

G.I.-30 SEPT. 1976

GEOCRES No. 30M14-275DIST. CR REGION W.P. No. 433-98-00CONT. No. W. O. No. STR. SITE No. 37-737/1 AND 37-737/2HWY. No. 404LOCATION BLOOMINGTON RD OVERPASSNo of PAGES -=====
OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. REMARKS:

Golder Associates Ltd.

2180 Meadowvale Boulevard
Mississauga, Ontario, Canada L5N 5S3
Telephone (905) 567-4444
Fax (905) 567-6561



REPORT ON

**FOUNDATION INVESTIGATION AND DESIGN
BLOOMINGTON ROAD TWIN OVERPASS BRIDGES
HIGHWAY 404 WIDENING
BLOOMINGTON ROAD TO AURORA ROAD
G.W.P. 433-98-00, SITE 37-737 / 1 AND 37-737 / 2
REGIONAL MUNICIPALITY OF YORK**

Submitted to:

Delcan Corporation
133 Wynford Drive
North York, Ontario
M6C 1K1

DISTRIBUTION:

- 2 Copies - Ministry of Transportation, Ontario,
Downsview, Ontario
- 3 Copies - Delcan Corporation,
North York, Ontario
- 2 Copies - Golder Associates Ltd.,
Mississauga, Ontario

December 1999

991-8024A

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
PART A - FIELD INVESTIGATION	
1.0 INTRODUCTION.....	1
2.0 SITE DESCRIPTION	2
3.0 INVESTIGATION PROCEDURES	3
4.0 GENERAL SITE GEOLOGY AND STRATIGRAPHY	4
4.1 Site Geology.....	4
4.2 Site Stratigraphy	4
4.2.1 Topsoil.....	5
4.2.2 Fills	5
4.2.3 Clayey Silt	6
4.2.4 Sand	6
4.2.5 Silt and Sand to Silty Sand	6
4.2.6 Groundwater Conditions.....	7
PART B - FOUNDATION DESIGN	
5.0 Engineering Recommendations	9
5.1 General	9
5.2 Bridge Foundations.....	9
5.2.1 Spread Footings.....	10
5.2.2 Driven Piles	11
5.2.3 Caissons.....	13
5.2.4 Frost Protection	13
5.3 Lateral Earth Pressures	14
5.4 Excavations	15
Excavation Support.....	16
5.5 Approach Embankments	18

In Order
Following
Page No. 19

List of Abbreviations and Symbols
Record of Borehole Sheets (Boreholes 99-1 to 99-4)
Drawing 1
Figures 1 to 7
Appendix A

LIST OF DRAWINGS

Drawing Highway 404 / Bloomington Road – Borehole Locations and Soil Strata

LIST OF FIGURES

Figure 1 Grain Size Distribution Curve – Clayey Silt
Figure 2 Plasticity Chart – Clayey Silt
Figure 3 Grain Size Distribution Curve - Sand
Figure 4 Grain Size Distribution Curve – Silt and Sand to Silty Sand
Figure 5 Grain Size Distribution Curve – Silt
Figure 6 Design Lateral Earth Pressures for Braced Excavations
Figure 7 Design Lateral Earth Pressures for Below Grade Permanent Walls and Temporary Anchored Walls

LIST OF APPENDICES

Appendix A Existing Borehole Logs
GEOCRE 30M15-158
“Regional Road #40 Extension Interchange, 2.6 Miles North of Regional Road #14”, W.P. 160-74-32, Highway 404, District 6, Site 37-737, Toronto, May 1978.

December 1999

991-8024A

**PART A - FIELD INVESTIGATION
BLOOMINGTON ROAD TWIN OVERPASS BRIDGES
HIGHWAY 404 WIDENING
BLOOMINGTON ROAD TO AURORA ROAD
G.W.P. 433-98-00, SITE 37-737 / 1 AND 37-737 / 2
REGIONAL MUNICIPALITY OF YORK**

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
PART A - FIELD INVESTIGATION	
1.0 INTRODUCTION.....	1
2.0 SITE DESCRIPTION	2
3.0 INVESTIGATION PROCEDURES	3
4.0 GENERAL SITE GEOLOGY AND STRATIGRAPHY	4
4.1 Site Geology	4
4.2 Site Stratigraphy	4
4.2.1 Topsoil.....	5
4.2.2 Fills.....	5
4.2.3 Clayey Silt.....	6
4.2.4 Sand.....	6
4.2.5 Silt and Sand to Silty Sand	6
4.2.6 Groundwater Conditions.....	7

1.0 INTRODUCTION

Golder Associates Ltd. has been retained by Delcan Corporation (Delcan) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out a foundation investigation at the site of the proposed widening of the twin overpass structures at Highway 404 and Bloomington Road in the Region of York, Ontario. The project consists of the widening of Highway 404 from south of Bloomington Road to Aurora Road, and the widening of the twin overpass structures at Bloomington Road and the CNR tracks within the project limits. This report addresses the proposed widening of the Highway 404 twin overpass structures at Bloomington Road and their approaches within 20 m of the structures.

The purpose of the foundation investigation is to determine the subsurface conditions at the site of the proposed additions to the bridge structures by drilling boreholes, and carrying out in-situ tests and laboratory tests on selected samples. Based on our interpretation of the data obtained, recommendations on the foundation aspects of design of the proposed works are provided. Comments are also provided on anticipated construction problems where they may affect the design of the proposed bridges and approach embankments.

The terms of reference for the scope of work are outlined in our proposal letter P91-1113, dated March 26, 1999. The work was carried out in accordance with our Quality Control Plan for Foundation Design Services, dated June 1999.

2.0 SITE DESCRIPTION

The site is located approximately 4.2 km north of the intersection of Stouffville Road and Highway 404 and 0.5 km west of the intersection of Woodbine Avenue and Bloomington Road, bordering the Towns of Aurora and Richmond Hill, in the Regional Municipality of York.

The topography of the general site area is undulating. The ground surface generally slopes down to the south towards Lake Ontario, but varies locally from about Elevation 303 m to Elevation 310 m. Based on available existing site information, it appears that Bloomington Road was constructed in cut at the location of Highway 404. A review of existing contract documents and the provided plan indicates the approximate grades of Highway 404 and Bloomington Road at the site are at about Elevation 310.6 m and Elevation 303.9 m, respectively.

The vegetation cover within the median and along the embankment slopes consists of grass. The existing median embankment slopes are at 2 horizontal to 1 vertical (2H:1V). At the time of site investigation, there was no evidence of surficial instabilities on the median embankment slopes.

The original MTO foundation report for the existing structures at the site is referenced as:

- GEOCRE 30M14-158, titled "Regional Road #40 Extension Interchange, 2.6 Miles North of Regional Road #14", W.P. 160-74-32, Highway 404, District 6, Site 37-737, Toronto, dated May 1978.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out on August 9 and 10, 1999. At this time four boreholes were put down at the site. Two boreholes, 99-1 and 99-2, were put down in the median at the base of the south and north embankments, respectively. Boreholes 99-3 and 99-4 were drilled in the median at the crest of the south and north approach embankments, respectively.

The investigation was carried out using a truck-mounted D-90 drill rig supplied and operated by Master Soil Investigation of North York. In the boreholes, samples of the overburden were obtained at regular intervals of depth using 50 mm outside diameter split-spoon samplers in accordance with the Standard Penetration Test (SPT) procedures. The boreholes were extended to depths of between 7.9 m and 12.8 m below the existing ground surface. Groundwater conditions in the open boreholes were observed throughout the drilling operations. Piezometers were installed in two boreholes to permit monitoring of the groundwater levels at the site.

The field work was supervised on a full-time basis by a member of our engineering staff who located the boreholes in the field, directed the drilling, sampling and in-situ testing operations, and logged the boreholes. The soil samples were identified in the field, placed in labeled containers and transported back to our laboratory in Mississauga for further examination. Index and classification tests were carried out on selected samples. The results of the testing are shown on the attached Record of Borehole sheets and on Figures 1 to 5.

A plan view for the twin bridge structures at Bloomington Road and Highway 404 was provided to us in digital format by J.D. Barnes Limited, professional land surveyors. J.D. Barnes Limited surveyed and staked in the field the Highway 404 median at 50 m chainage intervals within the project limits.

The boreholes were surveyed by J.D. Barnes Limited upon completion of the drilling operation. It is understood that the northing and easting co-ordinates of the borehole locations are given in UTM, and the borehole elevations are referenced to the Geodetic Datum. The co-ordinates of the boreholes are indicated on the Record of Borehole sheets and the locations of the boreholes are shown on Drawing 1.

4.0 GENERAL SITE GEOLOGY AND STRATIGRAPHY

4.1 Site Geology

The site is located in the physiographic region known as the Oak Ridges Moraine, which was formed between two opposing movements of ice during the late Wisconsinan period of glaciation (Chapman and Putnam, "The Physiography of Southern Ontario", 3rd Edition, 1984). The topography of the Oak Ridges Moraine is hilly, with knob and basin relief that is typical for an end moraine. The subsoils for this region are generally comprised of sandy or gravelly materials, which are underlain by glacial till. Interbeds of fine sand, silt, and clay are also common. Bedrock is generally deep below the ground surface in this region; a previous investigation carried out by others in the region found the top of bedrock varied between 180 m to 240 m below the ground surface.

4.2 Site Stratigraphy

The detailed subsurface soil and groundwater conditions encountered in the boreholes, together with the results of the laboratory tests carried out on selected soil samples, are given on the attached Record of Borehole sheets following the text of this report. The stratigraphic boundaries shown on the borehole sheets are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. Subsoil conditions will vary between and beyond the borehole locations.

Relevant information on subsurface conditions was obtained from Boreholes 99-1 to 99-4. The subsurface information obtained from the current investigation was supplemented by the borehole information from the original foundation report for the existing bridge structures. Copies of the boreholes put down as part of the original site investigation are found in Appendix A of this report.

In summary, the subsoils at the site consist of surficial topsoil underlain by about 0.6 m to 2.8 m of sand and / or clayey silt fill. The fills are underlain by a deposit of clayey silt up to 2.1 m in thickness encountered in all boreholes, except Borehole 99-2, which in turn is underlain by a granular deposit. The granular deposit consists of sand within the area of the south embankment (Borehole 99-3) and silt and sand to silty sand with occasional silt interlayers at the other areas of investigation. The silt / sand deposit extends to the full depth of the boreholes except in

Borehole 99-3, where a lower deposit of clayey silt was encountered. The lower clayey silt was not fully penetrated but proved to a thickness of at least 0.8 m.

Locations and elevations of the borings for the current and original investigations, together with the interpreted stratigraphical profile and sections, are shown on the attached Drawing 1. A detailed description of the subsurface conditions encountered in the boreholes for this investigation is provided in the following sections.

4.2.1 Topsoil

A surficial layer of topsoil was encountered at the location of all boreholes for this investigation. The topsoil thickness varies between 100 mm and 150 mm in the boreholes.

4.2.2 Fills

Below the topsoil is a 0.6 m to 1.3 m thick layer of sand fill, which varies from sand with some silt in Boreholes 99-1 and 99-2 to silty sand in Boreholes 99-3 and 99-4. Standard Penetration testing (SPT) carried out within the sand fill gave "N" values ranging from 8 blows to 22 blows per 0.3 m of penetration, indicating a loose to compact state of packing. The measured water contents for selected samples of the sand fill range from 5 percent to 10 percent.

