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GEOCRES No. 31D-331

DIST. 5 REGION

W.P. No. 210-85-01

CONT. No. 91-23

W. O. No.

STR. SITE No.

HWY. No. 27

LOCATION Hwy 27, Twp of Vespra Culvert Replacement

No of PAGES -

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION REPORT

CONTRACT NO 91-23

Ministry of Transportation

Ontario

INDEX

Note: For purposes of the contract, this report supersedes all other Foundation Reports prepared by, or for the Ministry in connection with the above mentioned project.

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 (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

FOUNDATION INVESTIGAION REPORT

For

Hwy. 27 Culvert Replacement

at Sta. 16+825, Township of Vespra

W.P. 210-85-01

District 5, Owen Sound

INTRODUCTION

This report summarizes the information obtained from a foundation investigation carried out at the above mentioned site. A triple C.S.P.A. structures has been proposed to replace the existing singe C.S.P.A. at the site.

The fieldwork was carried out between 90 08 21 and 90 08 23. Two boreholes (BH's 1 and 2) were advanced and sampled as part of this project by means of hollow stem augers. These boreholes extended down to the maximum depth of 23.3 m below the existing ground surface.

This report contains factual information obtained from this investigation pertaining to the culvert structure as shown on Dwg. No. 2108501-A.

SITE DESCRIPTION AND GEOLOGY

The site is located on Hwy. 27, approximately 10 km north of Barrie and 4 km south of the intersection of County Road #22 and Hwy. 27 in the Township of Vespra, County of Simcoe. The topography in the immediate area is generally flat to gently undulating. The immediate vicinity of the site is occupied by farms and mixed bushland.

Physiographically, the site is located in the "Simcoe Lowland" region known as the Nottawasaga Basin. (Ref.: Chapman and Putnam, 1984). This basin has several distinctive divisions. The terrain at the site bears the characteristics of the Camp Borden sand plain and the Minesing flats. Subsoil was believed to be deposited by the tributaries of the Nottawasaga River, the predominant sediments being fine sands and silty sands. The remainder of the basin is floored with calcareous clay, some marl and in the south, with the sandy delta of the early Nottawasaga.

SUBSURFACE CONDITIONS

The subsoil conditions are generally uniform consisting primarily of two distinct deposits. The upper layer consists of a deep deposit of clayey silt ranging in thickness of about 19.0 m at BH 2 and 19.2 m at BH 1. Underlying this stratum is a silty sand. The thickness of this deposit was not proven.

Overburden was covered with a thin layer of road fill material at two borehole locations. This layer consists of sand and gravel with a maximum thickness of about 1.1 m at BH 2.

The boundaries between the various soil types, in situ and laboratory test results are shown on the attached Record of Borehole sheets in the Appendix. The locations and elevations of the boreholes, along with a profile and section showing soil stratigraphy based on borehole data, are shown on Dwg. No. 2108501-A.

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

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Both boreholes encountered some 1.1 m of fill material whose composition is sand and gravel. Grain size distribution analysis was not carried out on this material. However, through visual observation, the material can be classified as a sand and gravel.

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This stratum encountered underneath the fill material. This deposit consists of clayey silt of low plasticity with varying amounts of sand and occasional clay and sand layers. The thickness of this layer was found to be the maximum 19.2 m at BH 1.

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From the plasticity chart, it is evident that the layer can be classified as clayey silt, trace to some sand with low plasticity (CL). Grain Size Distribution tests were carried out on this clayey silt. Figure 2 in the Appendix shows the results.

Undrained shear strength of the soil was determined by in situ vane tests and by laboratory tests, namely unconsolidated undrained triaxial tests. The results are plotted on Figure 3 and the Record of Borehole logs in the Appendix and summarized as follows:

Undrained Shear Strength	Cu (kPa)	Sensitivity (average)	
In Situ Vane Tests	10-46 (Av. 29.3)	1-7	(3)
Unconsolidated Undrained Triaxial Tests (Quick Triaxial Tests)	13-25 (Av. 19.3)	-	

As shown on Figure 3, it can be seen that the undrained shear strength increase with depth. Based on these results, it is estimated that the consistency of the soil varies from very soft to firm. The undrained shear strength values obtained from the laboratory testing (unconsolidated undrained triaxial test) gave slightly lower values than those obtained from the field vane tests. It is considered that this is primarily due to the unavoidable sample disturbance caused by the field and laboratory handling and subsequent testing of clayey silt. The sensitivity ranges from 1 to 7 with an average of 3. This would indicate that clayey silt is normal.

The results (e-log P curves) of three consolidation tests on representative samples obtained in the clayey silt deposit are shown on Figures 4 and 5. These tests indicate that this stratum has been normally consolidated in the past to an effective preconsolidation pressure ranging from 69 kPa to 132 kPa which is about 12 kPa below to 14 kPa in excess of the existing effective overburden pressure (P_c-P_o). The details of the results are as follows:

Parameters	Ranges
Preconsolidation Pressure, P_c (kPa)	69-132
Overconsolidation Pressure, P_c-P_o (kPa)	-12 to 14
Initial Void Ratio (e_o)	0.825-1.443
Compression Index (C_c)	0.292-0.800

Silty Sand

Silty sand deposit was encountered underneath the clayey silt at both borehole locations (BH's 1 and 2). The thickness of this layer was not fully proven with a drilling thickness of 3.2 m at BH 2.

This deposit contains trace of clay throughout its thickness. Figure 6 in Appendix shows the results of Grain Size Distribution tests.

In this stratum, the 'N' values ranges from 15 to 67 blows/0.3 m indicating a state of compaction described as compact to very dense.

GROUNDWATER CONDITIONS

Grounwater conditions were observed through the measurement of water level in the open boreholes. The groundwater level in both boreholes after completion was found to be some 2.1 m below the existing road surface which corresponds to an approximate elevation of 200.0 m. However, it should be noted that an artesian condition was also encountered at BH 2 after the completion of borehole. This borehole was sealed with a mixture of bentonite pellets and gravel at the source of artesian zone. No attempt was made to measure the artesian head in view of urgency of sealing the borehole without any undue delay.

MISCELLANEOUS

The fieldwork for this investigation was carrried out under the supervision of John Le Messurier, Student Engineer, and Tae. C. Kim, Senior Foundation Engineer. The equipment was owned and operated by Ancher Drilling Co. Ltd., Midhurst.

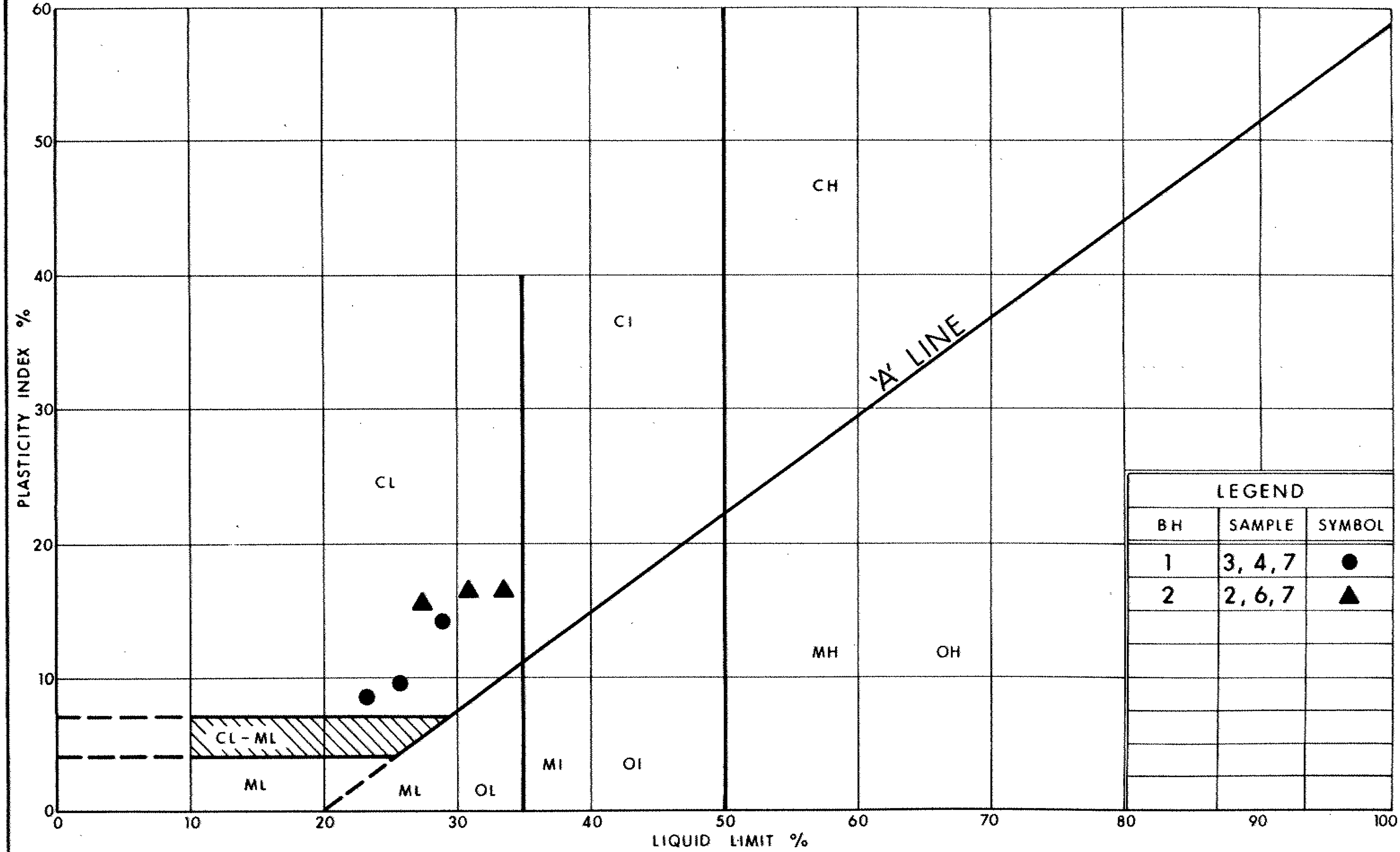
This report was written by T. C. Kim, Senior Foundation Engineer, reviewed by P. Payer, Senior Foundation Engineer and approved by M. Devata, Chief Foundation Engineer.

Tae C. Kim, P. Eng.
Sr. Foundation Engineer

M. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX

Oct 75, FF-S-21



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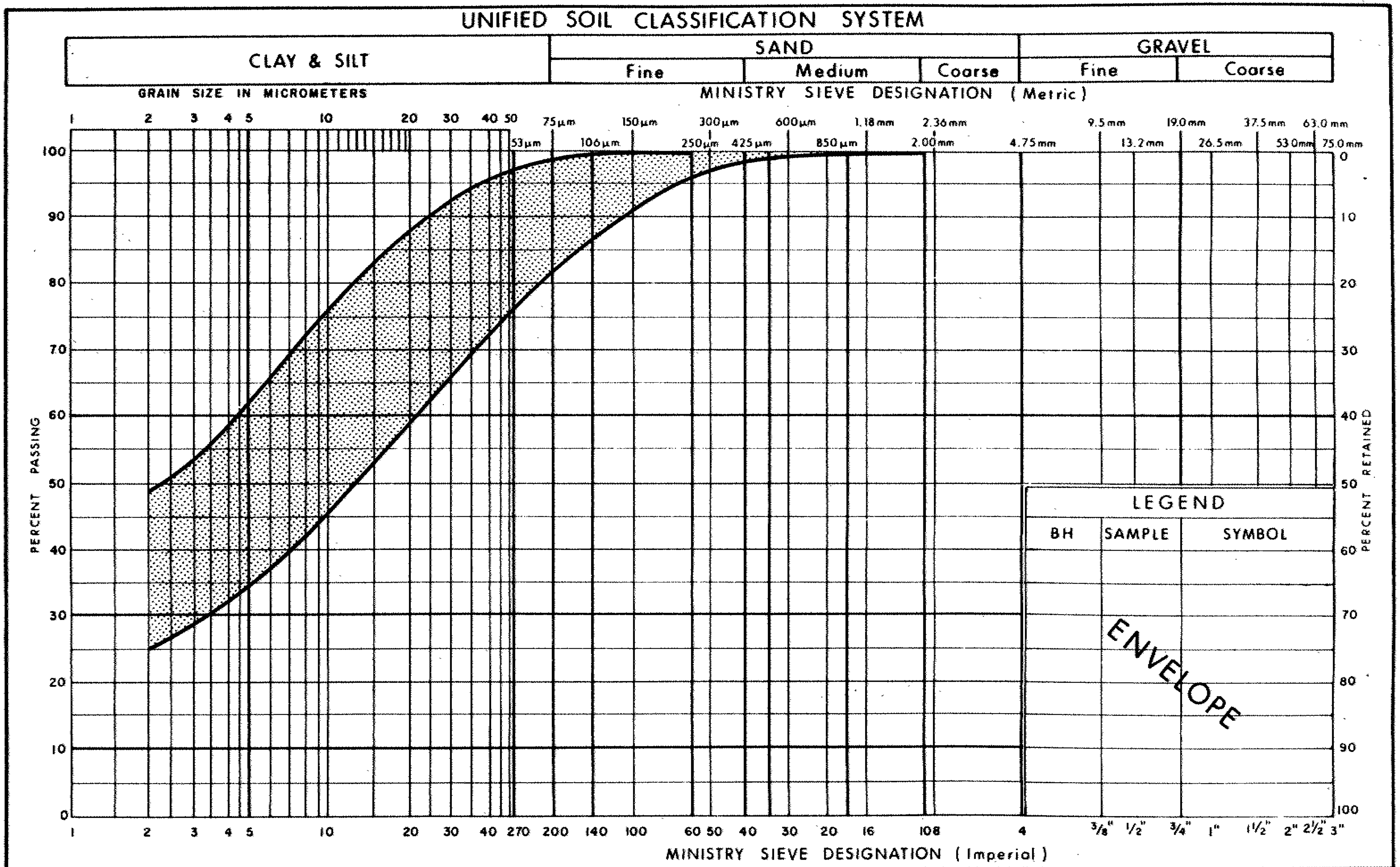
PLASTICITY CHART

