

ENGINEERING MATERIALS OFFICE  
FOUNDATION DESIGN SECTION

WO 86-26027

DIST 6

HWY 401

STR SITE -

Remedial Works for  
"Heart Lake Road Tunnel"  
across Tomken Road

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FOUNDATION INVESTIGATION REPORT  
For  
Remedial Works for  
"Heart Lake Road Tunnel" at Tomken Road  
W.O. 86-26027  
District 6, Toronto

INTRODUCTION

This report summarizes the factual information obtained from a foundation investigation carried out at the above-noted site between 86 10 20 and 86 10 30. The investigation consisted of advancing 7 boreholes in the area where the "Heart Lake Road Tunnel" intersects Tomken Road, south of Hwy. 401.

A Key Plan of the site is shown on Dwg.8626027-A in the Appendix, for reference.

The boreholes, identified as BH 1 through BH 7, were advanced by means of solid stem augers and NQ rock coring techniques. The boreholes ranged in depth from 4.3 to 7.3 m below the ground or pavement surface.

BH 5 and BH 6 were advanced through the pavement surface, while the remaining boreholes were advanced through the ground surface immediately adjacent to the concrete curb.

For purposes of referencing within this report, Point 'A' was established to represent the point of intersection of the "Heart Lake Road Tunnel" and the Tomken Road centrelines. Point 'A', as shown on Dwg. 8626027-A is identified as Sta. 10+000, Tomken Road. All borehole locations are based on this station.

SITE DESCRIPTION

This investigation was carried out at the location where the 3.05 m  $\pm$  I.D. "Heart Lake Road Tunnel" intersects Tomken Road immediately south of the Hwy. 401 and Hwy. 403 structures. Tomken Road is situated east of Hwy. 410 and west of Dixie Road, in the City of Mississauga, Regional Municipality of Peel.

The tunnel at this location was constructed entirely within the shale bedrock using drill and blast techniques under MTC Contract 73-124.

At this location, Tomken Road is constructed in a rock cut and is constructed with a 4-lane cross-section with raised concrete curbs immediately adjacent to the outside lane limits. Numerous overhead and underground utilities are found across the site.

The site is located in the physiographic region known as the "Peel Plain" (Ref: Chapman and Putnam, 1984). Bedrock within this area consists of shale with limestone seams. The bedrock is of the Georgian Bay Formation.

Land use in the vicinity of the site is primarily commercial or light industrial.

#### BOREHOLE LOCATIONS

Dwg. 8626027-A indicates in plan the location of each of the 7 boreholes. The following table summarizes the locations both in reference to the established Tomken Road stationing and in terms of co-ordinates:

<u>BH</u>	<u>STATION</u>	<u>O/S</u>	<u>CO-ORDINATES</u>	
			<u>N</u>	<u>E</u>
1	9+995.6	8.4 Rt.	4 833 218.9	292 569.8
2	10+002.5	8.4 Rt.	4 833 223.8	292 564.9
3	10+006.8	8.4 Rt.	4 833 226.9	292 561.9
4	9+995.9	8.5 Lt.	4 833 207.3	292 557.5
5	10+002.9	5.3 Lt.	4 833 214.6	292 554.9
6	10+004.4	5.3 Lt.	4 833 215.7	292 553.8
7	9+991.0	8.3 Lt.	4 833 203.9	292 561.0

#### SUBSURFACE CONDITIONS

The boundaries between the various soil types, insitu test results, and ground-water levels are shown on the Record of Borehole Sheets in the Appendix. The location of each borehole is shown in plan on Dwg. 8626027-A together with 4 stratigraphical sections.

Prior to the construction of the Tomken Road cut, bedrock was found at Elev. 169.8 ±. The existing pavement of Tomken Road at this location is at Elev. 163.8 ±.

As previously noted, two boreholes (BH 5 and BH 6) were advanced through the Tomken Road pavement. At these two locations, the thickness of asphalt was found to be approximately 100 mm.

The fill material overlying the bedrock surface consists of either silty clay or sand and gravel. Well-compacted silty clay fill was encountered in all boreholes with the exception of BH 6. No laboratory testing was carried out on samples of this cohesive material. However, based on visual identification, it appears that the silty clay is of low plasticity (CL group). The various proportions of sand and gravel within the silty clay fill vary, but are generally less than 25% of each.

