DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 31G-203

DIST. 9 REGION

W.P. No. 123-87-04

CONT. No. 94-50

W. O. No.

STR. SITE No. 3-554

HWY. No. 416

LOCATION Hwy 416 & Realigned Old Hwy 16 Underpass

No OF PAGES -

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

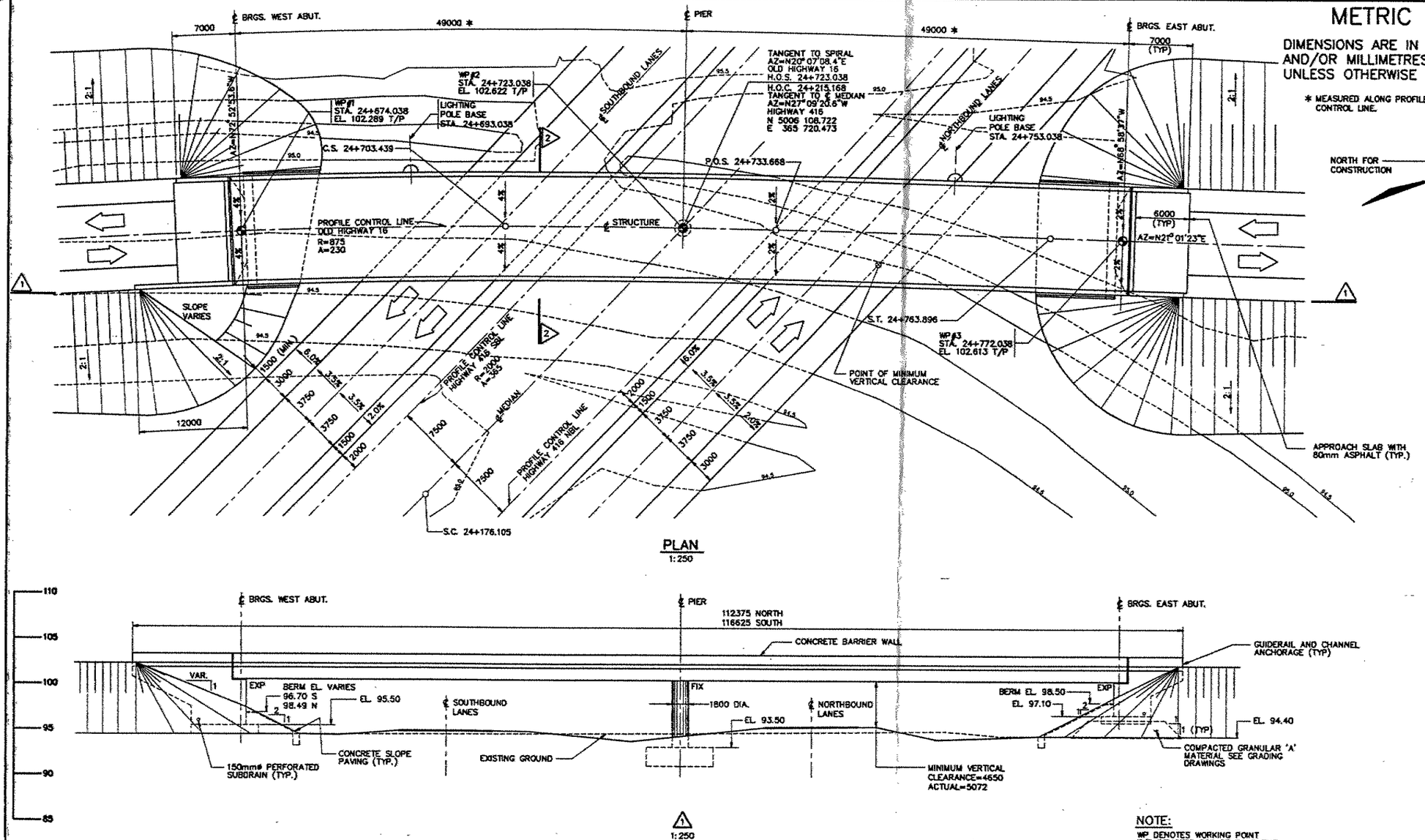
Ministry
of
Transportation
Ontario

FILE No. _____ **DATE** _____

REMARKS _____

Cont. 83-15 (WP 145-74-05)
(Mud Creek Bridge)

79-06



PLAN
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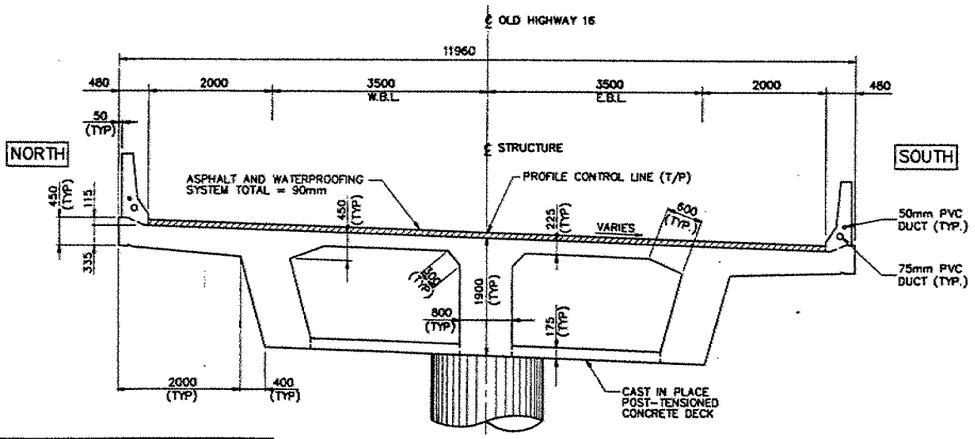
NOTE:
WP DENOTES WORKING POINT
T/P DENOTES TOP OF PAVEMENT



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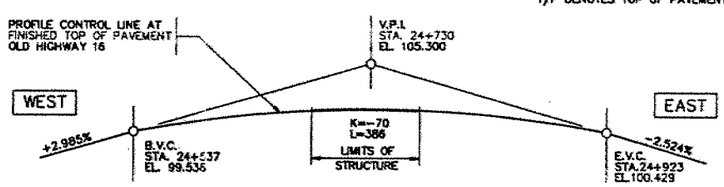
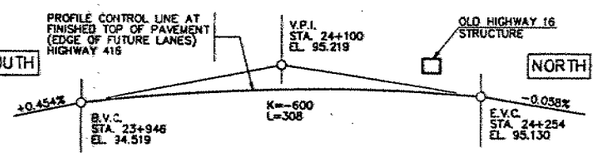


PROFILE OF OLD HIGHWAY 16
N.T.S.



PROFILE OF HIGHWAY 416
N.T.S.

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

GEODETIC DATUM BM ELEV. 94.137
NBW IN ROOT OF 0.15 ASH 22.61 RT 24+803.4

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

* MEASURED ALONG PROFILE CONTROL LINE.

DIST	No 9
CONT	No
WP	No 123-87-04

OLD HIGHWAY 16 UNDERPASS GENERAL ARRANGEMENT

SHEET

Sandwell

GENERAL NOTES:

CLASS OF CONCRETE	
DECK AND PIER COLUMNS	35 MPa
REMAINDER	30 MPa
CLEAR COVER TO REINFORCING STEEL	
FOOTINGS	100±25
ABUTMENTS AND WINGWALLS:	
FRONT FACE	80±20
BACK FACE	70±20
PIERS	80±20
DECK – TOP SLAB: TOP	70±20
BOT.	40±10
– BOT. SLAB: TOP	40±10
BOT.	50±10
– WEBS	60±10
REMAINDER	70±20

UNLESS OTHERWISE NOTED

REINFORCING STEEL
REINFORCING STEEL SHALL BE GRADE 400 UNLESS NOTED OTHERWISE. BAR MARKS WITH SUFFIX "C" DENOTES COATED BARS.

CONSTRUCTION NOTES
IF THE ACTUAL BEARING THICKNESSES ARE DIFFERENT FROM THOSE GIVEN IN THE BEARING DESIGN DATA, THE CONTRACTOR SHALL ADJUST THE BEARING SEAT ELEVATIONS AND THE REINFORCING STEEL TO SUIT.

