

REMARKS: \_\_\_\_\_

ENGINEERING MATERIALS OFFICE  
FOUNDATION DESIGN SECTION

WO 88-11001

DIST 6

HWY 401/GO TRANSIT STR SITE N/A

GO TRANSIT OVERHEAD AND APPROACHES

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# PRELIMINARY FOUNDATION INVESTIGATION REPORT

For

Go Transit Overhead and Approaches

FDS W.O. 88-11001

Hwy. 401, District 6, Toronto

## INTRODUCTION

This report summarizes the preliminary foundation investigation for the structure and approaches for the proposed crossing of Go Transit and the existing Hwy. 401. The report applies to the area between Sta. 28+000 and Sta. 29+200 (Go Transit alignment) except for Sta. 28+500 to Sta. 29+000 for which property clearance was not available.

## SITE DESCRIPTION

The site is located between Thickson Road and Thornton Road, near the border of the municipalities of Whitby and Oshawa. The site extends, along the Go Transit alignment, from just south of Hwy. 401, north, to approximately the intersection of Fox Street and Alcan Avenue. The portion of the alignment for which no property clearance was available extends from just north of Hwy. 401, north, to the CPR alignment.

The area is basically a glacial till plain with low local relief. The ground elevation varies from elevation 100± m at the southern portion, to elevation 111± m at the northern portion of the site. The till deposits generally consist of sandy silt although areas of clayey silt/silt and some sand zones were also encountered. The till deposits contain frequent random discontinuous silt and sand seams and pockets. Bedrock was not encountered during the investigation. Groundwater was generally within 1m to 2 m of the surface.

The land use in the area is a mixture of agricultural and residential, dissected by a number of major transportation corridors. A small motel and a drive-in theatre are located just north of Hwy. 401.

## INVESTIGATION PROCEDURES

A preliminary foundation investigation for this site was conducted between 88 05 09 and 88 05 20. A continuous flight auger machine, equipped with 82 mm I.D. hollow stem augers, and N and B casing was used.

The investigation consisted of 6 sampled boreholes accompanied by dynamic cone penetration tests. In addition a total of 5 piezometers were installed at 3 of the borehole locations.

The boreholes are identified as BH #1 to BH #6 inclusive. They extended for depths ranging from 13.7 m to 18.9 m. All boreholes were terminated within overburden.

Survey details were provided by M.M. Dillon, the design consultants for this project.

The sampling program consisted of split spoon samples collected at 0.8 m to 1.5 m intervals. They provided Standard Penetration Test (N) values for assessment of the in situ state of compaction of the non-cohesive materials, and for an indication of shear strengths of cohesive materials. These samples also provided material for identification purposes.

The laboratory testing program for representative samples consisted of:

- grain size analyses
- natural moisture content determinations
- Atterberg Limit determinations

## SUBSURFACE CONDITIONS

The Record of Borehole Sheets in the Appendix illustrate the subsurface conditions at the borehole locations. The locations and elevations of the boreholes, along with stratigraphical profiles based on the borehole data are shown on Drawing No. 8811001-A.

Based on the preliminary field investigation with its relatively widely dispersed borehole pattern, the subsurface conditions appear to consist essentially of a dense sandy silt till. However, an extensive deposit of hard clayey silt/silt till was encountered just north of the CPR tracks at the northern portion of site, from which it is inferred that other zones of clayey silt/silt till could exist along the Go Transit alignment. Both types of till deposits contained occasional sand and silt zones and occasional boulders. More extensive sand deposits were encountered immediately north of Hwy. 401 at BH #4 and north of the CPR at BH #6 and from this it is inferred that discontinuous pockets of sand may exist at other locations along the alignment. An artesian groundwater condition (to 2.4 m above existing ground surface) was encountered adjacent to the WB lanes of Hwy. 401 at BH #4 at elevation 95.4 m. It is noted that artesian conditions were also encountered north of Hwy. 401 at Corbett Creek during a previous investigation. From this it is inferred that there may be sand seams, charged with artesian pressure, at random locations across the site. Otherwise the groundwater level was encountered at 1 m to 2 m below ground surface.

Following are detailed descriptions of the soil strata encountered.

#### Sandy Silt Till

This basically non-cohesive material was encountered at all boreholes except BH #5 (immediately north of the CPR). At these locations, except for minor surficial topsoil deposits and road bed fills, and sand deposits at BH #4 and BH #6, the sandy silt till extended throughout these boreholes.

It has been described as a heterogeneous mixture of sandy silt containing some clay, traces of gravel, occasional silt and sand zones and occasional boulders. Although it is essentially non-cohesive, it does exhibit slight cohesion and it does contain occasional 2 m to 3 m thick zones of clayey silt to silt deposits.

Based on the results of Standard Penetration Tests (N=8 to 100+), the material is in a loose to very dense but generally compact to very dense state.

Typical properties of the materials, as determined by laboratory tests, are summarized as follows:

	<u>Range</u>	<u>Average</u>	<u>Median</u>
Water Content (w)	5.5-11.0%	7.4%	7.0%
Liquid Limit (w <sub>L</sub> )	11.0-16.0%	12.4%	12.0%
Plastic Limit (w <sub>p</sub> )	9.0-12.0%	10.0%	10.0%
Plasticity Index (I <sub>p</sub> )	1.0-3.5%	2.3%	2.5%

Figure 1 illustrates a typical plasticity distribution for this material.

Figure 2 illustrates a typical grain size distribution for this material.

#### Clayey Silt/Silt Till

This cohesive to slightly cohesive deposit was encountered at BH #5, immediately north of the CPR, where it extended for the full 17.7 m depth investigated.

It has been described as a heterogeneous mixture of clayey silt/silt, with sand, traces of gravel, occasional silt and sand seams and occasional boulders.

Based on the results of Standard Penetration Tests (N = 53 to 100+) the material is in a hard state.

Typical properties of the material, as determined by laboratory tests, are summarized as follows:

	<u>Range</u>	<u>Average</u>	<u>Median</u>
Water Content (w)	5.0-12.0%	7.7%	6.0%
Liquid Limit (w <sub>L</sub> )	14.0-18.0%	15.7%	15.0%
Plastic Limit (w <sub>p</sub> )	8.5-9.5%	9.0%	9.0%
Plasticity Index (I <sub>p</sub> )	5.5-8.5%	6.7%	6.0%

Figure 3 illustrates a typical plasticity distribution for this material.

Figure 4 illustrates a typical grain size distribution for this material.

### Sand

Significant deposits of this non-cohesive material were encountered at both BH #4 (immediately north of Hwy. 401) and at BH #6 (north of the CPR at the northern portion of the site). At BH #4, the sand layer extended for 1.2 m from elevation 95.4 m. At BH #6, the sand layer extended below elevation 98.3 m for an undetermined thickness of over 3 m.

Although these deposits are widely separated geographically, they have been grouped together for the purposes of this description. They have been described as sand, containing some silt and traces of clay. The deposit at BH #6 also contained some gravel.

Based on the results of Standard Penetration Tests ( $N = 100+$ ) the material is in a very dense state.

The results of 2 tests indicate natural water contents ranging from 7.0-16.5%.

Figure 5 illustrates a typical grain size distribution.

### Groundwater

At the time of the field investigation, the groundwater was generally within 1 m to 2 m of the ground surface. However, a significant artesian pressure, to 2.4 m above ground surface, was encountered at elev. 95.4 m at BH #4 (immediately north of Hwy. 401). Also, it should be noted that the sand deposits and the pockets of silt and sand within the overburden are water bearing and exhibit a tendency to flow or boil under conditions of unbalanced hydrostatic head.

## DISCUSSION

It has been proposed that Go Transit will cross beneath the existing Hwy. 401. This proposal would involve the construction of an overhead structure and extensive cuts up to 11± m deep.

## PRELIMINARY RECOMMENDATIONS

The following recommendations are intended for planning purposes and will require review after completion of a full scale foundation investigation during the design stage of this project. Due to the presence of artesian conditions, further detailed investigations will definitely be required before groundwater control recommendations can be finalized.

Transit structure could be founded on spread footings with O.H.B.D.C. loadings in the order of the values provided below.

Factored Bearing Capacity at U.L.S. = 525 kPa

Bearing Capacity at S.L.S. Type II = 350 kPa

For frost protection, 1.2 m of ground cover to the base of footings, or equivalent, is required.

The major concerns during construction of both the proposed structure and the proposed cuts will be control of groundwater and, to a lesser extent, the presence of boulders within the till deposits.

As the groundwater level is generally within 1 m to 2 m of the ground surface, and the cuts are up to 11± m deep, both a temporary (during construction) dewatering scheme and a permanent drainage system will be required.

It is our understanding that it is intended to install a gravity drainage culvert system through the Hwy. 401/Go Transit intersection prior to construction of the structure and approach cuts. It is also our understanding that the invert of this culvert will be at least 1.2 m below the base of the cut at the intersection. The presence of artesian conditions should be considered in the design and construction of this culvert.



The temporary (during construction) dewatering scheme should be required to lower the prevailing groundwater table a minimum of 0.5 m below the excavations and should be designed to prevent disturbance of the foundation soil or cut slopes. The dewatering scheme should also take into consideration the possibility of artesian conditions and the presence of silt and sand seams and pockets within the overburden. These materials are susceptible to disturbance under conditions of unbalanced hydrostatic head.

In order to dewater the deep cut, a larger scale scheme will probably be required. There is a possibility that the deep cut could be dewatered by excavating a pilot trench to facilitate dewatering while the required cut geometry is constructed. A typical design would involve construction of a pilot trench prior to the excavation of the proposed cut geometry. In this scheme the pilot trench would be excavated below the prevailing cut level, starting at the downstream end, and would be located, in plan, at the central portion of the proposed cut. However, in areas of artesian pressure, a relief well system may be required in order to relieve excess pressures and prevent blow-out of excavations.

Depending on the elevation of the base of footings for the proposed structure, it may be possible to dewater footing excavations with an oversize perimeter ditch/sump pumping system working in conjunction with an existing larger scale dewatering scheme.

As previously indicated, there is a strong possibility that artesian groundwater conditions may be encountered at random locations across this site. Due to the large extent of the site it will not be practical to define all of the locations affected by artesian conditions. Hence, it will be necessary to design a system capable of relieving artesian pressures and draining excess groundwater on a generalized basis. In this case, the toe of slope subdrains are intended to provide this function, in conjunction with a relief well system where required.

In any case, the contract for this project should alert the contractor to the concerns regarding groundwater control and boulders and require that the contractor consider these concerns in his proposal.

The proposed cut will expose numerous random pockets and some distinct zones of fine-grained granular soils that are susceptible to disturbance when the water table is lowered. Therefore slope protection and drainage measures will be required to ensure their long-term surficial stability. These measures are required to lower the groundwater table below the frost penetration depth to prevent the softening of material due to freeze-thaw cycles, and to dissipate excess pore water pressures that could contribute to surficial slope failures.

The cut geometry-surface treatment-drainage conditions have been analyzed utilizing Bishop's effective stress method. The assumptions and results of these analyses are illustrated in Figure 6.

Based on these analyses:

- for cuts less than 5.5 m in depth, the slope treatment should consist of a 2H:1V slope incorporating a 1.2 m deep toe drain and blanketed with 0.6 m (thickness) of Granular A. The recommended treatment is illustrated in Figure 7A.
- for cuts greater than or equal to 5.5 m in depth, the slope treatment should consist of 2H:1V slopes incorporating a 2 m wide bench (located so that no slope has an uninterrupted depth greater than 5.5 m). The bench may be graded out as soon as is practical beyond the designated bench area. The bench should slope back at 5%  $\pm$  towards the drain. The slope treatment should incorporate 1.2 m deep bench and toe drains, and the lower slope should be blanketed with 0.6 m (thickness) of Granular A. The recommended treatment is illustrated in Figure 7B.
- an interceptor ditch should be constructed along the crest of all slopes.

The granular blanket and drain backfill should consist of MTO Granular 'A'. The drain trenches should be lined with a suitable geotextile filter fabric. The perforated pipes should be 150 mm minimum diameter (or greater if required for any additional runoff or anticipated artesian groundwater flows) and should be

surrounded by a minimum of 150 mm of granular backfill. The drains should be connected to an appropriate permanent drainage system.

Normal slope vegetation should be established as soon as possible after completion of the cut in order to control surficial erosion.

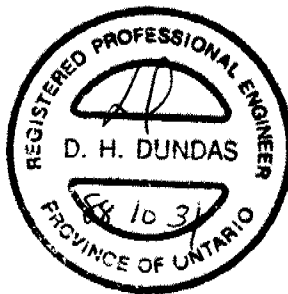
Consideration should be given to establishing the existing groundwater conditions in the area surrounding the site, and the effects of both temporary dewatering and permanent drainage, particularly in those areas where there is a potential for claims.

#### MISCELLANEOUS

The field investigation for this project was carried out under the supervision of J. Fellenius, Engineering Student.

The equipment used was owned and operated by Master Soil Investigation Ltd.

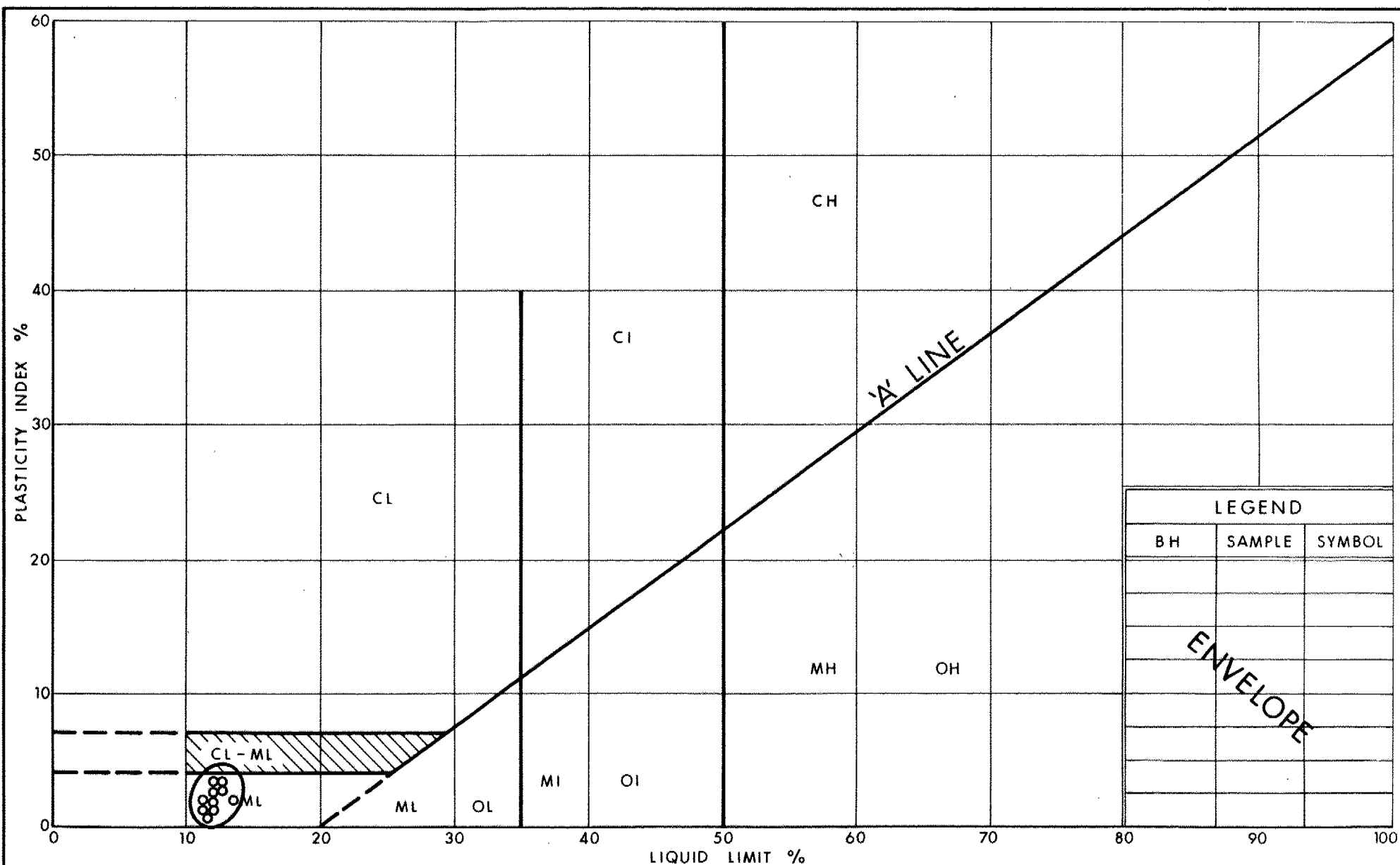
The report was written by D. Dundas, Sr. Foundations Engineer, and reviewed by M. Devata, Chief Foundations Engineer.



*D. H. Dundas*  
D. H. Dundas, P.Eng.  
Sr. Foundation Engineer

*M. Devata*  
M. Devata, P.Eng.  
Chief Foundations Engineer

## **A P P E N D I X**



Ontario

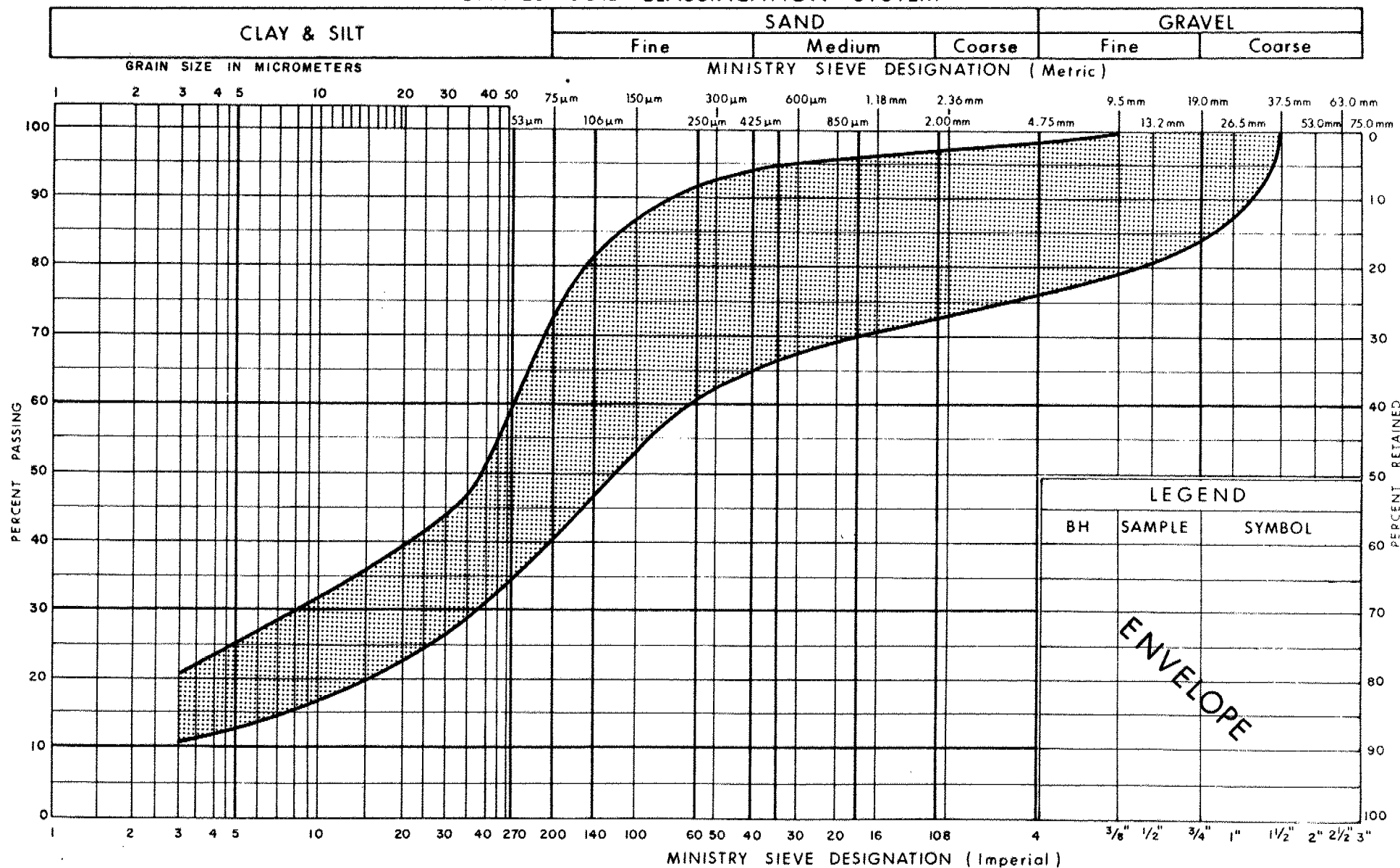
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# PLASTICITY CHART SANDY SILT (Till)