The thickness of the silty clay fill was found to range between 0.5 and 0.9 m.

Sand and gravel fill was encountered in BH 5, 6 and 7. The thickness of this non-cohesive fill ranged between 0.5 and 0.8 m. No laboratory testing was carried out on samples of this cohesionless material. Based on Standard Penetration Test 'N' values obtained during the field investigation, the sand and gravel fill appears to be well-compacted.

Bedrock was proven by obtaining between 3.1 and 6.2 m of NQ rock core in each borehole. All recovered core was visually identified by E. Magni (MTC Geologist) and the detailed descriptions are included in the Appendix for reference.

The bedrock at this site consists primarily of dark grey shale of the Georgian Bay Formation. The formation consists of approximately 75-80% shale, with 20-25% limestone interbeds. The limestone seams are randomly located and generally vary between 5 and 150 mm in thickness. In addition, mud seams are evident within the shale particularly within the weathered zones.

The existing bedrock surface is fairly level and is found between 0.7 and 1.1 m below the ground or pavement surface. This corresponds to elevations ranging between 162.6 and 163.1. Generally, however, the bedrock surface is found at approximately Elev. 162.8.

The upper surface of the shale bedrock is highly weathered. This zone ranges between 0.3 and 2 m in thickness. The various zones of weathering, together with % recoveries and RQD's are shown on the Record of Borehole Sheets in the Appendix.

It should be noted that in BH 5, concrete was encountered between Elev. 161.1 and 158.7. It is believed that this concrete is not part of the tunnel wall. As previously described, this section of tunnel was constructed using drill and blast methods. It is believed that during construction a certain amount of over-blasting occurred. Consequently, large cavaties were created around the outside perimeter of the tunnel. These cavaties were filled with lean mass concrete. It can be expected that numerous other such concrete filled cavaties will be encountered adjacent to the tunnel.

#### GROUNDWATER CONDITIONS

Because water was used in the boreholes in order to obtain rock cores it became difficult to obtain stabilized groundwater levels in the boreholes. Consequently, standpipes and piezometers were installed at representative locations in order to establish stabilized water levels and in order to determine if artesian conditions exist within the bedrock.

Standpipes were installed in BH 1 and BH 7. Two piezometers were installed in each of BH 2 and BH 4. The location of the standpipes and piezometers are shown on the Record of Borehole sheets. Groundwater levels are also indicated.

Based on monitoring of the piezometers and standpipes subsequent to the installations, it appears that the groundwater level within the area investigated is at approximately Elev. 160.3±. However, in BH 7, the groundwater level was measured on 86-12-12 and was found at Elev. 161.5.

## DISCUSSION

The 1.5 km long "Heart Lake Road Tunnel" was constructed between 1973 and 1975 using three different methods. Open-cut, drill and blast, and machine-boring techniques were employed for the construction. Precast concrete pipes were used for the open-cut section, whereas cast-in-place concrete lining was installed elsewhere.

The section of tunnel under Tomken Road is of particular interest. The original tunnel cover, including bedrock and overburden was in the order of 12 m. When Tomken Road was constructed in 1975, approximately 10.5 m of overburden and bedrock was removed across the 23 m width of roadway. Therefore, the rock cover to this portion of tunnel was reduced to as little as 1.5 m. Performance inspections have revealed that this section of tunnel shows the most severe distress.

The section of tunnel under Tomken Road was constructed using drill and blast methods. Inadequate control on the blasting operation caused overbreaks ranging between 0.3 and 1 m in the highly fissile rock. In addition, the blasting action caused loosening of the rock mass. The presence of the overbreak zone due to blasting necessitated an increase in the thickness of the concrete lining. Instead of the original design thickness of 0.3 m, the final lining thickness ranged generally from 0.6 to 1.2 m, depending on the depths of overbreak zones.

Subsequent to construction, the tunnel was inspected on several occasions to monitor performance. Cracking in the concrete was observed in the entire drill and blast section. Under Tomken Road, where the cover to the tunnel is only about 1.5 m, the state of distress is most severe. Spalling of the concrete from the haunch and crown has occurred, exposing steel reinforcing. Seepage of water into the tunnel through cracks is also evident. This indicates that some of the cracks extend for the full thickness of the liner. Cracks within this section of tunnel vary in thickness from 1 to 12 mm and reveal differential displacement in many instances.

