

60-F-3/50

W.P. 101-59

Hwy. 401 1/2 Cty. Rd.

3A 1038

FOUNDATION INVESTIGATION REPORT

60-F-315C  
Proposed Structure: Hwy. 401 & Cty. Rd.

Lots 37 and 38, Cornwall Township, #1

W. P. 101-59, District No. 9

DEPARTMENT OF HIGHWAYS OF ONTARIO

Submitted by

Associated Geotechnical Services Limited,  
Toronto, Ontario.

April 1960.



ONTARIO  
DEPARTMENT OF HIGHWAYS

Memo to Mr. A. M. Toye, Date May 3, 1960.  
Bridge Engineer. Subject FOUNDATION INVESTIGATION -- by  
Materials & Research Section. Associated Geotechnical Services  
Limited.

Attention: Mr. S. McCombie.

Re: Proposed Structure: Hwy. 401 & Cty. Rd.,  
Lots 37 & 38, Cornwall Twp., District 9,  
W.P. 101-59.

Enclosed herewith, is the report on the subsoil conditions existing at the above noted structure location, submitted by Associated Geotechnical Services, Ltd.

We have reviewed the factual data and recommendations contained in this report, and conclude that the dense glacial till stratum encountered at this site is competent to support spread footings loaded to a net intensity of 3 tons/sq.ft., at an elevation of 260.0' or below. Minimum frost protection cover in the area is considered to be 6 feet.

If you have any queries with regard to the contents of this report, or our comments, please contact our Office.

LGS/MdeF  
Attach.

L. G. Soderman,  
PRINCIPAL SOILS & FOUNDATIONS ENGINEER

cc: Messrs. A. M. Toye (2)  
H. A. Tregaskes  
D. G. Ramsay  
J. Ford  
L. E. Walker  
J. E. Guspier  
A. Watt

Foundations Office  
Gen. Files.

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## SECTION 1

### INTRODUCTION

The purpose of this report is to present the results of a foundation investigation made in connection with the proposed structure on Highway 401 and the County Road between Lots 37 and 38 in Cornwall Township.

This study was authorized by the A/Materials and Research Engineer, Department of Highways of Ontario, on March 30, 1960.

## SECTION 2

### SUMMARY AND RECOMMENDATIONS

The soils at the site can be summarized as follows in order of their occurrence below ground surface:-

- 1 - approximately 10 to 23 ft of a medium  
dense till-textured soil
- 2 - approximately 15 to 25 ft of a very dense  
till-textured soil overlying limestone  
bedrock.

It is proposed to pass the County Road over Highway 401.

The abutments may be founded at elevation 260 on spread footings with an allowable bearing capacity of 5 kips per sq ft for 6 ft wide footings provided that the structure is designed in anticipation of a possible differential settlement of one inch.

If so desired, the structure may be supported on H-piles driven to refusal in the lower till.

## SECTION 3

### DISCUSSION OF PROCEDURES

The borehole locations for this investigation were established by the Field Soils Engineer by chaining from the intersection of the proposed centrelines of Highway 401 and of the proposed County Road. Both of these lines have been established in the field by D. H. O. surveyors. The borehole locations are shown on Figure 1, Appendix I.

The elevation of each borehole was determined by spirit level from D. H. O. B. M. Elevation 267.56 which is located 205 ft left of Sta. 12 + 30.

A primary drilling program consisting of 4 soil borings and 4 dynamic cone probes was carried out in the vicinity of the proposed structure. Two skid-mounted Boyles screw-feed drilling rigs were used on this project. All boring and sampling operations were completed by an experienced soil sampling crew under the full-time supervision of a qualified Soils Engineer.

In general, the soil borings were performed by standard wash boring sequences; however, in order to expedite the advance of the casing into the pebbly till layers, the bottom end of the casing was fitted with a diamond shoe bit and the casing fed into the ground by diamond drilling techniques. Water was used in this method to clean and cool the diamond drill bit as well as to carry the sludge out of the hole during the actual drilling operations.