CLAYEY SILT, TRACE TO SOME SAND

FIG No 1

WP 210-85-01

78 12 M



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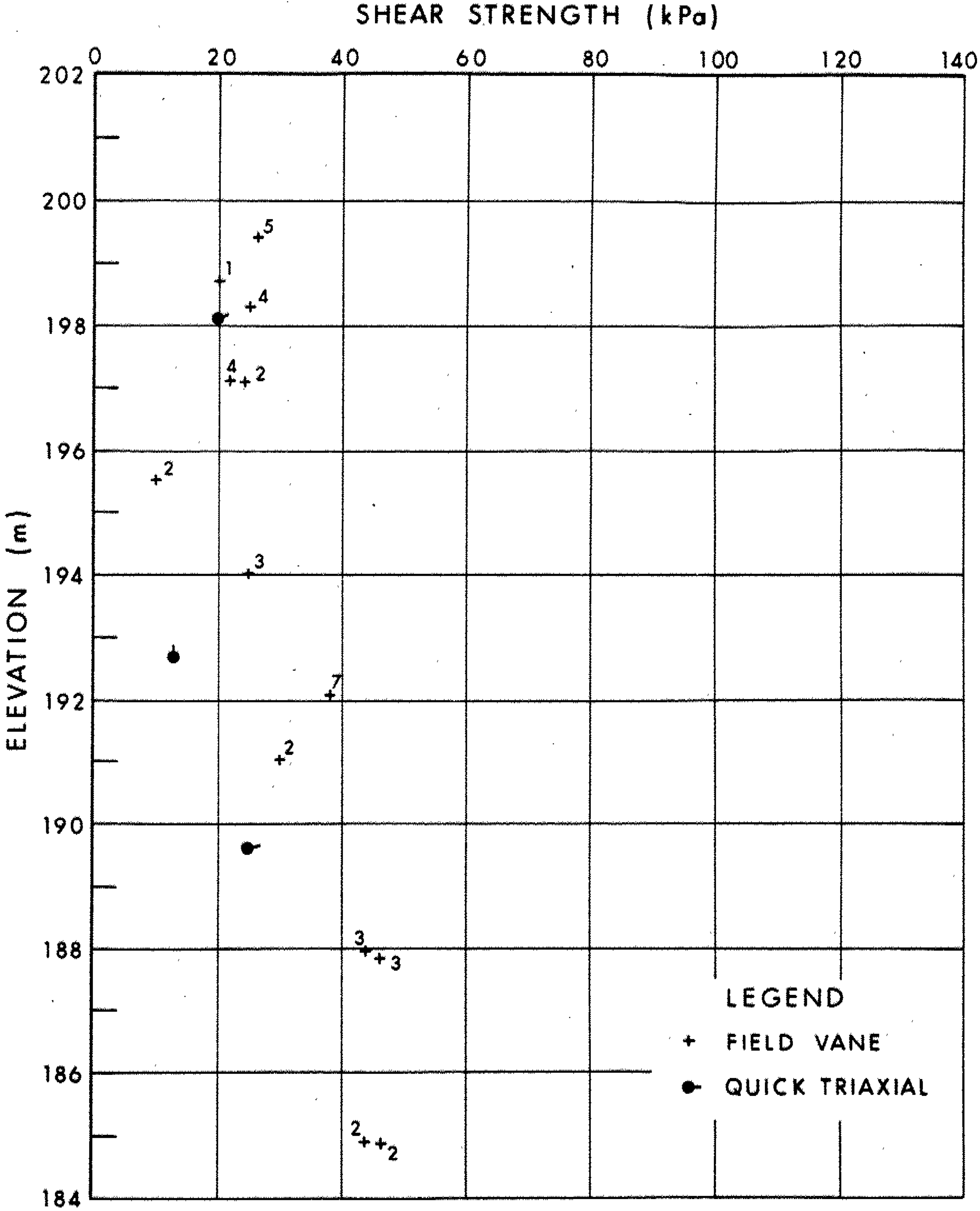
GRAIN SIZE DISTRIBUTION
CLAYEY SILT, TRACE TO SOME SAND

FIG No 2

W P 210-85-01

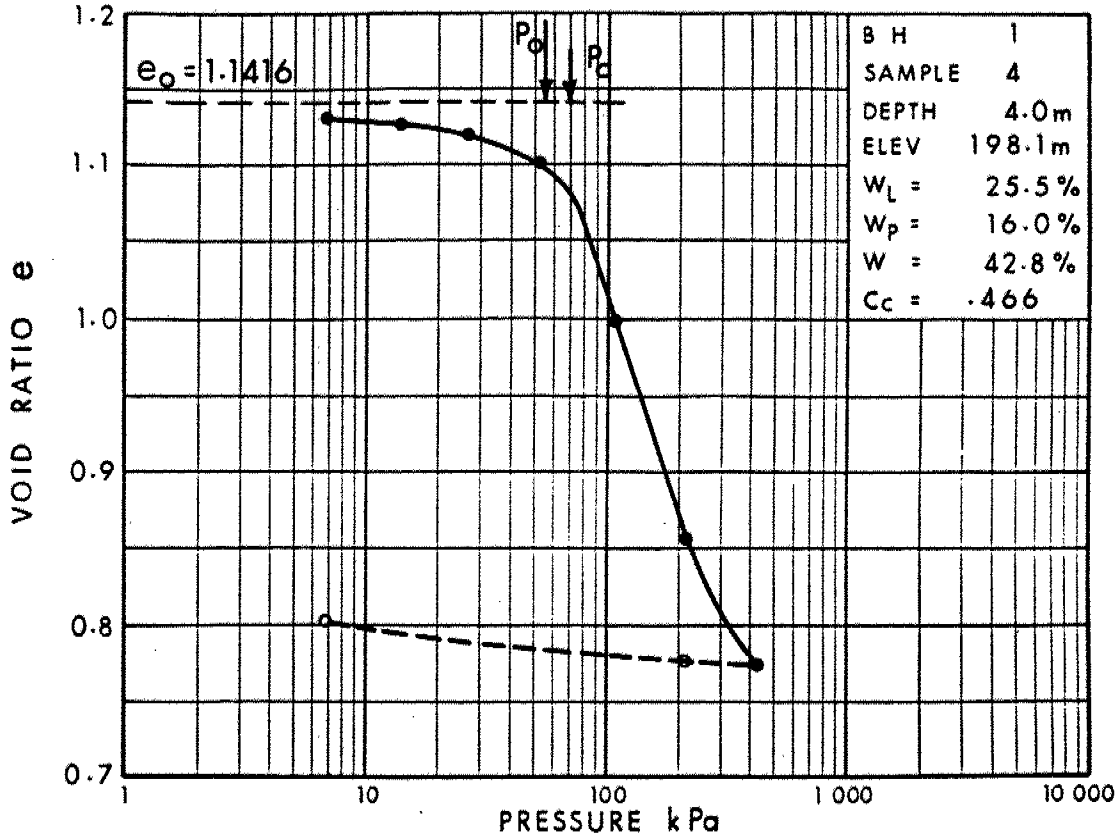
SHEAR STRENGTH (C_u) Vs ELEVATION



WP 210-85-01

Fig 3

VOID RATIO - PRESSURE CURVES



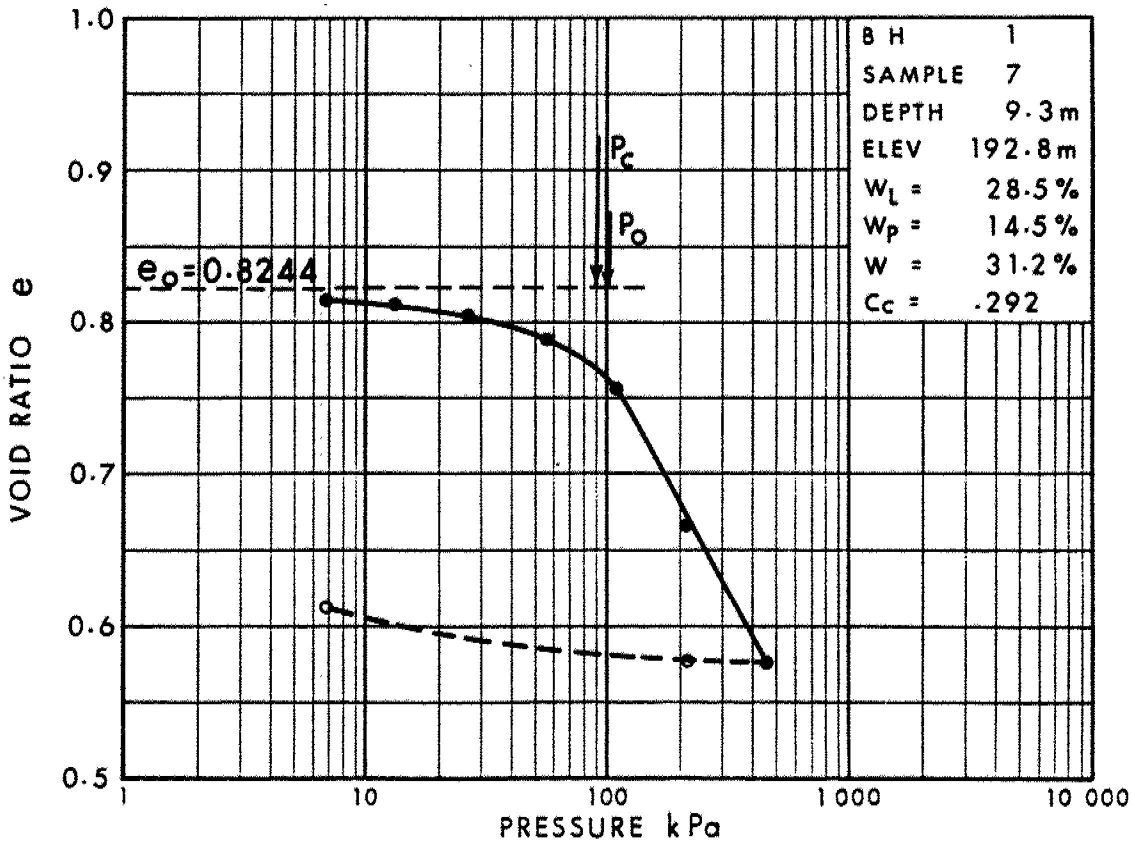
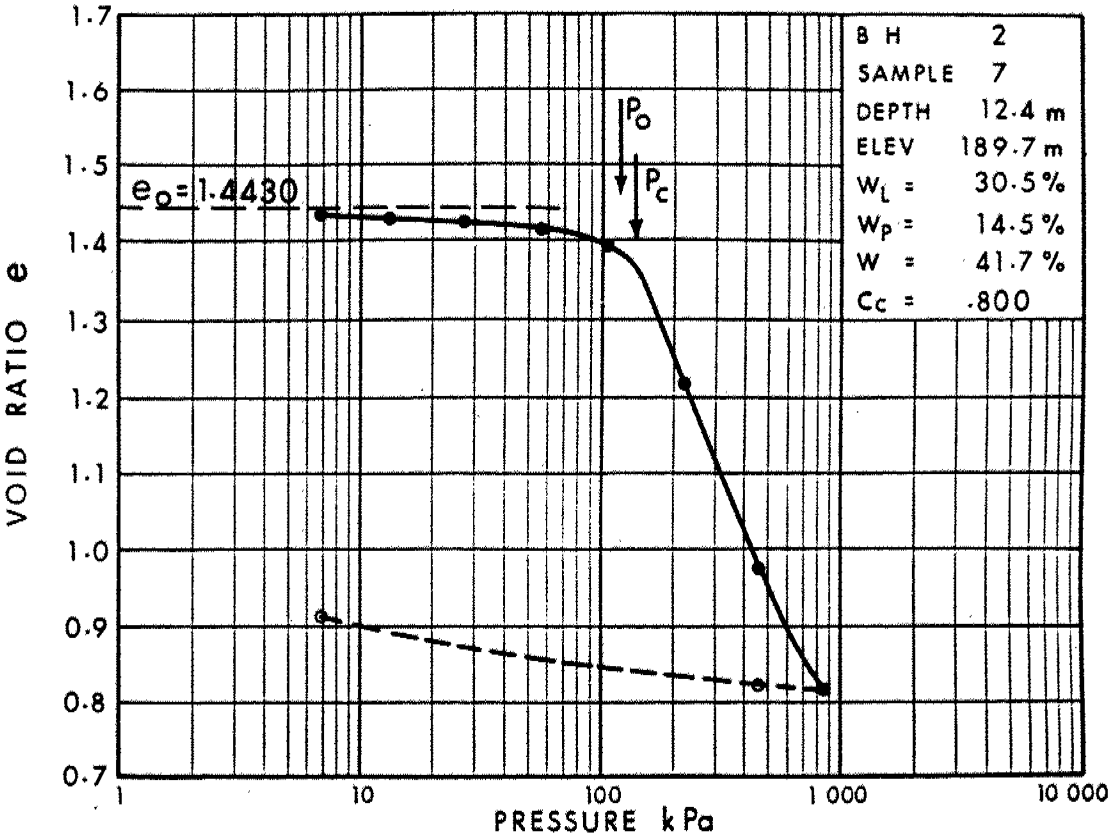


