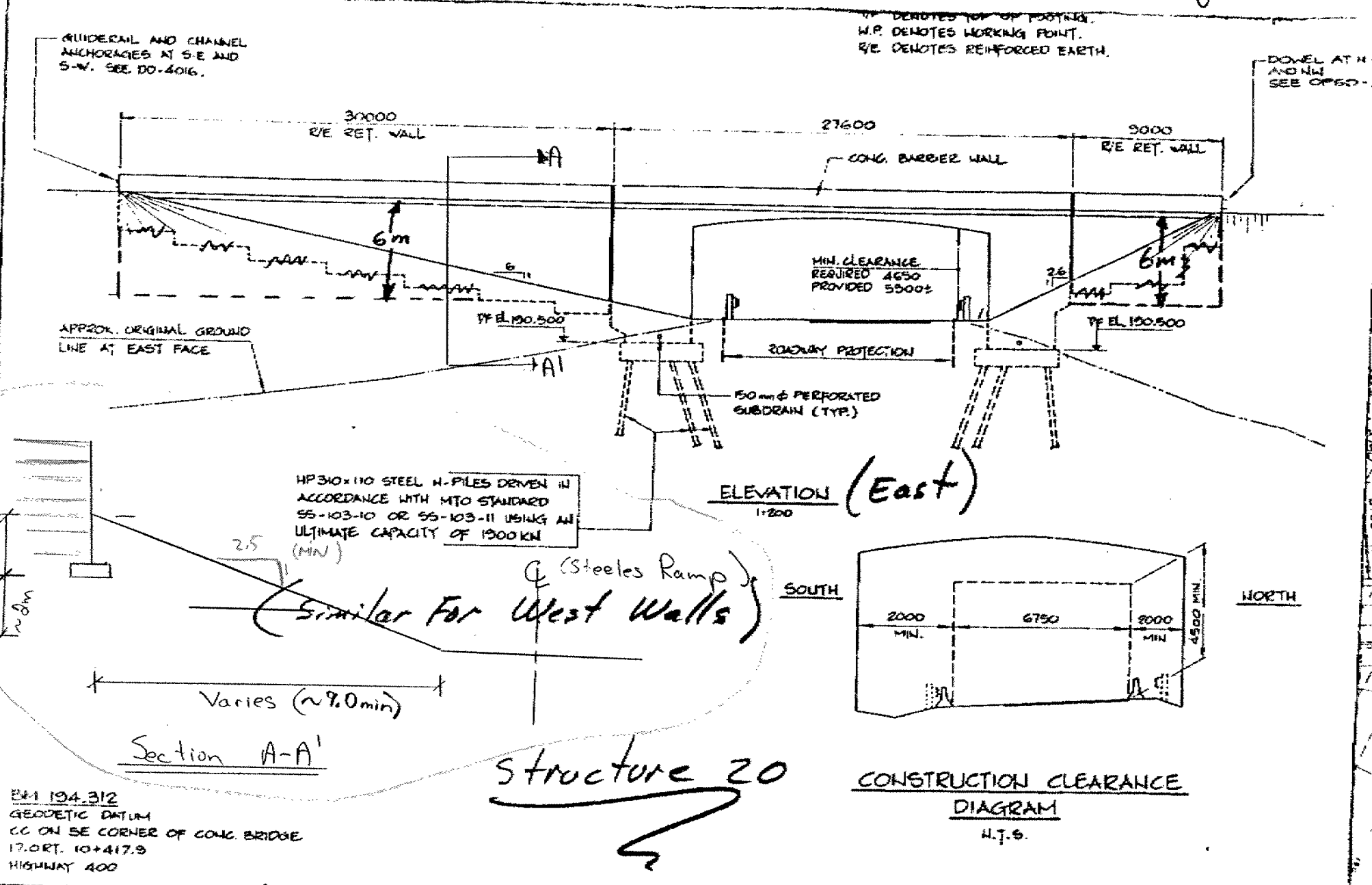


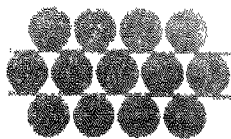
NTS

I hope this clarifies any  
ambiguities.