The investigation described in this report together with an investigation of the lining concrete carried out by District 6 reveals that the section of tunnel under Tomken Road requires attention.

Steps have been initiated to determine what remedial measures are necessary. In a meeting held on 86 12 10, and attended by representatives from the Foundation

Design Section, Structural Section, Structural Office and District 6, three alternatives were discussed. These are as follows:

ALT 1: Completely remove the section of tunnel under Tomken Road and reconstruct using open-cut methods.

ALT 2: Provide reinforcement within the tunnel section under Tomken Road by means of a steel liner. The steel liner could be constructed by plate segments. The gaps between the steel liner and existing concrete wall could be pressure grouted.

ALT 3: Construct a relief slab on the Tomken Road pavement to reduce the live loads acting on the tunnel liner. Repair spalled areas within tunnel.

The feasibility of each of these alternatives will be considered and evaluated by the staff from the offices previously mentioned. When a final alternative is selected, this section will provide the appropriate recommendations pertaining to the foundation design.

#### MISCELLANEOUS

The fieldwork for this investigation was carried out between 86 10 20 and 86 10 30 under the supervision of L. Politano, Project Foundations Engineer, and V. Bonnici, Student Engineer. The equipment was owned and operated by Master Soil Investigation Ltd. of Toronto.

This report was prepared by L. Politano and was reviewed by M. Devata, Chief Foundations Engineer (East).



*L. Politano*  
L. Politano, P.Eng.  
Project Foundations Engineer

*M. Devata*  
M. Devata, P.Eng.

Chief Foundations Engineer (East)

January, 1987

## APPENDIX



## EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	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						

# DESCRIPTION OF ROCK CORE -

W.O. 86-26027

BOREHOLE NUMBER				CORE DESCRIPTION	
	DEPTH (m)	% CR *	% RQD *	DEPTH (m)	DESCRIPTION
1	1.14 - 2.52	70	9	1.14 - 4.35	SHALE (75%), slightly to moderately weathered, closely to very closely spaced joints and breaks, containing LIMESTONE and SHALEY LIMESTONE (25%), unweathered. Highly weathered shale at approx. 4.04 - 4.24. This is probably the location of high core loss.  SHALE (90%), slightly weathered, closely spaced joints, containing LIMESTONE (10%), unweathered in layers from 3 - 10 cm thick.  SHALE (50%), unweathered, medium spaced joints with LIMESTONE (50%), unweathered in layers from 1 - 12 cm thick.
	2.52 - 3.13	83	17		
	3.13 - 4.24	55	0		
	4.24 - 5.79	93	46		
	5.79 - 7.32	93	93		
				4.32 - 5.79	
				5.79 - 7.32	
2	0.84 - 2.27	34	7	0.84 - 2.27	SHALE, with LIMESTONE layers, highly weathered, high core loss zone  SHALE (85%), unweathered, medium to widely spaced joints, with LIMESTONE (15%), unweathered in layers from 1 - 13 cm.
	2.27 - 3.79	93	60	2.27 - 3.79	
	3.79 - 5.31	100	97		
	5.31 - 6.33	100	98		
3	1.22 - 2.75	90	65	1.22 - 1.73	SHALE (75%), slightly weathered to moderately weathered, closely spaced joints, assumed zone of core loss  SHALE (85%), unweathered, medium spaced joints, with LIMESTONE (15%) in layers 1 - 12 cm thick
	2.75 - 4.27	100	90	1.73 - 4.27	
4	1.22 - 2.75	38	17	1.22 - 2.29	SHALE, highly weathered, high core loss zone  LIMESTONE, unweathered, medium spaced joints  SHALE (40%), unweathered, closely spaced joints, with LIMESTONE (60%), unweathered, in layers 1 - 12 mm thick  SHALE (80%), unweathered, medium spaced joints, with LIMESTONE (20%), unweathered, in layers 1 - 15 mm thick
	2.75 - 4.01	94	40	2.29 - 2.75	
	4.01 - 5.54	100	90	2.75 - 3.25	
	5.54 - 7.01	97	93		
				3.25 - 7.01	