FIG No 1

W O 88-11001

## UNIFIED SOIL CLASSIFICATION SYSTEM

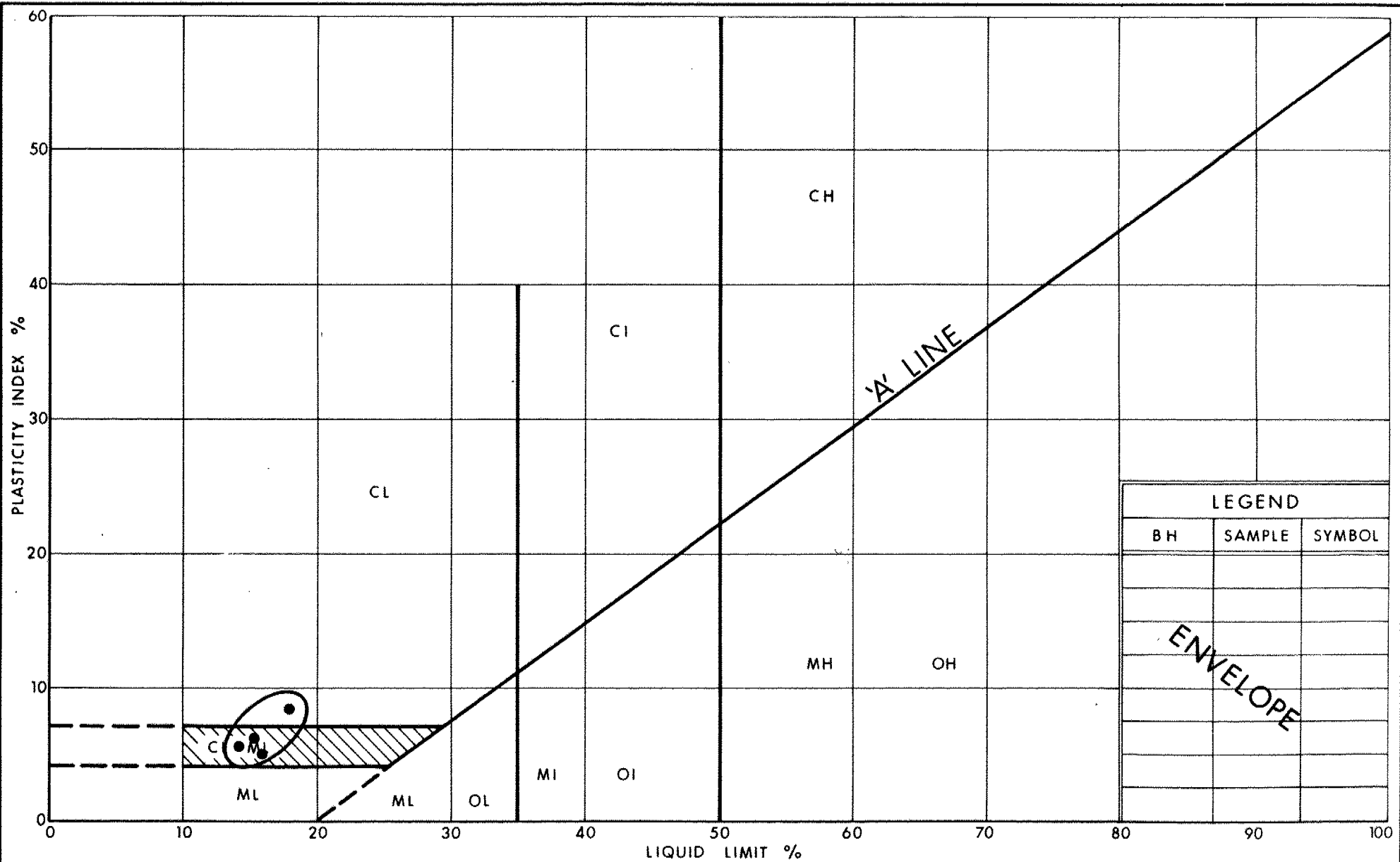


Ministry of  
Transportation

GRAIN SIZE DISTRIBUTION  
SANDY SILT (Till)

FIG No 2

W O 88-11001



Ministry of  
Transportation

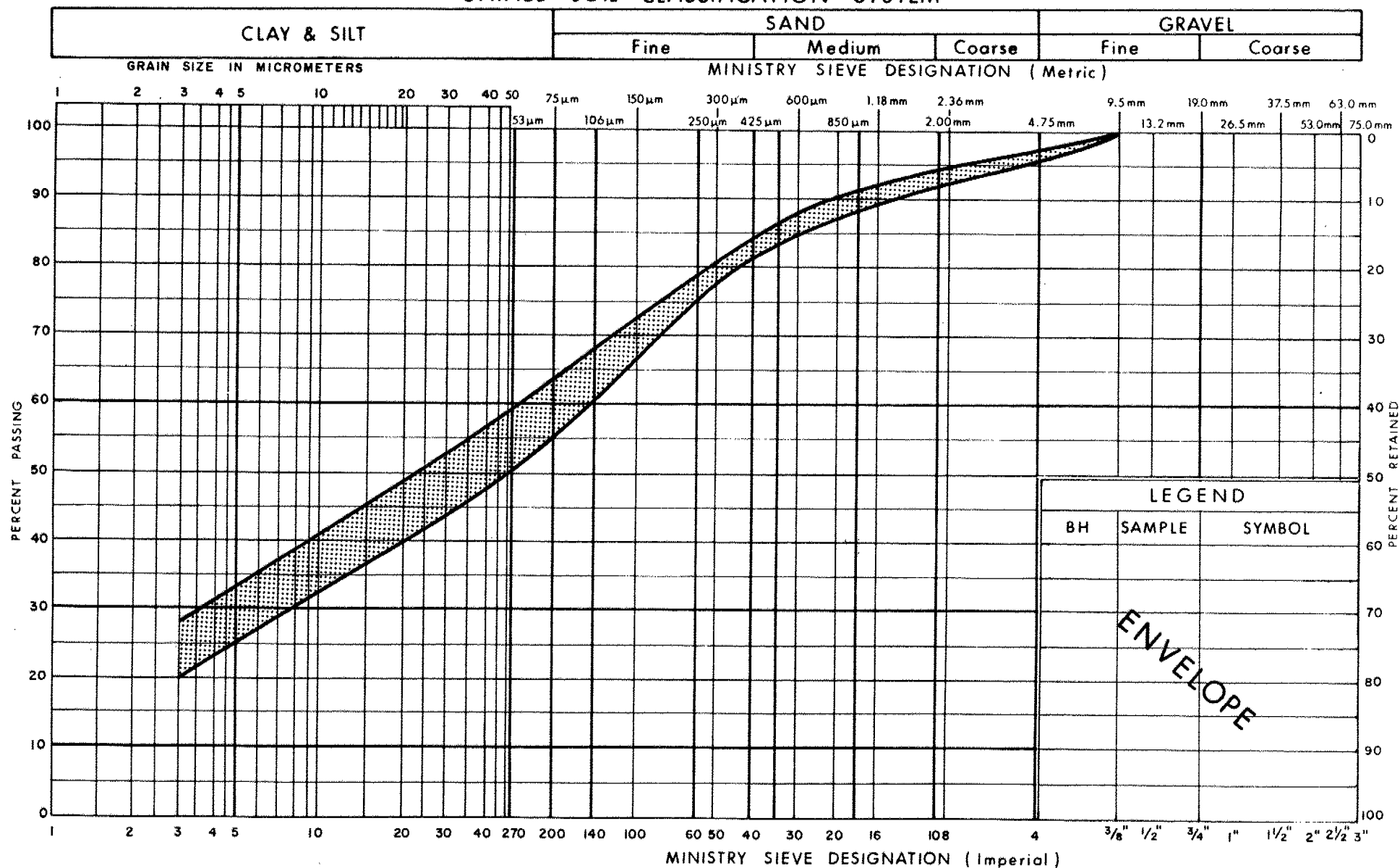
Ontario

# PLASTICITY CHART CLAYEY SILT / SILT (Till)

FIG No 3

W O 88-11001

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation

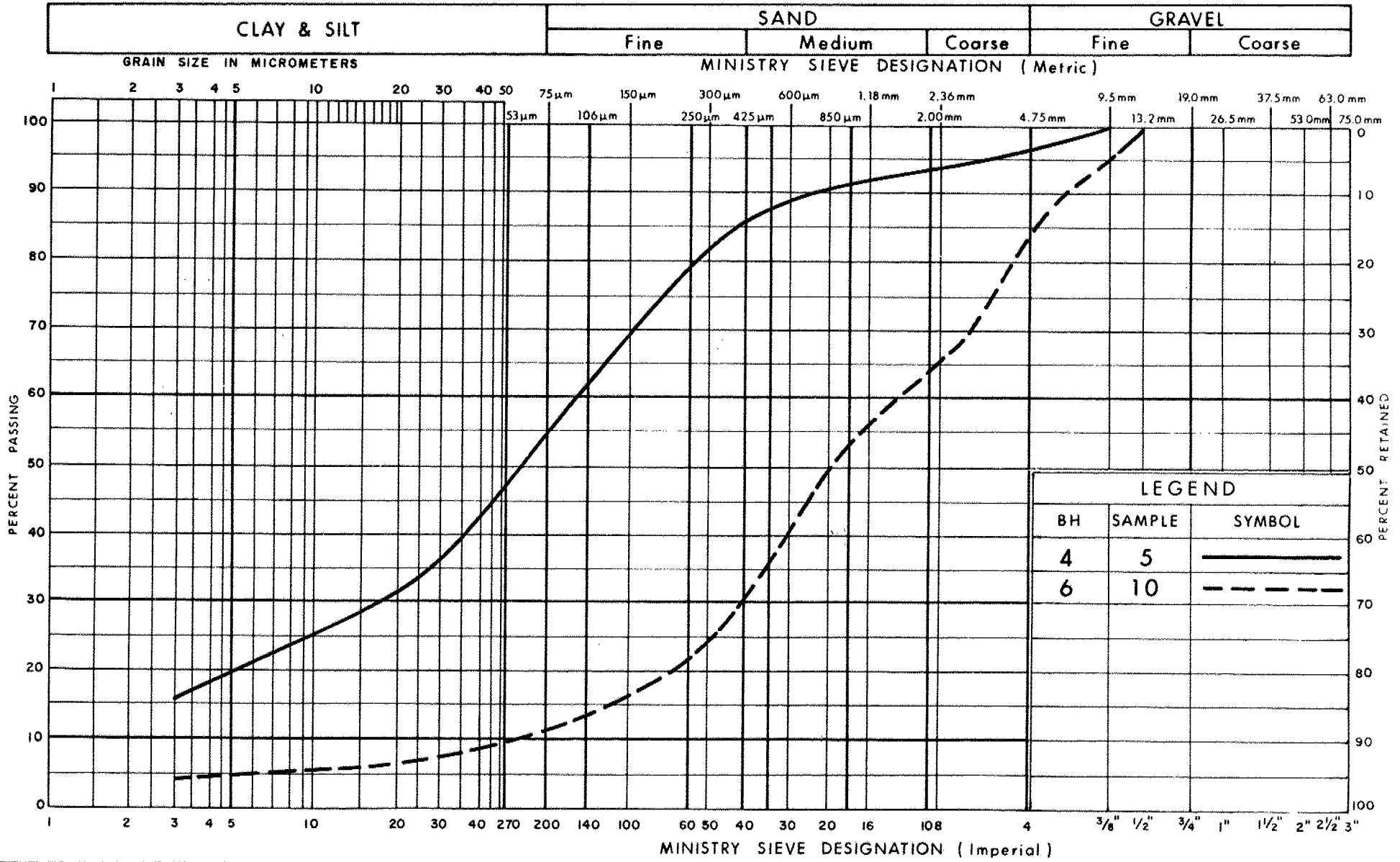
## GRAIN SIZE DISTRIBUTION CLAYEY SILT/SILT (Till)

FIG No 4

W O 88-11001



# UNIFIED SOIL CLASSIFICATION SYSTEM

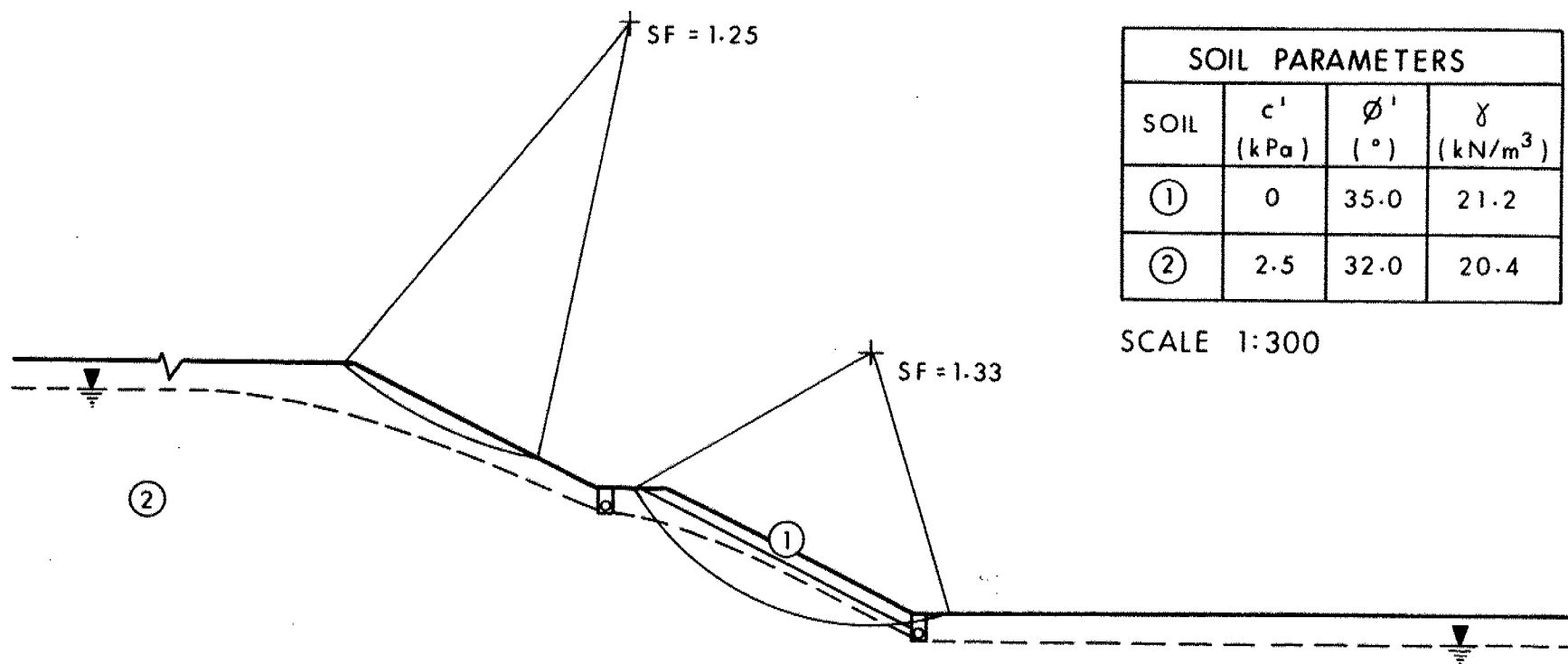


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Transportation

## GRAIN SIZE DISTRIBUTION SAND

FIG No 5

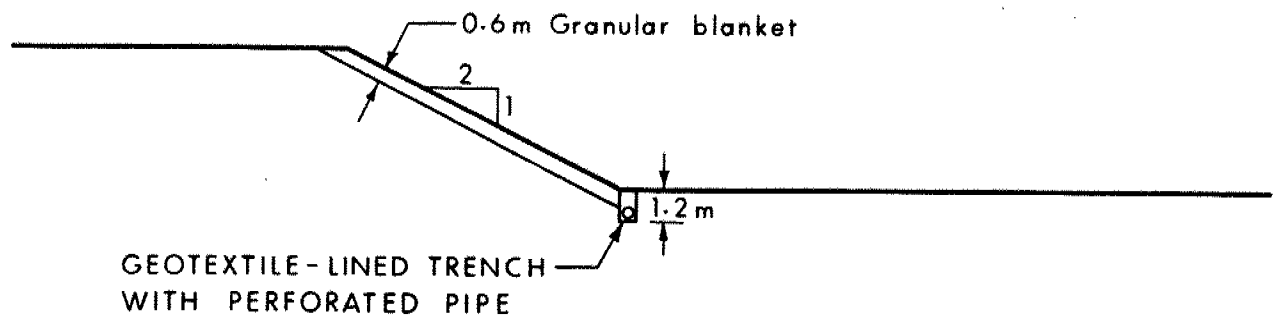
W O 88-11001



## EFFECTIVE STRESS ANALYSIS

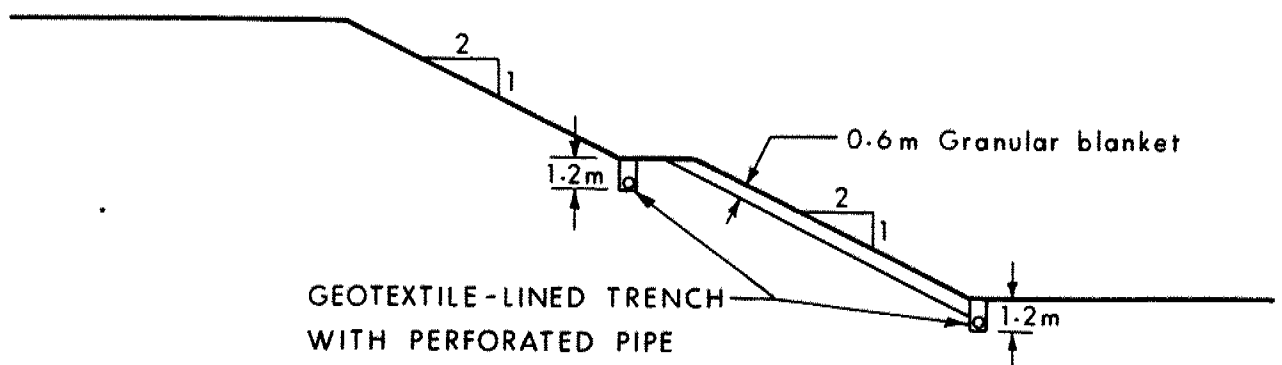
WO 88-11001

Fig 6



## RECOMMENDED CUT SLOPE TREATMENT FOR CUTS UNDER 5.5 m DEEP

Fig 7A



## RECOMMENDED CUT SLOPE TREATMENT FOR CUTS GREATER THAN OR EQUAL TO 5.5 m DEEP

Fig 7B

## 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 kg, 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

### MECHANICAL PROPERTIES OF SOIL

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

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	$\text{kg}/\text{m}^3$	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{\min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
$\rho_w$	$\text{kg}/\text{m}^3$	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	$\text{kg}/\text{m}^3$	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	$\text{kg}/\text{m}^3$	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	$\text{m}^3/\text{s}$	RATE OF DISCHARGE
$\gamma_d$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
$\rho_{\text{sat}}$	$\text{kg}/\text{m}^3$	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
$\gamma_{\text{sat}}$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	$\text{kg}/\text{m}^3$	DENSITY OF SUBMERGED SOIL	$e_{\max}$	1, %	VOID RATIO IN LOOSEST STATE	j	$\text{kn}/\text{m}^2$	SEEPAGE FORCE
$\gamma'$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SUBMERGED SOIL						



# RECORD OF BOREHOLE No 1

METRIC

W O 88-11001 LOCATION Co-Ords N 4 859 063.8; E354 142.3 ORIGINATED BY JBF  
DIST 6 HWY 401 BOREHOLE TYPE Cone Test, Hollowstem Augers COMPILED BY JBF  
DATUM Geodetic DATE 88 05 09 CHECKED BY DD

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
99.6	Ground Surface										
0.0	Trace Organics Occ. Zone of Clayey Silt/Silt Stiff to very Stiff (CL/CL-ML)		1	AS	-						
			2	SS	14						6 36 37 21
			3	SS	25						
	Heterogeneous Mixture Sandy Silt Some Clay trace Gravel		4	SS	48						4 43 39 14
			5	SS	31						6 41 43 10
	Occ. Silt & Sand Seams		6	SS	40						
	Occ. Boulders Compact to Dense		7	AS	-						13 37 39 11
	Slightly Cohesive (ML) (Till)		8	SS	47						
			9	SS	43						
			10	SS	36						
			11	SS	21						
	Occ. zones of Clayey Silt/silt Stiff to Hard (CL/CL-ML)		12	SS	14						
			13	SS	45						
			14	SS	43						
80.9			15	SS	33						
18.7	END OF BOREHOLE										
	Note: A S - Auger Sample										



