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W.P. No. 46-78-07

CONT. No. 81-97

W. O. No.

STR. SITE No.

HWY. No. 17

LOCATION Jeanne D'Arc Blvd.
Underpass

No of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:



**Ministry of
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REMARKS

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ENGINEERING MATERIALS OFFICE
PAVEMENT & FOUNDATION DESIGN SECTION

WP 46-78-07

DIST #9

HWY 17

STR SITE

Jeanne D'Arc Boulevard Underpass

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FOUNDATION INVESTIGATION REPORT

For

Jeanne D'Arc Boulevard Underpass
Lot 6, 7, Conc. 1, Gloucester Township
Hwy. 17, District 9, Ottawa
W.P. 46-78-07, Site 3-339

INTRODUCTION

This report contains the results of a foundation investigation carried out at the above site. The field work was carried out from July 14 to July 25, 1980 and consisted of three sampled boreholes and two supplementary dynamic cone tests. The borings were advanced by hollow stem augers to a depth of up to 15 metres below ground surface; thereafter washboring techniques were employed to advance the borings to bedrock at a depth of up to 42 metres below ground level. Diamond drilling techniques were then utilized in all boreholes to obtain up to 3 metres of BXL size rock core samples.

SITE DESCRIPTION AND GEOLOGY

This site is located on Hwy. 17 approximately 3.0 km east of Montreal Road/Hwy. 17 intersection in the Township of Gloucester, Regional Municipality of Ottawa-Carleton.

In the site vicinity, the terrain is generally flat. Hwy. 17 level crosses Jeanne D'Arc Blvd. at approximate elevation 56.

Physiographically, the site is located within the Ottawa Valley Clay Plains. This region is characterized by extensive deposits of sensitive marine clay overlying glacial till and dolomite bedrock.

SUBSURFACE CONDITIONS

General

Subsoil conditions across the site are generally uniform. Beneath a thin veneer of topsoil is a layer of silty sand, approximately 2 metres thick. Extending from this silty sand layer and to a depth

up to 37 metres below the ground surface is the dominant deposit consisting of firm to very stiff sensitive clay. The clay overlies 1 to 2 metres of a compact to very dense glacial till composed of a heterogeneous mixture of silt, sand, gravel and occasional cobbles and boulders. Underlying the glacial till is dolomite bedrock.

The boundaries between the various subsoil and bedrock types are shown on the Borehole Record Sheets. The locations of the boreholes are shown on Drawing No. 467807-A. This drawing will be replaced by a more detailed one, showing the stratigraphical profile once the site plan is available.

Following is a brief description of subsoil and bedrock types.

Silty Sand

A layer of silt sand, approximately 2 metres thick, was found below the topsoil. This granular material may be inferred from the construction of the existing Hwy. 17.

Sensitive Clay

This deposit was encountered immediately below a thin veneer of topsoil or granular fill material and is estimated to have a thickness ranging from 35 to 37 metres. The deposit is generally grey in colour except for the upper 2 to 4 metres which is desiccated and has a brownish grey mottled colour. Laboratory and in-situ testing performed on representative samples from this deposit gave the following results.

<u>Geotechnical Properties</u>	<u>In the Upper Desiccated Zone</u>		<u>Below the Desiccated Zone</u>	
	<u>Range</u>	<u>Average</u>	<u>Range</u>	<u>Average</u>
Natural Moisture Content (W)%	18-40	31	49-73	62
Liquid Limit (w_L)%	74	-	45-75	58
Plastic Limit (w_p)%	16-28	23	18-25	22
Plasticity Index (I_p)%	45	-	25-52	36
Liquidity Index (I_L)	0.1-0.45	0.31	1.21-2.40	1.84
Bulk Unit Weight (γ) kN/m ³	-	-	15.7-16.4	16
Undrained Shear Strength (C_u) Kpa	<u>Range</u>	<u>Sensitivity</u>	<u>Range</u>	<u>Sensitivity</u>
Field Vane Tests	>96	-	38-96	5-14
Unconfined Compression Tests	-	-	26-60	3-6

<u>Consolidation Tests</u>	<u>Range</u>
Degree of Preconsolidation ($\sigma'_p - \sigma'_{ro}$) Kpa	144-220
Initial Void Ratio	1.7364-2.006
Compression Index	1.4-2.8

The results of the Atterberg Limit testings are shown on the Plasticity Chart (Figure 1). These results indicate that the deposit is inorganic and mainly of high plasticity (CH zone). The deposit may be described as a sensitive clay as evidenced by the high sensitivities (5-14) measured by the field vane testing. Furthermore, the Liquidity Index of the cohesive soil below the desiccated zone is greater than 1, confirming that the non-desiccated cohesive deposit is sensitive to remoulding.

Six consolidation tests were performed on samples from this deposit and are summarized on Figure 2. The consolidation testing indicates that the deposit has been preconsolidated by a pressure of 144 to 220 kPa in excess of the preconsolidation pressure, the deposit will undergo significant consolidation.

The results of in-situ vane testing are summarized on the Shear Strength vs. Depth Profile, Figure 3.

The vane testing indicates that the undrained shear strength is greater than 96 kPa in the first meter of the desiccated zone and thereafter decreases abruptly to a low of 40 kPa at a depth of about 2 metres. The shear strength then gradually increases with depth to greater than 96 kPa at a depth of about 7 meters below ground surface. Based on these results the consistency is described as very stiff in the upper desiccated zone. Below this it is generally firm to stiff, generally increasing with depth.

Glacial Till

The glacial till stratum was found immediately below the sensitive clay deposit and was observed to have a thickness of 4 to 7 meters. The deposit is mainly composed of a heterogeneous mixture of silt, sand and gravel. However, just above the bedrock, numerous cobbles and boulders were found. In order to penetrate the cobbles and boulders, diamond drilling technique was utilized. The results of grain size

distribution testing performed on samples obtained from 2" O.D. split spoon samples from the deposit are plotted on Figure 4.

Based on the Standard Penetration Test 'N' values ranging from 32 to 88 blows per 0.3 m, the relative density of this non-cohesive glacial till deposit may be described as dense to very dense.

Dolomite Bedrock

Immediately below the glacial till is the bedrock. The bedrock surface was found to vary from 40.5 to 42.5 meters below ground surface which corresponds to elevations 13.5 to 15.5 meters. The bedrock is composed of hard, fine textured, medium grey dolomite. The upper 0.5 to 1.0 meter of the bedrock is generally in a weathered condition. However, below this upper layer is generally sound bedrock.

GROUNDWATER CONDITIONS

Groundwater conditions were observed by measuring the water level in the open boreholes. The groundwater levels were found to be 2.1 to 3 meters below ground surface in boreholes #4 and #2. This corresponds to elevation 53.9 and 53.5 meters.

DISCUSSION AND RECOMMENDATIONS

It is proposed to construct a two span (37.4 m, 37.4 m) structure to carry the Jeanne D'Arc Boulevard over the proposed Hwy. 17, E.B.L. and W.B.L. The centreline of the structure will be located at about station 19+118, Hwy. 17, E.B.L. No preliminary profile grades are available to date, but the information supplied by the Eastern Region indicates that the maximum fill height is approximately 7 meters.

Subsoil conditions across the site are generally uniform. Extending from the ground surface to a depth of 37 meters is a firm to very stiff grey sensitive clay. This deposit is underlain by up to 7 meters of dense to very dense glacial till which is in turn underlain by bedrock. Groundwater was observed at a depth of about 2 to 3 meters below ground surface.

The extensive deposit of sensitive clay is the governing factor from the foundation point of view, since it is imperative that this stratum should not be overstressed by the embankment loading. In view of the importance of this matter, this aspect will be discussed first.

Approach Fills - Stability Consideration

Analysis in terms of total stresses have been carried out to determine the stability of fills including surcharge requirements. In this method of analysis, stability is governed by the undrained shear strength properties of the foundation and fill materials. The following data and values were used in carrying out the stability analysis.

Fill Material

Rock fill material $\gamma = 21.2 \text{ kN/m}^3$ $\gamma' = 11.4 \text{ kN/m}^3$
 $\phi = 35^\circ$ $c = 0$

Granular fill material $\gamma = 20.4 \text{ kN/m}^3$ $\gamma' = 10.6 \text{ kN/m}^3$
 $\phi = 30^\circ$ $c = 0$

Subsoil Conditions

Groundwater level elevation 54 m.

<u>Elevation (m)</u>	<u>γ (kN/m³)</u>	<u>γ' (kN/m³)</u>	<u>ϕ°</u>	<u>C_u (kPa)</u>
56.0-55.1	16	6.2	0	96
55.1-54.0	16	6.2	0	45
54.0-53.0	16	6.2	0	60
53.0-50.7	16	6.2	0	75
50.7-14.5	16	6.2	0	96

The analysis was undertaken assuming forward and/or side slopes of 1½:1 constructed of rock fill, and 2:1 constructed of granular type fill. The results of the analysis show either type of fill will be stable for fill heights up to 9 meters (i.e. fill height of 7.0 meters + 2.0 meters of surcharge). See Figure 5 and 6.

The proposed fill height is in the order of 7 meters, and hence no stability problems are anticipated.

Approach Fills - Settlement Considerations

Settlement will occur due to the consolidation of the underlying compressible clay deposit as a result of the embankment loading. Settlement analysis indicates that the maximum settlement due to consolidation of the sensitive clay deposit beneath a 7 meter fill height will be in the order of 0.3 meters. It is estimated that 90% of this settlement would occur in about 9 years after construction. (Figure 7).

In order to minimize post construction maintenance costs due to settlements, and also to reduce the negative skin friction on piles, it is recommended that the embankment be surcharge loaded for 2 meters for a period of 12 to 18 months prior to the foundation construction. Attached on Figure 8 are the minimum dimensional requirements for the temporary surcharge. The exact location of the toe of the front slope would depend on the location of the front face of the abutment footing and the space available in front of the abutment.

As an alternative to surcharge preloading, very light weight material, e.g. styrofoam, may be used behind the abutment to eliminate the preloading requirement. However, the full amount of settlement or a large percentage of it would still occur where the styrofoam core terminates, i.e. at location 'A'. This can be as much as 254 mm over a 12 m distance. (Ref. Figure 9).

If styrofoam is acceptable in spite of its high cost, a full height abutment design is required to make the abutment construction more practical. To compensate the cost of the higher abutment, shorter bridge length may be considered.

	Piles 310 HP 110	Factored Capacity U.L.S.	S.L.S. Type II
	- 7 -		
	Abutment	1280	880.
Structure	Pier	1600	1100

The piers and the abutments should be supported on end bearing steel 'H' piles driven to the bedrock surface. For estimating purposes the following pile tip elevations may be used.

Estimated Pile Tip Elevation (m)

North Abutment	el. 15.5
Pier	el. 14.5
South Abutment	el. 13.5

Because of the presence of boulders and cobbles in the glacial till, it is suggested that the pile tips be reinforced. It is important to note that piles stopped by the boulders and cobbles will not perform satisfactorily upon loading. It is imperative that the piles be driven past boulders to sound bedrock.

Considerable negative skin friction may be imposed on the piles supporting the abutments due to consolidation of the underlying clay deposit as a result of roadway embankment loading. In view of this, it is recommended that the capacities for the abutment piles should be reduced by 20%, i.e. 80% of their maximum allowable loads. For example, a HP 12x74 steel 'H' pile may be designed for 880 kN per pile. Piles for the pier may be designed for their maximum allowable loads, i.e. a HP 12x74 steel 'H' pile may be designed for 1100 kN per pile.

In addition to the negative skin frictional forces, lateral movement of clay subsoil due to strain imposed by the embankment loading will generally tend to displace the piles laterally and can cause rotation of the abutments. In view of this, we suggest that consideration be given to supporting the extreme ends of the wingwalls on end bearing piles founded as aforementioned. It is considered that this will improve the stability of the structure in the longitudinal direction. It is understood that if the approaches are constructed of rock fill material, special measures are to be adhered. In such a case, no rock fill material should be placed in areas where piles are to be driven. A composite granular core should be provided in these areas. A recommended composite section is shown on Figure 10.

Backfill behind the abutments should be composed of well compacted free draining granular material containing no boulders. Adequate drainage should be provided. The lateral earth pressure exerted on the abutment wall by the granular backfill can be computed assuming a unit weight of 21 kN/m^3 for the backfill and a coefficient of earth

pressure of

k_a - 0.35 for the "active" case where rotation about the base is allowed.

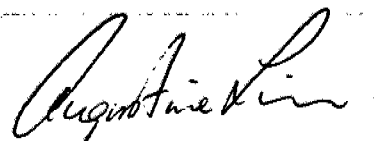
k_o - 0.5 for the "at rest" case where no rotation or translation about the base is permitted.

It should be noted that the aforementioned recommendations are provided based on preliminary data supplied by the Region. If and when proper geometry and other pertaining data become available, this Office will provide final recommendations based on the new information. Since no bridge site plan is available at this stage, only a sketch showing the borehole locations are included in this report. At a late date, a detailed subsurface drawing will be submitted when the proper bridge site plan is available.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of Mr. A. Liu, Trainee Engineer, using equipment rented from Johnston Drilling Co. Ltd., Ottawa.

This report was prepared by Mr. A. Liu, and reviewed by Mr. M. Devata, Senior Foundations Engineer.

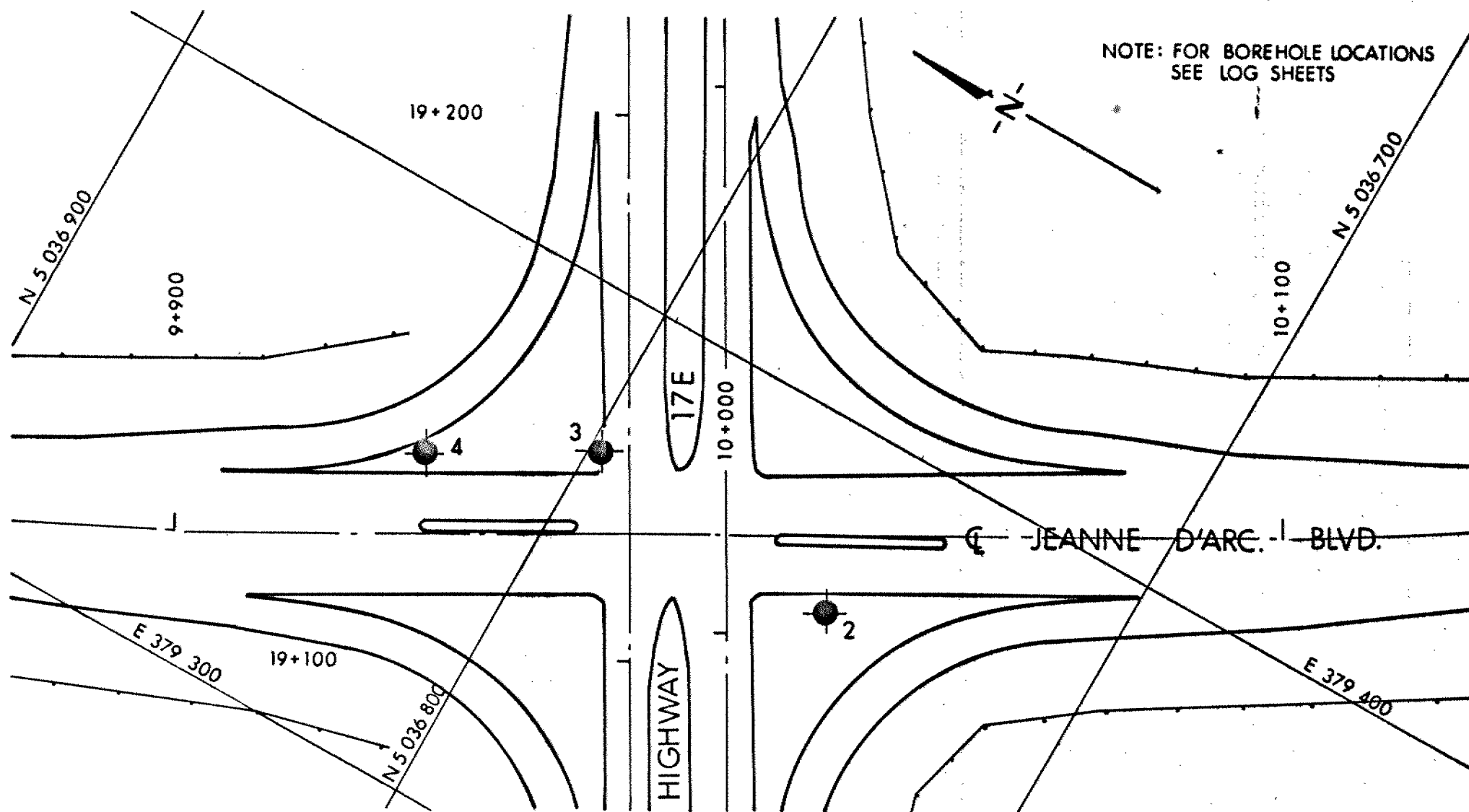


A. Liu, P. Eng.
Trainee Engineer



M. Devata, P. Eng.
Senior Foundations Engineer

October 8, 1980.