### SECTION 3 - continued

Attempts were made to obtain soil samples by means of a 2" O. D. standard split-spoon sampler. The standard penetration test using a 140 lb hammer falling 30 inches was recorded for each foot of sampler penetration. All samples were visually examined and classified on the site, then placed in jars and forwarded to the engineering office.

Where the split spoon samples appeared relatively undisturbed, apparent insitu density tests were made by the mercury displacement method. Grain size analyses were made on selective samples from each stratum. The results of all laboratory tests are given in the Appendices.

Dynamic cone probes were made using a 2" O. D. 60° cone point fastened to the end of an A-rod. The number of blows required by a 140 lb hammer falling 30 inches to drive the cone 12 inches were recorded for each foot of penetration.



## SECTION 4

### DISCUSSION OF SITE

#### 4.1 Geographical Location

The proposed bridge site is located in the Township of Cornwall, County of Stormont, where the County Road between Lots 37 and 38 will overpass Highway 401.

#### 4.2 Geology of Site Area

The Pleistocene and Recent geology of the site area are outlined in Paper 51-12 of the Geological Survey of Canada.

The overburden at the site consisted of two types, a very dense till and a medium dense till. Overlying bedrock, a very dense well-graded till was found. This material is extremely dense and tough as it has been consolidated by the weight of the continental ice sheet. A medium dense till-textured soil was found overlying the very dense till. In our opinion, the upper till represents a superglacial ablation moraine. This material was originally embedded in the ice and was brought to the surface in the terminal zone by gradual ablation where it was then lowered to the top of the ground surface as the ice gradually melted. Normally a deposit thus formed is quickly destroyed by glacial melt waters, however, it is preserved in areas of impeded drainage.

Limestone bedrock of the Ordovician Period was found in Borehole 2 at elevation 230.

## SECTION 4 - continued

### 4.3 Soil Conditions

The soils at the site are shown in cross section on Figure 1, Appendix I. The soils can be subdivided into two structural types as follows, in order of their occurrence below ground surface:

- Stratum 1      medium dense brown to grey sand and silt,  
                         some gravel, till texture
- Stratum 2      very dense grey silt and sand, some gravel,  
                         till texture, occasional boulder.

The upper foot or so of soil at the site was found to consist of an organic peat. Beneath the organic peat, a medium dense till-textured soil having a grading as shown on the grain size distribution chart in Appendix II was found. The penetration resistance of this soil varied from 9 to 35 blows per foot with an average of 20 blows per foot. In the deeper parts of Borehole 4, penetration resistances of 44 and 42 blows per foot were recorded in this layer.

The soils of stratum 1 were found to vary considerably in moisture content from 5 to 13 percent with values of 10 percent most common. The apparent unit weights as determined from split-spoon samples ranged from 138 to 150 lb per cubic foot. These unit weight results should be used with caution, however, as it is probable that compaction of the soil took place when driving the split-spoon, so that values listed may not represent insitu conditions. For purposes of design, we estimate this soil to have an angle of internal friction

#### SECTION 4 - continued

of 32 degrees and a unit weight of 140 lb per cubic foot. Due to the nature of this deposit, it is likely to vary in texture from place to place.

Two 8" boulders were encountered in upper till in Borehole 4 at 4 ft and at 13 ft, however, most of the stones found in this layer ranged from 1/4" to 2" in size.

The soils of stratum 2 consisted of a till-textured very dense grey silt and sand, some gravel, as shown on the grain size distribution chart in Appendix II. The penetration resistance of this material was found to be very high in the order of 200 to 400 blows per foot. In contrast to stratum 1, the soils in the lower till have a fairly consistent moisture content of about 5 percent and a unit weight of about 155 lb per cubic foot. While no boulders were found in this layer, several pebbles and cobbles up to 6" in diameter were encountered in the boreholes.

#### 4.4 Water Conditions

At the time of this investigation (March 1960), the ground water table was found to be at or above the ground surface. This was mostly due to melting snow, however, we would expect the ground water table to be close to ground surface at all times of the year.