# RECORD OF BOREHOLE No 2

METRIC

WO 88-11001 LOCATION Co-Ords N 4 859 150.0; E 354 182.0 ORIGINATED BY JBF  
DIST 6 HWY 401 BOREHOLE TYPE Cone Test, Hollow Stem Auger COMPILED BY JBF  
DATUM Geodetic DATE 88 05 09-10 CHECKED BY DD

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	10 20 30					
101.1	Ground Surface													
0.0	Trace Organics													
	Occ. Zones of													
	Clayey Silt/Silt		1	SS	11		100							
	Stiff to Very Stiff		2	SS	17	88 05 12								
	(CL/CL-ML)													14 39 37 10
	Heterogeneous Mixture													
	Sandy Silt		4	SS	37									
	Some Clay													
	Trace Gravel		5	SS	31									18 37 35 10
	Occ. Silt & Sand Seams													
	Occ. Boulders		6	SS	47									4 42 42 12
	Loose to Dense													
	Slightly Cohesive													9 41 35 15
	(ML) (Till)		7	SS	38									
			8	SS	43									
	Occ. Zones of													
	Clayey Silt/Silt		9	SS	26									
	Stiff to very Stiff													
	(CL/CL-ML)		10	SS	26									
			11	SS	9									
			12	SS	13									
82.4			13	SS	11									
18.7	END OF BOREHOLE													



# RECORD OF BOREHOLE No 3

METRIC

WO 88-11001 LOCATION Co-Ords N 4 859 218.1; E 354 207.6 ORIGINATED BY JBF  
DIST 6 HWY 401 BOREHOLE TYPE Cone Test, Hollowstem Augers COMPILED BY JBF  
DATUM Geodetic DATE 88 05 10-12 CHECKED BY DD

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W (LIQUID LIMIT W <sub>L</sub> ) WATER CONTENT (%) 10 20 30	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE						
101.9	Ground Surface								
0.0	Sand with Gravel (Fill)								
101.3									
0.6	Occ. Zones of Clayey Silt/Silt Very Stiff, (CL/CL-ML)	1	SS	26	88 05 22				
		2	SS	49	100				
	Heterogeneous Mixture	3	SS	20	98				12 39 40 9
	Sandy Silt Some Clay	4	SS	26	96				13 38 39 10
	trace Gravel	5	SS	41	94				4 41 42 13
	Occ. Silt, Sand Seams	6	SS	23	92				2 45 42 11
	Occ. Boulders Loose to Dense. Slightly Cohesive (ML) (Till)	7	SS	31	90				
		8	SS	33	88				9 41 38 12
		9	SS	19	86				
	Occ. Zones of Clayey Silt/Silt Stiff (CL/CL-ML)	10	SS	15	84				
		11	SS	8					
83.2		12	SS	10					
18.7	END OF BOREHOLE								

+3, x5: Numbers refer to Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 4

METRIC

W/O 88-11001 LOCATION Co-Ords N 4 859 316.0; E 354 210.6 ORIGINATED BY JBF  
 DIST 6 HWY 401 BOREHOLE TYPE Cone Test, Hollow-stem Auger COMPILED BY JBF  
 DATUM Geodetic DATE 88 05 17-20 CHECKED BY DD

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			VALUES	20 40 60 80 100					
103.3	Ground Surface												
0.0	Sand with Gravel (Fill)					Artesian Elev. 105.7							
102.7						88 04 03							
0.6	Occ. Zones of Clayey Silt/Silt hard (CL/CL-ML)		1	SS	34								
	Heterogeneous Mixture		2	SS	47								17 37 37 9
	Sandy Silt some Clay		3	SS	37								25 35 31 9
	Trace Gravel		4	SS	59								4 41 41 14
	Occ. Silt, sand seams		5	SS	100								0 78 18 4
	Occ. Boulders												
	Dense to very Dense Slightly Cohesive (ML) (Till)												
95.4													
7.9	Sand		6	SS	120	13cm							
94.2	Some Silt, Trace Clay Very Dense		7	SS	100	0cm							
9.1	Heterogeneous Mixture		8	SS	108	15cm							
	Sandy Silt												
	Some Clay												
	Trace Gravel												
	Occ. Silt & Sand Seams												
	Occ. Boulders												
	Very Dense Slightly Cohesive (ML) (Till)		9	SS	70	15cm							
89.4													
13.9	END OF BOREHOLE												





# RECORD OF BOREHOLE No 5

METRIC

WO 88 - 11001 LOCATION Co-Ords N 4 859 900.0; E 354 217.5 ORIGINATED BY JBF  
DIST 6 HWY 401 BOREHOLE TYPE Cone Test, Hollowstem Auger COMPILED BY JBF  
DATUM Geodetic DATE 88 05 13-16 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	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 kPa					
110.5	Ground Surface													
0.0	Trace Organics						110							
	Heterogeneous Mixture		1	SS	53		108							
	Clayey Silt/Silt		2	SS	70/15		106							
	with Sand		3	SS	80/10		104							
	Trace Gravel		4	SS	50/5		102							
	Occ. silt & Sand Seams		5	SS	80/15		100							
	Occ. Boulders		6	SS	83/15		98							
	Hard		7	SS	75/15		96							
	(CL/CL-ML)		8	SS	139		94							
	(Till)		9	SS	75/15									
			10	SS	92/15									
			11	SS	73/15									
92.8														
17.7	END OF BOREHOLE													

OFFICE REPORT ON SOIL EXPLORATION



# RECORD OF BOREHOLE No 6

METRIC

WO 88-11001 LOCATION Co-Ords N 4 860 022.0; E 354 244.0 ORIGINATED BY JBF  
DIST 6 HWY 401 BOREHOLE TYPE Cone Test, Hollowstem Auger COMPILED BY JBF  
DATUM Geodetic DATE 88 05 12 CHECKED BY DD

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION		NUMBER	TYPE	'N' VALUES			20	40	60	80	100				
109.0	Ground Surface															GR SA SI CL
0.0	Trace Organics		1	AS	-		108									
	Occ. zones of Clayey Silt / Silt Very Stiff (CL/CL-ML)		2	SS	20											
			3	SS	29											
	Heterogeneous Mixture		4	SS	104		106									1 44 44 11
	Sandy Silt					88 06 03										
	Some Clay		5	SS	101	23cm	104									4 37 46 13
	Trace Gravel															
	Occ. Silt & Sand Seams		6	SS	55	15cm	102									4 35 45 16
	Occ. Boulders															
	Compact to very dense Slightly Cohesive (ML) (Till)		7	SS	80	15cm	100									
			8	SS	70	15cm										2 25 63 10
98.3																
10.7	Sand		9	SS	91	23cm	98									
	Some Gravel															
	Some Silt		10	SS	80	10cm										20 68 11 1
	Trace Clay															
	Very Dense															
95.3			11	SS	100	0cm	96									
13.7	END OF BOREHOLE															
	Note: A S = Auger Sample															

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

CONT No  
WO No 88-11001

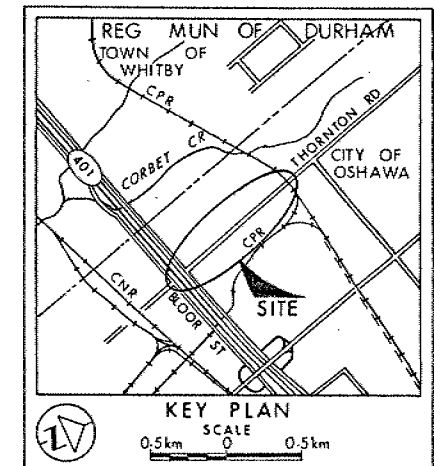


GO TRANSIT  
(STA 28+200 TO STA 29+200)  
BORE HOLE LOCATIONS & SOIL STRATA

SHEET



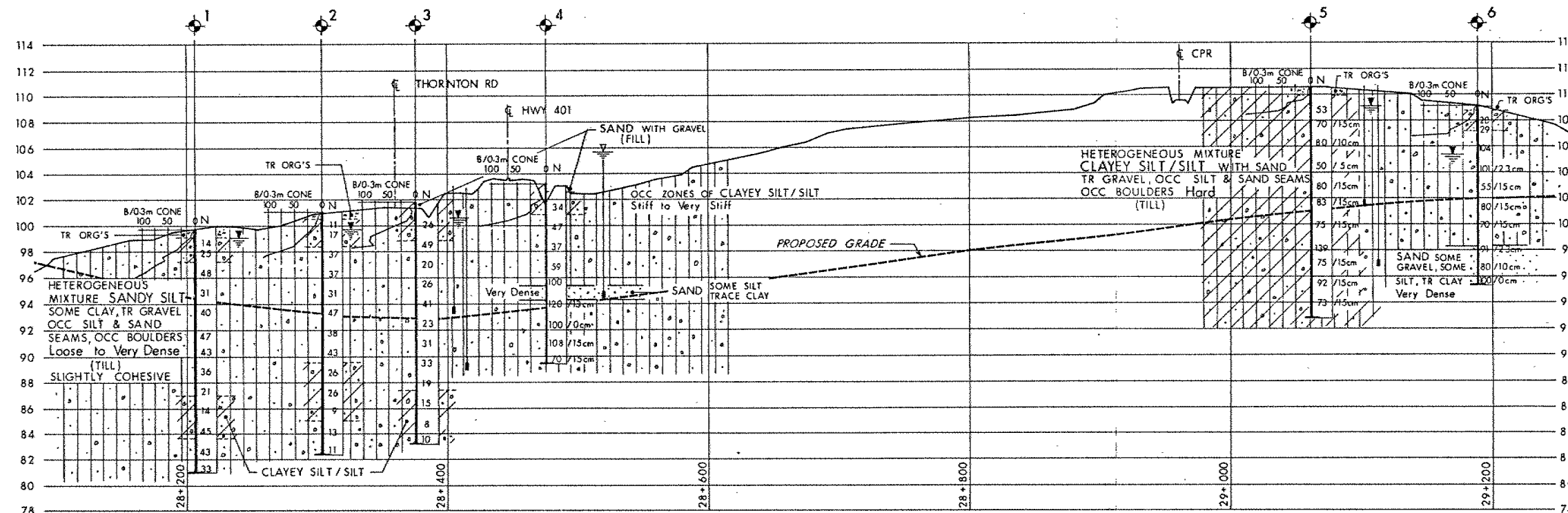
PLAN  
SCALE  
40m 20 0 20m 40m



# LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W/L at time of investigation 1988 05 and 1988 06
- W/L in Piezometer Artesian Head
- Piezometer

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	99.6	4 859 063.8	354 142.3
2	101.1	4 859 150.0	354 182.0
3	101.9	4 859 218.1	354 207.6
4	103.3	4 859 316.0	354 210.6
5	110.5	4 859 900.0	354 217.5
6	109.0	4 860 022.0	354 244.0



PROFILE GO TRANSIT  
SCALE  
40m 20 0 20m 40m Hor  
4m 2 0 2m 4m Vert

**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 30M15-79

HWY No 401	SUBMIT DD	CHECKED	DATE 88 11 21	DIST 6
DRAWN DT	CHECKED	APPROVED	SITE	DWG 8811001-A



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## PICKERING-OSHAWA SECTION



Ministry of  
Transportation and  
Communications



## **Golder Associates**

CONSULTING GEOTECHNICAL AND MINING ENGINEERS

# **PICKERING-OSHAWA SECTION**

ENGINEERING MATERIALS OFFICE  
FOUNDATION DESIGN SECTION

W O GGE 001-018 DIST 6

HWY GO-ALRT STR SITE

OSHAWA PROJECT

THORNTON ROAD CROSSING

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## 1.0 INTRODUCTION

On behalf of GO-ALRT, the Ministry of Transportation and Communications has retained Golder Associates to carry out a foundation investigation for the proposed crossing of the GO-ALRT track at Thornton Road in Oshawa, Ontario.

Golder Associates conducted a subsurface investigation for the GO-ALRT/Thornton Road crossing some 30 m north of the present site in September, 1983. Subsequently, the horizontal alignment was relocated and the vertical alignment was changed from embankment to cut section. These changes necessitated the present subsurface investigation.

The purpose of the latest investigation was to determine the subsurface conditions at the site and based on these, to provide recommendations relating to the geotechnical design of the GO-ALRT cut and the Thornton Road bridge structures.

## 2.0 SITE AND PROJECT DESCRIPTION

The site is located about 1 km north of Highway 401 at Thornton Road in the City of Oshawa, Regional Municipality of Durham. An Ontario Hydro substation is located along the northern limit of the proposed GO-ALRT right-of-way west of Thornton Road. The centreline of the proposed GO-ALRT line traverses farmland on both sides of Thornton Road.



### 3.0 SUBSURFACE CONDITIONS

#### 3.1 Site Geology

The site is located in the physiographic region known as the Iroquois plain. The overburden soils in the area consist of glacial till deposited during the last glacial advance. The present Lake Ontario basin was subsequently inundated by glacial Lake Iroquois following the recession of the ice. The shoreline of this glacial lake is located just north of the site. The depth to bedrock at the site is unknown.

#### 3.2 Soil Stratigraphy

The detailed stratigraphy encountered in each of the boreholes, put down as part of the current investigation, together with the results of laboratory tests carried out on representative samples, are given on the attached Record of Borehole sheets, 101 to 108, including 103A and on Figures 1 to 11, inclusive. Boreholes 7 and 8 from the 1983 investigation were put down within the relocated area of the site and the Record of Borehole sheets for these boreholes are included in Appendix B. Laboratory test results from samples from these boreholes have been included in the relevant figures. It should be noted that the stratigraphic boundaries shown on the Record of Borehole sheets are approximate and are not intended to define an exact plane of geological change. Further, subsurface conditions will vary between and beyond the borehole locations. The Record of Borehole sheets have been summarized on Drawing A.

The deepest stratum encountered in the investigation is a layer of highly overconsolidated silty clay. This material is overlain by a deposit of very hard silty clay till, which in turn is overlain by three zones of silt till. The middle silt till zone is the weakest material on site and, in place, contains layers of varved

clay. The upper silt till zone is overlain by topsoil or fill material. 'N'\* values, in situ vane shear strengths and water contents have been plotted against elevation in Figure 9.

### 3.2.1 Topsoil and Fill

Up to 0.85 m of organic sandy silt topsoil was found below the ground surface in all boreholes except Borehole 103. Borehole 103, located on the shoulder of the existing Thornton Road, encountered about 40 mm of asphalt overlying approximately 1 m of silty sand and gravel fill. Borehole 7, put down as part of the previous investigation and located on the gravel driveway, encountered about 1.5 m of sand and gravel fill. A layer of organic material, which is probably the original topsoil, was encountered beneath this granular fill.

### 3.2.2 Silt Till

The predominant soil type at the site is a glacial till consisting primarily of silt. The silt is very sandy in places although it is generally plastic and contains varying amounts of clay. Trace amounts of gravel and occasional boulders were found throughout the deposit. The till has a low plasticity based on plasticity indexes of less than 12, with an average value of about 7. The till can generally be classified as a silt or clay of low plasticity. Typical grain size curves are shown on Figures 1 and 2. The results of Atterberg limits tests are shown on Figure 7.

The till has three distinct zones; an upper weathered crust extending to a depth of about 4.5 m below ground surface, a weaker zone extending to between 7.5 and 10.0 m depth and a very hard zone to about 16 m depth.

---

\*'N' Values - Standard Penetration Resistance  
Refer to Explanation of Terms

The upper weathered zone of the till has a very stiff to hard consistency with 'N' values of 15 or more. The zone is brown in colour and contains many rust stained fissures at random orientations. The water content of samples of till from this zone is generally around 10 per cent. The unit weight of a sample of this material was 23.1 kN/cu.m.

The middle zone of the till is considerably weaker and more variable in composition than the overlying and underlying materials. 'N' values as low as 4 and generally of about 10 blows/ft. were obtained within this zone. In situ vane tests were carried out in this zone and measured undrained shear strengths as low as 30 kPa although shear strengths in excess of 45 kPa were more common. The sensitivity of the till is typically between 1 and 4, with a maximum measured value of 4.7. The water content of samples of till from this weaker zone ranged between 9 and 21 per cent and were typically about 12 per cent. The unit weight of a sample of the till was 21.6 kN/cu.m.

The composition of this till deposit varies within and between boreholes from a loose sandy silt with trace clay and gravel, to a firm to very stiff silty clay with sand and trace gravel. Additionally, a thin deposit of varved clay was encountered within the weak till in Boreholes 101, 105 and 106. Because continuous sampling was not carried out, it is possible that a thin layer of this material is present at the location of the other boreholes.

A series of four stress controlled, drained triaxial tests were conducted using 'undisturbed' samples of the weak silt till from Borehole 107, Sample 7a (2 tests) and Borehole 102, Sample 7a (2 tests). The results of these "S" tests are presented on Figure 10. The tests on Sample 107/7a indicated effective stress parameters of  $\phi' = 32.5^\circ$  and  $c' = 0$ . Tests on Sample 102/7a indicated effective stress parameters of  $\phi' = 36.0^\circ$  and  $c' = 0$ .

The lower zone of the till is very hard as indicated by the 'N' values in excess of 60. Samples of the till within this zone had water contents ranging from 6 to 9 per cent. The unit weight of a sample of the very hard silt till was found to be 23.9 kN/cu.m. Boreholes 104, 105 and 106 were terminated within this zone. Borehole 105 encountered refusal to augering on a boulder.

### 3.2.3 Varved Clay

A thin deposit of varved clay was encountered within the weak till zone in Boreholes 101, 105 and 106. Each varve was about 10 mm thick and was comprised of a dark grey and a light grey layer. A sample of the dark grey material was found to have a clay size content in excess of 50 per cent and a plasticity index of 32. A sample of the light grey material had a clay content of about 25 per cent and a plasticity index of 11. The results of the particle size determinations and the plasticity characteristics of this material are shown on Figures 4 and 8, respectively. The water contents of samples of the dark grey material was determined for two samples and were found to be 34 and 36 per cent. The water contents of two samples of the lighter material were measured to be 14 and 24 per cent.

A series of three stress controlled undrained triaxial tests were conducted on samples from Borehole 101, Sample 8. The results of these tests are presented on Figure 11. The triaxial tests indicated that the effective stress parameters for this material are  $\phi' = 30^\circ$  and  $c' = 11.5$  kPa.

### 3.2.4 Silty Clay Till

Approximately 3.5 m of dark grey silty clay till was encountered in Boreholes 102, 103A and 108. Boreholes 101 and 107 also encountered this material and these boreholes were terminated within the deposit. The till is very hard in consistency as indicated by 'N' values in excess of

60 blows/300 mm. Typical particle size distributions for this material are shown on Figure 5. A liquid limit of 29 per cent and a plasticity index of 15 were measured on a sample from Borehole 8. The water content of samples of the till was found to increase with depth from about 11 to 23 per cent.

### 3.2.5 Silty Clay

Boreholes 102, 103A and 108 were terminated within a deposit of dark grey faintly layered silty clay. A typical particle size distribution is shown on Figure 6. The silty clay is hard in consistency with 'N' values ranging from 33 to in excess of 60 blows/300 mm. The water content of a sample of the silty clay from Borehole 101 was measured to be 28 per cent.

### 3.3 Groundwater Conditions

On March 14, 1985, the water levels in some of the piezometers sealed into deep strata on the site had not stabilized. The levels in some of these installations had risen to within 2 m of ground surface by that date. Other installations in comparable strata show groundwater levels as deep as 13 m; however, the information from the previous investigation indicates that the groundwater level in these deep layers is generally within 5 m of the surface.

The groundwater monitoring installations located within and above the weak till strata are subject to seasonal variation. On March 14, 1985, during a seasonal thaw, these installations indicated groundwater levels between 0.4 and 1.4 m below ground surface. On September 14, 1983, one week after drilling, the piezometer at 3.2 m depth in Borehole 8 was dry. Table 1 summarizes water level readings taken at the site.