\* CR = CORE RECOVERY ; RQD = ROCK QUALITY DESIGNATION

# DESCRIPTION OF ROCK CORE - W.O. 86-26027

BOREHOLE NUMBER				CORE DESCRIPTION	
	DEPTH (m)	% CR *	% RQD *	DEPTH (m)	DESCRIPTION
5	1.42 - 1.71	55	0	1.42 - 2.49	SHALE and LIMESTONE, highly weathered, high core loss zone
	1.71 - 3.10	56	N/A	2.49 - 4.93	CONCRETE, friable, honeycombed (poor compaction)
	3.10 - 4.57	97	N/A		
	4.57 - 6.10	90	38	4.93 - 5.38	SHALE (90%), moderately weathered, very closely spaced joints, with LIMESTONE (10%), slightly weathered in layers 1 - 2 cm
	6.10 - 6.71	96	96	5.38 - 6.71	SHALE (85%), unweathered, medium spaced, with LIMESTONE (15%) in layers 1 - 12 cm thick
6	1.22 - 2.75	18	0	1.22 - 2.44	NO RECOVERY
	2.75 - 4.27	98	60	2.44 - 2.90	SHALE, highly weathered, very closely spaced joints, with LIMESTONE layers up to 15 cm thick
	4.27 - 5.54	100	60	2.90 - 5.54	SHALE (80%), unweathered, medium to widely spaced joints, with LIMESTONE (20%) in layers 1 - 9 cm thick
7	1.37 - 2.90	52	7	1.37 - 2.90	SHALE (80%), slightly to highly weathered, high core loss zone, with LIMESTONE (20%) in layers 1 - 10 cm thick
	2.90 - 4.42	98	47	2.90 - 4.42	SHALE (80%), unweathered, closely spaced joints, with LIMESTONE (20%) in layers 1 - 8 cm thick

\* CR= CORE RECOVERY ; RQD = ROCK QUALITY DESIGNATION



## METRIC

WO 86-26027 LOCATION Sta. 9 + 995.6, 8.4 m Rt. (Tomken Rd.) ORIGINATED BY VB  
DIST 6 HWY Tomken Rd. BOREHOLE TYPE Solid Stem Auger, NQ Rock Core COMPILED BY LP  
DATUM Geodetic DATE 86 10 20/21 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			20	40						60	80	100
								SHEAR STRENGTH							WATER CONTENT (%)		
							○ UNCONFINED + FIELD VANE										
							● QUICK TRIAXIAL × LAB VANE										
163.7	Ground Surface																
0.0	Topsoil																
162.8	Silty Clay with sand trace gravel (Fill)		1	SS	76	22#5cm**	163										
0.9	Highly Weath.		2	RC			162							Rec = 70% RQD = 9%			
	Shale Bedrock		3	RC			161							Rec = 83% RQD = 17%			
	Slight - Moderately Weathered		4	RC		↓ *	160							Rec = 55% RQD = 0%			
	Slightly Weathered		5	RC			159							Rec = 93% RQD = 46%			
	Unweathered		6	RC			158							Rec = 93% RQD = 93%			
156.4	End of Borehole					seal	157										
7.3	** Spoon bouncing * On 86 12 12					STANDPIPE INSTALLED, BOTTOM 300mm SLOTTED											

# OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity



Ministry of  
Transportation and  
Communications  
Ontario

## RECORD OF BOREHOLE No 2

METRIC

WO 86-26027 LOCATION Sta. 10 + 002.5, 8.4 m Rt (Tomken Road) ORIGINATED BY VB  
DIST 6 HWY Tomken Rd. BOREHOLE TYPE Solid Stem Auger, NQ Rock Core COMPILED BY LP  
DATUM Geodetic DATE 86 10-22/23 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	'N' VALUES			20	40					
163.6	Ground Surface													
0.0	Topsoil		1	SS	5									
162.8	Silty clay, trace sand, gravel, organic (Fill)		2	SS	70/7	5 cm								
0.8	Highly Weathered		3	RC	**									Rec = 34% RQD = 7%
	Shale Bedrock		4	RC										Rec = 93% RQD = 60%
	Unweathered		5	RC										Rec = 100% RQD = 97%
			6	RC										Rec = 100% RQD = 98%
157.3	End of Borehole					*								
6.3	*spoon bouncing  2 piezometers installed #1 @ Elev. 157.5 #2 @ Elev. 160.4  * On 86 10 24													