## SECTION 5

### DISCUSSION OF FOUNDATIONS

#### 5.1 General

The proposed structure will be designed to take the County Road over Highway 401. It is expected that approach fills in the order of 30 ft will be required for this structure.

#### 5.2 Spread Footings

Considering the use of spread footings for the foundations of this structure and assuming that the footings are placed at elevation 260 with a minimum surcharge to elevation 266, we have determined that the allowable bearing capacity, with a factor of safety of 3 against shear failure, for a 6 ft wide footing would be 5 kips per sq ft and for a 10 ft wide footing would be 6.8 kips per sq ft.

Due to the difference in the thickness of the medium dense soil layer on the north and south sides of the proposed 401 Highway, some differential settlement between abutments founded on spread footings is likely to occur. With the permissible bearing pressures given above, we are of the opinion that the maximum differential settlement would not likely exceed one inch. Due to the low permeability of the medium dense till, settlements are likely to be still taking place upon completion of the structure although this will depend upon construction procedure and timing. Thus, in our opinion, the structure should be designed in anticipation of a differential settlement in the order of one inch.

## SECTION 5 - continued

With respect to excavation for the footings, it is assumed that material will be removed down to elevation 260, a depth of 6 ft below the ground water table. Because of the low permeability of this material, we are of the opinion that the soils at the site can be drained down to elevation 260 from sumps in an open excavation without danger of piping due to excess upward hydraulic pressures.

### 5.3 Piles

Should design or construction requirements dictate the consideration of a pile supported structure, it would be possible, in our opinion, to drive H-piles through the upper till to refusal in the very dense lower till and thus obtain high pile load capacities with a small amount of settlement. It is expected that refusal will be encountered within a few feet of penetration of the lower till.

### 5.4 Approach Fills

Depending upon the rate of construction of the approach fills, it may be desirable to check the effect of pore pressures in the foundation soils on the stability of the approach fills.

## SECTION 6

### PERSONNEL

The site drilling supervision was performed by W. Naumko,  
P. Eng.

The writing of this report was the responsibility of  
J. Kilgour, P. Eng.

APPENDIX I

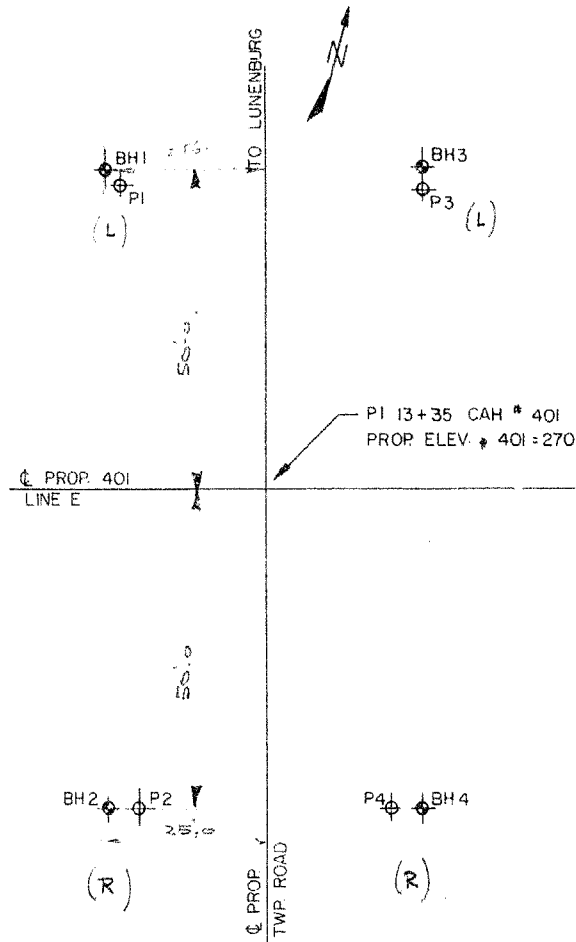
CLIENT Department of Highways of Ontario  
 JOB NO. 609 LOCATION  
 PROJECT W.P. 101-59  
 DATE FIELD INVESTIGATION  
 DATE REPORT BY CHHD