Fig 4

VOID RATIO - PRESSURE CURVES



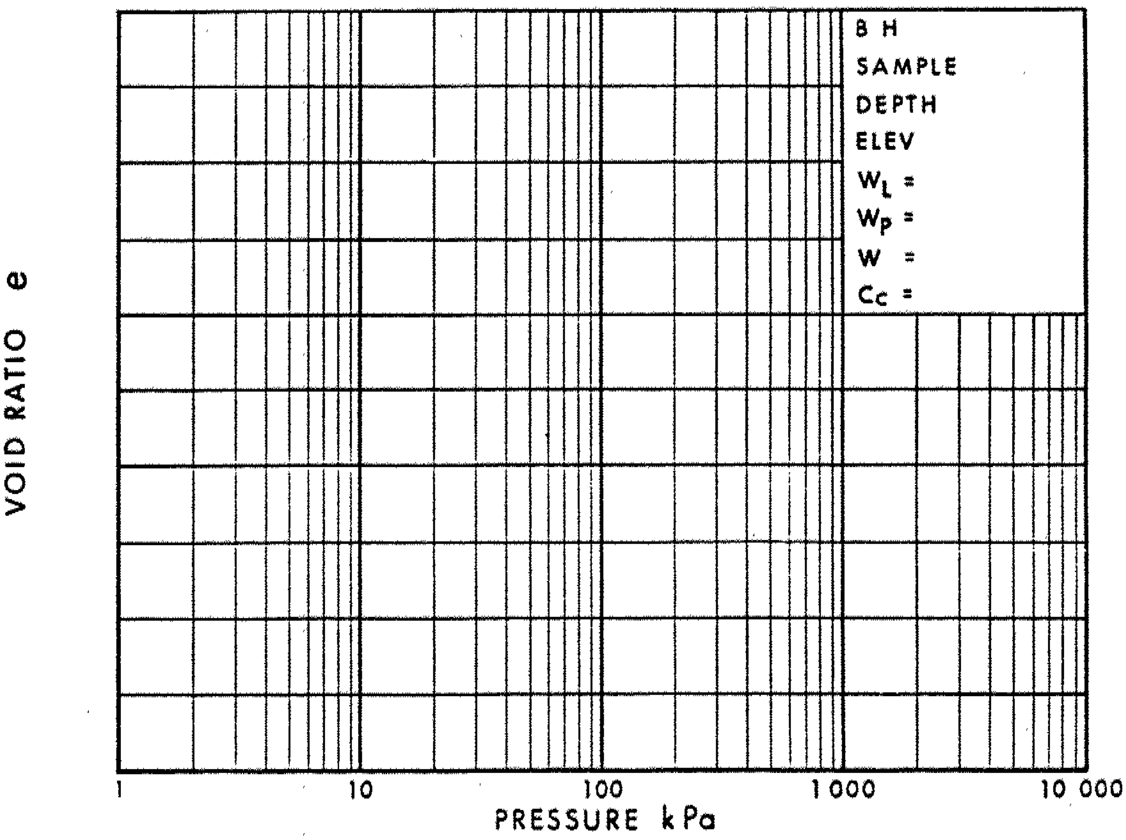
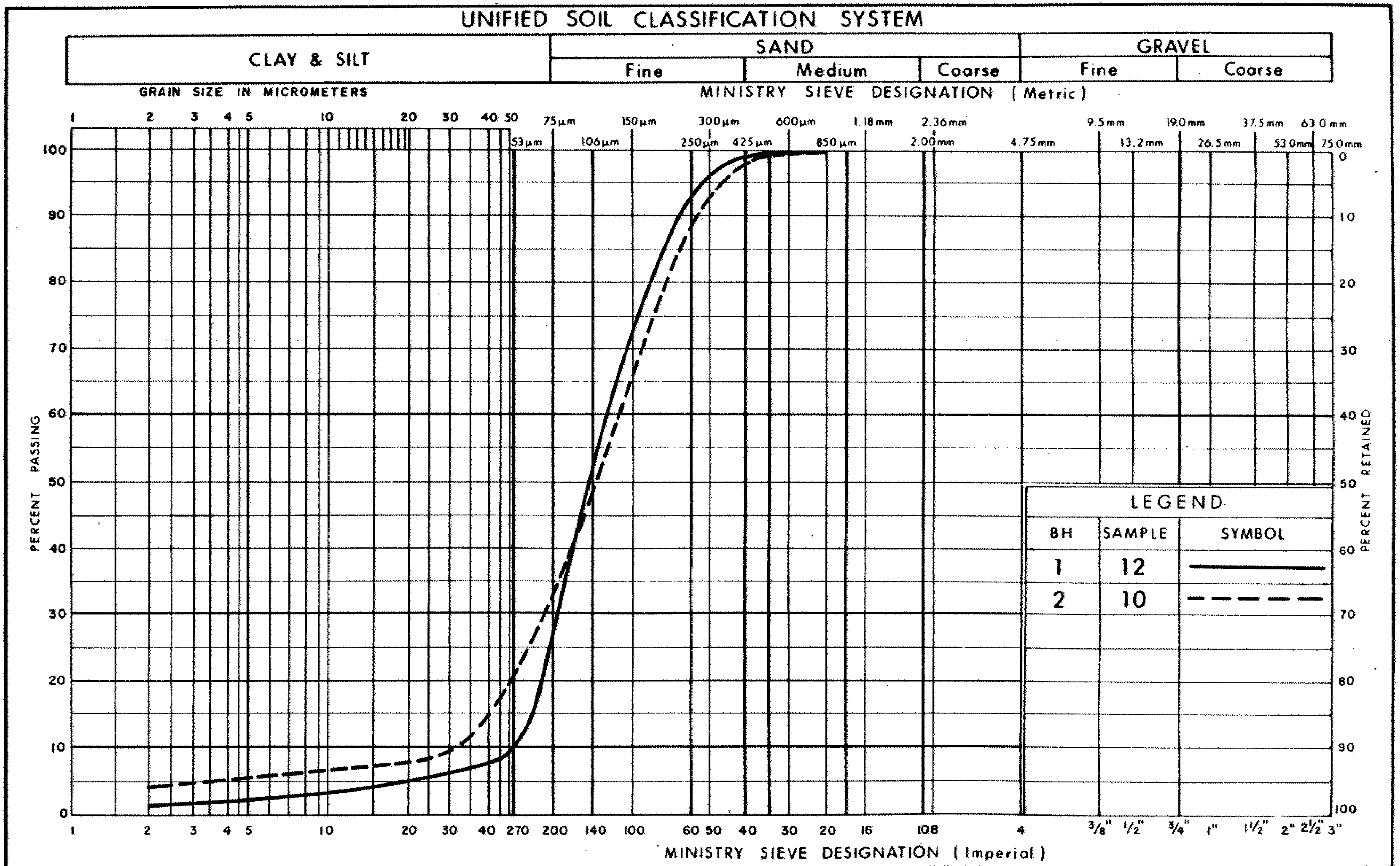


Fig 5

WP 210-85-01

78 12 M



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GRAIN SIZE DISTRIBUTION
SILTY SAND

FIG No 6

W P 210-85-01

RECORD OF BOREHOLE No 1

METRIC

W.P. 210-85-01 LOCATION STATION 16+820 ; O/S 7.5 m RT ORIGINATED BY JLM

DIST 5 HWY 27 BOREHOLE TYPE H S AUGER AND CONE TEST COMPILED BY TCK

DATUM GEODETIC DATE 1990 08 21 CHECKED BY TCK

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	WATER CONTENT: PLASTIC LIMIT – NATURAL – LIQUID LIMIT	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
202.1	GROUND SURFACE									
0.0 201.2	SAND and GRAVEL (FILL) Brown									
0.9	CLAYEY SILT, Trace to Some Sand, Occ. Clay and Sand Layers, Very Soft to Firm; Grey	1	SS	3						
		2	SS	2						
		3	SS	0			0	4	71	25
		4	TW	PM		17.4	0	11	64	25
		5	TW	PM						
		6	SS	1						
		7	TW	PM		18.1	0	1	54	45
		8	SS	1						
		9	TW	PM						
		10	SS	1			0	1	22	77
		11	SS	1						
182.0 20.1	SILTY SAND Compact									
180.3		12	SS	15			0	73	26	1
21.8	End of Borehole									

ELEVATION SCALE: 200, 198, 196, 194, 192, 190, 188, 186, 184, 182

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 10 20 30 40 50

WATER CONTENT (%): 20 40 60

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

15-5 (20 above, 10 below) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 2

1 OF 1 METRIC

W.P. 210-85-01	LOCATION STATION 16+830 :O/S 7.5 m LT		ORIGINATED BY JLM
DIST 5	HWY 27	BOREHOLE TYPE HS AUGER and Cone Test	COMPILED BY TCK
DATUM GEODETIC		DATE 1990 08 22 and 23	CHECKED BY TCK

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE: 10 20 30 40 50

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L. WATER CONTENT (%): 20 40 60

Soil Profile

ELEV / DEPTH	DESCRIPTION
202.1	GROUND SURFACE
0.0	SAND and GRAVEL (FILL) Brown
201.0 / 1.1	Grey CLAYEY SILT, trace to some Sand, Occ.Clay and Sand Layers, Very Soft to Firm
182.0 / 20.1	SILTY SAND, Dense to Very Dense
178.8 / 23.3	End of Borehole

Samples

NUMBER	TYPE	'N' VALUES	Water Content (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
1	SS	1						
2	SS	2	plotted		0	2	51	47
3	TW	PM						
4	SS	0						
5	SS	0						
6	SS	2	plotted		0	18	34	48
7	TW	PM	plotted	17.0	0	3	42	55
8	TW	PM						
9	SS	3						
10	SS	33	plotted		0	67	29	4
11	SS	67						

Elevation scale: 200, 198, 196, 194, 192, 190, 188, 186, 184, 182, 180

Field vane sensitivity values plotted: +5, +2, +3, +2, +3, +2

* Artesian Condition was encountered after completion of Borehole. Head was not measured in view of urgency of sealing.

+3, ×5 : Numbers refer to Sensitivity

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

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 210-85-01 DIST 5

HWY 27 STR SITE

Hwy. 27 Culvert Replacement
at Sta. 16+825, Township of Vespra

CONT 91-23

DISTRIBUTION

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E.J. Zavitski (2)
K.G. Bassi
S.J. Dunham
E.A. Joseph
G. Laithwaite (Cover Only)
I. Bullen (Cover Only)
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GEOCRES 31D-331 DATE DEC 10 1990

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In this stratum, the 'N' values ranges from 15 to 67 blows/0.3 m indicating a state of compaction described as compact to very dense.

GROUNDWATER CONDITIONS

Grounwater conditions were observed through the measurement of water level in the open boreholes. The groundwater level in both boreholes after completion was found to be some 2.1 m below the existing road surface which corresponds to an approximate elevation of 200.0 m. However, it should be noted that an artesian condition was also encountered at BH 2 after the completion of borehole. This borehole was sealed with a mixture of bentonite pellets and gravel at the source of artesian zone. No attempt was made to measure the artesian head in view of urgency of sealing the borehole without any undue delay.