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10



Ministry of  
Transportation and  
Communications

# RECORD OF BOREHOLE No 3

METRIC

WO 86-26027 LOCATION Sta. 10 + 006.8, 8.4 m Rt. (Tomken Rd) ORIGINATED BY VB  
DIST 6 HWY Tomken Rd. BOREHOLE TYPE Solid Stem Auger, NQ Rock Core COMPILED BY LP  
DATUM Geodetic DATE 86 10 23/24 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	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								
163.5	Ground Surface												
0.0	Silty clay, trace sand, gravel (Fill)		1	SS	8	*	163						
162.7			2	SS	30								
0.8	Highly Weathered Slightly to Moderately Weathered		3	RC			162						Rec = 90% RQD = 65%
	Shale Bedrock Unweathered		4	RC			161						
							160						Rec = 100% RQD = 90%
159.2	End of Borehole												
4.3	Stabilized groundwater level not established												

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

20  
15 5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 4

METRIC

WO 86-26027 LOCATION Sta. 9 + 995.9, 8.5 m Lt (Tomken Rd.) ORIGINATED BY VB  
DIST 6 HWY Tomken Rd. BOREHOLE TYPE Solid Stem Auger, NQ Rock Core COMPILED BY LP  
DATUM Geodetic DATE 86 10 24-27 CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100		
163.8	Ground Surface												
0.0	Topsoil		1	SS	8								
163.1	Silty Clay, some sand, gravel, trace organics		2	SS	37								
0.7	Shale Bedrock		3	RC		163							
	Highly Weathered		4	RC		162							Rec = 38% RQD = 17%
	Unweathered		5	RC		161							Rec = 94% RQD = 40%
			6	RC		160							Rec = 100% RQD = 90%
156.8						159							
						158							
						157							Rec = 97% RQD = 93%
7.0	<p>* 2 Piezometers installed #1 @ Elev. 156.8 #2 @ Elev. 160.4</p> <p>GWL On 86 10 30, Pz.#2 @ Elev. 160.1 Pz.#1 Dry</p>												

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

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

# RECORD OF BOREHOLE No 5

METRIC

WO 86-26027 LOCATION Sta. 10 + 002.9, 5.3 m Lt. (Tomken Rd.) ORIGINATED BY VB  
DIST 6 HWY Tomken Rd. BOREHOLE TYPE Solid Stem, NQ Rock Core COMPILED BY LP  
DATUM Geodetic DATE 86 10 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 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					
163.6 0.0	Pavement Surface													
	Asphalt					**								
	Sand and gravel (Fill)													
162.6 1.0	Silty Clay, some sand gravel (Fill)		1	SS	50/10cm*		163							
	Shale Bedrock		2	RC			162							Rec = 55% RQD = 0%
	Highly Weathered		3	RC										Rec = 56% RQD = N/A
161.1 2.5	Concrete		4	RC			161							
							160							Rec = 97% RQD = NA
158.7 4.9	Mod. Weathered		5	RC			159							Rec = 90% RQD = 38%
	Shale Bedrock						158							
	Unweathered		6	RC			157							Rec = 96% RQD = 96%
156.9 6.7	End of Borehole													
	* spoon penetrating weathered bedrock													
	** stabilized GWL not established													

\*3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10





Ministry of  
Transportation and  
Communications

# RECORD OF BOREHOLE No 6

METRIC

WO 86-26027 LOCATION Sta. 10 + 004.4, 5.3 m Lt. (Tomken Rd.) ORIGINATED BY VB  
DIST 6 HWY Tomken Rd BOREHOLE TYPE Solid Stem Auger, NQ Rock Core COMPILED BY LP  
DATUM Geodetic DATE 86 10 29 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH						
163.6	Pavement Surface					*	20 40 60 80 100					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT
0.0	Asphalt		1	SS	85		○ UNCONFINED      + FIELD VANE					W <sub>p</sub>	W	W <sub>L</sub>
162.8	Sand and Gravel (Fill)						● QUICK TRIAXIAL      x LAB VANE					WATER CONTENT (%)		
0.8	Shale Bedrock													
	Highly Weathered		2	RC										
	Unweathered	3	RC											
		4	RC											
158.1	End of Borehole													
5.5	* Groundwater level not established													

