

GEOCRES No. 30M5-196DIST. 4 REGION _____W.P. No. 199-77-06

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W. O. No. _____

STR. SITE No. _____

HWY. No. 403LOCATION Proposed Culverts
No 3 & 4NO. OF PAGES -OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.REMARKS: _____



Ministry
of
Transportation

FILE

FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

**ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION**

WP 199-77-06 REGION Central
HWY 403 STR SITE

Proposed Culverts No. 3 and 4
Highway 403 (QEW Freeman) to Highway 5

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GEOCRES 30M5-196

DATE NOV 10 1995

FOUNDATION INVESTIGATION REPORT
For
Proposed Culverts No 3 and 4
Highway 403 (QEW Freeman) to Highway 5
W.P. 199-77-06, Hwy. 403, Central Region

INTRODUCTION

This report summarizes the results of a Foundation investigation at the above mentioned site. The investigation was carried out at the request of Central Region Structural Section.

This report contains factual information obtained from this investigation pertaining to culvert foundations and related earthworks as shown on Dwg. No. 1997706-A.

SITE DESCRIPTION

The site is located on the proposed alignment of Hwy 403 north of existing Guelph Line in the City of Burlington, Regional Municipality of Halton. The sites for the proposed culverts 3 and 4 are located 210 m and 810 m north of Guelph Line respectively. The topography in the area is generally flat with ground surface gently sloping to the northeast. Land use in the vicinity (east and west) of the site is primarily residential. The ground surface is covered with grass.

Physiographically, the site is located in the "Peel Plain" region (after Chapman and Putnam, 1984) which is characterized by a glacial till containing large amount of palaeozoic shale. Underlying the glacial till deposit are the red Queenston shale from which the glacial till's reddish colour is derived.

INVESTIGATION PROCEDURES

The fieldwork for the investigation was carried out during 95 05 17 and 95 05 23 and consisted of 7 sampled boreholes (BH 1 through BH 7) advanced to depths ranging from 6.3m to 7.8m below ground surface.

The boreholes were advanced using a CME 55 track-mounted auger machine equipped with solid stem augers.

Soil Samples were obtained at each borehole location by means of a 50mm O.D. split spoon sampler driven into the soil according to the specifications of the Standard Penetration Test (ASTM D 1586).

Samples were retrieved at 0.7m intervals within the first 6.1m and then at 1.5m thereafter. Dynamic cone test was carried out in Borehole 1.

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

Ground elevations and locations (co-ordinates) at each borehole were obtained from drawings Sheet No 64 and 101, produced by McCormick Rankin Consulting Engineers.

SUBSURFACE CONDITIONS

General

All boreholes encountered glacial till as a native soil. In general, at most of the locations, underlying the 0.9m to 1.8m thick surficial fill the strata consists of clayey silt glacial till. The glacial deposit contains layers of silty sand and some gravel. The glacial till deposits occasionally contain cobbles and boulders. The boundaries between the various soil types and laboratory test results are shown on the attached Record of Borehole sheets in the Appendix. The locations of boreholes (BH1 through BH7) are shown on the attached drawing Dwg. No. 1997706-A.

Following are the detailed soil condition.

Fill Material

Fill material was encountered in all boreholes except Borehole 4. The fill material consisted of clayey silt to silty clay with sand and some gravel. Moisture content of the fill material was found to be 15 to 20 per cent. The top elevation of this material ranged from 157.7m to 160.1m. The thickness of fill ranged from 0.9m to 1.8m. The Standard Penetration test, N-values, ranged from 6 to 14 blows/0.3m. Average N-value was about 8 blows/0.3m. This indicated that the fill material is firm to stiff but on average stiff.

Clayey Silt Till

Underlying the fill material, this cohesive deposit was encountered in all boreholes. This deposit contained layers of silt, sand and some gravel. The top elevation of this deposit ranged from 156.4m to 159.7m. All boreholes were terminated within this deposit, therefore, full depth of this deposit was not proven. The boreholes penetrated to a maximum depth of 7.8m within this deposit. The Standard Penetration test result, N-values, ranged from 14 blows to more than 100 blows/0.3m. The N-values in excess of 50 blows/0.3m were encountered at a depth of 0 to 2.5m within this deposit (elevation range 155.0m to 158m). The N-values indicate that this deposit is stiff to hard but on average hard.

Groundwater Conditions

Groundwater was encountered in three boreholes (BH 1,2 and 3). All other boreholes remained dry. The water level ranged from 152.9m (BH 2) to 156.7m (BH 3). However, it is assumed that in other boreholes water level did not stabilize. The depth of water level below ground level was 2.1m (BH 3) to 5.5m (BH 2).

DISCUSSION AND RECOMMENDATIONS

General

It is proposed to construct two concrete box culverts under proposed Hwy 403 between Hwy 5 and Guelph Line in Burlington. At present there are open channels at the proposed culvert locations. At proposed Culvert 3 the invert elevation of the existing channel ranges from 156.3m to 158.8m. At proposed Culvert 4 the invert elevation of the existing channel ranges from 155.9m to 157.4m.