DISCUSSION AND RECOMMENDATIONS

It is understood that the original proposal was for a concrete box culvert replacement. In view of the soft normally consolidated subsoil at the site, substantial deformations are anticipated as a result of applied vertical loading. It was recommended by the Regional Geotechnical Section that the proposed concrete culvert be replaced with a triple steel pipe arch culverts.

It is proposed to replace the existing single small size C.S.P.A. (1.0 m x 0.7 m x 18.4 m) at the site with a triple larger size C.S.P.A. (1.630 m x 1.12 m x 22.0 m). The proposed culverts are to be located at the same location. The proposed invert elevation is about 200.8 m while the proposed grade elevation of Hwy. 27 is about 202.5 m. Based on this, a culvert roof cover of approximately 0.7 m and approach fills in the order of 1.7 m will be required.

Recommendation for the Steel Pipe Arch Culverts

The steel pipe arch culverts can be founded at the proposed invert elevation (200.8 m) provided it is constructed in accordance with current MTO bedding and backfilling requirements as specified in OPSS 421 and OPSD 802 series. The major items of consideration are summarized below.

Bedding to Structure

1) The bedding should consist of a granular pad (Granular 'A') with a minimum thickness of 300 mm. The excavation for the bedding shall extend to a width of a minimum 1.5 m on the outer side of the outside culverts.

2) All softened material created during construction of foundation and any deleterious or organic material present at the founding elevation shall be removed and replaced with a granular material.

3) For the width of the area under the bottom radius of the pipe arch the bed should be levelled and left uncompacted for a depth of 300 mm below the invert level.

4) The culvert pipe bed is to be carefully shaped to receive the lowest segment of pipe formed by the bottom radius.

5) The area adjacent to the haunches of the pipe and below the portion of the sloping invert should be compacted by means of hand tamping.

6) The minimum depth of cover shall be the span of the pipe culvert divided by 6 or 300 mm, whichever is greater.

7) Scour protection at the culvert inlet and outlet shall be provided to protect the culvert bedding. The design of the scour protection shall be made in conjunction with applicable hydrological requirements.

Backfill to Structure

Backfill for the plate pipe culverts shall be designed and constructed according to OPSD 803 series. The following items of consideration are hereby reinforced.

1) The frost penetration depth at the site is 1.5 m and the frost taper should be designed accordingly to the Regional geotechnical requirements.

2) The backfill material should be machine compacted on both sides of the pipe and between culverts, simultaneously in equal lifts in accordance with OPSS 501.08.02.

✓3) To prevent piping around the culvert, a 1 m thick blanket of approved impermeable material (refer to OPSS 1205) should be placed at the culvert inlet as a sealer behind a 600 mm layer of rip-rap. This blanket should extend to the high water level. Around the culvert outlet, a 1 m thick blanket of Granular 'A' material should be placed as a filter behind a 600 mm layer of rip-rap.

4) Backfill material shall consist of a free draining material such a Granular 'A' or Granular 'B' to prevent hydrostatic pressure build-up on the culvert walls. Design parameters of the soil are given in Table 1 below.

Table 1 - Backfill Properties

	Granular 'A'	Granular 'B'
Angle of Internal Friction (ø)	35°	30°
Unit Weight (kN/m^3), γ	22.8	21.2
Coefficient of Active Earth Pressure(Ka)	0.27	0.33
Coefficient of Earth Pressure at Rest(Ko)	0.43	0.50

The earth pressure coefficient at rest is to be used when the design of the abutment walls are rigid and unyielding.

The backfill beyond the granular wedge as illustrated on OPSD 803 series can consist of acceptable borrow material as defined in OPSS 212.05.

Stability and Settlement

No stability problems are anticipated for the proposed height of permanent embankment (about 1.7 m) constructed to a 2H:1V geometry.

However, as discussed previously, in view of the soft normally consolidated subsoil at the site, substantial settlements are anticipated if additional embankment load is applied. Therefore, it is recommended that the proposed grade of Hwy. 27 must be maintained without any grade revision.

Recommendations for the Concrete Box Culverts

The existing steel pipe culvert has been performed satisfactorily for the last 16 years without any signs of structural distress, in spite of the settlement induced by roadway embankment. It is believed that the major portion of the settlement has been completed. No further settlement will take place in this area if no grade revision is contemplated. In view of this, a concrete box type culvert could be equally suitable at this location. However, the final choice should be based on the economical and practical construction considerations. If concrete type of culverts is considered at this particular location, the following design values are recommended for the purpose of the O.H.B.D.C.

Factored Bearing Capacity at U.L.S.	75 kPa
Bearing Capacity at S.L.S. Type II	50 kPa

A footing width of 3.0 m with an embedded depth of 1.5 m was used in calculation of the above capacities. The magnitude of the differential settlement of the footings for S.L.S. Type II is anticipated to be within 25 mm, provided the subsoil is not disturbed by construction activities.

Bedding and backfilling for the concrete box culverts will be similar to those for the steel pipe culverts.

Construction Considerations

Temporary Diversion

To facilitate the construction of the culvert, a temporary diversion of the Creek should be considered.

Dewatering

It is recommended that conventional sump pump techniques with perimeter ditches be applied to assure that the foundation construction is advanced in the dry.

Temporary Excavation Slopes

Temporary excavation cuts for foundation elements should be at a slope no steeper than 2H:1V in view of the high water table.

MISCELLANEOUS

The fieldwork for this investigation was carrried out under the supervision of John Le Messurier, Student Engineer, and Tae. C. Kim, Senior Foundation Engineer. The equipment was owned and operated by Archer Drilling Co. Ltd., Midhurst.

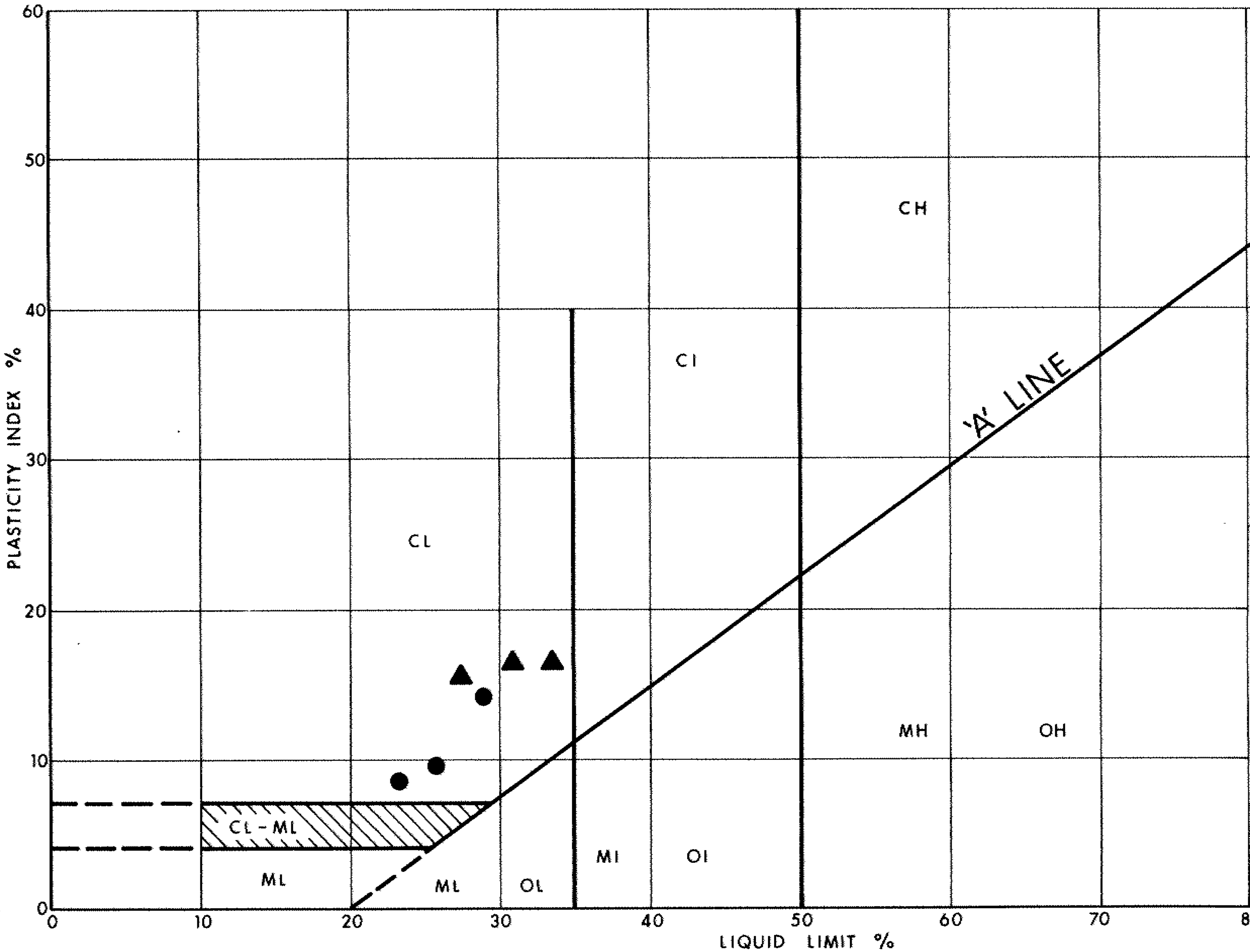
This report was written by T. C. Kim, Senior Foundation Engineer, reviewed by P. Payer, Senior Foundation Engineer and approved by M. Devata, Chief Foundation Engineer.