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 7

METRIC

WO 86-26027 LOCATION Sta. 9 + 991.0, 8.3 m Lt. (Tomken Rd.) ORIGINATED BY VB  
DIST 6 HWY Tomken Rd. BOREHOLE TYPE Solid Stem Auger, NQ Rock Core COMPILED BY LP  
DATUM Geodetic DATE 86 10 30 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			20	40					
163.8	Ground Surface													
0.0	Topsoil		1	SS	10									
	Silty Clay (Fill)		2	SS	27									
162.7	Sand and Gravel (Fill)													
1.1	Highly Weathered		3	RC										Rec = 52% RQD = 7%
	Shale Bedrock													
	Slightly Weathered													
	Unweathered		4	RC										Rec = 98% RQD = 47%
159.4	End of Borehole													
4.4	* GWL on 86 12 12													
<div style="position: absolute; left: 300px; top: 500px; transform: rotate(-90deg); transform-origin: left top;">           STANDPIPE INSTALLED, BOTTOM 300mm SLOTTED         </div>														

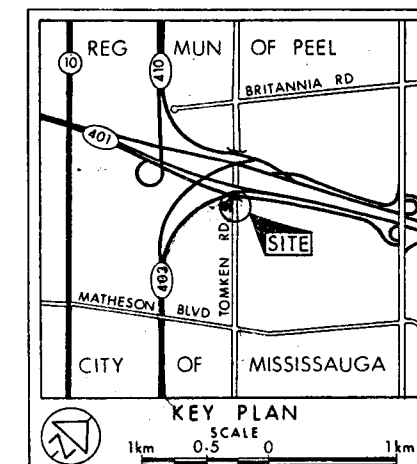
**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES UNLESS  
OTHERWISE SHOWN. STATIONS  
IN KILOMETRES + METRES.

CONT No  
WO No 86-26027



HEART LAKE ROAD TUNNEL  
BORE HOLE LOCATIONS & SOIL STRATA

SHEET



LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Sid Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation 86 10
- ⊕ Piezometer
- ⊕ Standpipe

No	ELEVATION	STATION	OFFSET
1	163.7	9+995.6	8.4m Rt
2	163.6	10+002.5	8.4m Rt
3	163.5	10+006.8	8.4m Rt
4	163.8	9+995.9	8.5m Lt
5	163.6	10+002.9	5.3m Lt
6	163.6	10+004.4	5.3m Lt
7	163.8	9+991.0	8.3m Lt *

\* BOREHOLES REFERENCED TO TOMKEN RD STATIONS

NOTE

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

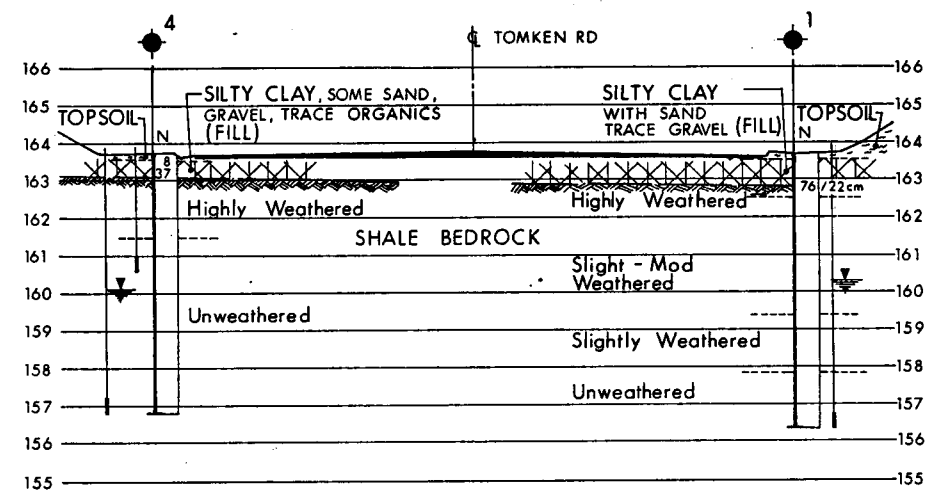
NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2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