LEGEND  
 BOREHOLE  
 DYNAMIC CONE PROBE

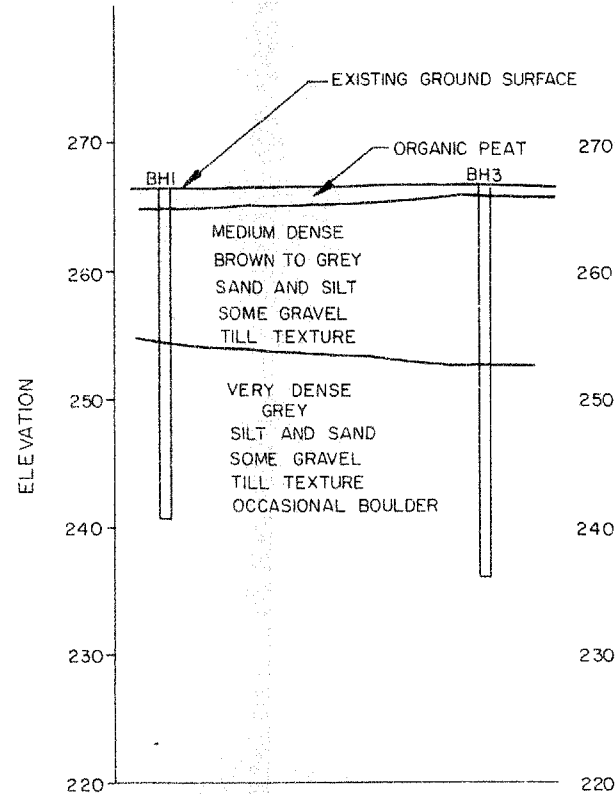
SCALES  
 HORIZONTAL 1" = 20'  
 VERTICAL 1" = 10'

ASSOCIATED GEOTECHNICAL SERVICES  
 Limited

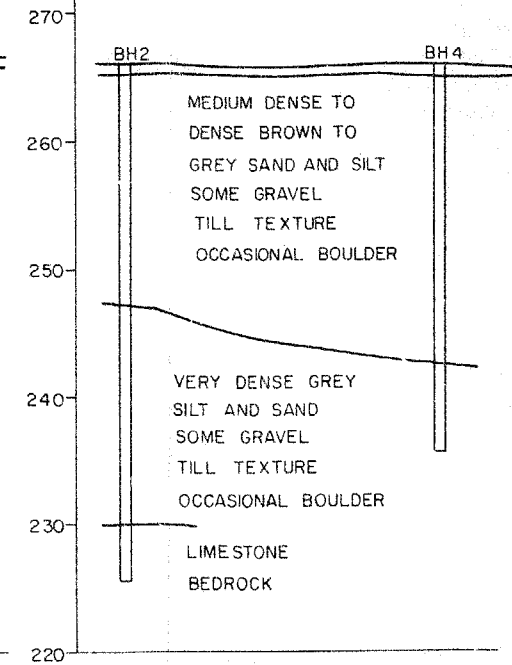
PLAN AND SOIL SECTIONS



PLAN  
 SCALE 1" = 20'