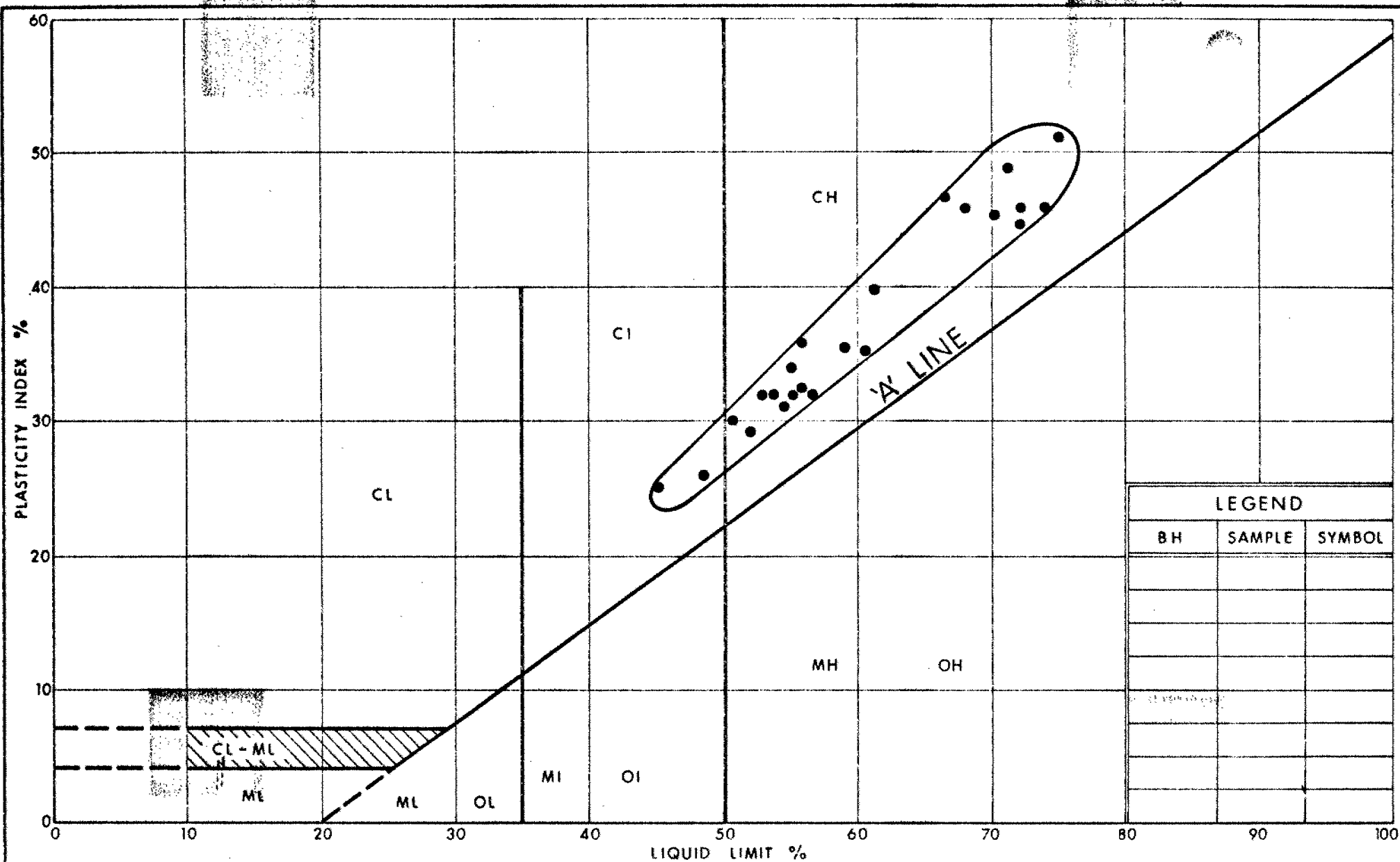
BOREHOLE LOCATION PLAN

SCALE 1:1000

WP 46-78-07
Dwg No 467807-A

APPENDIX

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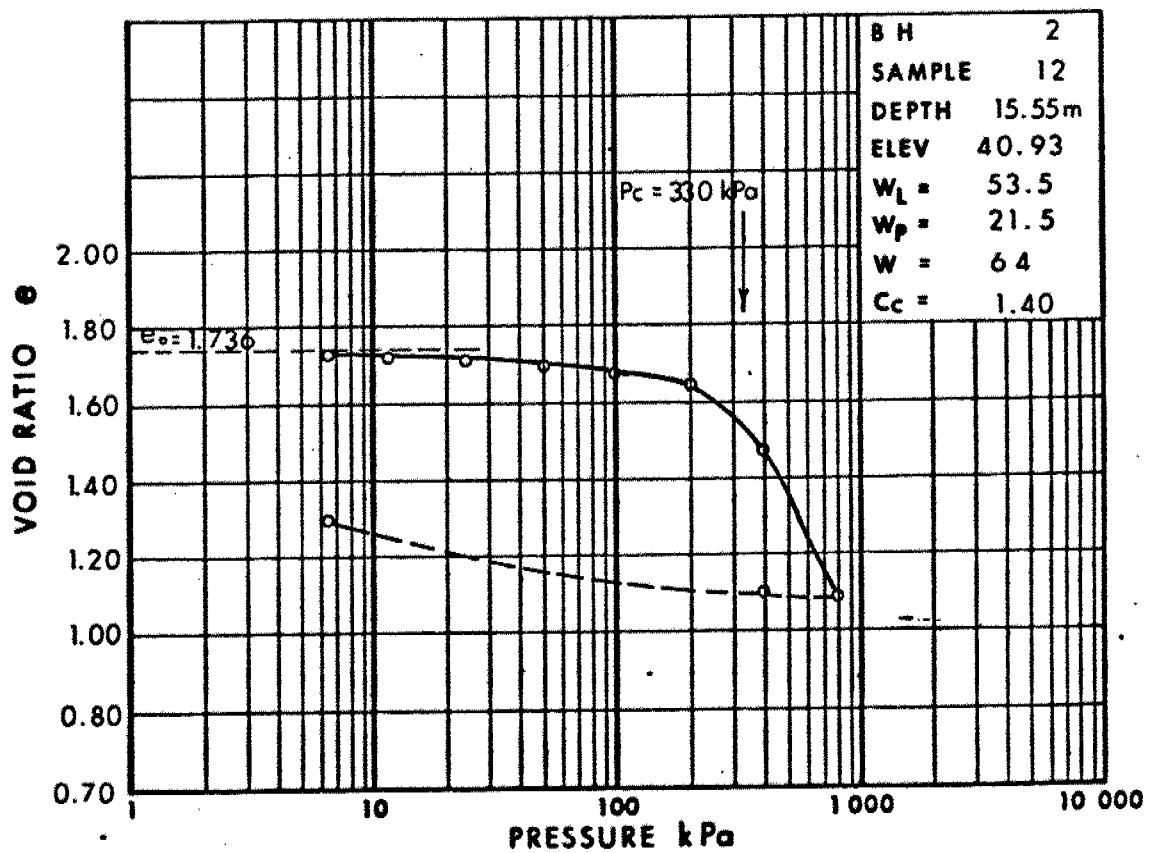
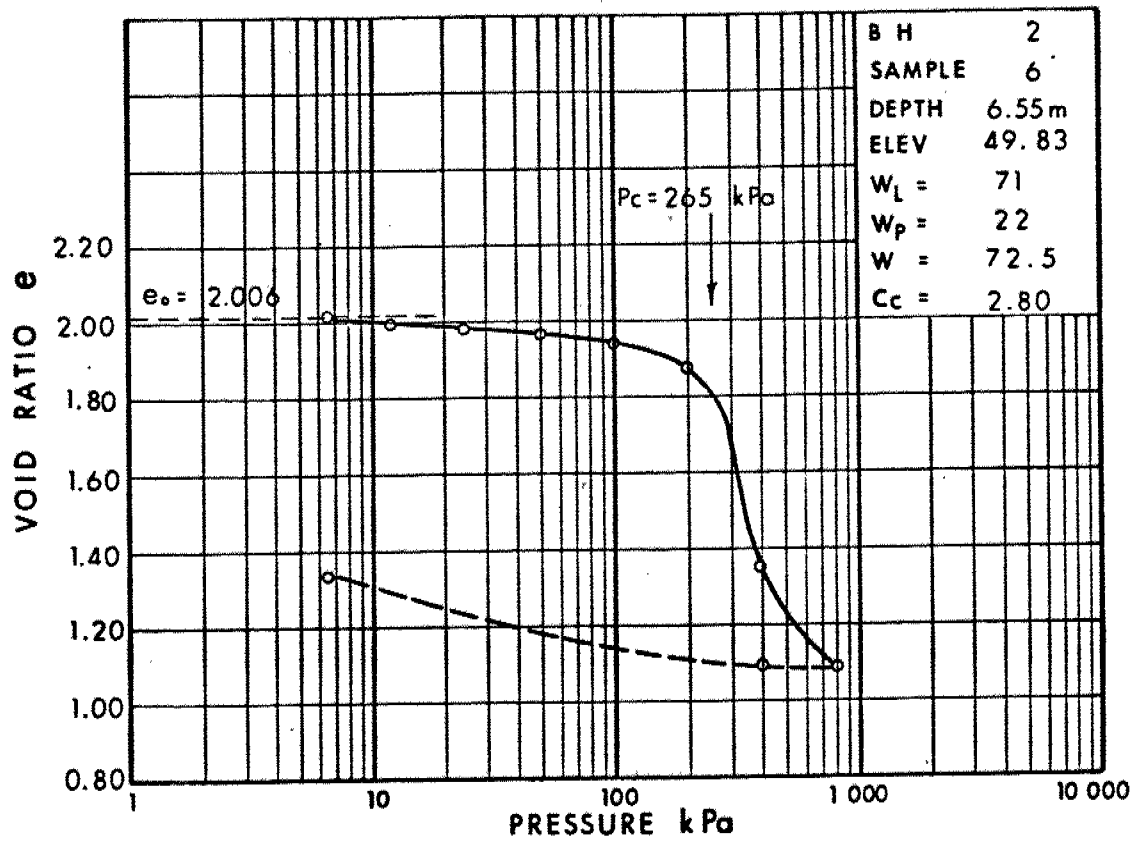
PLASTICITY CHART

SENSITIVE CLAY

FIG No 1

W P 46-78-07

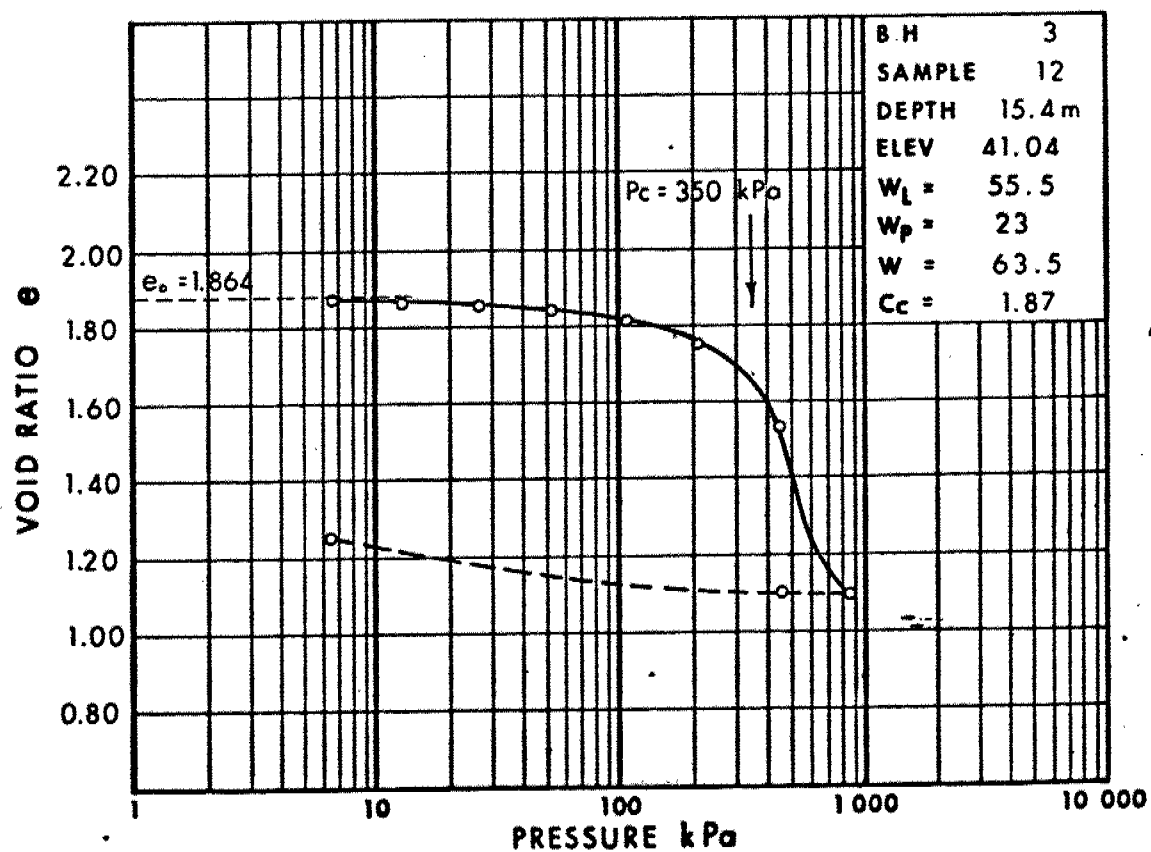
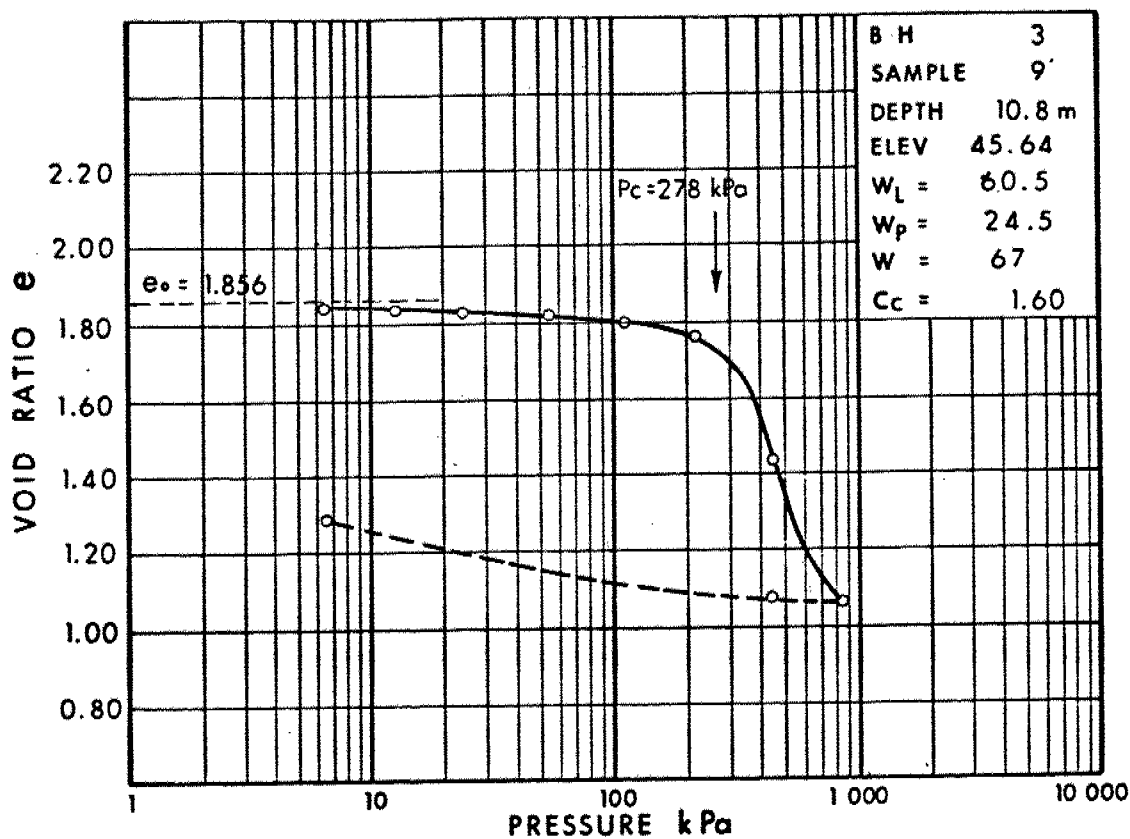
VOID RATIO - PRESSURE CURVES