TABLE 1WATER LEVEL READINGSDEPTH OF WATER BELOW GROUND LEVEL

<u>Borehole and Installation</u>	<u>83/09/14</u>	<u>85/02/04</u>	<u>85/02/08</u>	<u>85/02/21</u>	<u>85/03/14</u>
7	5.2 m	-	-	-	-
8	Dry to 3.5 m	-	-	-	-
101(A)	-	5.7	5.3	5.1	4.4
101(B)	-	1.8	1.7	1.6	0.4
102(A)	-	-	10.3	8.6	7.2
102(B)	-	-	1.9	1.4	Blocked
103A(A)	-	-	18.1	13.1	7.3
103A(B)	-	-	8.6	2.9	1.9
104	-	2.7	2.8	1.7	1.8
105	-	-	Dry	13.3	13.0
106(A)	-	2.5	2.4	2.4	1.4
106(B)	-	1.4	1.4	0.9	0.4
107(A)	-	12.1	10.2	6.3	2.8
107(B)	-	4.5	2.1	1.6	0.6
108	-	13.8	12.2	8.8	5.5

#### 4.0 DISCUSSION AND RECOMMENDATIONS

##### 4.1 General

Preliminary plans of the proposed structure were provided in a drawing titled "Preliminary Structural Site Plan" drawing PD1-601. This plan indicates that the proposed GO-ALRT alignment passes beneath Thornton Road in a cutting of 12 m maximum depth. A single span bridge structure is proposed to carry Thornton Road over the cutting. The approaches to the bridge structure would be supported by retaining walls. It is understood that the retaining walls will probably parallel the GO-ALRT line, but it is possible that an alternative in which the retaining walls will be parallel to Thornton Road, will be constructed. It is further understood that the grade of Thornton Road will be lowered by some 2 m from its present elevation.

##### 4.2 Abutments and Retaining Walls

It is recommended that the bridge abutments and the retaining walls be founded on spread footings within the hard lower zone of the silt till. Spread footings should be located within undisturbed material at a depth of at least 1.2 m below the final grade outside the wall or abutment. Under these conditions, the factored bearing capacities at U.L.S. and S.L.S., Type II bearing capacities for spread footings may be taken as 800 kPa and 350 kPa, respectively. The S.L.S. Type II value will ensure settlement of less than 25 mm. The U.L.S. bearing value should be reduced in accordance with the inclination of load on the foundation.

For retaining walls and bridge abutments, the lateral earth loads will depend on the type and method of placement of the backfill materials and on the subsequent lateral movement of the structure. The following recommendations are made concerning the lateral loading of abutments and retaining walls.

- o Selected "free draining" granular fill, such as MTC Granular 'B', Type 1, in accordance with MTC specifications should be used as backfill immediately behind the structures. The granular fill should be placed in the wedge-shaped zone defined by a 60 degree line extending up and back from the bottom of the rear face of the structures' footings.
- o All granular fill should be compacted in 200 mm thick lifts to 95 per cent of the standard Proctor density of the material. However, heavy compaction equipment should not be used behind any structure within a lateral distance equal to the current height of the fill above the base of the structures.
- o Longitudinal drains should be provided within the granular backfill to ensure that it is positively drained. These drains should be located at the lowest elevation permitted by the available outfall. Ideally, the drains should be located immediately behind the heel of the wall. If drains are located above the heel of the wall, destabilizing water pressures must be taken account of in the earth pressure and sliding resistance computations.
- o Structures retaining horizontal ground and backfilled in the prescribed manner may be designed based on earth pressures of 8.0 kPa and 6.5 kPa per metre of retained height for



U.L.S. and S.L.S. Type II, respectively. Where retaining walls support sloping backfill, placed as described above, the corresponding design earth pressures are 10 kPa and 8 kPa per metre of wall height, for U.L.S. and S.L.S. Type II, respectively.

- o The shear resistance along the base of spread footings poured directly on undisturbed, freshly excavated native material may be taken as 0.45 times the effective vertical force on the footing.

Retaining walls parallel to Thornton Road are not recommended from a geotechnical viewpoint since, along most of their length, their base would be in the upper softer materials which are not suitable for the support of spread footings. If other considerations lead to the selection of this arrangement, the walls which are not at the base of the cut can be founded on piles driven into the hard till which is present at about elevation 97 m. Because of the possible presence of boulders, a steel H Pile is considered to provide the most suitable foundation although care must be taken to detect any deflection during driving. An HP 310 x 110 pile driven with a hammer of rated energy approaching, but not exceeding 55 kJ to an average set of 2.5 mm per blow for 10 blows, or to elevation 94 m, will have a factored capacity at U.L.S. of 1000 kN. The capacity at S.L.S. can be taken as 700 kN. The piles should not be driven below elevation 94 m as the soil below elevation 87 m is less competent.

#### 4.3 Temporary Excavations

The stability of temporary excavations will be controlled by the thin layer of firm clay which was encountered at a maximum depth of 7.0 m (Borehole 101). An undrained analysis of this condition with side slopes of 2 horizontal

to 1 vertical gave a minimum factor of safety of 1.3. This side slope may be used for temporary cuts (open for less than 6 months) if surcharge loads are kept at least 5 m from the top of the slope, and if the slopes are monitored on a daily basis.

The silt till is well graded and is therefore relatively impermeable and relatively insensitive to disturbance due to upward seepage. Extensive dewatering of the silt till will not be required. It is anticipated that seepage into the excavation can be controlled using sumps and ditches. Local sloughing of the slope may take place in zones of water seepage and this can be controlled through the placement of a granular blanket over the affected area. Cross slope ditches are recommended for the control of water flowing down the slope.

#### 4.4 Permanent Cut Slopes

Slope stability analyses have been carried out for various slope geometries and drainage conditions. The analyses were based on a limit equilibrium method originally developed by Sarma (1973). Searches for critical circular arcs were carried out by computer and the critical surfaces obtained are shown in Figures 12 and 13.

Groundwater levels near the existing ground surface, combined with the low permeability of the till and clay deposits, will result in high porewater pressures within the banks of the GO-ALRT cuts. The results of the analyses showed that slopes as flat as 3.5:1 would be surficially unstable in the long term. The surficial instability can be controlled by the placement of a granular blanket and if a 0.5 m deep, free draining blanket is placed on the slope, the gradient may be increased to 3:1.

It is understood that the available property restricts the location of the top of the slope to a line some 2.5 m beyond a 2:1 top-of-slope line drawn from the base of the cut. For the anticipated 12 m maximum depth of cut, the above 3:1 slope will fall outside the property line. An alternative which will allow the cuts to remain within the property line is to cut the slope at 1.9:1 and to place a 1.5 m deep Granular 'B' blanket on the slope below 3.5 m vertical depth from the top of the cut. Drains having a minimum depth of 1.5 m should be placed at the base of the upper slope and at the toe of the slope as shown on the recommended slope profile, Figure 13. An upper 0.5 m granular blanket is required to ensure a minimum factor of safety of 1.2 in the long term. This is satisfactory for the effective stress analysis adopted.

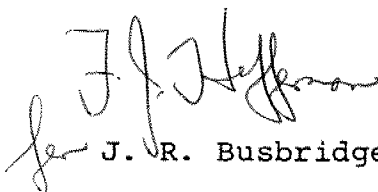
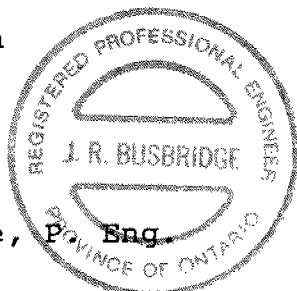
A third alternative is to construct a low retaining wall at the base of the cut as shown in Figure 14. The design of this wall should be in accordance with the above geotechnical recommendations.

The choice of slope treatment should be based on an economic comparison of the alternatives. All slopes should be topsoiled and seeded to prevent erosion. Once final grades and sections have been selected, the slope design must be reviewed by a qualified geotechnical engineer.

GOLDER ASSOCIATES



M. R. Ankenmann

  
for J. R. Busbridge, P. Eng.

MRA/JRB/cg

APPENDIX A  
INVESTIGATION PROCEDURE

April, 1985

851-1016

The field work for this investigation was carried out between January 29 and February 8, 1985. During this period, nine boreholes were put down at the locations shown on the borehole location plan (Figure 66E-001-18A). The boreholes were put down using a track-mounted CME 55 power auger drillrig supplied and operated by K & S Drilling Limited. The field work was supervised by an engineer from Golder Associates who directed the drilling and sampling operations, supervised the in situ testing and logged the boreholes.

The boreholes were advanced through the soil using continuous flight solid stem augers. At regular intervals of depth in each borehole, samples of the soil were obtained as part of the Standard Penetration Test using a conventional split barrel sampler. Within the weak till zone, in situ vane tests were carried out to measure the soil's undrained shear strength. Thin-walled type samples of the soil were obtained for detailed laboratory testing. Standpipes were sealed into different strata in the boreholes to permit monitoring of groundwater levels across the site.

The locations and elevations of the boreholes were surveyed by Golder Associates. The elevations are referenced to the temporary benchmark - cut cross S.E. side concrete base of fence post Station 28+236 26.5 mL. The Geodetic elevation of this point is 103.996 m and was supplied by MTC staff.

## 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

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

### MECHANICAL PROPERTIES OF SOIL

$m_v$	$\text{kPa}^{-1}$	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	$\text{m}^2/\text{s}$	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_f$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	$\text{kg}/\text{m}^3$	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	$\text{kg}/\text{m}^3$	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	$\text{kg}/\text{m}^3$	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	$\text{kg}/\text{m}^3$	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	$\text{m}^3/\text{s}$	RATE OF DISCHARGE
$\gamma_d$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
$\rho_{sat}$	$\text{kg}/\text{m}^3$	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
$\gamma_{sat}$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	$\text{kg}/\text{m}^3$	DENSITY OF SUBMERGED SOIL	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE	j	$\text{kN}/\text{m}^2$	SEEPAGE FORCE
$\gamma'$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SUBMERGED SOIL						

# RECORD OF BOREHOLE No 101

METRIC

W P GGE-001-18 LOCATION Co-ordinates 4,859,983.9 N; 353,900.3E ORIGINATED BY M.A.  
 DIST 6 HWY GO-ALRT BOREHOLE TYPE Solid Stem Augers COMPILED BY EFO/RM  
 DATUM GEODETIC DATE 1985 01 31 TO 1985 02 01 CHECKED BY M.A.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE. PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
105.4	GROUND SURFACE																
105.0	TOPSOIL																
0.4	Silt till with varying amounts of sand & clay, trace gravel. Generally ML, silt of low plasticity fissured from 100.2 to 103.3 m.		1	SS	18												
			2	SS	36												5 34 46 15
			3	SS	60												
			4	SS	36												9 40 38 13
	Very stiff to hard Light brown		5	SS	25												
100.2	Silt till with varying amounts of sand & clay, trace gravel, CL, clay of low plasticity. Stiff to very stiff Grey		6	SS	12												12 25 41 22
5.2			7	TW	PH												
98.4	Varved clay - 10 mm varves light and dark grey		8	TW	PH												3 33 38 26
7.0			9	SS	8												1 8 39 52
97.8	Silt till sandy trace gravel and clay. Loose Grey		10	SS	75/75mm												
7.6			11	SS	62												
96.3			12	SS	100/100mm												
9.1	Silt till with varying amounts of sand and clay, trace gravel occasional boulders. Generally ML, silt of low plasticity.		13	SS	100/125mm												
			14	SS	50/50mm												2 33 40 25
89.4	Hard Grey		15	SS	100/125mm												
16.0	Silty clay till some sand, dark grey																
88.4	Hard dark grey																
17.0	END OF BOREHOLE																

WATER LEVEL  
IN PIEZOME-  
TER 'A' AT  
ELEV. 101.0 m  
AND IN PIE-  
ZOMETER 'B'  
AT ELEV.  
105.0 m ON  
85 03 14

# RECORD OF BOREHOLE No 102

METRIC

W P GGE-001-18 LOCATION Co-ordinates 4,860,006.4 N; 353,910.8 E ORIGINATED BY M.A.  
 DIST 6 HWY GO-ALRT BOREHOLE TYPE Solid Stem Augers COMPILED BY EEO/RM  
 DATUM GEODETIC DATE 1985 02 04 CHECKED BY M.A.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
105.0	GROUND SURFACE													
0.0	TOPSOIL													
104.1														
0.9	Silt till with varying amounts of sand & clay trace gravel. Generally ML, silt of low plasticity. Stiff to hard Light brown		1	SS	13		104							
			2	SS	40									
			3	SS	63									
101.3			4	SS	23		102							
3.7	Silt till with varying amounts of sand & clay trace gravel. Generally CL clay of low plasticity. Firm to very stiff Grey		5	SS	10		100							11 36 39 14
			6	TW	PH									5 39 36 20
			7	TW	PH									
			8	SS	4		98							
96.2			9	SS	8									
8.8	Silt till with varying amounts of sand and clay trace gravel. Generally ML, silt of low plasticity. Hard Grey		10	SS	95/150mm		96							8 45 38 9
			11	SS	100/75mm		94							
			12	SS	95/100mm		92							
90.5			13	SS	100/75mm		90							
14.5	Silty clay till some sand. Hard Dark grey		14	SS	100/150mm		88							0 17 45 38
87.5			15	SS	145		86							
17.5	Silty clay layered. Hard Dark grey		16	SS	67		84							
84.7			17	SS	53									0 1 35 64
20.3	END OF BOREHOLE													

+3, x5: Numbers refer to  
Sensitivity

20  
15-5 (%) STRAIN AT FAILURE  
10

WATER LEVEL  
IN PIEZOME-  
TER 'A' AT  
ELEV. 97.8 m  
ON 85 02 02  
AND IN PIE-  
ZOMETER 'B'  
AT ELEV.  
103.6 m ON  
85 03 14



## METRIC

W P GGE-001-18 LOCATION Co-ordinates 4,859,997.5 N; 353,927.3 E ORIGINATED BY M.A.  
DIST 6 HWY GO-ALRT BOREHOLE TYPE Solid Stem Augers COMPILED BY EFO/RM  
DATUM GEODETIC DATE 1985 02 05 CHECKED BY M.A.

[illegible]

+3, x5 : Numbers refer to Sensitivity

20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 103A

METRIC

W P GGE-001-18 LOCATION Co-ordinates 4,859,994.7 N; 353,912.9 E ORIGINATED BY M.A.  
 DIST 6 HWY GO-ALRT BOREHOLE TYPE Solid Stem Augers COMPILED BY EFO/RM  
 DATUM GEODETIC DATE 1985 02 07 CHECKED BY M.A.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
105.8	GROUND SURFACE																
105.3	TOPSOIL																
0.5	Silt till with varying amounts of sand and clay trace gravel. Generally ML, silt of low plasticity. Fissured below elev. 104.3 m; approx. 150 mm sand layer at elev. 104.7 m		1	SS	25												
			2	SS	37		104										
			3	SS	45												
			4	SS	115		102										
			5	SS	48												
100.6	Very stiff Light Brown		6	SS	20												
5.2	Silt till with varying amounts of sand and clay, trace gravel. Generally CL, clay of low plasticity.		7	SS	12		100										
			8	SS	12												
	Very stiff to hard Grey		9	SS	6/150 mm		98										
97.3			10	SS	80/150 mm		96										
8.5	Silt till with varying amounts of sand and clay trace gravel occasional boulders. Generally ML silt of low plasticity.		11	SS	98/150 mm		94										
			12	SS	100/50 mm												
			13	SS	100/100 mm												
			14	SS	70/50 mm		90										
90.0	Hard Grey		15	SS	107		88										
15.8	Silty clay till some sand.		16	SS	64												
86.8	Hard Dark grey		17	SS	33		86										
19.0	Silty clay trace sand layered.																
85.5	Hard Dark grey																
20.3	END OF BOREHOLE						84										

WATER LEVEL  
IN PIEZOME-  
TER 'A' AT  
ELEV. 98.5 m  
AND IN PIE-  
ZOMETER 'B'  
AT ELEV.  
103.9 m ON  
85 03 14



## METRIC

W P GGE-001-18 LOCATION Co-ordinates 4,859,983.2 N; 353,925.9 E ORIGINATED BY M.A.  
DIST 6 HWY GO-ALRT BOREHOLE TYPE Solid Stem Augers COMPILED BY EFO/RM  
DATUM GEODETIC DATE 1985 01 29 CHECKED BY M.A.

[illegible]

+3, x5: Numbers refer to Sensitivity

# RECORD OF BOREHOLE No 105

METRIC

W P GGE-001-18 LOCATION Co-ordinates 4,860,022.7 N; 353,939.8 E ORIGINATED BY M.A.  
 DIST 6 HWY GO-ALRT BOREHOLE TYPE Solid Stem Augers COMPILED BY EFO/RM  
 DATUM GEODETIC DATE 1985 02 08 CHECKED BY M.A.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	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					
105.3	GROUND SURFACE																
104.8	TOPSOIL																
0.5	Silt till with varying amounts of sand & clay trace gravel fissured below elev. 103.8 m. Generally ML, silt of low plasticity. Very stiff to hard	Light Brown	1	SS	15		104										
			2	SS	53												
			3	SS	42												
101.6			4	SS	34		102										
3.7	Silt till with varying amounts of sand & clay trace gravel. Generally CL clay of low plasti- city.		5	SS	16												
			6	SS	11												
98.7	Stiff	Grey	7	SS	4		100										
6.6	Varved clay, inclined varves approx. 10mm thick Light & dark grey																
97.6	Silt till with varying amounts of sand & clay trace gravel. Generally CL clay of low plasti- city.		8	SS	3		98										
96.9																	
8.4	Stiff	Grey	9	SS	110/ 150mm		96										
	Silt till with varying amounts of sand & clay trace gravel occasional boulders. Generally ML, silt of low plasticity.		10	SS	100/ 50mm		94										
			11	SS	130/ 75mm												
93.0	Hard	Grey					92										
12.3	END OF BOREHOLE						90										

WATER LEVEL  
IN PIEZOME-  
TER AT ELEV.  
104.0 m ON  
85 03 14

## METRIC

W P GGE-001-18 LOCATION Co-ordinates 4,859,992.6 N; 353,950.3 E ORIGINATED BY M.A.  
DIST 6 HWY GO-ALRT BOREHOLE TYPE Solid Stem Augers COMPILED BY EFO/RM  
DATUM GEODETIC DATE 1985 01 29 CHECKED BY M.A.