PROBABLE SOIL SECTION  
 NORTH ABUTMENT



PROBABLE SOIL SECTION  
 SOUTH ABUTMENT



CLIENT: Department of Highways of Ontario JOB NO. 609 LOCATION: Cornwall Township CO-ORDINATES: Sta. 13+10 - 50' L ELEVATION SURFACE: 266.4 (COLLAR) DATUM: D.H.O. DATE STARTED: 14/3/60 (FINISHED) 17/3/60 COMPILED: JK PLOT NO. 1 TYPE: B FIELD SUP. W. Naumko				<b>SYMBOLS</b> <div style="display: flex; flex-wrap: wrap;"> <div style="width: 50%;">  SILT   CLAY   SAND         </div> <div style="width: 50%;">  GRAVEL   PEAT   FILL         </div> </div> <div style="display: flex; flex-wrap: wrap;"> <div style="width: 50%;">  VANE SHEAR (NATURAL)   VANE SHEAR (REMOLDED)   STANDARD PENETRATION         </div> <div style="width: 50%;">  UNDISTURBED   DISTURBED BUT REPRESENTATIVE   FAIR   LOST         </div> </div>				<b>ABBREVIATIONS</b> <div style="display: flex; flex-wrap: wrap;"> <div style="width: 50%;">           SS - SPLIT SPOON            ST - SHELBY TUBE            TWP. - THIN WALLED            PISTON            DB - DIAMOND BIT         </div> <div style="width: 50%;">           C - CONSOLIDATION TEST            M - MECHANICAL ANALYSIS            T - TRIAXIAL COMPRESSION            K - PERMEABILITY            U - UNSATURATED COMP.            PCF - POUNDS PER CUBIC FOOT            W% - NATURAL WATER CONTENT         </div> </div>				<b>ASSOCIATED GEOTECHNICAL SERVICES</b> Limited  <b>OFFICE BOREHOLE LOG</b> BOREHOLE NO. 1							
BORING LOG				FIELD TESTS				SAMPLING				LABORATORY				TESTS			
SCALE	DEPTH	ELEV.	WATER OBSERVATION	LOG	DESCRIPTION	SHEAR STRENGTH (TONS PER SQUARE FOOT)		PENETRATION RESISTANCE (BLows PER FOOT)	SAMPLE NUMBER	CONDITION	DEPTH		RECOVERY LENGTH REC. DIST. DRY	UNIT WEIGHT PCF		ATTERING LIMITS		REMARKS	
FEET	FEET	FEET				20	40				60	80		FEET	FEET	TYPE	140		150
	0.2	266.2			Organic peat			5	1		1.0	2.0	SS	11/12					
	1.8	264.6																	
5					Medium dense brown to grey sand and silt, some gravel. Till texture			15	2		5.0	6.2	SS	13/15				Pebble core recovered	
10											6.2	10.0	DB						
12		254.4						20	3		10.0	11.4	SS	2/17					
					Very dense grey silt and sand, some gravel. Till texture			29/4"	3A		12.0	12.3	SS	0/4					
15									4		12.5	13.5	DB	12/12					
								95/5"	5		14.6	15.0	SS	5/5					
20									6		15.0	18.0	DB					Pebble and cobble core recovered	
25					Occasional cobble			151/8"	7		18.0	20.0	DB	5/24					
									8		20.0	20.7	SS	0/8				Pebble and cobble core recovered	
25.8		240.6									20.7	23.3	DB						
									9		23.3	25.8	DB	8/30					
30																			
35					End of borehole														
40																			
45																			