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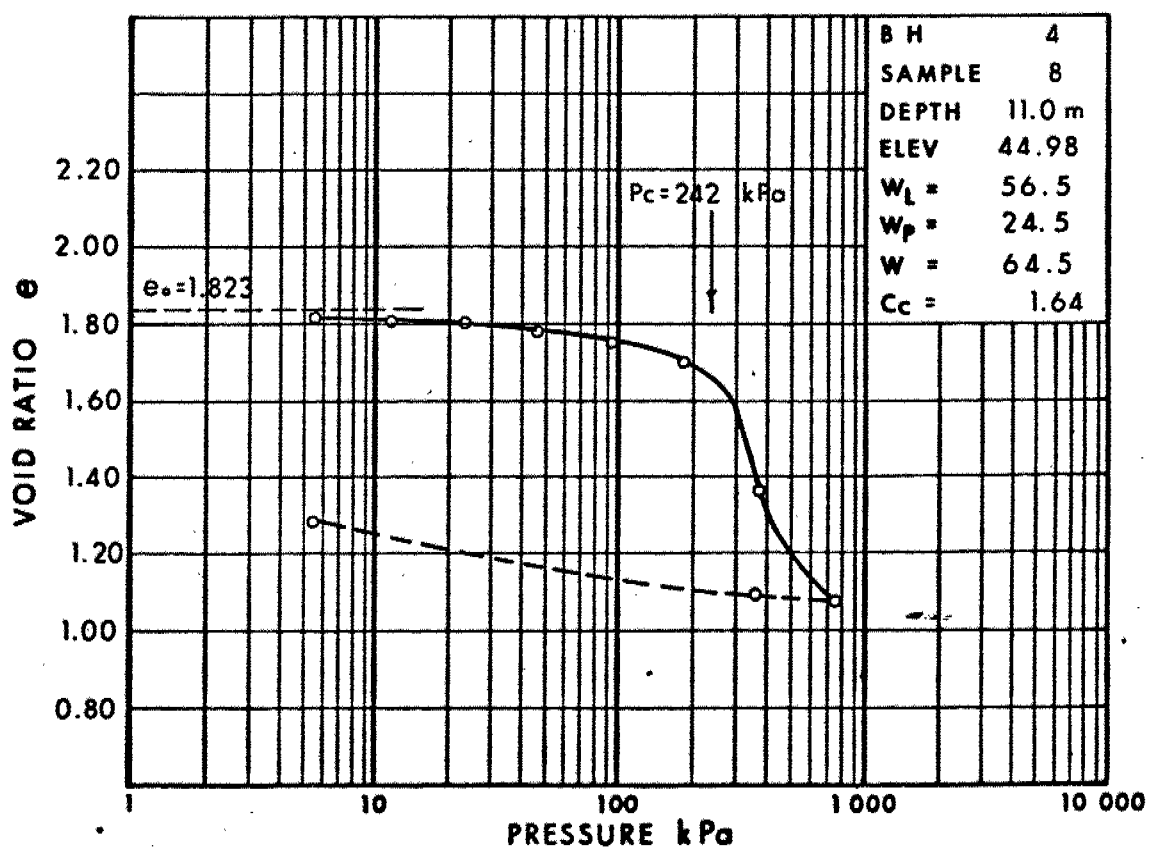
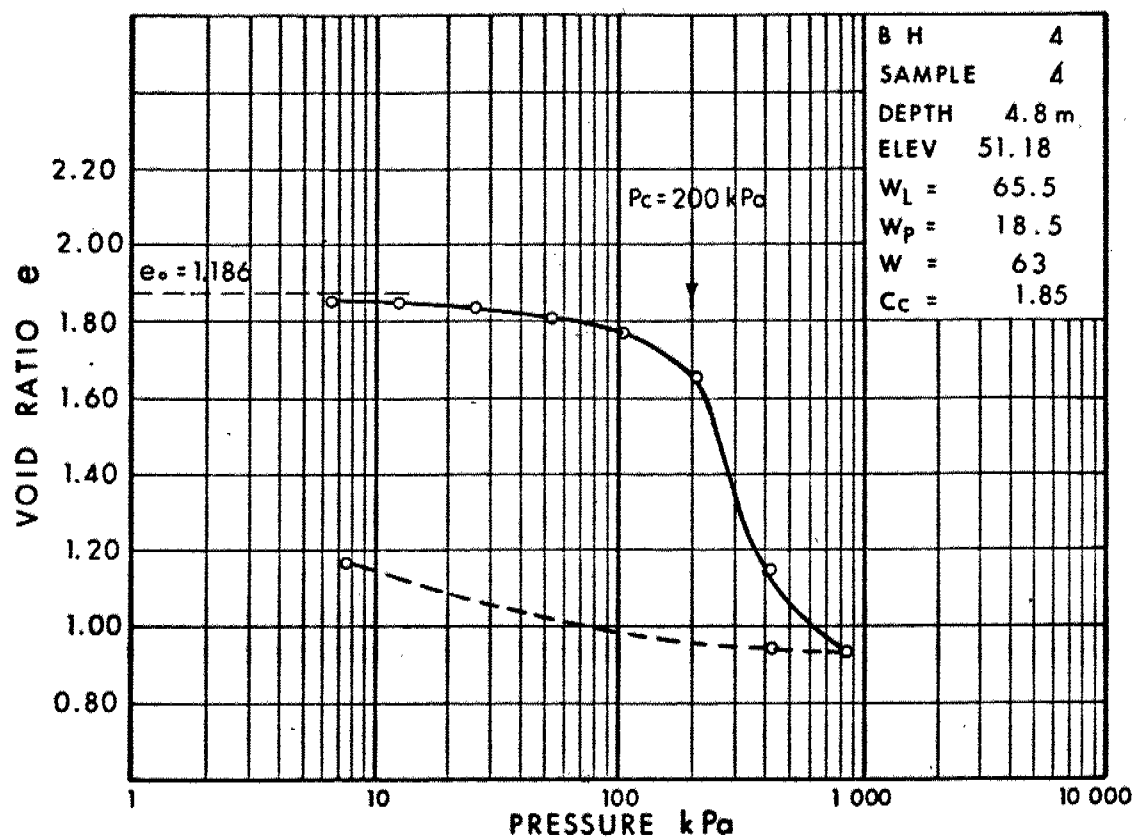
FIG No 2

VOID RATIO - PRESSURE CURVES

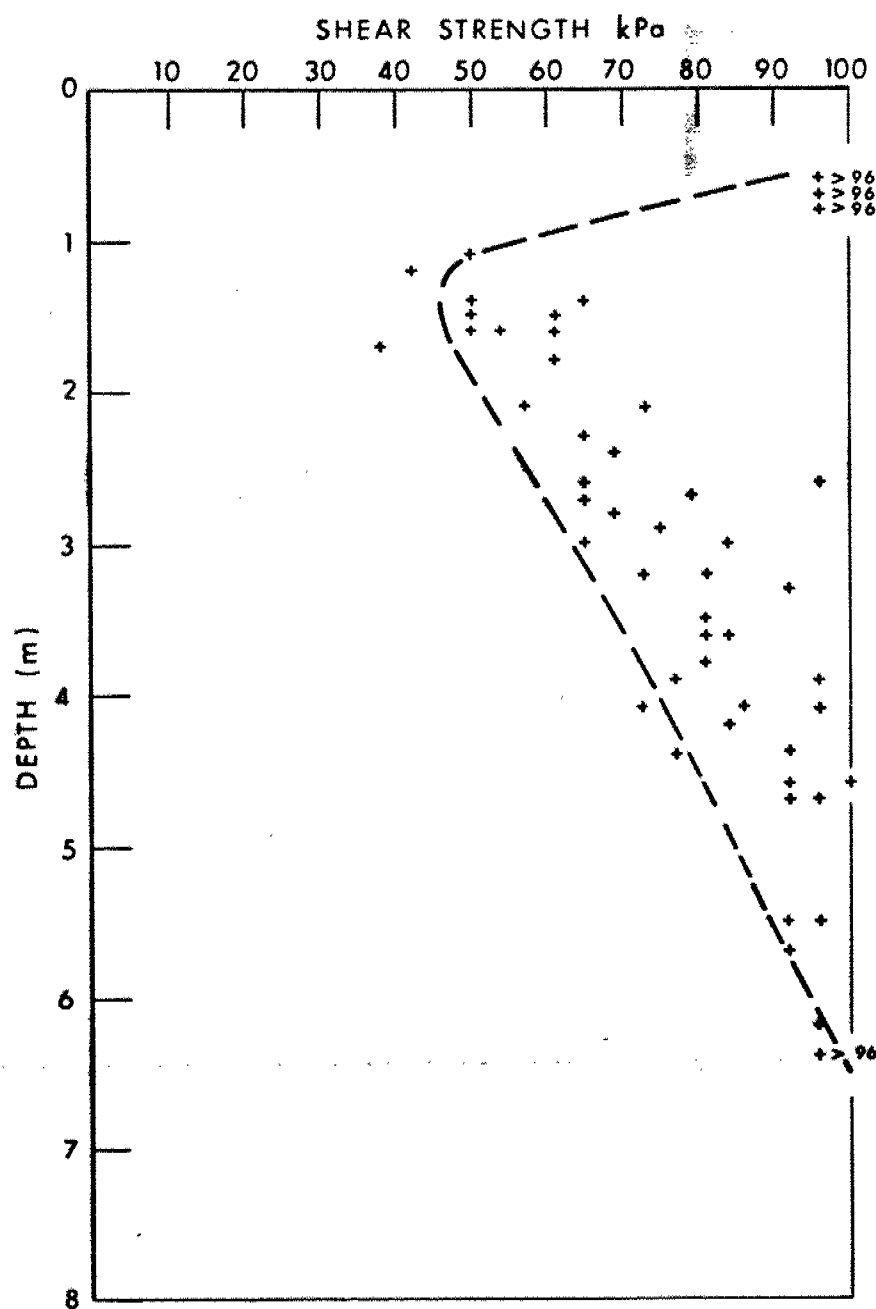


WP 46-78-07

VOID RATIO - PRESSURE CURVES

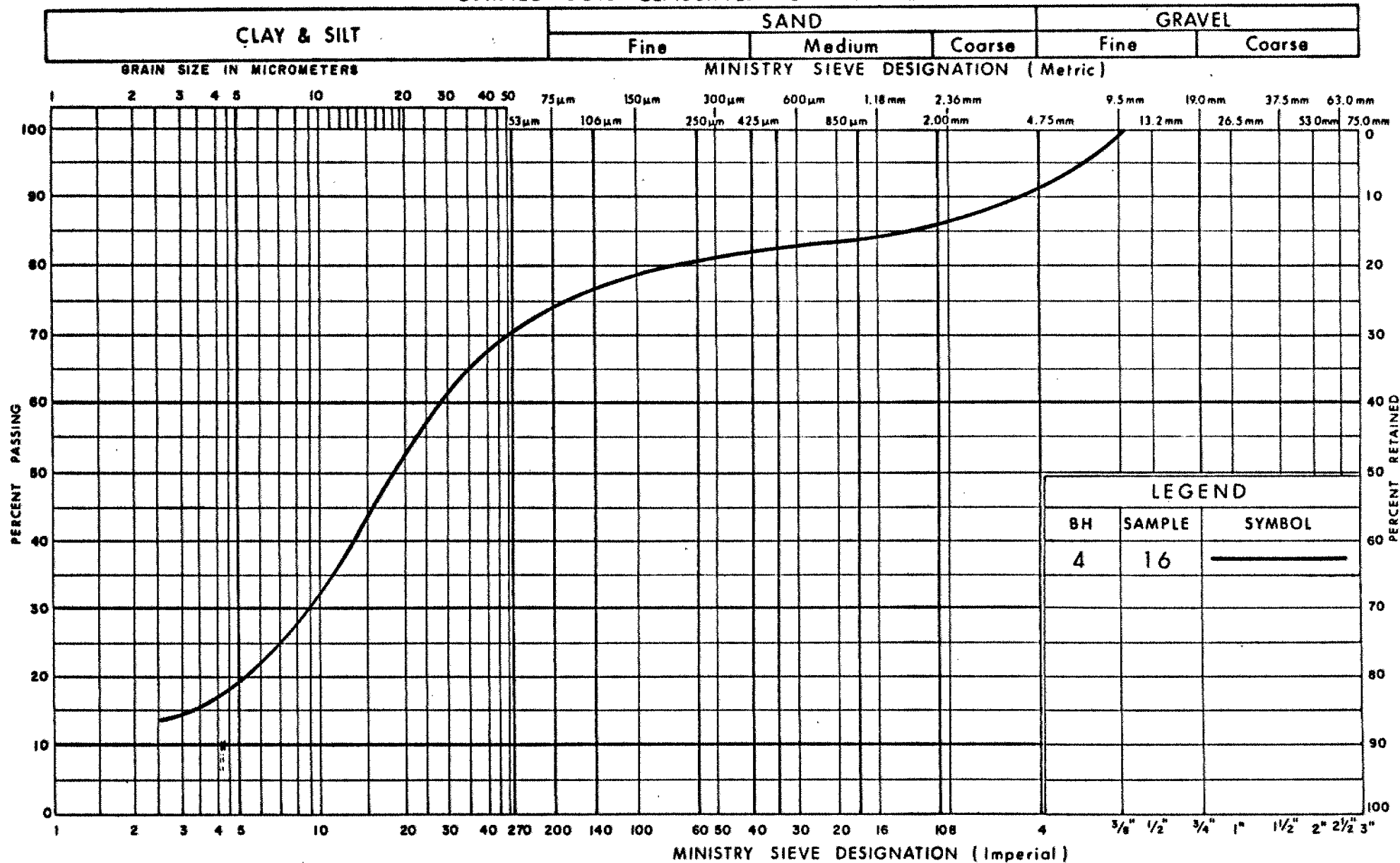


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SHEAR STRENGTH vs DEPTH SUMMARY

UNIFIED SOIL CLASSIFICATION SYSTEM

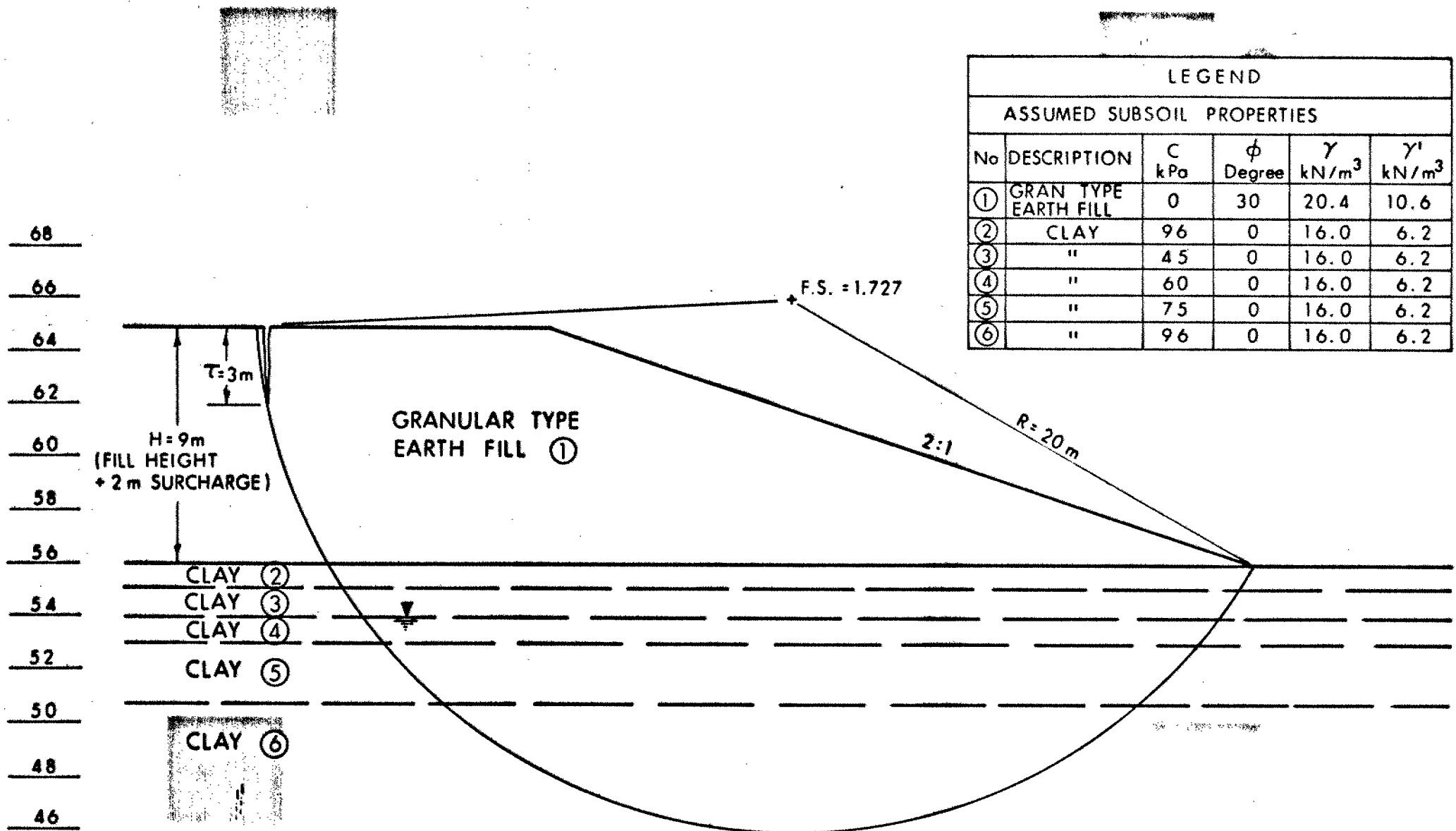


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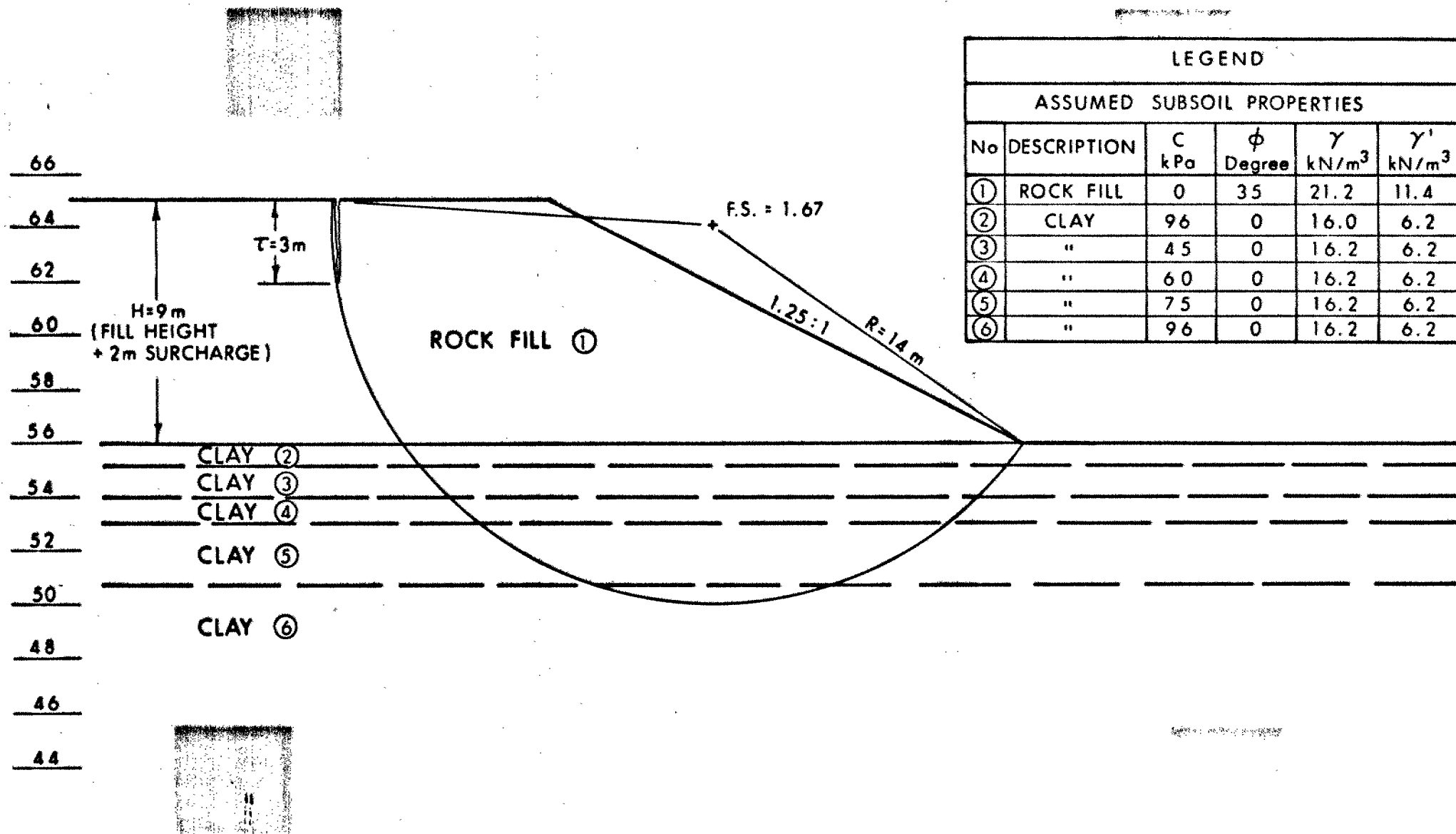
GRAIN SIZE DISTRIBUTION GLACIAL TILL

FIG No 4

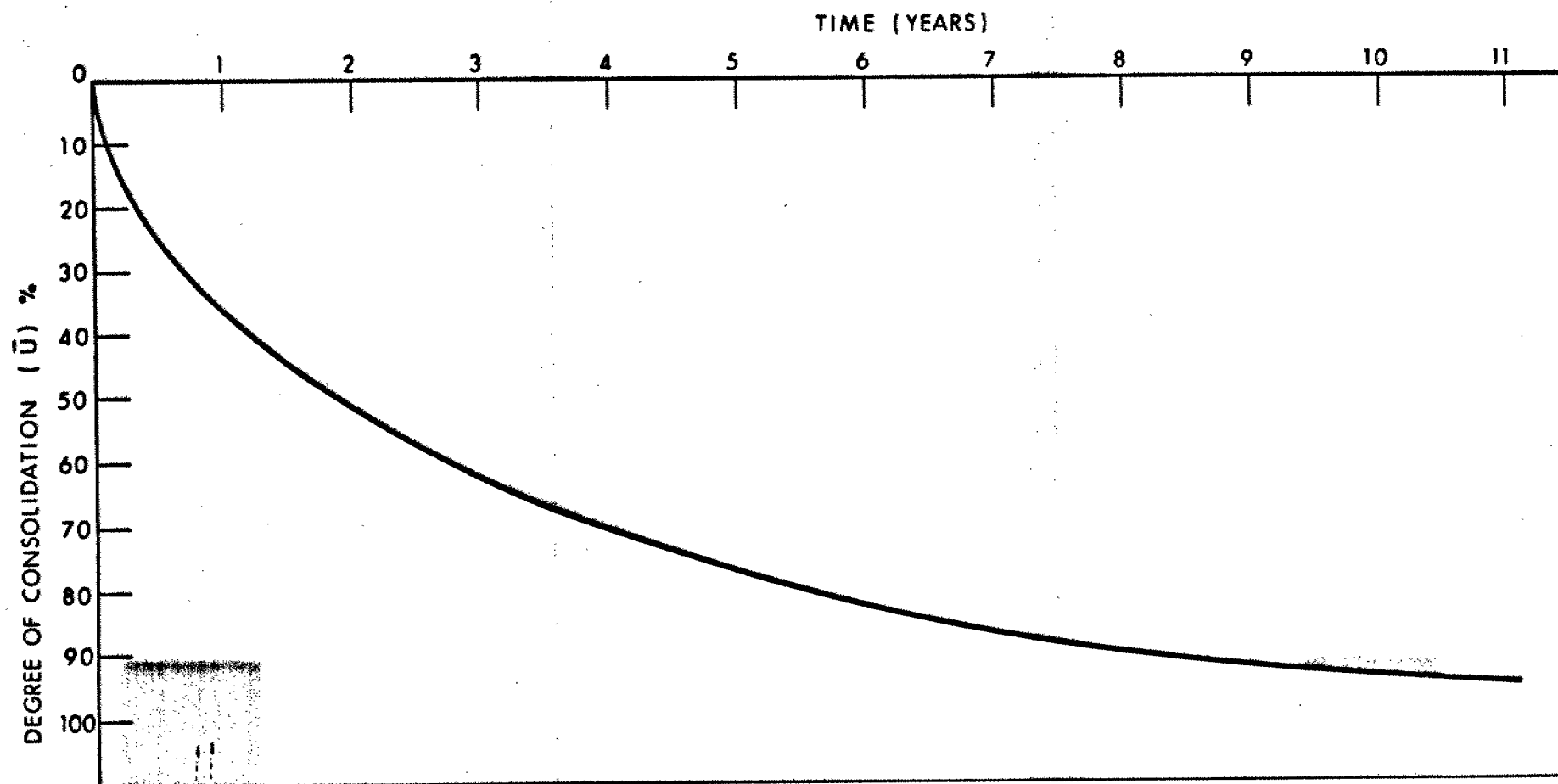
W P 46 - 78 - 07



TOTAL STRESS ANALYSIS
ASSUMED SUBSOIL STRATIGRAPHY, CRITICAL CIRCLE & FACTOR OF SAFETY



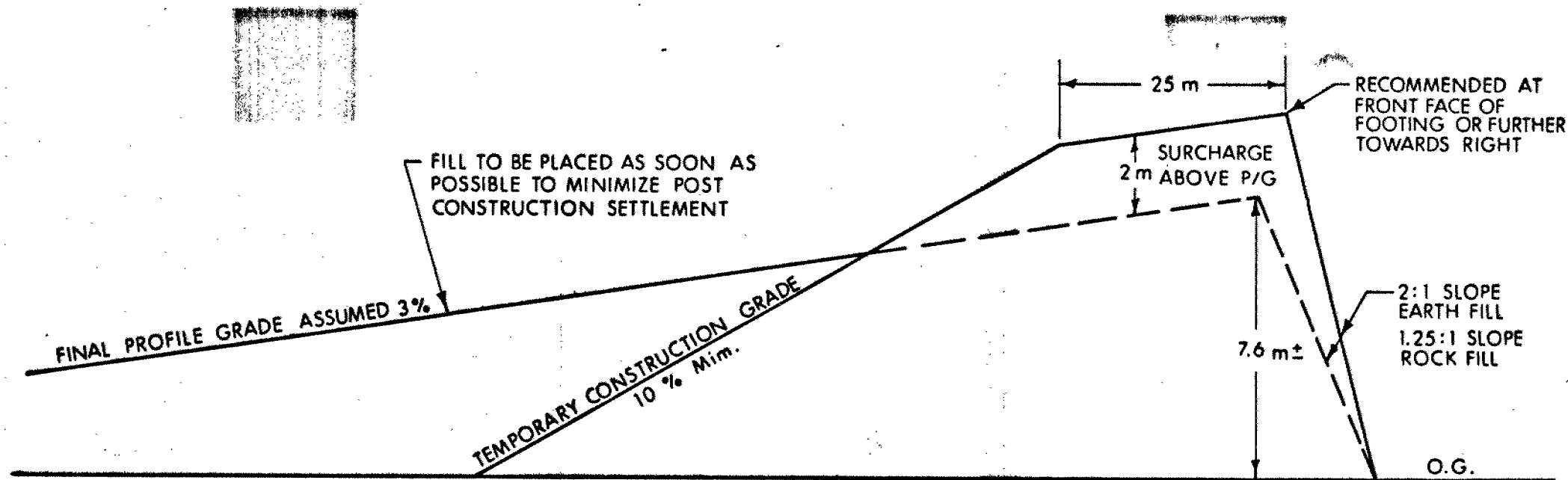
TOTAL STRESS ANALYSIS
 ASSUMED SUBSOIL STRATIGRAPHY, CRITICAL CIRCLE & FACTOR OF SAFETY



