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W. O. No.

STR. SITE No. C26-170

HWY. No. 7

LOCATION Plato Creek Culvert

No of PAGES -

=====  
OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

# FOUNDATION INVESTIGATION REPORT

CONTRACT NO 81 - 68



Ministry of  
Transportation and  
Communications



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31C-137

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

'N' VALUE: AN INDICATOR OF SUBSOIL QUALITY. IT IS OBTAINED FROM THE STANDARD PENETRATION TEST (CSA STD. A119.1). SPT 'N' VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 2 INCH O.D. SPLIT-BARREL SAMPLER TO PENETRATE 12 INCHES INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WEIGHING 140 POUNDS, FALLING FREELY A DISTANCE OF 30 INCHES. FOR PENETRATIONS OF LESS THAN 12 INCHES 'N' VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. 'N' VALUES CORRECTED FOR OVERBURDEN PRESSURE ARE DENOTED THUS  $N_c$ .

**DYNAMIC CONE PENETRATION TEST (CSA STD. A119.3):** CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (2" O.D. 60 CONE ANGLE) DRIVEN BY 350 FT-LB IMPACTS ON "A" SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 12 INCH ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

**SOIL QUALITY:** SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSITY.

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

$S_u$ (PSF)	0 - 250	250 - 500	500 - 1000	1000 - 2000	2000 - 4000	> 4000
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

**DENSENESS:** COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF SPT 'N' VALUES AS FOLLOWS:

'N' (BLOW/FT)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

**ROCK QUALITY:** 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 DRILLED IN THAT CORING RUN.

**MODIFIED RECOVERY:** SUM OF THOSE NATURALLY FRACTURED CORE PIECES, 4" 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	2"	2" - 12"	1' - 3'	3' - 10'	> 10'
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

#### ABBREVIATIONS & SYMBOLS

##### LABORATORY TESTING

TRIAXIAL TESTS ARE DESCRIBED IN TERMS OF WHETHER THEY ARE CONSOLIDATED (C) OR NOT (U) ISOTROPICALLY (I) OR NOT (A) AND SHEARED DRAINED (D) OR UNDRAINED (U) WITH PORE PRESSURE MEASUREMENTS (BAR OVER SYMBOLS) EG.  $C_{IU}$  = CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENT UNLESS OTHERWISE SPECIFIED IN REPORT ALL TESTS ARE IN COMPRESSION

##### FIELD SAMPLING

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

##### EARTH PRESSURE TERMS

$\mu$  COEFFICIENT OF FRICTION  
 $\delta$  ANGLE OF WALL FRICTION  
 $k_o$  COEFFICIENT OF EARTH PRESSURE AT REST  
 $k_a$  COEFFICIENT OF ACTIVE EARTH PRESSURE  
 $k_p$  COEFFICIENT OF PASSIVE EARTH PRESSURE  
 $i$  ANGLE OF INCLINATION OF SURCHARGE  
 $w$  SLOPE ANGLE-BACKFACE OF WALL  
 $\beta$  ANGLE OF SLOPE  
 $N_q, N_c$  BEARING CAPACITY FACTORS  
 $D_f$  DEPTH OF FOOTING  
B, L FOOTING DIMENSIONS

##### INDEX PROPERTIES

$\gamma$  UNIT WEIGHT OF SOIL (BULK DENSITY)  
 $\gamma_w$  UNIT WEIGHT OF WATER  
 $\gamma_d$  UNIT DRY WEIGHT OF SOIL (DRY DENSITY)  
 $\gamma'$  UNIT WEIGHT OF SUBMERGED SOIL  
 $G_s$  SPECIFIC GRAVITY OF SOLIDS  
 $e$  VOIDS RATIO  
 $e_o$  INITIAL VOIDS RATIO  
 $e_{max}$  " IN LOOSEST STATE  
 $e_{min}$  " IN DENSEST STATE  
 $D_r$  RELATIVE DENSITY =  $\frac{e_{max} - e}{e_{max} - e_{min}}$   
 $n$  POROSITY  
 $w$  WATER CONTENT  
 $w_L$  LIQUID LIMIT  
 $w_p$  PLASTIC LIMIT  
 $w_s$  SHRINKAGE LIMIT  
 $I_p$  PLASTICITY INDEX =  $w_L - w_p$   
 $I_L$  LIQUIDITY INDEX =  $\frac{w - w_p}{w_L - w_p}$   
 $I_c$  CONSISTENCY INDEX =  $\frac{w_L - w}{w_L - w_p}$   
 $A_c$  ACTIVITY =  $\frac{I_p \text{ of soil}}{I_p \text{ of } 2\mu m \text{ Soil Fraction}}$   
 $O_m$  ORGANIC MATTER CONTENT  
 $S_r$  DEGREE OF SATURATION  
 $S$  SENSITIVITY =  $\frac{S_u(\text{undisturbed})}{S_u(\text{remoulded})}$

##### STRENGTH PARAMETERS

$\phi$  ANGLE OF SHEARING RESISTANCE  
 $\tau_f$  PEAK SHEAR STRENGTH  
 $\tau_R$  RESIDUAL SHEAR STRENGTH  
 $c$  COHESION INTERCEPT  
 $\sigma_1, \sigma_2, \sigma_3$  NORMAL PRINCIPAL STRESSES  
 $u$  PORE WATER PRESSURE  
 $u_e$  EXCESS  $u$   
 $r_u$  PORE PRESSURE RATIO  
 $q_u$  UNCONFINED COMPRESSIVE STRENGTH  
 $s_u$  UNDRAINED SHEAR STRENGTH  
 $\epsilon$  LINEAR STRAIN  
 $\gamma$  SHEAR STRAIN  
 $\nu$  POISSON'S RATIO  
 $E$  MODULUS OF ELASTICITY  
 $G$  MODULUS OF SHEAR DEFORMATION  
 $k_s$  MODULUS OF SUBGRADE REACTION  
 $m, n$  STABILITY COEFFICIENTS  
A, B PORE PRESSURE COEFFICIENTS

NOTE: EFFECTIVE STRESS PARAMETERS ARE DENOTED BY USE OF APOSTROPHE ABOVE THE SYMBOL, THUS:  
 $\phi'$  = EFFECTIVE ANGLE OF SHEARING RESISTANCE;  
 $\sigma'$  = EFFECTIVE NORMAL STRESS

##### HYDRAULIC TERMS

$h$  HYDRAULIC HEAD OR POTENTIAL  
 $q$  RATE OF DISCHARGE  
 $v$  VELOCITY OF FLOW  
 $i$  HYDRAULIC GRADIENT  
 $j$  SEEPAGE FORCE PER UNIT VOLUME  
 $\eta$  COEFFICIENT OF VISCOSITY  
 $k$  COEFFICIENT OF HYDRAULIC CONDUCTIVITY  
 $k_h$   $k$  IN HORIZONTAL DIRECTION  
 $k_v$   $k$  IN VERTICAL DIRECTION  
 $\alpha_v$  COEFFICIENT OF VOLUME CHANGE  
 $c_v$  COEFFICIENT OF CONSOLIDATION  
 $C_c$  COMPRESSION INDEX  
 $C_r$  RECOMPRESSION INDEX  
 $d$  DRAINAGE PATH DISTANCE  
 $T_v$  TIME FACTOR  
 $U$  DEGREE OF CONSOLIDATION  
 $O_r$  OVERCONSOLIDATION RATIO (OCR)

## FOUNDATION INVESTIGATION REPORT

For

Plato Creek Culvert  
W.P. 904-66-02, Site C26-170  
Highway 7, District 7, Port Hope

### INTRODUCTION

This report contains the results of the foundation investigation carried out to provide information for the design and construction of a replacement culvert at Highway 7 and Plato Creek. Field work, consisting of 4 sampled boreholes each accompanied by a dynamic cone penetration test, was carried out September 29th and 30th, 1980. A CME 75 auger machine equipped with 3½ inch I.D. hollow stem augers was employed.

### SITE DESCRIPTION

The site is located about 1/2 mile east of Havelock at which point Highway 7 crosses Plato Creek. The area surrounding is flat, low lying and swampy and is covered by brush and scattered trees. Plato Creek is slow flowing, meandering through the area in a channel about 20 feet in width. The banks are low and in places are flooded due to the presence of a series of beaver dams. Highway 7 which is on tangent runs on a low embankment 5 to 8 feet above the surrounding area.

The existing 4' x 20' concrete culvert is supported on open footings. It consists of a central portion with additions on both ends constructed when the road was widened. The exposed portions of the culvert show no structural ill effects from the undermining and piping which occurred during the high flow conditions in March 1980.

### SUBSURFACE CONDITIONS

#### Subsoil General

Subsoil conditions over the site are generally uniform. The upper 5 to 8 feet consist of loose granular fill underlain by a 1 to 2 foot thick layer of organic silt trapped when the fill was constructed. This



layer is in turn underlain by sand containing some gravel and silt which extends to a depth of at least 28.5 feet below the road surface at which depth the deepest borehole was terminated.

Reference should be made to the Record of Borehole Sheets which are contained in the report Appendix. They show the different soil types, as well as a summary of all field and laboratory tests performed. Reference should also be made to Drawing No. 9046602-A which shows the location and elevation of all borings together with sections showing inferred subsoil stratigraphy. A more detailed description of the various soil types follows.

#### Sand, Gravel, Cobbles and Boulders (Fill)

The existing road embankment consists of 5 to 8 feet of loose granular fill made up of sand, gravel, cobbles and boulders. Difficulty in penetrating this layer with augers was experienced due to the coarser grain sizes. This was especially a problem in the north east corner where new fill was dumped to replace that washed away during the high water conditions in March 1980.

#### Organic Silt

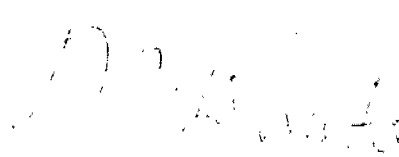
The fill is underlain by a 1 to 2 foot thick layer of organic silt trapped when the embankment was constructed. It is assessed to have a soft consistency.

#### Sand, Some Gravel and Silt

This deposit underlies the organic silt and extends below the depth of the deepest borehole which was terminated 28.5 feet below the road surface. It consists of sand, some gravel and silt. Typical grain size distribution curves for split spoon samples are shown in Figure 1. The upper portion of the deposit is loose to compact increasing to very dense below elevation 620. Standard Penetration 'N' values generally increase with depth varying from a low of 4 blows per foot at the upper boundary to in excess of 100 blows per foot where sampling was terminated.

Groundwater

Groundwater was encountered at approximately elevation 636 which corresponded to the water level in Plato Creek at the time of the investigation.



M. Devata, P. Eng.  
Senior Foundations Engineer

APPENDIX





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# RECORD OF BOREHOLE No 1

7

W P 904-66-02 LOCATION Sta. 317+63 24.5' Rt. ORIGINATED BY R.B.  
DIST 10 HWY 7 BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY  
DATUM Geodetic DATE 1980/09/29 CHECKED BY

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								WATER CONTENT (%)	
641.7	Ground Level														GR SA SI CL		
0.0	Sand, Gravel Cobbles and Boulders Loose (Fill)						640										
634.7	Organic Silt		1	SS	12										0 81 18 1		
7.0			2	SS	7		630								5 78 61 1		
8.5	Sand, Some Gravel and Silt Loose to Compact		3	SS	10										18 69 11 2		
			4	SS	30		620										
			5	SS	83												
613.2	Very Dense		6	SS	100/ 9"										30 58 7 5		
28.5	End of Borehole  Note: Water Level Not Established.																

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10



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## RECORD OF BOREHOLE No 2

8

W P 904-66-02 LOCATION Sta. 318+44 24.0' Rt. ORIGINATED BY R.B.  
DIST 10 HWY 7 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY R.B.  
DATUM Geodetic DATE 1980/09/29 CHECKED BY \_\_\_\_\_

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	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								
641.8													
0.0	Sand, Gravel Cobbles and Boulders Loose (Fill)						640						
635.8			1	SS	6								
6.0	Organic Silt		2	SS	4								5 81 11 3
7.0	Sand, Some Gravel and Silt		3	SS	26		630						
	Loose to Compact		4	SS	32								41 37 19 3
	Very Dense												
620.3			5	SS	69								
21.5	End of Borehole  Note: Water Level Not Established.												

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10



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# RECORD OF BOREHOLE No 3

9

W P 904-66-02 LOCATION Sta. 318+10, 28.0 Lt. ORIGINATED BY R.B.  
DIST 10 HWY 7 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.B.  
DATUM Geodetic DATE 1980/09/30 CHECKED BY \_\_\_\_\_

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	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								
641.0	Ground Level						640						
0.0	Sand, Gravel Cobbles and Boulders Loose (Fill)												
633.0	Organic Silt		1	SS	2/	18"							
8.0			2	SS	6								
9.5	Sand, Some Gravel and Silt Loose to Compact		3	SS	10								
			4	SS	17								
			5	SS	13								
	Very Dense		6	SS	32								
615.5			7	SS	52								
25.5	End of Borehole												

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

20  
15  
10  
5 (%) STRAIN AT FAILURE



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# RECORD OF BOREHOLE No 4

10

W P 904-66-02 LOCATION Sta. 318+73 23.0' Lt. ORIGINATED BY R.B.  
DIST 10 HWY 7 BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY R.B.  
DATUM Geodetic DATE 1980/09/30 CHECKED BY \_\_\_\_\_

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ 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						
640.6	Ground Level										
635.6	Sand, Gravel, Cobbles & Boulders, Loose										
5.0	Organic Silt (Fill)		1	SS	7						
6.0	Sand, Some Gravel and Silt		2	SS	31						
	Compact to Very Dense		3	SS	64						
623.1			4	SS	48						
17.5	End of Borehole										

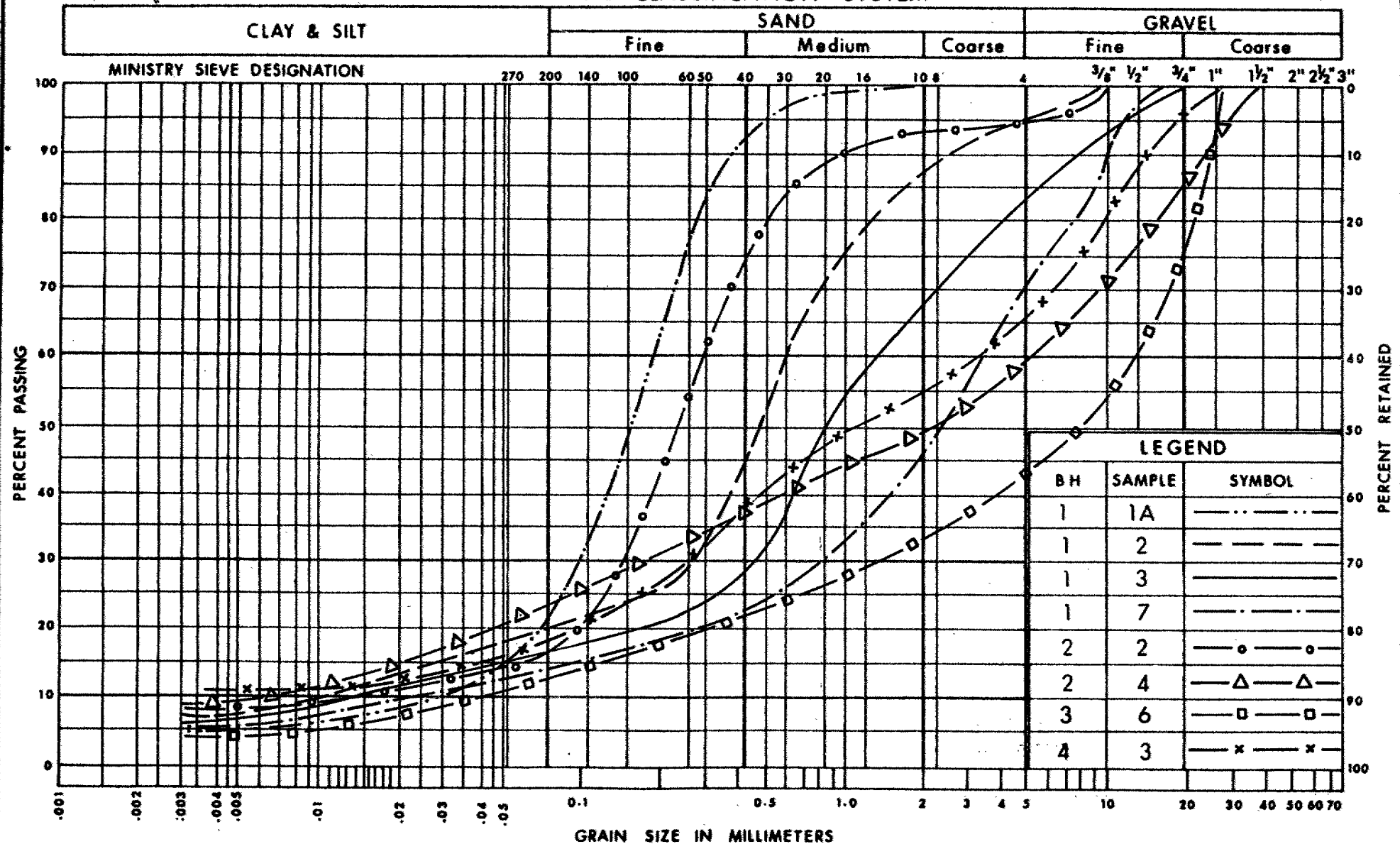
9"  
Spoon Bouncing

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

## UNIFIED SOIL CLASSIFICATION SYSTEM



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**GRAIN SIZE DISTRIBUTION**  
**SAND**  
SOME GRAVEL & SILT

FIG No 1

W P 904-66-02

OVERSIZE  
DRAWING(S)