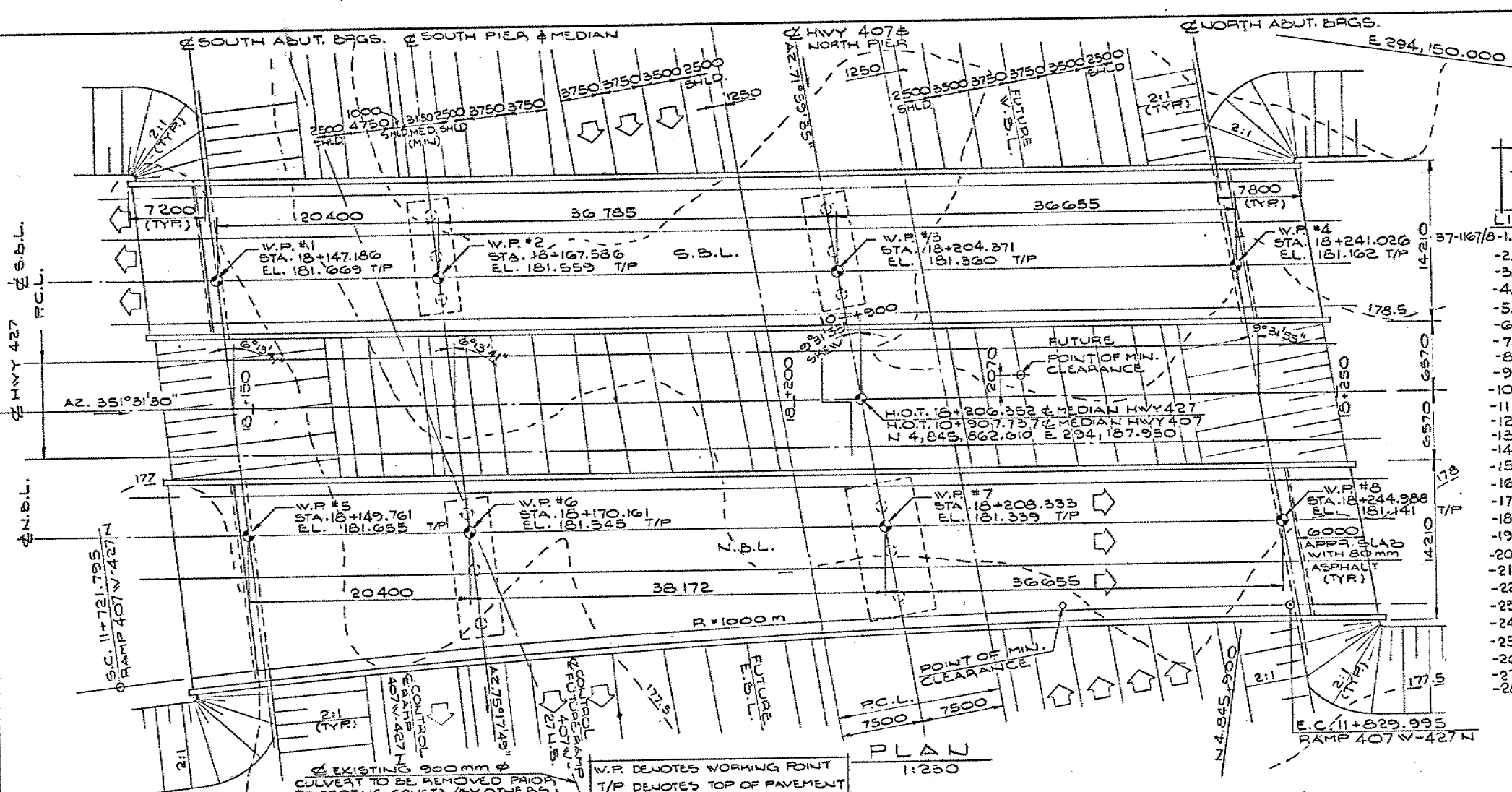


GEOCRES No. 30M13-67DIST. 6 REGION W.P. No. 150-87-01/02CONT. No. 89-62W. O. No. STR. SITE No. 37-1167 & 37-1168HWY. No. 427LOCATION Hwy 427 NBL over Hwy 407 &
Hwy 427 SBL over Hwy 407No of PAGES -

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. REMARKS:



METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

DIST. 6
CONT No
WP No 150-87-01/02

HWY. 427 N.B. & S.B.
0° PASSES AT HWY. 407
GENERAL ARRANGEMENT

Fenco
FENCO ENGINEERS INC.

SHEET

NOTE: APPROACH SLABS,
ASPHALT & WATERPROOFING
NOT PART OF THIS CONTRACT.

- LIST OF DRAWINGS:**
- 1. GENERAL ARRANGEMENT
 - 2. BOREHOLES DATA
 - 3. FOUNDATION LAYOUT AND REINF.
 - 4. NORTH ABUTMENT - I
 - 5. NORTH ABUTMENT - II
 - 6. SOUTH ABUTMENT - I
 - 7. SOUTH ABUTMENT - II
 - 8. SOUTH ABUTMENT - III
 - 9. PIERS
 - 10. BEARINGS I
 - 11. BEARINGS II
 - 12. DECK LAYOUT & DETAILS
 - 13. DECK PRESTRESSING - I
 - 14. DECK PRESTRESSING - II
 - 15. DECK PRESTRESSING - III
 - 16. DECK REINFORCEMENT - I
 - 17. DECK REINFORCEMENT - II
 - 18. DECK REINFORCEMENT - III
 - 19. DECK REINFORCEMENT - IV
 - 20. BARRIER WALL - I
 - 21. BARRIER WALL - II
 - 22. JOINT ANCHORAGE AND ARMOURING
 - 23. 6000mm APPROACH SLAB - I
 - 24. 6000mm APPROACH SLAB - II
 - 25. DETAILS OF CONC. SLOPE PAVING
 - 26. BRIDGE DATE AND SITE NUMBER DATA
 - 27. AS CONSTRUCTED ELEV. AND DIM. S
 - 28. ELECTRICAL EMBEDDED WORK

GENERAL NOTES:

CLASS OF CONCRETE	
SLOPE PAVING & MASS CONC.	20 MPa
COLUMNS & DECK	35 MPa
ABUTMENTS, BARRIER WALLS, APPROACH SLABS & FOOTINGS	30 MPa
REMAINDER	30 MPa

CLEAR COVER TO REINFORCING STEEL

ITEM	COVER (mm)
FOOTINGS	100 ± 25
ABUTMENTS, WINGWALLS	
FRONT FACE	80 ± 20
BACK FACE	70 ± 20
PIERS	80 ± 20
DECK	
TOP	70 ± 20
BOTTOM & SIDES	50 ± 10
REMAINDER	70 ± 20

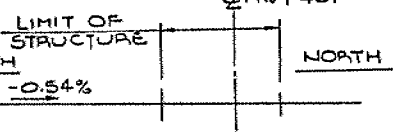
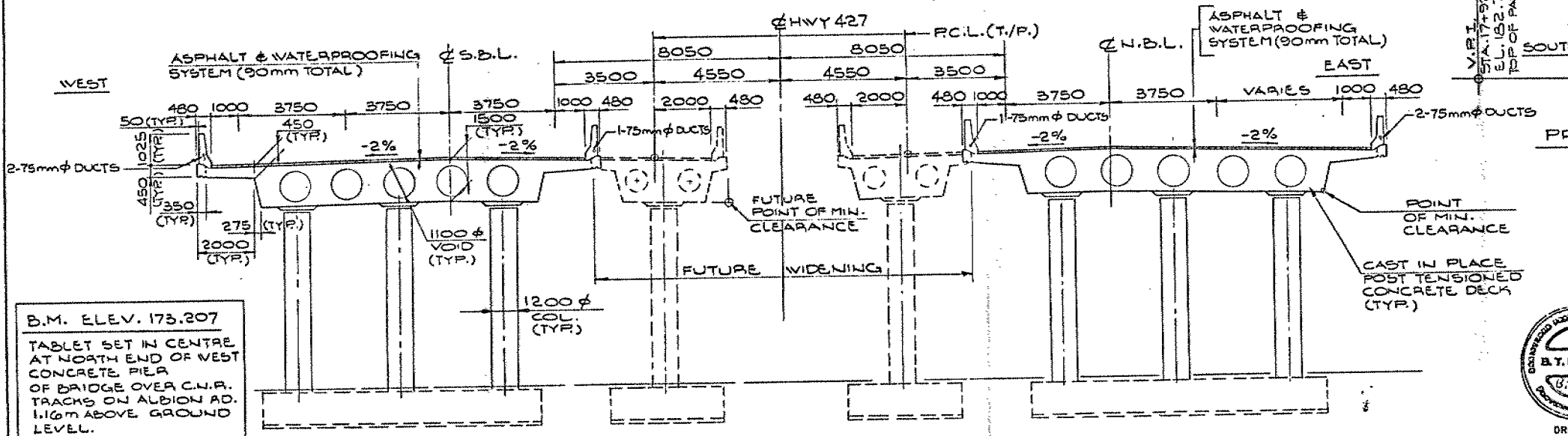
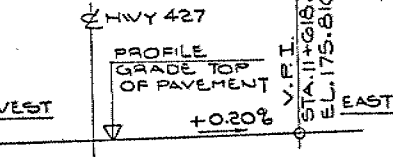
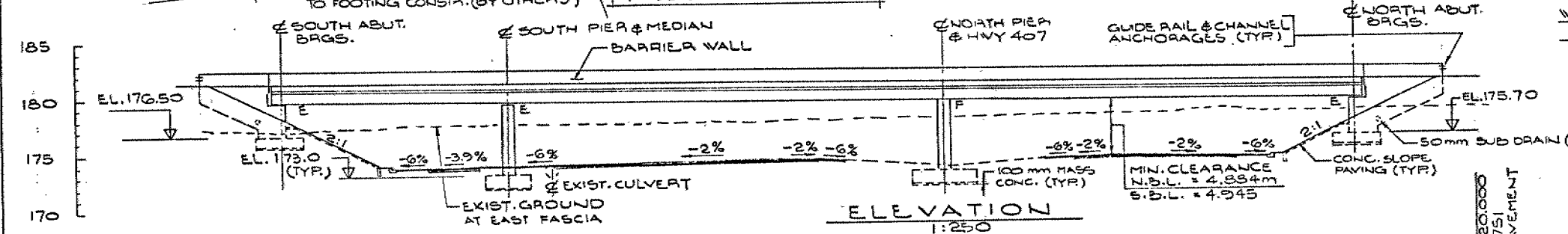
UNLESS OTHERWISE SPECIFIED

REINFORCING STEEL

REINFORCING STEEL SHALL BE GRADE 400 UNLESS OTHERWISE SPECIFIED. BAR MARKS WITH SUFFIX C DENOTE COATED BARS.

CONSTRUCTION NOTES:

BEARING SEATS SHALL BE FINISHED LEVEL AND TO THE SPECIFIED ELEVATIONS.



B.M. ELEV. 173.207
TABLET SET IN CENTRE
AT NORTH END OF WEST
CONCRETE PIER
OF BRIDGE OVER C.N.R.
TRACKS ON ALBION RD.
1.16m ABOVE GROUND
LEVEL.