[illegible]

# RECORD OF BOREHOLE No 107

METRIC

W P GGE-001-18 LOCATION Co-ordinates 4,680,011.0 N; 353,950.0 E ORIGINATED BY M.A.  
DIST 6 HWY GO-ALRT BOREHOLE TYPE Solid Stem Augers COMPILED BY EEO/RM  
DATUM GEODETIC DATE 1985 01 31 CHECKED BY M.A.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
106.4	GROUND SURFACE																
0.0	TOPSOIL																
105.7																	
0.7	Silt till with varying amounts of sand & clay trace gravel fissured from elev. 102.7 m to 104.9 m. Generally ML, silt of low plasticity. Very stiff to hard		1	SS	19												
			2	SS	28												
			3	SS	30												
			4	SS	29												
102.4			5	SS	18												
4.0	Silt till, sandy in places. Varying amounts of clay trace gravel. Non plastic to ML, silt of low plasticity. Firm to Hard		6	TW	PH												
			7	TW	PH												
99.2																	
7.2	Silt till with varying amounts of sand & clay trace gravel. Generally CL clay of low plasticity. Firm to Hard		8	SS	8												
97.2																	
9.2	Silt till with varying amounts of sand & clay trace gravel. Generally ML silt of low plasticity.		9	SS	38												
			10	SS	88/150 mm												
			11	SS	120/125 mm												
			12	SS	100/100 mm												
			13	SS	100/75 mm												
89.9	Hard																
16.5	Silty clay till some sand trace gravel.		14	SS	93												
87.6	Hard		15	SS	62												
18.8	END OF BOREHOLE																

WATER LEVEL  
IN PIEZOME-  
TER 'A' AT  
ELEV. 103.6m  
AND IN  
PIEZOMETER  
'B' AT ELEV.  
105.8 m ON  
85 03 14

# RECORD OF BOREHOLE No 108

METRIC

W P GGE-001-18 LOCATION Co-ordinates 4,860,040.8 N; 353,978.0 E ORIGINATED BY M.A.  
 DIST 6 HWY GO-ALRT BOREHOLE TYPE Solid Stem Augers COMPILED BY EFO/RM  
 DATUM GEODETIC DATE 1985 01 30 CHECKED BY M.A.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	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					
106.3	GROUND SURFACE																
0.0	TOPSOIL																
0.6	SILT TILL with varying amounts of sand & clay trace gravel fissured below elev. 104.8 m occasional boulders generally ML silt of low plasticity.  Very stiff to hard Light Brown		1	SS	17												
			2	SS	28												
			3	SS	36												
			4	SS	29												
101.8	SILT TILL with varying amounts of sand & clay trace gravel generally CL clay of low plas- ticity.  Firm to very stiff Grey		5	SS	11												
4.5			6	TW	PH												
99.0	SILT TILL with varying amounts of sand and clay trace gravel oc- casional boulders. Generally ML silt of low plasticity.  Hard Grey		7	SS	83												
7.3			8	SS	77												
			9	SS	110/ 150mm												
			10	SS	135/ 150mm												
91.8	Silty clay till some sand trace gravel.  Hard Dark grey		11	SS	133/ 125mm												
14.5			12	SS	105/ 150mm												
	Silty clay trace sand layered Hard Dark grey		13	SS	97												
			14	SS	81												
87.1	Hard Dark grey		15	SS	38												
19.2																	
86.0	END OF BOREHOLE																
20.3																	

+<sup>3</sup>, x<sup>5</sup>: Numbers refer to  
Sensitivity

20  
15-5 (%) STRAIN AT FAILURE  
10

WATER LEVEL  
IN PIEZOME-  
TER AT ELEV.  
100.8 m ON  
85 03 14

APPENDIX B

RECORD OF BOREHOLE SHEETS  
(PREVIOUS INVESTIGATION)

April, 1985

851-1016



## METRIC

W P GGE-001-18 LOCATION Co-ordinates 4,860,024.9 N; 353,912.3 E ORIGINATED BY JKB  
DIST 6 HWY GO-ALRT BOREHOLE TYPE Solid Stem Augers COMPILED BY EFO  
DATUM Geodetic DATE 1983 09 02 CHECKED BY HCO

[illegible]

+3, x5: Numbers refer to Sensitivity

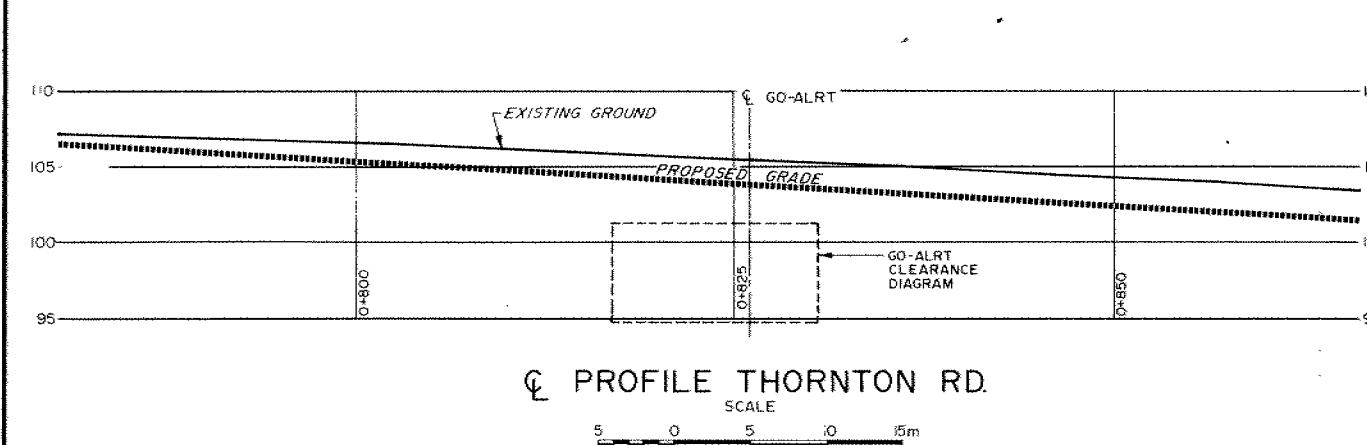
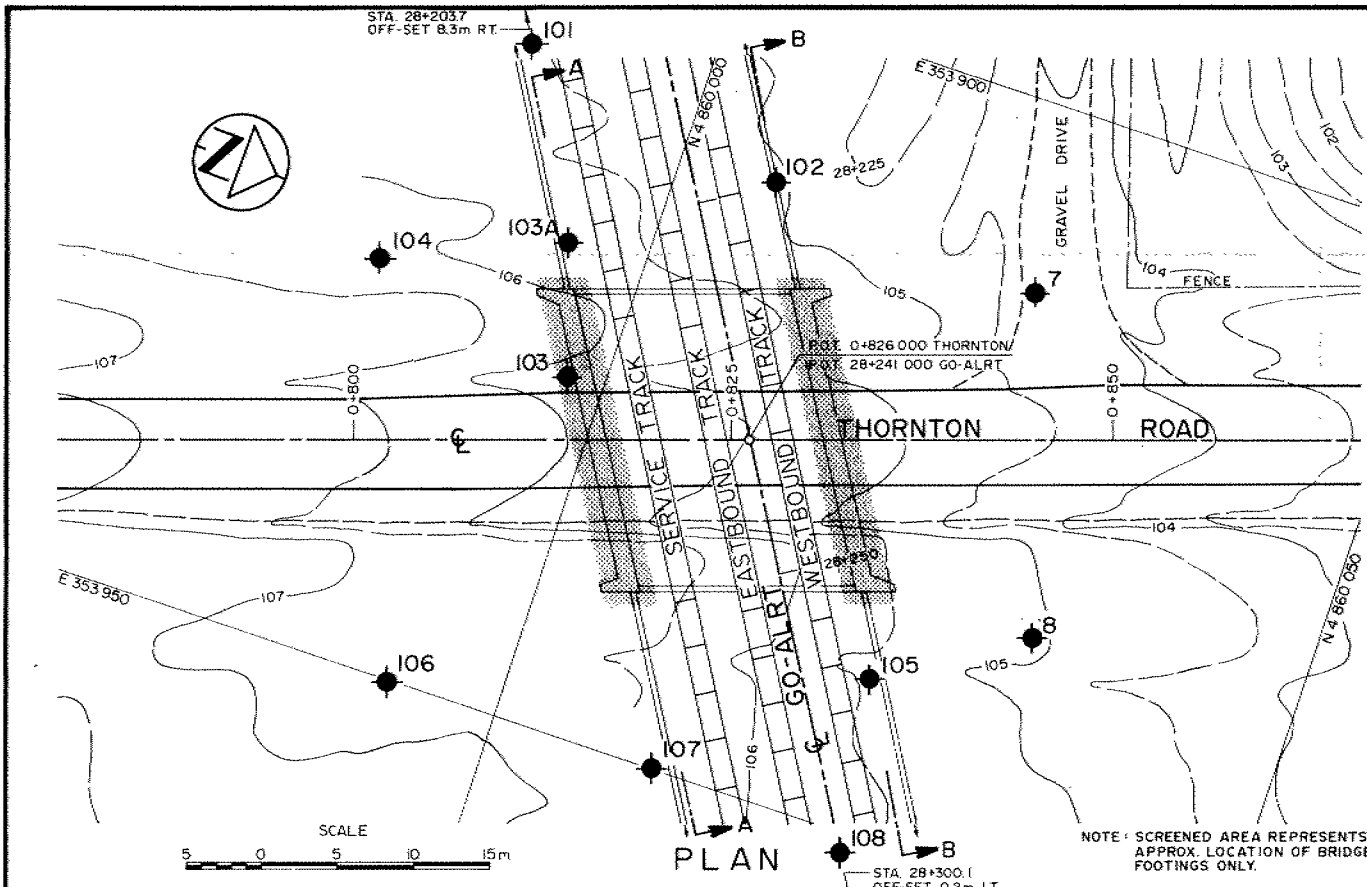
20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 8

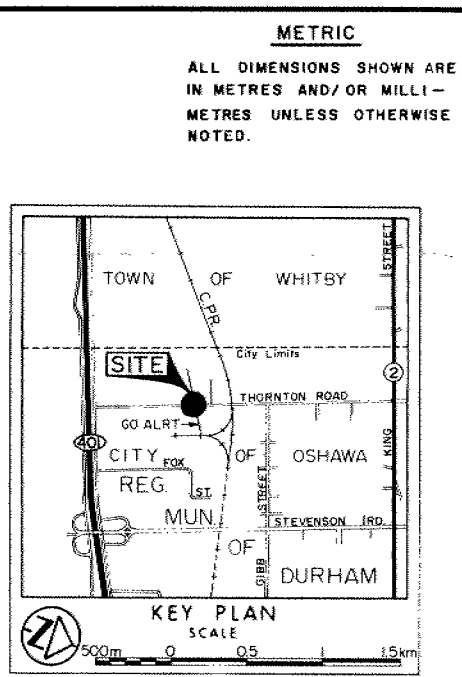
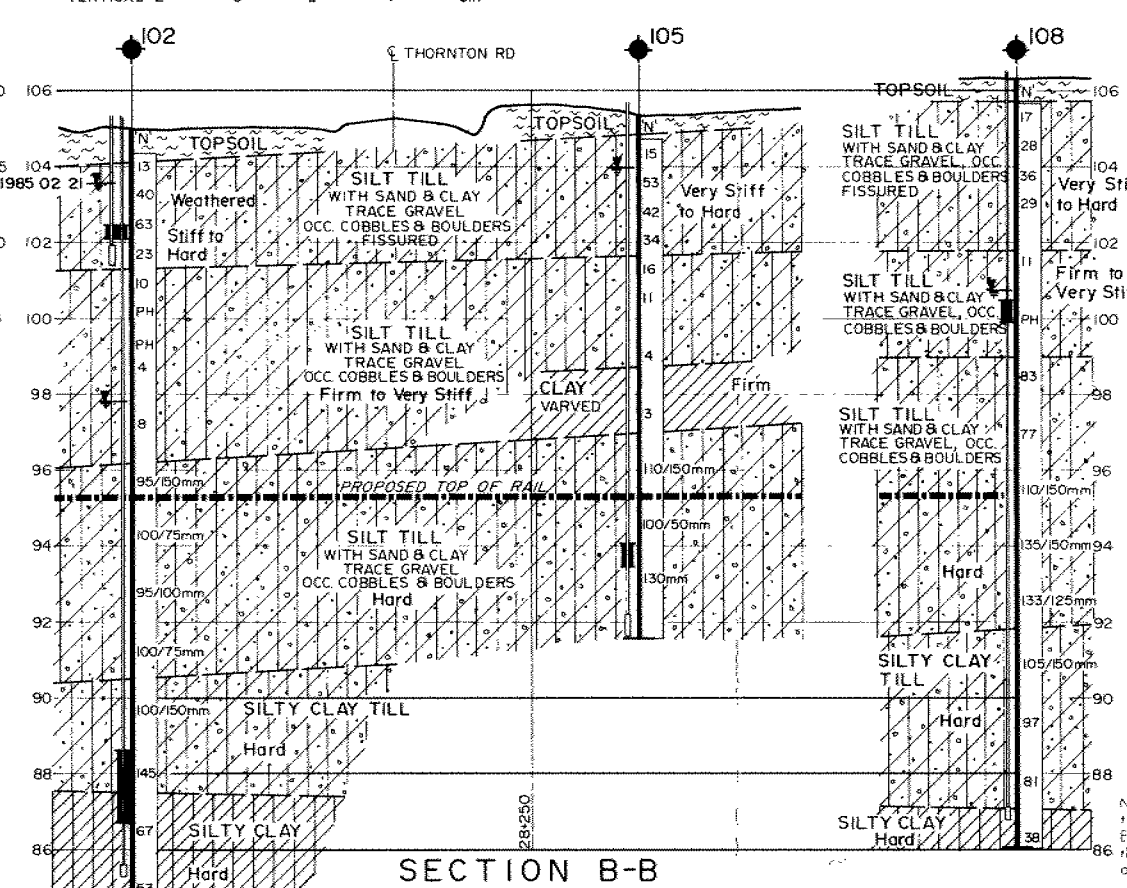
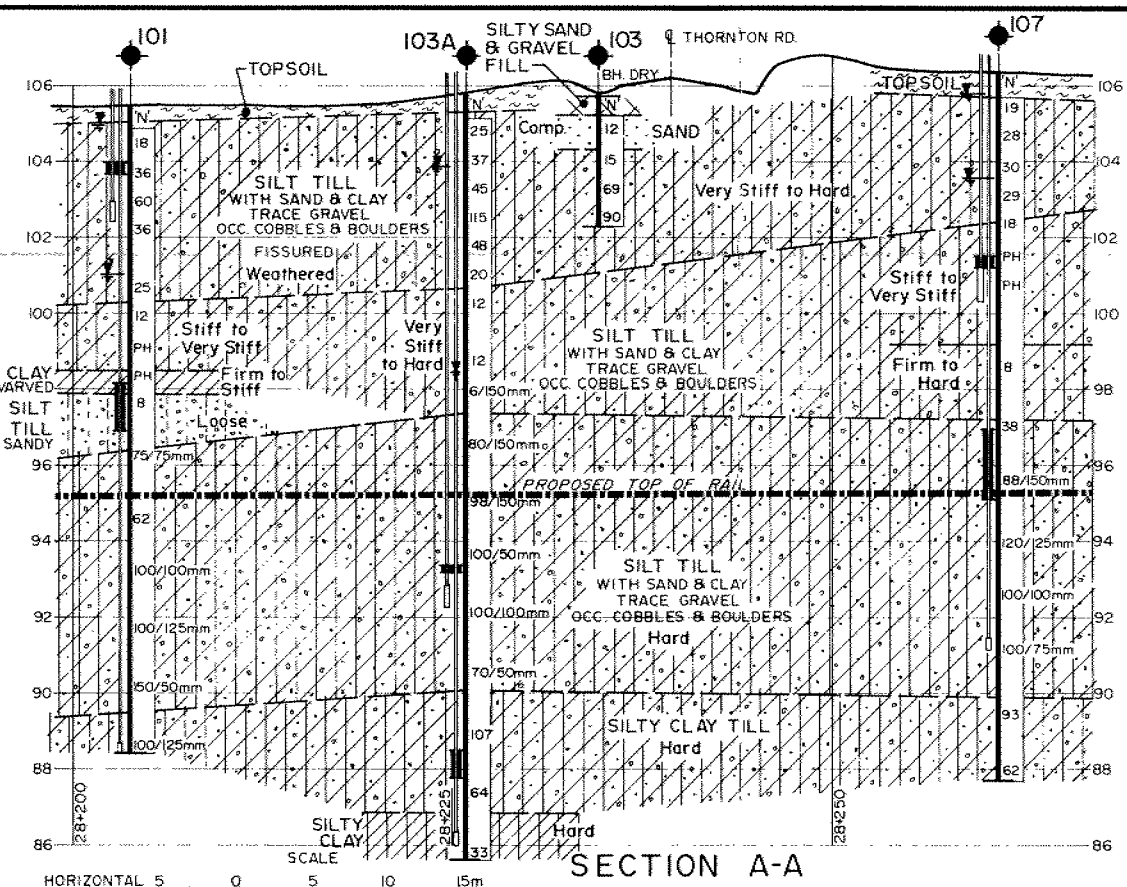
METRIC

W P GGE-001-18 LOCATION Co-ordinates 4,860,032.0 N; 353,933.7 E ORIGINATED BY JKB  
 DIST 6 HWY GO-ALRT BOREHOLE TYPE Solid Stem Augers COMPILED BY EFO  
 DATUM Geodetic DATE 1983.09.07 CHECKED BY HCO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
104.9	GROUND SURFACE																
0.3	TOPSOIL																
	Sandy silt some clay trace gravel (TILL) fissured between elev. 102.8 and 100.9. Silty clay pocket at elev. 100.9 m.		1	SS	22		104										
			2	SS	29												
			3	SS	42												
			4	SS	31												
			5	SS	9												
			6	TW	PH		100										
			7	TW	PH												
			8	SS	16		98										
95.9	Brown be- coming Dense to Loose grey below elevation 100.6 m		9	SS	90/												
9.0	Sandy silt some clay trace gravel (TILL)		10	SS	100/												
92.7	Very Dense Grey		11	SS	100/												
12.2	Silty clay some sand trace gravel (TILL)		12	SS	100/												
89.4	Hard Grey		13	SS	112/		90										
15.5	END OF BOREHOLE						88										



NOTE: FOR SOIL STRATA AND INSITU TESTING RESULTS FOR BOREHOLES 7, 8, 104 AND 106 REFER TO RECORD OF BOREHOLE SHEETS.



**LEGEND**



- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation 1985 03 14
- Seal
- Piezometer

No	ELEVATION	CO-ORDINATES NORTH	EAST
7	104.1	4 860 024.9	353 912.3
8	104.9	4 860 032.0	353 933.7
101	105.4	4 859 983.9	353 900.3
102	105.0	4 860 006.4	353 910.8
103	105.8	4 859 997.5	353 927.3
103A	105.8	4 859 994.7	353 918.9
104	106.3	4 859 983.2	353 923.9
105	105.3	4 860 022.7	353 939.8
106	107.0	4 859 992.6	353 950.3
107	106.4	4 860 011.0	353 950.0
108	106.3	4 860 040.8	353 978.0

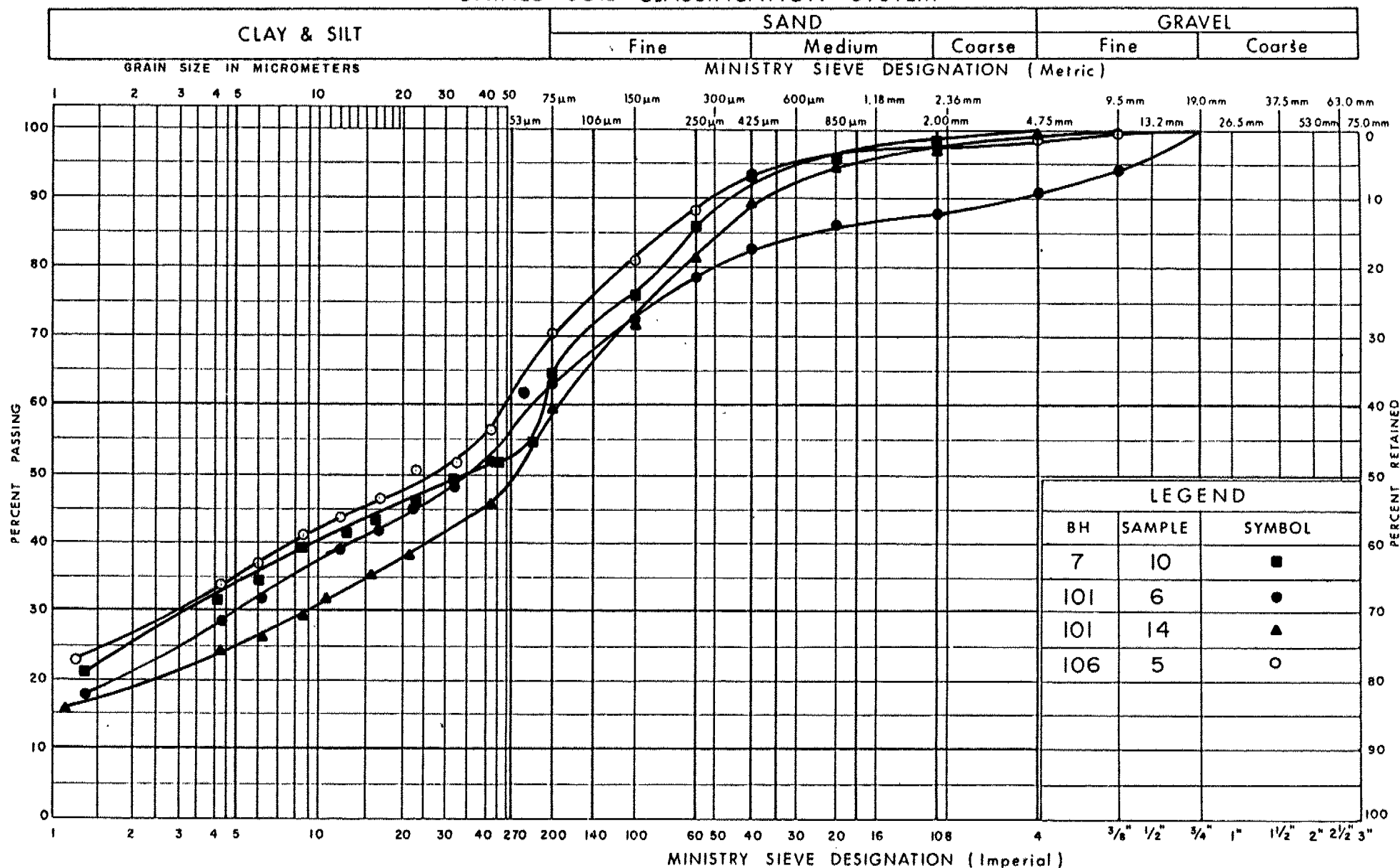
**NOTE**

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

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

REFERENCE DRAWINGS		REVISIONS		DRAWN BY: EFO 1985 02 19	DESIGNED BY:	 <b>Golder Associates</b> CONSULTING GEOTECHNICAL AND MINING ENGINEERS	 Ministry of Transportation and Communications	PROPOSED UNDERPASS AT THORNTON ROAD GO ALRT EXTENSION - OSHAWA BOREHOLE LOCATIONS & SOIL STRATA							
				CHK'D BY: M.A. 1985 04 08	APPROVED BY:							CONTRACT NO	DWG NO GGE00118A	REV	SHEET
				SCALE: FULL SIZE ONLY											
				AS NOTED								PROJECT MANAGER			