416 674 7000 0430.000

416 674 7000 0430.000



**reinforced earth®**

— FAX MESSAGE —

TO : MTO  
Foundation Design  
Attn: Mr. Tony Sangiuliano

FROM: Bill Brockbank, P. Eng.,  
Senior Project Engineer

REINFORCED EARTH COMPANY LTD.  
Toronto - Canada  
Telefax (416) 674-7385

FAX # : 235-5240

RE : Structure # 20

DATE: Jan 6/89

NO. OF PAGES = 2, INCL COVER PAGE FROM A 3M FACSIMILE 2127, GROUP 2, 3 (AUTO)

In the event this Fax has reached an incorrect number, please call Reinforced Earth Company Ltd., Toronto - Canada collect at (416) 674-1818. Thank You.

Tony

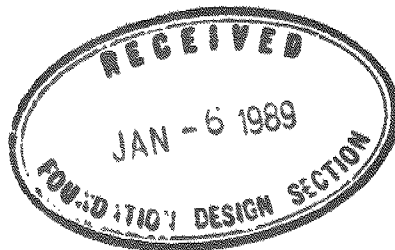
To confirm our telephone conversation I have sent a "marked up" elevation of the General Arrangement Drawing. Is this the required configuration to satisfy the global stability?

Contrary to what I said on the phone, I believe the west wing walls are in a similar situation thus requiring the same treatment.

✓ Please call

Thanks

Bill



\* Reinforced Earth® and the Reinforced Earth logo are registered trade marks of Reinforced Earth Company.

REINFORCED EARTH COMPANY LTD. 190 Attwell Drive, Suite 501, Rexdale, Ontario M9W 6H8 / Tel: (416) 674-1818 / Telefax: (416) 674-7385

TORONTO

MONTREAL

VANCOUVER

JAN 9 1989 10:17

416 674 7385 PAGE.001



# memorandum



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

Date: 1988 12 20

Atten: J. Lam, Sr. Structural Engineer

From: Foundation Design Section  
Room 315, Central Building

RE: Preliminary Drawing Review  
Ramp 407 E, W to 400S Over  
Steeles Ave. E, W to 400 S, Bridge #20  
W.P. 138-87-09, Site 37-1183, Dist. #6

As requested, the revised preliminary drawing for the aforementioned structure reflecting the replacement of the conventional reinforced concrete walls with the prefabricated reinforced earth retaining walls has been reviewed by this Section and the following geotechnical related comments are provided.

## **REINFORCED EARTH PREFABRICATED WALLS**

The major geotechnical considerations associated with the concept of reinforced earth prefabricated walls, other than the correct design and construction of the reinforced earth wall module, are the related external stability beyond this module and settlement of the prefabricated wall unit. These areas of concern are addressed below.

### Overall Stability

In the original foundation report, it was concluded that in view of the substantial fill heights ( $\pm 13$  m), the approach fills were to be constructed with standard 2H:1V slopes and with nominal 2.0 m wide mid-height berms at all locations but the south-east quadrant where the Steeles Ave. E, W to 400S ramp in essence provides the stabilizing berm. These requirements have not been illustrated on the submitted drawing. Furthermore, stability computations were carried out to determine the overall stability of the approach fills in the transverse direction incorporating the geometry of the reinforced earth walls illustrated in the general arrangement drawing. Bishop's total stress analysis and a minimum factor of safety of 1.3 were incorporated in the evaluation. Soil parameters used in the analysis are given below:

### Cohesive Fill

Unit Weight -  $20 \text{ kN/m}^3$

Undrained Shear Strength (cu) - 50 kPa

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Cohesionless Fill

Unit Weight - 22 kN/m<sup>3</sup>

Angle of Internal Friction ( $\phi$ ) - 30°

Failure surfaces were specified beyond the reinforcement zone assuming a reinforcement length of 0.7 H, where H represents the height of the wall.