LICENSED PROFESSIONAL ENGINEER
T.-C. KIM
PROVINCE OF ONTARIO

Tae C. Kim, P.Eng.
Senior Foundation Engineer

M. Devata, P.Eng.
Chief Foundation Engineer

APPENDIX



LEGEND		
BH	SAMPLE	SYMBOL
1	3, 4, 7	●
2	2, 6, 7	▲

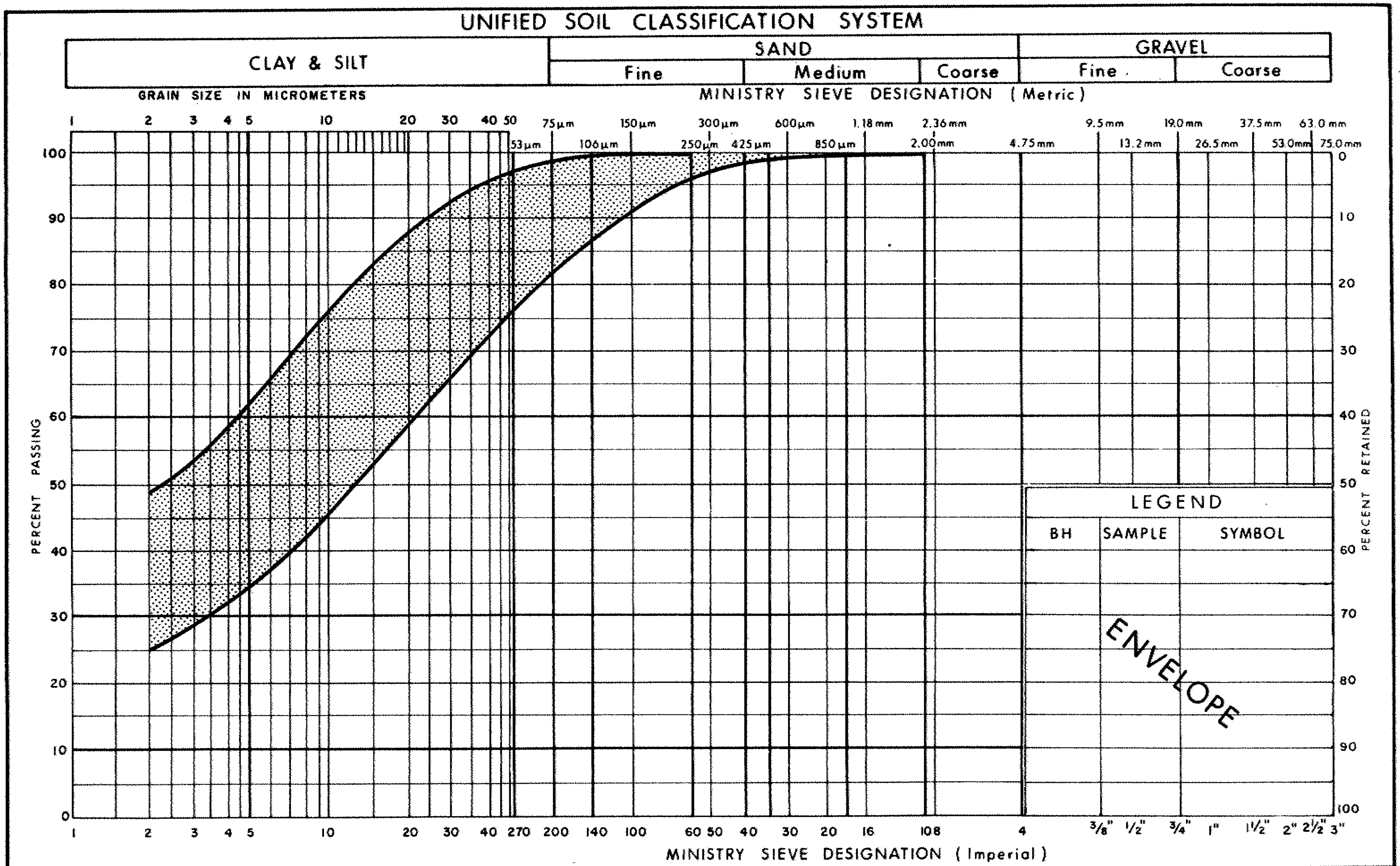
Ministry of Transportation Ontario

PLASTICITY CHART
CLAYEY SILT, TRACE TO SOME SAND

FIG No 1

W P 210-85-01

78 12 M



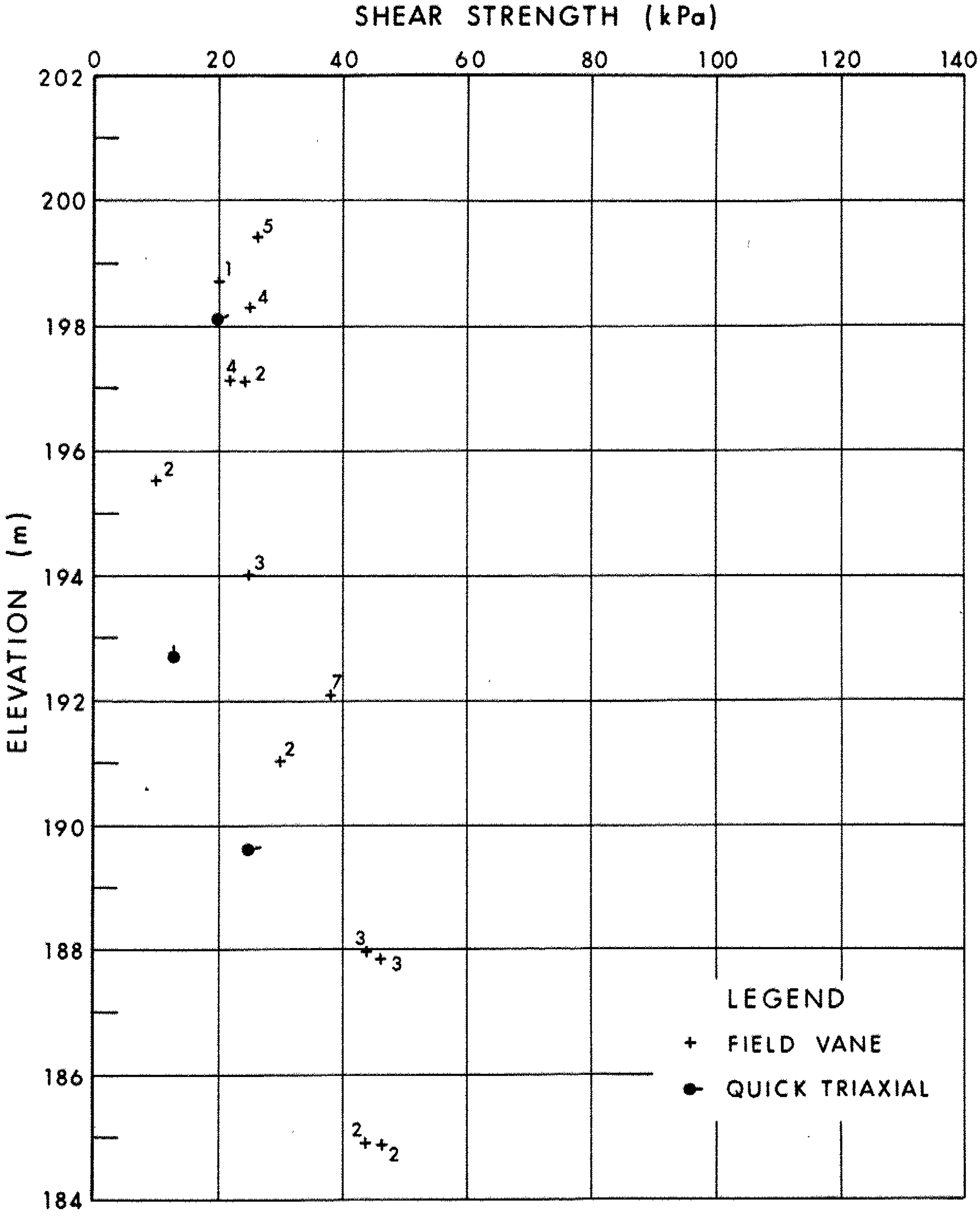
Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
CLAYEY SILT, TRACE TO SOME SAND

FIG No 2

W P 210-85-01

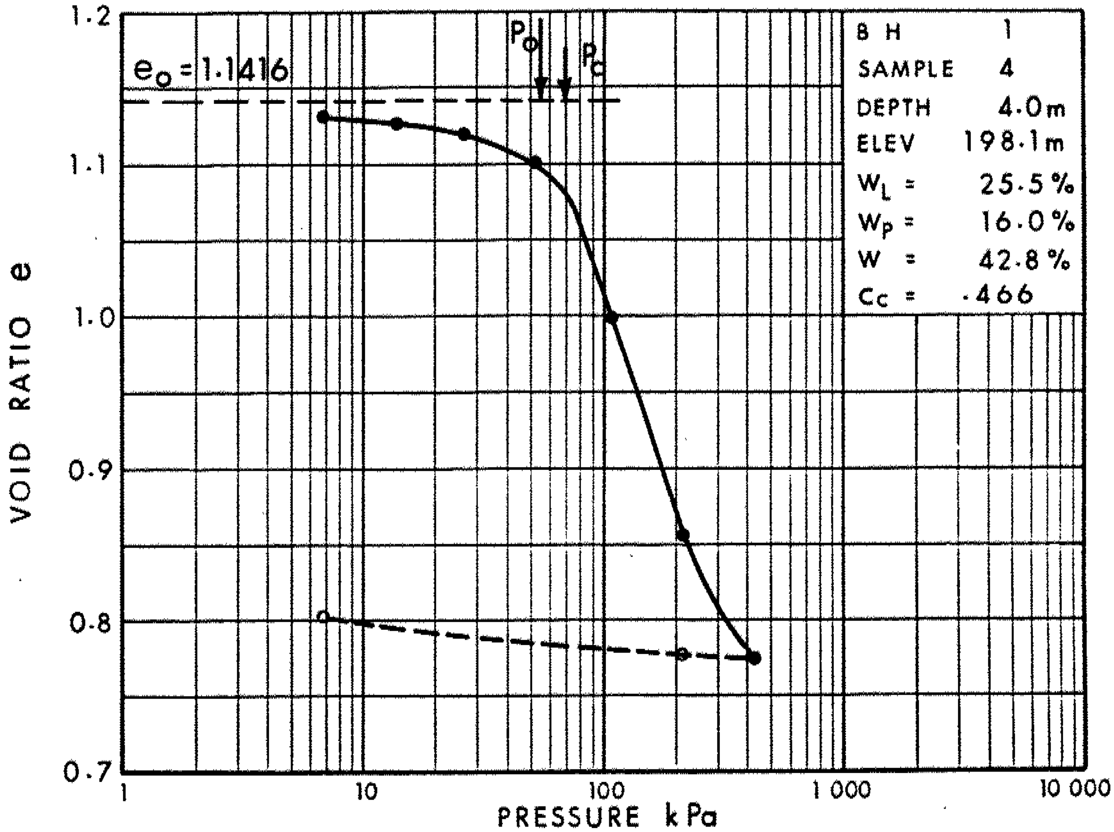
SHEAR STRENGTH (C_U) Vs ELEVATION



WP 210-85-01

Fig 3

VOID RATIO - PRESSURE CURVES



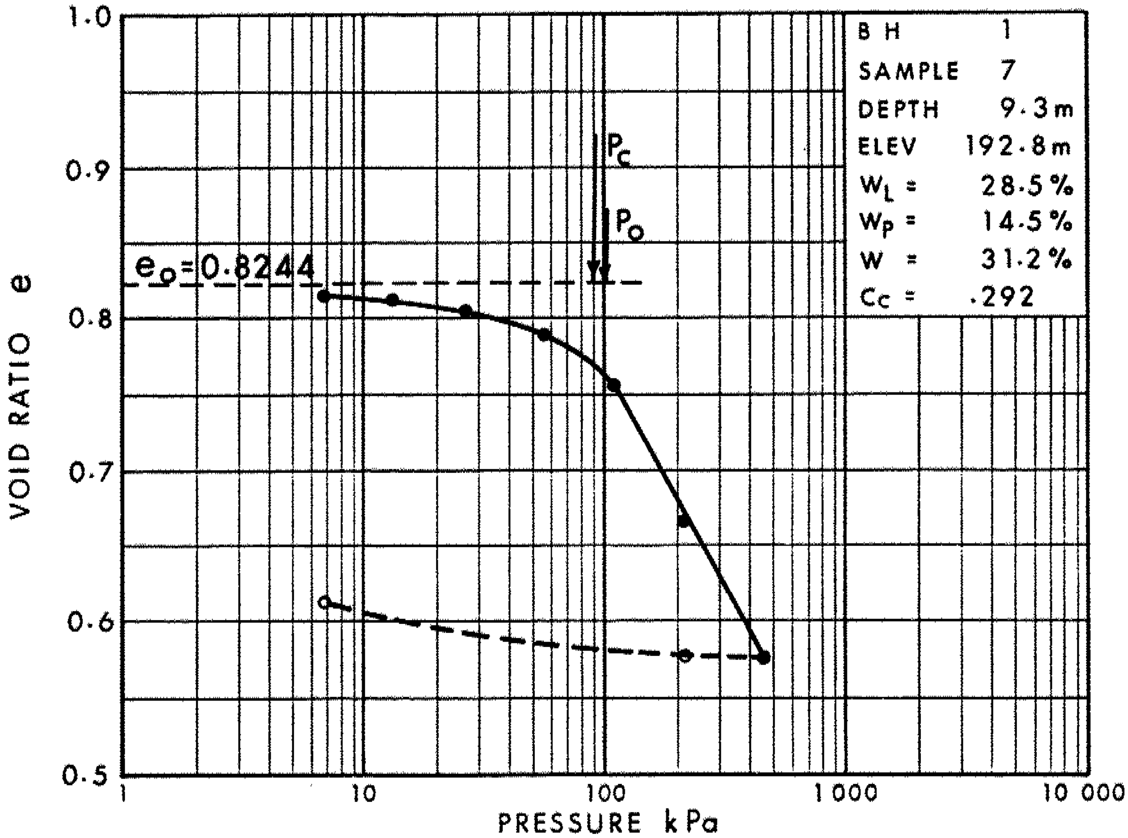
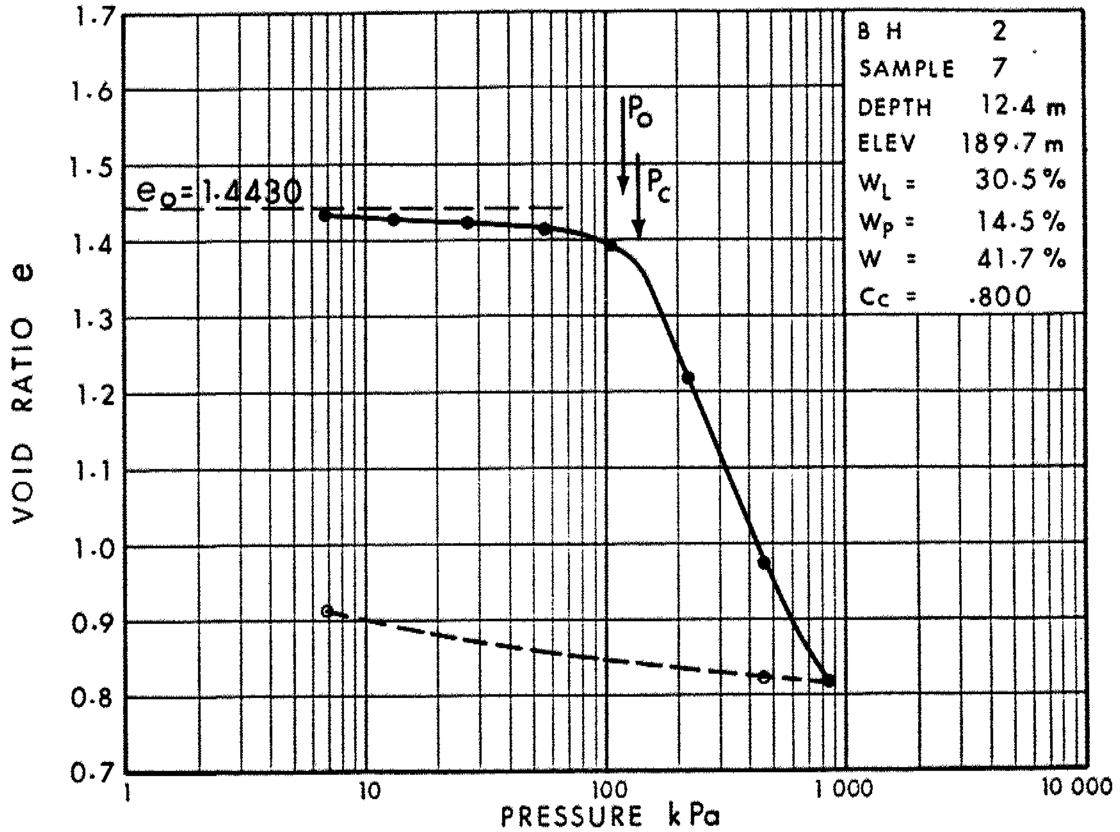