LIST OF DRAWINGS

1. GENERAL ARRANGEMENT
2. BOREHOLE LOCATIONS AND SOIL STRATA
3. FOOTING LAYOUT
4. FOOTING AND PIER REINFORCING
5. WEST ABUTMENT
6. WEST ABUTMENT WINGWALLS
7. EAST ABUTMENT
8. EAST ABUTMENT WINGWALLS
9. DECK DETAILS
10. LONGITUDINAL TENDONS
11. TRANSVERSE TENDONS
12. DECK REINFORCING I
13. DECK REINFORCING II
14. DECK REINFORCING III
15. JOINT ANCHORAGE AND ARMOURING
16. BARRIER WALLS
17. 6000mm APPROACH SLAB
18. DETAILS OF CONCRETE SLOPE PAVING
19. AS CONSTRUCTED ELEVATIONS & DIMENSIONS
20. STANDARD DETAILS I
21. STANDARD DETAILS II
22. ELECTRICAL EMBEDDED WORK
23. QUANTITIES – STRUCTURES I
24. QUANTITIES – STRUCTURES II

REGISTERED PROFESSIONAL ENGINEER PROVINCE OF ONTARIO 92-02-14 D. J. REED

REGISTERED PROFESSIONAL ENGINEER PROVINCE OF ONTARIO 92-02-14 B.J.J. ELLIS

APPLICABLE STANDARD DRAWINGS

OD-3503 MINIMUM GRANULAR BACKFILL REQUIREMENTS

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN DJR	CHK B.E.	CODE OHBDC-83	LOAD CLASS A	DATE JAN. 1992	
DRAWN GVL	CHK DJR	SITE 03-554	STRUCT	SCHEME	DWG. 1

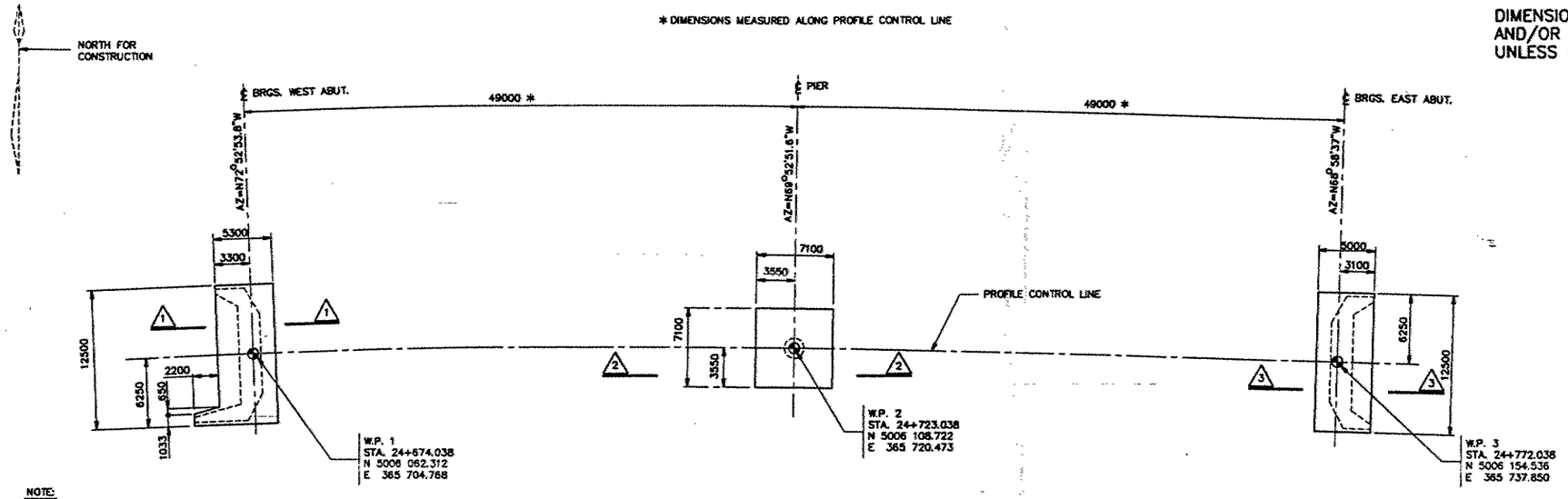
FEB 11, 1992

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No WP No 123-87-04	
OLD HIGHWAY 16 UNDERPASS FOOTING LAYOUT	SHEET

Sandwell



NOTE:
CONCRETE DIMENSIONS ARE MEASURED PARALLEL TO, OR AT RIGHT ANGLES TO, THE AZIMUTHS GIVEN FOR EACH FOOTING.

PLAN
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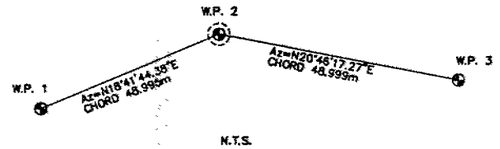

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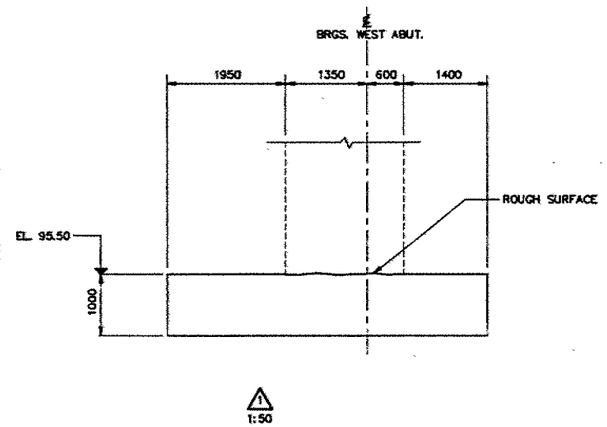

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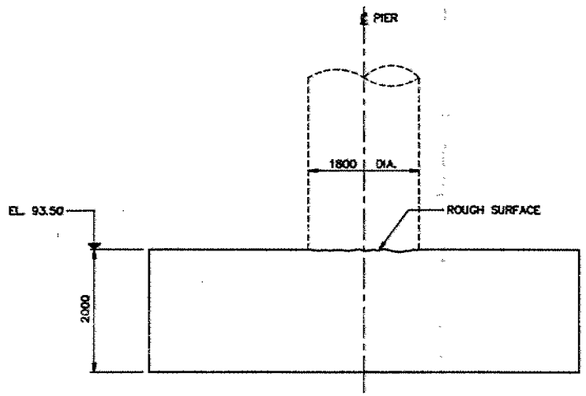

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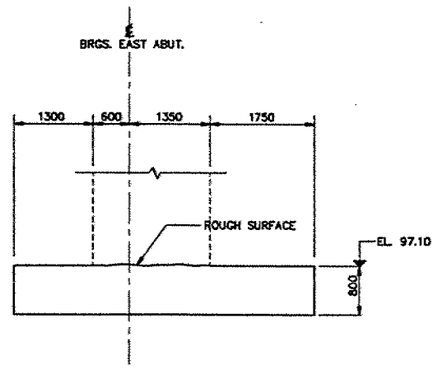

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REGISTERED PROFESSIONAL ENGINEER 92-02-14 D. J. REED PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER 92-02-14 B.J.J. ELLIS PROVINCE OF ONTARIO

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS			
DATE	BY	DESCRIPTION	
DESIGN DJL	CHK B.E.	CODE OHBDC-83	LOAD CLASS A DATE JAN. 1992
DRAWN GVL	CHK DJR	SITE 03-554 STRUCT	SCHEME DWG. 3

FEB 13/92

NOTES: DIMENSIONS ARE MEASURED PARALLEL TO, OR AT RIGHT ANGLES TO THE ℄ OF BEARINGS.
DIMENSIONS ARE SYMMETRICAL ABT. ℄ (UNLESS OTHERWISE NOTED).