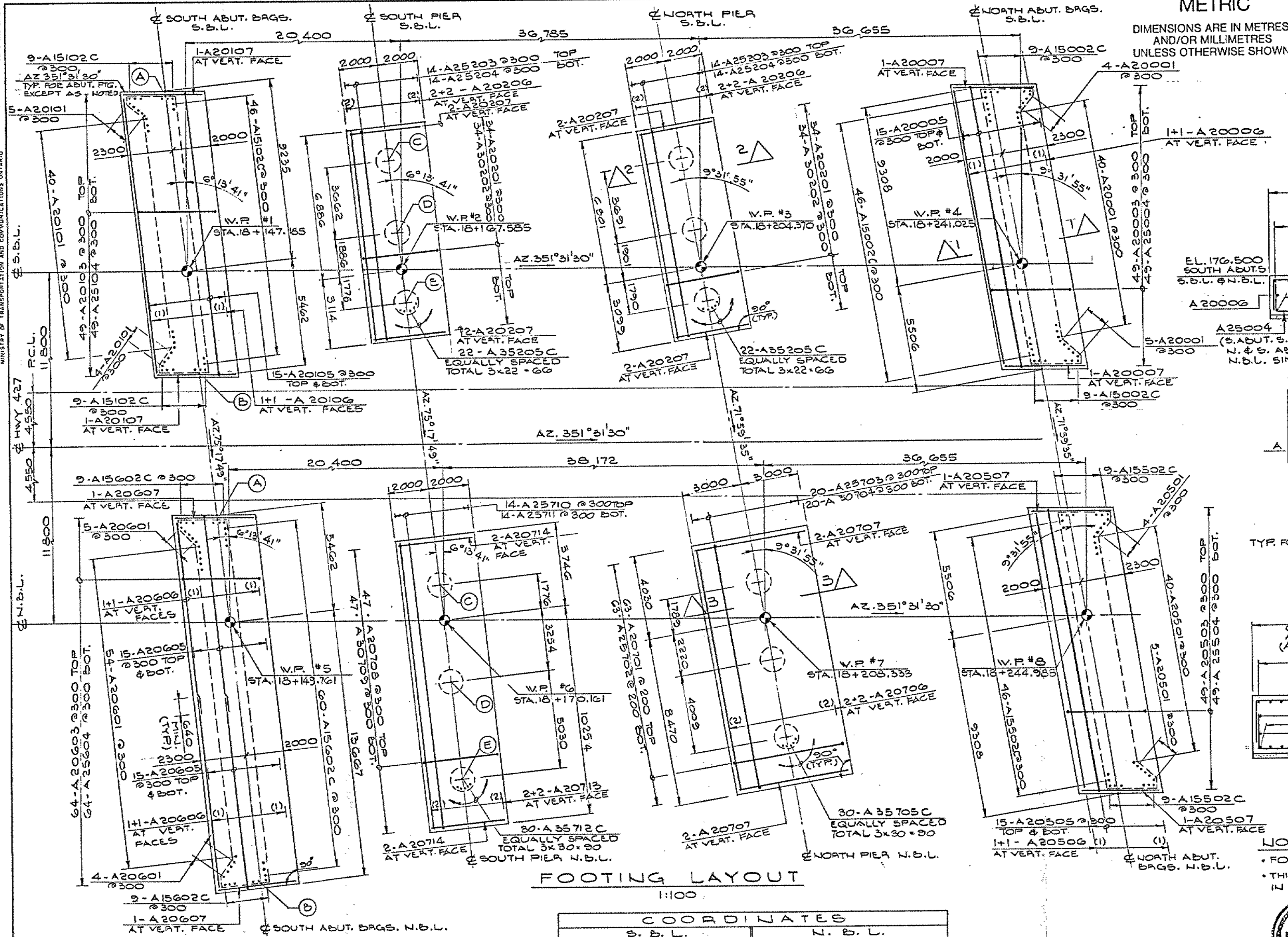
- APPLICABLE STD. DRAWINGS:**
- DD 3502 MINIMUM GRANULAR BACKFILL REQUIREMENTS
 - OPSD 508.02 WATERPROOFING

REVISIONS

NO.	DATE	BY	DESCRIPTION
1			
2			
3			
4			
5			

DESIGN L. W. CHK B.T.P. CODE OH-DC-83 LOAD CLASS A DATE AUG. 1985
DRAWN M. W. CHK L. W. SITE 37-11676/STRUCT SCHEME DWG 1

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING



FOOTING LAYOUT

1:100

COORDINATES			
S. B. L.		N. B. L.	
SOUTH ABUT.	NORTH ABUT.	SOUTH ABUT.	NORTH ABUT.
N4 845 800.071	N4 845 892.367	N4 845 807.053	N4 845 900.940
E 294 176.309	E 294 162.558	E 294 202.921	E 294 188.931
N4 845 802.351	N4 845 895.166	N4 845 805.376	N4 845 902.564
E 294 184.999	E 294 171.169	E 294 207.921	E 294 193.927
N4 845 803.673	N4 845 896.790	N4 845 811.781	N4 845 903.363
E 294 190.039	E 294 176.165	E 294 220.937	E 294 202.538

COORDINATES			
S. B. L.		N. B. L.	
SOUTH PIER	NORTH PIER	SOUTH PIER	NORTH PIER
N4 845 821.120	N4 845 857.183	N4 845 828.103	N4 845 865.756
E 294 176.626	E 294 171.253	E 294 203.238	E 294 197.623
N4 845 822.049	N4 845 858.324	N4 845 829.379	N4 845 866.995
E 294 180.168	E 294 174.763	E 294 208.103	E 294 201.440
N4 845 822.976	N4 845 859.465	N4 845 830.856	N4 845 868.234
E 294 183.709	E 294 178.273	E 294 212.970	E 294 205.253
N4 845 822.528	N4 845 858.911	N4 845 823.534	N4 845 866.309
E 294 181.992	E 294 176.571	E 294 204.933	E 294 199.329

METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

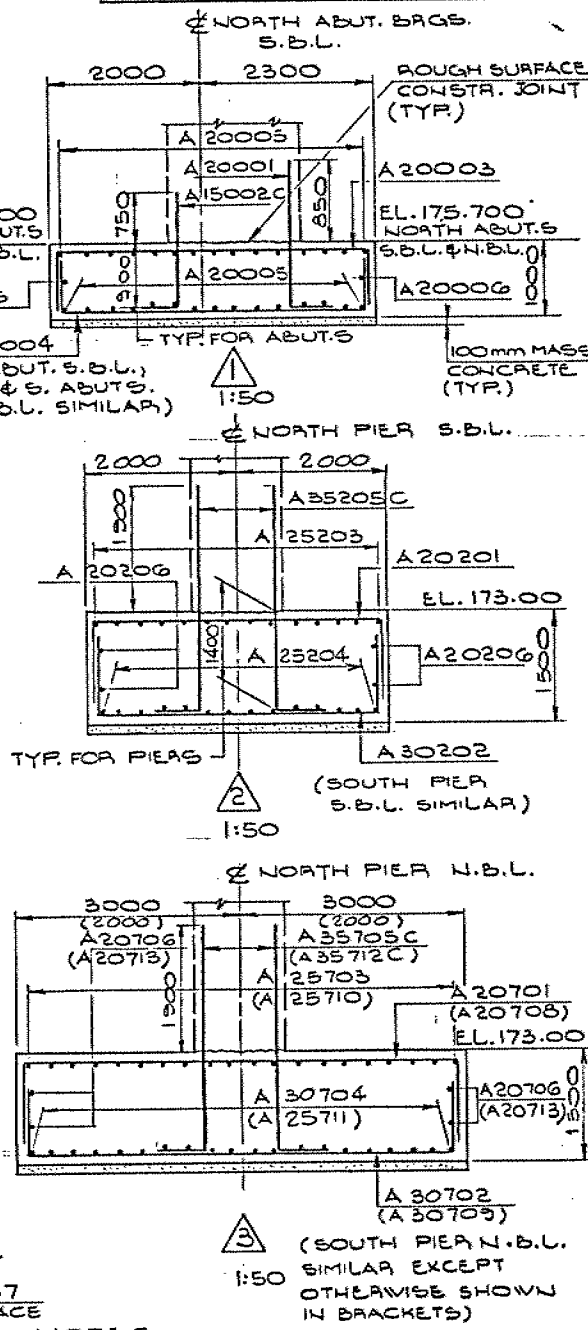
DIST. 6
CONT No
WP No 150-87-01/02

HWY. 427 N.B. & S.B.
O-PASSES AT HWY. 407
FOUNDATION LAYOUT & REINF'T.

Fenco FENCO ENGINEERS INC.



SHEET



NOTES:
• FOR GENERAL NOTES SEE DWG.-1
• THIS DRAWING TO BE READ
IN CONJUNCTION WITH DWG.-4 TO -9

REVISIONS	DATE	BY	DESCRIPTION

DESIGN L. NG CHK J. K. CODE 04-BCC-83/LOAD CLASS A/DATE AUG. 1993
DRAWN M. K. CHK L. NG SITE 57-1167/3/STRUCT SCHEME DWG 3

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

30M13-67

REPORT ON
FOUNDATION INVESTIGATION
FOR PROPOSED
HIGHWAY 407 AND HIGHWAY 427 INTERCHANGE

HWY 427 N.B.L. OVER HWY 407: W.P. 150-87-01, SITE 37-1167
HWY 427 S.B.L. OVER HWY 407: W.P. 150-87-02, SITE 37-1168

TOWN OF VAUGHAN

DIST. 6

REG. MUN. OF YORK

89-62

B.P. WALKER ASSOCIATES LTD.

B.P.Walker Associates Ltd.

Consulting Geotechnical, Inspection and Testing Engineers

101 Amber Street, Suite 2, Markham, Ontario, L3R 3B2

(416)491-4075

REPORT ON
FOUNDATION INVESTIGATION
FOR PROPOSED
HIGHWAY 407 AND HIGHWAY 427 INTERCHANGE

HWY 427 N.B.L. OVER HWY 407: W.P. 150-87-01, SITE 37-1167
HWY 427 S.B.L. OVER HWY 407: W.P. 150-87-02, SITE 37-1168

TOWN OF VAUGHAN

DIST. 6

REG. MUN. OF YORK

Prepared for
Ministry of Transportation
Foundation Design Section
1201 Wilson Avenue
Downsview M3M 1J8 Ontario

Project No. 2121

January 5, 1988

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DRAWINGS

Explanation of terms used in report

Record of Boreholes 1, 3, 4, 6, 8, 9, 11, 13, 14 and 16

Grain Size Distribution Curves Fig. 1 and 2

Abutment on Compacted Fill Fig. 3

Drawing No. 150870102-A

1. INTRODUCTION

B. P. Walker Associates Limited, Consulting Geotechnical, Inspection and Testing Engineers, were authorized by the Ministry of Transportation, Highway Engineering Division to conduct a geotechnical investigation at the site of the proposed Highway 407 and Highway 427 interchange in the Town of Vaughan, Ontario. The southbound lanes and northbound lanes of Highway 427 will be carried by separate overpass structures above Highway 407. Conceptual design data regarding the project were transmitted to us by M. Devata, P.Eng., Chief Foundation Engineer (East) of the Ministry. The Memorandum of Agreement bears the number of 4238-9087-182 and is dated the 9th day of October, 1987.

The purpose of the geotechnical investigation was to explore the subsurface conditions by means of boreholes for the design and construction of the foundations and earthworks of the project. The assignment was executed in conformance with the Memorandum of Agreement, Article 2, Engineering Services, 2.1, Consultant's Services for Foundation Design.

This report presents a brief account of the procedures followed in the investigation, the field and laboratory test results, and our interpretation of the findings. Included herein are our recommendations for the geotechnical design of the project together with the anticipated construction conditions and our opinion of how to deal with them.

2. SUMMARY

The ten boreholes drilled at the site indicate that competent soil deposits are present at the proposed founding level. The two overpass structures can therefore be supported on shallow spread footings.

In most cases, however, the excavation will be below the ground water level, in a very dense stratified sandy silt deposit which is sensitive to disturbance and can become jellylike and liverish when wet. We recommend therefore that temporary perimeter drains should be installed at the footing locations prior to excavating below the ground water table. Perched-type abutments may prove to be an attractive alternative in order to reduce dewatering costs.

Stability problems are not foreseen at this site.

3. THE SITE

The site is located in the Town of Vaughan, just outside the northern boundary of Metropolitan Toronto, north of Steeles Avenue West, directly east from the northwest corner of Metro Toronto where Albion Road, Alcide Street and Steeles Avenue West intersect. Presently the area is utilized as farmland. The topography is fairly flat, without marked relief, gently sloping (at about 2%) towards the east.

According to THE PHYSIOGRAPHY OF SOUTHERN ONTARIO (Chapman and Putnam, 1966) the site belongs to the Peel plain physiographic region which has flat or slightly rolling topography and is sloping uniformly towards Lake Ontario. The surficial prevalent soil types are clayey tills and stratified clays.

4. FIELD AND LABORATORY WORK

Ten boreholes, numbered 1, 3, 4, 6, 8, 9, 11, 13, 14 and 16, were drilled as shown on the borehole location plan. These locations were selected in agreement with MTC, as indicated on a preliminary site plan transmitted to us. The site plan shows the centreline of the proposed highways and the conceptual layout of the proposed interchange.

The boreholes were staked out in the field and the geodetic ground elevations were determined by the surveyors of M.T.C.

The ten boreholes were drilled in the interim between October 29 and November 24, 1987, to depths ranging from 11.0 to 18.7m. Total length of drilling: 169.6m. A bombardier mounted drilling rig, equipped with solid stem augers of 100mm dia, was used for advancing the holes. The drilling, sampling and field testing procedures were supervised and the borings were logged by experienced geotechnical engineer from our office.

Adjacent to borehole 6 a dynamic cone penetration test was performed in a hole preaugered to about 7m depth to test the density of the submerged fine sand and silt without disturbance caused by the augering. The cone could only be driven over a depth of about 1.5m with extremely high blow counts (see the relevant Record of Borehole sheet).

Samples were taken with a 51mm o.d. split spoon (SS) in accordance with ASTM D 1586-84, Standard Method for PENETRATION TEST AND SPLIT BARREL SAMPLING OF SOILS. Although the recovered samples are disturbed, they are representative of the stratum from which they were obtained and the STANDARD PENETRATION RESISTANCES (N-values) indicate the relative density or consistency of the sampled soil. In the dynamic cone penetration test a 50mm dia. cone is driven with the same driving energy as in the Standard Penetration Test.