Fig 4

VOID RATIO - PRESSURE CURVES



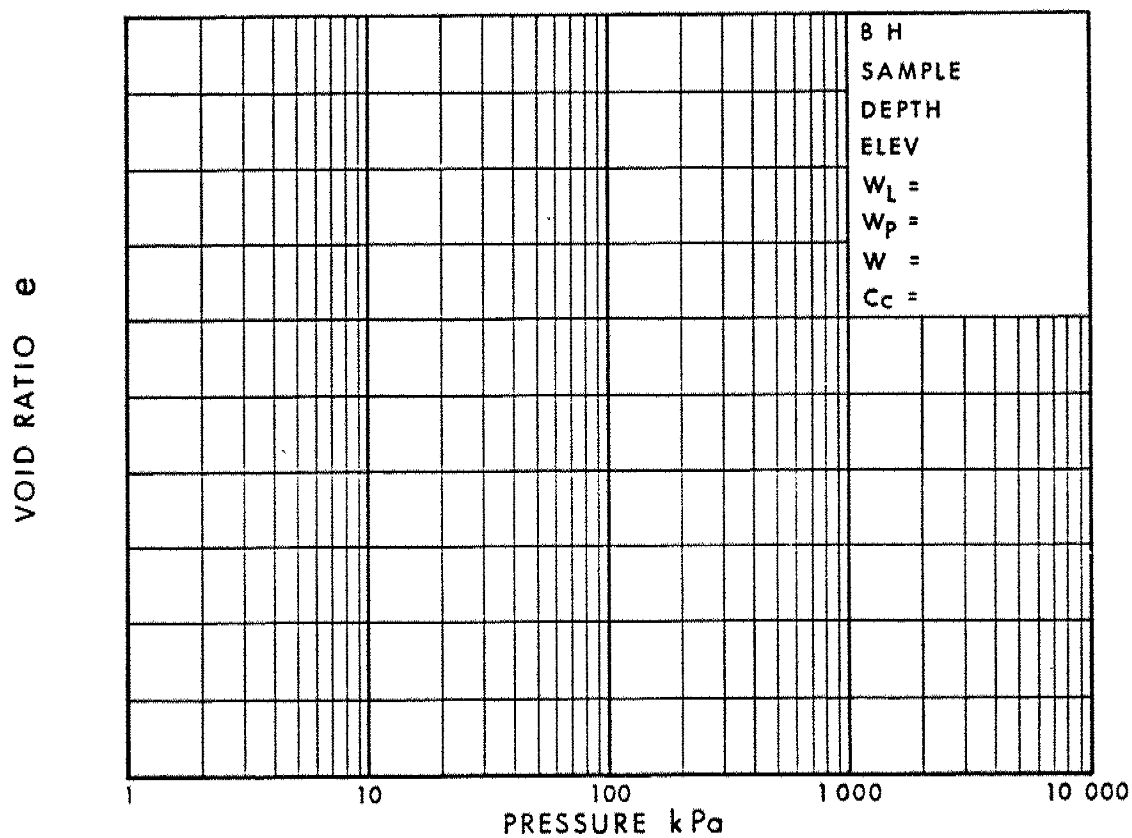
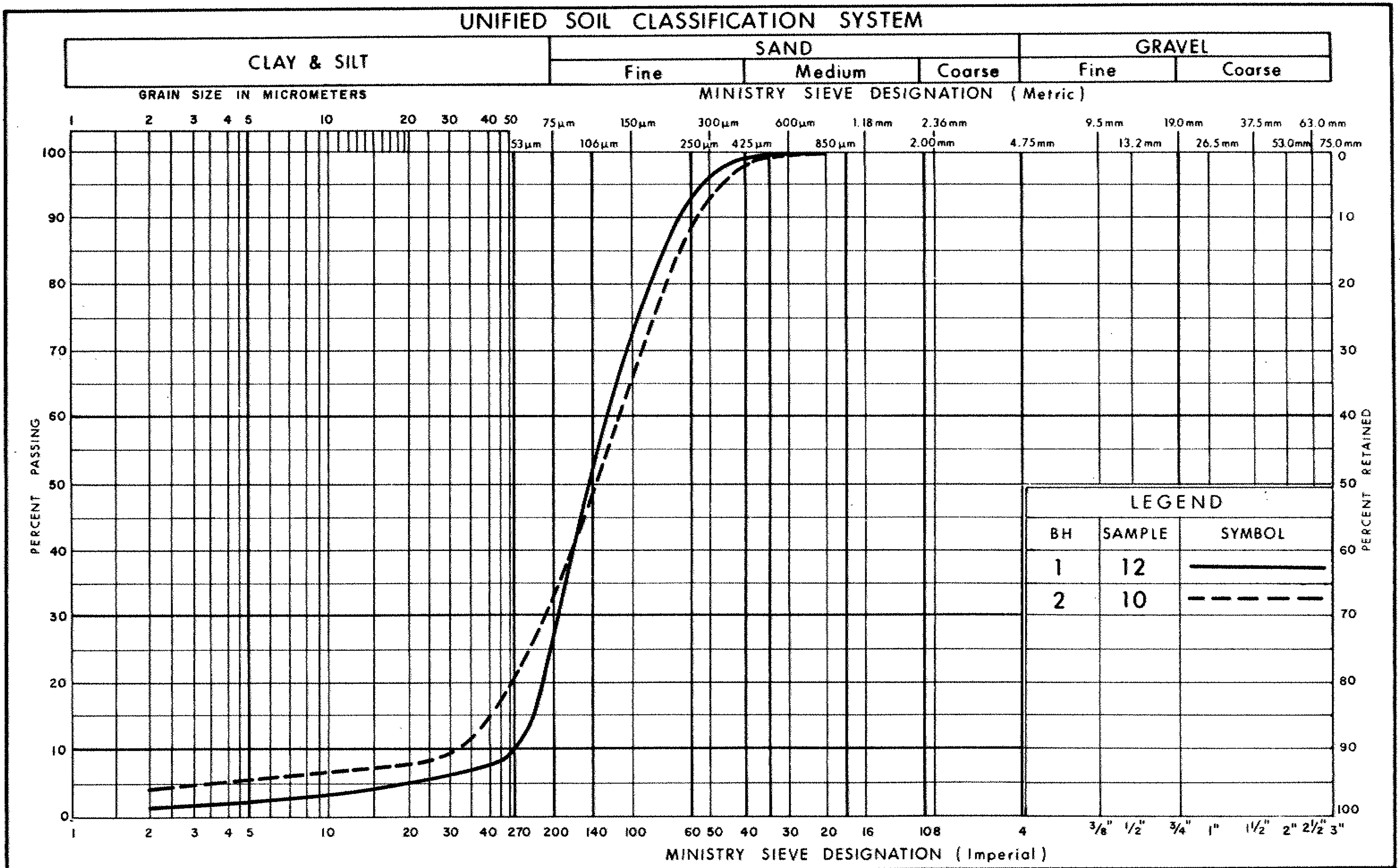


Fig 5

WP 210-85-01

78 12 M



Ministry of Transportation

Ontario

GRAIN SIZE DISTRIBUTION
SILTY SAND

FIG No 6

W P 210-85-01

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/0.3 m)	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:

R Q D (%)	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

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No 1

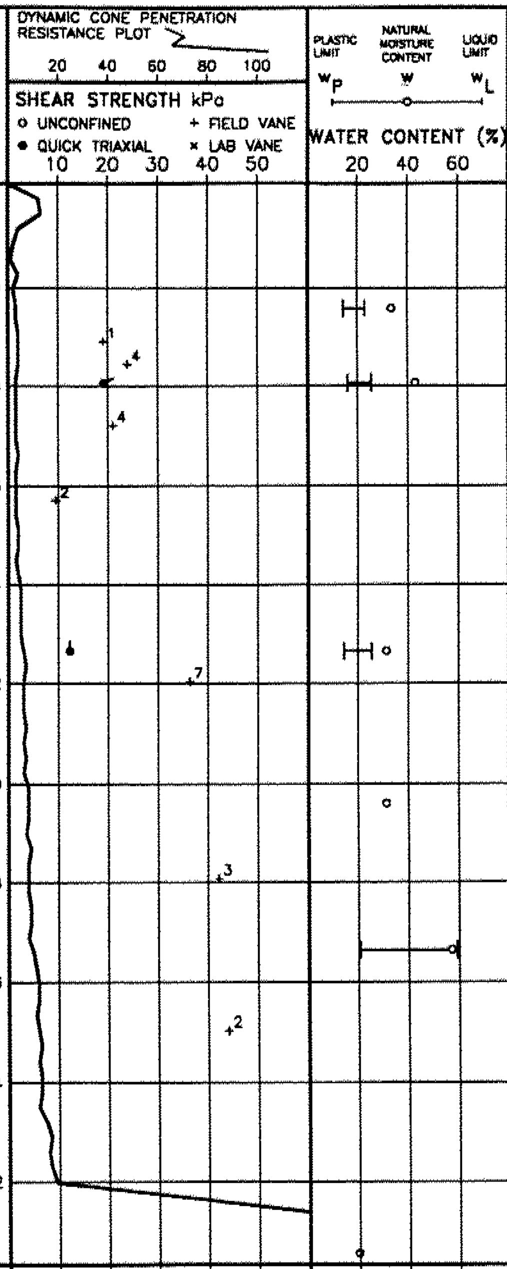
 METRIC

W.P. 210-85-01 LOCATION STATION 16+820 : O/S 7.5 m RT ORIGINATED BY JLM

DIST 5 HWY 27 BOREHOLE TYPE H S AUGER AND CONE TEST COMPILED BY TCK

DATUM GEODETIC DATE 1990 08 21 CHECKED BY TCK

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
202.1	GROUND SURFACE										
0.0	SAND and GRAVEL (FILL) Brown										
201.2 / 0.9	Grey	1	SS	3							
	CLAYEY SILT, Trace to Some Sand, Occ. Clay and Sand Layers, Very Soft to Firm	2	SS	2	▼	200					
		3	SS	0				0	4	71	25
		4	TW	PM		198	17.4	0	11	64	25
		5	TW	PM		196					
		6	SS	1		194					
		7	TW	PM		192	18.1	0	1	54	45
		8	SS	1		190					
		9	TW	PM		188					
		10	SS	1		186		0	1	22	77
		11	SS	1		184					
182.0 / 20.1	SILTY SAND Compact					182					
180.3		12	SS	15				0	73	26	1
21.8	End of Borehole										



+³, ×³ : Numbers refer to Sensitivity

15 ◇ 5 (%) STRAIN AT FAILURE (20 above, 10 below)

RECORD OF BOREHOLE No 2

METRIC

W.P. 210-85-01 LOCATION STATION 16+830 ;O/S 7.5 m LT ORIGINATED BY JLM

DIST 5 HWY 27 BOREHOLE TYPE HS AUGER and Cone Test COMPILED BY TCK

DATUM GEODETIC DATE 1990 08 22 and 23 CHECKED BY TCK

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
202.1	GROUND SURFACE
0.0 / 201.0	SAND and GRAVEL (FILL) Brown
1.1	Grey CLAYEY SILT, trace to some Sand Occ.Clay and Sand Layers Very Soft to Firm
182.0 / 20.1	SILTY SAND Dense to Very Dense
178.8 / 23.3	End of Borehole

* Artesian Condition was encountered after completion of Borehole. Head was not measured in view of urgency of sealing.