## UNIFIED SOIL CLASSIFICATION SYSTEM



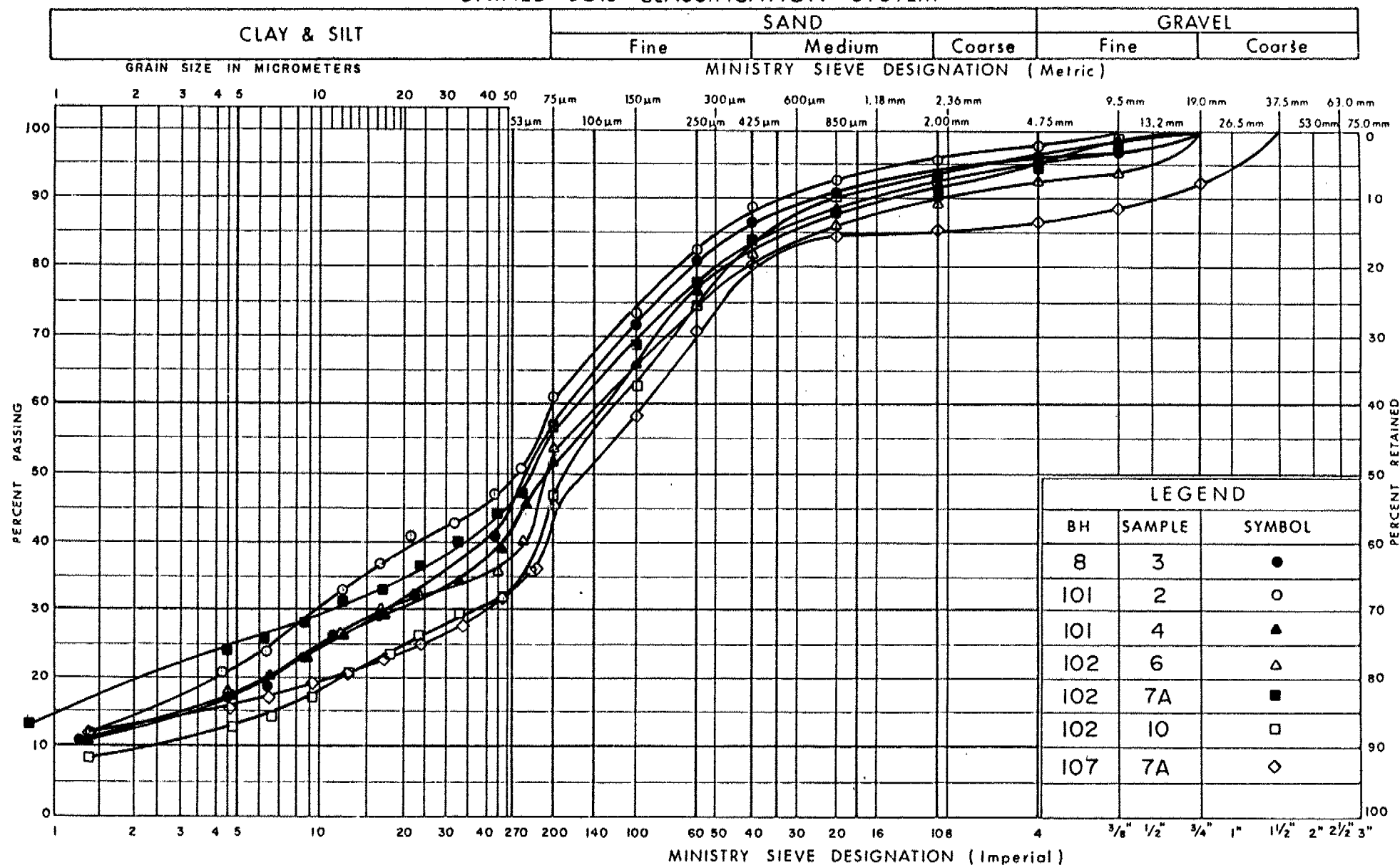
Ministry of  
Transportation and  
Communications

GRAIN SIZE DISTRIBUTION  
SILT TILL

FIG No 1

W P GGE-001-18

## UNIFIED SOIL CLASSIFICATION SYSTEM



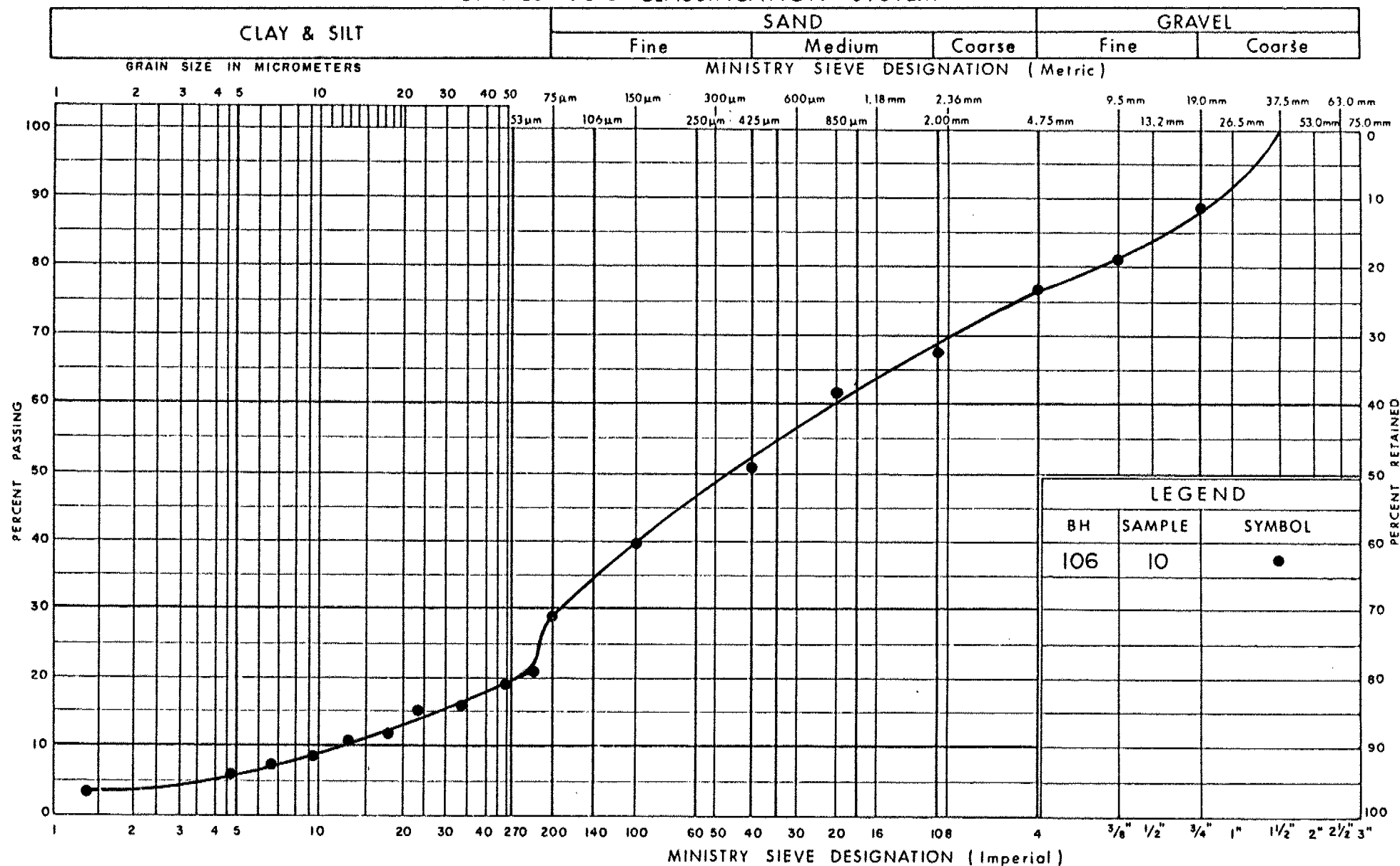
Ministry of  
Transportation and  
Communications

GRAIN SIZE DISTRIBUTION  
SILT TILL

FIG No 2

W P GGE-001-18

## UNIFIED SOIL CLASSIFICATION SYSTEM



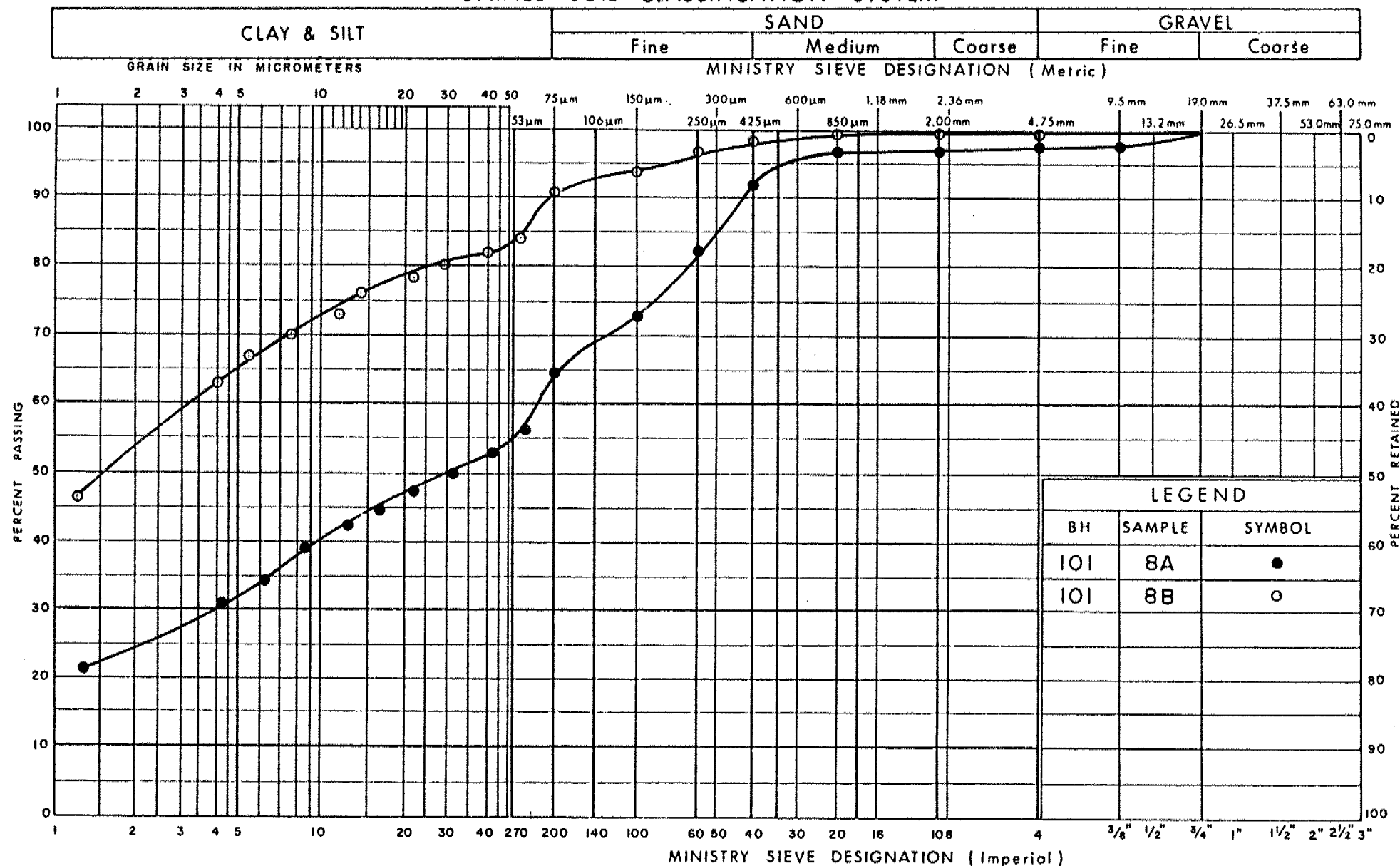
Ministry of  
Transportation and  
Communications

GRAIN SIZE DISTRIBUTION  
SILTY SAND TILL

FIG No 3

W P GGE-001-18

## UNIFIED SOIL CLASSIFICATION SYSTEM



## LEGEND

BH	SAMPLE	SYMBOL
101	8A	●
101	8B	○



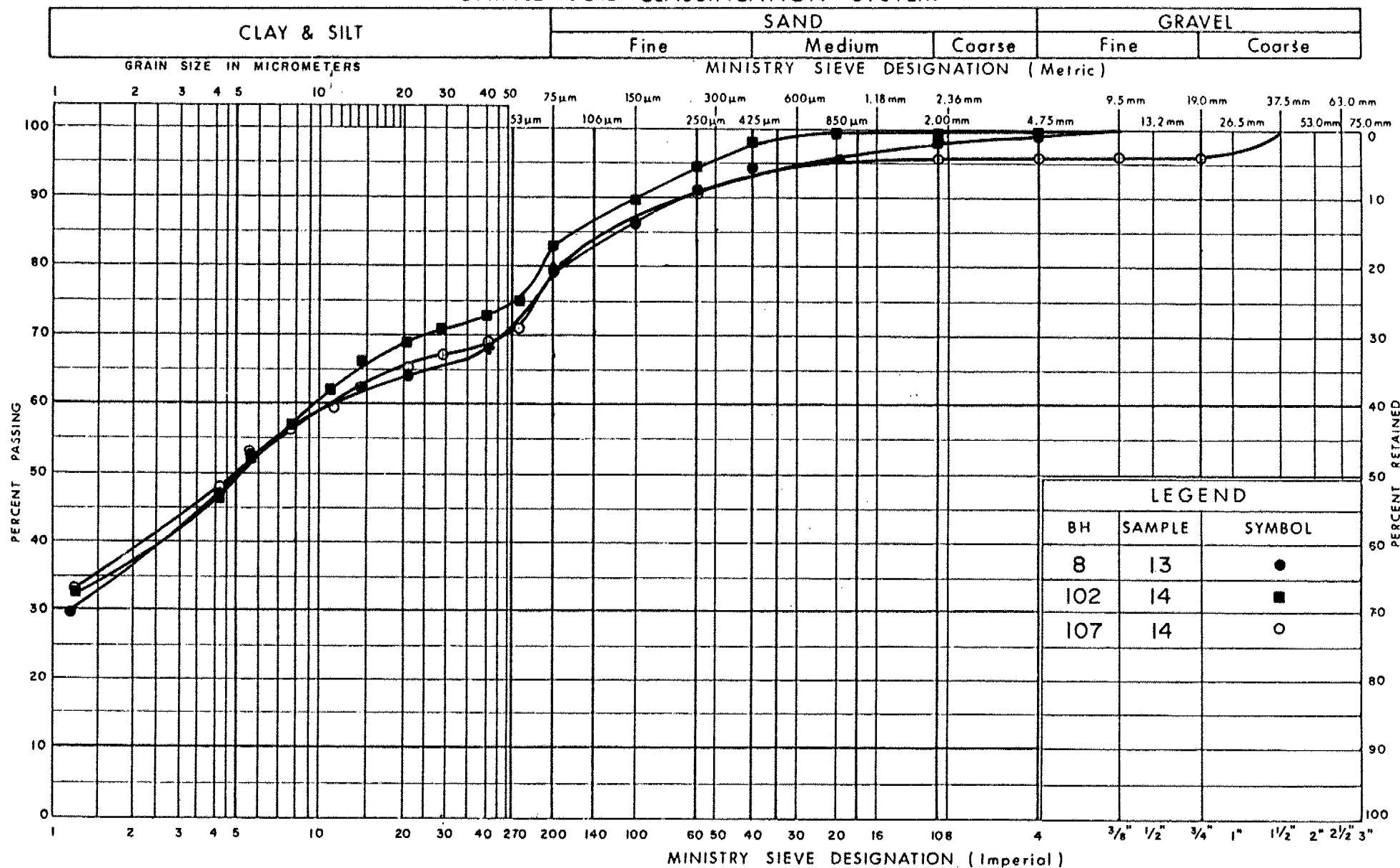
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GRAIN SIZE DISTRIBUTION  
VARVED CLAY

FIG No 4

W P GGE-001-18

## UNIFIED SOIL CLASSIFICATION SYSTEM



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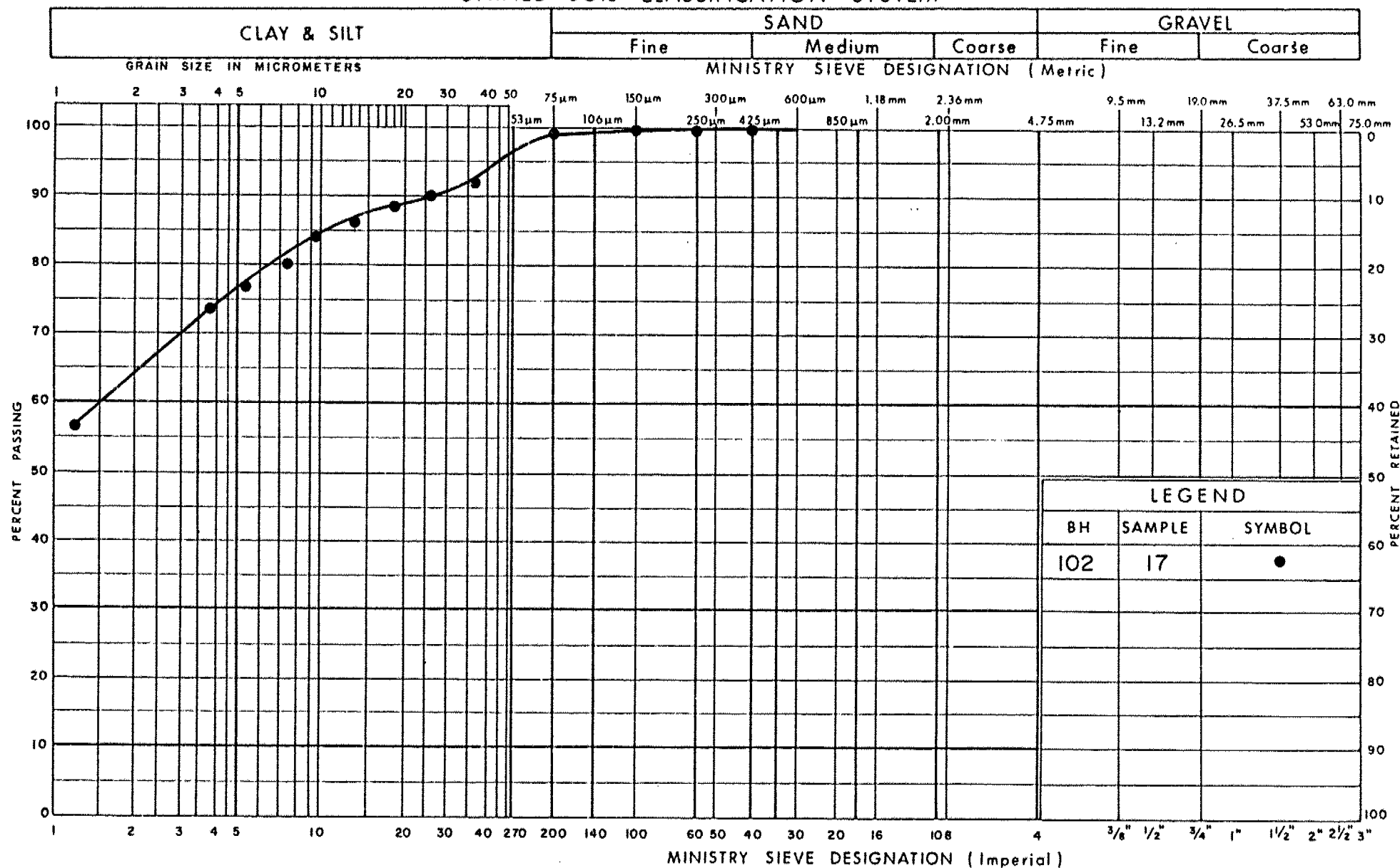
GRAIN SIZE DISTRIBUTION  
SILTY CLAY TILL