METRIC

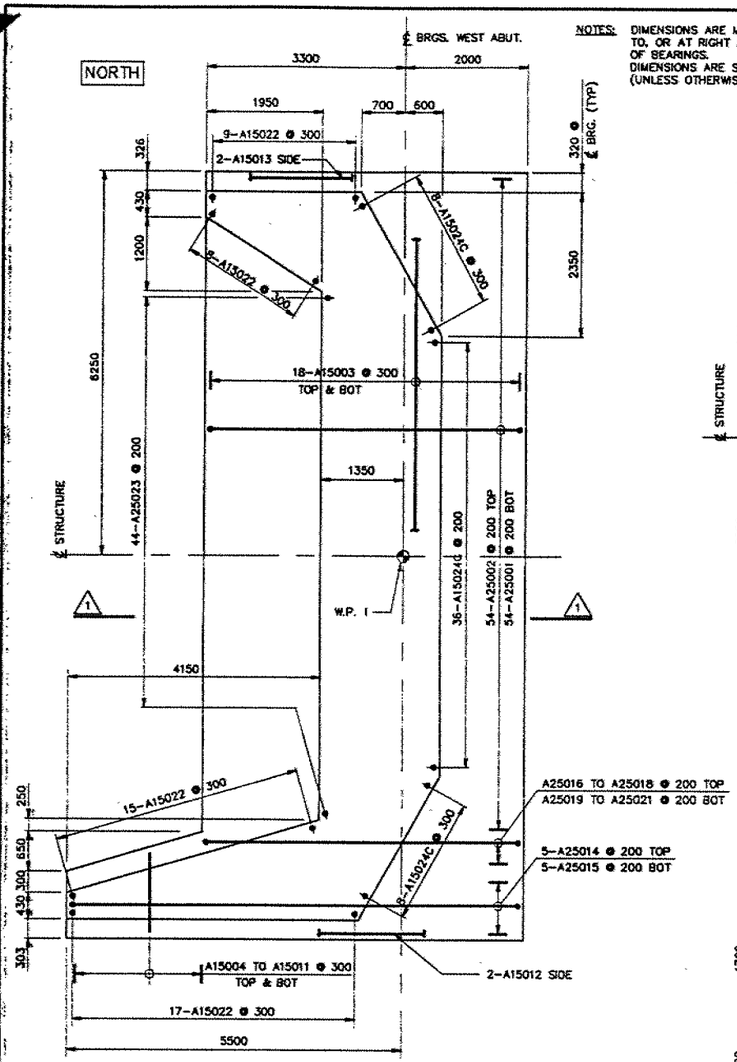
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
WP No 123-87-04

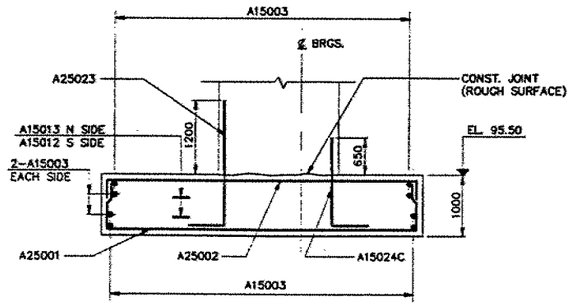
OLD HIGHWAY 16 UNDERPASS
FOOTING & PIER REINFORCING

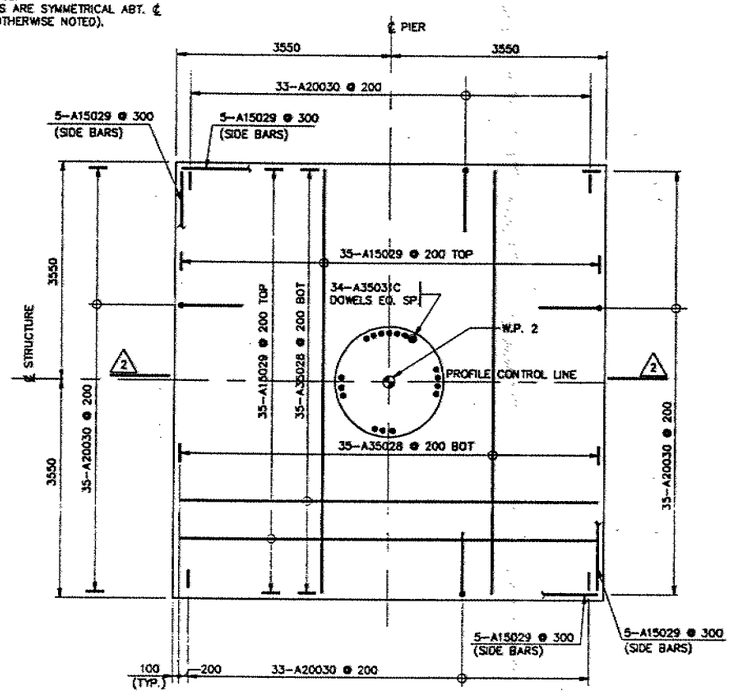
SHEET

Sandwell



WEST ABUTMENT FOOTING
SCALE 1:50





PIER FOOTING
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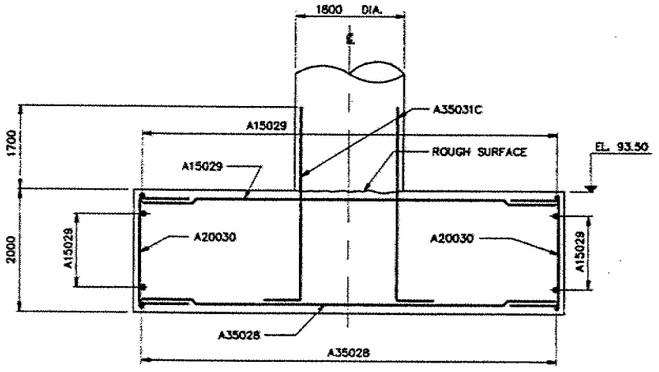

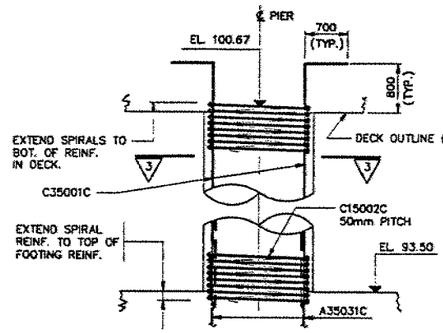

PIER
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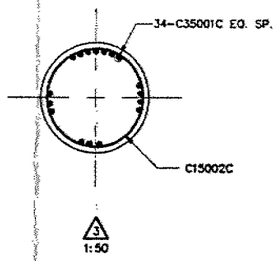
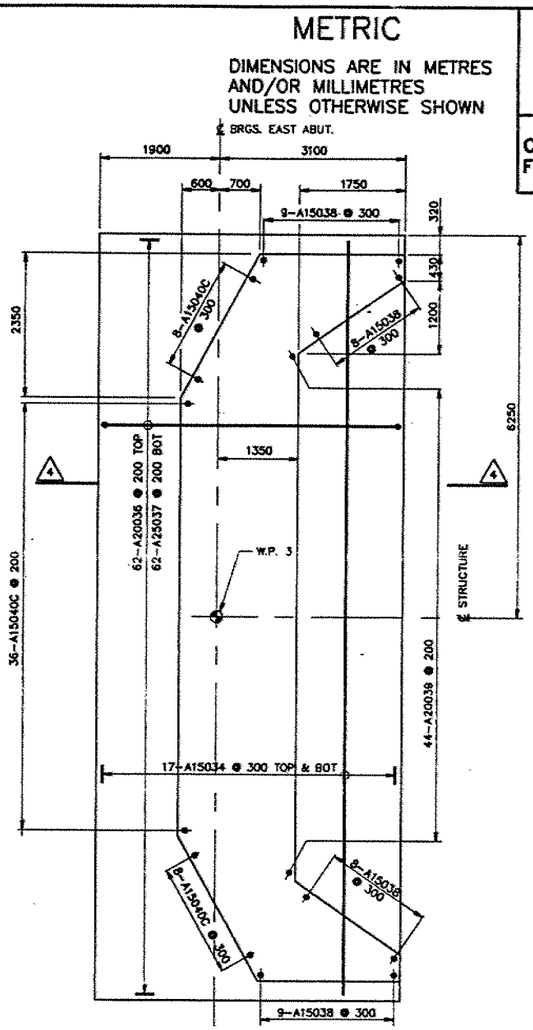
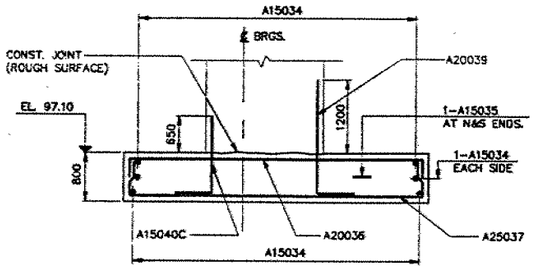




EAST ABUTMENT FOOTING
SCALE 1:50



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REVISIONS	DATE	BY	DESCRIPTION

DESIGN DJL	CHK DJL	CODE OHBDC-83	LOAD CLASS A	DATE JAN. 1992	
DRAWN GVL	CHK DJR	SITE 03-554	STRUCT	SCHEME	DWG. 4

FEB. 12, 1992

FILE COPY

Ministry
of
Transportation
Ontario

FOUNDATION DESIGN SECTION

foundation investigation and design report

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

CONT 94-50

WP 123-87-04 DIST 9

HWY 416 STR SITE 3-554

Hwy. 416 and Realigned Old Hwy. 16 Underpass
(at Century Road)

DISTRIBUTION

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GEOCRES 31G-203 DATE APR 25 1991

FOUNDATION INVESTIGATION REPORT

For

Hwy. 416 and Realigned Old Hwy. 16 Underpass

(at Century Road)

W.P. 123-87-04, Site 3-554

Hwy. 416, District 9, Ottawa

INTRODUCTION

This report summarizes the results of a foundation investigation conducted at the aforementioned site. The report describes the subsurface conditions at the site and includes recommendations pertaining to structure foundations and related earthworks.