Based on the analysis, it can be concluded that the prefabricated walls "perched" in the fill with the geometry and configuration illustrated, will be unstable as a result of external instability of the fill. It should be noted that this analysis was based on a number of assumptions including as mentioned above, the reinforcement embedment length and also the height and gradient of the slope in front of the structure. It is recommended that the external stability be re-analyzed with more precise information pertaining to the slopes and coordinating the actual capacities and strengths of the reinforced earth module.

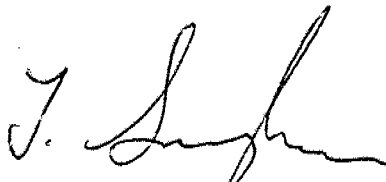
Settlement

The original foundation report informed of anticipated settlements within the fills as a result of its own weight. It should be ascertained that the prefabricated wall can tolerate these settlements.

**APPROACH FILLS BEYOND REINFORCED  
EARTH PREFABRICATED WALLS**

Approach fills beyond the reinforced earth prefabricated walls shall be designed and constructed as per the recommendations provided in the original foundation report, that is with standard 2H:1V slopes and a 2.0 m wide mid-height berm for fills exceeding 8.0 m in height. Compliance to this recommendation was not illustrated on the submitted drawing.

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



T. Sangiuliano, P. Eng.  
Foundation Engineer

for

M. Devata, P. Eng.  
Chief Foundation Engineer

TS/MD/mmj

# memorandum



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

Date: 1988 08 15

Attn: J. Lam  
Senior Structural Engineer

From: Foundation Design Section  
Room 315, Central Building

RE: Preliminary Drawing Review  
Ramp 407 EW to 400 S Over  
Ramp Steeles Avenue EW to 400 S  
Site 37-1183, W.P. 138-87-09  
Highway 400, District 6

As requested, the preliminary drawing for the aforementioned project has been reviewed by this section and the following comments pertaining to structure foundations and related earthworks are provided.

1) Approach Fills

As specified in the original foundation report and indicated in the Minutes of Meeting dated 1988 07 13, all fills exceeding 9 metres in height are to be constructed with a nominal 2.0 metre wide berm at midheight. This includes the approach fills BEYOND the retaining walls.

As an alternative, the cost-effectiveness of using

- (a) Geogrid Reinforced Earth Embankments with 1:1 slopes  
or
- (b) Reinforced earth retaining wall system should be evaluated and examined.

However, as a reminder, if one of these alternatives are selected, this office should be involved in the review of the design as it relates to the overall stability. In the selection process, the adaptability of the chosen system to the future widening should be investigated.

To minimize approach settlements and to increase the stability of the approach fills, the new approach fills are to be "benched" to the existing fills in accordance with MTO standards. All softened and/or organic material should be excavated for their full depth within the planned limits prior to fill placement.

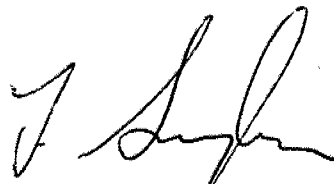
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2) Roadway Protection

The roadway protection illustrated on the drawing may conflict with the construction of the abutment foundations. Consequently, careful planning should be implemented to ascertain that the temporary shoring system does not interfere with the placement of the structure foundations.

All remaining geotechnical related items conform to the recommendations provided.

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

A handwritten signature in black ink, appearing to read 'T. Sangiuliano', is positioned above the printed name.

T. Sangiuliano, P. Eng.  
Foundations Engineer.

TS/mj

MINISTRY OF TRANSPORTATION  
RAMP 407 EW TO 400 S OVER RAMP STEELES AVE. EW TO 400 S  
(STRUCTURE 20)  
SITE 37-1183 W.P. 138-87-09  
HIGHWAY 400, DISTRICT 6

MINUTES OF MEETING



DATE: July 13, 1988

PLACE: MTO Foundation Section, 1201 Wilson Avenue

PRESENT: D. Dundas - MTO (Senior Foundation Engineer)  
R. Otway - MTO (Foundation Engineer)  
J. Lam - MTO  
N. Garland - R.V. Anderson Assoc. Ltd.