Culvert # 3 will be located at station 21+080 (Ref.: Sheet # 101 produced by McCormick Rankin Consulting Engineers). The proposed 2.4m by 2.1m concrete box culvert will be 190m long. The culvert will be fed by a 1.98m ϕ concrete pipe. At the inlet there will be 4m long wing walls. At the outlet the proposed culvert will connect to an existing box culvert of the same size. The existing ground elevation at the proposed culvert location ranges from 158.4m to 160.1m. The proposed culvert invert elevation will range from 152.6m to 153.4m.

Culvert # 4 will be located at station 21+682 (Ref.: Sheet # 101 produced by McCormick Rankin Consulting Engineers). The proposed 3.0m by 2.1m concrete box culvert will be 146m long. The culvert will be fed by a 2.1m ϕ concrete pipe sewer. At the outlet the proposed culvert will connect to an existing box culvert of the same size. The existing ground elevation at the proposed culvert location ranges from 157.7m to 158.2m. The proposed culvert invert elevation will range from 152.2m to 153.0m.

There will be embankments on the east and west sides of Hwy 403. The embankments will be located above the inlets and the outlets of the culverts. The embankments will be 25m to 38m wide and 5.2m to 6.0m high above the existing ground surface. The grade of Hwy 403 will be about 2.2m below existing ground at proposed Culvert 3 (existing ground elevation 159.5m and proposed Hwy 403 grade 157.4m). At Culvert 4 the grade of Hwy 403 will be about 0.3m higher than the existing ground (existing ground elevation 158.0m and proposed Hwy 403 grade 158.3m).

Structural Foundations

The soil at the proposed culvert invert elevations (152.6m to 153.4m for Culvert 3 and 152.2m to 153.0m for Culvert 4) is a competent hard glacial till. The culvert can be founded on spread footing on granular bedding (see 'Bedding' section for details) constructed on the glacial till deposit.

The depth of wing walls should be determined based on frost depth and scour depth whichever is greater. Frost depth at the site is 1.2m. RSS walls should be considered as an alternative to conventional wing walls.

The following values can be utilized for the design of proposed culvert foundations for the purposes of the O.H.B.D.C.

Bearing Capacity at U.L.S.	= 500 kPa
Bearing Capacity at S.L.S.	= Not Applicable (Unyielding soil)

The following values can be utilized for the design of proposed wing wall foundations for the purposes of the O.H.B.D.C.

Bearing Capacity at U.L.S.	= 250 kPa
Bearing Capacity at S.L.S.	= 150 kPa

Lateral Pressure

The following properties are recommended for the calculation of lateral pressure:

Granular 'A'	$\gamma = 22.8 \text{ kN/m}^3$, $\phi = 35^\circ$, $K_o = 0.43$, $K_a = 0.27$
Granular 'B'	$\gamma = 21.2 \text{ kN/m}^3$, $\phi = 30^\circ$, $K_o = 0.50$, $K_a = 0.33$
Native Soil	$\gamma = 20.0 \text{ kN/m}^3$, $\phi = 26^\circ$, $K_o = 0.56$, $K_a = 0.39$

If the structure is to be designed as a rigid frame then the coefficient of earth pressure at rest (K_o) should be used. For structural elements rigidly connected to the concrete box culvert, at rest condition (K_o) should be used to calculate the lateral pressure.

Active condition (K_a) will govern for the calculation of pressure against wing walls.

Lateral Resistance for Retaining Walls

Sliding resistance between the base of retaining wall footings and underlying material should be calculated assuming an angle of internal friction of $\phi = 26^\circ$. If required, sliding resistance can be supplemented by keys or anchors. Lateral resistance design will not be required for the culverts.

Stability and Settlement

No deep seated stability problems are anticipated for the proposed height (5.2m to 6.0m) of permanent embankment. The permanent embankment side slope should be at 2H:1V. For surface stability a 2m wide berm should be incorporated in the design so that no uninterrupted slope is higher than 6m. Under the concrete box culverts settlement will be minimal, not exceeding 50mm.

CONSTRUCTION CONSIDERATIONS

Temporary Diversion

To facilitate the construction of the proposed culverts, the flow of the creeks would have to be diverted. This could be achieved by intercepting the water flow in the existing concrete pipe at the inlets and pumping into the existing box culvert at the outlets of the proposed culverts.

Dewatering

The excavation for culvert construction would extend to a depth of 3.75m below prevailing groundwater table, particularly at Culvert 3. Due to the cohesive and very stiff to hard nature of the soil a major dewatering scheme may not be required. It is expected that the seepage of water into the excavation will be minor and would be controlled by sump pump.

However, a special provision should be incorporated in the contract requiring the Contractor to construct the culvert without disturbance to the foundations. The dewatering method is the responsibility of the Contractor and the Contractor should submit his dewatering proposal for review a minimum of 15 working days prior to construction.

Excavation

Excavation up to 6.5m deep will be required for the construction of the culverts. Temporary excavation will be stable at 1.5H:1V above water table and 2H:1V below water table.

Bedding

Normally bedding for box culverts over a competent subgrade is not required. However, for cast in place culverts, in order to avoid softening of the subgrade, the subgrade should be covered with a minimum 150mm thick working slab (mass concrete) within 4 hours of the excavation. The culvert should be then constructed on the working slab. For precast concrete culverts a 0.3m thick granular bedding should be used to level the ground.