SITE DESCRIPTION AND GEOLOGY

The site is located approximately 200 metres west of the existing Hwy. 16 - Century Road intersection in the City of Nepean, Regional Municipality of Ottawa-Carleton. The existing Century Road is a two lane paved roadway that intersects the site location and continues for some distance on either side of this intersection.

A residential dwelling with an asphaltic driveway entrance from Century Road is located immediately north of the site. The home has been landscaped with trees and low lying shrubs. A medium dense forested area is located immediately south of the site.

The terrain at the site is generally flat adjacent to the existing Century Road. The Century Road roadway is elevated approximately 1-1.5 metres higher than the adjacent terrain.

Physiographically, the site lies in the area known as the Ottawa Valley Clay Plains founded in the lowlands of the St. Lawrence. The native subsoil consists of clay plains interrupted by ridges of rock or sand. Bedrock at the site is of the Oxford Formation and consists of dolostone.

Th overburden was deposited during and immediately following the Wisconsinan glaciation approximately 12,000 years ago during the Pleistocene Epoch. At that

time, the area was depressed from the effect of the glaciation. Following the retreat of the glacier, the brackish waters of the Champlain Sea flooded the area and then gradually receded as the land rebounded with the deposition of sediments to its present level.

INVESTIGATION PROCEDURES

Soil and rock properties were obtained by in situ and laboratory testing conducted. The procedures employed are discussed below.

Field Investigation

The fieldwork for the investigation was carried out between 90 12 19 and 91 01 16 and consisted of five sampled boreholes. The boreholes were advanced to depths ranging from 4.0 to 12.0 metres below the existing ground surface which corresponds to elevations ranging from 90.1 m to 82.6 m.

Track mounted CME equipment employing continuous hollow stem augering and casing-washboring techniques was used to advance the boreholes in the overburden. Samples in the overburden were retrieved using a split spoon sampler driven in accordance with the Standard Penetration Test (ASTM D1586). Conventional rock coring methods were applied in penetrating cobbles and boulders present within the overburden and in sampling the bedrock at the site. A standard BX core barrel within BW casing was used in the coring of rock.

All samples retrieved in the overburden and all rock core samples were identified in the field and then returned to the laboratory for applicable testing.

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

Survey information related to the location and elevation of the boreholes was provided by the Eastern Region Surveys and Plans Office.

Laboratory Analysis

To identify the behaviour and gradation of the overburden and to determine the physical index properties of the rock, some laboratory testing was performed. These tests included:

1) Atterberg Limit Tests
2) Grain Size Distributions
3) Natural Moisture Contents
4) Rock Core Logging

Laboratory test results have been summarized in the subsequent section of this report entitled "Subsurface Conditions" and are illustrated on corresponding figures and boreholes included in the attached Appendix.

SUBSURFACE CONDITIONS

General

The natural ground surface at the site is generally flat and has an elevation varying from 94.1 m to 95.1 m. The subsurface conditions are uniform across the site and consists of a cohesionless deposit comprised of a heterogeneous mixture of silt, sand, gravel, cobbles and boulders that extends to bedrock. Bedrock, consisting of a dolostone with interbedded shale was confirmed at one location of the site (BH 26-3) at a depth of 10.4 metres or equivalently at an elevation of 84.2 metres.

The boundaries between the soil and rock types, in situ and laboratory test results as well as groundwater levels established at the time of investigation, are shown on the attached Record of Borehole sheets in the Appendix. A plan of the site illustrating the locations and elevations of the boreholes and a subsoil stratigraphical section is provided on Dwg. No. 1238704-A.

A detailed description of the subsurface conditions encountered is given below.

Heterogeneous Mixture of Silt, Sand, Gravel, Cobbles and Boulders (Glacial Till)

The surficial deposit at the site consists of a heterogeneous mixture of silt, sand, gravel, cobbles and boulders. This deposit which is of a glacial till origin was explored to a maximum thickness of 10.4 metres at which depth the underlying bedrock was encountered. A grain size distribution envelope illustrating the gradation of the deposit smaller than 75 mm is illustrated in Figure 1 in the Appendix. The envelope illustrates the wide range of grain sizes that are typical of glacial till deposits. Cobbles and boulders, however, are also present within the deposit, as verified by rock core samples retrieved in the deposit and inferred by auger refusal encountered within the deposit. The cobbles and boulders are present throughout the deposit.

The deposit is unsorted and unstratified which is characteristic of glacial till deposits. The deposit has been oxidized for depths ranging from 2.1 metres to 5.5 metres below the natural ground surface and hence is brown in colour within this depth. The deposit is unoxidized and grey in colour below this depth.

Although this deposit is a coarse grained material as defined by the MTO soil classification system (greater than 50% of the material coarser than 75 micrometers), Atterberg Limit tests were carried out to evaluate the behaviour of the fine grained portion of the deposit. The results revealed that the fine grained material, which is comprised primarily of silt with only minor traces of clay, varies from a non-plastic silt to a silt of low plasticity. Plasticity indices (Ip), as illustrated on the indivdual Record of Borehole sheets, were generally less than 3%.

Standard Penetration tests carried out in this deposit revealed 'N' values ranging from 26 blows/0.3 m to 100 blows/.08 m indicating a denseness ranging from compact to very dense. However, a correction of the lower values due to disturbance created by unbalanced hydrostatic head during the sampling process and a correction for the higher 'N' values due to the gravel, cobble and boulder sizes limits this range of denseness from probable dense to very dense.

Bedrock

The surficial heterogeneous mixture of silt, sand, gravel, cobbles and boulders is underlain by dolostone bedrock of the Oxford Formation. The bedrock surface as identified at BH 26-3 by retrieving approximately 1.6 metres of BX core, exists at a depth of 10.4 metres below the ground surface or equivalently an elevation of 84.2 metres.

The dolostone bedrock is light in colour and contains dark grey shale interbeds up to 7 cm in thickness. The bedrock is generally unweathered to only slightly weathered and has moderately close to extremely close spaced fractures. The fractures are flat, planar to undulating and smooth in texture.

Core recoveries and Rock Quality Designations (RQD) were determined in situ and also in the laboratory to evaluate the competence and integrity of the rock. Recovery was 100% and the rock quality designation of the core was 75%. Based on these results and visual examination, the dolostone rock can be described as sound, good and medium strong with weak interbeds of shale.

A summary of core recoveries and descriptions is included on the Table entitled "Rock Core Description" in the Appendix.

Groundwater Conditions

Observation of the groundwater level was carried out by measuring the water level in the open boreholes. Groundwater levels determined at the time of the invesigation ranged from 1.5 metres to 3 metres below the natural ground surface, equivalent to elevations of 92.6 metres to 91.9 metres.

Groundwater levels, in general, are subject to seasonal fluctuations and hence can vary from the values given in this report.

DISCUSSION AND RECOMMENDATIONS

It is proposed to construct a two span structure (51 m-47.5 m) that will carry the proposed realigned old Hwy. 16 over the proposed Hwy. 416. The proposed structure has a width of 12 metres comprised of two roadway traffic lanes and adjoining shoulders. The proposed Hwy. 416 is a four lane median divided highway.

The proposed profile grade for the structure is approximately 101± metres and the proposed Hwy. 416 grade is approximately 94.5 to 95.0 metres which corresponds to the existing ground surface elevation. Consequently, approach fills in the order of 6 to 6.5 metres will be required at the approaches to the structure.

A plan illustrating the proposed structure and profile grade is illustrated on Dwg. No. 1238704-A in the Appendix.

To faciliate the design and construction of the proposed structure foundations and related earthworks, the following foundation and geotechnical recommendations have been provided in the scope of this report.