REV.	DATE	BY	DESCRIPTION

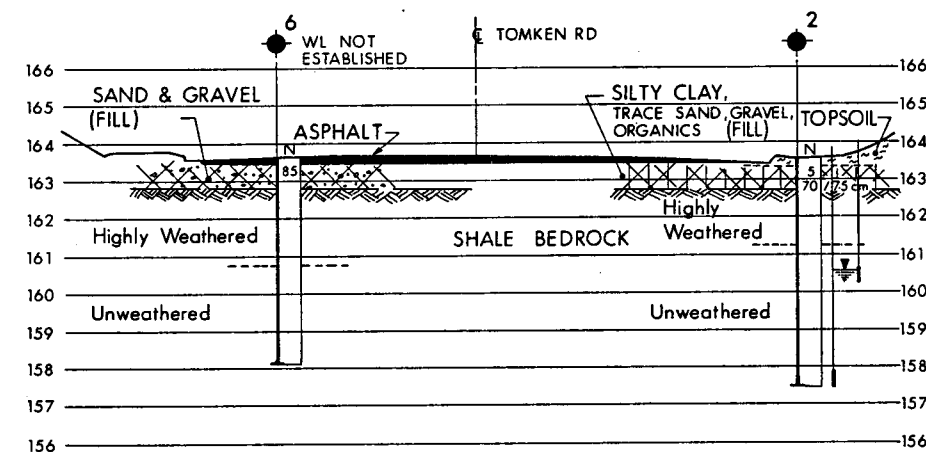
Geocres No 30M12 - 199

HWY No 401	DIST 6
SUBMD LP CHECKED	DATE 86 12 23
DRAWN DT CHECKED	APPROVED

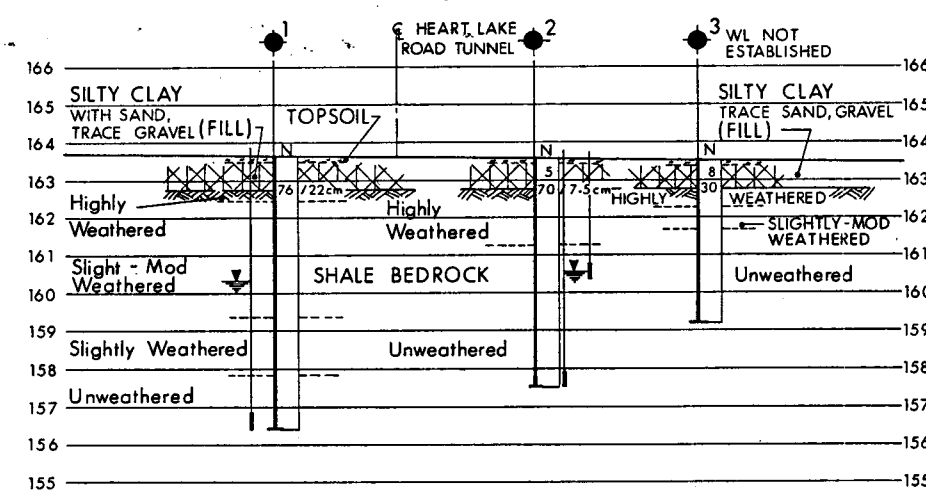
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A-A