In each borehole the ground water conditions were observed during drilling and sampling and after completion of the borehole. For long-term observations, sealed PIEZOMETERS were installed in boreholes 1, 4, 13 and 16 and on January 4, 1988, a standpipe was installed at borehole 9.

After completion of the field work the samples were taken to our laboratory for examination and testing. Representative samples were selected and the following tests were performed: water content (w%), liquid and plastic limits (i.e. Atterberg limits, LL% and PL%) and unit weight. The grain size distribution of fourteen samples was determined by sieve and hydrometer analyses. The field and laboratory tests results are shown on the Record of Boreholes Sheets and on figures 1 and 2.

5. SUBSURFACE CONDITIONS

The site is ploughed farmland which explains the presence of relatively deep **TOPSOIL**. At the ten borehole locations the thickness of the topsoil ranged from 0.25 to 0.50m, the average being about 0.40m. Below the topsoil a **SILTY CLAY TILL** deposit was encountered which was found to extend to depths ranging from 1.4m to 4.0m; the average is 2.6m. This depth corresponds to an average elevation of about 175m (range: between El. 173.7m and 176.1m). The consistency of the silty clay till is hard; with very few exceptions the N-values were over 30. The material is widely graded, and exhibits low to medium plasticity (the group symbol is CL-CI in the Unified Soil Classification System). The water content is 10 to 18 percent, near the plastic limit, which also indicates the hard consistency of the silty clay till.

At the average elevation of about 175m (2.6m depth) a stratified **SANDY SILT** deposit was encountered which is interbedded with layers of **SILT**, **FINE SAND** and **SILTY SAND**. The base elevation of this stratified and fine granular material was found to range from a low of 161.6m (in borehole 4) to a high of 170.8m (in borehole 1). Twelve samples taken from this deposit were subjected to grain size analysis; the envelopes are shown on

Figure 1. Most of the curves fall within the SM, SM-ML, ML-SM or ML classification group; the coefficients of uniformity are about 5 which indicates that all components of the stratified deposit are rather uniformly graded. Based on the gradation curves the coefficient of permeability (k) is estimated to range from about 10^{-3} to 10^{-5} cm/s in the horizontal direction. In the vertical direction the k-value is determined by the permeability of the least pervious layers. Due to lack of cohesion (Atterberg limits tests were attempted but could not be performed) the deposit is sensitive to erosion, which can cause piping and slope instability.

The stratified **SANDY SILT** deposit is very dense as indicated by the very high N-values; occasional lower values (see BH3, SS12) were caused by the loosening effect of suction in the bore and groundwater which inevitably develops in the wake of the withdrawn augers. (The dynamic cone penetration test performed adjacent to borehole 6 proves the phenomenon.)

Generally, the **GROUNDWATER** table was found to be within the stratified **SANDY SILT** deposit, at an average elevation of 172.8m (range: 172m to 173.6m). In boreholes 11 and 13 perched groundwater was encountered at a higher level (about El. 175m) due to the presence of underlying clayey and less pervious deposits. In borehole 14, the groundwater level was lower, at about El. 170.8m.

Below the stratified and water bearing sandy silt, a laminated **CLAY** deposit was encountered in boreholes 1 and 11. This stratum is interwoven with **FINE SAND** and **SILT** beds. In borehole 11 the clay lies higher, between El. 174.1m and 166.5m; here it was also less competent with N-values increasing gradually from 27 to 82, with depth. Based on the N-values and visual examination, the **CLAY** can be characterized as having a hard consistency. The plasticity index lies between wide limits from CL to CI (the minimum and maximum liquid limits were 18% and 41%, respectively). Typical grain size distribution curves are shown on Figure 2.

GLACIAL TILLS (widely graded massive deposits of **SILTY CLAY** and **SANDY SILT**) were encountered below the stratified sandy silt and laminated clay deposits. The top elevation of these tills is about El. 170m in the northern borings (13, 14 and 16) and about El. 162.5m in the southern ones (1, 3 and 4). The excellent engineering characteristics of these tills is indicated by the very high N-values (well in excess of 100). The borings were terminated in these deposits.

Shale fragments in some deepest samples indicate that the bedrock may be at around El. 158m.

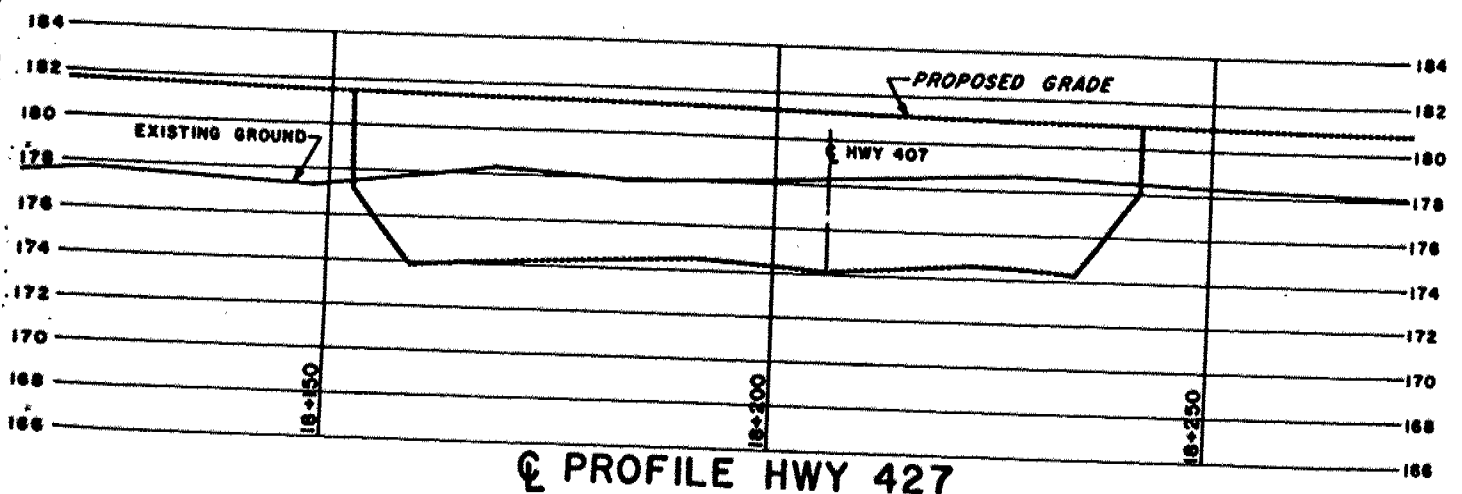
6. DISCUSSION AND RECOMMENDATIONS

6.1 Project

The proposed highway 427 and highway 407 will run approximately in a north-south and east-west direction, respectively. According to the conceptual layout of the interchange, which is shown on drawings E-6083-1 sheets 1 and 2, dated November 5, 1987, the northbound and southbound lanes of highway 427 will be carried by two separate overpass structures. Each overpass will consist of three spans, supported by two piers and two abutments. The existing ground level at the site ranges from about El. 177m to 179m. At the location of the interchange highway 407 will be in cut, with the profile grade at approximately El. 174.4m. Highway 427 is planned to run at approximately El. 181.2m, on 3 to 4m high approach embankments. As the invert of side ditches along highway 407 will be at El. 174±m, the highest foundation base level is estimated to be about El. 172.8m which will allow for 1.2m frost protection. Our recommendations are based on this information. The figure below illustrates the profile of Highway 427.

SOUTH

NORTH



6.2 Foundation Design

The proposed structures can be supported on shallow spread foundations. As the soil and groundwater conditions are not consistent across the site, the founding elevations and recommended bearing pressures will be discussed separately at each pier and abutment location. In the following tables the suitable foundation elevations are shown together with the type of bearing stratum and groundwater elevation.

SOUTHBOUND STRUCTURE

	<u>BOREHOLE</u>	<u>FOUNDING STRATUM</u>	<u>GROUNDWATER ELEVATION</u> (Nov. 1987)	<u>FOUNDATION ELEVATION</u> (m)	F.B.C. at U.L.S. kPa *
South Abutment	1	very dense SANDY SILT	173	175 or lower	1000
South Pier	6	very dense SILT	173	175 or lower	1000
North Pier	9	very dense SANDY SILT	173.5	175 or lower	1000
North abutment	13	very dense	174.5	175.5	1000
	14	SILTY SAND or SILT	* * 170.8	or lower	

F.B.C. at U.L.S. = factored bearing capacity at ultimate limit states
Possibly perched ground water table

NORTHBOUND STRUCTURE

<u>BOREHOLE</u>		<u>FOUNDING</u> <u>STRATUM</u>	<u>GROUNDWATER</u> <u>ELEVATION</u> (Nov. 1987)	<u>FOUNDATION</u> <u>ELEVATION</u> (m)	F.B.C. at U.L.S. <u>kPa *</u>
South	3	very dense	172.8	174 or lower	1000
Abutment	4	SANDY SILT			
South	8	very dense	172.1	175 or lower	1000
Pier		SILT			
North	11	hard CLAY	175 **	174 to 171	500
Pier					
North	16	hard SILTY	173.1	175 or lower	1000
Abutment		CLAY or very dense SILT			

F.B.C. at U.L.S. = factored bearing capacity at ultimate limit states.
Possibly perched ground water table

Where the Factored Bearing Capacity at Ultimate Limit States is 1000kPa, settlements will be negligibly small and the bearing capacity at serviceability limit states (Type II) need not be checked.

Where the Factored Bearing Capacity at Ultimate Limit States is 500kPa, the foundation design should be checked for the serviceability limit states (Type II) in which case the design bearing capacity is 350kPa. This value is based on the empirical criterion of limiting the settlement of the foundation to 25mm.

Under inclined loading conditions the bearing capacity at the ultimate limit state should be reduced in accordance with Clause 5 - 7.3.3.5 of the Ontario Highway Bridge Design Code, Second edition, 1983 (OHBDC).

For horizontal forces the sliding resistance of the footing should be calculated by assuming that the friction angle is 26 degrees between the concrete footing and natural subgrade.

6.3 Perched Abutments

The tables in the previous section indicate that the groundwater level, at many locations, is at or above the assumed foundation base elevation. As the founding stratum will generally consist of the stratified sandy silt deposit which is very sensitive to the erosive and loosening effect of the groundwater, we recommend that the water table should temporarily be lowered below the level of excavation for the duration of construction. The methods of dewatering will be discussed in Section 6.5 of this report.

At the abutments of the two structures consideration should be given to designing and constructing "perched" typed foundations. This concept consists of placing engineered fill, Granular A conforming to M.T.C. Std. Form, 1010, in the end section of the approach embankments and building the abutment foundations atop this fill as described below.

All topsoil, and weathered and disturbed earth materials should be removed to the surface of the natural and inorganic, stiff silty clay till deposit. The material used for embankment construction under the footings should be well graded, clean, crushed stone fill conforming to M.T.C. Std. Form, 1010, Granular "A" aggregate. The geometry of the outline of granular A engineered fill is shown on Figure 3, included with this report. The structural fill should be placed in 150mm thick lifts and each lift should be uniformly compacted at the optimum moisture content to at least 100% of its Standard Proctor maximum dry density.

For footings transmitting loads to the engineered fill, Granular A, placed in accordance with the above requirements, the Factored Bearing Capacity at Ultimate Limit States is 600kPa. The Bearing Capacity at Serviceability Limit States Type II is 250kPa. With this value, the maximum total settlement should be limited to 25mm.

For the evaluation of the sliding resistance of perched footings, the ultimate value of the angle of friction between the concrete and Granular A fill should be taken as 35 degrees.

6.4 Lateral Earth Pressure

It is recommended that properly compacted and free-draining granular material should be used as backfill behind retaining walls. Perforated pipes and/or drainage holes should be incorporated in the design to minimize the buildup of hydrostatic pressures. The perforated pipes and drainage holes should be surrounded with Terrafix 270R (or approved equal) filter fabric to prevent clogging.

Assuming that free draining granular material and adequate drainage is provided behind retaining structures (Figure 6-9.6.1 OHBDC) the lateral earth pressure can be calculated by using the following equivalent fluid pressures.

On the major portion of the retaining wall where active earth pressure conditions could develop:

At Ultimate Limit State	8 kPa/m
At Serviceability Limit State Type II	6.5kPa/m

Rigid walls of bridge abutments should be designed to withstand the at-rest earth pressures which can be approximated using the following equivalent fluid pressures:

At Ultimate Limit State	10kPa/m
At Serviceability Limit State Type II	8.5kPa/m

When using the above values, it is assumed that the slope of the backfill behind the retaining structure is approximately level.

As an alternative to the "equivalent fluid pressure method" the earth pressures can also be calculated using the analytical approach, assuming that backfill to the abutments will consist of Granular "A" or "B" type aggregates.