SAMPLES

NUMBER	TYPE	'N' VALUES
1	SS	1
2	SS	2
3	TW	PM
4	SS	0
5	SS	0
6	SS	2
7	TW	PM
8	TW	PM
9	SS	3
10	SS	33
11	SS	67

GROUND WATER CONDITIONS

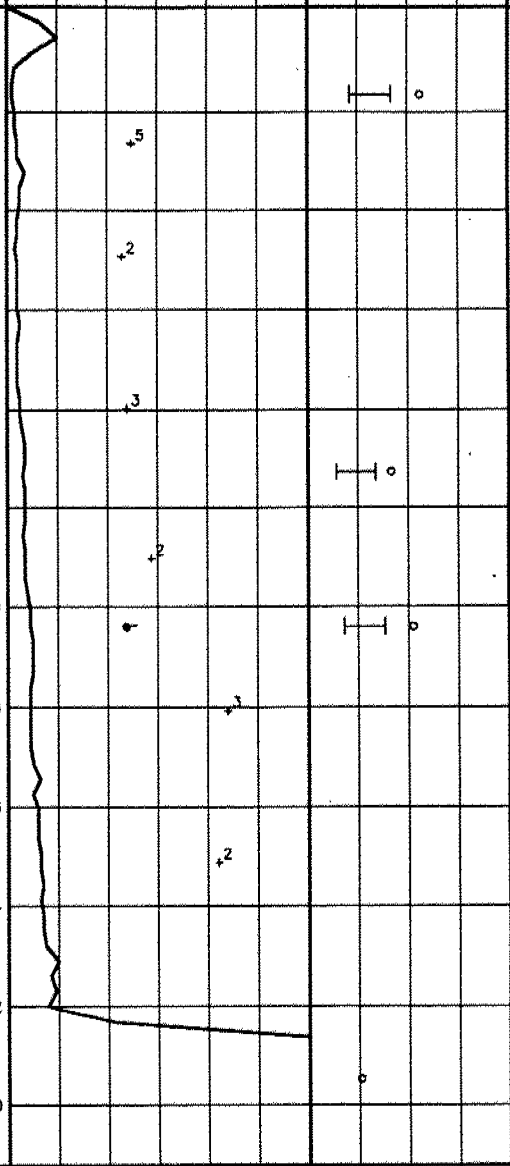
ELEVATION SCALE: 200, 198, 196, 194, 192, 190, 188, 186, 184, 182, 180

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, x LAB VANE: 10 20 30 40 50

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

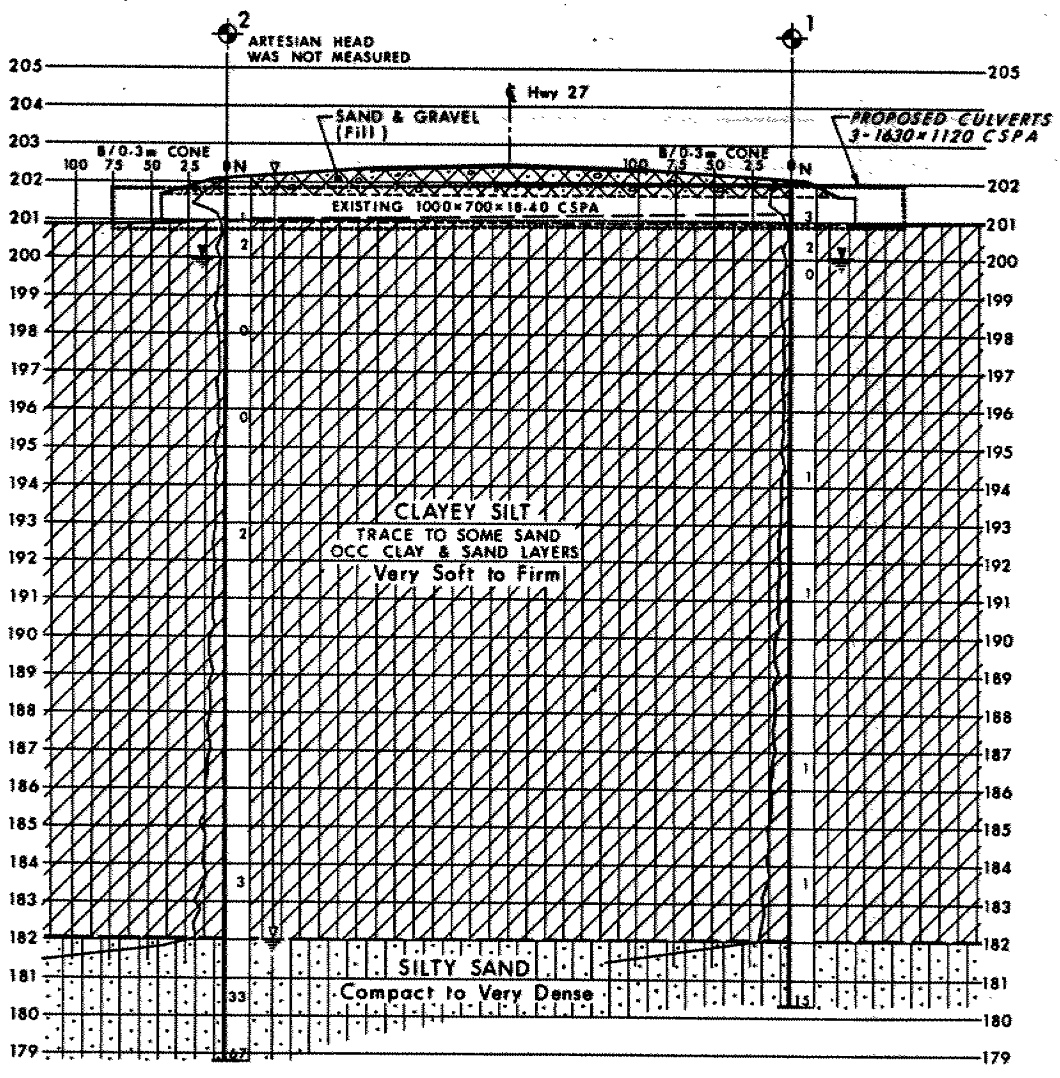


UNIT WEIGHT / REMARKS & GRAIN SIZE DISTRIBUTION (%)

Sample	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
2		0	2	51	47
6		0	18	34	48
7	17.0	0	3	42	55
10		0	67	29	4

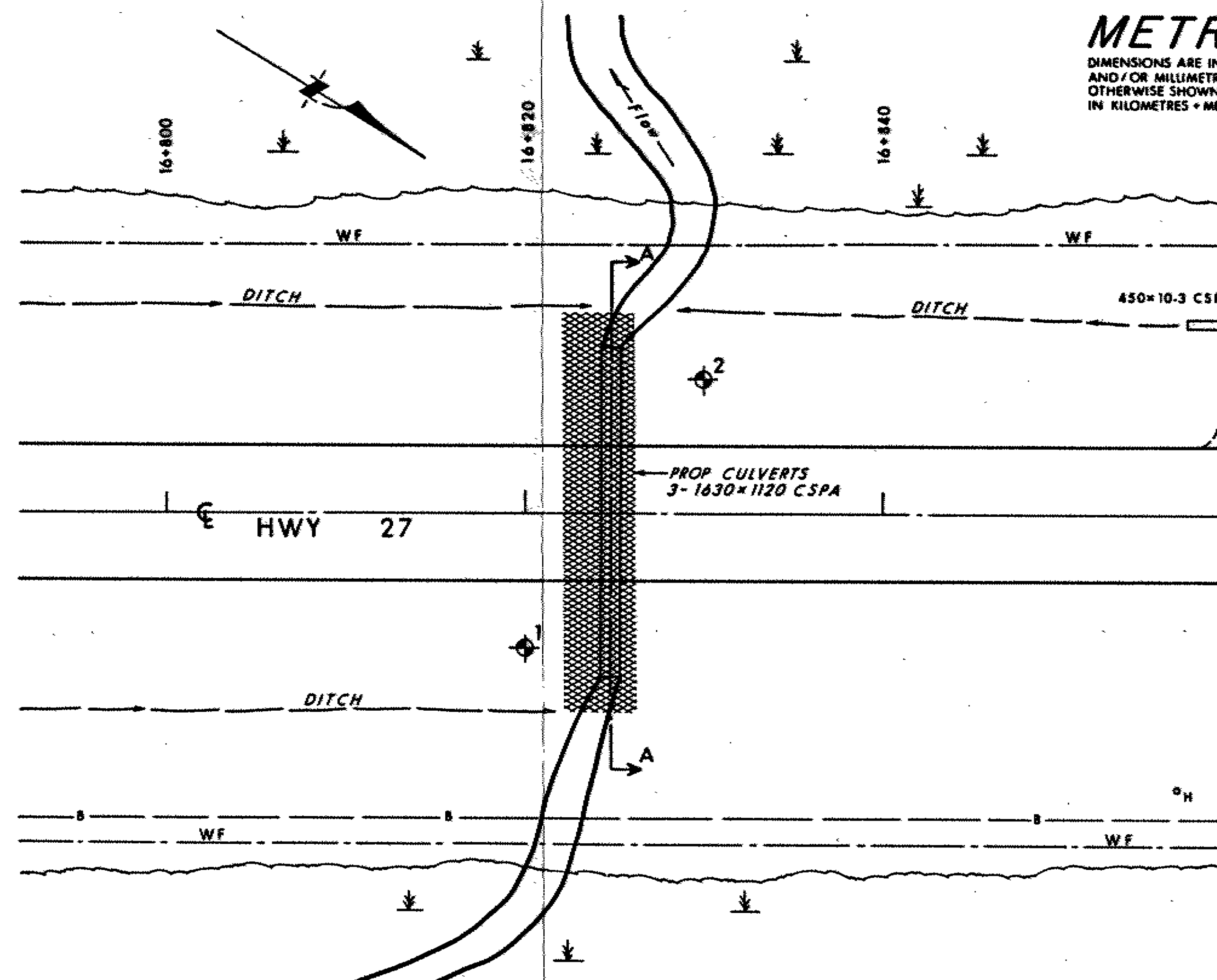
$+^3, x^3$: Numbers refer to Sensitivity

15 ◇ 5 (%) STRAIN AT FAILURE (20 above, 10 below)



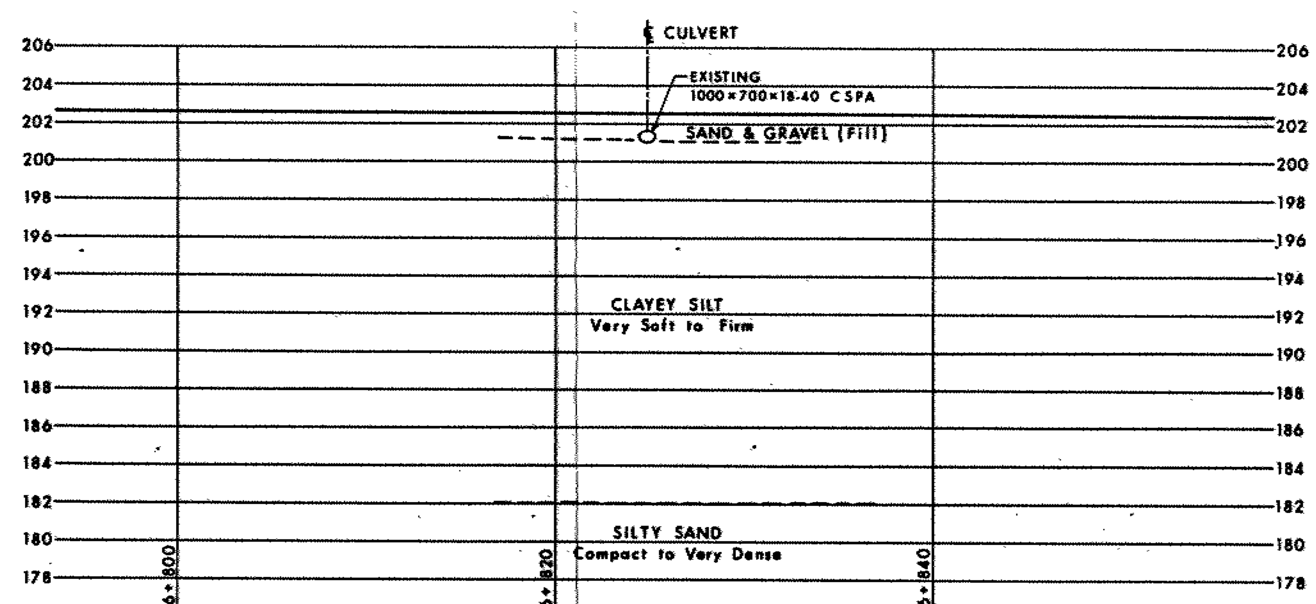
SECTION A-A

SCALE 2m 1 0 2m



PLAN

SCALE 4m 2 0 4m



℄ PROFILE HWY 27

SCALE 4m 2 0 4m

REF PLATE No 78-27/39-0

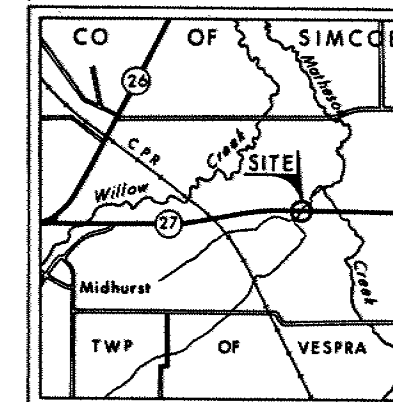
METRIC

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

CONT No
WP No 210-85-01

SHEET

HWY 27 CULVERT REPLACEMENT
(STA 16+824.8)
BORE HOLE LOCATIONS & SOIL STRATA



KEY PLAN
SCALE 1km 0 1 2km

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)
▽	WL at time of investigation 1990 08
⊥	Artesian Head
▽	Artesian Encountered