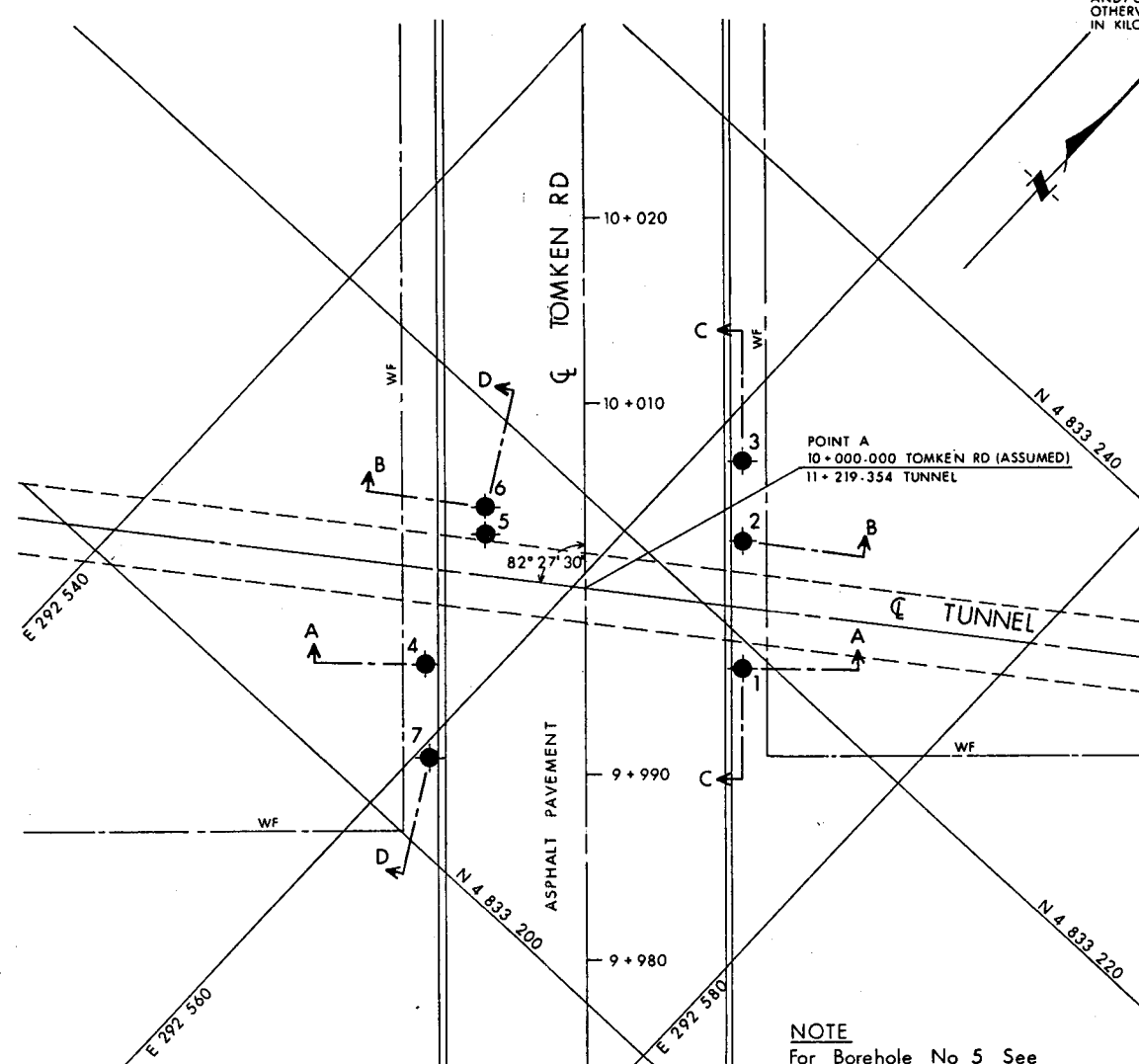


B-B

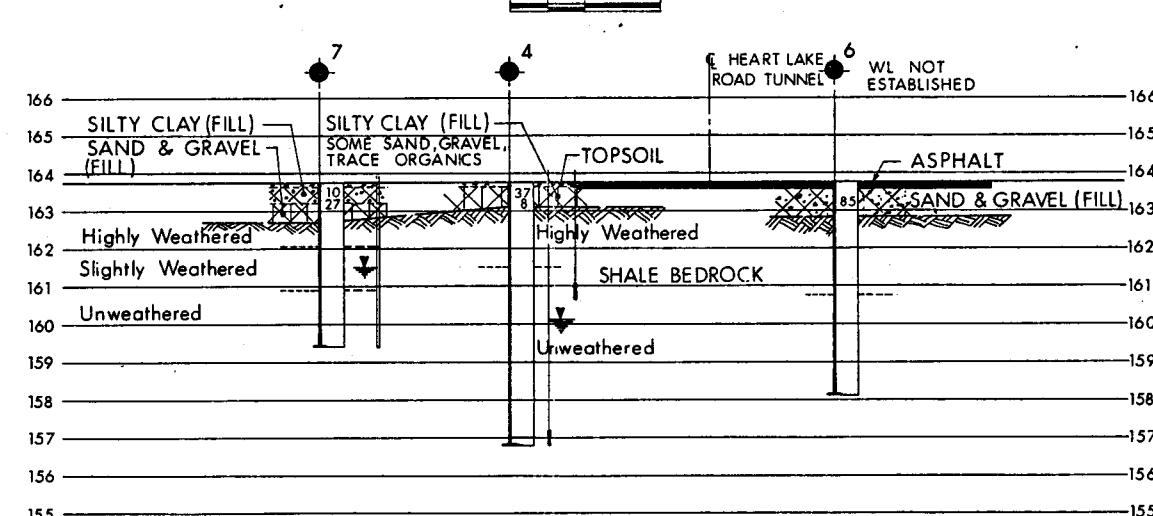


C-C

SECTIONS  
SCALE  
2m 1 0 2m



PLAN  
SCALE  
4m 2 0 4m



D-D