The sand fill is likely the result of the original highway embankment and road construction works.

At the location of Borehole 99-3 and 99-4 a layer of clayey silt fill was encountered, which immediately underlies the sand fill. The clayey silt fill contains trace to some sand, trace gravel, and occasional organics. The clayey silt fill is stiff to very stiff in consistency. Standard Penetration testing carried out within this layer gave "N" values of 12 blows to 19 blows per 0.3 m of penetration. The natural water content for a selected sample of this layer was measured at 12 percent.

The clayey silt fill likely originates from the native surficial clayey silt deposit identified in the original foundation investigation, which was probably reworked and graded to construct the existing embankments.

4.2.3 Clayey Silt

A 1.5 m to 2.1 m thick deposit of clayey silt to silty clay was encountered below the fill in Boreholes 99-1, 99-3 and 99-4. The clayey silt contains trace to some sand and trace gravel. A grain size distribution curve for a selected sample of clayey silt is shown on Figure 1. The clayey silt is very stiff to hard in consistency. Standard Penetration testing carried out within this deposit gave "N" values of between 22 blows to greater than 50 blows per 0.3 m of penetration. Atterberg limits testing carried out on two selected samples of the clayey silt to silty clay gave a liquid limit of 24 percent and 22 percent, and a plasticity index of 11 percent and 8 percent, respectively; this indicates the clay is of low plasticity. A plasticity chart, which includes the results of the Atterberg limits tests, is shown on Figure 2. The water contents measured for selected samples of the clayey silt range from 10 percent to 16 percent, and were generally near or below the plastic limit.

4.2.4 Sand

Below the clayey silt in Borehole 99-3 a deposit of sand was encountered. The sand deposit contains trace gravel and silt. A grain size distribution curve for the sand is shown on Figure 3. Standard Penetration testing carried out within the sand gave "N" values of 45 blows to greater than 50 blows per 0.3 m of penetration, indicating a dense to very dense state of packing. The natural water contents for two selected samples of this deposit were measured at about 2 percent.

4.2.5 Silt and Sand to Silty Sand

Immediately below the clayey silt deposit in Boreholes 99-1, 99-2 and 99-4 exists a deposit of silts and sands. In general, the deposit is comprised of silt and sand to silty sand with occasional layers of silt of up to about 1.5 m in thickness. Grain size distribution curves for three selected samples of silt and sand to silty sand deposit are shown on Figure 4. At the location of Borehole 99-4 a silt interlayer that was encountered was not fully penetrated, but proved to be at least 3.4 m in thickness. Grain size distribution curves for selected samples of the silt interlayers are shown on Figure 5.

Standard Penetration Testing carried out within the sands and silts gave "N" values of 14 blows to greater than 50 blows per 0.3 m of penetration, indicating a compact to very dense state of packing. The natural water content for selected samples of this deposit range from 15 percent to 23 percent, and generally decrease with depth.

The sands and silts extend to the full depth of all the borings, except in Borehole 99-3 where a lower deposit of hard clayey silt with some sand and trace gravel was encountered at the base of the borehole. The lower clayey silt deposit was not fully penetrated, but proved to a thickness of at least 0.8 m.

4.2.6 Groundwater Conditions

Groundwater levels were noted in the open boreholes during and upon completion of the drilling operation; the noted levels are shown on the attached record of Borehole sheets. Piezometers were sealed in Borehole 99-1 and 99-3 to permit the monitoring of the stabilized groundwater conditions at the site. Details of the piezometer installations and water level measurements are shown on the attached Record of Borehole sheets. A summary of the monitoring results are provided in the following table.

<i>Borehole</i>	<i>August 18, 1999</i>		<i>August 24, 1999</i>		<i>October 19, 1999</i>	
	<i>Depth (m)</i>	<i>Elevation (m)</i>	<i>Depth (m)</i>	<i>Elevation (m)</i>	<i>Depth (m)</i>	<i>Elevation (m)</i>
99-1	4.4	299.5	4.4	299.5	4.4	299.5
99-3	dry	-	dry	-	dry	-

Groundwater levels are expected to fluctuate seasonally and are expected to be higher during wet periods of the year.

GOLDER ASSOCIATES LTD.

Andrew J. Walker

Andrew J. Walker, P.Eng.
Associate

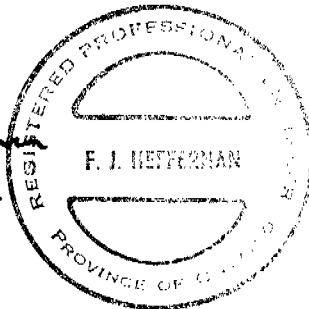
Murty S. Devata

Murty S. Devata, P.Eng.
Consultant



F. J. Heffernan

Fintan J. Heffernan, P.Eng.
Designated MTO Contact



DKB/AJW/MSD/FJH/clg
WORD S/FINAL.DAT/1100991-8024/8024ALR1

December 1999

991-8024A

**PART B - FOUNDATION DESIGN
BLOOMINGTON ROAD TWIN OVERPASS BRIDGES
HIGHWAY 404 WIDENING
BLOOMINGTON ROAD TO AURORA ROAD
GWP: 433-98-00, SITE 37-737 / 1 AND 37-737 / 2
REGIONAL MUNICIPALITY OF YORK**

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
PART B - FOUNDATION DESIGN	
5.0 ENGINEERING RECOMMENDATIONS	9
5.1 General	9
5.2 Bridge Foundations	9
5.2.1 Spread Footings	10
5.2.2 Driven Piles	11
5.2.3 Caissons	13
5.2.4 Frost Protection	13
5.3 Lateral Earth Pressures	13
5.4 Excavations	15
Excavation Support	16
5.5 Approach Embankments	18

5.0 ENGINEERING RECOMMENDATIONS

5.1 General

This section of the report provides our recommendations on the geotechnical aspects of design of widening of the twin bridge structures at Bloomington Road based on our interpretation of the factual information obtained during the investigation. It should be noted that the interpretation and recommendations are intended for use only by the design engineer. Where comments are made on construction they are provided only in order to highlight those aspects which could affect the design of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction method and scheduling.

The works described in this report are associated with the proposed twin bridge widening and their approaches within 20 m of the structure. It is understood that the widened bridge structures will carry an additional lane in each direction of Highway 404 over Bloomington Road. It is further understood that the additional lanes will be constructed in the median area adjacent to the existing median lanes and that the proposed twin bridge widening will be placed adjacent to the existing bridge structures. It is assumed the additional lanes will be built to coincide with the existing Highway 404 grade of about Elevation 311 m at the site. It is therefore anticipated that about 1.0 m to 1.5 m of fill material will be placed on the existing embankments to provide the appropriate grade at the bridge structures.

5.2 Bridge Foundations

The available contract documents for the original twin bridge structures (Contract No. 81-65) indicate the existing abutments are founded on spread footings at about Elevation 302.1 m (for a 1.2 m thick footing). It should be noted that this founding elevation might not represent the as-built conditions. Based on stratigraphic interpretation, this elevation generally corresponds to the upper zone of the compact to very dense silt and sand to silty sand deposit, interbedded with occasional silt layers. The water level in the piezometer sealed within the silt and sand deposit is at Elevation 299.5 m.

5.2.1 Spread Footings

Based on the above, it is recommended that the proposed twin bridge structures be supported using closed type abutments with spread footings founded at about Elevation 302 m. This elevation corresponds to the approximate existing footing elevation for the north and south abutments. Local excavation will be required to obtain the desired founding level, and will vary from about 2 m at the embankment toe up to about 6 m for the rear of the footings.

Geotechnical Resistance

Spread footings for the abutments placed on properly prepared subsoil at the recommended founding level may be designed for a factored geotechnical resistance at Ultimate Limit States (ULS) and Serviceability Limit States (SLS) in accordance with the following footing lengths:

<i>Footing Length (m)</i>	<i>ULS</i>	<i>SLS</i>	
	<i>Factored Resistance (kPa)</i>	<i>Resistance (kPa)</i>	<i>Maximum Settlement (mm)</i>
5	900	300 400	15 25
7	1,000	350	25

NOTE: assumed footing width is 4 m.

These values are for vertical concentric loads only. Effects of load inclination and eccentricity need to be taken into account as appropriate. The majority of the settlements are due to elastic compression of the granular subsoil which will occur when the loads are applied on the shallow foundations. As a result the long-term settlements will be negligible. A construction joint with dowels should be incorporated between the new and existing footings to accommodate differential settlements. In addition, a water stop should be provided for any possible leaks from the cracks.

Note the existing bridge was designed using an allowable bearing pressure of about 290 kPa (3 tsf).

Horizontal Resistance

Resistance to lateral forces / sliding resistance between the concrete spread footings and subsoil should be calculated in accordance with Section 6-8.4.3 of the OHBDC. For the spread footings

placed on the silt and sand to silty sand deposit, a factored ultimate base friction factor of 0.55 may be assumed for design.

5.2.2 Driven Piles

Alternatively, the proposed twin bridge structures could be supported using steel H-piles driven into the silt / sand deposit to practical refusal at an estimated tip elevation of 273 m. Based on this elevation and the approximate ground surface elevation of 304 m, the approximate driven length is about 30 m.

Geotechnical Resistance

The factored geotechnical resistance at ULS for piles driven to practical refusal at an estimated tip elevation of 273 m within the silt / sand at this site will be greater than the structural capacity of the piles. Since the piles will be driven to an unyielding deposit of very dense silt / sand, the geotechnical resistance at SLS is not applicable.

For this site, therefore, the structural capacity of the pile shall govern and the capacities will be determined by MTO current practices (Standard SS103-11). For example, HP 310 x 110 piles driven to refusal may be assumed to have a factored axial resistance at ULS of 2,000 kN.

Horizontal Resistance

The lateral loading could be resisted fully or partially by the use of battered piles. If vertical piles are used to resist the lateral loading, the horizontal reaction to the pile can be estimated using the following table and where

k_h	= coefficient of horizontal subgrade reaction (MPa/m)
d	= pile width or diameter (m)
n_h	= constant of horizontal subgrade reaction (MPa/m)
z	= depth below pile cap (m)

Horizontal Subgrade Reaction

<i>Soil Type</i>	<i>k_h</i>	<i>n_h (MPa/m)</i>	<i>Note</i>
Silt / Sand	$n_h (z/d)$	5	k_h increasing with depth

Group action for lateral loading should be considered when the pile spacing in the direction of loading is less than six to eight pile diameters. Group action can be evaluated by reducing the coefficient of lateral subgrade reaction in the direction of loading by a reduction factor R as follows:

Subgrade Reduction Factors

<i>Pile Spacing in Direction of Loading d = Pile Diameter</i>	<i>Subgrade Reaction Reduction Factor R</i>
8d	1.00
6d	0.70
4d	0.40
3d	0.25

Abutments that are supported on steel H-piles will create disturbance to the existing shallow foundations due to vibrations during pile driving. This could be minimized by pre-augering to a depth well below the existing foundation and then driving the pile. The cased augered hole would then have to be filled with concrete.

Since pre-augering will extend below the groundwater level, a temporary liner will be required. Care would have to be exercised in order to ensure no loss of ground occurs during caisson installation. If special measures are not adopted to balance the head, any loss of ground could impact the entire structure.

5.2.3 Caissons

Alternatively, the proposed twin bridge extensions could be supported using caissons installed in the silt/sand deposit to an approximate base elevation of 277 m. Based on this elevation and the approximate ground surface elevation of 304 m, the estimated caisson length is about 25 m.

Geotechnical Resistance

The axial capacity of the caissons is achieved primarily by end-bearing resistance. For design of the drilled shafts at the recommended base elevation of 277 m, the factored axial resistance at ULS of 2,200 kN may be assumed for a 0.76 m diameter caisson. Since the caissons will extend to an unyielding deposit of very dense silt/sand, the geotechnical resistance at SLS is not applicable.

Horizontal Resistance

The horizontal reaction to the caissons may be determined using the method and values provided for the driven pile alternative (Section 5.2.2).

Since installation of caissons would be necessary below the groundwater level and within granular sub-soils, care would have to be exercised in order to ensure that no loss of ground occurs during caisson installation. If special measures are not adopted to balance the head, any loss of ground could impact the existing structure.

5.2.4 Frost Protection

All footings should be provided with a minimum of 1.2 m of earth cover for frost protection purposes.

5.3 Lateral Earth Pressures

The lateral pressures acting on the bridge abutments will depend on the type and method of placement of the backfill materials, on the nature of the soils behind the backfill and on the

subsequent lateral movement of the structure. The following recommendations are made concerning the design of the abutments and the retaining walls in accordance with OHBDC:

Select free-draining granular fill meeting the specifications of OPSS Granular A or Granular B but with less than 5 percent passing the 200 sieve should be used as backfill behind the walls. All granular fill should be compacted in lifts of loose thickness not greater than 200 mm to 95 percent of the material's Standard Proctor maximum dry density.

Longitudinal drains and weep holes should be installed to provide positive drainage of the granular backfill.

The granular fill may be placed either in a zone with width equal to at least 1.2 m behind the back of the stem (Case I) or within the wedge-shaped zone defined by a 60 degree line extending up and back from the bottom of the rear face of the footing (Case II).

If the wall support allows lateral yielding of the stem (unrestrained structure), active earth pressures may be used in the geotechnical design of the structure. If the abutment support does not allow lateral yielding (restrained structure), at-rest pressures should be assumed for geotechnical design.

A compaction surcharge equal to 16 kPa should be included in the lateral earth pressures for the structural design of the abutment wall in accordance with OHBDC Figure 6-7.4.3. Compaction equipment should be used in accordance with OPSS 501.06.

For Case I, the pressures are based on the embankment fill materials and the following parameters (unfactored) may be assumed:

Soil unit weight (assuming compacted clean earth fill)	21 kN/m ³
Coefficients of lateral earth pressure:	
'active'	0.33
'at rest'	0.5

For Case II, the pressures are based on the granular fill as placed and the following parameters (unfactored) may be assumed:

	Granular A 22 kN/m ³	Granular B 21 kN/m ³
Soil Unit Weight		
Coefficients of Lateral Earth Pressure		
'active'	0.27	0.31
'at rest'	0.43	0.47

It should be noted that the above design parameters assume level backfill and ground surface behind the wall. Other aspects of the abutment granular backfill requirements with respect to sub-drains and frost taper should be in accordance with OPSD-3501.00.

5.4 Excavations

At the abutments, the excavations for footing construction will range in depth from about 1.5 m for the abutment footing to 6 m for the wing wall footings, and will generally extend through the fill and clayey silt into the silt and sand to silty sand deposit with silt interbeds. The abutment footing is at about Elevation 302 m and the wing wall footings step up to about Elevation 304 m. The existing road grade of Bloomington Road at the site is at about Elevation 303.5 m to Elevation 304 m. The embankments rise at about a 2 horizontal to 1 vertical slope up to the crest at about Elevation 310 m along the median line of Highway 404. The grade of Highway 404 is at about Elevation 311 m at the site.

Conventional excavation equipment would be suitable for excavation of the subsoil. Temporary cuts may be made with side slopes not steeper than 1 horizontal to 1 vertical (1H:1V).

All excavation side slopes should conform to the requirements of the latest edition of the Occupational Health & Safety Act.

The water level measured in the piezometer was at Elevation 299.5 m in the area of the south abutments (about 4.4 m depth below existing ground surface). The base of the footing excavations will likely be above the groundwater level, however, some water inflow into the excavations should be expected from perched water conditions. This inflow can be handled by conventional pumping from properly filtered sumps. The sumps should be maintained outside the footing area. Surface run-off should be directed away from the excavations at all time.

All footing excavations should be inspected by qualified geotechnical personnel prior to placing concrete to ensure that the base has been adequately cleaned and that the subsoil conditions as exposed at the founding level are consistent with the design assumptions. All loose material within the footprint of the footings and at the founding level should be removed and replaced with concrete.

Excavation Support

The excavations will be carried out adjacent to the existing bridges' wing walls. These walls may require temporary support during excavation. The requirement for temporary support should be determined by the structural engineer.

Assuming that the new footings for the bridges will be constructed at about the same founding elevation and have a similar geometry to the existing footings then the excavation adjacent to the wing wall will, even using 1 horizontal to 1 vertical (1H:1V) temporary cuts, expose a vertical face of embankment fill. This face requires temporary support to prevent undermining at the Highway 404. Temporary support to this face may be provided by a conventional soldier pile and lagging wall.

Roadway protection should be included in the tender documents, as per current MTO end result specifications.

Rakers

Support of the exposed retaining walls can be achieved with the use of rakers. For design, allowable bearing pressures given in the following table may be assumed for raker footings founded on the native sand / silt at about Elevation 302 m.

<i>Footing Size (m)</i>	<i>ULS</i>	<i>SLS</i>	
	<i>Factored Resistance (kPa)</i>	<i>Resistance (kPa)</i>	<i>Maximum Settlement (mm)</i>
2 by 2	600	400	25
3 by 3	700	300	25

Note that the bearing pressures must be reduced to allow for the effect of load inclination.

The horizontal resistance provided in Section 5.2.2 may be used for the raker footings founded on the native silt / sand at the assumed elevation. The design of the rakers should be checked using the rectangular pressure distribution as shown on Figure 6 using; $K = 0.5$ and $\gamma = 21 \text{ kN/m}^3$.

Soldier Pile and Lagging

Excavation carried out beyond the limits of the abutment walls can be achieved using a soldier pile and lagging support system. To prevent any disturbance to the existing foundations augered caissons with soldier piles should be considered. The cased auger holes should extend to the required design depth. The steel H-pile will be placed in the augered hole and the annular space concreted to the base of the future excavation. This will facilitate the installation of timber lagging to support the excavation above the base.

The design of the soldier pile and lagging wall should be based on the earth pressure distribution shown on Figure 7, assuming an average earth pressure coefficient (K) equal to 0.3 and unit weight of soil (γ) of 21 kN/m^3 . Soldier piles should extend to at least 2 m below the base of the excavation. A design ground water level at Elevation 300 m and a construction surcharge of 16 kPa should be assumed. Unfactored socket resistances, for sockets located above the design groundwater level, can be determined based on the following relationship:

$$R_p = 1.5 K_p \gamma H^2 D$$

Where:

- R_p = unfactored passive resistance of socket (kPa)
- K_p = coefficient of passive resistance
- γ = unit weight of soil (kN/m^3)
- H = embedded length of pile below base of excavation (m)
- D = diameter of pile (m)

A coefficient of passive resistance of 6.0, and a unit weight of soil of 20 kN/m^3 may be assumed for design. The resistance of the upper 1 m of the embedded length of the pile should be ignored. As per OHBDC requirements a resistance factor of 0.5 should be applied to obtain the factored ultimate geotechnical resistance.

The proposed shoring system should be reviewed by a geotechnical engineer prior to installation. Stability and design checks should be made for each stage of the excavation.

5.5 Approach Embankments

The proposed overpass structures will require about 1.0 m to 1.5 m additional height to raise the existing embankments within the median area up to the existing Highway 404 grade. Based on the subsurface information, the subsoils for the embankments consist of a thin layer of topsoil underlain by 0.6 m to 1.3 m of compact silty sand fill, which in turn is underlain by about 1.5 m of stiff to very stiff clayey silt fill. The clayey silt fill contains occasional organics. The fill materials are underlain by about 1.5 m to 2.1 m of very stiff to hard clayey silt. An extensive deposit of sand with silt interbeds underlies the clayey silt. The groundwater level is below the base of the embankments.

Topsoil and fill materials containing organics should be stripped from below the footprint area of the fill embankments and all subgrade soils should be proof-rolled prior to fill placement.

Construction of the embankment above the prepared subgrade may be carried out using clean earth fill (in accordance with OPSS 212) or Select Subgrade Material (in accordance with OPSS 1010), depending on material availability. Benching into the existing slopes should be carried out in accordance with OPSD 208.010. All embankment fill should be placed in regular lifts with loose thickness not exceeding 300 mm, and be compacted to at least 95 percent of the material's Standard Proctor maximum dry density. The final lift prior to placement of the granular subbase or base course should be compacted to 100 percent of the Standard Proctor maximum dry density. Inspection and field density testing should be carried out by qualified geotechnical personnel during all fill placement operations to ensure that appropriate materials are used and that adequate levels of compaction have been achieved. The permanent slopes of the embankment should be maintained not steeper than 2 horizontal to 1 vertical (2H:1V). Vegetation cover should be established on all slopes to protect embankment fill against surficial erosion.

There are no special drainage measures adopted at the approaches of the bridge at Bloomington Road and Highway 404. The widening for an additional lane in each direction will alter the existing median width, however, it is believed the surface drainage will still be conveyed

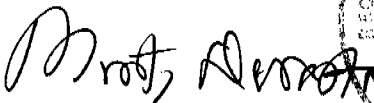
within the median ditch. To prevent localized erosion of the forward and side slopes due to surface run-off, proper drainage measures are warranted. This could be achieved by constructing armoured drainage channels protected with rip-rap.

The addition of fill onto the existing embankment does not unduly effect embankment slope stability.

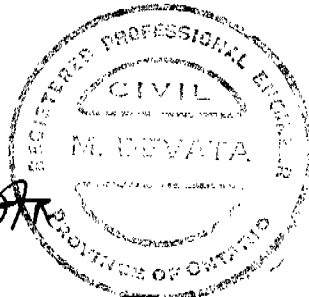
GOLDER ASSOCIATES LTD.



Andrew J. Walker, P.Eng.
Associate



Murty S. Devata, P.Eng.
Consultant



Fintan J. Heffernan, P.Eng.
Designated MTO Contact



DKB/AJW/MSD/FJH/clg
WORD S/FINAL.DAT/11/1999-8024/8024ALR1

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO	Drive open
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.).

Dynamic Penetration Resistance; N_d :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH:	Sampler advanced by hydraulic pressure
PM:	Sampler advanced by manual pressure
WH:	Sampler advanced by static weight of hammer
WR:	Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT):

An electronic cone penetrometer with a 60° conical tip and a projected end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	N Blows/300 mm or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

Consistency	c_u, s_u kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO ₄	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane test (L.V.-laboratory vane test)
γ	unit weight

Note:

1. Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	= 3.1416
$\ln x$	natural logarithm of x
$\log_{10} x$ or $\log x$	logarithm of x to base 10
g	acceleration due to gravity
t	time
F	factor of safety
V	volume
W	weight

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ϵ	linear strain
ϵ_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stresses (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation
*	Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density \times acceleration due to gravity)

(a) Index Properties (con't.)

w	water content
w_L	liquid limit
w_p	plastic limit
I_p	plasticity Index $= (w_L - w_p)$
w_s	shrinkage limit
I_L	liquidity index $= (w - w_p) / I_p$
I_C	consistency index $= (w_L - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(c) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(d) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (overconsolidated range)
C_s	swelling index
C_α	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	Overconsolidation ratio $= \sigma'_p / \sigma'_{vo}$

(e) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction $= \tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3) / 2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3) / 2$
q	$(\sigma_1 - \sigma_3) / 2$ or $(\sigma'_1 - \sigma'_3) / 2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1. $\tau = c' + \sigma' \tan \phi'$

2. Shear strength = (Compressive strength)/2

PROJECT 991-8024			RECORD OF BOREHOLE No 99-1			1 OF 2		METRIC															
W.P. 433-98-00			LOCATION N 4870628.02; E 313378.93			ORIGINATED BY DKB																	
DIST 6 HWY 404			BOREHOLE TYPE 114mm SOLID STEM AUGERS			COMPILED BY DKB																	
DATUM GEODETIC			DATE 9.8.99			CHECKED BY AJW																	
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			SHEAR STRENGTH kPa			WATER CONTENT (%)			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV	DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	W _p	W	W _L	○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL X REMOULDED	10 20 30	γ	GR SA SI CL					
303.88	0.00	Topsoil		1	50 DO	18																	
	0.10	Sand, some silt, trace gravel		2	50 DO	22																	
		Compact Brown Moist (Fill)																					
302.61	1.27	Clayey Silt, trace gravel and sand		3	50 DO	41																	
		Hard Brown Moist		4	50 DO	70																	
301.14	2.74	Silt and Sand to Silty Sand, occ. layers of silt		5	50 DO	38																	
		Compact to Dense Brown Moist to wet		6	50 DO	34																	
300.13	3.75	Silt		7	50 DO	20																	
				8	50 DO	24																	
299.38	4.50			9	50 DO	20																	
				10	50 DO	17																	
				11	50 DO	23																	
				12	50 DO	24																	
291.08	12.80	END OF BOREHOLE																					

ON MOT 991-8024 GPJ ON MOT GDT 24/1/99

Continued Next Page

+ 3 . X 3 . Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT 991-8024		RECORD OF BOREHOLE No 99-1				2 OF 2		METRIC							
W.P. 433-98-00		LOCATION N 4870628.02; E 313378.93				ORIGINATED BY DKB									
DIST 6 HWY 404		BOREHOLE TYPE 114mm SOLID STEM AUGERS				COMPILED BY DKB									
DATUM GEODETIC		DATE 9.8.99				CHECKED BY AJW									
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	W _p W W _L	10 20 30	γ	GR SA SI CL		
	Note: 1. Water level measured in open borehole at 3.4m depth (Elev. 300.5) upon completion of drilling. 2. Water level measured in piezometer at 4.4m depth (Elev. 299.5) on August 18/99. 3. Water level measured in piezometer at 4.4m depth (Elev. 299.5) on August 24/99 and October 19/99.														

ON MOT 991-8024 GPJ ON MOT.GDT 24/11/99

PROJECT 991-8024

RECORD OF BOREHOLE No 99-2

1 OF 1

METRIC

W.P. 433-98-00

LOCATION N 4870653.58; E 313376.02

ORIGINATED BY DKB

DIST 6 HWY 404


BOREHOLE TYPE 114mm SOLID STEM AUGERS

COMPILED BY DKB

DATUM GEODETIC

DATE 9.8.99

CHECKED BY AJW

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 (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)				
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× REMOULDED	20					40	60	80	100	10
303.87 0.98	Topsoil Sand, some silt, trace gravel Loose Brown Moist (Fill)		1	50 DO	8	▽															
303.18 0.69	Silt and Sand to Silty Sand, occasional layers of silt Compact to very dense Brown Moist to wet		2	50 DO	24																
302.37 1.50			3	50 DO	32																
			4	50 DO	36																
300.87 3.00			5	50 DO	50																
300.12 3.75			6	50 DO	70																
299.47 4.40			7	50 DO	62																
			8	50 DO	26																
298.77 7.10			9	50 DO	28																
298.27 8.60			10	50 DO	26																
			11	50 DO	14																
291.07 12.80			12	50 DO	24																
END OF BOREHOLE																					
Note: Water level measured in open borehole at 3.05m depth (Elev. 300.82) upon completion of drilling.																					

ON MOT 991-8024.GPJ ON MOT.GDT 28/9/99

PROJECT 991-8024

RECORD OF BOREHOLE No 99-3

1 OF 1

METRIC

W.P. 433-98-00

LOCATION N 4870610.30; E 313384.54

ORIGINATED BY DKB

DIST 6 HWY 404

BOREHOLE TYPE 114mm SOLID STEM AUGERS

COMPILED BY DKB

DATUM GEODETIC

DATE 10.8.99

CHECKED BY AJW

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			SHEAR STRENGTH kPa						
310.14								20 40 60 80 100						
0.00	Topsoil							○ UNCONFINED + FIELD VANE						
0.15	Silty Sand, trace gravel		1	50 DO	19			● QUICK TRIAXIAL × REMOULDED						
309.44	Compact Brown Moist (Fill)													
0.70	Clayey Silt, trace to some sand, trace gravel, occ. silty sand seams/pockets, occ. organics		2	50 DO	12									
	Stiff to very stiff Brown Moist (Fill)		3	50 DO	16									
307.93	Clayey Silt, trace to some sand, trace gravel													
2.21	Very stiff to hard Brown Moist		4	50 DO	39									
	Sand layer noted at 2.97m-3.35m depth.		5	50 DO	24									
305.87	Sand, trace silt, trace gravel		6	50 DO	39									
4.27	Dense to very dense Brown Dry to moist		7	50 DO	45									
			8	50 DO	78									
302.97	Clayey Silt, some sand, trace gravel													
7.17	Hard Brown Moist													
302.22			9	50 DO	50/15									
7.92	END OF BOREHOLE													
	Note: 1. Open borehole dry upon completion of drilling. 2. Piezometer dry on August 18/99. 3. Piezometer dry on August 24/99.													

ON MDT 991-8024 GPJ ON MOT.GDT 28/9/99

PROJECT 991-8024

RECORD OF BOREHOLE No 99-4

1 OF 1

METRIC

W.P. 433-98-00

LOCATION N 4870872.81, E 313371.74

ORIGINATED BY DKB

DIST 6 HWY 404

BOREHOLE TYPE 114mm SOLID STEM AUGERS

COMPILED BY DKB

DATUM GEODETIC

DATE 10.8.99

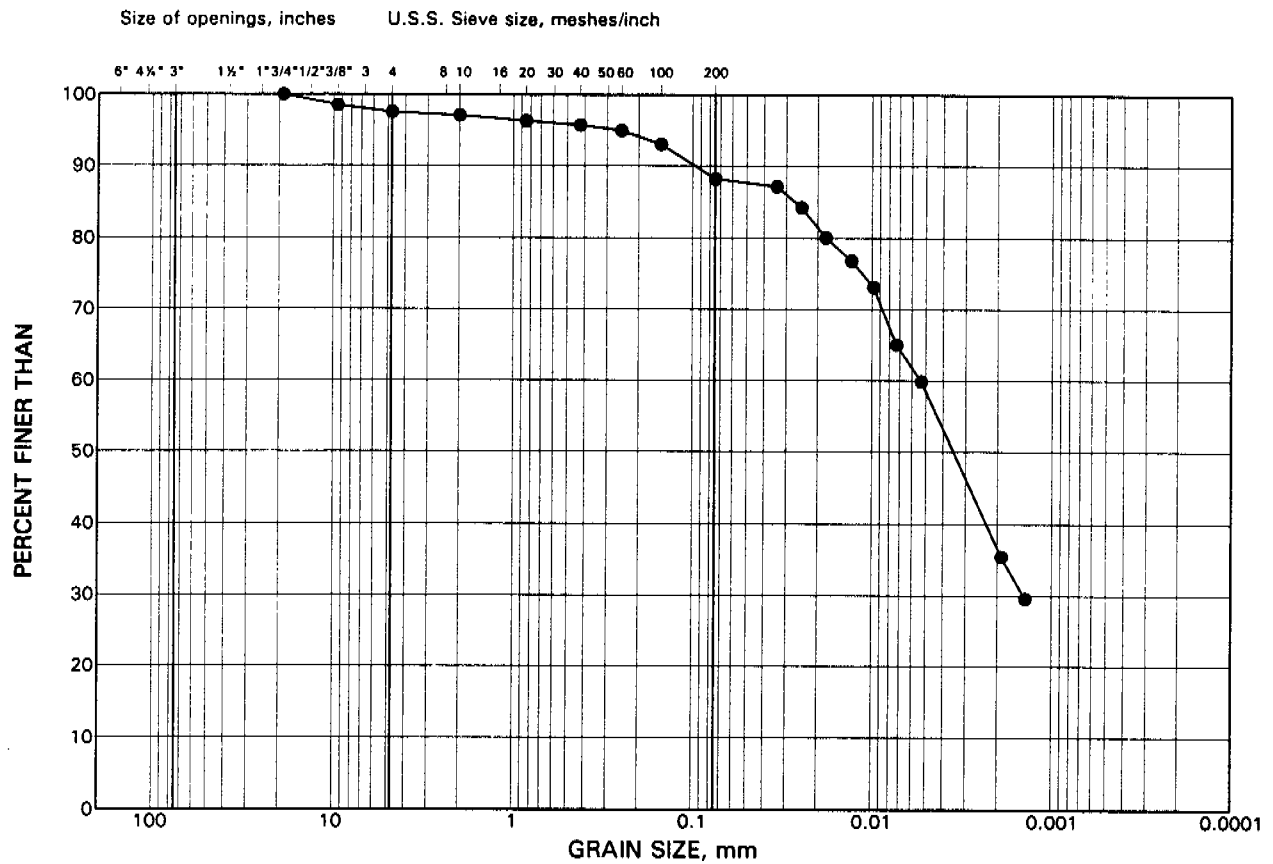
CHECKED BY AJW

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
310.09	Topsoil																
0.00	Silty Sand, trace gravel		1	50 DO	10												
0.13	Compact Brown Moist (Fill)		2	50 DO	18												
308.64	Clayey Silt, trace to some sand, trace gravel, occ. silty sand seams/pockets, occ. organics		3	50 DO	17												
1.45	Very stiff Brown Moist (Fill)		4	50 DO	19												
307.12	Clayey Silt, trace to some sand, trace gravel		5	50 DO	22												
2.97	Very stiff Brown Moist		6	50 DO	24												
305.59	Sand layer noted from 3.35m to 3.74m depth.		7	50 DO	19												
4.50	Silt, trace sand		8	50 DO	34												
	Compact to very dense Brown Moist to wet		9	50 DO	50/15												
302.17	END OF BOREHOLE																
7.92	Note: Open borehole dry upon completion of drilling.																

GRAIN SIZE DISTRIBUTION

Silty Clay, some sand, trace gravel

FIGURE 1



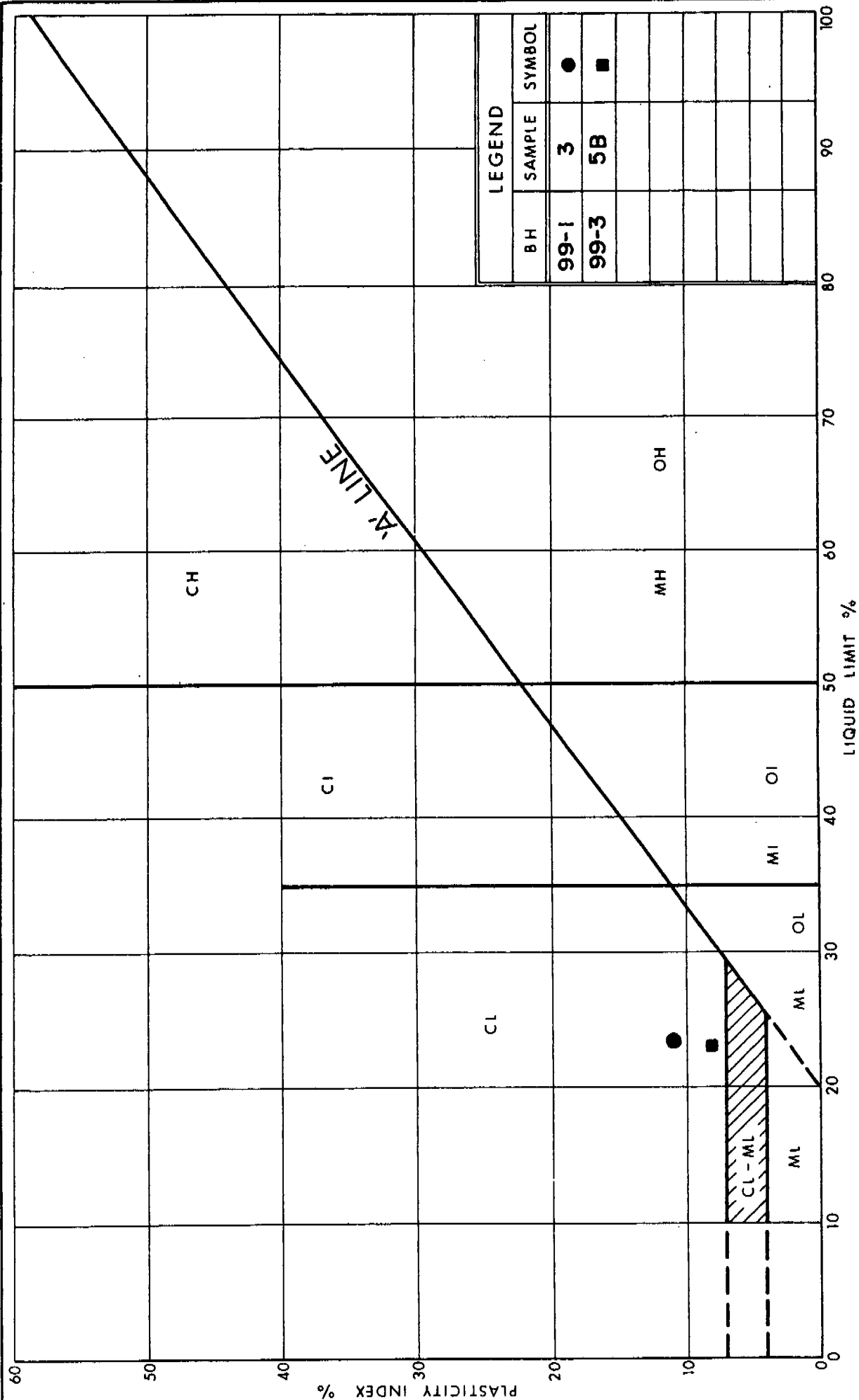
COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL BOREHOLE SAMPLE ELEVATION(m)

• 99-1 3 301.8

Oct 75, FF-S-21



LEGEND		
BH	SAMPLE	SYMBOL
99-1	3	●
99-3	5B	■

PLASTICITY CHART

CLAYEY SILT

FIG No 2

W P 433-98-00

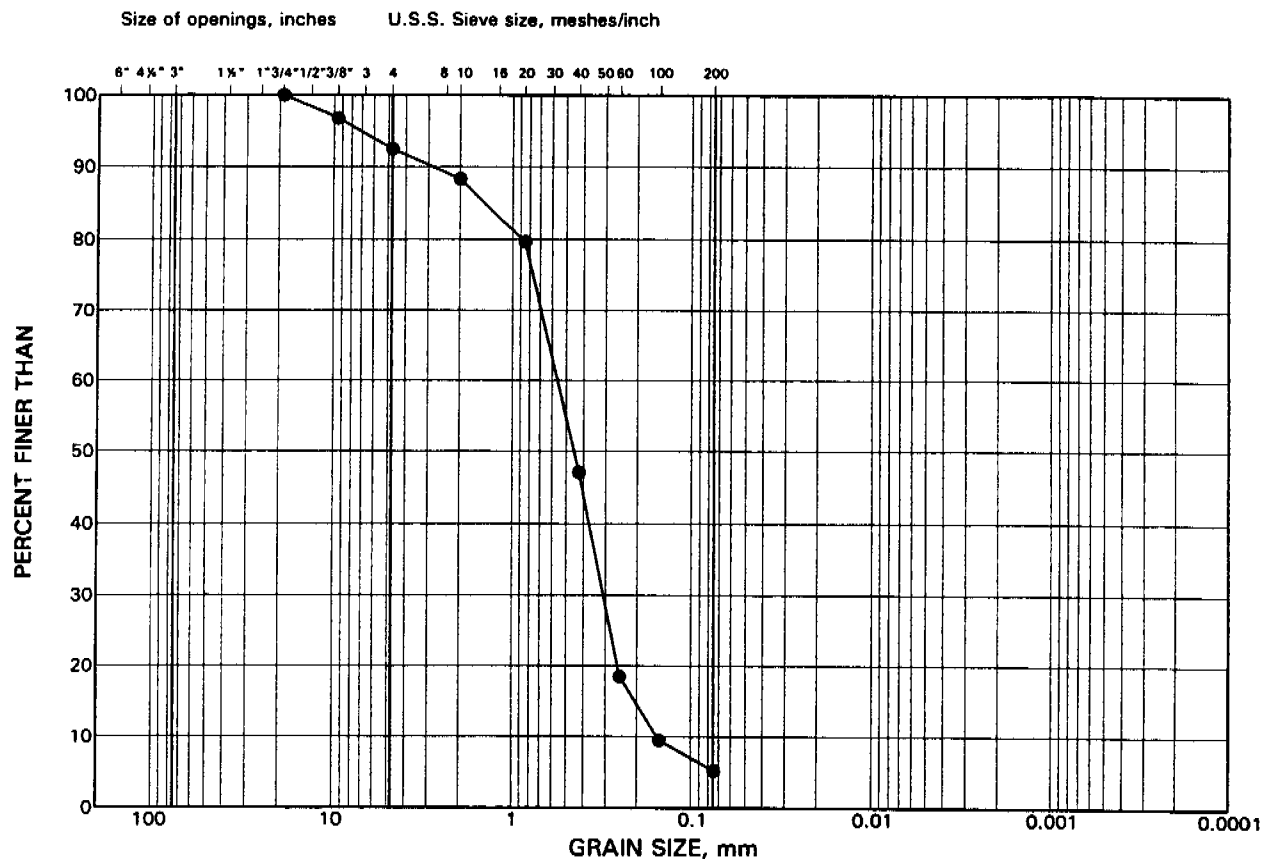
Ministry of
Transportation



GRAIN SIZE DISTRIBUTION

Sand, trace to some gravel, trace silt

FIGURE 3



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
	GRAVEL SIZE		SAND SIZE			FINE GRAINED

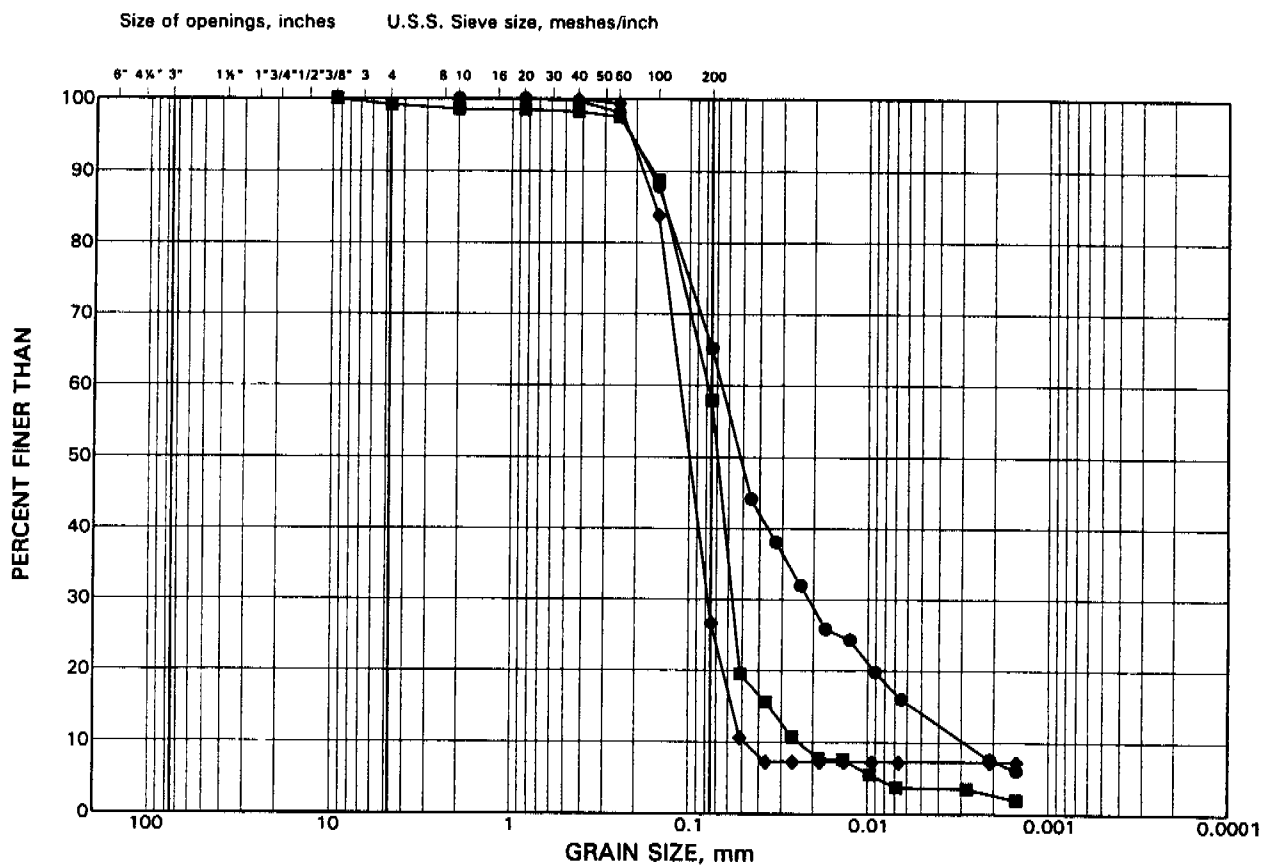
LEGEND

SYMBOL	BOREHOLE	SAMPLE ELEVATION(m)
•	99-3	7 304.9

GRAIN SIZE DISTRIBUTION

Silt and Sand to Silty Sand

FIGURE 4



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

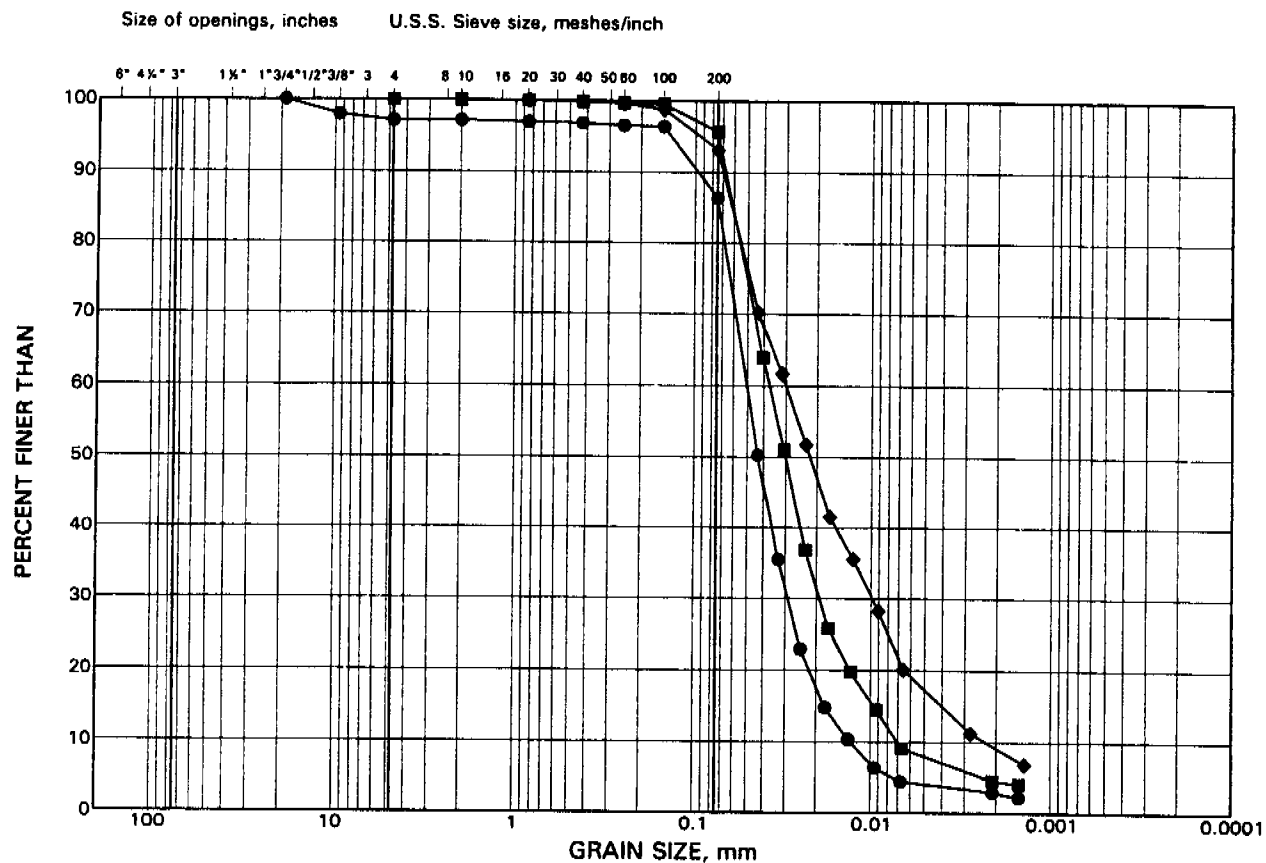
LEGEND

SYMBOL BOREHOLE SAMPLE ELEVATION(m)

●	99-1	7	298.7
■	99-1	11	292.6
◆	99-2	11	292.6

GRAIN SIZE DISTRIBUTION Silt

FIGURE 5



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

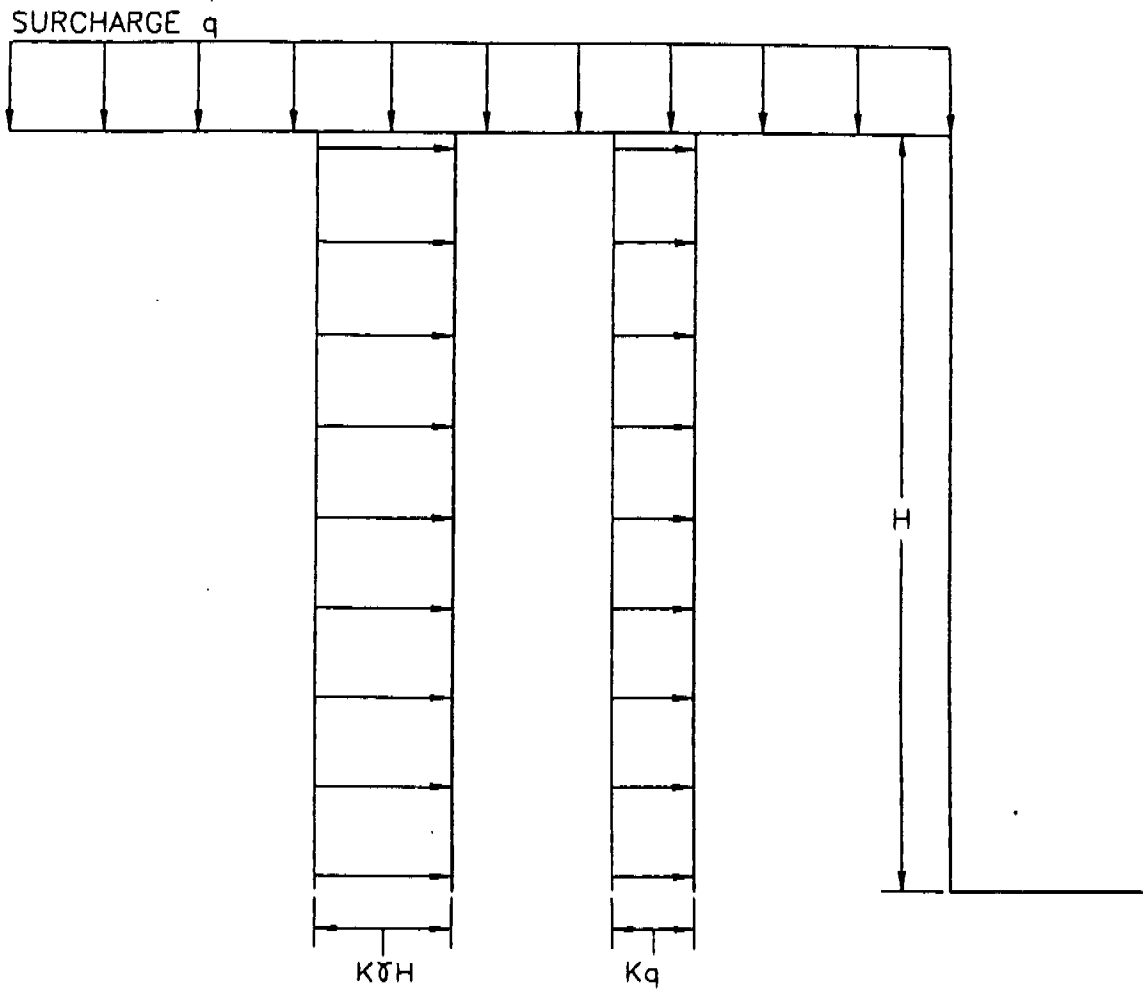
SYMBOL BOREHOLE SAMPLE ELEVATION(m)

●	99-2	3	301.7
■	99-2	6	299.6
◆	99-4	8	303.4

DESIGN LATERAL EARTH PRESSURES FOR BRACED EXCAVATION

FIGURE 6

CHECK PRINT SEP 22 1999



γ = UNIT WEIGHT OF SOIL

K = EARTH PRESSURE COEFFICIENT

Date SEPTEMBER, 1999

Project 991-8024

Golder Associates

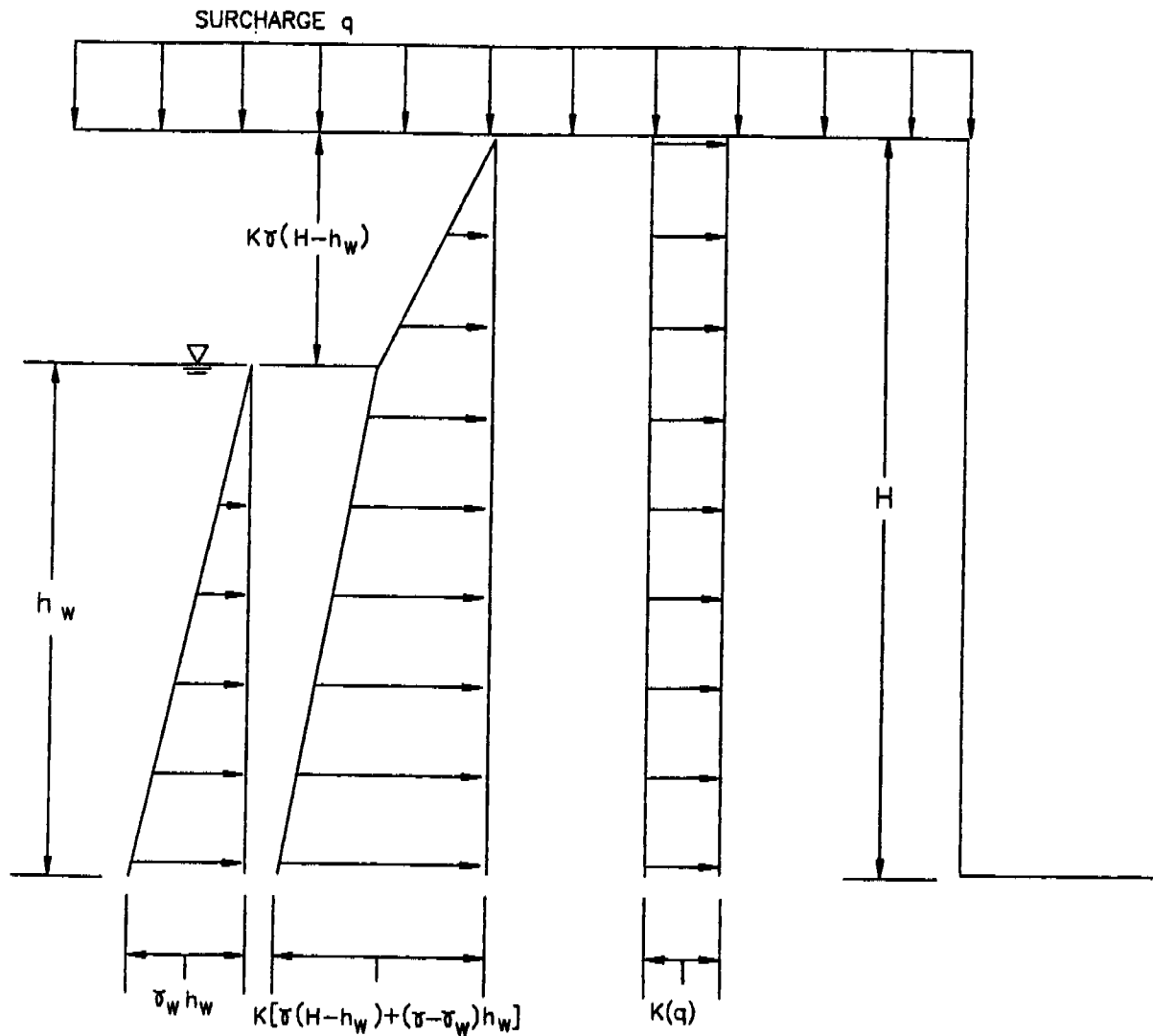
Drawn R.J.

Chkd. D.K.B.

DESIGN LATERAL EARTH PRESSURES FOR
BELOW GRADE PERMANENT WALLS
AND TEMPORARY ANCHORED WALLS

FIGURE 7

CHECK PRINT SEP 22 1999



γ = UNIT WEIGHT OF SOIL
 γ_w = UNIT WEIGHT OF WATER
 K = EARTH PRESSURE COEFFICIENT

File: C:\My Documents\Ron\Visio Files\Drawing Plate vcd | Date: September 1999 | Drawn: R.J. | Checked:

Date SEPTEMBER, 1999

Project 991-8024

Golder Associates

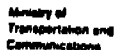
Drawn R.J.

Chkd. D.K.B.

APPENDIX A

**EXISTING BOREHOLE LOGS
GEOCRE 30M15-158**

**"REGIONAL ROAD #40 EXTENSION INTERCHANGE,
2.6 MILES NORTH OF REGIONAL ROAD #14",
W.P. 160-74-32, HIGHWAY 404,
DISTRICT 6, SITE 37-737, TORONTO,
MAY 1978**



RECORD OF BOREHOLE No 1

LOCATION **Coords.** N 15 979 708, E 1 028 052

ORIGINATED BY OL. J.

DIST 6

HWY

404

BOREHOLE TYPE

Hollow Stem Auger BX Casing and Cone Test

COMPILED BY OL. J.

DATUM Geodetic

DATE February 22-27, 1978

CHECKED BY UJ.

[illegible]

RECORD OF BOREHOLE No 1 cont.

W P 160-74-32 LOCATION Coords. N 15 979 708, E 1 028 052 ORIGINATED BY OL. J.
DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem Auger BX Casting and Cone Test COMPILED BY OL. J.
DATUM Geodetic DATE February 27, 1978 CHECKED BY *[Signature]*

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					
951.5							920										
61.5	Silty Fine Sand Very Dense		17	SS	151		910										
			18	SS	188/	10"	900										
			19	SS	90		890										
							880										
878.5			20	SS	142/	9"											
134.5	End of Borehole																

RECORD OF BOREHOLE No 2

WP 160-74-32

LOCATION Coords. N 15 979 737, E 1 028 145

ORIGINATED BY OL. J.

DIST 6 HWY 404

BOREHOLE TYPE Hollow-Stem Auger and Cone Test

COMPILED BY OL. J.

DATUM Geodetic

DATE February 22, 1978

CHECKED BY cl

[illegible]

RECORD OF BOREHOLE No 3

160-74-32 LOCATION Coords. N 15 979 772, E 1 028 251 ORIGINATED BY OI. J.
 HWY 404 BOREHOLE TYPE Hollow Stem Augers and Cone Test COMPILED BY OI. J.
 DATUM Geodetic DATE February 28, 1978 CHECKED BY VJ.

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	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
			NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
1023.7	Ground Level																
1020.0	Silty Top Soil						1020										0 49 33 18
	Clayey Silt, with Sand		1	SS	6												
	Firm to stiff		2	SS	21												
1009.7							1010										
1007.0	Sand		3	SS	66												8.88 (4)
	trace to some																
	gravel		4	SS	79												
	very dense						1000										
			5	SS	103												
995.7																	
28.0	Silty fine sand		6	SS	54												
	with occasional layers																
	of silt		7	SS	100		990										
	boulder																
	very dense																
	silt		8	SS	83												2 13 81 4
							980										
977.2			9	SS	149												
46.5	End of borehole																

3, x 5 : Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4

W P 160-74-32 LOCATION Coords. N 15 979 808 E 1 028 035 ORIGINATED BY OL. J
 DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem Auger BX Casing & Cone Test COMPILED BY OL. J
 DATUM Gauderic DATE May 7, 1978 CHECKED BY *u.f.*

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					
1005.9	Ground Level																
0	Silty Top Soil																
2.0	Clayey/Silt with Sand		1	SS	14												
	Stiff to very Stiff		2	SS	38												0 10 84 6
993.9																	
12.0	Silty fine sand with occasional layers of silt. Compact to very dense.		3	SS	43												
			4	SS	37												
	----- silt		5	SS	51												0 13 71 16
	Generally		6	SS	27												
	Dense to very dense		7	SS	28												0 49 49 2
			8	SS	22												
			9	SS	4												
			10	SS	32												
			11	SS	56												
944.6																	
61.5	End of borehole																

RECORD OF BOREHOLE No 5

W P 160-74-32 LOCATION Coords. N 15 979 847 N 1 028 150 ORIGINATED BY 01. J
 DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem Auger BX Casing & Cone Test COMPILED BY 01. J
 DATUM Geodetic DATE March 3 & 7 1978 CHECKED BY *WJ*

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	VALUES			20	40	60	80	100				
1047.9	Ground Level															
2.0	Silty Top Soil															
	Clayey Silt with Sand		1	SS	18											
	Stiff to very stiff		2	SS	25											
1003.9																
14.0	Sand. Traces of gravel		3	SS	47											0 89 (11)
4.7	very dense															
997.9			4	SS	89											0 15 68 17
20.4	Silt															
6.1	Traces of Clay and Sand		5	SS	134											0 11 83 6
			6	SS	103											
	Silty fine Sand		7	SS	80											
	with occasional layers of silt		8	SS	37											
	Compact to very Dense		9	SS	41											
			10	SS	116											
	Generally dense to very dense		11	SS	53											
			12	SS	71											
			13	SS	9											0 77 (23)
			14	SS	26											
916.4																
101.5																

HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 5 cont

W.P. 160-74-32 LOCATION Coords. N 15 979 847 E 1 028 150 ORIGINATED BY 01. J.
 DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem Auger BX Casing & Cone Test COMPILED BY 01. J.
 DATUM Geodetic DATE March 7, 1978 CHECKED BY

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			20	40	60	80	100					
916.4 101.5	Cont.															
			15	SS	154	11"										2 31 62 5
991.4 126.5	End of borehole		16	SS	75											

RECORD OF BOREHOLE 'No 6

160-74-32 LOCATION Coords. N 15 979 872 E 1 028 230 ORIGINATED BY OL. J.
 6 HWY 404 BOREHOLE TYPE Hollow Stem Auger BX Casing & Cone Test COMPILED BY OL. J.
 Geodetic DATE March 1 & 2 1978 CHECKED BY *OL*

ELEV DEPTH IN FOOT	SOIL PROFILE DESCRIPTION	STRAT PLOT	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
			NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
1013.3	Ground Level																
10.0	Silty Top Soil																
	Clayey silt with sand and a trace of gravel		1	SS	9												3 25 52 20
	firm to very stiff		2	SS	32												
14.0	Sand		3	SS	92												0 96 (4)
995.3	Trace of gravel		4	SS	30												
22.0	Dense to very dense																
	Silty Fine Sand		5	SS	44												0 12 69 19
	with																
	----- silt		6	SS	33												
	Occasional layers of Silt		7	SS	36												
	Low plasticity.		8	SS	19												
	Generally		9	SS	39												
	Dense to very dense		10	SS	75												
			11	SS	69												
			12	SS	106												
			13	SS	99												
925.8			14	SS	35												
91.5																	