CLIENT Department of Highways of Ontario				SYMBOLS				ABBREVIATIONS				ASSOCIATED GEOTECHNICAL SERVICES							
JOB NO. 609 LOCATION Cornwall Township				CLAY				UNDISTURBED				Limited							
COORDINATES Sta. 13 + 10 - 50' R				SAND				DISTURBED BUT REPRESENTATIVE				OFFICE BOREHOLE LOG BOREHOLE NO. 2							
ELEVATION (SURFACE) 265.7 COLLAR DATE D. H. O.				PEAT				FAIR											
DATE STARTED 17/3/60 TEST SHEET 21/3/60 COMPILED JK				PILL				LOST											
RIG NO. 1 TYPE B FIELD SUP. W. Naumko																			
BORING LOG				FIELD TESTS				SAMPLING				LABORATORY TESTS							
SCALE DEPTH FEET	DEPTH FEET	ELEV. FEET	WATER OBSERVATION	LOG	DESCRIPTION	SHEAR STRENGTH (TONS PER SQUARE FOOT)				PENETRATION RESISTANCE (BLOWS PER FOOT)	SAMPLE NUMBER	CONDITION	DEPTH		RECOVERY LENGTH REC. DIST. DRIV.	UNIT WEIGHT PCF		TESTS	REMARKS
						STANDARD PENETRATION TEST (10 TONS PER FOOT)							FROM FEET	TO FEET		140 150	ATTERBERG LIMITS		
						20	40	60	80							WP X	AN	OWL	
	1.0	264.7			Organic peat					9	1	1.0	2.5	SS	12/18				*
5					Medium dense brown grey sand and silt, some gravel.					95	2	5.0	6.5	SS	10/18				High blows probably due to pebble wedging in split spoon.
10										12	3	6.5	8.6	DB	2/15				Pebble core recovered.
15					Till texture						4	10.0	11.5	SS	18/18				
18.5		247.2								24	5	13.7	15.0	DB	2/16				
20	1.5										6	15.0	16.5	SS	4/18				
25					Very dense grey silt and sand, some gravel.					186/7"	7	20.0	20.6	SS	4/7				Pebble and cobble core recovered in lower till
30					Till texture					276	8	24.2	25.2	DB	10/16				
35	35.7	230.0			Occasional cobble					226/7"	9	30.0	30.6	SS	2/7				
40	39.8	225.9									10	34.0	35.0	DB	6/12				Recovery in rock 33/49
45					End of borehole								35.0	39.8	DB				

I - 3

CLIENT

Department of Highways of Ontario

JOB NO.

609

LOCATION

Cornwall Township

COORDINATES

Sta. 13+60 - 50' I.

ELEVATION (SURFACE)

266.8

COLLAR

DATUM

D.H.O.

DATE (STARTED)

21/3/60

FINISHED

23/3/60

COMPILED

JK

RIG. NO.

2

TYPE

B

FIELD SUP.

W. Naumko

SYMBOLS

SILT

GRAVEL

CLAY

SAND

PEAT

TILL

UNDISTURBED

DISTURBED BUT REPRESENTATIVE

FAIR

LOST

ST. - SPLIT SPOON

ST. - SHOVEL THRU

TWP. - THIN WALLED PISTON

DB - DIAMOND BIT

AA - VANE SHEAR (NATURAL)

OV - VANE SHEAR (REMOLDED)

• - STANDARD PENETRATION

ABBREVIATIONS

C - CONSOLIDATION TEST

U - MECHANICAL ANALYSIS

T - TRIAXIAL COMPRESSION

K - PERMEABILITY

U - UNCONFINED COMP.

PCF - POUNDS PER CUBIC FOOT

WA - NATURAL WATER CONTENT

ASSOCIATED GEOTECHNICAL SERVICES

Limited

OFFICE BOREHOLE LOG

BOREHOLE NO. 3

BORING LOG				FIELD TESTS				SAMPLING				LABORATORY TESTS				REMARKS
SCALE	DEPTH	ELEV.	WATER OBSERVATION	LOG	DESCRIPTION	SHEAR STRENGTH (TONS PER SQUARE FOOT)	PENETRATION RESISTANCE (BLOWS PER FOOT)	SAMPLE NUMBER	LOCATION	FROM	TO	TYPE	RECOVERY LENGTH REC. DIST. DRIV	UNIT WEIGHT PCF	ATTENBERG LIMITS	
FEET	FEET	FEET								FEET	FEET					
						STANDARD PENETRATION TEST (BLOWS PER FOOT)										
	1.0	265.8			Organic peat		10	1		1.0	2.5	SS	14/18			
5					Medium dense brown to grey sand and silt, some gravel.		25	2		2.5	6.0	DB	18/18			Pebble core recovered
10					Till texture		30	3		6.0	7.5	SS	9/18			Pebble core recovered
15	14	252.8								7.5	11.0	DB				Pebble core recovered
20					Very dense grey silt and sand, some gravel		05/9"	4		11.0	12.5	SS	4/9			Pebble & cobble core recovered.
25					Till texture		180/8"	5		12.5	16.0	DB	4/8			Pebble & cobble core recovered.
30					Occasional cobble		100/5"	6		16.0	16.8	SS	4/5			Pebble & cobble core recovered.
35							126/6"	7		16.8	21.0	DB	1/6			Pebble & cobble core recovered.
40	30.7	230.1					85/5"	8		21.0	21.7	SS	2/2			
45										21.7	26.0	DB				
50					End of borehole					26.0	26.4	SS				
										26.4	30.0	DB				
										30.0	30.5	SS				
										30.5	30.7	SS				

[illegible]

# DYNAMIC CONE PENETRATION TEST

No. : F1

Location: Sta.: 13 + 12  
Offset: 48' L  
Elevation: 266.4

<u>Depth</u>	<u>Blows per ft</u>
1	1
2	2
3	8
4	19
5	28
6	33
7	64
8	136
9	42
10	35
11	46
12	126
12.6	170

# DYNAMIC CONE PENETRATION TEST

No. : P2

Location: Sta.: 13 + 15  
Offset: 50' R  
Elevation: 265

<u>Depth</u>	<u>Blows per ft</u>
1	2
2	4
3	30
4	64
5	71
6	85
7	86
8	44
9	74
10	77
11	48
12	75
13	319

# DYNAMIC CONE PENETRATION TEST

No. : P3

Location: Sta. : 13 + 60  
Offset: 47' L  
Elevation: 266.8

<u>Depth</u>	<u>Blows per ft</u>
1	1
2	8
3	22
4	36
5	36
6	47
7	75
8	89
9	78
10	45
11	71
12	179
13	62
14	76
14.25	150

# DYNAMIC CONE PENETRATION TEST

No. : P4

Location: Sta.: 13 + 55  
Offset: 50' R  
Elevation: 265.9

<u>Depth</u>	<u>Blows per ft</u>
1	3
2	5
3	26
4	90
5	73
6	50
7	78
8	191
9	107
10	59
10.2	223



## APPENDIX II

CLIENT Department of Highways of Ontario

JOB NO. 609 LOCATION Cornwall Twp.

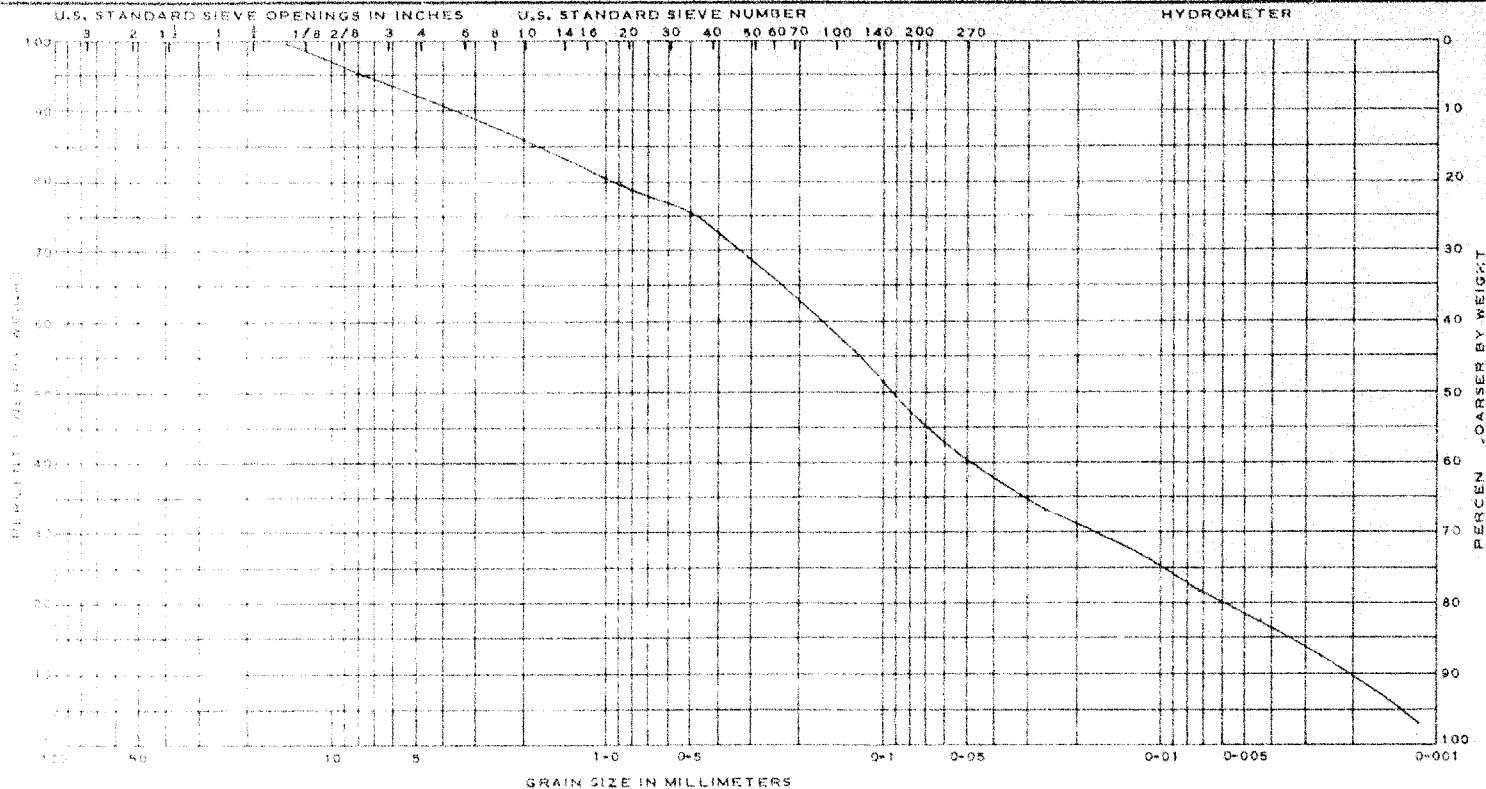
BOREHOLE NUMBER 2 DEPTH 25'

SAMPLE NUMBER 8 DATE

ASSOCIATED GEOTECHNICAL SERVICES

Limited

SOIL MECHANICS LABORATORY  
MECHANICAL ANALYSIS



SOIL CLASSIFICATION

GRAVEL	SAND			SILT			CLAY
	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	

Sand and silt,  
some gravel,  
trace of clay.

Stratum 2

SOIL MECHANICAL ANALYSIS

BOREHOLE - 2

DEPTH - 25'



## SOIL CLASSIFICATION SYSTEM

The following system was used to describe the various soils encountered at the site as determined by visual field examination and test. It was also used to classify those soils upon which a laboratory grain size determination had been made.

### Soil Components

### Particle Size

Clay	< .002 mm
Silt	> .002 mm < .06 mm
Sand	> .06 mm < 2.0 mm
Gravel	> 2.0 mm < 2 in.
Cobbles	> 2 in. < 6 in.
Boulders	> 6 in.

### Descriptive Terms

### Range of Proportions

and	greater than 40%
with	25% to 40%
some	10% to 25%
trace	less than 10%

### Examples

1. Silt (predominant type) with (25% - 40%) sand.
2. Sand and silt (predominant types), some (10% - 25%) gravel, trace (< 10%) clay.

## STANDARD PENETRATION CLASSIFICATION

Relative Density of Sands as determined by Standard Penetration Tests		
N	D <sub>d</sub>	Designation on Borehole Log
0 - 4	0 - 0.2	Very Loose
4 - 14	0.2 - 0.4	Loose
10 - 30	0.4 - 0.6	Medium Dense
30 - 50	0.6 - 0.8	Dense
Over 50	0.8 - 1.0	Very Dense

Shear Strengths of Clays as determined by Standard Penetration Tests		
N	s psf	Designation on Borehole Log
2	250	Very Soft
2 - 4	250 - 500	Soft
4 - 8	500 - 1000	Medium
8 - 15	1000 - 2000	Stiff
15 - 30	2000 - 4000	Very Stiff
30	4000	Hard