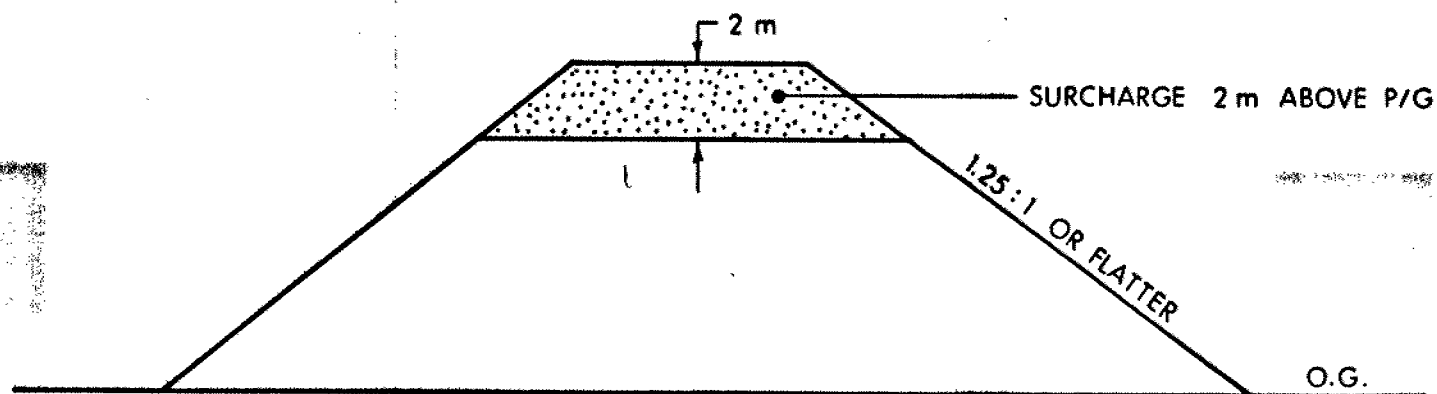
DEGREE OF CONSOLIDATION vs TIME

WP 46-78-07

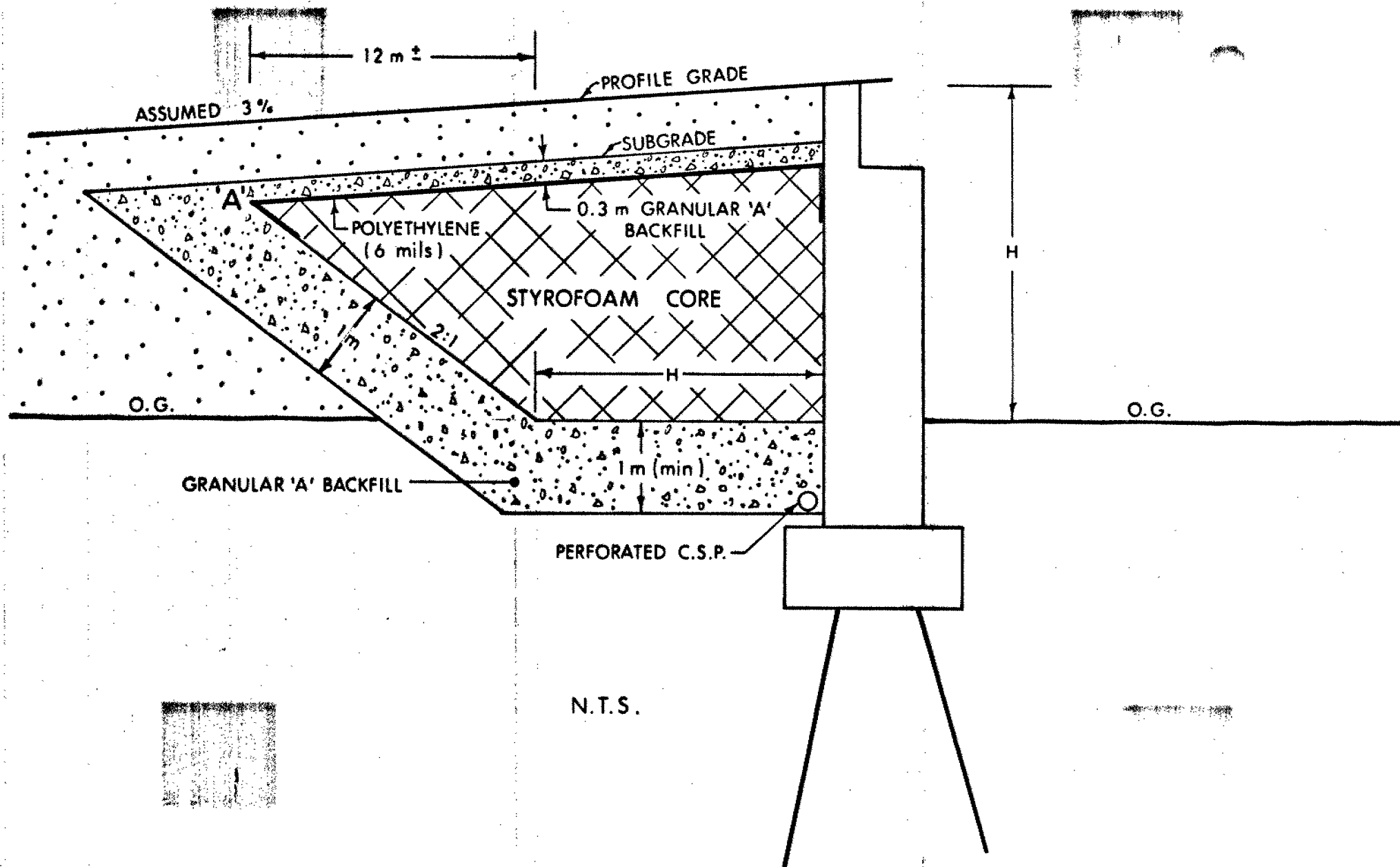
FIG 7



LONGITUDINAL PROFILE



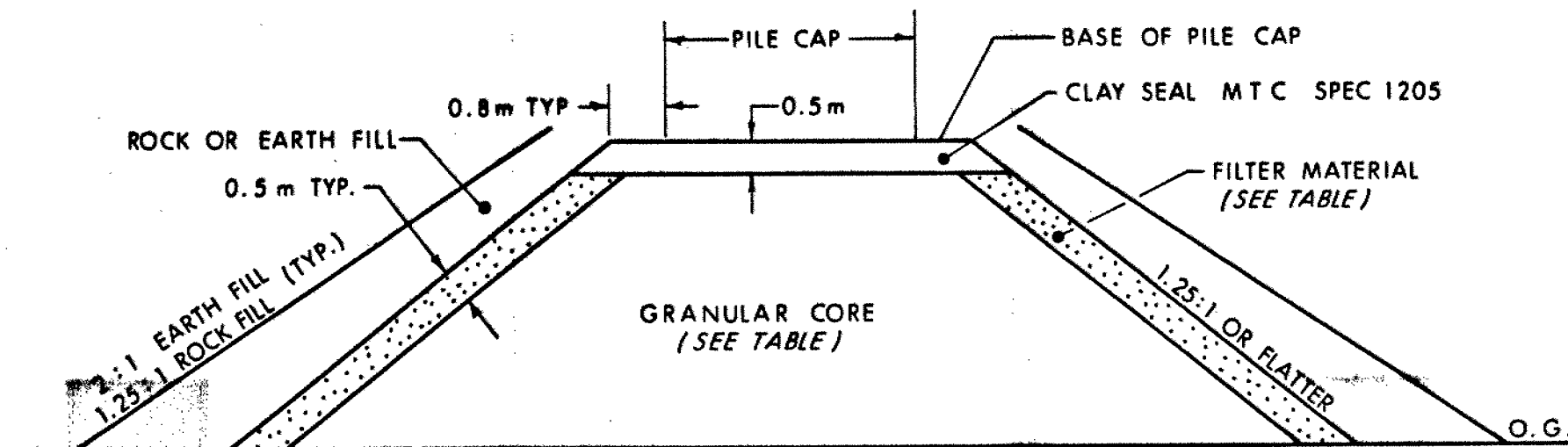
X - SECTION
SURCHARGE REQUIREMENTS



REQUIREMENT FOR STYROFOAM CORE

FIG. 9

FILTER MATERIAL REQUIREMENTS	GRANULAR CORE COMPOSITION
NOT REQUIRED	GRAN 'A'
NOT REQUIRED	GRAN 'B'
GRAN 'A' or 'B'	GRAN 'C' MINUS STONES LARGER THAN 75 mm
DEPENDENT ON GRADATION OF CORE	OTHER GRANULAR MATERIAL



REQUIREMENTS FOR GRANULAR CORE

NTS

FIG 10

WP 46-78-07

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

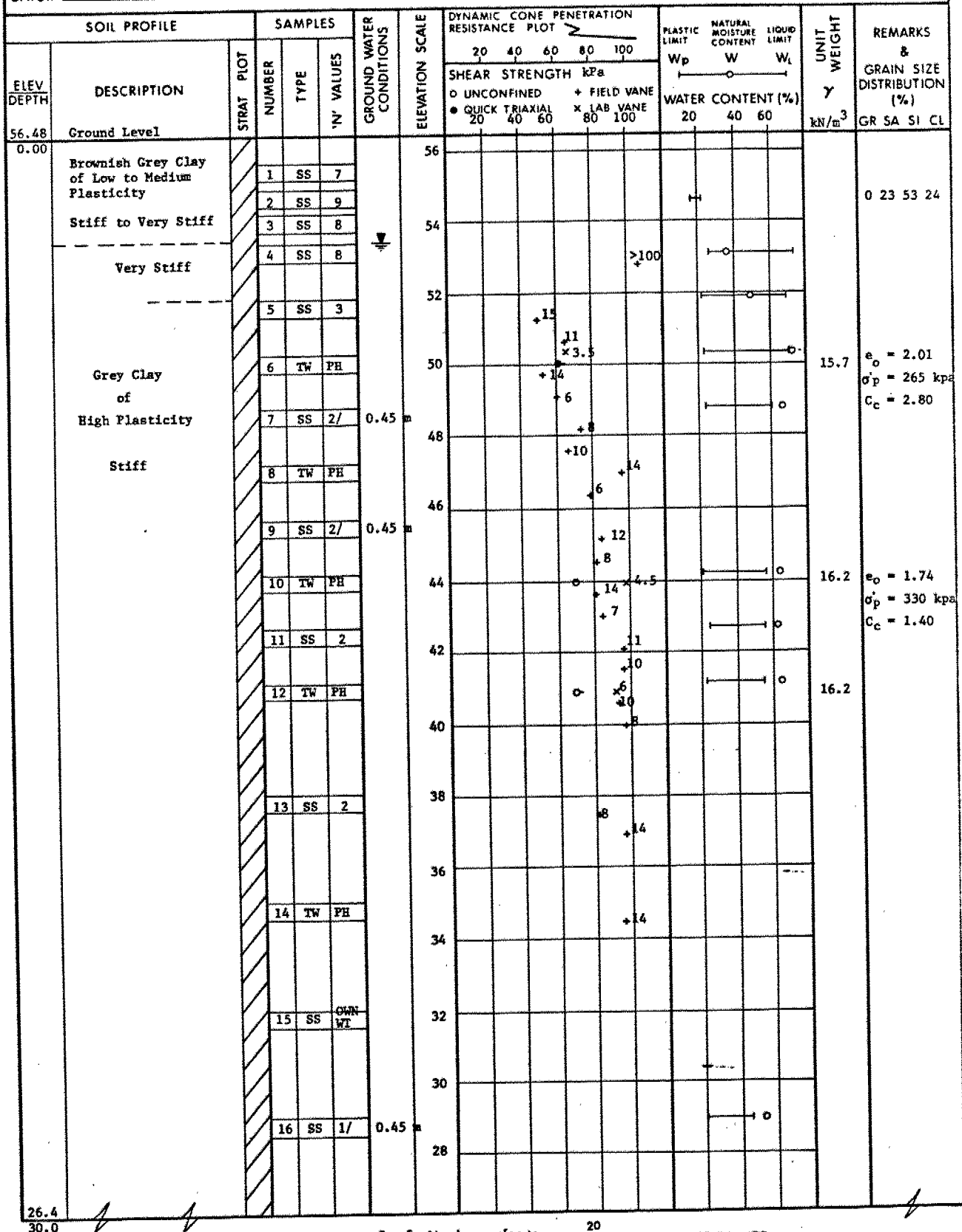
m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
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_f	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 ³	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						

RECORD OF BOREHOLE No 2

W P 46-78-07 LOCATION Co-ords. N5 036 748; E379 367 (14.7 m Rt. of 10+018.3) Sta. ORIGINATED BY W.T.
 DIST 9 HWY 17 BOREHOLE TYPE Hollow Stem Auger (0-35 m) Washbore (35-46 m) COMPILED BY W.T.
 DATUM Geodetic DATE 80-07-15, 16, 17 CHECKED BY A.L.



OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 2 Cont.

W P 46-78-07 LOCATION Co-ords. N5 036 748; E379 367(14.7 m Rt. of Sta. 10+018.3) ORIGINATED BY W.T.
DIST 9 HWY 17 BOREHOLE TYPE Hollow Stem Auger (0-35 m), Washbore (35-46 m) COMPILED BY W.T.
DATUM Geodetic DATE 80-07-16, 17 CHECKED BY A.L.

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					
26.4	Grey Clay of High Plasticity		17	SS	DN WT		26										
30.0							24										
20.82							22										
35.66	Sandy Silt to Silty Sand Trace of Clay Dense to Very Dense 75 mm Cobble		18	SS	32		20										
							18										
			19	SS	88		16										
	Numerous Cobbles Boulders		20	RC	36% EXT REC		14										
13.72			21	RC	18% EXT REC		12										
42.76			22	RC	74% EXT REC		10										
	Sound Dolomite Bedrock		23	RC	98% EXT REC												
10.61																	
45.87	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3

W P 46-78-07 LOCATION Co-ords. N5 036 798; E 379 372 (14.9 m Lt. of 9+976.9) Sta. ORIGINATED BY W.T.
 DIST 9 HWY 17 BOREHOLE TYPE Hollow Stem Auger (0-15 m) Washbore (15-45 m) COMPILED BY W.T.
 DATUM Geodetic DATE 80-07-23 CHECKED BY A.L.

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 (%)
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa						
56.43	Ground Level						20 40 60 80 100	20 40 60					GR SA SI CL
0.00	Silty Sand with Some Gravel, Brownish Grey	1	SS	30									33 52 15
		2	SS	33									25 63 12
54.00	Dense	3	SS	5									
2.43	Clay of High Plasticity	4	SS	9									
		5	SS	2									
		6	TW	PH									
		7	SS	2/	0.45 m								
		8	SS	1/	0.45 m								
		9	TW	PM									
		10	SS	1/	0.45 m								
		11	SS	1/	0.45 m								
		12	TW	PH									
	Grey												e _o = 1.86
	Stiff												σ _p ' = 278 kPa
													C _c = 1.6

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity 20 15 10 (% STRAIN AT FAILURE)

RECORD OF BOREHOLE No 3 Cont.

W P 46-78-07 LOCATION Co-ords. N5 036 798; E379 372; (14.9 m Lt. of Sta. 9+976.9) Originated by: W.T.
 DIST 9 HWY 17 BOREHOLE TYPE Hollow Stem Auger (0-15 m) Washbore (15-45 m) COMPILED BY W.T.
 DATUM Geodetic DATE 1980-07-23 CHECKED BY A.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					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		
26.40	Clay of High Plasticity Grey Soft						26							
30.00							24							
			15	TW	PH		22							
20.47	Sandy Silt Till						20							
35.97							18							
							16							
15.07	Sound Bedrock Dolomite						14							RQD = 16% RQD = 0% RQD = 77%
41.36			16	BXL RC	38% REC		12							
			17	BXL RC	90% REC									
11.54	End of Borehole		18	BXL RC	90% REC		10							
44.90														

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 4

W P 46-78-07 LOCATION Co-ord. N5 036 825; E 379 356 (14 m Lt. of Sta. 9+845.6) ORIGINATED BY A.L.
 DIST 9 HWY 17 BOREHOLE TYPE Hollow Stem Auger (0-16 m) Washbore (16-43 m) COMPILED BY W.T.
 DATUM Geodetic DATE 1980-07-21 to 24 CHECKED BY A.L.

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	20 40 60 80 100					
55.98	Ground Level													
0.00	Clay of Medium Plasticity Stiff to Very Stiff		1	SS	8									0 47 44 9
	Silty Sand Loose		2	SS	5									
	Clay of High Plasticity Brownish Grey Very Stiff		3	TW	PH									16.2
			4	TW	PH									
	Clay of High Plasticity		5	SS	2									
	Grey		6	TW	PH									
	Stiff		7	SS	2									15.9
			8	TW	PH									
			9	SS	OWN WL									
			10	TW	PH									
			11	SS	2									16.3
			12	TW	PH									
			13	SS	3									
			14	TW	PH									
25.90														
30.00														

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 : Numbers refer to 20
Sensitivity 15 x 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4 Cont.

W P 46-78-07 LOCATION Co-ord. N5 036 825; E379 356 (14.0 m Lt. of Sta. 9+945.6) ORIGINATED BY A.L.
 DIST 9 HWY 17 BOREHOLE TYPE Hollow Stem Auger (0-16 m) Washbore (16-43 m) COMPILED BY W.T.
 DATUM Geodetic DATE 80-07-21 to 24 CHECKED BY A.L.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				NATURAL MOISTURE CONTENT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		SHEAR STRENGTH				W _p	W	W _L		
25.90							20 40 60 80 100				WATER CONTENT (%)				GR SA SI CL
30.00	Clay of High Plasticity		15	TW	PH										
	Grey Stiff					24									
						22									
19.71						20									
36.27	Sandy Silt Till		16	SS	83										9 16 64 11
	Grey Very Dense					18									
16.39						16									
39.59	Boulders - Dolomite		17	BXL	67% REC										RQD = 30%
15.59	and Limestone			AC											RQD = 45%
40.39			18	BXL	85% REC										RQD = 9%
	Dolomite Bedrock			RC		14									
			19	BXL	30% REC										
13.16															
42.82	End of Borehole					12									

OFFICE REPORT ON SOIL EXPLORATION

*3, *5: Numbers refer to Sensitivity 20
15 → 5 (%) STRAIN AT FAILURE
10

I N D E X

<u>Page No.</u>	<u>Description</u>
1	Index
2	Abbreviations & Symbols
3-20	Foundation Investigation Report For W. P. 46-78-07, Highway 17 Jeanne D'Arc Boulevard Underpass

NOTE: For purposes of the contract this report
superseces all other foundation reports
prepared by or for the Ministry in connection
with the above-mentioned project.

EXPLANATION OF TERMS USED IN REPORT

2

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'_{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	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^3	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

FOUNDATION INVESTIGATION REPORT

For

Jeanne D'Arc Boulevard Underpass
Lot 6, 7, Conc. 1, Gloucester Township
Hwy. 17, District 9, Ottawa
W.P. 46-78-07, Site 3-339

INTRODUCTION

This report contains the results of a foundation investigation carried out at the above site. The field work was carried out from July 14 to July 25, 1980 and consisted of three sampled boreholes and two supplementary dynamic cone tests. The borings were advanced by hollow stem augers to a depth of up to 15 metres below ground surface; thereafter washboring techniques were employed to advance the borings to bedrock at a depth of up to 42 metres below ground level. Diamond drilling techniques were then utilized in all boreholes to obtain up to 3 metres of BXL size rock core samples.

SITE DESCRIPTION AND GEOLOGY

This site is located on Hwy. 17 approximately 3.0 km east of Montreal Road/Hwy. 17 intersection in the Township of Gloucester, Regional Municipality of Ottawa-Carleton.

In the site vicinity, the terrain is generally flat. Hwy. 17 level crosses Jeanne D'Arc Blvd. at approximate elevation 56.

Physiographically, the site is located within the Ottawa Valley Clay Plains. This region is characterized by extensive deposits of sensitive marine clay overlying glacial till and dolomite bedrock.

SUBSURFACE CONDITIONSGeneral

Subsoil conditions across the site are generally uniform. Beneath a thin veneer of topsoil is a layer of silty sand, approximately 2 metres thick. Extending from this silty sand layer and to a depth

up to 37 metres below the ground surface is the dominant deposit consisting of firm to very stiff sensitive clay. The clay overlies 1 to 2 metres of a compact to very dense glacial till composed of a heterogeneous mixture of silt, sand, gravel and occasional cobbles and boulders. Underlying the glacial till is dolomite bedrock.

The boundaries between the various subsoil and bedrock types are shown on the Borehole Record Sheets. The locations of the boreholes are shown on Drawing No. 467807-A.

Following is a brief description of subsoil and bedrock types.

Silty Sand

A layer of silt sand, approximately 2 metres thick, was found below the topsoil. This granular material may be inferred from the construction of the existing Hwy. 17.

Sensitive Clay

This deposit was encountered immediately below a thin veneer of topsoil or granular fill material and is estimated to have a thickness ranging from 35 to 37 metres. The deposit is generally grey in colour except for the upper 2 to 4 metres which is desiccated and has a brownish grey mottled colour. Laboratory and in-situ testing performed on representative samples from this deposit gave the following results.

<u>Geotechnical Properties</u>	<u>In the Upper Desiccated Zone</u>		<u>Below the Desiccated Zone</u>	
	<u>Range</u>	<u>Average</u>	<u>Range</u>	<u>Average</u>
Natural Moisture Content (W)%	18-40	31	49-73	62
Liquid Limit (w_L)%	74	-	45-75	58
Plastic Limit (w_p)%	16-28	23	18-25	22
Plasticity Index (I_p)%	45	-	25-52	36
Liquidity Index (I_L)	0.1-0.45	0.31	1.21-2.40	1.84
Bulk Unit Weight (γ) kN/m ³	-	-	15.7-16.4	16
Undrained Shear Strength (C_u) Kpa	<u>Range</u>	<u>Sensitivity</u>	<u>Range</u>	<u>Sensitivity</u>
Field Vane Tests	>96	-	38-96	5-14
Unconfined Compression Tests	-	-	26-60	3-6

<u>Consolidation Tests</u>	<u>Range</u>
Degree of Preconsolidation ($\sigma'_p - \sigma'_{ro}$) Kpa	144-220
Initial Void Ratio	1.7364-2.006
Compression Index	1.4-2.8

The results of the Atterberg Limit testings are shown on the Plasticity Chart (Figure 1). These results indicate that the deposit is inorganic and mainly of high plasticity (CH zone). The deposit may be described as a sensitive clay as evidenced by the high sensitivities (5-14) measured by the field vane testing. Furthermore, the Liquidity Index of the cohesive soil below the desiccated zone is greater than 1, confirming that the non-desiccated cohesive deposit is sensitive to remoulding.

Six consolidation tests were performed on samples from this deposit and are summarized on Figure 2. The consolidation testing indicates that the deposit has been preconsolidated by a pressure of 144 to 220 kPa in excess of the preconsolidation pressure, the deposit will undergo significant consolidation.

The results of in-situ vane testing are summarized on the Shear Strength vs. Depth Profile, Figure 3.

The vane testing indicates that the undrained shear strength is greater than 96 kPa in the first meter of the desiccated zone and thereafter decreases abruptly to a low of 40 kPa at a depth of about 2 metres. The shear strength then gradually increases with depth to greater than 96 kPa at a depth of about 7 meters below ground surface. Based on these results the consistency is described as very stiff in the upper desiccated zone. Below this it is generally firm to stiff, generally increasing with depth.

Glacial Till

The glacial till stratum was found immediately below the sensitive clay deposit and was observed to have a thickness of 4 to 7 meters. The deposit is mainly composed of a heterogeneous mixture of silt, sand and gravel. However, just above the bedrock, numerous cobbles and boulders were found. In order to penetrate the cobbles and boulders, diamond drilling technique was utilized. The results of grain size

distribution testing performed on samples obtained from 2" O.D. split spoon samples from the deposit are plotted on Figure 4.

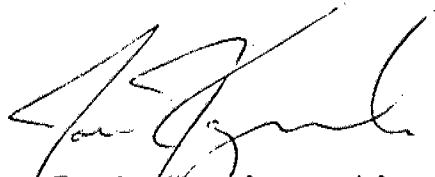
Based on the Standard Penetration Test 'N' values ranging from 32 to 88 blows per 0.3 m, the relative density of this non-cohesive glacial till deposit may be described as dense to very dense.

Dolomite Bedrock

Immediately below the glacial till is the bedrock. The bedrock surface was found to vary from 40.5 to 42.5 meters below ground surface which corresponds to elevations 13.5 to 15.5 meters. The bedrock is composed of hard, fine textured, medium grey dolomite. The upper 0.5 to 1.0 meter of the bedrock is generally in a weathered condition. However, below this upper layer is generally sound bedrock.

GROUNDWATER CONDITIONS

Groundwater conditions were observed by measuring the water level in the open boreholes. The groundwater levels were found to be 2.1 to 3 meters below ground surface in boreholes #4 and #2. This corresponds to elevation 53.9 and 53.5 meters.

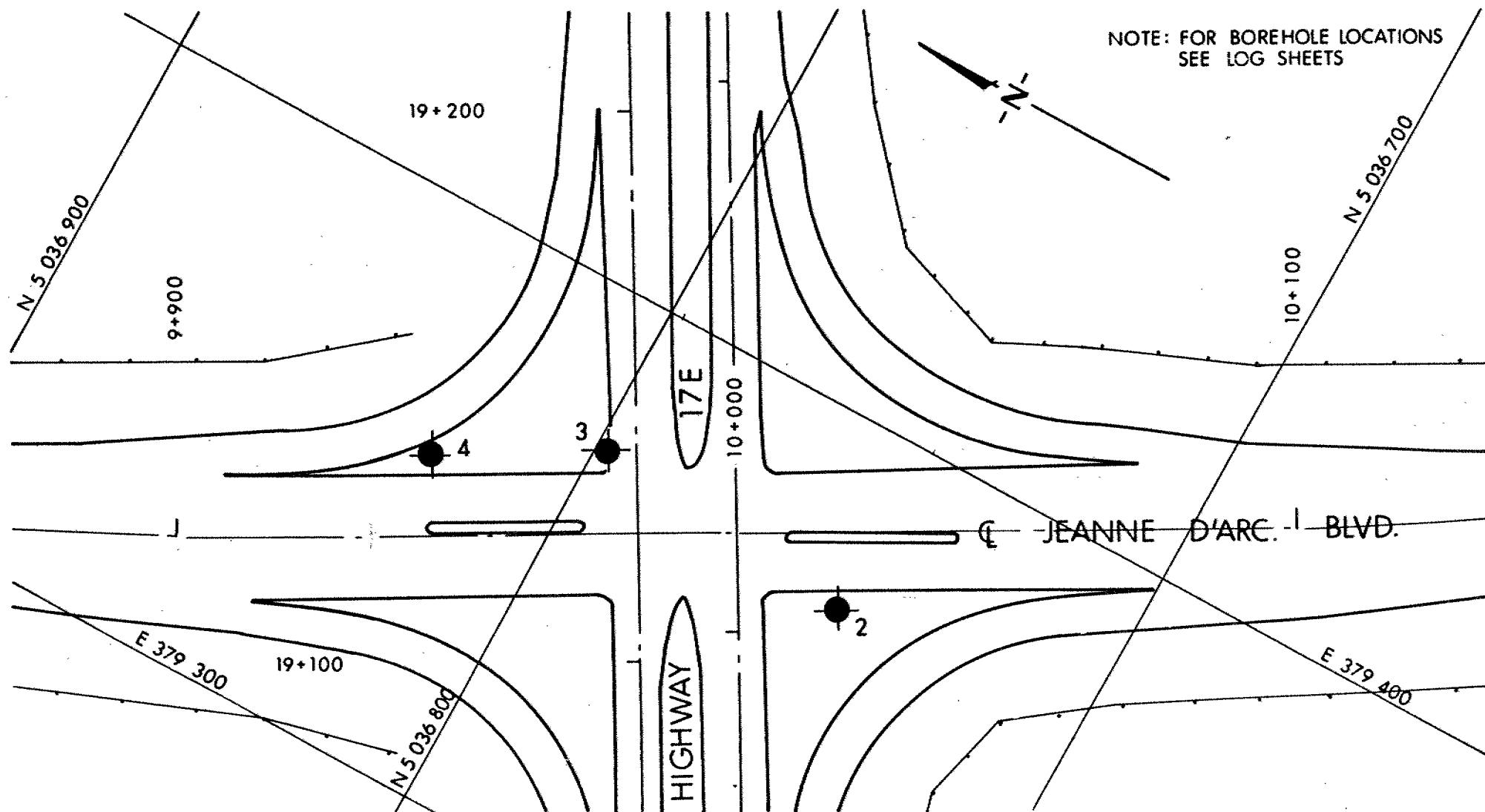


T. J. Kazmierowski,
Foundations Engineer



M. Devata,
Senior Foundations Engineer

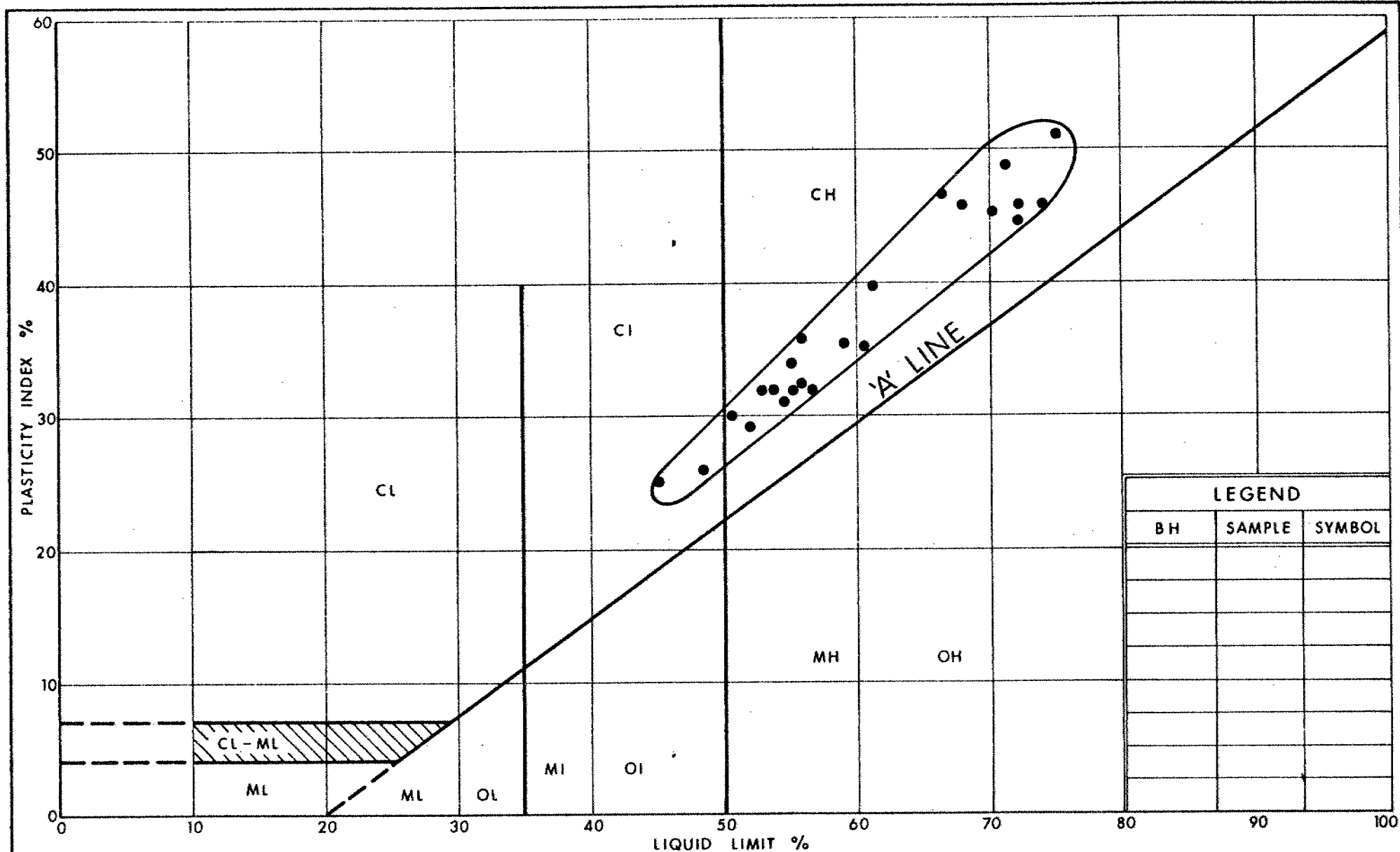
APPENDIX



BOREHOLE LOCATION PLAN

SCALE 1:1000

WP 46-78-07
Dwg No 467807-A

Ministry of
Transportation and
Communications

PLASTICITY CHART SENSITIVE CLAY

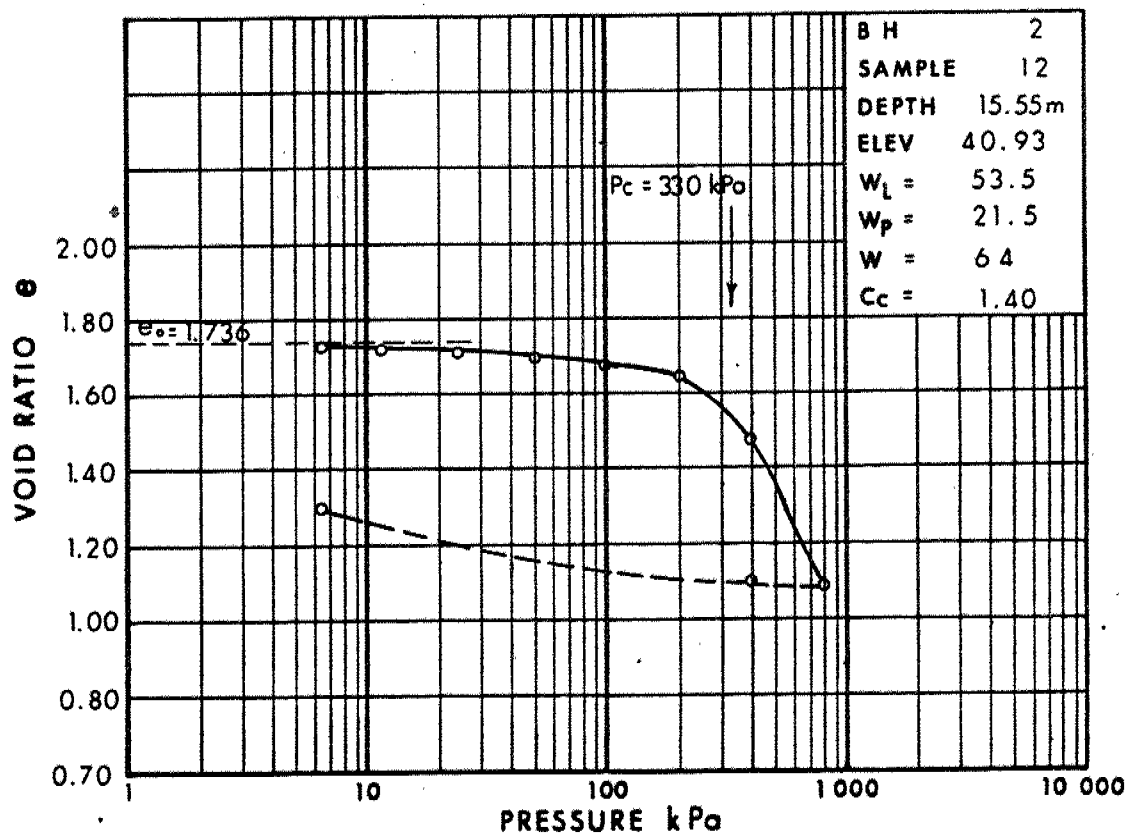
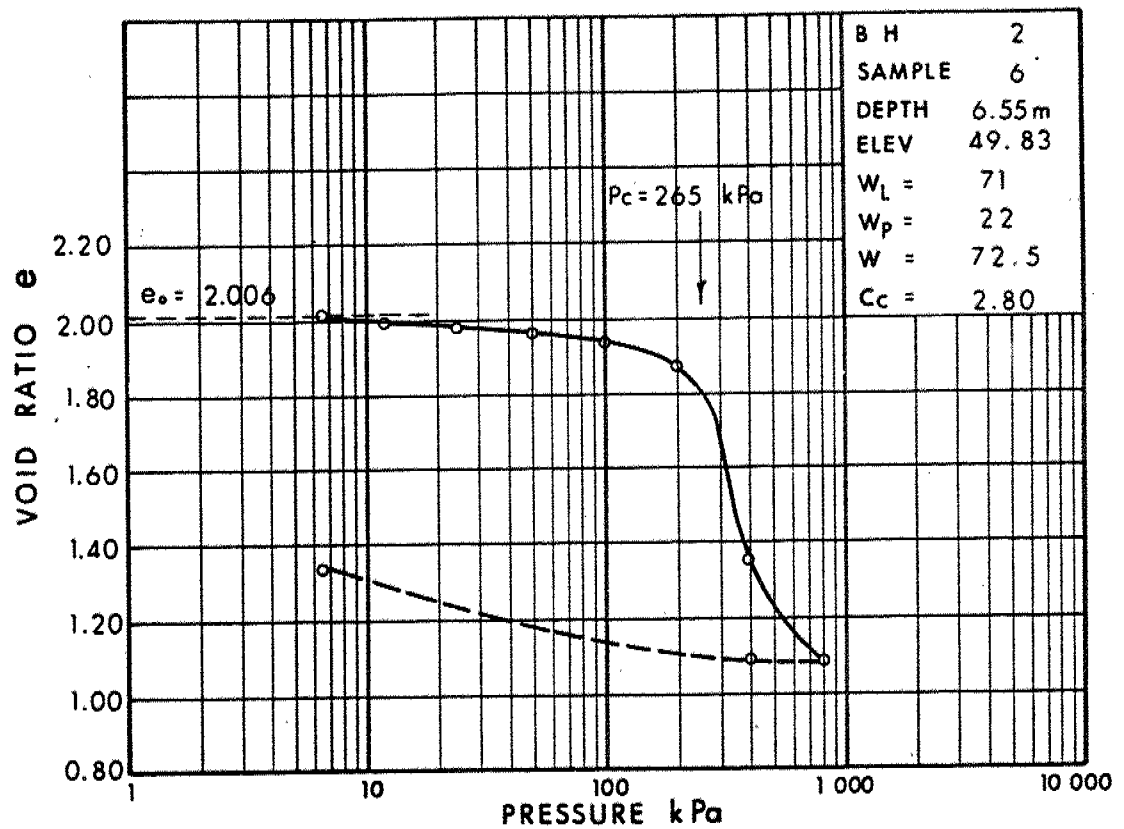
FIG No 1

W P 46-78-07

2

VOID RATIO - PRESSURE CURVES

10

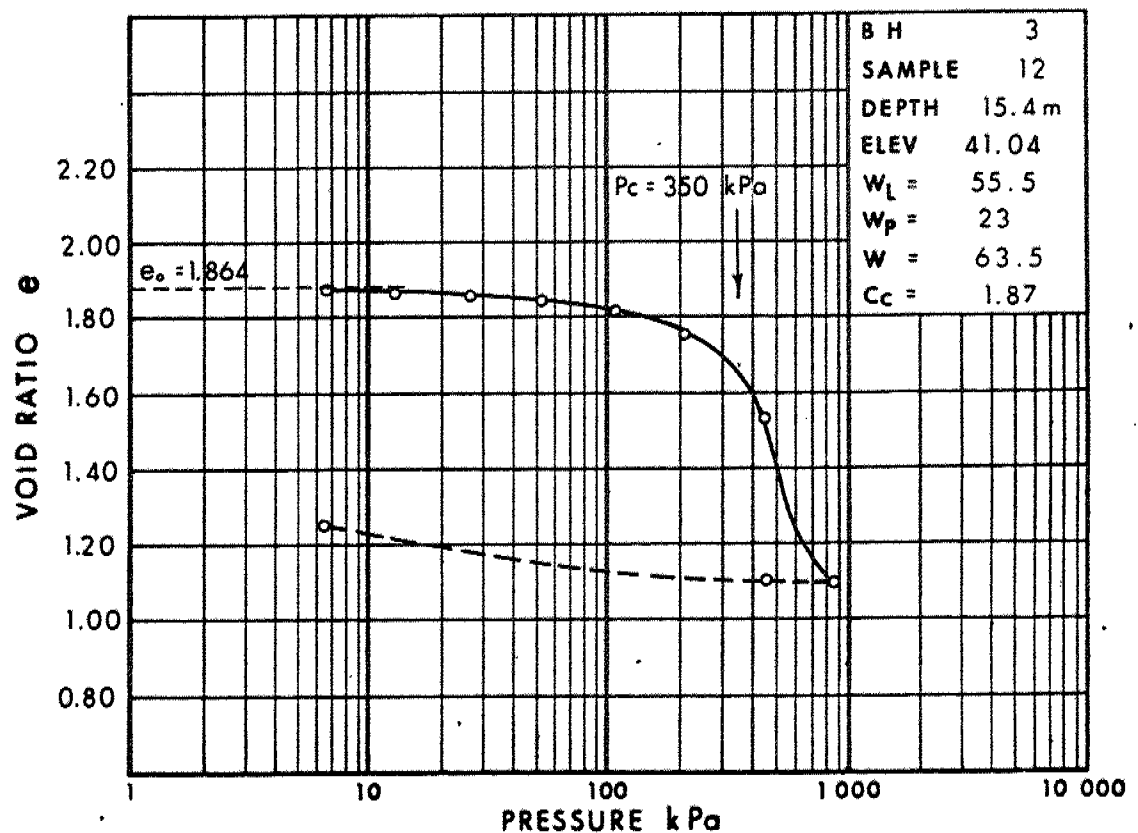
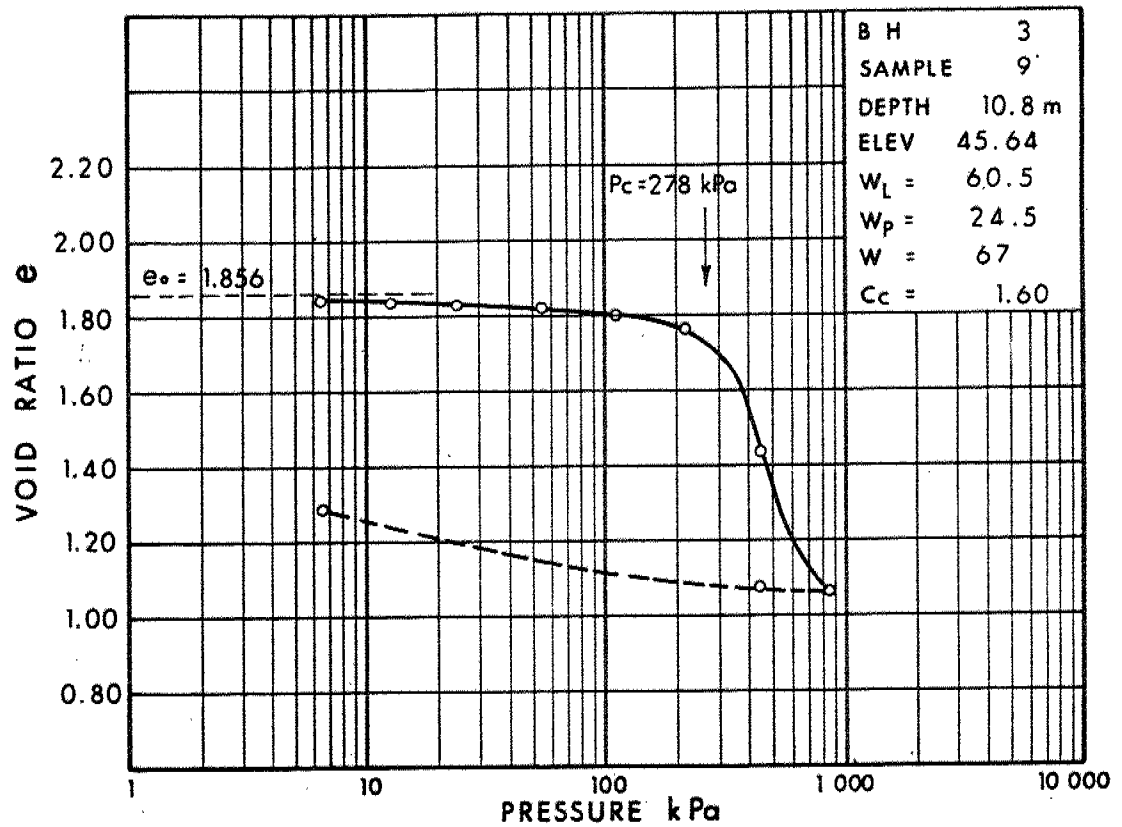


W P 46-78-07

FIG No 2

VOID RATIO - PRESSURE CURVES

11

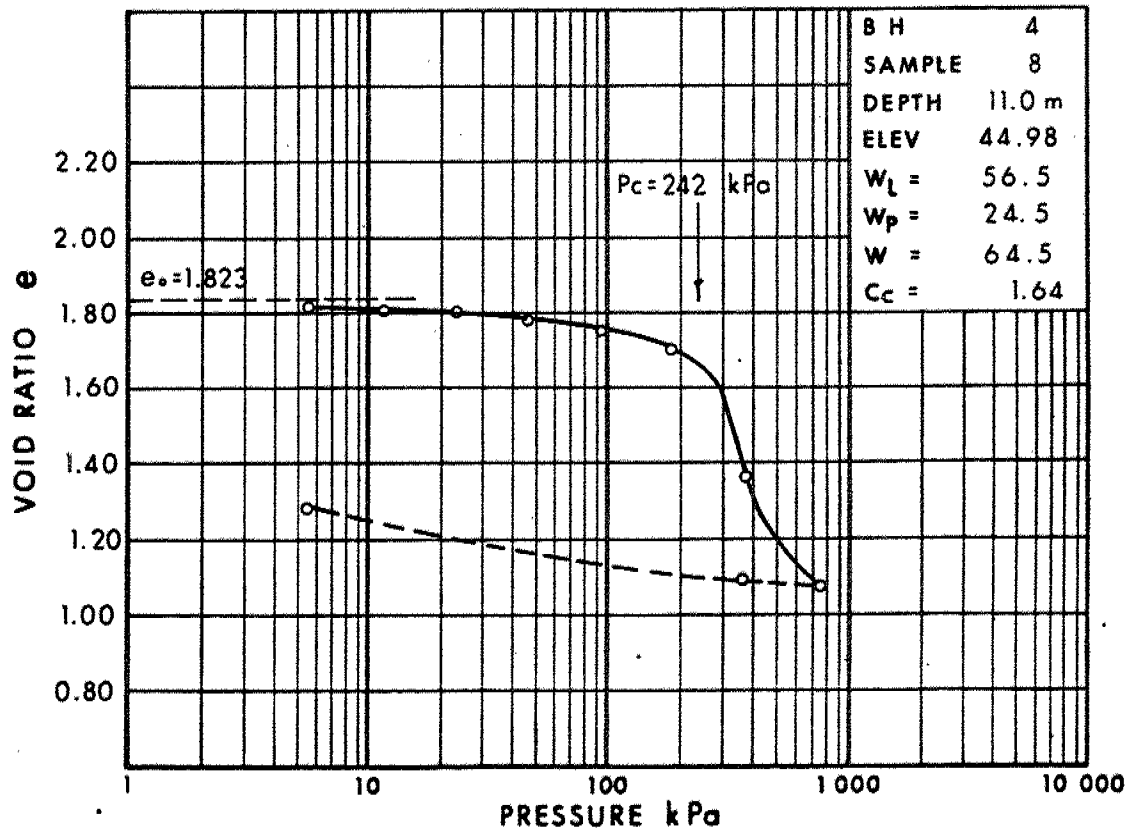
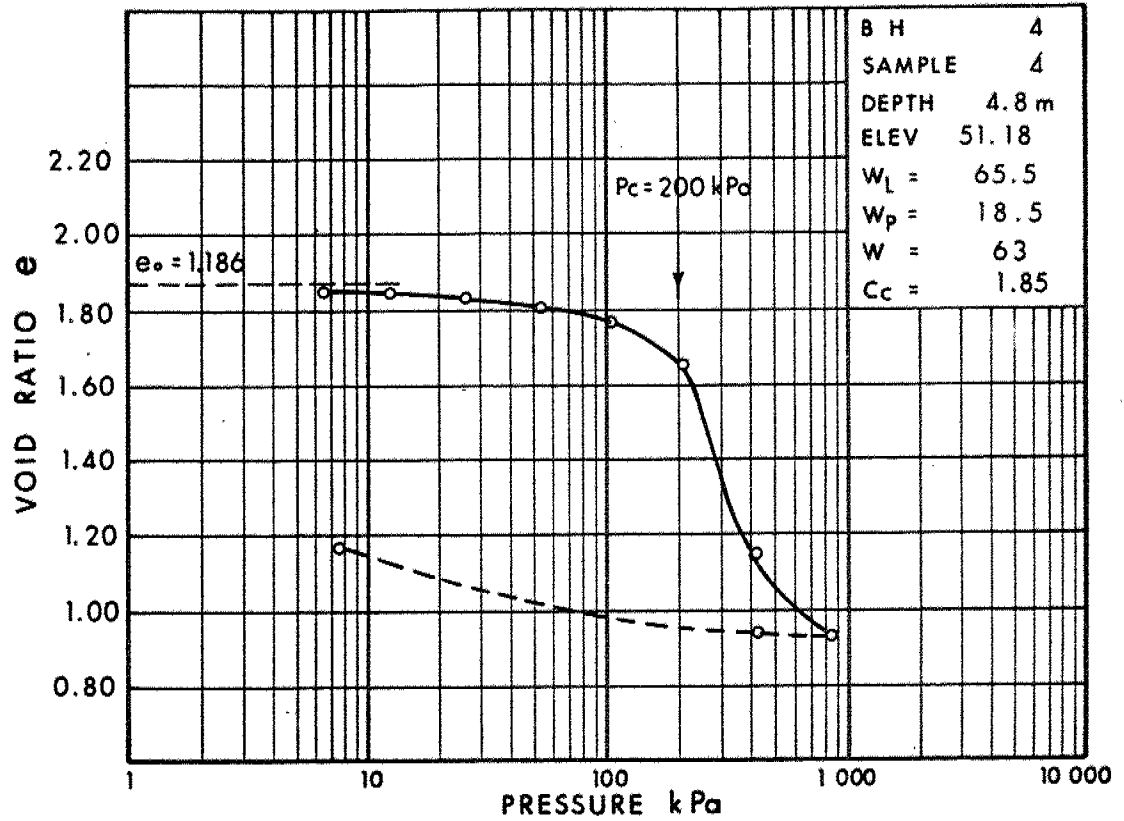


W P 46-78-07

FIG No 2 Cont.

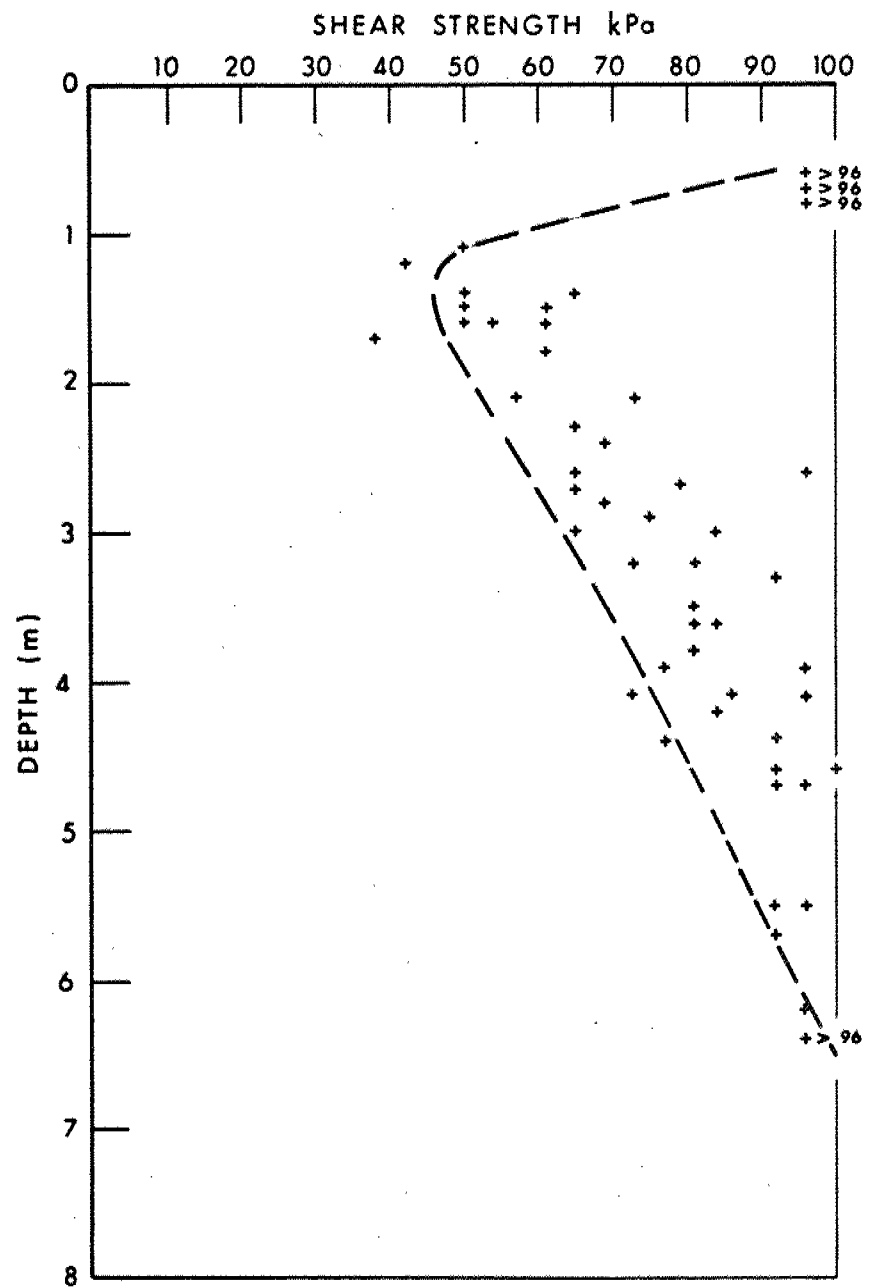
VOID RATIO - PRESSURE CURVES

12



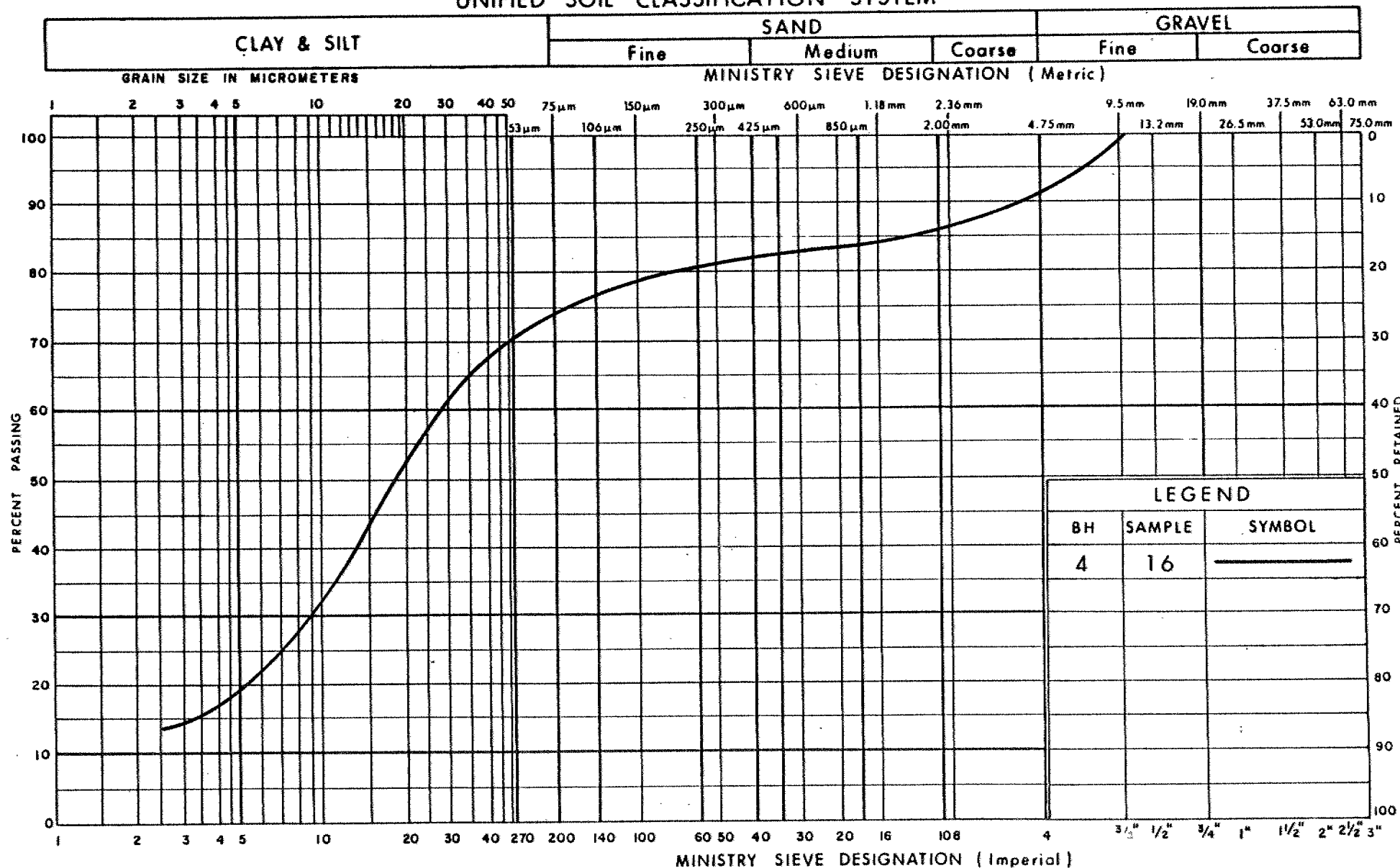
W P 46-78-07

FIG No 2 Cont.



SHEAR STRENGTH vs DEPTH SUMMARY

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

 Ministry of
Transportation and
Communications

 GRAIN SIZE DISTRIBUTION
GLACIAL TILL

FIG No 4

W P 46-78-07



RECORD OF BOREHOLE No 2

15

W P 46-78-07 LOCATION Co-ords. N5 036 748; E379 367 (14.7 m Rt. of 10+018.3) Sta. .
DIST 9 HWY 17 BOREHOLE TYPE Hollow Stem Auger (0-35 m) Washbore (35-46 m) ORIGINATED BY W.T.
DATUM Geodetic DATE 80-07-15, 16, 17 COMPILED BY W.T.
CHECKED BY A.L.

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
56.48	Ground Level																
0.00																	
	Brownish Grey Clay of Low to Medium Plasticity		1	SS	7		56										
			2	SS	9												
	Stiff to Very Stiff		3	SS	8		54										
			4	SS	8												
	Very Stiff		5	SS	3		52										
			6	TW	PH		50										
	Grey Clay of High Plasticity		7	SS	2/	0.45 m	48										
			8	TW	PH		46										
	Stiff		9	SS	2/	0.45 m	44										
			10	TW	PH		42										
			11	SS	2		40										
			12	TW	PH		38										
			13	SS	2		36										
			14	TW	PH		34										
			15	SS	OWN WT		32										
			16	SS	1/	0.45 m	30										
26.4							28										
30.0																	

t³, x⁵: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2 Cont.

16

W P 46-78-07 LOCATION Co-ords. N5 036 748; E379 367(14.7 m Rt. of Sta. 10+018.3) ORIGINATED BY W.T.
 DIST 9 HWY 17 BOREHOLE TYPE Hollow Stem Auger (0-35 m), Washbore (35-46 m) COMPILED BY W.T.
 DATUM Geodetic DATE 80-07-16, 17 CHECKED BY A.L.

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					
26.4																	
30.0																	
	Grey Clay of High Plasticity		17	SS	OWN WT		26										
							24										
							22										
20.82																	
35.66	Sandy Silt to Silty Sand		18	SS	32		20										
	Trace of Clay						18										
	Dense to Very Dense																
	75 mm Cobble		19	SS	88		16										
	Numerous Cobbles Boulders		20	RC	36% BXL REC		14										
13.72			21	RC	18% BXL REC												
42.76																	
	Sound Dolomite Bedrock		22	RC	74% BXL REC		12										RQD = 38%
			23	RC	98% BXL REC												RQD = 77%
10.61																	
45.87	End of Borehole						10										

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 3

17

W P 46-78-07 LOCATION Co-ords. N5 036 798; E 379 372 (14.9 m Lt. of 9+976.9) Sta. ORIGINATED BY W.T.
DIST 9 HWY 17 BOREHOLE TYPE Hollow Stem Auger (0-15 m) Washbore (15-45 m) COMPILED BY W.T.
DATUM Geodetic DATE 80-07-23 CHECKED BY A.L.

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 kPa		WATER CONTENT (%)				
								○ UNCONFINED	+ FIELD VANE					
								● QUICK TRIAXIAL	x LAB VANE					
56.43	Ground Level							20 40 60 80 100	20 40 60				KN/m ³	GR SA SI CL
0.00	Silty Sand with Some Gravel, Brownish Grey		1	SS	30		56							33 52 15
			2	SS	33		54							
54.00	Dense	3	SS	5	54									
2.43	Clay of High Plasticity	4	SS	9	52									
		5	SS	2	52									
		6	TW	PH	50									
		7	SS	2/	50									
		8	SS	1/	48									
		9	TW	PM	46									
		10	SS	1/	44									
		11	SS	1/	42									
		12	TW	PH	40									

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 3 Cont.

W P 46-78-07 LOCATION Co-ords. N5 036 798; E379 372; (14.9 m Lt. of Sta. 9+976.9) Originated by: W.T.
DIST 9 HWY 17 BOREHOLE TYPE Hollow Stem Auger (0-15 m) Washbore (15-45 m) COMPILED BY W.T.
DATUM Geodetic DATE 1980-07-23 CHECKED BY A.L.

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									
								SHEAR STRENGTH					WATER CONTENT (%)								
							○ UNCONFINED + FIELD VANE														
							● QUICK TRIAXIAL × LAB VANE														
26.40	Clay of High Plasticity Grey Soft		15	TW	PH		26														
30.00							24														
							22														
20.47	Sandy Silt Till						20														
35.97							18														
							16														
15.07	Sound Bedrock Dolomite		16	EXL RC	38% REC		14								RQD = 16%						
41.36							17	EXL RC	90%									RQD = 0%			
							18	EXL RC	90% REC									RQD = 77%			
11.54	End of Borehole						12														
44.90							10														

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 4

19

W P 46-78-07 LOCATION Co-ord. N5 036 825; E 379 356 (14 m Lt. of Sta. 9+845.6) ORIGINATED BY A.L.
DIST 9 HWY 17 BOREHOLE TYPE Hollow Stem Auger (0-16 m) Washbore (16-43 m) COMPILED BY W.T.
DATUM Geodetic DATE 1980-07-21 to 24 CHECKED BY A.L.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20 40 60 80 100	20 40 60 80 100	W _p	W	W _L		
55.98	Ground Level												
0.00	Clay of Medium Plasticity Stiff to Very Stiff		1	SS	8								0 47 44 9
	Silty Sand Loose		2	SS	5								
	Clay of High Plasticity Brownish Grey Very Stiff		3	TW	PH			>100					
			4	TW	PH			>100					
	Clay of High Plasticity		5	SS	2							16.2	$e_o = 1.86$ $\sigma'_p = 200$ kPa $C_c = 1.85$
	Grey		6	TW	PH								
	Stiff		7	SS	2								
			8	TW	PH							15.9	$e_o = 1.82$ $\sigma'_p = 242$ kPa $C_c = 1.64$
			9	SS	WT								
			10	TW	PH							16.3	
			11	SS	2								
			12	TW	PH								
			13	SS	3								
			14	TW	PH								
25.90													
30.00													





+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4 Cont.

20

W P 46-78-07 LOCATION Co-ord. N5 036 825; E379 356 (14.0 m Lt. of Sta. 9+945.6) ORIGINATED BY A.L.
DIST 9 HWY 17 BOREHOLE TYPE Hollow Stem Auger (0-16 m) Washbore (16-43 m) COMPILED BY W.T.
DATUM Geodetic DATE 80-07-21 to 24 CHECKED BY A.L.

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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100										
								SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE										
25.90	Clay of High Plasticity Grey Stiff		15	TW	PH													
30.00																		
19.71	Sandy Silt Till Grey Very Dense		16	SS	83													
36.27																	9 16 64 11	
16.39	Boulders - Dolomite and Limestone		17	BXL AC	67% REC													
39.59																	RQD = 30%	
15.59																		RQD = 45%
40.39	Dolomite Bedrock		18	BXL RC	85% REC													
																		RQD = 9%
13.16	End of Borehole		19	BXL RC	30% REC													
42.82																		
							12											

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15
10

5 (%) STRAIN AT FAILURE