In this case, backfill to structures should consist of granular materials, in accordance with MTC Standard Special Provision No. 121, dated October, 1983. Earth pressures acting on the wall may be computed in accordance with Section 6.6.1.2.1 of the O.H.B.D.C. assuming a non-yielding foundation where the "at rest" condition applies. The physical properties to be assumed for the backfill are as follows:

Granular "A" - $\phi = 35^\circ$, $\gamma = 22.8 \text{ kN/m}^3$	$K_o = 0.43$
Granular "B" - $\phi = 30^\circ$, $\gamma = 21.2 \text{ kN/m}^3$	$K_o = 0.50$

Construction joints should be provided between those portions of retaining walls which can yield and those which are rigidly restrained.

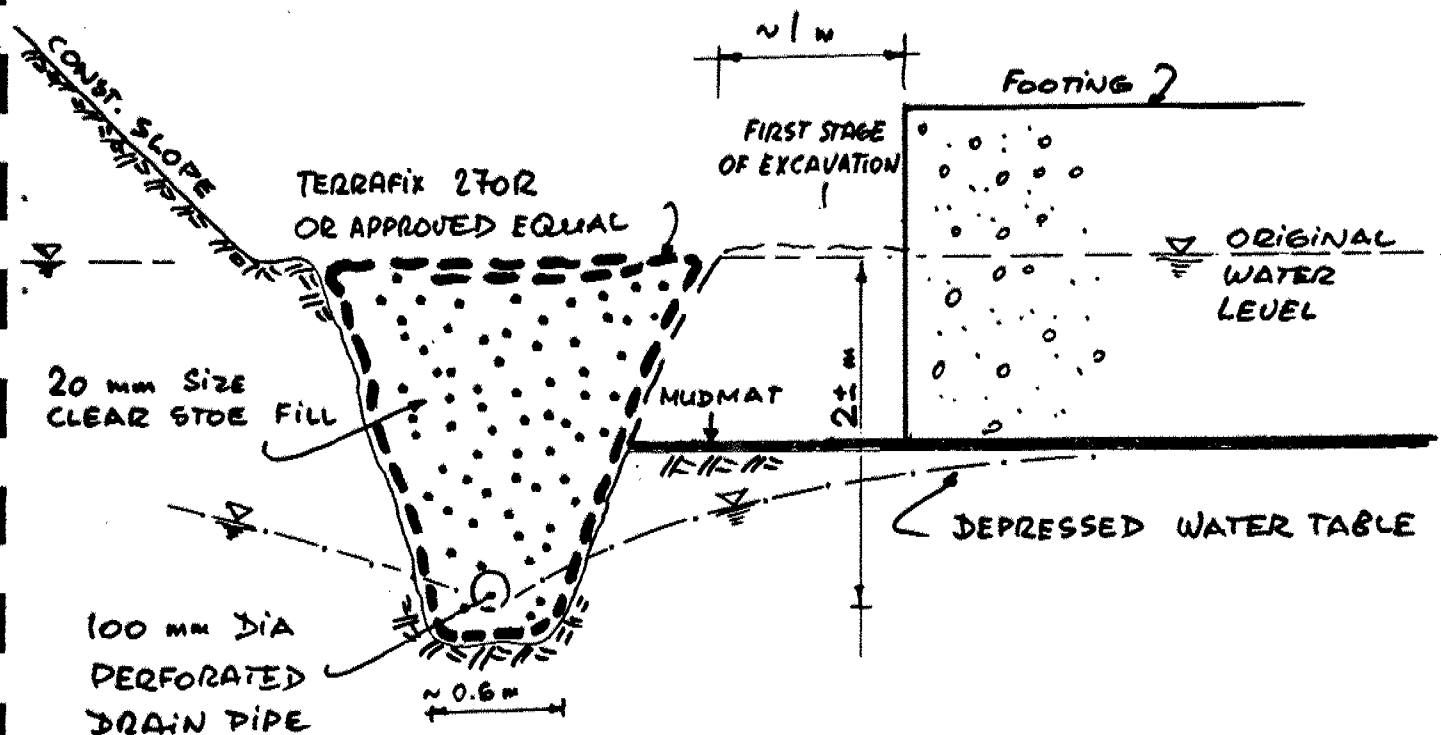
Care should be given to avoid the development of large horizontal pressures when compacting the backfill behind retaining walls and abutments. Vibratory compaction equipment, for use behind retaining structures, must be restricted in size as per current M.T.C. specifications.

6.5 Excavation and Dewatering

Within the general excavation for highway 407 additional excavation will be necessary for the footings. In the surficial silty clay till deposit, practically vertical walls should be temporarily stable, provided that the excavation is not deeper than 1.2m. If the depth of cut exceeds 1.2m, the excess height should be cut back at 45 degrees to comply with the provisions of the Ontario Construction Law. In the very stiff to hard silty clay till steeper slopes (1 to 2, H to V) should be temporarily stable but such slopes would have to be inspected and certified by geotechnical personnel at regular intervals. In the stratified sandy silt deposit, which lacks cohesion, the excavated slopes should not be steeper than 1 to 1.

In the vicinity of boreholes 11, 13 and 14, no special dewatering measures appear to be necessary. At the other locations the foundation base elevation will be at or slightly below the groundwater level therefore the excavated test pit for the footings will have to be dewatered prior to excavating. We recommend the following procedure.

Excavation can progress until the ground water table is reached. Then, perimeter drains should be installed at about 2m depth below the water table outside the footing area. The drain should consist of a 100mm perforated pipe surrounded with 20mm clear stone which is protected by filter fabric. The water from the drain pipes should be collected in temporary sumps and removed by pumping. The figure below illustrates the concept.



In our opinion, the quantity of groundwater flowing into the perimeter drain system will be comparatively small because the stratified sandy silt is very dense. The main purpose of the drainage system is to turn the direction of the groundwater seepage downwards, away from the excavation, and thereby to prevent the erodible foundation subgrade from becoming jellylike and liverish, which could ultimately result in loosening of the subgrade and increase settlements.

After the water table is sufficiently depressed, which could take about a week, the excavation can continue to the required level. We recommend that a 100mm thick concrete mudmat should be placed over the footing grade to prevent disturbance to the wet sands and silts and to assure a reasonably clean work area for placing reinforcing steel, formwork and concrete.

It is emphasized that pumping of water from temporary sumps made within the footing area should not be attempted because this could considerably loosen the cohesionless footing grade.

In our opinion, this method of dewatering should be satisfactory provided that the foundation base level is not more than about 1.5m below the groundwater table. If deeper excavation is needed, a more elaborate dewatering system (e.g. vacuum wellpoints) may have to be installed.

6.6 Slope Stability

At the location of the interchange up to about 4m deep excavation will be required to achieve the grade of highway 407. We recommend that cut slopes should not be steeper than 2 to 1 (H to V) for long term stability.

Highway 427 will run atop embankments of 3 to 4m height. The design of the approach embankments will not be limited by the strength of the foundation materials underlying the site and stability or settlement problems are not anticipated to occur. In the case where the approach embankments are constructed from locally available clean earth materials, 2 to 1 (H to V) side slopes can be designed.

All slopes should be protected against erosion by grassing. Flatter slopes may be required to operate grass mowing equipment.

7. INSPECTION AND CLOSURE

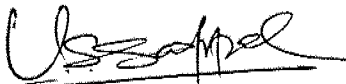
The conclusions and recommendations given in this report are based on information determined at the borehole locations. The soil stratigraphy and groundwater conditions between and beyond the boreholes may differ from those encountered at the borehole locations and subsurface conditions may become apparent during construction which could not be detected or anticipated from the site investigation. Also, depending on seasonal factors, the groundwater table could be at a different level than at the time of the field work. Therefore, we recommend that we should be retained during excavation and construction of the foundations to inspect and certify the foundation conditions.

The recommendations given in this report are applicable only to the project described in the text and then only if constructed in accordance with the general principles stated in the report. Since all details of the design may not be known at the time of

submitting this report, we recommend that we be retained during finalizing the drawings and specifications to verify that the design is consistent with our recommendations and the assumptions made in our analysis are valid.

Yours very truly,

B. P. WALKER ASSOCIATES LTD.



L. S. Rolko, P.Eng.



B.P. Walker, Ph.D., P.Eng.



EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
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'_{v0}	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	kN/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	kN/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	kN/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	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	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}	kN/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 ²	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						



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Consulting Geotechnical Inspection and Testing Engineers
Project No. 2121.1

RECORD OF BOREHOLE No 1

METRIC

150-87-01

W P 150-87-02

LOCATION N 4 845 802.2; E 294 176.2

ORIGINATED BY LSR

DIST 6 HWY 407/427

BOREHOLE TYPE 100mm dia. Solid Stem Augering

COMPILED BY LSR

DATUM Geodetic

DATE 1987 - 10 - 29

CHECKED BY UR

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					
177.5	Ground Level																
0.0	0.38m Topsoil					Seal	177										
176.1	Silty Clay, Some Sand, Trace Gravel, Hard, Glacial Till, Damp		1	SS	43												
1.4	Sandy Silt, trace compact Gravel with very dense Fine Sand Layers		2	SS	15												
			3	SS	56		175										
			4	SS	75												
	Damp to moist Saturated					Seal	173										
			5	SS	94												0 44 53 3
			6	SS	68												
170.8	Brown Grey cobbles		7	SS	76		171									23.2	1 5 85 9
6.7	Silty Sand, Some Gravel, V. Dense, Glacial Till, Moist		8	SS	100/	Piezometer										23.5	
170.1	Clay, with Silt Laminations and Layers		9	SS	60/	0.15m											
7.4							169										
			10	SS	83												
							167										3 10 34 53
	Hard Grey Damp		11	SS	98												
							165										
			12	SS	100/	0.23 m											
			13	SS	80/	0.06 m											
162.9							163										
14.6	Silty Clay, Some Sand, Trace Gravel, Glacial Till Hard Grey Damp		14	SS	100/	0.13 m											
							161										
	Shale Possibly Fragments Bedrock		15	SS	42/	0.05 m											
159.7			16	SS	100/	0.10m											
17.8	End of Borehole						159										

+3, x5: Numbers refer to
Sensitivity

20
15 ÷ 5 (%) STRAIN AT FAILURE
10



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Project NO. 2121.1

RECORD OF BOREHOLE No 3

METRIC

150-87-01
W P 150-87-02 LOCATION N 4 845 809.4; E 294 202.5 ORIGINATED BY LSR
DIST 6 HWY 407/427 BOREHOLE TYPE 100mm dia. Solid Stem Augering COMPILED BY LSR
DATUM Geodetic DATE 1987 - 11 - 03 & 04 CHECKED BY lse

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 Y 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					
177.1	Ground Level																
0.0	0.38m Topsoil Silty Clay, some Sand, trace Gravel, Glacial Till		1	SS	31		177										
175.0	Hard Brown Damp		2	SS	67		175										
2.1	Sandy Silt, with Fine Sand and Silt layers		3	SS	65												0 28 64 8
	very dense		4	SS	90												
	Moist Saturated		5	SS	96		173										
	Brown Grey		6	SS	85												0 80 15 5
			7	SS	106		171										2 80 13 5
			8	SS	68												
			9	SS	76		169										0 15 80 5
			10	SS	63		167										
			11	SS	59		165										SS 12: Low N probably due to sample disturbance caused by groundwater
			12	SS	18												
162.9	Boulders		13	SS	27/0	0.01m	163										
14.2	Silty Clay, some Sand, trace Gravel, Occasional Sandy lenses		14	SS	100/	0.18m	161										
	hard		15	SS	39/	0.08m											
158.7	Grey Damp		16	SS	100/	0.14m	159										
18.4	End of Borehole																

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



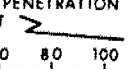
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Project No. 2121.1

RECORD OF BOREHOLE No 4

METRIC

150-87-01
W P 150-87-02 LOCATION N 4 845 814.0; E 294 220.0 ORIGINATED BY LSR
DIST 6 HWY 407/427 BOREHOLE TYPE 100mm dia. Solid Stem Augering COMPILED BY LSR
DATUM Geodetic DATE 1987 - 11 - 02 & 03 CHECKED BY ue

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				
177.1	Ground Level															
0.0	0.4m Topsoil		1	SS	43		177									
	Silty Clay, some Sand		2	SS	35		175									
	trace Gravel, occasional		3	SS	64											
	Silt lenses															
	Glacial Till															
174.2	Hard Brown Damp		4	SS	100/0.16m											
2.9	Sandy Silt with Fine		5	SS	100/0.23m		173									
	Sand and Silt layers		6	SS	100/0.26m											
	very dense		7	SS	100/0.27m		171									
	Moist to Wet		8	SS	115											
	Saturated		9	SS	100/0.24m		169									
	Brown Grey		10	SS	100/0.23m		167									
			11	SS	100/0.03m		165									
	cobbles		12	SS	55		163									
			13	SS	17		161									
161.6			14	SS	100/0.24m											
15.5	Silty Clay, some Sand,		15	SS	100/0.18m		159									
	trace Gravel, with Sand															
	lenses															
	Glacial Till															
	Moist to Wet		16	SS	100/0.09m											
158.7	Hard Grey															
18.4	End of Borehole															
	Possibly Shale Bedrock															