Cambering

Due to competent soil condition, no significant settlements are anticipated. Therefore, cambering is not required.

Weeping Holes

To relieve excess hydrostatic pressure behind the culvert walls, weeping holes should be provided at 6m centre to centre.

Construction Joints

The construction joint will be required between the precast concrete segments. The construction joints should be able to accommodate differential settlement and provide proper seal.

Backfilling

Backfilling to the culvert and retaining walls should consist of suitable material compacted in accordance with MTO Standards and conform to OPSD 800 series. The backfill operations should be carried out simultaneously on both sides of the culvert as per MTO specifications. For the concrete box culverts, above the bedding level backfilling to the culverts should consist of suitable compacted material in accordance with MTO Standard. For fill below groundwater level and within frost depth Granular A or B should be used.

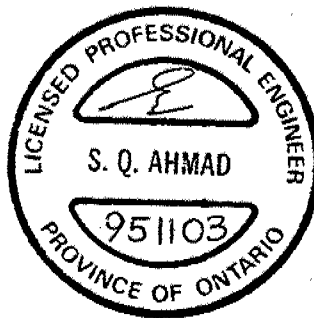
Erosion Protection

For the erosion protection at the inlet of Culvert 3, it is proposed to construct a 0.6m thick rip rap within an area of 7m by 10m. Also there will be wing walls at the inlet of Culvert 3. At the inlet of Culvert 4 there will be a drop structure that would connect the existing 2.1m ϕ concrete pipe to the proposed culvert. Therefore, erosion protection will not be required at the inlet of Culvert 4.

Erosion protection will not be required at the outlets of Culvert 3 and Culvert 4 as they will be connected to existing box culverts.

Miscellaneous

The fieldwork for this project was carried out under the supervision of K. Ahmad, Foundation Engineer and Deanna Brooker Engineering student, using equipment owned and operated by K & S Drilling. This report was prepared by K. Ahmad, Foundation Engineer, reviewed and approved by D. Dundas, Sr. Foundation Engineer.



A handwritten signature in cursive script, reading "K.S.Q. Ahmad".

K.S.Q. Ahmad, P. Eng.
Foundation Engineer



A handwritten signature in cursive script, reading "D. Dundas".

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

APPENDIX

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 199-77-06 LOCATION Coords: N 4 803 624.9; E 277 811.9 ORIGINATED BY DB
DIST CR HWY 403 BOREHOLE TYPE SS Auger COMPILED BY DB
DATUM Geodetic DATE 1995 05 17 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
160.1	Ground Surface													
0.0	Clayey Silt with Sand, some Gravel, stiff Brown, moist (Fill)		1	SS	10									
158.4			2	SS	19									
1.7			3	SS	33									2 17 54 27
	Clayey Silt trace Gravel Reddish-Brown to Brown moist very stiff to hard (Glacial Till)		4	SS	50 /15cm									
			5	SS	60 /15cm									8 17 54 21
			6	SS	50 /8cm									
153.7			7	SS	80									
6.4	End of Borehole • Borehole appeared to be dried, left open, water level rose to stabilized level				/13cm									

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 199-77-06 LOCATION Coords: N 4 803 702.5; E 277 884.1 ORIGINATED BY DB
 DIST CR HWY 403 BOREHOLE TYPE SS Auger COMPILED BY DB
 DATUM Geodetic DATE 1995 05 17 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
158.4	Ground Surface													
0.0	Silty Clay Dark Brown, stiff (Fill)		1	SS	9		158							
156.6			2	SS	14		157							
1.8			3	SS	33		156							4 15 58 23
	Clayey Silt trace of Gravel, Brown, moist Hard (Glacial Till)		4	SS	67		155							
			5	SS	75		154							
			6	SS	100		153							
					26cm									
151.8	Silty Sand with Gravel, trace of clay (Glacial Till)		7	SS	100									17 14 (69)
6.5	End of Borehole * Approximate water level at time of boring				21cm									

RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. 199-77-06 LOCATION Coords: N 4 803 680.1; E 277 841.8 ORIGINATED BY DB
DIST CR HWY 403 BOREHOLE TYPE SS Auger COMPILED BY DB
DATUM Geodetic DATE 1995 05 17 CHECKED BY KA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100	W _p	W	W _L		
158.8	Ground Surface															
0.0																
157.4	Silty Clay Reddish-Brown, moist, stiff (Fill)		1	SS	8											
1.4			2	SS	62											
			3	SS	101											
	Clayey Silt with Sand				23cm											
	some layers of Sandy Silt to Silt		4	SS	70											
					15cm											
	Brown to Reddish-Brown damp to moist		5	SS	95											
					21cm											
	Hard		6	SS	70											
	(Glacial Till)				10cm											
152.5			7	SS	71											
6.3	End of Borehole • Stable water level after leaving borehole open for one day				/8cm											

RECORD OF BOREHOLE No 5

1 OF 1

METRIC

W.P. 199-77-06 LOCATION Coords: N 4 804 266.3; E 277 846.2 ORIGINATED BY DB
DIST CR HWY 403 BOREHOLE TYPE SS Auger COMPILED BY DB
DATUM Geodetic DATE 1995 05 18 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	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					
157.7	Ground Surface																
0.0	Silty Clay moist, Dark Brown, firm (Fill)					DRY	157										
156.8			1	SS	6												
0.9			2	SS	14		156										
	Stiff		3	SS	38		155										
	Hard		4	SS	63		154										
	Clayey Silt		5	SS	63		153										
	trace of Gravel and Sand		6	SS	69		152										
	Brown, moist		7	SS	65												
	(Glacial Till)		8	SS	80												
151.3																	
6.4	End of Borehole																