PURPOSE: To discuss foundation alternatives for Structure 20.

DISCUSSION:

ACTION BY

A. SLOPE STABILITY

1. Mr. Lam asked Foundation Section to confirm that berms will not be required in front of the abutments of Structure 20. Mr. Otway agreed, but noted that berms will be required at mid-height of the SW, NW and NE side slopes beyond the retaining walls.

B. FOUNDATION ALTERNATIVES

1. Mr. Garland showed a variation of the granular mat alternative whereby left-in-place sheet pile shoring walls and the existing sand fill under Steeles Ave. ramp would form the front slope of the mat. Mr. Otway had indicated in previous telephone conversations that lower allowable bearing pressures for the granular mat than those given in the Foundation Investigation Report would result. Mr. Dundas agreed, and stated that both additional field and office work would be required to calculate new allowable bearing pressures; further, present commitments by Foundation Section prevented such work being started for 2 to 3 weeks.
2. Mr. Otway in turn gave three variations of the granular mat alternative:
  - a) close Steeles Ave. ramp, excavate, and place a continuous mat between the abutments. Mr. Garland noted that the Structural Design Report requires the ramp to remain open throughout construction.

ACTION BY

- b) detour Steeles Ave. ramp to give complete access to the site. Mr. Lam did not think such a detour was possible due to the proximity of the CNR tracks to the north, and the sharpness of curve required to the south.
  - c) building out Steeles Ave. ramp alternately north and south, excavating and placing the mat in two stages with a shoring wall in the middle. Mr. Lam was doubtful this would be cost effective.
3. Mr. Garland expressed concern w.r.t. the lateral capacity of the H-pile alternative: 950 kN U.L.S. at 1:4 batter (increased batter possibly resulting in tip interference between the opposing abutment raker piles) for a lateral capacity of 238 kN U.L.S. per pile vs. 1650 kN U.L.S. at 1:3 batter for 550 kN U.L.S. lateral for piles on rock. Mr. Dundas suggested light weight backfill or anchored deadmen as possible solutions. Mr. Lam suggested struts between the abutment footings, if the Steeles Ave. ramp could be closed.

<u>Pile Capacity</u>		
<u>Vertical</u>	<u>Lateral</u>	<u>Batter</u>
1650	550	1:3
950	238	1:4

C. RETAINING WALLS

1. Mr. Dundas stated that R/E retaining walls, or equivalent, should be cost effective on Structure 20. Mr. Dundas also stated that although founding retaining walls on normal fill is possible, it should not be considered as an option for this project.

D. SUMMARY

1. Mr. Dundas stated that from a geotechnical standpoint, founding the structure on H-piles was the preferred alternative.

Minutes recorded by N. Garland of RVA. Please report any errors or omissions to our office.

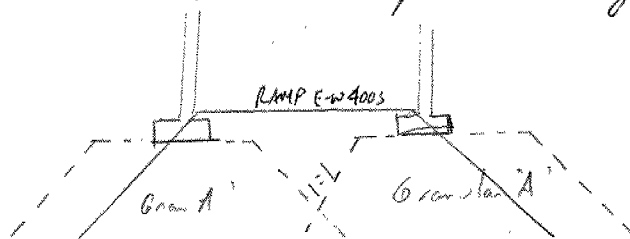
Distribution: All present  
K. Pilgrim

W.P. 138-87-09

July 8/88

TO: FILE

Received a call from N. Garland - R.V. Anderson & Associates. He wanted to know if granular 'A' pads were used to found the structure, did the 1:1 slopes have to be maintained in the direction of the existing ramp. I.E. did the existing ramp have to be excavated in order to allow placement of granular 'A'.