No	ELEVATION	STATION	OFFSET
1	202.1	16+820	7.5m Rt
2	202.1	16+830	7.5m Lt

=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 31D-331

HWY No 27			DIST 5
SUBM'D T K	CHECKED	DATE 1990 11 20	SITE
DRAWN	CHECKED	APPROVED	DWG 2108501-A

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

memorandum

Ontario

To: M. Bond
Head, Geotechnical Section
Southwestern Region

Date: 1991 01 17

Attn: D. McLay, Soils Supervisor

From: Foundation Design Section
Room 315, Central Building

Re: Review of Preliminary Drawing
Culvert Replacement at Hwy. 27
Township of Vespra
W.P. 210-85-01
District 5, Owen Sound

Further to the telephone conversation between your Mr. D. McLay and our Mr. Tae Kim, and subsequent "FAX' message from Mr. G. Gates of Planning & Design Section on January 16, 1991, the schematic drawing has been reviewed by this section.

Based on our review, it is concluded that the design confirms our recommendations. However, it should be noted that for the 600 mm rock protection, geotextile underneath the rip-rap be eliminated since the potential sliding would occur along the surface of the geotextile and the angular rock would puncture the geotextile.

It is also understood that the designer would like to eliminate the proposed clay sealer behind a 600 mm layer of rip-rap due to the difficulty of installation. However, it is still our opinion that a 1 m thick blanket of clay material should be placed at the culvert inlet as recommended in our report (WP 210-85-01, Dec. 10/90) in order to prevent piping around the culvert. This technique has been used successfully for the similar situation of high water level in Central and Northwestern Regions for a long period of time. Alternatively, interlocking sheet piling or wing walls with cut-off wall can be considered if the clay seal is not favourable. However, it should be noted that the alternatives would be much more expensive than the clay sealing.

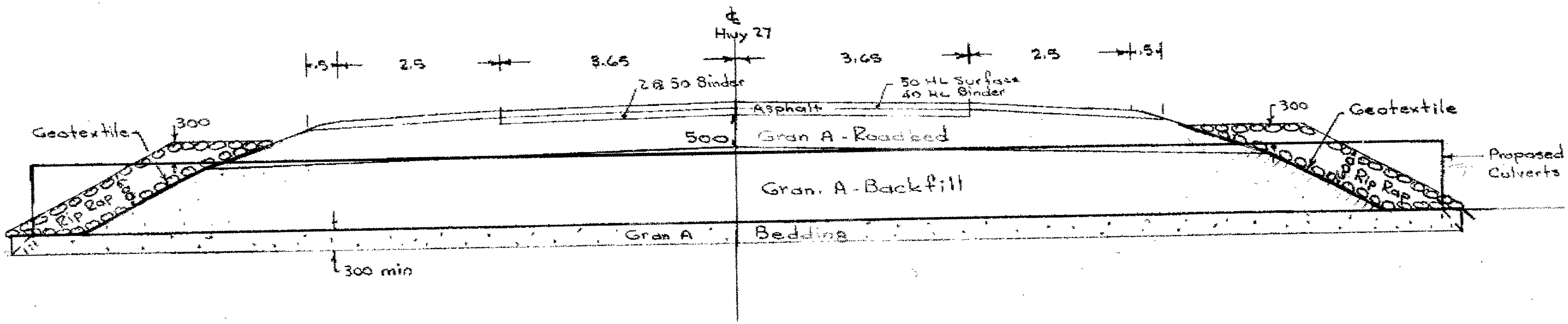
We have no further comments. If you have any questions, please contact this office.

Tae C Kim

Tae C. Kim, P. Eng.
Sr. Foundation Engineer
for
M. Devata, P. Eng.
Chief Foundation Engineer

MD/TCK/jb

cc: G. Gates - Planning & Design Section
Southwestern Region



PLACE 3 1630 x 1120 x 22.0 CSPA CULVERTS

Hwy 27
WP 210-85-00
DIST. 5

memorandum

Ontario

~~235-3731~~

To: Mr. M. Bond
Head, Getoechnical Section
Southwestern Region

Date: 1990 11 13

Attn: D.A. Hohnstein
Pavement Design & Evaluation Officer

From: Foundation Design Section
Room 315, Central Building

Subject: Hwy. 27 Culvert Replacement
at Sta. 16+825, with a triple C.S.P.A.
Township of Vespra, W.P. 210-85-01
District 5, Owen Sound

The field work for the foundation investigation for the above noted project has been completed. Due to the urgency of this project as per your request, we are herewith submitting our advanced recommendations. This memo provides summary of subsurface conditions and recommendations which will permit your office to proceed with design of the above structure.

The complete foundation investigation and design report will be forwarded to your office at a later date upon the completion of laboratory testing and drafting. In the mean time, if additional information is required, please contact this office.

SITE DESCRIPTION AND GEOLOGY

The site is located on Hwy. 27, approximately 10 km north of Barrie and 4 km south of the intersection of County Road #22 and Hwy. 27 in the Township of Vespra, County of Simcoe. The topography in the immediate area is generally flat to gently undulating. The immediate vicinity of the site is occupied by farms and mixed bushland.

Physiographically, the site is located in the "Simcoe Lowland" region known as the Nottawasaga Basin. (Ref.: Chapman and Putnam, 1984). This basin has several distinctive divisions. The terrain at the site bears the characteristics of the Camp Borden sand plain and the Minesing flats. Subsoil was believed to be deposited by the tributaries of the Nottawasaga River, the predominant sediments being fine sands and silty sands. The remainder of the basin is floored with calcareous clay, some marl and in the south, with the sandy delta of the early Nottawasaga.

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SUBSURFACE CONDITIONS

The subsoil conditions are generally uniform consisting primarily of two distinct deposits. The upper layer consists of a deep deposit of clayey silt ranging in thickness of about 19.0 m at BH 2 and 19.5 m at BH 1. Underlying this stratum is a silty sand. The thickness of this deposit was not proven.

Overburden was covered with a thin layer of road fill material at two borehole locations. This layer consists of sand and gravel with a maximum thickness of about 1.1 m at BH 2.

Grounwater conditions were observed through the measurement of water level in the open boreholes. The groundwater level in both boreholes after completion was found to be some 2.1 m below the existing road surface which corresponds to an approximate elevation of 200.0 m. However, it should be noted that an artesian condition was also encountered at BH 2 after the completion of borehole. This borehole was sealed with a mixture of bentonite pellets and gravel at the source of artesian zone. No attempt was made to measure the artesian head in view of urgency of sealing the borehole without any undue delay.

RECOMMENDATIONS

It is understood that the original proposal was for a concrete box culvert replacement. In view of the soft normally consolidated subsoil at the site, substantial deformations are anticipated as a result of applied vertical loading. It was recommended by the regional Geotechnical Section that the proposed concrete culvert be replaced with a triple steel pipe arch culverts.

It is proposed to replace the existing single small size C.S.P.A. (1.0 m x 0.7 m x 18.4 m) at the site with a triple larger size C.S.P.A. (1.630 m x 1.12 m x 22.0 m). The proposed culverts are to be located at the same location. The proposed invert elevation is about 200.8 m while the proposed grade elevation of Hwy. 27 is about 202.5 m. Based on this, a culvert roof cover of approximately 0.7 m and approach fills in the order of 1.7 m will be required.

Recommendation for the Steel Pipe Arch Culverts

The steel pipe arch culverts can be founded at the proposed invert elevation (200.8 m) provided it is constructed in accordance with current MTO bedding and backfilling requirements as specified in OPSS 421 and OPSD 802 series. The major items of consideration are summarized below.

Bedding to Structure

1) The bedding should consist of a granular pad (Granular 'A') with a minimum thickness of 300 mm. The excavation for the bedding shall extend to a width of a minimum 1.5 m on either side of the culvert.

2) All softened material created during construction of foundation and any deleterious or organic material present at the founding elevation shall be removed and replaced with a granular material.

3) For the width of the area under the bottom radius of the pipe arch the bed should be levelled and left uncompacted for a depth of 300 mm below the invert level.

4) The culvert pipe bed is to be carefully shaped to receive the lowest segment of pipe formed by the bottom radius.

5) The area adjacent to the haunches of the pipe and below the portion of the sloping invert should be compacted by means of hand tamping.

6) The minimum depth of cover shall be the span of the pipe culvert divided by 6 or 300 mm, whichever is greater.

7) Scour protection at the culvert inlet and outlet shall be provided to protect the culvert bedding. The design of the scour protection shall be made in conjunction with applicable hydrological requirements.

Backfill to Structure

Backfill for the plate pipe culverts shall be designed and constructed according to OPSD 803 series. The following items of consideration are hereby reinforced.

1) The frost penetration depth at the site is 1.5 m and the frost taper should be designed accordingly to the Regional geotechnical requirements.

2) The backfill material should be machine compacted on both sides of the pipe and between culverts, simultaneously in equal lifts in accordance with OPSS 501.08.02.

3) To prevent piping around the culvert, a 1 m thick blanket of approved impermeable material (refer to OPSS 1205) should be placed at the culvert inlet as a sealer behind a 600 mm layer of rip-rap. This blanket should extend to the high water level. Around the culvert outlet, a 1 m thick blanket of Granular 'A' material should be placed as a filter behind a 600 mm layer of rip-rap.

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4) Backfill material shall consist of a free draining material such a Granular 'A' or Granular 'B' to prevent hydrostatic pressure build-up on the culvert walls. Design parameters of the soil are given in Table 1 below.

Table 1 - Backfill Properties

	Gran. 'A'	Gran. 'B'
Angle of Internal Friction (ϕ)	35°	30°
Unit Weight (kN/m^3), γ	22.8	21.2
Coefficient of Active Earth Pressure(Ka)	0.27	0.33
Coefficient of Earth Pressure at Rest(Ko)	0.43	0.50

The earth pressure coefficient at rest is to be used when the design of the abutment walls are rigid and unyielding.

The backfill beyond the granular wedge as illustrated on OPSD 803 series can consist of acceptable borrow material as defined in OPSS 212.05.

Stability and Settlement

No stability problems are anticipated for the proposed height of permanent embankment (about 1.7 m) constructed to a 2H:1V geometry.

However, as discussed previously, in view of the softy normally consolidated subsoil at the site, substantial settlements are anticipated if additional embankment load is applied. Therefore it is recommended that the proposed grade of Hwy. 27 must be maintained without any grade revision.

Recommendations for the Concrete Box Culverts

The existing steel pipe culvert has been performed satisfactorily for the last 16 years without any signs of structural distress, in spite of the settlement induced by roadway embankment. It is believed that the major portion of the settlement has been completed. No further settlement will take place in this area if no grade revision is contemplated. In view of this, a concrete box type culvert could be equally suitable at this location. However, the final choice should be based on the economical and practical construction considerations. If concrete type of culverts is considered at this particular location, the following design values are recommended for the purpose of the O.H.B.D.C.

Factored Bearing Capacity at U.L.S.	75 kPa
Bearing Capacity at S.L.S. Type II	50 kPa

A footing width of 3.0 m with an embedded depth of 1.5 m was used in calculation of the above capacities. The magnitude of the differential settlement of the footings for S.L.S. Type II is anticipated to be within 25 mm, provided the subsoil is not disturbed by construction activities.

Bedding and backfilling for the concrete box culverts will be similar to those for the steel pipe culverts.

Construction Considerations

Temporary Diversion

To facilitate the construction of the culvert, a temporary diversion of the Creek should be considered.

Dewatering

It is recommended that conventional sump pump techniques with perimeter ditches be applied to assure that the foundation construction is advanced in the dry.

Temporary Excavation Slopes

Temporary excavation cuts for foundation elements should be at a slope no steeper than 2H:1V in view of the high water table.

We believe this memorandum meets with your present requirements.

If you have any questions, please contact us.

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for

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