1) Structure Foundations
2) Reinforced Earth Abutment/Retaining Walls
3) Approach Embankments
4) Construction Considerations

STRUCTURE FOUNDATIONS

In view of the competent nature of the surficial material at the site, all foundations can be founded on conventional spread footings. Structure foundations can be founded on the native soil but major consideration should be given to "open-type" abutments supported on a well-compacted Granular 'A' pad. This option would eliminate dewatering at the abutment foundation location which will be required as discussed in the "Construction Considerations" section of this report.

Deep foundation units are not considered on economically feasible alternative at the site because of difficulty anticipated as a result of installation impediment caused by the presence of the numerous cobbles and boulders in the overburden at the site.

The most economical and technical feasible shallow foundation alternative or combination thereof shall be selected.

Compacted Granular 'A' Pad

"Open-type" abutments can be founded on a well compacted granular 'A' pad as illustrated in Figure 2 in the Appendix. The granular pad shall be constructed to a minimum 1 metre edge distance from the top of the footing to the crest of the pad and with 1H:1V slopes. All footings must be protected against frost penetration and consequently a 1.8 m earth cover or equivalent frost penetration is required. All loosened and/or organic material shall be subexcavated prior to the granular pad placement. For purposes of the O.H.B.D.C. and for the conditions described above, the bearing capacities tabulated in Table 1 below can be used in the foundation design.

Table 1 - Perched Abutment on Granular Pad

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

Settlement of the granular pad foundation as a result of the applied footing pressure will be elastic in nature and consequently is expected to take place during or immediately following the construction period. The magnitude of this settlement is anticipated to be within 25 mm, provided the granular material is not loosened by construction or related activities.

The Granular 'A' material must be placed and compacted to achieve 100% of the Proctor maximum dry density as outlined in OPSS 501.08.02 (Method A). Quality control in the form of material inspection and field density measurements shall be conducted.

Reduction for the inclination of loading on the shallow foundation shall be carried out in accordance with Section 6.7.3.3.5 of the O.H.B.D.C.

The computation of the sliding resistance of the foundation shall be computed in accordance with Section 6-7.3.3.2 of the O.H.B.D.C. An unfactored friction angle of 35° can be used between the concrete footing and the Granular 'A' material.

Spread Footings on Native Soil

Should the abutments be designed as "closed-type" abutments, it is recommended that abutment foundations be founded directly on the surface of the surficial heterogeneous mixture of silt, sand, gravel, cobbles and boulders provided the frost penetration depth criteria of 1.8 metres depth is satisfied and any deleterious material at the surface is removed. Pier foundations can be founded within the native soil below the frost penetration. For purposes of the O.H.B.D.C., the bearing capacities as tabulated in Table 2 below are recommended. Bearing capacities are based on an assumed footing width of 4 metres.

Table 2 - Spread Footings on Native Soil

Structure	Factored Capacity at U.L.S. (kN)	Bearing Capacity at S.L.S. Type II (kN)
Abutments	1000	450
Piers	1000	450

The magnitude of settlement as a result of the applied pressures tabulated in Table 2 is expected to be within 25 mm provided that the founding soil is not loosened by construction or related activities and any deleterious material is removed. It is recommended that a working slab comprised of granular material or mass concrete be placed to preserve the founding soil against construction disturbances and also against the elements of weathering.

Bearing capacity reduction to account for the inclination of loading on the shallow foundation shall be carried out in accordance with Section 6.7.3.3.5 of the O.H.B.D.C., using a granular soil and the appropriate depth/width (D/B) ratio.

The computation of the sliding resistance of the foundation soil shall be computed in accordance with Section 6-7.3.3.2 of the O.H.B.D.C. An unfactored friction angle of 35° can be used between the concrete footing and the native soil. If additional sliding resistance is required, consideration can be given to employing shear keys beneath the footing. The passive resistance developed by the shear key can be computed using the aforementioned unfactored friction angle of 35° and a unit weight of 20 kN/m^3.

A dewatering scheme will be equired to facilitate the construction of the shallow foundations beneath the prevailing groundwater table. A proposed dewatering method has been given in the "Construction Considerations" section of this report (see page 11).

Reinforced Earth Abutments/Retaining Walls

Reinforced earth abutment and/or retaining walls are considered a technically feasible alternative at the site. The reinforced earth structure can be founded on the compacted Granular 'A' pad or on the native soil as previously discussed. It is recommended that a non-standard special provision that specifies the materials and construction of the reinforced earth walls be included in the contract documents.

APPROACH EMBANKMENTS

Approach fills in the order of magnitude of 6 to 6.5 metres will be required for structure approach embankments. Discussion of the lateral earth pressures on the structure, stability, settlement and construction of the approach embankments are provided below.

Lateral Earth Pressure on Structure

Free draining material such as Granular 'A' or Granular 'B' shall be used within a wedge behind the abutments and retaining walls bounded by a plane rising at 60° to the horizontal as shown in Figure 6-9.6.1 of the O.H.B.D.C. The application of granular material combined with weep holes in the abutment walls to drain any accumulation of water in the backfill will prevent hydrostatic pressure build-up. Design parameters of the soil are given in Table 3 below.

Table 3 - Backfill Properties

	Granular 'A'	Granular 'B'
Angle of Internal Friction (ϕ) (unfactored)	35°	30°
Unit Weight (kN/m^3)	22.8	21.2
*Coefficient of Active Earth Pressure (Ka)		
- S.L.S.	0.27	0.33
- U.L.S.	0.33	0.4
*Coefficient of Earth Pressure at Rest (Ko)		
- S.L.S.	0.43	0.5
- U.L.S.	0.5	0.58

*These earth pressure coefficients apply to horizontal backfill surfaces only. The appropriate consideration shall be given to account for sloping backfill.

Stability/Settlement

No deep-seated or surficial stability problems are anticipated for the proposed embankment fill heights both in the forward and transverse direction for slopes constructed at 2H:1V. The exposed slopes should be protected from erosional forces by providing an effective erosion control protection scheme.

Settlements in the order of magnitude of 35 mm are expected at the approaches due to the elastic compression of the native soil and settlement within the fills under its own weight. It is predicted that the majority of the settlements will be realized during or immediately following the construction of the embankment.

Embankment Construction

In the construction of the embankment fills, all loosened and/or organic material should be excavated for their full depth within the plan limits prior to fill placement.

Embankment fills shall be placed and compacted as specified in OPSS 206.07.07 and OPSS 501 series.

Heavy compaction equipment should not be used behind the abutment/retaining walls within a lateral distance equal to the current height of fill above the wall footing in order to avoid imposing damage or deflection to the wall during the fill placement.

CONSTRUCTION CONSIDERATIONS

Dewatering

A dewatering scheme will be required to facilitate the construction of foundations within the heterogeneous mixture of silt, sand, gravel, cobbles and boulders submerged below the prevailing groundwater table. The groundwater table at the time of the investigation revealed depths approximately equal to the frost penetration depth. However, as stated in the factual part of this report ("Groundwater Conditions") groundwater levels are subject to seasonal fluctuations.

Consequently, it is recommended that the excavation for structure foundations within the surficial heterogeneous mixture of silt, sand, gravel, cobbles and boulders be carried out within an oversized excavation that will enable gravity drainage. An illustration of this scheme is provided on Figure 3 in the Appendix. The system includes perimeter drainage ditches in collaboration with discharge sump pumps.

Staging the excavation from the centre of the proposed cut and progressing laterally to either excavation slope is recommended such that any soil sloughing of cut slopes created by seepage are effectively contained with the limits of

the excavation. Soil migration from the slopes of the final excavation geometry and from the pile cap foundation must be controlled during the construction of the deep foundation units. A properly designed soil and/or geotextile filter can be placed on the excavated slopes to achieve the retention of soil migration. Temporary side slopes should not be steeper than 2H:1V.

The contractor shall be prepared to excavate any boulders or cobbles that exist within the surficial till deposit at the site.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano and M. Michalek, Foundation Engineers, and F. Tannous, Engineer Trainee, utilizing equipment owned and operated by Johnston Drilling Ltd. and Marathon Drilling Ltd. Logging of rock core in the laboratory was carried out by D. Williams, Petrographer.

The project was carried out by T. Sangiuliano under the general supervision of Dr. B. Iyer, Senior Foundation Engineer. The report was written by T. Sangiuliano, reviewed by Dr. B. Iyer and approved by Mr. M.S. Devata, Chief Foundation Engineer.

T. Sangiuliano, P.Eng.
Foundation Engineer

LICENSED PROFESSIONAL ENGINEER
A. J. Sangiuliano
PROVINCE OF ONTARIO

M.S. Devata, P.Eng.
Chief Foundation Engineer

APPENDIX

EXPLANATION OF TERMS USED IN REPORT

N VALUE THE STANDARD PENETRATION TEST (S.P.T.) 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 $\tilde{N}$.

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 S.P.T. 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 (R.Q.D.), 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

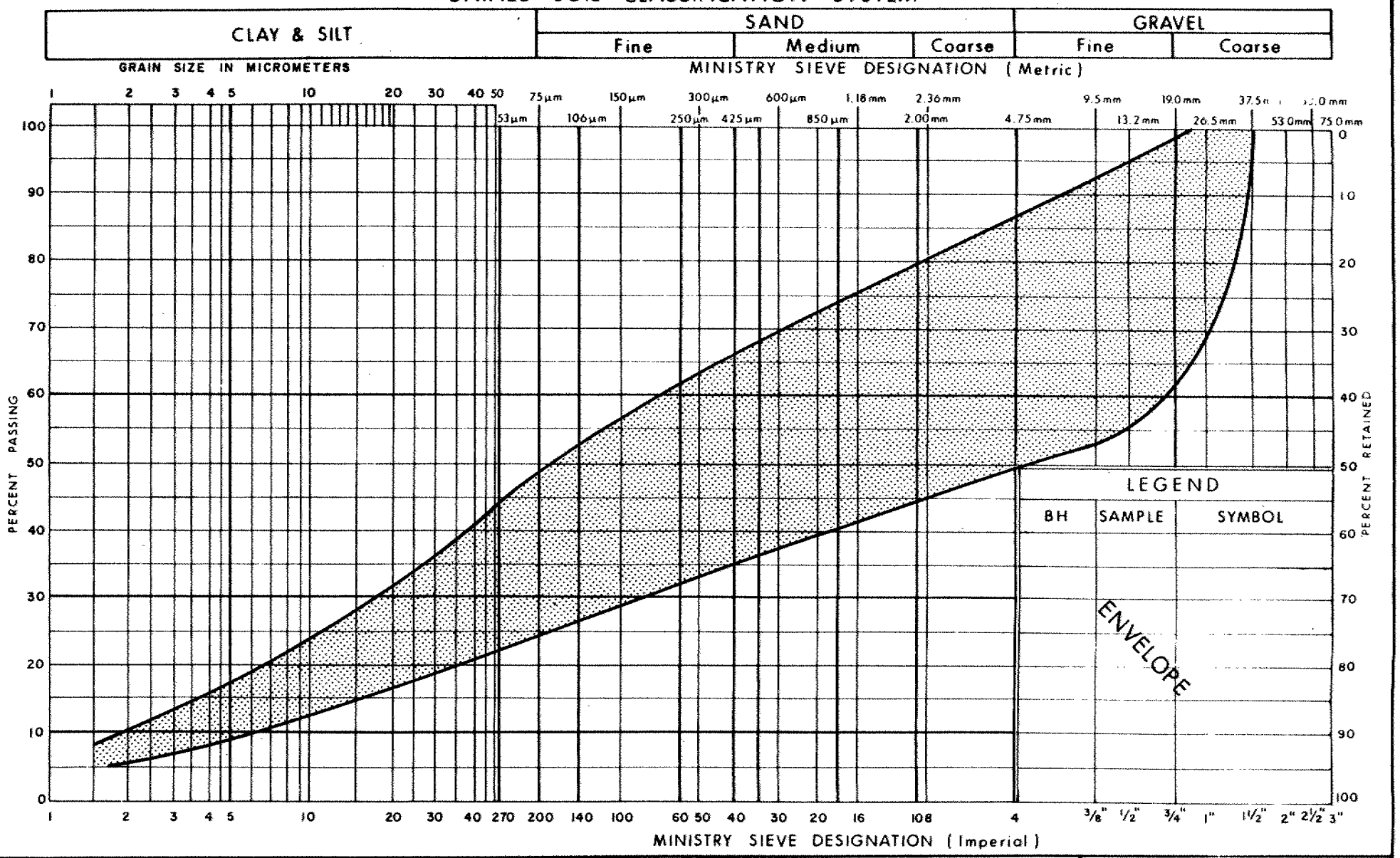
m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE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

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL

e	1, %	VOID RATIO
n	1, %	POROSITY
w	1, %	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_p	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_p	%	PLASTICITY INDEX = $w_L - w_p$
I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
e_{max}	1, %	VOID RATIO IN LOOSEST STATE
e_{min}	1, %	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

UNIFIED SOIL CLASSIFICATION SYSTEM



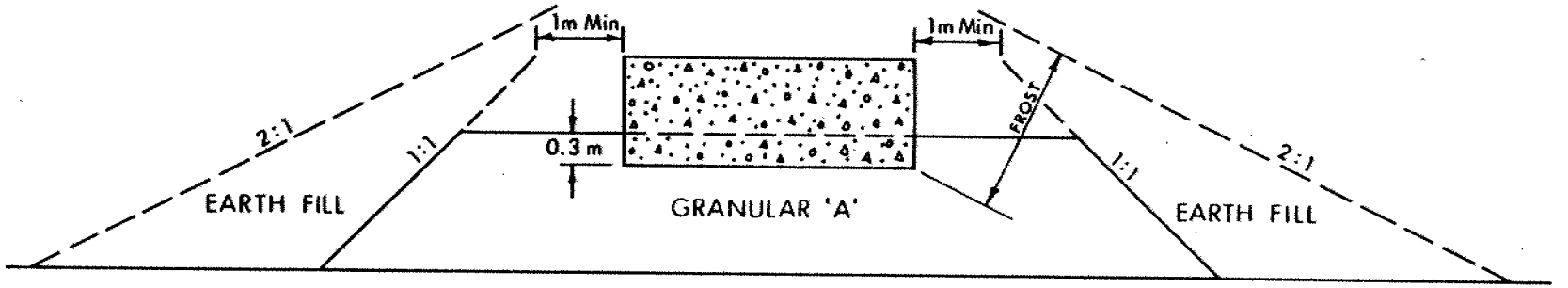
Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

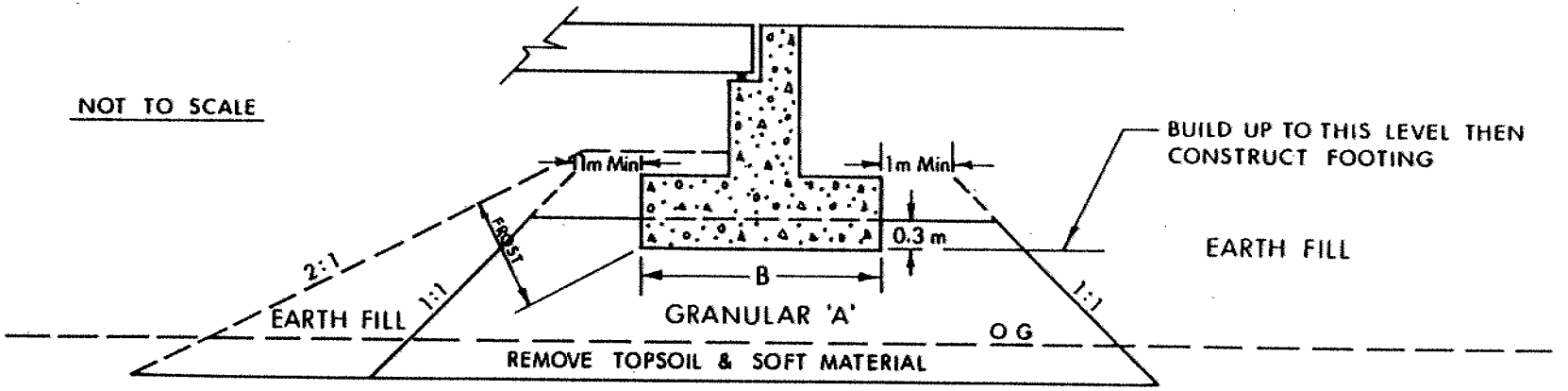
HETEROGENEOUS MIXTURE OF SILT, SAND, GRAVEL, COBBLES & BOULDERS

FIG No 1

W P 123-87-04



X SECTION



LONGITUDINAL SECTION

NOTES:

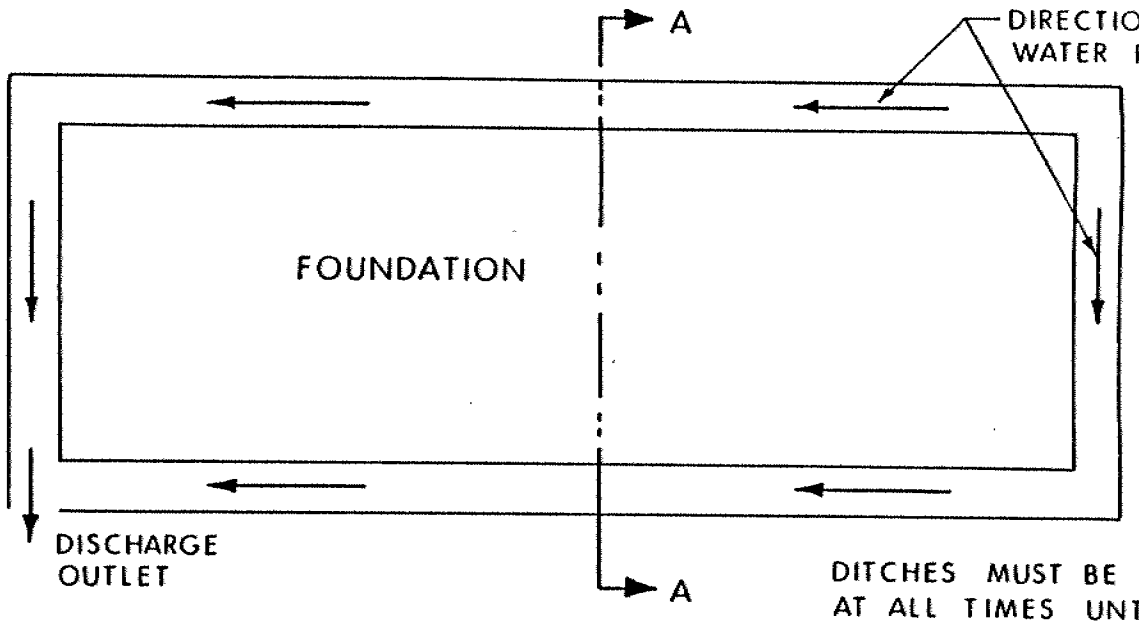
1 - REMOVE TOPSOIL &/OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' & EARTH FILL.

2 - PLACE GRANULAR 'A' & EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO CURRENT M T O STANDARDS.

3 - CONSTRUCT CONCRETE FOOTING.

4 - PLACE REMAINDER OF GRANULAR 'A' & EARTH FILL AS REQUIRED.

Ministry of Transportation Ontario	ABUTMENT ON COMPACTED FILL SHOWING GRANULAR 'A' CORE	FIG No 2 W P 123-87-04



SECTION A-A
(NTS)

DEWATERING SCHEME - PERIMETER DITCHES

WP 123-87-04
FIG 3

ROCK CORE DESCRIPTION
WP 123-87-04

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
3	5	3.56-3.91	50	43	3.56-10.16	**OVERBURDEN** (boulder till).
	8	4.57-5.18	92	71	10.16-11.96	**DOLOSTONE**, light olive grey to medium light grey to medium dark grey, with dark grey SHALE interbeds up to 7 cm thick (8%); fine crystalline; medium strong to weak; unweathered to slightly weathered; fractures moderately close to extremely close spaced, flat, planar to undulating, smooth.
	10	6.10-6.96	56	24		
	12	7.62-7.87	80	0		
	14	9.60-9.85	100	40		
	15	9.85-10.42	45	41		
	16	10.42-11.96	100	75		

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

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

RECORD OF BOREHOLE No 26-1 1 OF 1 METRIC

W.P. 123-87-04 LOCATION Co-ords: N 5 006 028.6 E 385 704 ORIGINATED BY TS

DIST 9 HWY 416 BOREHOLE TYPE HS Auger COMPILED BY TS

DATUM Geodetic DATE 90 12 21 CHECKED BY TS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, x LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
94.1	Ground Surface										
0.0	Heterogeneous Mixture of Silt, Sand, Gravel, Cobbles and Boulders (Glacial Till) Brown, Very Dense		1	SS	120	/28cm	92		o		13 39 40 8
			2	SS	100	/8cm					
90.1			3	SS	100	/8cm					
4.0	End of Borehole Auger Refusal (Probable Boulder) • 90 12 21										

$+^3$, $\times^5$: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 26-2 1 OF 1 METRIC

W.P. 123-87-04 LOCATION Co-ords: N 5 006 062 E 365 698 ORIGINATED BY MM

DIST 9 HWY 416 BOREHOLE TYPE HS Auger, BW Casing, Washboring, Rock Coring COMPILED BY TS

DATUM Geodetic DATE 90 12 19-21 CHECKED BY TS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
95.1	Ground Surface										
0.0	Heterogeneous Mixture of Silt, Sand, Gravel, Cobbles and Boulders (Glacial Till) Brown, Very Dense		1	SS	34		94				26 33 36 5
			2	SS	130	▼*					
			3	SS	100/15cm						
			4	SS	59		92		H		22 33 40 5
			5	SS	100/5cm						
			6	RC	REC 32%						RQD = 24%
89.6			7	SS	52		90				
5.5	End of Borehole										

* 90 12 21

+³, ×⁵: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 26-3 1 OF 1 METRIC

W.P. 123-87-04 LOCATION Co-ords: N 5 006 105.4 E 365 730 ORIGINATED BY MM

DIST 9 HWY 416 BOREHOLE TYPE HS Auger, BW Casing, Washboring, Rock Coring COMPILED BY TS

DATUM Geodetic DATE 91 01 16 CHECKED BY TS

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
94.6	Ground Surface										
0.0			1	SS	87		94				
			2	SS	113	/22cm					
			3	SS	120	/28cm	92				
	Brown		4	SS	120	/15cm					
	Grey		5	RC	REC	= 50%					RQD = 43 %
			6	SS	36						
			7	SS	46		90				
	Heterogeneous Mixture of Silt, Sand, Gravel, Cobbles and Boulders (Glacial Till) Dense to Very Dense		8	RC	REC	= 92%					RQD = 71 %
			9	SS	32						
			10	RC	REC	= 56%	88				RQD = 24 %
			11	SS	44						
			12	RC	REC	= 80%					RQD = 0 %
			13	SS	60	/5cm	86				
			14	RC	REC	= 100%					RQD = 40 %
84.2			15	RC	REC	= 45%					RQD = 41 %
10.4	Dolostone with interbedded Shale						84				
82.6	Grey, Medium Strong Unweathered		16	RC	REC	= 100%					RQD = 75 %
12.0	End of Borehole										
	* 91 01 16										

+³, ×⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 26-4 1 OF 1 METRIC

W.P. 123-87-04 LOCATION Co-ords: N 5 006 155 E 365 731 ORIGINATED BY TS

DIST 9 HWY 416 BOREHOLE TYPE HS Auger COMPILED BY TS

DATUM Geodetic DATE 91 01 15 CHECKED BY TS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, x LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
94.9	Ground Surface										
0.0	Heterogeneous Mixture of Silt, Sand, Gravel, Cobbles and Boulders; Brown / Grey; (Glacial Till); Dense to Very Dense / Compact		1	SS	42		94				
			2	SS	41						
			3	SS	104	▼*	92				
			4	SS	120	/25cm					
			5	SS	26						
			6	SS	29		90				
			7	SS	100	/15cm					
			8	SS	100	/15cm	88				
85.5			9	SS	100	/15cm	86				
9.4	End of Borehole										

* 91 01 15

+³, x⁵: Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 26-5 1 OF 1 METRIC

W.P. 123-87-04 LOCATION Co-ords: N 5 006 196.8 E 365 764 ORIGINATED BY FT

DIST 9 HWY 416 BOREHOLE TYPE HS Auger COMPILED BY TS

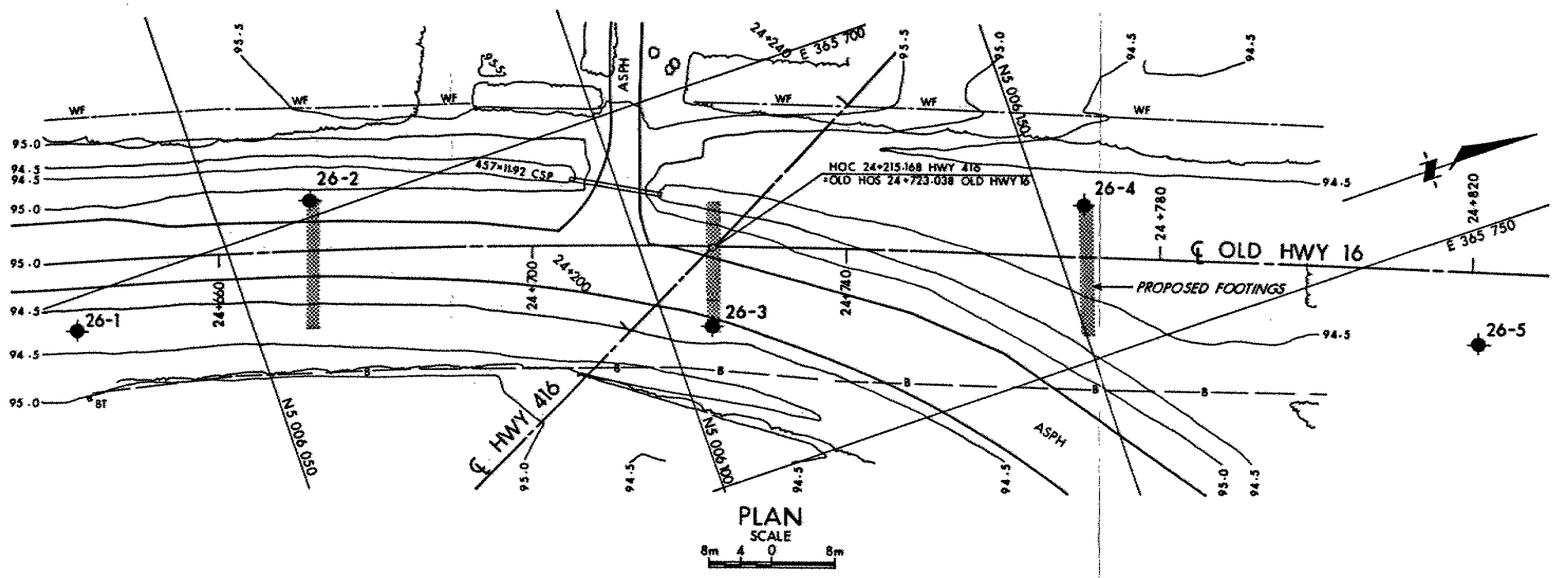
DATUM Geodetic DATE 90 12 21 CHECKED BY TS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
94.5	Ground Surface										
0.0	Compact / Very Dense Heterogeneous Mixture of Silt, Sand, Gravel, Cobbles and Boulders (Glacial Till) Brown		1	SS	28	▼	94 92 90		○ H		50 25 20 5
			2	SS	111						
89.2			3	SS	111						
5.3	End of Borehole Auger Refusal (Probable Boulder) ▪ 90 12 21										

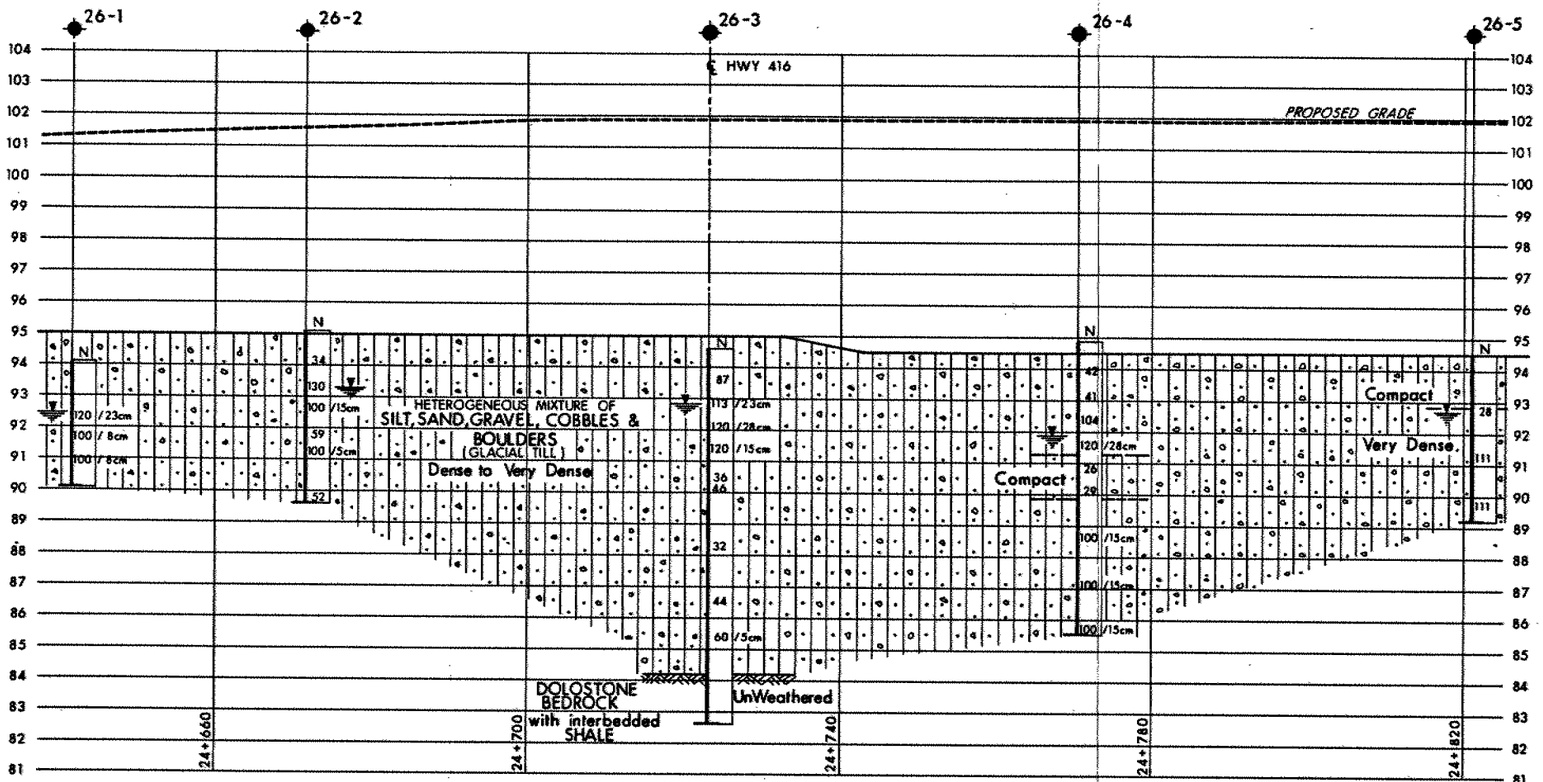
+³, ×⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

MINISTRY OF TRANSPORTATION, ONTARIO PH-O-207 88 10



PLAN
SCALE
8m 4 0 8m



℄ PROFILE OLD HWY 16
SCALE
8m 4 0 8m Hor
2m 1 0 2m Vert

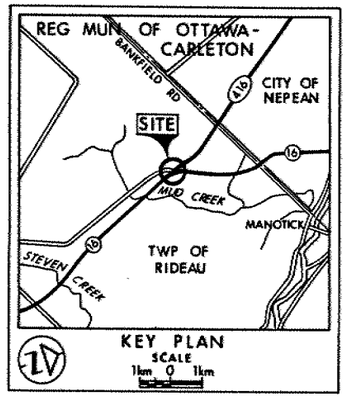
METRIC

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

CONT No
WP No 123-87-04

HWY 416
& REALIGNED OLD HWY 16 U'PASS
(CENTURY RD)
BORE HOLE LOCATIONS & SOIL STRATA

SHEET



LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L at time of investigation 90 12 and 91 01

No	ELEVATION	CO-ORDINATES NORTH	EAST
26-1	94.1	5 006 028.6	365 704.0
26-2	95.1	5 006 062.0	365 698.0
26-3	94.6	5 006 105.4	365 730.0
26-4	94.9	5 006 155.0	365 731.0
26-5	94.5	5 006 196.8	365 764.0

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

Geocres No 31G-[redacted] 203

REF No E-55-416-1, 90 08

HWY No 416			DIST 9
SUBM'D TS	CHECKED	DATE 91 04 12	SITE 3-554
DRAWN DT	CHECKED	APPROVED	DWG 1238704-A