He also wanted to know how to place granular 'A' for the retaining walls if piles were used to support the abutments. I.E. in the vicinity of the piles, how could they maintain the 1:1 slopes.

I discussed with M. Devata and we informed Mr. Garland the following:

- 1) It is possible to use not to excavate the existing ramp and still build the Granular 'A' pad, however the allowable loading must be reduced.
- 2) It is possible to use soil anchors to anchor shoring but must have angle such that the anchor base rests in native soil.
- 3) It is possible to bolt together shoring on each side of the ramp through the ramp itself with tie rods and bolts.
- 4) Granular 'A' for retaining walls should be placed first before pile driving begins.

# memorandum



To: J.K. Lam  
Sr. Structural Engineer  
5000 Yonge Street

Date: 88 03 30

From: Foundation Design Section  
Room 315, Central Building

RE: Preliminary Recommendations  
W.P. 138-87-09  
Hwy. 407 - Structure #20

We have completed an investigation for bridge #20 and in order to expedite the design, offer you the following preliminary recommendations. A full foundation design report will follow as soon as possible.

## Site Description

The site is located in the northwest quadrant of the Hwy. 400/Steeles Ave. Interchange. The original ground in the area is generally flat, located approximately four metres below profile grade of Highway 400 and the existing ramp Steeles E-W to 400 S.

## Subsurface Conditions

The soil conditions can be classified generally as 6.0 m of fill material overlying a 12.0 m layer of clayey silt (glacial till) which in turn overlies a thick deposit of silty sand.

Groundwater is estimated to be at elevation 186.0 m. No bedrock was encountered during the investigation.

## Recommendations

It is proposed to construct a single span rigid frame bridge that will carry 407 traffic over the existing ramp Steeles Ave. E-W 400S to south bound Hwy. 400. The elevation of Hwy. 407 at this point will be approximately 12.0 m above original ground.

The abutments may be founded on steel 'H' piles at an estimated elevation of 170.0 m. The following O.H.B.D.C. design loads are recommended:

	Factored Capacity at U.L.S.	S.L.S. Type II
310 HP 110	950 kN	625 kN

Alternatively, the abutments may be founded on compacted granular 'A' fill. The following O.H.B.D.C. bearing capacity values can be utilized for design.

Factored Capacity @ U.L.S.	- 900 kPa
S.L.S. Type II	- 350 kPa

Excavation of original ground to an elevation of 184.0 m is required before construction of the fill. Fill material is to be constructed with a minimum of 1:1 slopes in all directions, as per the attached drawing.

Roadway protection will be required to protect existing slopes of Ramp Steeles Ave. E-W 400S.

Dewatering of excavations may be accomplished by using sumps.

All footings require 1.2 m of granular cover for frost protection. (measured from the underside of the footing)

#### Earth Pressure

Backfill should consist of free draining granular fill. For retaining walls, the active case should be used for design while the "at-rest" case should be used for design of the abutment walls. The following values can be used for design:

		$\phi$	$K_a$	$K_o$
Granular 'A'	22.0 kN/m <sup>3</sup>	35°	0.33	0.50
Granular 'B'	21.2 kN/m <sup>3</sup>	30°	0.27	0.43

Lateral resistance should be computed in accordance with 6.6.1.2.1 of the code for granular fills. Adhesion between the soil-footing interface may be computed using an unfactored adhesion value of 75 kPa.

#### Retaining Walls

The retaining walls may be founded on spread footings on compacted granular 'A' fill. The O.H.B.D.C. values previously stated can be used for design.

Alternatively, the retaining walls can be supported on piles. The information provided for the abutments may also be used for retaining wall design.

As an alternative to standard retaining walls, a reinforced earth retaining wall system may be utilized. If more information is required, please contact the undersigned.

#### Approach Fills

Approach fills should be constructed with standard 2:1 side and forward slopes. No major stability problems are anticipated at this time. However, a potential problem may exist on the west slope of Highway 407.

All stability recommendations will be contained in the final report.



R. Otway, P.Eng.  
Foundations Engineer