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 199-77-06 LOCATION Coords: N 4 804 251.0; E 277 796.3 ORIGINATED BY DB
DIST CR HWY 403 BOREHOLE TYPE SS Auger COMPILED BY DB
DATUM Geodetic DATE 1995 05 19 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
157.8	Ground Surface													
0.0	Silty Clay with some Gravel Reddish-Brown, stiff (Fill)		1	SS	10	DRY	157							
156.4			2	SS	61		156							
1.4			3	SS	44		155							
	Clayey Silt with trace of Sand and Gravel Brown to Reddish-Brown damp to moist, Hard (Glacial Till)		4	SS	84		154							6 21 51 22
			5	SS	67		153							
			6	SS	80		152							
151.4			7	SS	75									
5.4	End of Borehole													

RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 199-77-06 LOCATION Coords: N 4 804 249.2; E 277 759.3 ORIGINATED BY DB
DIST CR HWY 403 BOREHOLE TYPE SS Auger COMPILED BY DB
DATUM Geodetic DATE 1995 05 23 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
158.2	Ground Surface																
0.0	Silty Clay trace Gravel, Dark Brown, moist, firm (Fill)		1	SS	6	DRY	158										
156.8			2	SS	14		157										
1.4	Stiff Hard		3	SS	33		156										
	Clayey Silt some Sand, trace Gravel		4	SS	58		155										
	Brown, moist		5	SS	70		154										
	(Glacial Till)		6	SS	70		153										
151.6			7	SS	84		152										
6.6	End of Borehole																

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

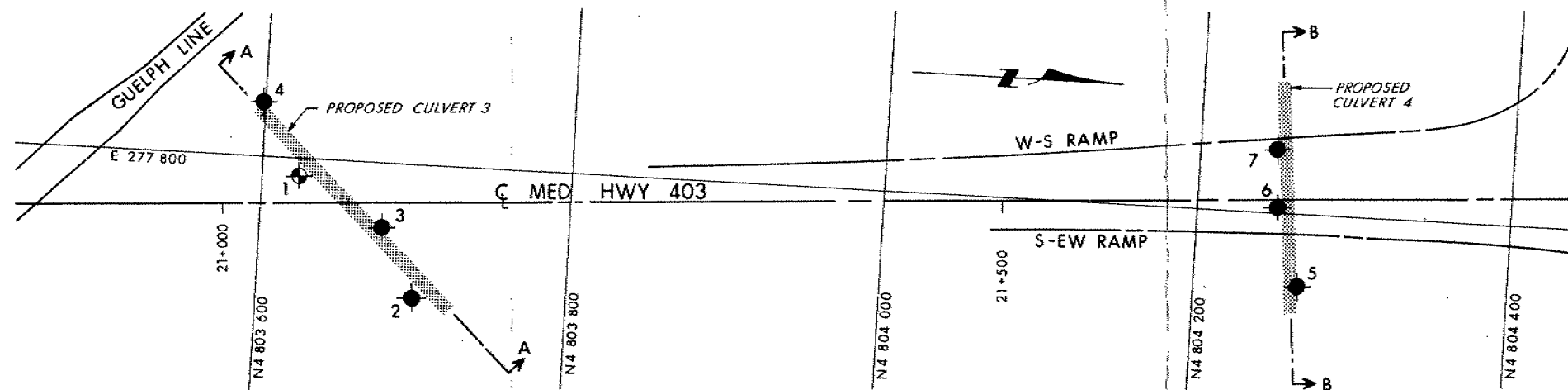
u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kg/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kg/m ³	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kg/m ³	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m ³	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m ³ /s	RATE OF DISCHARGE
γ_d	kg/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $\frac{w_L - w_p}{w_p}$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kg/m ³	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kn/m ³	SEEPAGE FORCE
γ'	kg/m ³	UNIT WEIGHT OF SUBMERGED SOIL						