+3, x5: Numbers refer to
Sensitivity

20
15 + 5 (%) STRAIN AT FAILURE
10

SS13: low W
probably due
to sample
disturbance
caused by
groundwater



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RECORD OF BOREHOLE No 6

METRIC

150-87-01
W P 150-87-02 LOCATION N 4 845 824.2; E 294 187.0 ORIGINATED BY LSR
DIST 6 HWY 407/427 BOREHOLE TYPE 100mm dia. Solid Stem Augering COMPILED BY LSR
DATUM Geodetic DATE 1987 - 11 - 04 CHECKED BY *LR*

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					
178.1	Ground Level																
0.0	0.25m Topsoil		1	SS	37		177										
	Silty Clay, some Sand, trace Gravel		2	SS	35												
	Glacial Till																
175.2	Hard Brown Damp		3	SS	100/0.28m		175										
2.9	Silt, with Fine Sand layers		4	SS	97												2 9 82 7
	Moist Saturated		5	SS	107		173										
			6	SS	61												
			7	SS	66												
	Brown Grey		8	SS	100/0.26m		171										
			9	SS	24												0 13 74 13
	very dense		10	SS	44		169										
			11	SS	99		167										
			12	SS	46												
			13	SS	56		165										
			14	SS	15		163										
161.8																	SS14: low W probably due to sample disturbance caused by groundwater
16.3	Sandy Silt, trace Gravel,		15	SS	100/0.15m		161										
	very Glacial Till dense Damp Grey to moist		16	SS	100/0.10m												
159.7																	
18.4	End of Borehole						159										

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



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Project No. 2121.1

RECORD OF BOREHOLE No 8

METRIC

W P 150-87-01
150-87-02 LOCATION N 4 845 832.0; E 294 216.0
DIST 6 HWY 407/427 BOREHOLE TYPE 100mm dia. Solid Stem Augering
DATUM Geodetic DATE 1987 - 11 - 24
ORIGINATED BY LSR
COMPILED BY LSR
CHECKED BY LR

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				
177.2	Ground Level															
0.0	0.30m Topsoil						177									
	Silty Clay, trace Sand and Gravel		1	SS	34											
	Glacial Till		2	SS	68											
175.1	Hard Brown Damp						175									
2.1	Silt, some Fine Sand, trace Gravel, with occasional Fine Sand layers		3	SS	98											
			4	SS	100/0.21m											
							173									
			5	SS	100/0.17m											
			6	SS	100/0.28m											
			7	SS	106		171									
			8	SS	100/0.28m											
			9	SS	100/0.24m		169									
			10	SS	100/0.23m		167									
166.2	Silty Clay, Hard, Glacial Till		11	SS	100/0.28m											
11.1	End of Borehole						165									

+3, x5: Numbers refer to
Sensitivity

20
15 + 5 (%) STRAIN AT FAILURE
10



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Project No. 2121.1

RECORD OF BOREHOLE No 9

METRIC

W P 150-87-01 LOCATION N 4 845 856.7; E 294 168.5 ORIGINATED BY LSR
DIST 6 HWY 407/427 BOREHOLE TYPE 100mm dia. Solid Stem Augering COMPILED BY LSR
DATUM Geodetic DATE 1987 - 11 - 24 CHECKED BY LSR

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					
178.1	Ground Level																GR SA SI CL
0.0	0.34m Topsoil																
	Silty Clay, some Sand,		1	SS	35		177										
	trace Gravel Glacial		2	SS	20												
176.0	Hard to Till																
	very stiff Brown damp		3	SS	24		175										
2.1	Sandy Silt, with Fine		4	SS	66												
	compact Sand and Silt																
	v. dense lenses or																
	layers moist																
	saturated																
			5	SS	100/0.25m		173										
			6	SS	100/0.24m		Piezometer										
			7	SS	99												
	Brown		8	SS	100/0.19m		171										
	Grey		9	SS	100/0.24m												
			10	SS	100/0.27m		169										
168.0																	
10.1	Silty Clay, some Sand,																
	trace Gravel, with Silt																
167.1	lenses																
	Hard Grey Moist		11	SS	100/0.23m												
11.0	End of Borehole						167										

+3, x5: Numbers refer to
Sensitivity

20
15 ÷ 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION



Ministry of
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B. P. WALKER ASSOCIATES LIMITED
Consulting Geotechnical, Inspection and Testing Engineers
Project No. 2121.1

RECORD OF BOREHOLE No 11

METRIC

W P 150-87-01
150-87-02 LOCATION N 4 845 865.0; E 294 194.2 ORIGINATED BY LSR
DIST 6 HWY 407/427 BOREHOLE TYPE 100mm dia. Solid Stem Augering COMPILED BY LSR
DATUM Geodetic DATE 1987 - 11 - 04 & 05 CHECKED BY C2

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	SHEAR STRENGTH					
178.1	Ground Level													GR SA SI CL
0.0	0.4m Topsoil Silty Clay, some Sand trace Gravel, Glacial Till		1	SS	40		177							
			2	SS	35									
175.2	Hard Brown Damp		3	SS	64		175							
2.9	Silty Fine Sand, very		4	SS	86									
174.1	dense Brown Damp													
4.0	Clay, with Silt lamin- ations and layers, occasional Sand lenses		5	SS	34		173							
			6	SS	27									
	hard Brown Damp Grey		7	SS	35		171							
			8	SS	48									
			9	SS	47									
			10	SS	82		169							
			11	SS	69		167							
166.5	cobbles													
11.6	Silty Clay, some Sand trace Gravel		12	SS	100/0.24m		165							
	Glacial Till		13	SS	100/0.23m									
	hard Brown Damp Grey		14	SS	100/0.01m		163							
			15	SS	33/0.04m		161							
159.4			16	SS	100/0.22m									
18.7	End of Borehole						159							

+3, x5: Numbers refer to
Sensitivity

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



Ministry of
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Ontario

B. P. WALKER ASSOCIATES LIMITED
Consulting Geotechnical, Inspection and Testing Engineers
Project No. 2121.1

RECORD OF BOREHOLE No 13

METRIC

W P 150-87-01
150-87-02 LOCATION N 4 845 892.3; E 294 163.0 ORIGINATED BY LSR
DIST 6 HWY 407/427 BOREHOLE TYPE 100mm dia. Solid Stem Augering COMPILED BY LSR
DATUM Geodetic DATE 1987 - 10-30 CHECKED BY LM

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					
178.6	Ground Level													
0.0	0.40m Topsoil					seal								
	Silty Clay, some Sand		1	SS	33									
	trace Gravel		2	SS	40									
175.9	Hard brown Damp to Moist		3	SS	69									
2.7	Silty Sand, occasional coarse Sand lenses, trace Gravel		4	SS	88									
	very dense		5	SS	35/0.03m									
172.6	Brown Grey		6	SS	42/0.08m									
6.0	Silty Clay, some Sand trace Gravel, with Silt and Sand lenses, Glacial Till		7	SS	79	Piezometer								
			8	SS	90									
			9	SS	78									
169.3	Hard Grey Moist		10	SS	80									
9.3	Sand, trace Gravel, Very Dense Grey Wet													
168.4	Silty Clay, some Sand trace Gravel		11	SS	49									
10.2	Glacial Till		12	SS	100/0.25m									
	Hard Grey Damp to Moist		13	SS	60/0.05m									
	Water Seepage at 15m Boulders		14	SS	60/0.00m									
	occasional shale fragments		15	SS	100/0.08m									
160.2			16	SS	100/0.13m									
18.4	End of Borehole													
							159							

+3, x⁵: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE



Ministry of
Transportation and
Communications

B. P. WALKER ASSOCIATES LIMITED
Consulting Geotechnical, Inspection and Testing Engineers
Project No. 2121.1

RECORD OF BOREHOLE No 14

METRIC

W P 150-87-01
150-87-02 LOCATION N 4 845 896.7; E 294 176.5 ORIGINATED BY LSR
DIST 6 HWY 407/427 BOREHOLE TYPE 100mm dia. Solid Stem Augering COMPILED BY LSR
DATUM Geodetic DATE 1987 - 11 - 05 CHECKED BY LSR

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					
178.3	Ground Level																GR SA SI CL
0.0	0.5m Topsoil Silty Clay, some Sand Hard trace Gravel Stiff Glacial Moist Till		1	SS	30		177										
175.8	Brown		2	SS	8												
2.5	Silt, with Sand layers or lenses, trace Gravel		3	SS	12												
			4	SS	94		175										
	Very Dense Brown Damp		5	SS	100/0.16m												
			6	SS	100/0.08m		173										
	Boulders		7	SS	40/0.08m												
171.7	Silty Clay, some Sand trace Gravel, occasional more Sandy zones		8	SS	61		171										
6.6			9	SS	57												
	Glacial Till Gravel Lenses		10	SS	109		169										
	Hard Grey cobbles Brown		11	SS	72		167										
	Damp to Moist		12	SS	112												
	grey		13	SS	100/0.23m		165										
	frequent gravel lenses		14	SS	100/0.13m		163										
			15	SS	39/0.08m		161										
159.8			16	SS	48/0.03m												
18.5	End of Borehole																

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



Ministry of
Transportation and
Communications

B. P. WALKER ASSOCIATES LIMITED
Consulting Geotechnical, Inspection and Testing Engineers
Project No. 2121.1

RECORD OF BOREHOLE No 16

METRIC

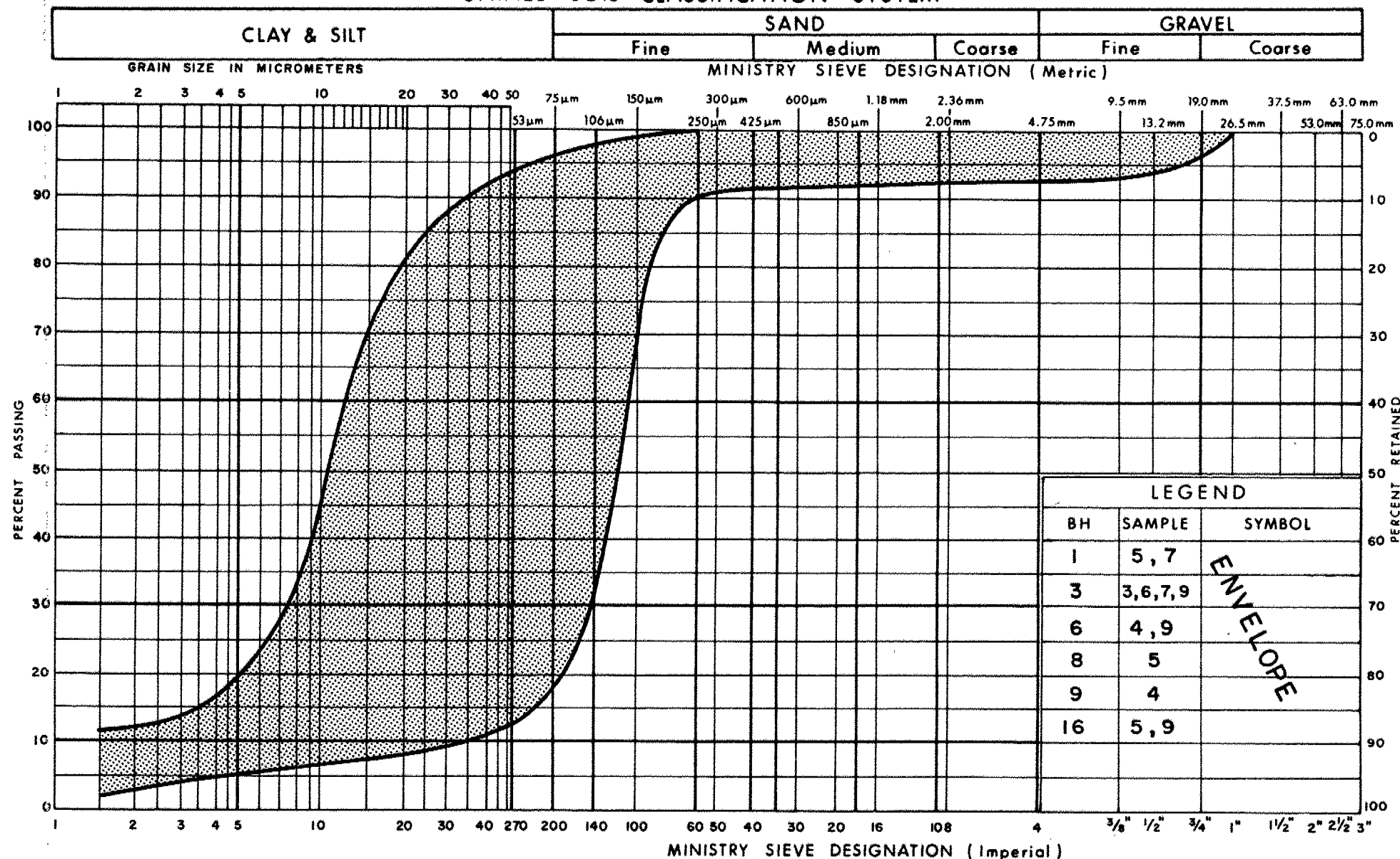
W P 150-87-01
150-87-02 LOCATION N 4 845 905.2; E 294 202.0 ORIGINATED BY LSR
DIST 6 HWY 407/427 BOREHOLE TYPE 100mm dia. Solid Stem Augering COMPILED BY LSR
DATUM Geodetic DATE 1987 - 10 - 30 & 31 and 11 - 02 CHECKED BY *WJL*

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				
177.7	Ground Level															
0.0	0.4m Topsoil Silty Clay, some Sand trace Gravel		1	SS	36		177									
	Glacial Till		2	SS	41											
			3	SS	85											
	Hard Brown Damp		4	SS	83/0	15m	175									
173.7																
4.0	Silt with Fine Sand lenses moist saturated		5	SS	86/0	15m	173									0 18 72 10
			6	SS	58/0	10m										
	Very Dense Brown		7	SS	80/0	15m	171									
			8	SS	100/0	22m										
			9	SS	100/0	19m										2 11 78 9
168.4							169									
9.3	Sandy, Silt, trace Gravel with Gravelly and Sandy lenses		10	SS	100/0	17m										
	Glacial Till		11	SS	100/0	23m	167									
			12	SS	100/0	13m	Piezometer 165									
	Grey		13	SS	100/0	10m										
	Very Dense Moist Traces of Shale Fragments		14	SS	100/0	14m	163									
			15	SS	100/0	14m	161									
159.2																
			16	SS	100/0	09m										
18.5	End of Borehole						159									

+3, x5: Numbers refer to
Sensitivity

20
15 ± 5 (%) STRAIN AT FAILURE
10

UNIFIED SOIL CLASSIFICATION SYSTEM



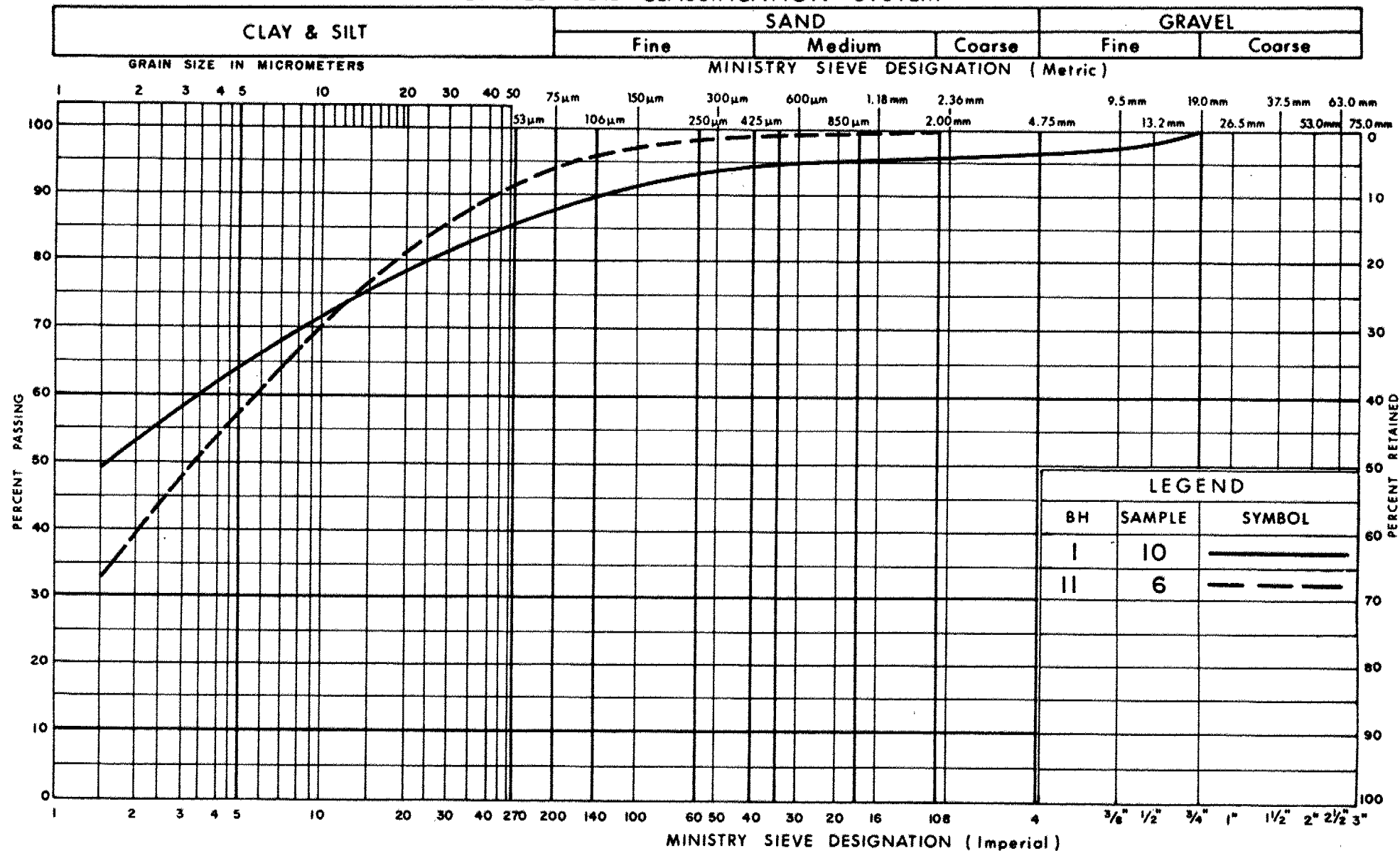
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Transportation

GRAIN SIZE DISTRIBUTION
SILT TO SANDY SILT with fine Sand layers
(layered deposit)

FIG No 1

W P 150-87-01/02

UNIFIED SOIL CLASSIFICATION SYSTEM

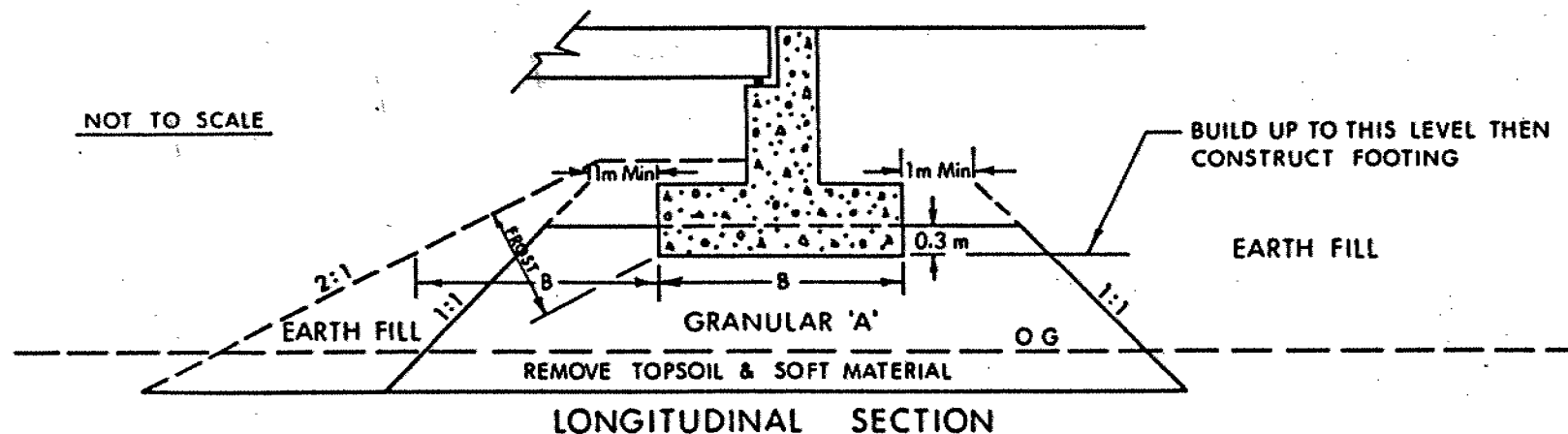
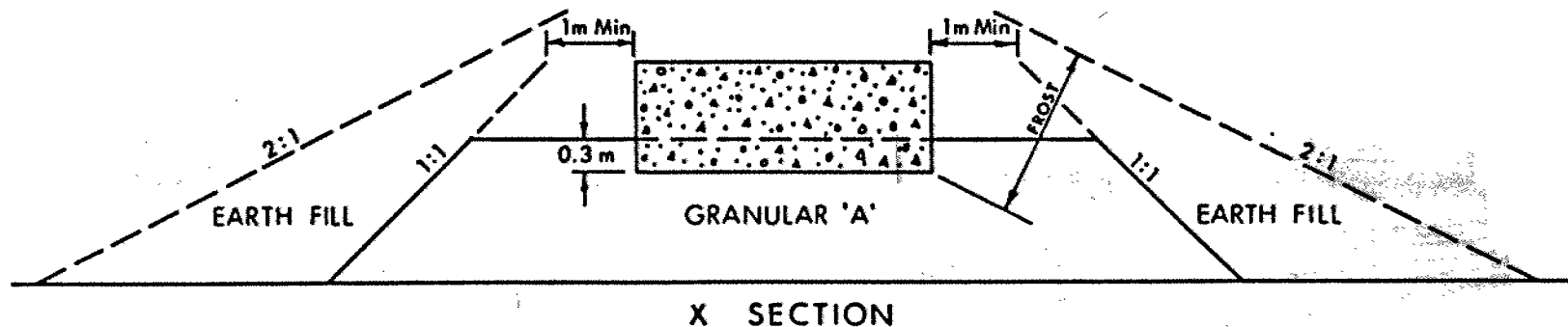


Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
CLAY, with Silt Laminations and Layers

FIG No 2

W P 150-87-01/02



NOTES:

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



Ontario

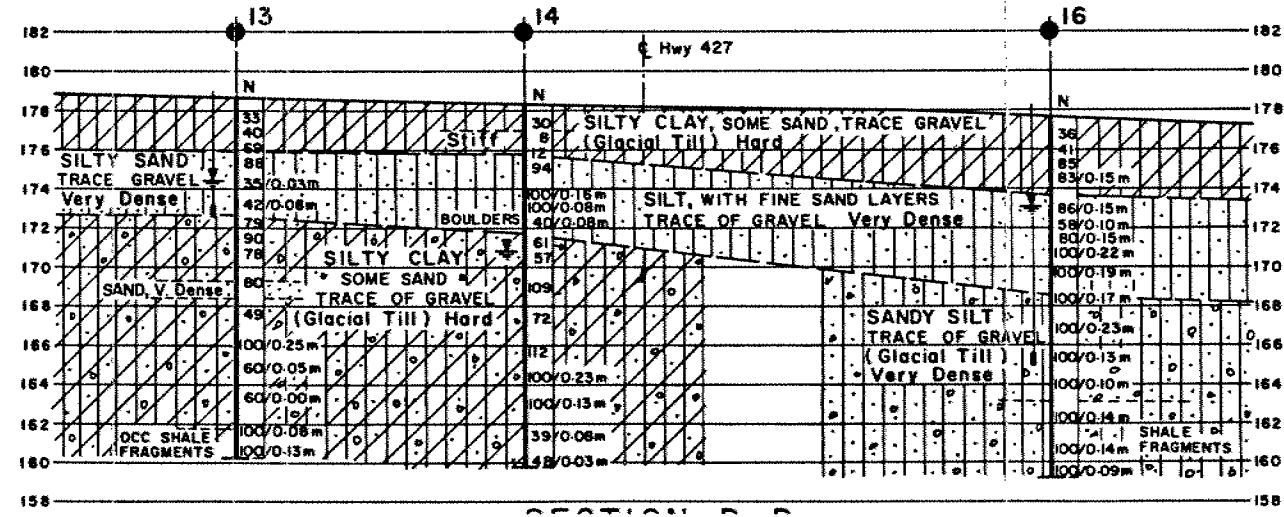
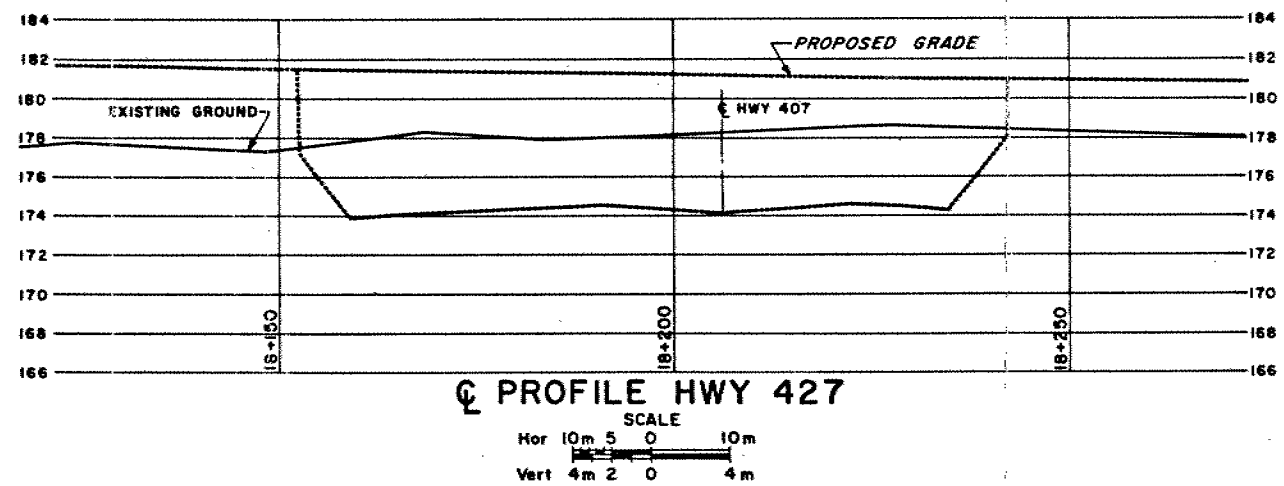
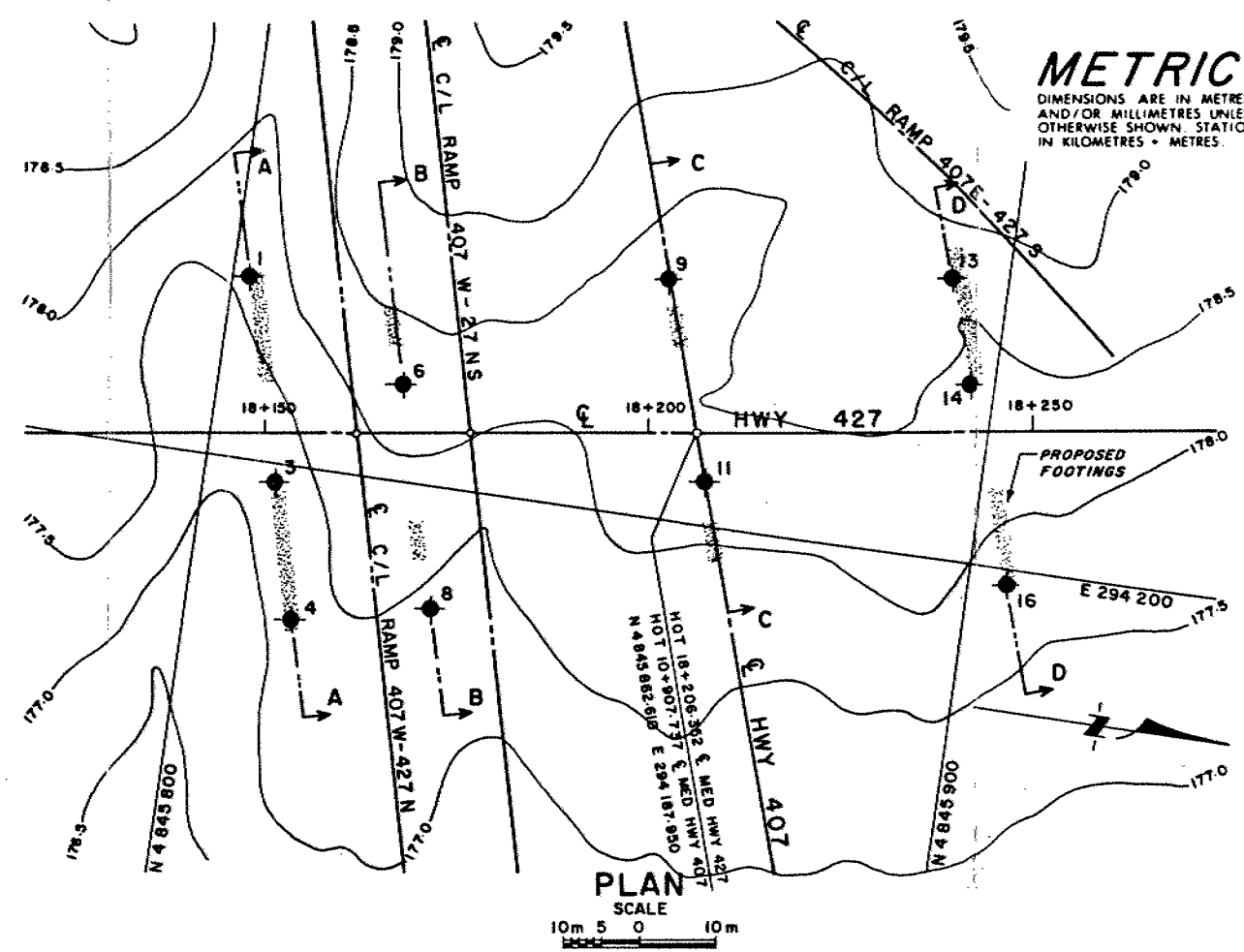
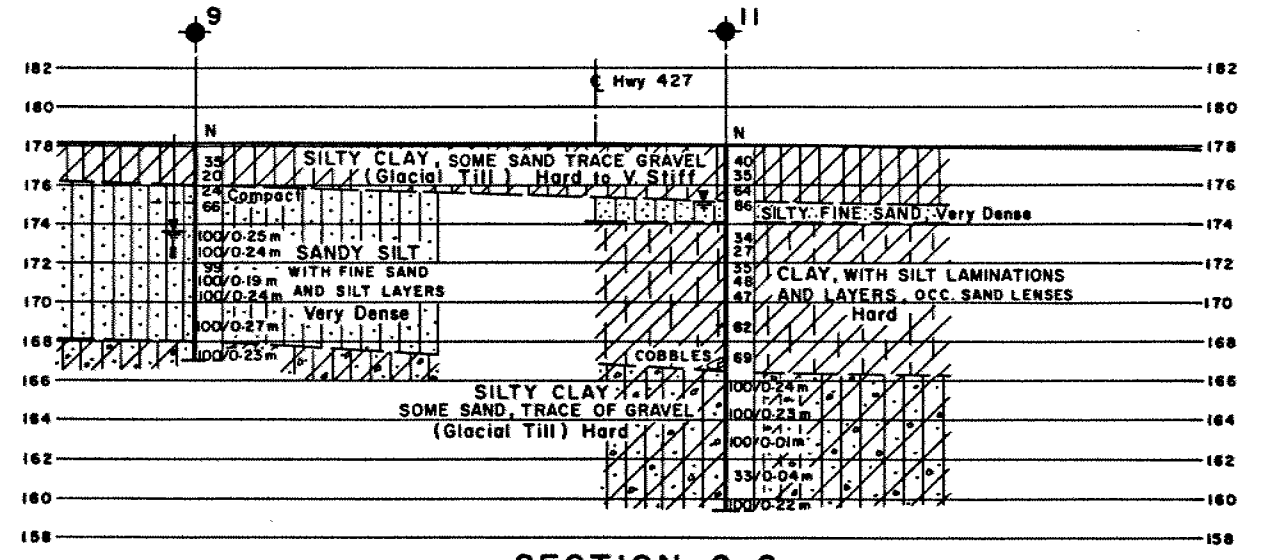
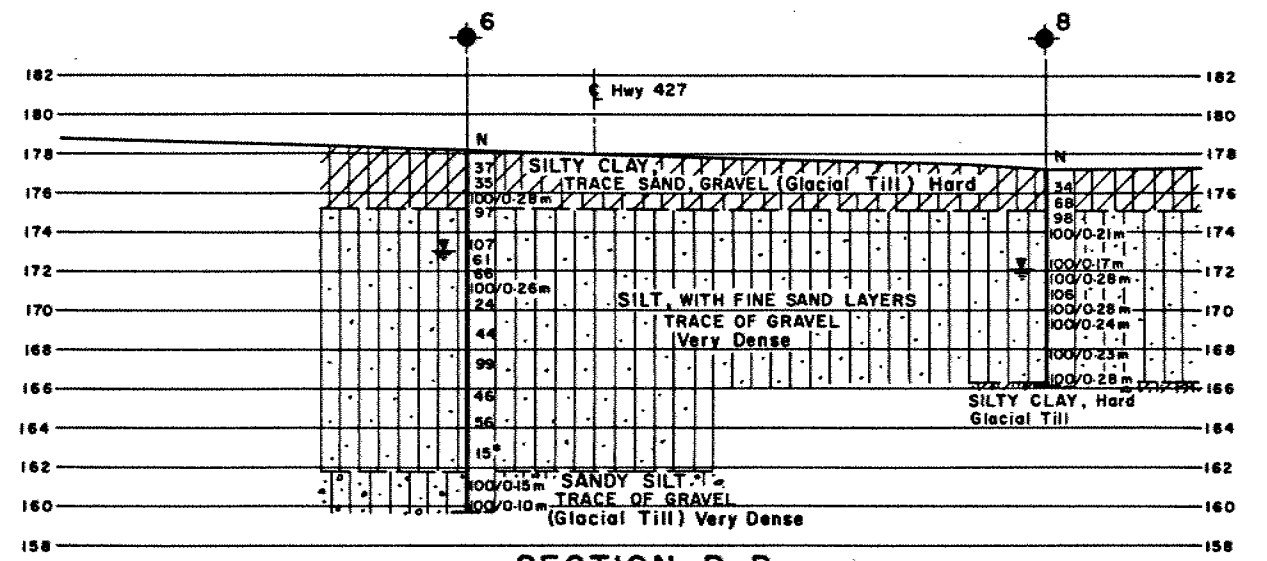
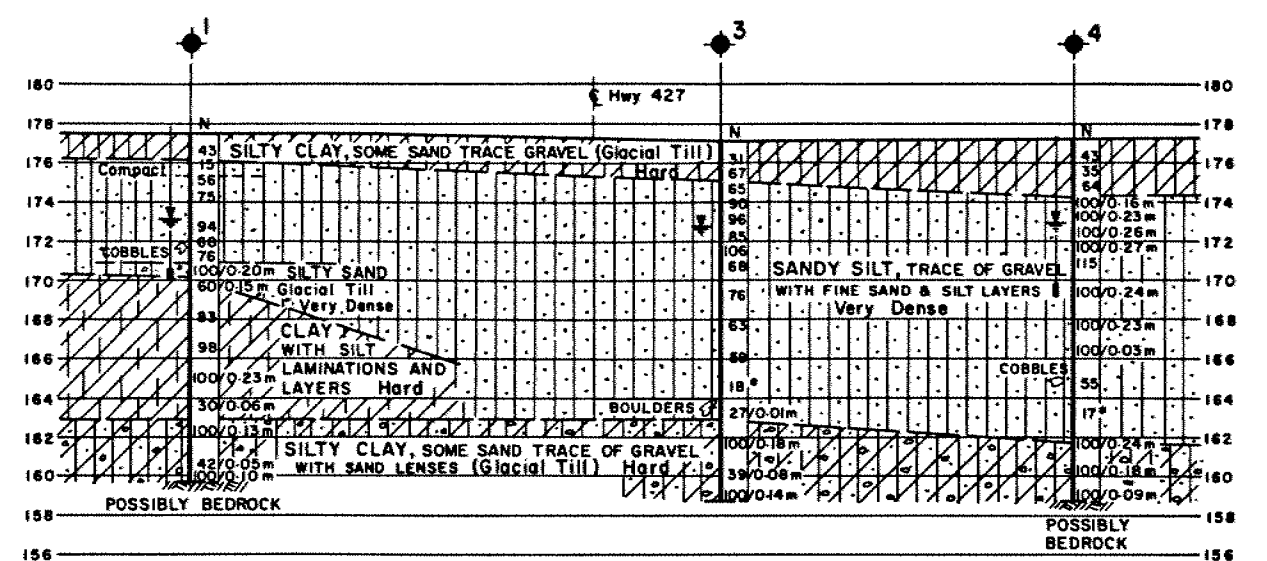
Ministry of
Transportation

**ABUTMENT ON COMPACTED FILL
SHOWING GRANULAR 'A' CORE**

FIG No 3

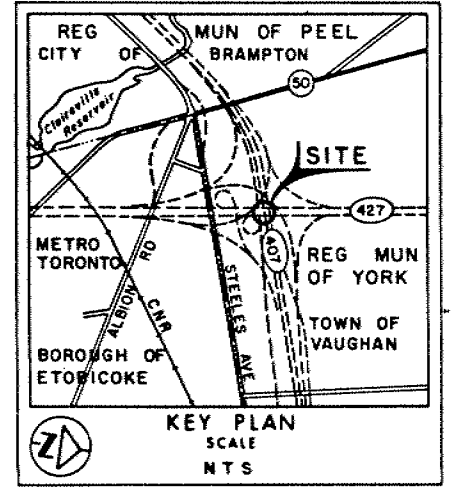
W P 150 - 87 -01/02

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO PH-D-207 42 04



CONT No
WP No 150-87-01/02
HWY 427 OVER HWY 407
BORE HOLE LOCATIONS & SOIL STRATA

B. P. Walker Associates Ltd.



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 B7 II
- W.L. in Piezometer
- Piezometer

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	177.5	4845 802.2	294 176.2
3	177.1	4845 809.4	294 202.5
4	177.1	4845 814.0	294 220.0
6	178.1	4845 824.2	294 187.0
8	177.2	4845 832.0	294 216.0
9	178.1	4845 856.7	294 168.5
11	178.1	4845 865.0	294 194.2
13	178.6	4845 892.3	294 163.0
14	178.3	4845 896.7	294 176.5
16	177.7	4845 905.2	294 202.0

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

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

REV	DATE	BY	DESCRIPTION

Geacres No 30M13-67
[HWY No 407 / 427] [DIST 6]

memorandum



235-3731

To: G. Al-Bazi
Design Engineer
Structural Office

Date: 88 12 06

Attention: I. Husain

From: Foundation Design Section
Room #315, Central Building

RE: Hwy. 427 N.B. and S.B. Overpass at Hwy 407
WP 150-87-01/02, Site 37-1167/8
Hwy. 427, District 6, Toronto

We have reviewed the final drawings and supporting documents for the above mentioned project. Our comments are as follows:

1. Excavations below the groundwater table will be required at the pier locations. A positive dewatering scheme will be required to prevent disturbance of the foundation soil. It has been suggested in the Foundation Report that oversize perimeter ditches and sump pumping may be sufficient. Alternatively, a well point system may be required. The high density of the soil may preclude the sheet pile option. In any case the contract should require that the prevailing groundwater elevation must be lowered a minimum of 0.5m below the base of the excavations and that the dewatering/excavation operations should not disturb the foundation soil.

If there are any questions, please advise.

DHD:st

A handwritten signature in black ink that reads "D. H. Dundas".

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

for

M. Devata, P.Eng.
Chief Foundation Engineer

memorandum



Tel; 235-3731

To: G. Al-Bazi
Design Engineer
Structural Office

Date: 1988 03 10

From: Foundation Design Office
Room 315, Central Bldg.

RE: General Arrangement Drawing Review
Hwy. 427 NB & SB O'passes at Hwy. 407
W.P. 150-87-01/02, Site 37-1167/8
District 6

The General Arrangement Drawing 37-1167/8-P1 has been reviewed by this office and the following foundation and geotechnical related comments are provided.

- 1) The north and south abutments appear to be perched at elevations 177.0 m and 176.4 m respectively in the surficial silty clay deposit (glacial till). This does not comply with the recommendations provided in the Foundation Investigation Report. However, it has been concluded from this office, that the footings can be "perched" in this deposit at the indicated elevations using the following bearing capacities:

Factored Bearing Capacity at U.L.S. = 525 KPa
Bearing Capacity at S.L.S. Type II = 350 KPa

In addition, any localized soft or weak zones are to be subexcavated and replaced with compacted granular "A" or mass concrete.

Alternatively, the abutments can be perched on compacted granular "A" Fill as recommended in the foundation investigation report.

- 2) There is no illustration of the proposed excavation cut scheme. The cut is of important significance because of two reasons:
 - 1) The slope gradient cannot exceed a 2H:IV ratio to ensure acceptable resistance to slope instability.
 - 2) The cut configuration will have a direct effect on the positioning of the abutment footings. The footings must be located beyond a 3 metre distance from the edge of the slope. This may affect the bridge structure span length.

- 3) The pier foundation elevations occur below the groundwater level. Consequently, an effective de-watering system will be required to lower the water table during construction. In view of the fact that the footing elevations do not exceed a depth of 1.5 metre below the groundwater level, the recommended perimeter drain system should be adequate in lowering the water level and preventing loosening of the founding stratum. The report should be referenced for details.

The above comments should be reviewed with deliberation. If any further information is required, please do not hesitate to contact this office.

Thank you.



T. Sangiuliano
Foundations Engineer

TS/mj

c.c. Mr. G. Burkhardt

memorandum



Tel: 3731

To: G.C.E. Burkhardt
Head, Structural Section
5000 Yonge Street

Date: 1988 02 03

From: Foundation Design Section
Room 315, Central Building

RE: Foundation Investigation for
Hwy. 407/427 Interchange
Hwy. 427 N.B.L./S.B.L. Over Hwy. 407
W.P. 150-87-01/02, Sites 37-1167/1168

B.P. Walker Associates Ltd., geotechnical consultants were retained by the Ministry to carry out a foundation investigation for the above-mentioned structure sites. Due to the urgency of this project, we submitted to you the preliminary recommendations on 87 11 27. We have now received the final report for this project and in general it appears to be satisfactory, however, we would like to offer the following comments:

The northbound structure south and north abutments could be founded on shallow foundations at a higher elevation 176.5 with slightly lower capacities as suggested below:

Factored Bearing Capacity at U.L.S.	500 kPa
Bearing Capacity at Serviceability	
Limit states Type II	350 kPa

Alternatively all the abutments for both the structures may be constructed on engineered fills consisting of well compacted Granular 'A' with the following capacities:

Factored Bearing Capacity at U.L.S.	900 kPa
Bearing Capacity S.L.S. Type II	350 kPa

Sliding resistance may be computed by assuming a frictional resistance of 0.57 between the underside of the footing and the Granular 'A' material. However, for footings constructed on natural subsoil, the sliding resistance may be computed by assuming a frictional value of 0.57 for footings founded on silt or fine sands, whereas an adhesion value of 150 kPa may be used for footings founded on cohesive subsoil of silty clay.

Backfill to abutments and any retaining walls should consist of Granular 'A' or Granular 'B' for which the following properties are recommended.

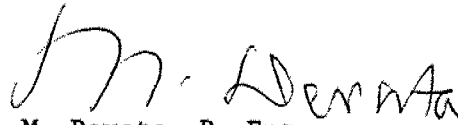
Granular 'A'	-	22.8 kN/m ³	=	35°	k _A = 0.27
Granular 'B'	-	21.2 kN/m ³	=	30°	k _A = 0.33

.....2

Lateral pressures should be computed in accordance with Section 6.6.1.2.1 of the O.H.B.D. code.

In order to ensure the overall stability of the cuts in the silt stratum, a toe sub-drain should be located some 1.2 m below the finished grade of the future ground.

We believe the enclosed foundation investigation report together with the aforementioned comments and the contents of our previous memorandum dated 88 11 27 will be adequate for your design requirements. Should you require additional details with regard to this project, please contact us.

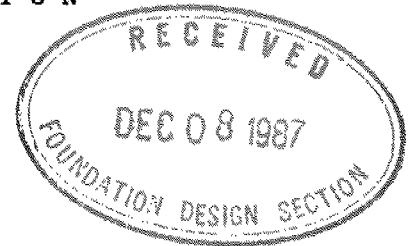

M. Devata, P. Eng.
Chief Foundations Engineer
(East)

MD/nmj

c.c. - R.D. Gunter
A. Wittenberg
J. Smrcka
K. Bassi
J.H. Peer
T. Yakutchuk
G. Szekreny

MINISTRY OF TRANSPORTATION

MEMORANDUM



TO: M. Devata
Chief Foundations Engineer - East
Foundation Design Section
Central Building
1201 Wilson Avenue

DATE: 1987-12-03

FROM: Structural Section
Central Region

RE: Foundation Investigation for
Hwy 407/427 Interchange
Hwy 427 NBL/SBL over Hwy 407
W.P. 150-87-01/02, Sites 37-1167/1168

With regard to the recently submitted Preliminary Foundation Investigation performed by B.P. Walker Associates Ltd., we have the following queries and comments.

- a) Since the abutments will be located partially up the 2:1 slope (perched), the underside of footing elevations will be approx. elev. 176 to 177. (This may have been unclear due to the exaggerated scales used on the profile of Hwy 427 sent to your previously.)

From our conversation yesterday, you suggested that it may be possible to subexcavate down to competent material (elev 174?) which is very close to existing ground (177 to 178.5) and place the abutment on compacted Granular 'A'. The resulting bearing capacities given in the Preliminary Foundation Report would then still be applicable. Please confirm this with elevations for subexcavation at your earliest convenience.

We also ask that you consider the alternatives of abutments on H-piles. We realize however, that depending on pile tip elevations, the H-pile alternative may result in short piles and be impractical.

- b) For structural considerations, we are considering moving the south abutments southerly by approximately 6 meters. This will be determined during the initial stages of final design when the preliminary General Arrangement is prepared, a copy

of which will be sent to you. Would additional borings be necessary or do you have enough additional information to avoid this? Please advise if the recommendations already given would still be applicable.

Thank you for your consideration of these matters.

D. F. Burkhardt

per

W.F. Young
Structural Engineer
for:
G.C.E. Burkhardt
Head, Structural Section

WFY/jlk

cc: K. Bassi
J. Klowak
B. Hurd (Cole Sherman)

memorandum



Tel: 3731

To: G.C.E. Burkhardt
Head, Structural Section
5000 Yonge Street

Date: 1987 11 27

Atten: W.F. Young

From: Foundation Design Section
Room 315, Central Building

RE: Foundation Investigation for
Hwy. 407/427 Interchange
Hwy. 427 N.B.L./S.B.L. Over Hwy. 407
W.P. 150-87-01/02, Sites 37-1167/1168

B.P. Walker Associates Ltd. have recently completed the fieldwork for the above-mentioned project. Due to the urgency of the project and as requested by you, we are herewith enclosing for your information and use, a summary of subsurface conditions together with complete foundation recommendations for the design and construction of the project. This will enable you to complete your design work without further delay. The complete foundation investigation and design report will be forwarded to you at a later date. However, if additional information is required, please contact this Office immediately. We would also like to offer the following comments:

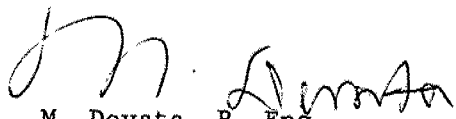
Backfill to abutments and any retaining walls should consist of Granular 'A' or Granular 'B' for which the following properties are recommended:

Granular 'A'	= 22.8 kN/m ³	= 35°	K _A = 0.27
Granular 'B'	= 21.2 kN/m ³	= 30°	K _A = 0.33

Lateral pressures should be computed in accordance with Section 6.6.1.2.1 of the code. Sliding resistance may be computed by assuming a frictional resistance of 0.57 between the underside of footings and the soil.

Excavations for footings carried out below the water level prevailing at the time of construction will require to be dewatered. Due to the relatively pervious nature of the sandy subsoil within the footing excavation a dewatering scheme will be necessary. It is desirable however, that the excavation for Hwy. 407 be completed prior to construction of the bridge in which case a more favourable groundwater regime will result.

Approach fills and cuts should be constructed with standard 2:1 side and forward slopes in which event in general, no major stability problems are anticipated.


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

MD/mmj

c.c. - K. Bassi
Encl.

B.P. Walker**Associates Ltd.****Consulting Geotechnical, Inspection and Testing Engineers****101 Amber Street, Suite 2, Markham, Ontario, L3R 3B2****(416)491-4075**November 16, 1987
Project No. 2121

Ministry of Transportation &
Communications
Foundation Design Section
Room 315, Central Building
1201 Wilson Avenue
Downsview, Ontario
M3M 1L8



ATTENTION: Mr. Devata, P.Eng.
Chief Foundations Engineer (East)

Re: Hwy 407/427 Interchange
W.P. 150-87-01
W.P. 150-87-02

Dear Sir:

We have drilled eight boreholes at the site as shown on the attached drawing. In accordance with your request we are herewith submitting our preliminary recommendation for designing the foundations of the above structures.

Hard clayey tills and saturated silty fine sands or sandy silts were encountered on the site. Based on the available soil data, in our opinion, the project structures can be supported on spread footings. Assuming a foundation base level at El. 170.50m, the load carrying capacity of the foundations can be calculated by using the following bearing pressure:

Factored Bearing Capacity
at Ultimate Limit States:

1000kPa

- 2 -

Due to the unyielding nature of the subsoils to which the footings will transmit the loads, settlements are anticipated to be negligibly small and need not be checked for the servicability condition (Ontario Highway Bridge Design Code, 1983 edition, Section 6, Articles 5.3.1 and 5.3.2.).

The ground water level is generally at El. 172±m across the site but occasionally perched water was encountered at El. 175m which is caused by the sandy soils underlain by clayey tills. At about 50% of the site, however, saturated sandy and silty soils are above and below the footing elevation which will necessitate some form of dewatering, possibly vacuum wellpoints. At present laboratory tests are in progress to determine the feasible methods to maintain the footing excavation dry during construction.

Yours very truly,

B. P. WALKER ASSOCIATES LTD.



L. S. Rolko, P.Eng.