FIG No 5

W P GGE-001-18



## UNIFIED SOIL CLASSIFICATION SYSTEM



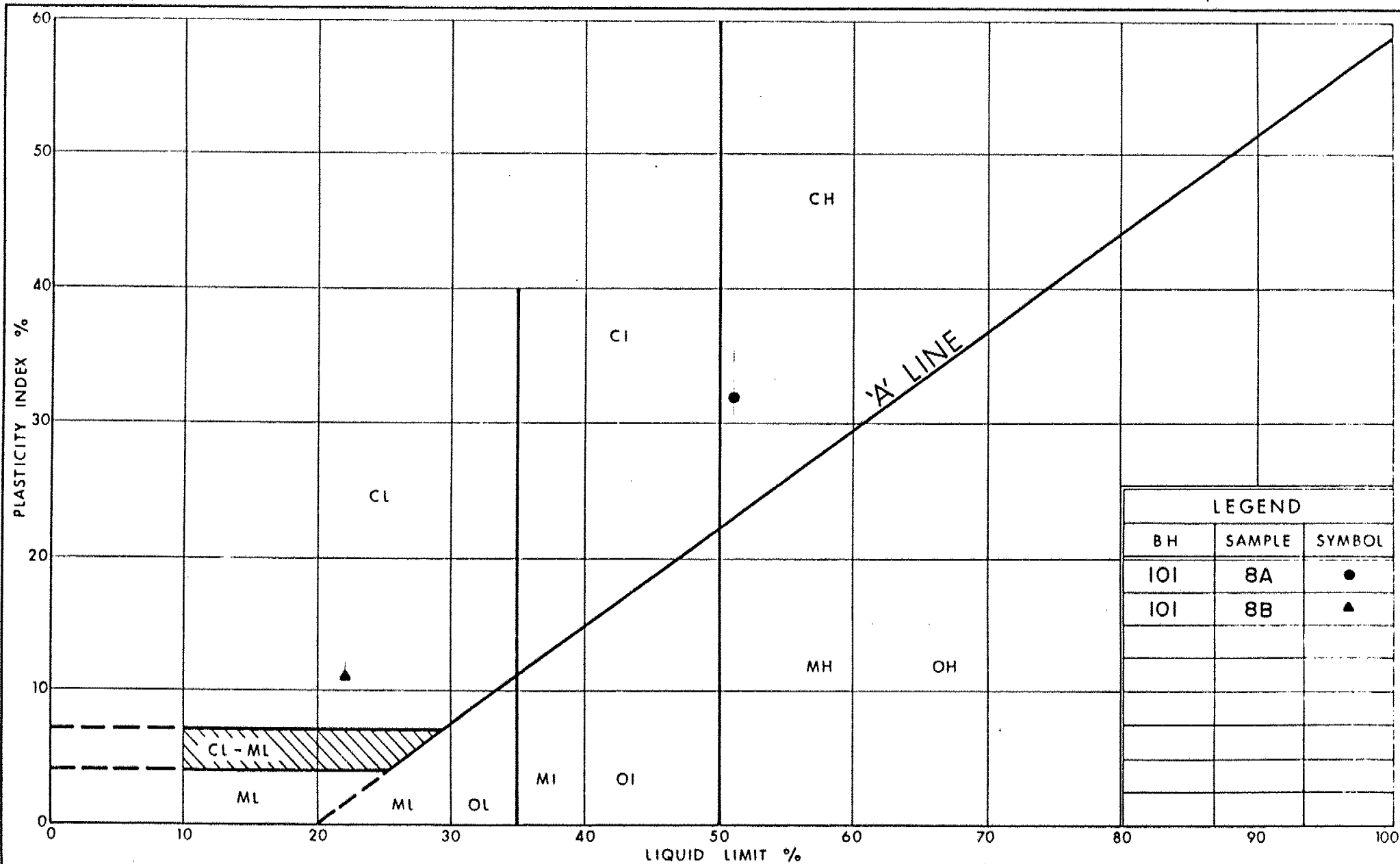
Ontario

 Ministry of  
Transportation and  
Communications

 GRAIN SIZE DISTRIBUTION  
SILTY CLAY

FIG No 6

W P GGE-001-18



LEGEND		
BH	SAMPLE	SYMBOL
101	8A	●
101	8B	▲

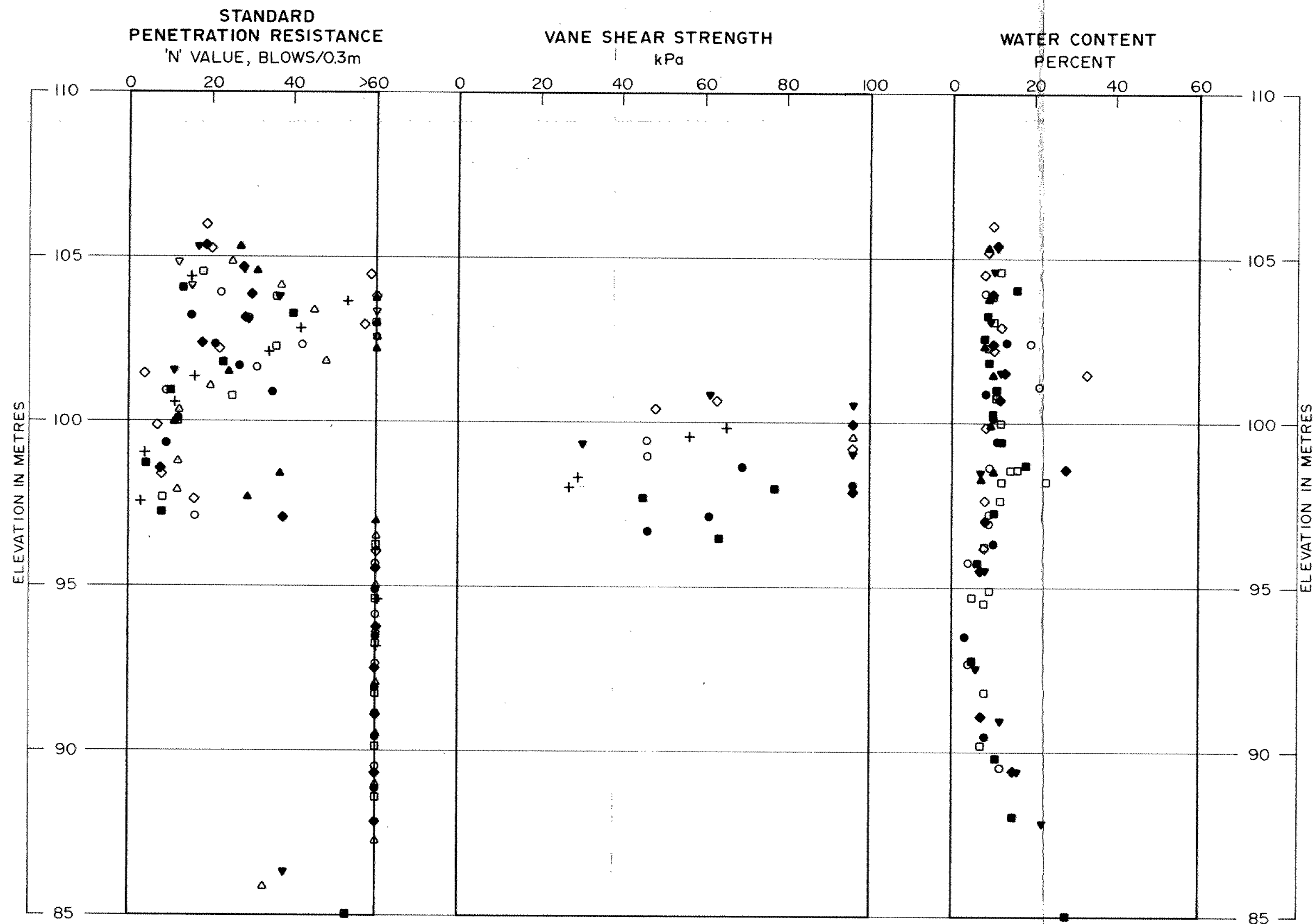


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Ontario

## PLASTICITY CHART VARVED CLAY

FIG No 8

W P GGE-001-18



#### LEGEND

- Borehole 7
- Borehole 8
- Borehole 101
- Borehole 102
- ▽, △ Borehole 103, 103A
- ▲ Borehole 104
- + Borehole 105
- ◇ Borehole 106
- ◆ Borehole 107
- ▼ Borehole 108

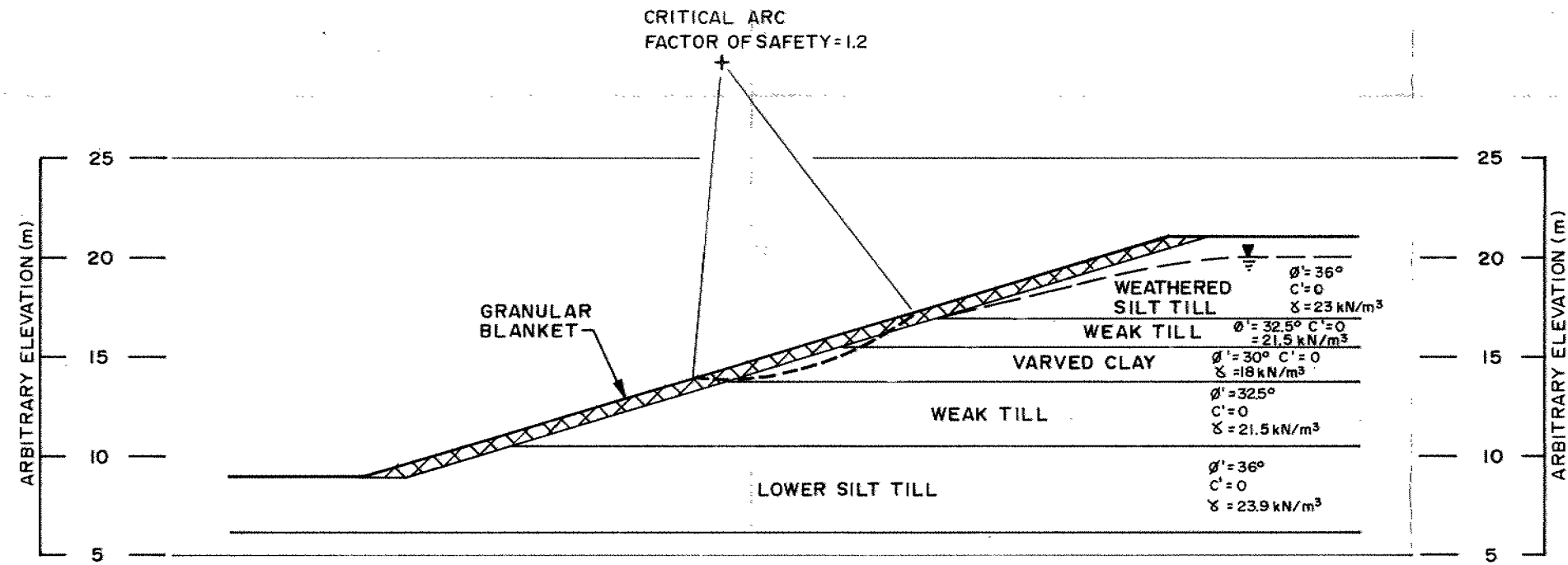


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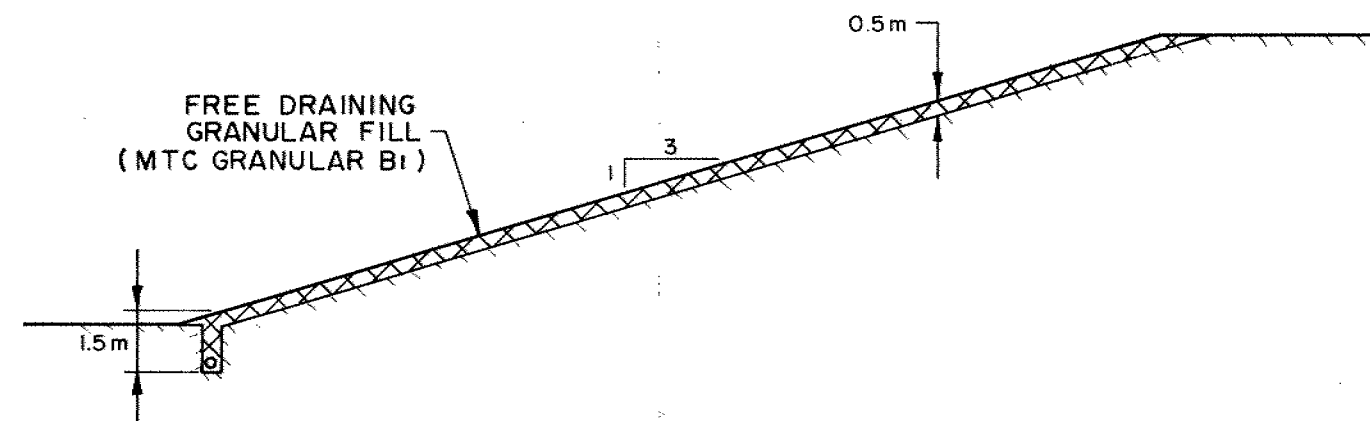
#### SUMMARY OF SOILS PROPERTIES

FIG No 9

WP GGE-001-18



**STABILITY ANALYSIS**  
NOT TO SCALE



**SUGGESTED SLOPE PROFILE**  
NOT TO SCALE

# NOTES

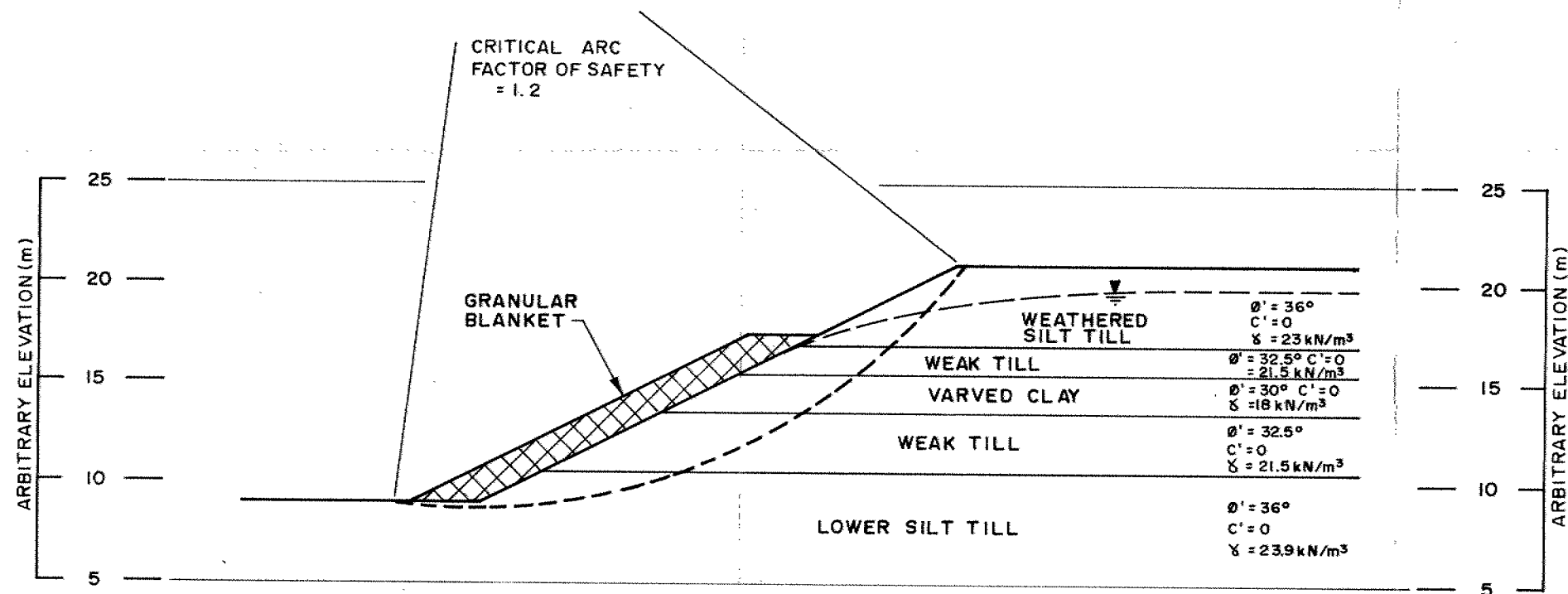
1. ALL SLOPES TO BE REVEGETATED FOR EROSION PROTECTION.
2. GRANULAR BLANKET TO BE PLACED IMMEDIATELY FOLLOWING EXCAVATION OF SLOPES TO FINAL GRADE.
3. DRAIN TO BE INSTALLED FOLLOWING PLACEMENT OF BLANKET AND WITHIN 4 WEEKS OF EXCAVATION OF SLOPES TO FINAL GRADE.



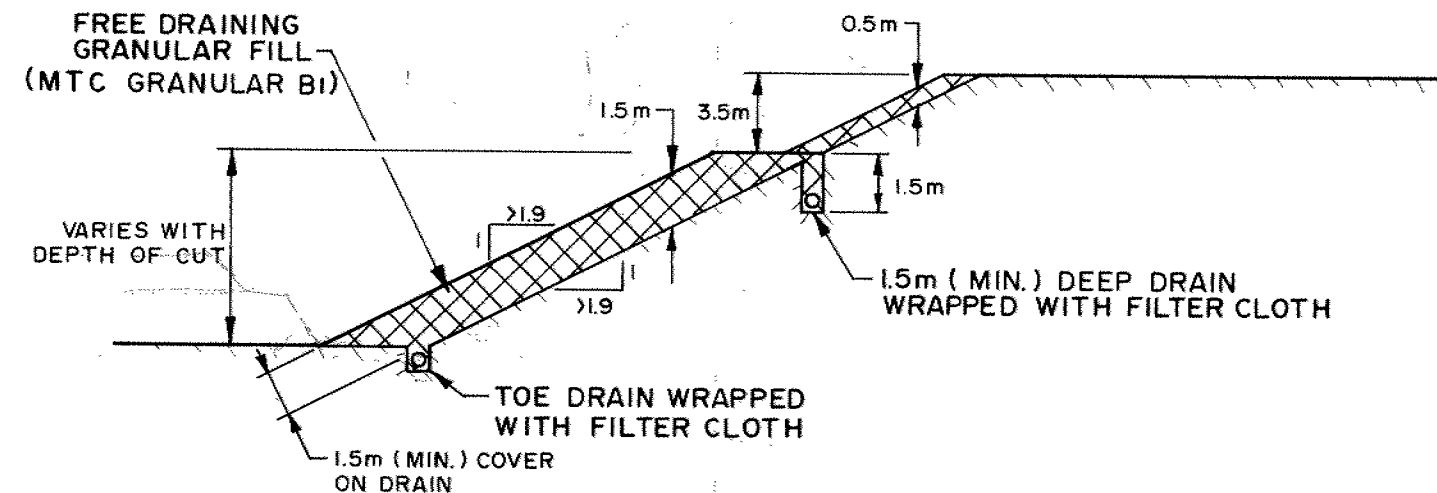
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**CUT SLOPE ANALYSIS AND DESIGN**  
**3:1 SLOPE WITH GRANULAR BLANKET AND DRAIN**

**FIG No 12**  
**WP GGE-001-18**



STABILITY ANALYSIS  
NOT TO SCALE



SUGGESTED SLOPE PROFILE  
NOT TO SCALE

# NOTES

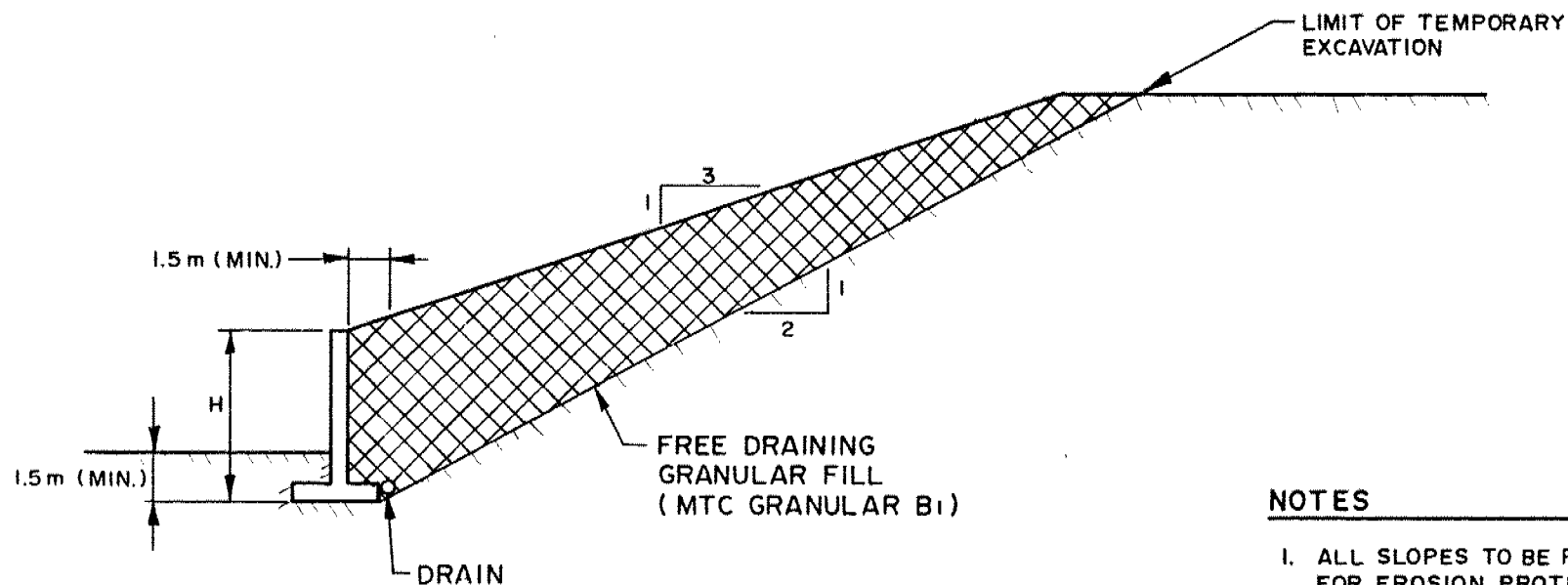
1. ALL SLOPES TO BE REVEGETATED FOR EROSION PROTECTION.
2. GRANULAR BERM TO BE PLACED IMMEDIATELY FOLLOWING EXCAVATION OF SLOPES TO FINAL GRADE.
3. DRAINS TO BE INSTALLED FOLLOWING PLACEMENT OF BERM AND WITHIN 4 WEEKS OF EXCAVATION OF SLOPES TO FINAL GRADE.