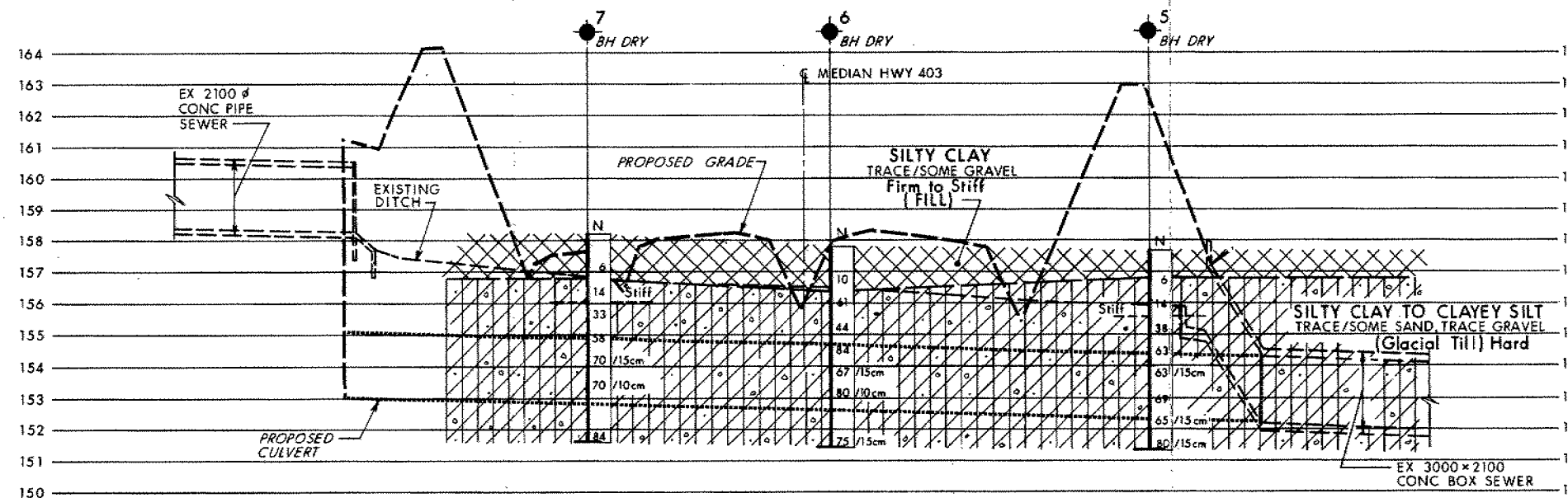
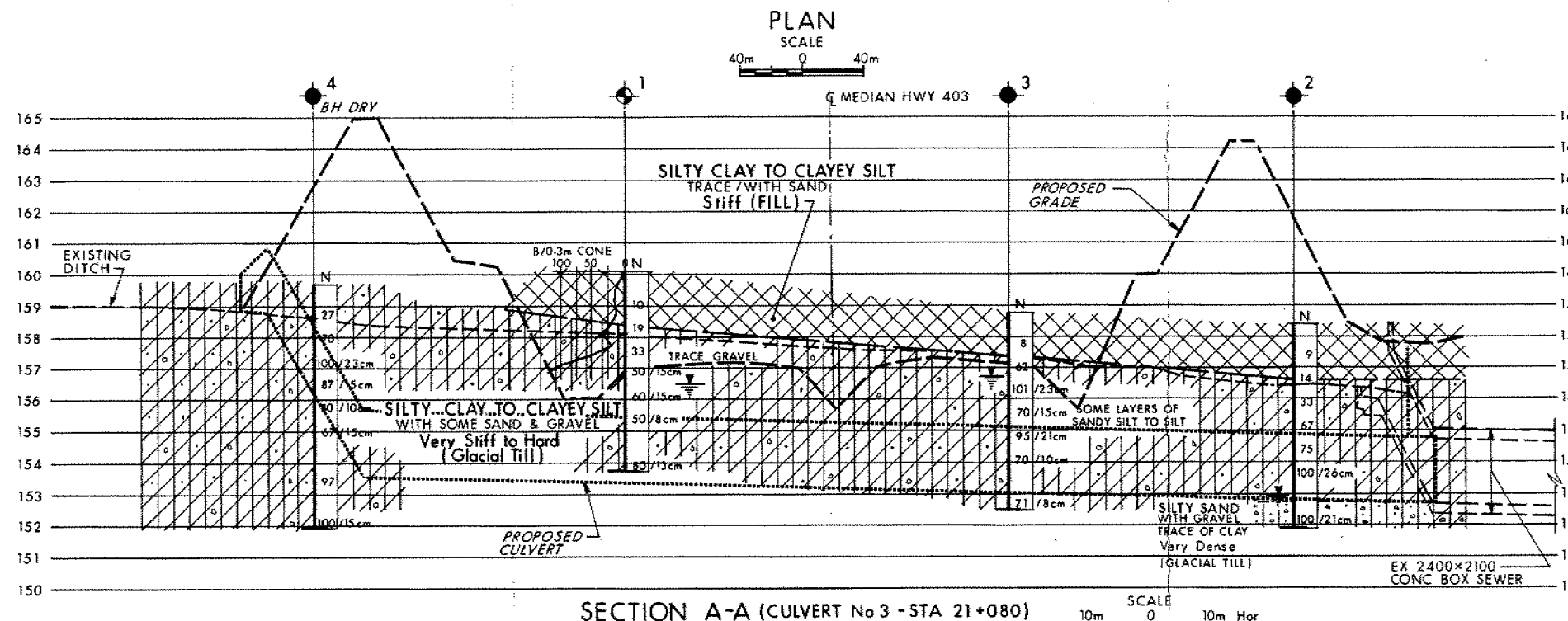
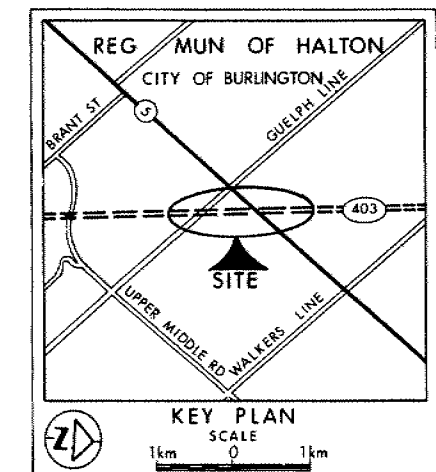


METRIC
DIMENSIONS ARE IN METRES
AND / OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

CONT No
WP No 199-77-06
CULVERTS No 3 & 4
(GEW FREEMAN TO HWY 5)
BORE HOLE LOCATIONS & SOIL STRATA



SHEET



LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation 1995 05

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	160.1	4 803 624.9	277 811.9
2	158.4	4 803 702.5	277 884.1
3	158.8	4 803 680.1	277 841.8
4	159.7	4 803 599.0	277 765.2
5	157.7	4 804 266.3	277 846.2
6	157.8	4 804 251.0	277 796.3
7	158.2	4 804 249.2	277 759.3

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 GC 2-01 of OPS Gen Cond.



REV	DATE	BY	DESCRIPTION
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Geocres No 30M5-196
HWY No 403
SUBM'D KA [CHECKED KA] DATE 1995 08 08 SITE
DRAWN DT [CHECKED DT] APPROVED DWG 1997706-A



memorandum

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

1995 03 23

Attn.: N. Potak, P. Eng.

From: Pavement & Foundations Section
Room 315, Central Building
Downsview, Ontario

Re: Preliminary Recommendations
Proposed Culverts No 3 and 4
Highway 403 (QEW Freeman) to Highway 5
W.P. 199-77-06
Hwy 403, Central Region

This memo presents preliminary foundation recommendations for the above mentioned project for your design to proceed. The recommendations are based on soil information obtained from two projects (Geocres 30M-162, WP 199-77-19, Hwy 403 and Guelph Line Underpass; and Geocres 30M-163, WP 199-77-21, Hwy 403/Hwy 5 Underpass). Since, the sites for proposed culverts are located between Guelph Line and Hwy 5 in a low ground, it is possible that the soil condition at the culvert locations may be different than the soil condition at the two reference sites. Therefore, a Foundation investigation at the proposed culvert locations is required to confirm our assumptions. However, it is not expected that any major revision in the recommendations will be required. The final report will be provided after the Foundation investigation is completed.

General

It is proposed to construct two concrete box culverts under proposed Hwy 403 between Hwy 5 and Guelph Line in Burlington.

Culvert # 3 will be located at station 21+080 (Ref.: Sheet # 101 produced by McCormick Rankin Consulting Engineers). The proposed 2.4m by 2.1m concrete box culvert will be 190m long. The culvert will be fed by a 1.98m ϕ concrete pipe sewer which will not connect to the proposed culvert. At the inlet there will be 4m long wing walls. At the outlet the proposed culvert will connect to an existing box culvert of the same size. The existing ground elevation at the proposed culvert location ranges from 156.2m to 159m. The proposed culvert invert elevation will range from 152.6m to 153.4m.

Culvert # 4 will be located at station 21+682 (Ref.: Sheet # 101 produced by McCormick Rankin Consulting Engineers). The proposed 3.0m by 2.1m concrete box culvert will be 146m long. The culvert will be fed by a 2.1m ϕ concrete pipe sewer. At the outlet the proposed culvert will connect to an existing box culvert of the same size. The existing ground elevation at the proposed culvert location ranges from 155.9m to 157.5m. The proposed culvert invert elevation will range from 152.2m to 153.0m.

Structural Foundations

Based on the soil information in the adjacent areas the proposed culvert construction is feasible. The culverts can be founded on spread footing on granular bedding constructed on native soil (to be confirmed by field investigation).

The depth of wing walls should be determined based on frost depth and scour depth whichever is greater. Frost depth at the site is 1.2m.

The following values can be utilized for the design of proposed culvert foundations for the purposes of the O.H.B.D.C.

Bearing Capacity at U.L.S.	= 300 kPa
Bearing Capacity at S.L.S.	= 200 kPa

The following values can be utilized for the design of proposed wing wall foundations for the purposes of the O.H.B.D.C.

Bearing Capacity at U.L.S.	= 250 kPa
Bearing Capacity at S.L.S.	= 150 kPa

Lateral Pressure

The following properties are recommended for the calculation of lateral pressure:

Granular 'A'	$\gamma = 22.8 \text{ kN/m}^3$, $\phi = 35^\circ$, $K_o = 0.43$, $K_a = 0.27$
Granular 'B'	$\gamma = 21.2 \text{ kN/m}^3$, $\phi = 30^\circ$, $K_o = 0.50$, $K_a = 0.33$
Native Soil	$\gamma = 21.0 \text{ kN/m}^3$, $\phi = 30^\circ$, $K_o = 0.50$, $K_a = 0.33$

If the structure is to be designed as a rigid frame then the coefficient of earth pressure at rest (K_o) should be used. For structural elements rigidly connected to the concrete box culvert, at rest condition (K_o) should be used to calculate the lateral pressure.

Active condition (K_a) will govern for the calculation of pressure against wing walls.

Lateral Resistance for Retaining Walls

Sliding resistance between the base of retaining wall footings and underlying material should be calculated assuming an angle of internal friction of $\phi = 26^\circ$. Lateral resistance design will not be required for the culverts.

Stability and Settlement

No deep seated stability problems are anticipated for the proposed height of permanent embankment. The permanent embankment side slope should be at 2H:1V. For surface stability a 2m wide berm should be incorporated in the design so that no uninterrupted slope is higher than 6m. Under the concrete box culverts settlement will be minimal not exceeding 50mm.

Excavation

Excavation up to 5m deep will be required for the construction of the culverts. Temporary excavation can be stable at 1.5H:1V above water table and 2H:1V below water table.

Bedding

Normally bedding for box culverts over a competent subgrade (subject to verification) is not required. However, for cast in place culverts, in order to avoid softening of the subgrade, the subgrade should be covered with a minimum 150mm thick working slab (mass concrete) within 4 hours of the excavation. The culvert should be then constructed on the working slab. For precast concrete culverts a 0.3m thick granular bedding should be used to level the ground. Any seepage of water should be controlled with sump pump technique.

Weeping Holes

To relieve excess hydrostatic pressure behind the wall, weeping holes should be provided at 6m centre to centre.

Construction Joints

The construction joint will be required between the precast concrete segments. The construction joints should be able to accommodate differential settlement and provide proper seal.

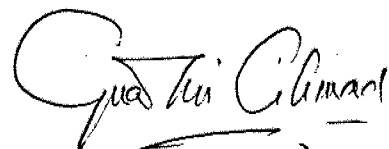
Backfilling

For the concrete box culverts, above the bedding level backfilling to the culverts should consist of suitable compacted material in accordance with MTO Standard. For fill below groundwater level and within frost depth Granular A or B should be used. The backfilling will be as per OPSD - 803.06.

Erosion Protection

It is understood that cutoff walls will be constructed at the inlet. As an alternate to the cutoff wall, equivalent apron of impermeable material may be constructed. For the apron a seal of cohesive material (CI-CH clay) with a minimum thickness of 0.6m should be constructed at the culvert inlet extending a minimum of 4m in front of the inlet. As an alternative to the head walls a clay seal could be constructed at the inlet. A clay seal should extend a minimum of 2m on each side of the culvert inlet and from the high water level down the embankment to the creek bed. The material for the clay seal should be as per OPSS 1205. If suitable clay is not available then the clay mixture should be prepared as per OPSS 1205.05.03.

The erosion protection at the inlet may consists of a 0.6m thick rock blanket consisting of 300 mm size rock. It should extend from the high water level to the toe of the slope and at least 2m along the creek bed. In transverse direction, the erosion protection should extend a minimum of 5m on each side of the culvert. At the outlet erosion protection will not be required as the proposed culvert will connect to an existing culvert.



K.S.Q. Ahmad, P. Eng.
Foundation Engineer

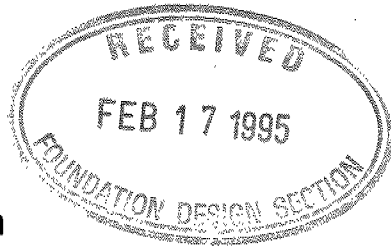
For

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



Ontario

memorandum

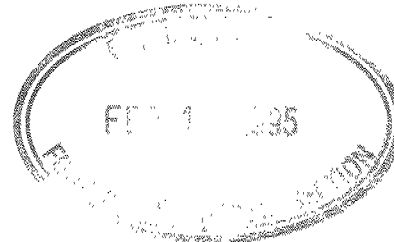


MINISTRY OF TRANSPORTATION
Structural Engineering
1201 Wilson Avenue
Atrium Tower, 4th Floor
Downsview, Ontario, M3M 1J8
Telephone: 235-4001

DATE: February 15, 1995

TO: D. Dundas
Foundation Design Section
3rd. Floor, Central Building

RE: Highway 403 (QEW Freeman) to Highway 5
Culvert Design
W.P. 199-77-06



Attached please find the following:

- Design data for concrete culverts;
- Drawings showing proposed culvert.
- Geotechnical Soils Survey Data.

Kindly provide foundation recommendations for Culvert #3 and Culvert #4 where fill height exceeds standard fill height as tabulated in Concrete Culvert Design and Detailing Manual.

We appreciate you forward the preliminary recommendations by February 24, 1995, so we can proceed with the design.

N. Potak
Sr. Structural Engineer
for:
V. F. Boehnke
Head, Structural Engineering

NP:vn

cc: E. Salva, Hwy. Eng.



DESIGN DATA FOR CONCRETE CULVERTS

Sheet 1 of 2
Date 95/01/18

Project Engineer McCormick Rankin J.D. Elliott Group WP No 199-77-06

Group WP Location from QEW (Freeman Interchange) Northerly to Highway 5 Hwy No 403 District 4 Burlington

City of Burlington Region of Halton Nearest Railway Siding on Railway

		WP	Range or		Type of Culvert	Span S	Height H	Total Length L*	Extension		Max Cover Over Slab F	Skew No	** End Treatment				Special Treatment and/or remarks
		Station	Lot	Con					Existing				New				
									Lt	Rt			Lt	Rt			
The following	is for a continuous culvert (Culvert No. 1)																
between Sta.	17 + 550 ± and Sta. 17 + 858				Total Length 389.67m												
Burl- ington	Halton	10 + 000 to 10 + 121.463	8	1 SDS	Rigid Frame Box	4.5m	3.5m	121.46	-	-	5.0 m	N/A					10 + 000 Fit to existing 4.5 x 3.5 rigid frame box
																	10 + 121 transition to 4.5 x 3.0 rigid frame box
Burl- ington	Halton	10 + 121.463 10 + 250	8	1 SDS	Rigid Frame Box	4.5m	3.0m	128.54	-	-	3.5 m	N/A					10 + 121 Transition from 4.5 x 3.5 rigid frame box
																	10 + 245 to 10 + 250 step 1.635 m
Burl- ington	Halton	10 + 250 10 + 389.667	8	1 SDS	Rigid Frame Box	4.5 m	3.0m	139.67			2.0 m	N/A					10 + 389.67 culvert joins to 2550 mm Ø Conc. pipe

Notes: All dimensions in metres

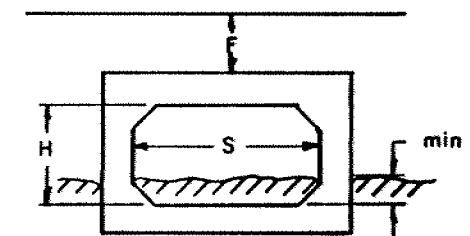
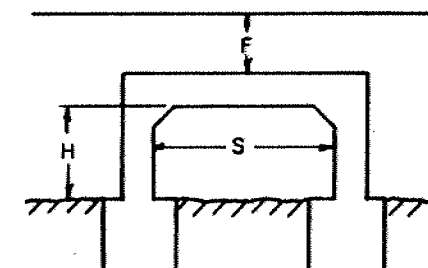
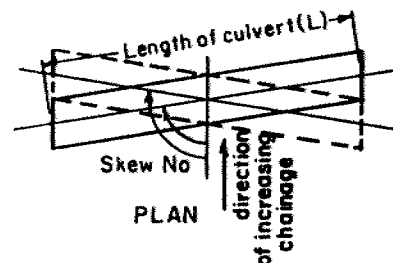
* Length to be shown to the nearest

** For end treatments, specify the following:

Square (⊥ to culv C) - □ or Sq

Skewed (∥ to road C) - ◇ or Sk

(other) - specify



Prepared by Approved by



DESIGN DATA FOR CONCRETE CULVERTS

Sheet 2 of 2

Date 95/01/18

Project Engineer McCormick Rankin J.D. Elliott Group WP No 199-77=06

Group WP Location from QEW (Freeman Interchange) northerly to Highway 5 Hwy No 403 District 4 Burlington

City of Burlington Region of Halton Nearest Railway Siding on Railway

City	Region	WP Station	Range or		Type of Culvert	Span S	Height H	Total Length L*	Extension		Max Cover Over Slab F	Skew No	** End Treatment				Special Treatment and/or remarks
			Lot	Con					Existing				New				
		Lt							Rt	Lt			Rt	Lt	Rt		
Burl- ington	Halton	18 + 840 28 Lt. to 57 Lt.	19	1 SDS	Rigid Frame Box	1.8m	0.9m	29m			5.6 m Earth Berm	90					Entrance treatment 3.0 m improved inlet. Outlet bevelled to fit 2:1 slope
Burl- ington	Halton	21 + 080	15	1 SDS	Rigid Frame Box	2.4m	2.1m	170m			9.4m Berm 2.2m Road	46					Entrance treatment 20.0 m improved inlet. Outlets into existing 2.4 x 2.1 m concrete culvert.
Burl- ington	Halton	21 + 682	14	1 SDS	Rigid Frame Box	3.0m	2.1m	146m			9.2m Berm 3.8 m Road	88					Inlet drop structure from existing 2100 mm Ø concrete pipe, outlets into existing 3.0 m x 2.1 m concrete culvert

Notes: All dimensions in metres

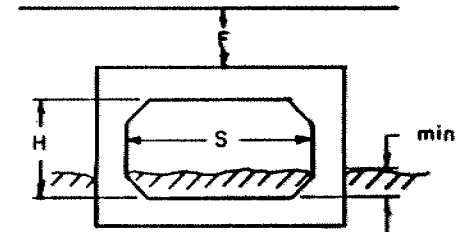
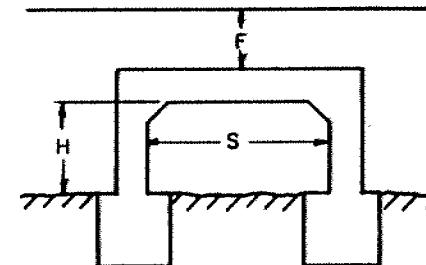
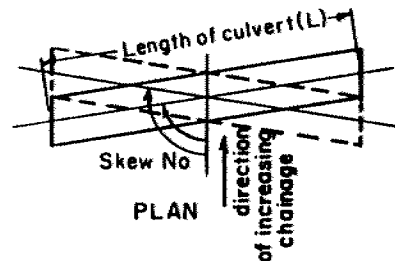
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** For end treatments, specify the following:

Square (⊥ to culv C) - □ or Sq

Skewed (|| to road C) - ◇ or Sk

(other) - specify



Prepared by Approved by