*3, *5: Numbers refer to
Sensitivity

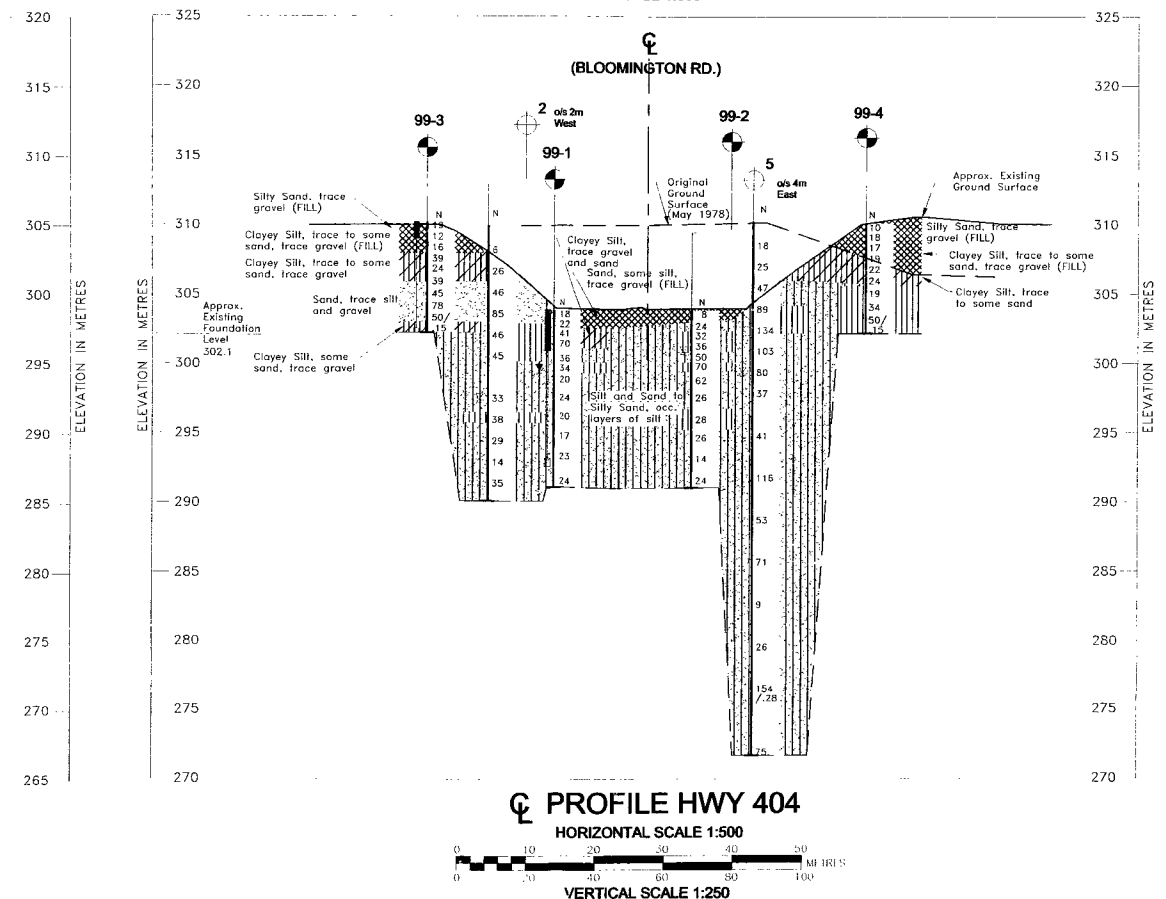
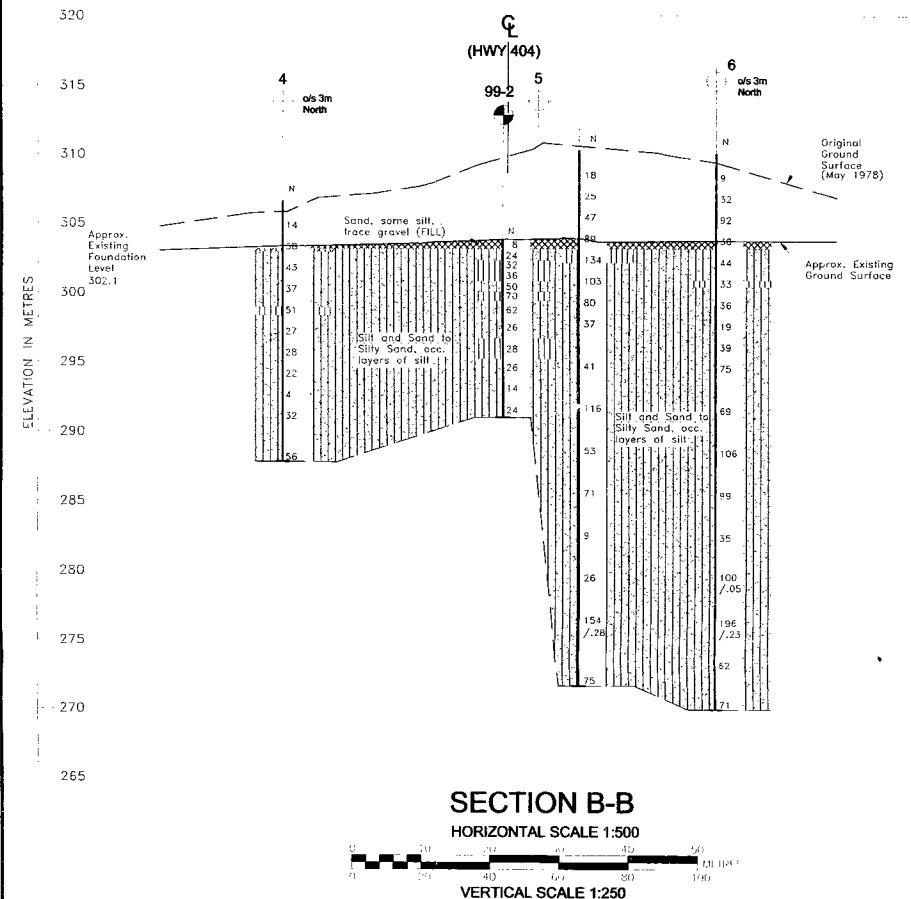
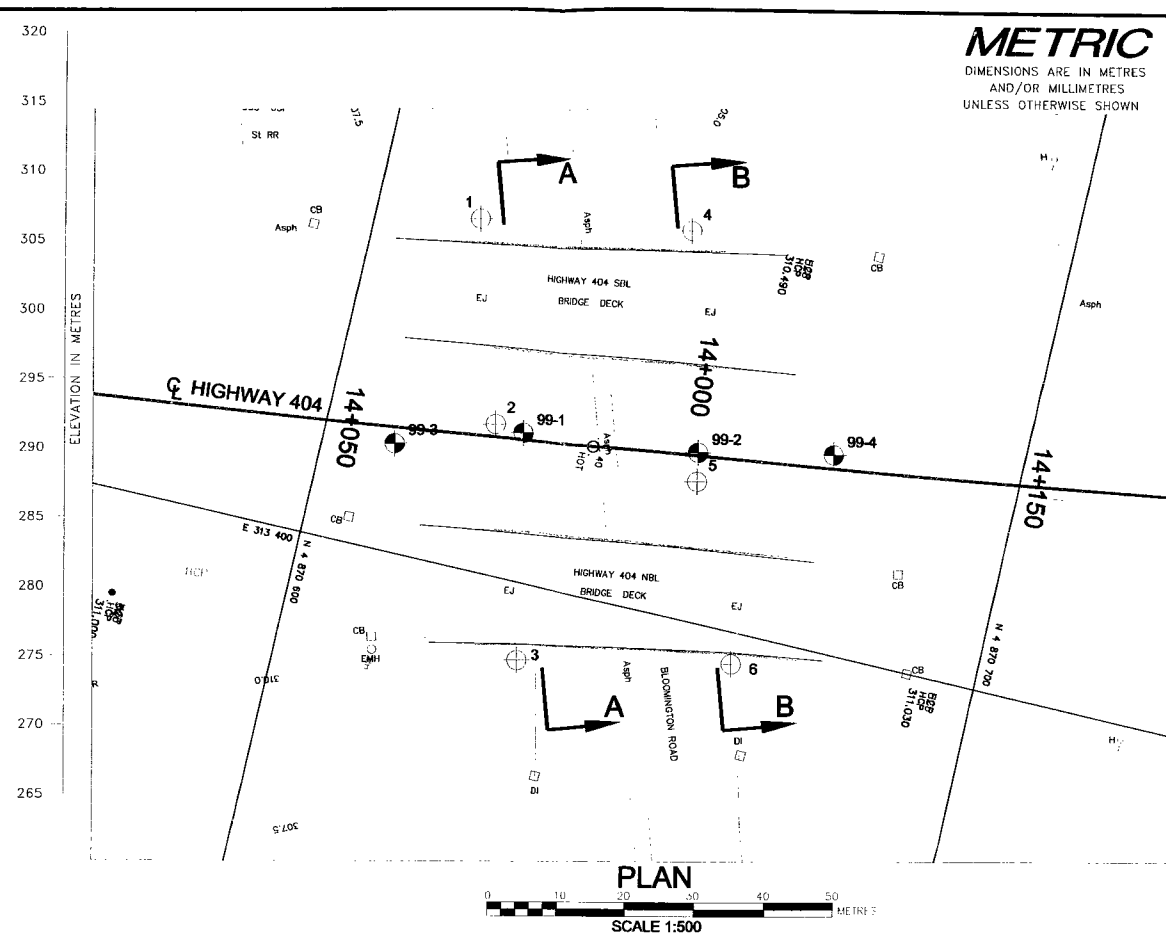
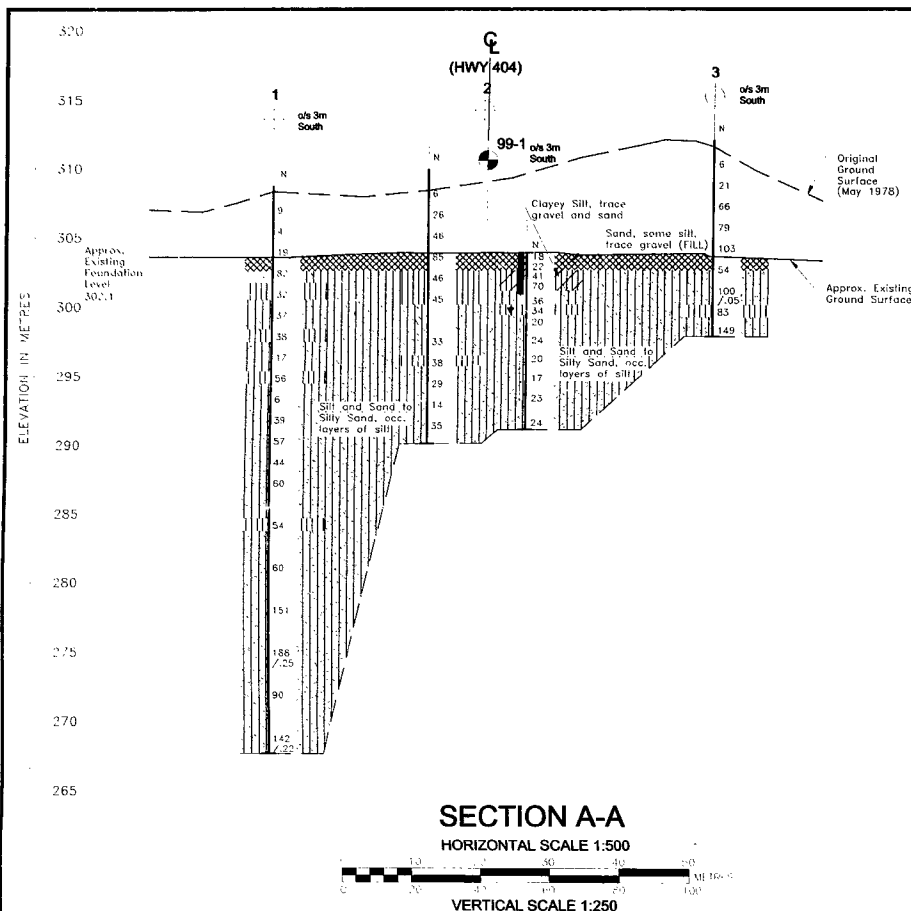
20
15 \div 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 6 cont

PROJECT 160-74-32 LOCATION Coords. N 15 979 872 E 1 028 230 ORIGINATED BY OL J.
 DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem Auger BX Casing & Cone Test COMPILED BY OL J.
 DATUM Geodetic DATE March 3 & 6 1978 CHECKED BY *2/*

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					
925.8	Cont.																
91.5																	
			15	SS	100	/2"	920										0 85 (15)
	Silty fine Sand																
	Very dense		16	SS	196	/9"	910										
			17	SS	62		900										
885.8			18	SS	71		890										
131.5	End of Borehole																

OVERSIZE
DRAWING(S)



DIST 6 HWY 404
WP No. 433-98-00

HIGHWAY 404 & BLOOMINGTON ROAD
BOREHOLE LOCATIONS & SOIL STRATA

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA

SHEET

KEY PLAN

LEGEND

- Borehole - Current Golder Associates Ltd. Investigation
- Borehole - Previous MTO Investigation Geocres 30M14-158, dated May 1978
- Seal
- Piezometer
- Blows/0.3m (Std. Pen. Test, 475 j/blow)
- WL in piezometer on October 19, 1999
- WL upon completion of drilling (current and existing boreholes)

No.	ELEVATION	LOCATION	
		NORTHING	EASTING
99-1	303.88	4870628.02	313378.93
99-2	303.87	4870653.58	313376.02
99-3	310.14	4870610.30	313384.54
99-4	310.09	4870672.81	313371.74
1	308.76	4870615.00	313350.25
2	309.89	4870623.84	313378.60
3	312.02	4870634.51	313410.90
4	306.60	4870645.48	313345.07
5	310.26	4870657.37	313380.12
6	310.07	4870664.99	313404.50

NOTES

The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

No.	DATE	BY	REVISION
2	99 12 02	AJW	FINAL
1	99 09 29	AJW	ISSUED FOR REVIEW

Geocres No. _____

HWY. No. 404 PROJECT NO.: 991-8024A DIST. 6

SUBM'D. DKB CHKD: AJW DATE: 1999 09 09

DRAWN: PS CHKD: DKB APPD. _____ DWG. 1