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CUT SLOPE ANALYSIS AND DESIGN  
2:1 SLOPE WITH GRANULAR BERM AND DRAINS

FIG No 13  
WP GGE-001-18



### SUGGESTED SLOPE PROFILE

NOT TO SCALE

### NOTES

1. ALL SLOPES TO BE REVEGETATED FOR EROSION PROTECTION.
2. MINIMUM COVER ON RETAINING WALL FOOTING 1.5m.
3. EARTH PRESSURE FROM  $P=KH$   
FOR ULS.  $K=10 \text{ kN/m}^3$   
FOR SLS.  $K=8 \text{ kN/m}^3$



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## CUT SLOPE ANALYSIS AND DESIGN

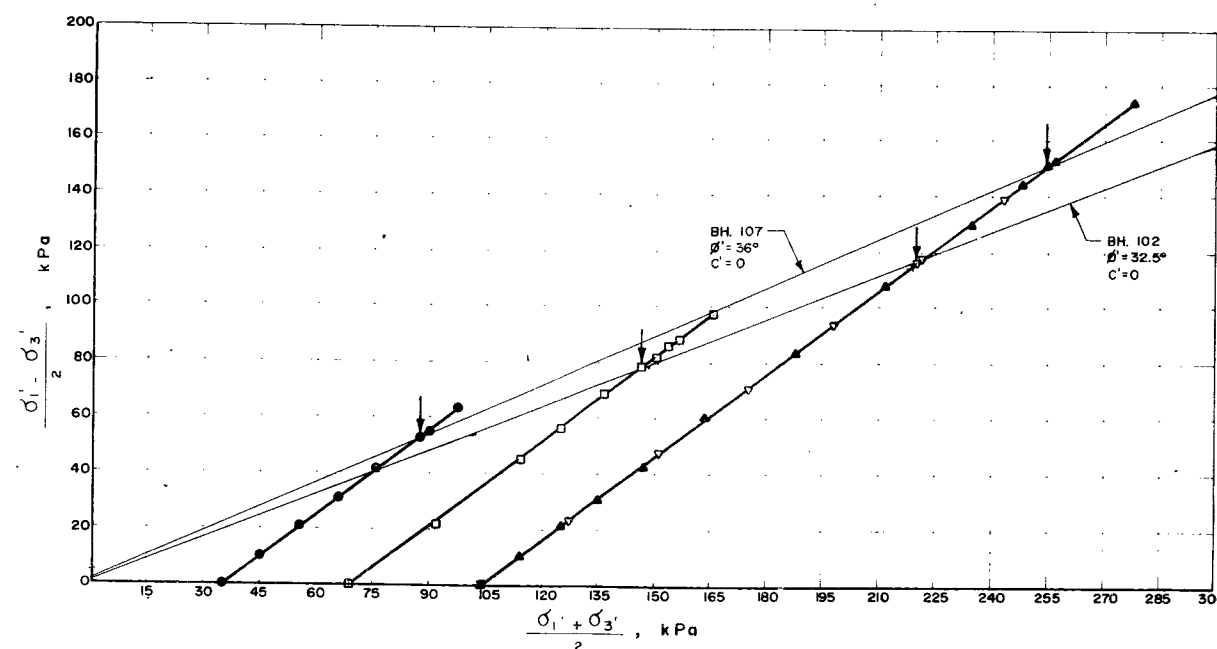
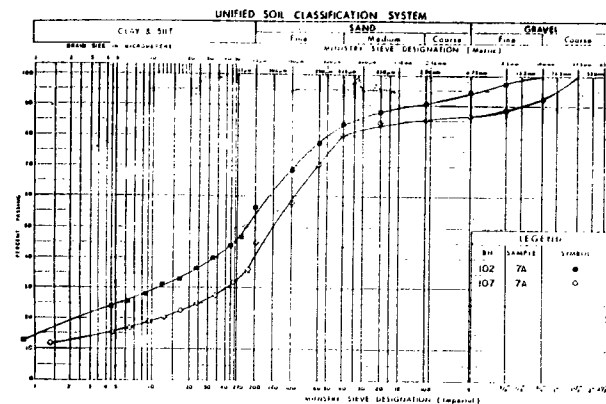
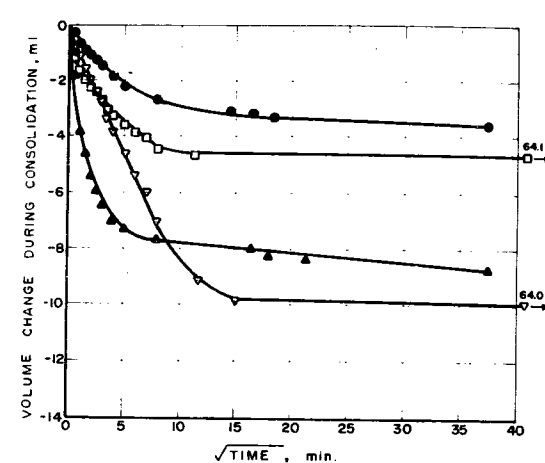
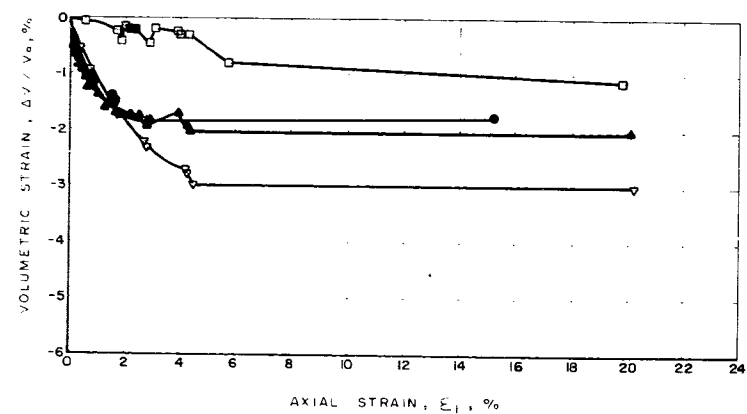
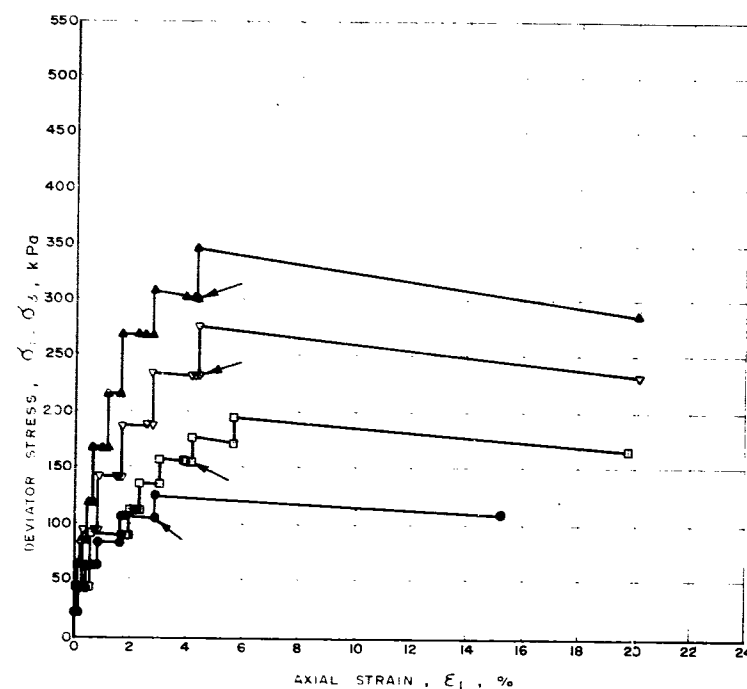
### 3:1 SLOPE WITH LOW RETAINING WALL

FIG No 14

W P GGE-001-18

S TESTS  
CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TESTS  
SANDY SILT SOME CLAY

FIGURE 10



	A	B	C	D	FAILURE SKETCH
BOREHOLE NUMBER	107	107	102	102	
SAMPLE NUMBER	7A	7A	7A	7A	
SAMPLE DEPTH, m.	5.64	5.94	5.64	5.94	

SPECIMEN DIAMETER, mm	50.20	49.60	50.10	49.80
SPECIMEN HEIGHT, mm	99.80	97.60	101.10	97.60

WATER CONTENT, BEFORE CONSOLIDATION, %	12	12	18	17
CELL PRESSURE, $\sigma_3$ , kPa	234.9	304.5	199.8	235.6
BACK PRESSURE, kPa	199.8	199.8	130.9	130.9
PORE PRESSURE PARAMETER 'B'	0.96	0.96	0.97	0.97
CONSOLIDATION PRESSURE, $\sigma_c$ , kPa	35.1	104.7	68.9	104.7
VOLUME CHANGE DURING CONSOLIDATION, $\Delta V_c$ , ml	-3.6	-8.7	-4.7	-9.9
WATER CONTENT, AFTER CONSOLIDATION, %	12	12	16	14
AVERAGE RATE OF STRAIN, % / hr.				
AVERAGE LOAD INCREMENT, kPa	200	300	200	400
AVERAGE LOAD DURATION, hr.	240	240	240	240
TIME TO FAILURE, days	6	12	7	6
WATER CONTENT AFTER TEST, %	10	10	16	14

MAX. DEVIATOR STRESS, $(\sigma_1 - \sigma_3)_{max}$ , kPa	103.8	258.5	171.9	231.5
AXIAL STRAIN AT $(\sigma_1 - \sigma_3)_{max}$ , %	2.87	2.79	5.67	4.46
MAX. EFFECTIVE PRINCIPAL STRESS RATIO $(\sigma_1 / \sigma_3)_{max}$ , kPa	4.0	3.48	3.5	3.2
AXIAL STRAIN AT $(\sigma_1 / \sigma_3)_{max}$ , %	2.87	2.79	5.67	4.46

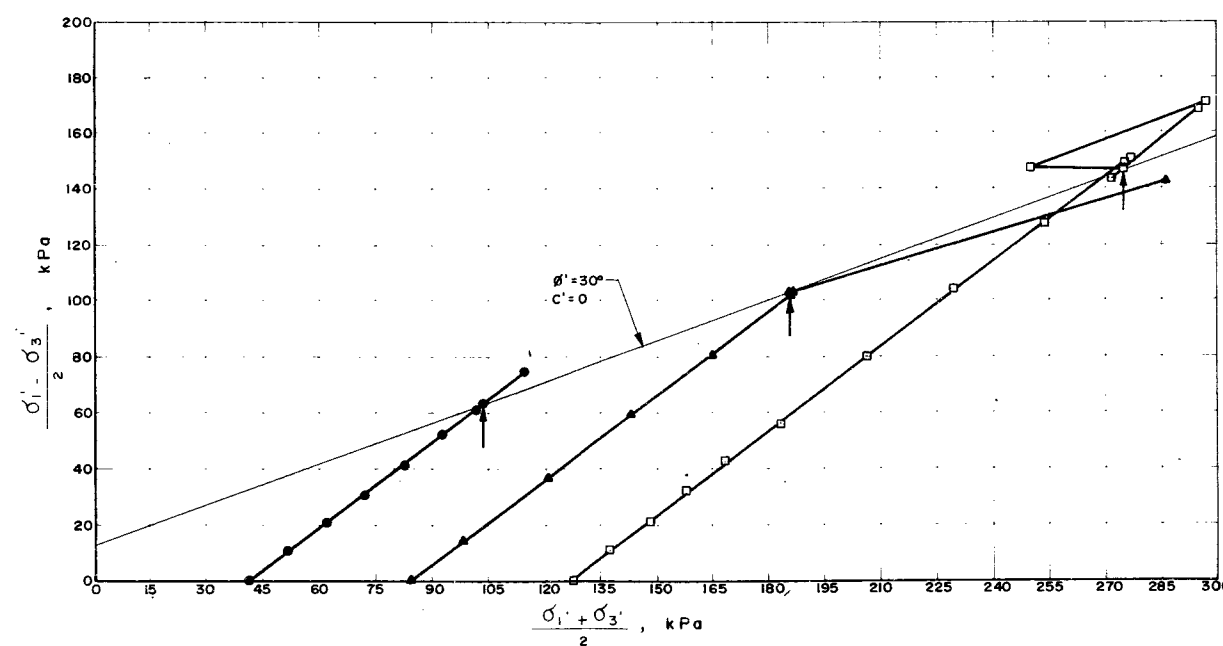
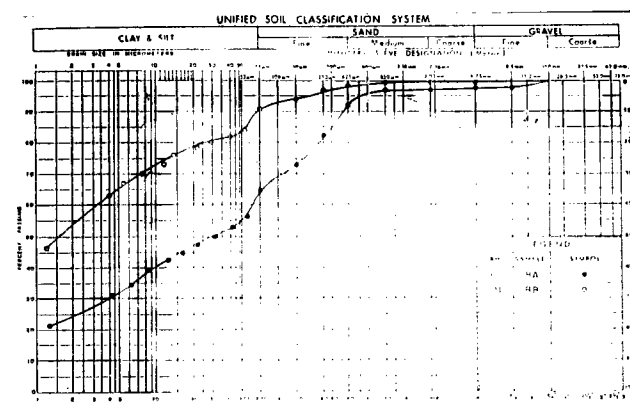
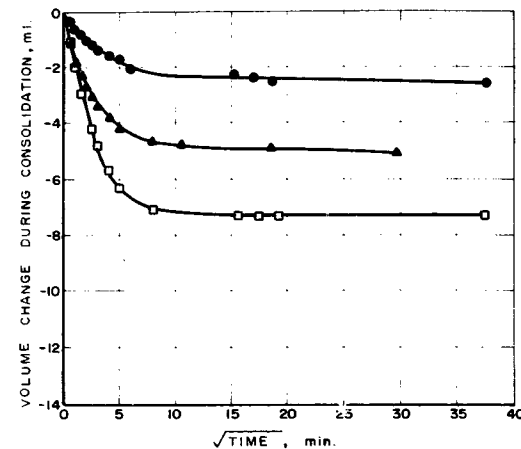
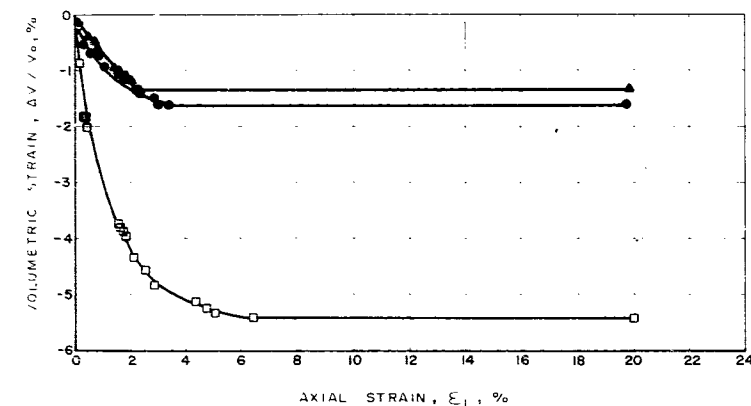
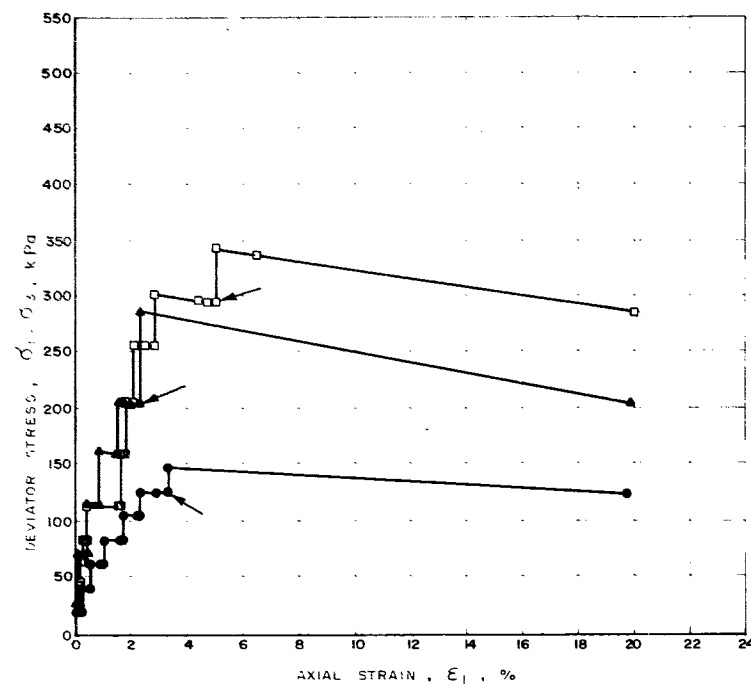
NATURAL WATER CONTENT, w, %	12	11	17	16
LIQUID LIMIT, $w_L$	12	12	21	21
PLASTIC LIMIT, $w_P$	10	10	11	11
DENSITY, $\rho_s$ , Mg / m <sup>3</sup>	2.106	2.031	1.856	1.934

REMARKS: ARROWS MARK PEAK EFFECTIVE STRESS CONDITIONS.

Date: MAR. 7, 1985  
Project: 85-1016

Golder Associates

Drawn: EFO  
Checked:



# S TESTS CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TESTS VARVED CLAY

FIGURE II

	A	B	C	D
BOREHOLE NUMBER	101	101	101	
SAMPLE NUMBER	8	8	8	
SAMPLE DEPTH, m	7.16	7.01	7.47	

FAILURE  
SKETCH

SPECIMEN DIAMETER, mm	50.8	50.8	50.2	0
SPECIMEN HEIGHT, mm	101.6	101.4	101.2	

(A)

WATER CONTENT, BEFORE CONSOLIDATION, %	33	24	16	
CELL PRESSURE, $\sigma_3$ , kPa	2410	2850	3270	
BACK PRESSURE, kPa	2000	2000	2000	
PORE PRESSURE PARAMETER 'B'	0.97	0.97	0.96	
CONSOLIDATION PRESSURE, $\sigma_c$ , kPa	420	850	1270	
VOLUME CHANGE DURING CONSOLIDATION, $\Delta v_c$ , ml	-2.6	-5.1	-7.3	
WATER CONTENT, AFTER CONSOLIDATION, %	32	23	15	
AVERAGE RATE OF STRAIN, % / hr.				
AVERAGE LOAD INCREMENT, kPa	200	400	400	
AVERAGE LOAD DURATION, hr.	24	24	24	
TIME TO FAILURE, days	7	6	10	
WATER CONTENT AFTER TEST, %	32	22	16	

(B)

MAX. DEVIATOR STRESS, $(\sigma_1 - \sigma_3)_{max}$ , kPa	1250	2040	2950	
AXIAL STRAIN AT $(\sigma_1 - \sigma_3)_{max}$ , %	3.40	2.40	5.00	
MAX. EFFECTIVE PRINCIPAL STRESS RATIO $(\sigma_1' / \sigma_3')_{max}$ , kPa	4.1	3.4	3.3	
AXIAL STRAIN AT $(\sigma_1' / \sigma_3')_{max}$ , %	3.40	3.40	5.00	

(C)

NATURAL WATER CONTENT, w, %	32	22	16	
LIQUID LIMIT, $w_L$	51			
PLASTIC LIMIT, $w_P$	19			
DENSITY, $\rho_t$ , Mg / m <sup>3</sup>	1900	2050	2170	

(D)

REMARKS: ARROWS MARK PEAK EFFECTIVE STRESS  
CONDITION.

Date: MAR 5, 1985  
Project: 85-1016

Golder Associates

Drawn: EFO  
Check: