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(see also: 152-75-07, Cont 83-41)

CONT. No. 84-01

W. O. No.

STR. SITE No. 36-1336-142

HWY. No.

LOCATION Redhill Creek

No of PAGES -

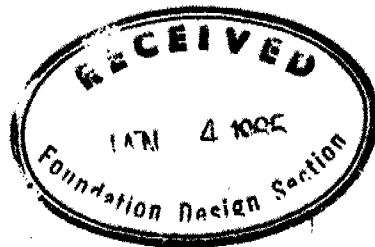
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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION REPORT

CONTRACT NO 84 - 01



Ministry of
Transportation and
Communications

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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.

EXPLANATION OF TERMS USED IN REPORT

2

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

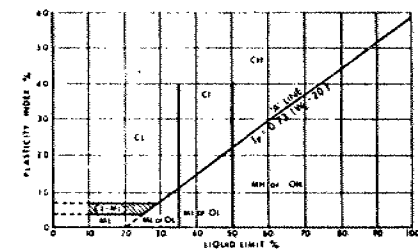
m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE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

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m ³	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
P	kg/m ³	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m ³	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m ³	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m ³ /s	RATE OF DISCHARGE
γ_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m ³	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						

EXTENDED CASAGRANDE SOIL CLASSIFICATION SYSTEM

FIELD IDENTIFICATION PROCEDURES (EXCLUDING PARTICLES LARGER THAN 75 mm AND BASING FRACTIONS ON ESTIMATED MASS)					GRP SYMB	TYPICAL NAMES	INFORMATION REQUIRED FOR DESCRIBING SOILS	LABORATORY CLASSIFICATION CRITERIA			
COARSE GRAINED SOILS MORE THAN HALF OF MATERIAL IS LARGER THAN 75 μ m (75 μ m IS ABOUT THE SMALLEST PARTICLE VISIBLE TO THE NAKED EYE)	GRAVELS MORE THAN HALF OF COARSE FRACTION IS LARGER THAN 4.75 mm	CLEAN GRAVELS (LITTLE OR NO FINES)	WIDE RANGE IN GRAIN SIZE & SUBSTANTIAL AMOUNTS OF ALL INTERMEDIATE PARTICLE SIZE			GM	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES; LITTLE OR NO FINES	GIVE TYPE, NAME, IF NECESSARY, INDICATE APPROX. % OF SAND & GRAVEL, MAX. SIZE, ANGULARITY, SURFACE CONDITION, & HARDNESS OF THE COARSE GRAINS; LOCAL OR GEOLOGIC NAME & OTHER PERTINENT DESCRIPTIVE INFORMATION; & SYMBOL IN PARENTHESES. FOR UNDISTURBED SOILS ADD INFORMATION ON STRATIFICATION, DEGREE OF COMPACTNESS, CEMENTATION, MOISTURE CONDITIONS & DRAINAGE CHARACTERISTICS.	DETERMINE PERCENTAGES OF GRAVEL & SAND FROM GRAIN SIZE CURVE. DEPENDING ON PERCENTAGE OF FINES (FRACTION SMALLER THAN 75 μ m) COARSE GRAINED SOILS ARE CLASSIFIED AS FOLLOWS: LESS THAN 5% GM, GP, SW, SP MORE THAN 12% GM, GC, SM, SC 5% TO 12% <u>BORDERLINE CASES</u> REQ. USE OF DUAL SYMBOLS	$C_u = \frac{D_{60}}{D_{10}}$ GREATER THAN 4 $C_c = \frac{(D_{30})^2}{D_{10} \cdot D_{60}}$ BETWEEN ONE AND 3 NOT MEETING ALL GRADATION REQUIREMENTS FOR GM	
		GRAVEL WITH FINES (APPRECIABLE AMOUNT OF FINES)	PREDOMINANTLY ONE SIZE OF A RANGE OF SIZES WITH SOME INTERMEDIATE SIZES MISSING			GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES; LITTLE OR NO FINES		ATTENBERG LIMITS BELOW A-LINE, OR I_p LESS THAN 4	ABOVE A-LINE WITH I_p BETWEEN 4 AND 7 ARE <u>BORDERLINE CASES</u> REQUIRING USE OF DUAL SYMBOLS	
			NON-PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)			GM	SILTY GRAVELS, POORLY GRADED GRAVEL-SAND-SILT MIXTURES		ATTENBERG LIMITS ABOVE A-LINE WITH I_p GREATER THAN 7		
	SANDS MORE THAN HALF OF COARSE FRACTION IS SMALLER THAN 4.75 mm	CLEAN SANDS (LITTLE OR NO FINES)	WIDE RANGE IN GRAIN SIZES & SUBSTANTIAL AMOUNTS OF ALL INTERMEDIATE PARTICLE SIZES			SM	WELL GRADED SANDS, GRAVELLY SANDS; LITTLE OR NO FINES		$C_u = \frac{D_{60}}{D_{10}}$ GREATER THAN 4 $C_c = \frac{(D_{30})^2}{D_{10} \cdot D_{60}}$ BETWEEN ONE AND 3 NOT MEETING ALL GRADATION REQUIREMENTS FOR SM	ATTENBERG LIMITS BELOW A-LINE OR I_p LESS THAN 4	ABOVE A-LINE WITH I_p BETWEEN 4 AND 7 ARE <u>BORDERLINE CASES</u> REQUIRING USE OF DUAL SYMBOLS
			PREDOMINANTLY ONE SIZE OR A RANGE OF SIZES WITH SOME INTERMEDIATE SIZES MISSING			SP	POORLY GRADED SANDS, GRAVELLY SANDS; LITTLE OR NO FINES		ATTENBERG LIMITS ABOVE A-LINE WITH I_p GREATER THAN 7		
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	NON-PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)			SM	SILTY SANDS, POORLY GRADED SAND-SILT MIXTURES				
		PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)			SC	CLAYEY SANDS, POORLY GRADED SAND-CLAY MIXTURES					
FINE GRAINED SOILS MORE THAN HALF OF MATERIAL IS SMALLER THAN 75 μ m (75 μ m IS ABOUT THE SMALLEST PARTICLE VISIBLE TO THE NAKED EYE)	IDENTIFICATION PROCEDURES ON FRACTION SMALLER THAN 425 μ m							GIVE TYPE, NAME, IF NECESSARY, INDICATE DEGREE & CHARACTER OF PLASTICITY, AMOUNT & MAXIMUM SIZE OF COARSE GRAINS, COLOUR IN WET CONDITION, ODOUR, IF ANY, LOCAL OR GEOLOGIC NAME & OTHER PERTINENT DESCRIPTIVE INFORMATION & SYMBOL IN PARENTHESES. FOR UNDISTURBED SOILS ADD INFORMATION ON STRUCTURE, STRATIFICATION, CONSISTENCY IN UNDISTURBED & REMOULDED STATES, MOISTURE & DRAINAGE CONDITIONS.			
	LIQUID LIMIT LESS THAN 35%	DRY STRENGTH (CRUSHING CHARACTERISTICS)	DEFLATANCY (REACTION TO SHAKING)	TOUGHNESS (CONSISTENCY NEAR PLASTIC LIMIT)	ML	INORGANIC SILTS & SANDY SILTS OF SLIGHT PLASTICITY, ROCK FLOUR					
		NONE	QUICK	NONE	CL	CLAYEY SILTS (INORGANIC), GRAVELLY CLAYS, SANDY CLAYS, LEAN CLAYS					
		MEDIUM TO HIGH	NONE TO VERY SLOW	MEDIUM	OL	ORGANIC SILT OF LOW PLASTICITY, ORGANIC SANDY SILTS					
	LIQUID LIMIT BETWEEN 35% AND 50%	SLIGHT TO MEDIUM	SLOW	SLIGHT	MH	INORGANIC COMPRESSIBLE FINE SANDY SILT WITH CLAY OF MEDIUM PLASTICITY, CLAYEY SILTS					
		HIGH	NONE	MEDIUM TO HIGH	CL	SILTY CLAYS (INORGANIC) OF MEDIUM PLASTICITY					
		SLIGHT TO MEDIUM	VERY SLOW	SLIGHT	OL	ORGANIC SILTY CLAYS OF MEDIUM PLASTICITY					
	LIQUID LIMIT GREATER THAN 50%	SLIGHT TO MEDIUM	SLOW TO NONE	MEDIUM	MH	INORGANIC SILTS, HIGHLY COMPRESSIBLE MICACEOUS OR DIATOMACEOUS FINE SANDY SILTS, ELASTIC SILTS					
		HIGH TO VERY HIGH	NONE	HIGH	CH	CLAYS (INORGANIC) OF HIGH PLASTICITY, FAT CLAYS					
		MEDIUM TO HIGH	NONE TO VERY SLOW	SLIGHT TO MEDIUM	OH	ORGANIC CLAYS OF HIGH PLASTICITY					
	HIGHLY ORGANIC SOILS					PT	PEAT & OTHER HIGHLY ORGANIC SOILS				



PLASTICITY CHART
FOR LABORATORY CLASSIFICATION OF FINE GRAINED SOILS

BOUNDARY CLASSIFICATIONS: SOILS POSSESSING CHARACTERISTICS OF TWO GROUPS ARE DESIGNATED BY COMBINATIONS OF GROUP SYMBOLS. FOR EXAMPLE GM-GC, WELL GRADED GRAVEL-SAND MIXTURE WITH CLAY BINDER

FOUNDATION INVESTIGATION REPORT
FOR
BEACH STRIP ARTERIAL BRIDGE
RED HILL CREEK
W.P.152-75-06; SITE 36-1336-142
DISTRICT#4 (HAMILTON)

1.0 INTRODUCTION

An evaluation of soil conditions has been completed in Hamilton, Ontario where the proposed Beach Strip Arterial Road crosses Redhill Creek. This report describes the site conditions and discusses some considerations for the design of the structure foundations and approaches. A more general summary of soil conditions and design considerations was submitted to Mr. K. Selby, P. Eng. in a letter dated August 25, 1981. The study was completed under the terms of agreement No. 4242-9081-45.

The northerly part of the structure area is underlain by relatively deep deposits of fill and organic soils. Consequently the structure will have to be supported by piles. Alternative types of pile support are considered in the report. These include the possible use of piles below an existing bridge structure that extends below a substantial part of the new structure.

Recommendations and discussions included in this report are provided for the guidance for the structural design engineers for preparing design drawings and cost estimates. In no case should they be construed as specific instructions for contractors. Interpretations of soil profiles have been completed for similar reasons. While these interpretations are believed to be a good representation of soil conditions, some irregularities should be expected. Tender documents and project cost allowances should allow for such irregularities and actual soil strata limits should be confirmed by observations during construction.

2.0 FIELD WORK

Four boreholes were drilled at the site to evaluate soil conditions. The locations of borings and a general soil profile are shown on Drawing No. 2 of the contract drawings. More detailed soil profile and field test data summaries are provided on the attached Records of Boreholes.

2.0 FIELD WORK (cont.)

Boreholes 1 and 3 were completed in March 1981 using a raft mounted diamond drill and wash boring procedures. These two borings are part of a series of borings for an alternative structure located west of the currently proposed structure. Boreholes #200 and #201 were completed on August 12 to 18, 1981 using a truck-mounted CME 75 power drill equipped with 82 mm internal diameter hollow stem augers.

Soil samples were obtained with 50 mm "split spoon" samplers driven using standard penetration test procedures. Additional indication of soil variability and density were obtained by driving 50 mm dynamic cone probes with the hammer energy similar to that used for the standard penetration test (63.5 kg hammer falling 760 mm).

3.0 SOIL CONDITIONS

3.1 General

The site area outside the limits of the creek channel is underlain by fill, generally consisting of sand and gravel, that extends roughly to the streambed level. In the south abutment area at borehole #201 the fill is underlain directly by layered gravelly sand while at the north abutment area, at borehole #200 the layered inorganic sand stratum is separated from the fill by 4.4 m of interbedded silt and organic silt soils. Deep deposits of partly organic sediments also exist at borehole #3.

The layered sand and gravelly sand soils are underlain by till-textured soils consisting of silty clay that contains a trace to some sand and gravel. In the south abutment area the boundary between the gravelly sand stratum and the till-textured soils occurs near elevation 72 m or roughly 5 m below the existing road grade.

All boreholes were terminated in the till-textured silty clay soils between elevation 57.95 m and elevation 56.58 m.

3.2 Fill

Fill encountered behind existing abutments and retaining walls consists primarily of relatively clean gravelly sand and sandy gravel. There are occasional silty lenses.

Standard penetration resistances of 12 to 48 blows per 0.3 m are indicative of compact to dense soil.

3.3 Partly Organic Sediments

Soils immediately below creek bed level at boreholes #1, #3 and #200 consist of relatively soft or loose layered sediments ranging from sand to peat. At boreholes #3 and #200 (north abutment area) these sediments are 4.23 to 4.96 m thick while at the south abutment at borehole #1 these sediments are only 1.23 meters thick. No organic sediments were noted at borehole #201.

The proportion of organic sediments in this stratum is less than 40 percent and most of that can be classified as slightly to moderately organic. Highly organic very compressible silt or peat layers are rare and thin.

Penetration resistances of 3 to 6 blows per 0.3 in this zone indicate loose and soft soils.

3.4 Sand Stratum

A northward dipping stratum of layered sand and gravelly sand, encountered in boreholes #3, #200 and #201, consists primarily of relatively clean fine to coarse sand and gravelly sand. There are some silty seams, however, and a 2.4 m thick silty seam at borehole #3 is a till-textured mixture of gravel, sand and silt. Particle sizes of typical soils from the sand stratum are provided on Figures 4, 5, 6 and 8.

Penetration resistances of 12 to 32 blows per 0.3 m in the sand indicate compact to dense soil. A low resistance of 3 blows per 0.3 m in the upper part of the stratum at borehole #3 is attributed to disturbance during sampling and a resistance in excess of 100 blows per 0.3 m is attributed to the influence of coarse gravel particles.

3.5 Silty Clay (Glacial till)

All borings penetrated the till-textured silty clay stratum that is classified as very stiff to hard on the basis of standard penetration resistances of 11 to more than 100 blows per 0.3 m. Generally the hardness increases with depth and all borings were terminated in extremely hard soil in which penetration resistances exceeded 100 blows per 0.3 m.

Occasional thin sand and gravel seams were encountered within the till-textured silty clay soils.

The silty clay has a low plasticity, with liquid limits of less than 25 percent, and generally contains a trace to some sand and gravel. Particle analyses on typical soils from this stratum are summarized on Figure 2, 3 and 7.

3.6 Groundwater

Groundwater levels were at or close to the water level of the adjacent creek and bay at the time of drilling. A similar close relationship is expected to prevail as water levels in the creek and bay fluctuate. There was no evidence of artesian conditions in any of the boreholes.

NOTE: THIS REPORT IS A COPY OF PAGES 1-4 OF A REPORT PREPARED FOR THE MINISTRY BY SITE INVESTIGATION SERVICES LTD. DATED OCT. 1981. THE ORIGINAL REPORT WAS SIGNED BY R. MARTILLA, P. ENG.

APPENDIX

RECORD OF BOREHOLE No 1

METRIC

W P 152-75-06 LOCATION Co-ords. 4,791,260 N; 282,609 E. ORIGINATED BY P.S.
 DIST 4 HWY Q.E.W. BOREHOLE TYPE Washboring, NX Casing COMPILED BY D.N.
 DATUM Geodetic DATE 1981-03-26 to 1981-03-27 CHECKED BY R.E.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
74.688	Water Level																
0.0 73.91	Water						74										
.770	Organic sandy silt. Some peaty material. Soft Black		1	SS	3		73										
72.68																	
2.00	Silty clay, some sand trace of gravel. Trace of root fibres above 3.5 M (glacial till). Low plasticity Stiff to hard Brown		2	SS	9		72							0			
							71										
			3	SS	65		70							0			
69.18							69										
5.50	Silty clay, some sand trace of gravel (glacial till). Very stiff to hard. Light grey		4	SS	35		68							10-1			
							67								0		4 15 (81)
66.48			5	SS	32		66										
8.20	Silty clay, some sand trace to some gravel (glacial till)		6	SS	41		65							10-1			
	Hard						64								0		5 20 (75)
	Dark grey		7	SS	39		63										
	Reddish brown below 11.5 M		8	SS	47		62							0-1			
							61								0		
			9	SS	80		60										
							59										
			10	SS	110+		58										
							57										
	Some cobbles and boulders below 16.5 m			RC BX	14%		56										
56.58 18.10	End of Borehole																

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

VERTICAL SCALE ON SOIL EXPLORATION



RECORD OF BOREHOLE No 3

METRIC

W P 152-75-06 LOCATION Co-ords. 4,791,303 N; 282,603 E. ORIGINATED BY P.S.
DIST 4 HWY Q.E.W. BOREHOLE TYPE Washboring, NX Casing COMPILED BY D.N.
DATUM Geodetic DATE 1981-03-30 to 1981-03-31 CHECKED BY R.E.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
74.688	Water Level																
0.0	Water																
73.91																	
72.88	Organic silty sand, Loose Black		1	SS	3												
1.80	Sand, fine to medium. Loose		2	SS	5												
70.28	Dark grey																
69.88	Organic silt. Fibrous Dark grey		3	SS	4												
5.00	Fine sand, traces of gravel. Loose Dark grey		4	SS	3												
68.18																	
6.50	Gravelly sand, medium to coarse. Layered. Dense Grey		5	SS	30												
67.08																	
7.60	Silty sand, some gravel (Glacial till) Very dense		6	SS	100/	0.15m											
64.68	Grey																
10.00	Silty clay, some sand trace of gravel. (Glacial till) Very stiff to hard Reddish to grey		7	SS	19												
			8	SS	32												
			9	SS	127												
			10	SS	100/	.15m											
	Bouldery below 17 M		11	SS	100/	.075m											
			12	SS	100/	.15m											
56.58																	
18.10	End of Borehole																

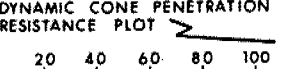





+³, x⁵: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 200

METRIC

W P 152-75-06 LOCATION Co-ords. 4,791,288 N; 282,641 E. ORIGINATED BY D.B.
 DIST 4 HWY Q.E.W. BOREHOLE TYPE 82mm Hollow Stem Auger & Cone Test COMPILED BY D.B.
 DATUM Geodetic DATE 1981-08-17 to 1981-08-18 CHECKED BY R.E.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
76.70	Ground Level													GR SA SI CL
0.0	Fill - Gravelly sand to sandy gravel, traces of silt. Compact to dense. Grey		1	SS	42		76							
73.13			2	SS	12		75							
3.57	Layers of silty clay to organic silt.		3	SS	6		74							
	Firm to stiff. Brown to dark grey.		4	SS	11		73							
69.69			5	SS	4		72				0			
7.01	Sand with organic silt seams. Loose		6	SS	32		71							
68.17			7	SS	---		70				0			
8.53	Sand, medium to coarse. Trace of silty and gravel. Dense		8	SS	30		69							
	Brown to grey.		9	SS	29		68							
63.90			10	SS	78		67							
12.80	Silty clay, traces of sand and gravel. Low plasticity. (Glacial Till) Very stiff to hard. Reddish grey to grey.		11	SS	69/15m		66							
57.95							65							
18.75	End of Borehole						64							
							63				0			
							62							
							61				0			
							60							
							59							
							58				0			
							57							

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 201

METRIC

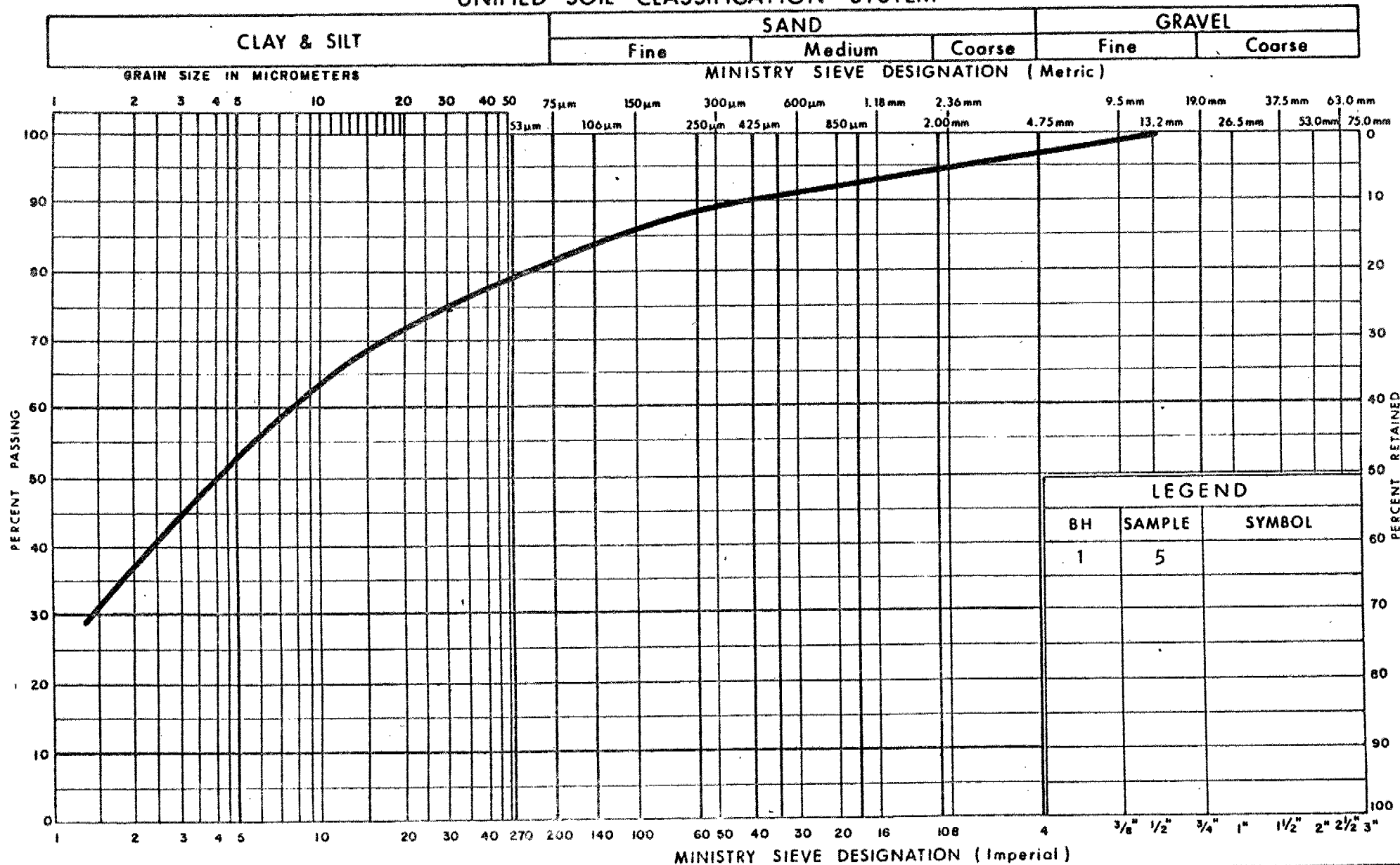
W P 152-75-06 LOCATION Co-ords. 4,791,198 N; 282,654 E. ORIGINATED BY P.S.
DIST 4 HWY Q.E.W. BOREHOLE TYPE 82mm Hollow Stem Auger COMPILED BY D.W.N.
DATUM Geodetic DATE 1981-08-12 to 1981-08-13 CHECKED BY R.E.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
76.41	Ground Level													
0.0	Fill - mixture of silt, sand and gravel. Brown - grey.													
75.19	1.22 Fill - Gravel.		1	SS	48									
73.67	Dense. Brown-grey.													
2.74	Gravelly sand		2	SS	12									44 52 4 0
72.14	Compact. Grey.													
4.27	Silty clay Some sand and gravel (Glacial Till)		3	SS	22									
			4	SS	11									
	Reddish below 6.09m.		5	SS	11									
	Very stiff above 9m depth.		6	SS	26									
	Hard below 9m depth.		7	SS	27									3 24 33 40
			8	SS	30									
			9	SS	45									
			10	SS	75									
			11	SS	120									
57.66	Sandy gravel. Very dense.		12	SS	160									48 39 (13)
18.75	End of Borehole.													

+3, x5 : Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

**Ministry of
Transportation and
Communications**

GRAIN SIZE DISTRIBUTION
SILTY CLAY (TILL)

FIG No 2

W P 152-75-06

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

Fine

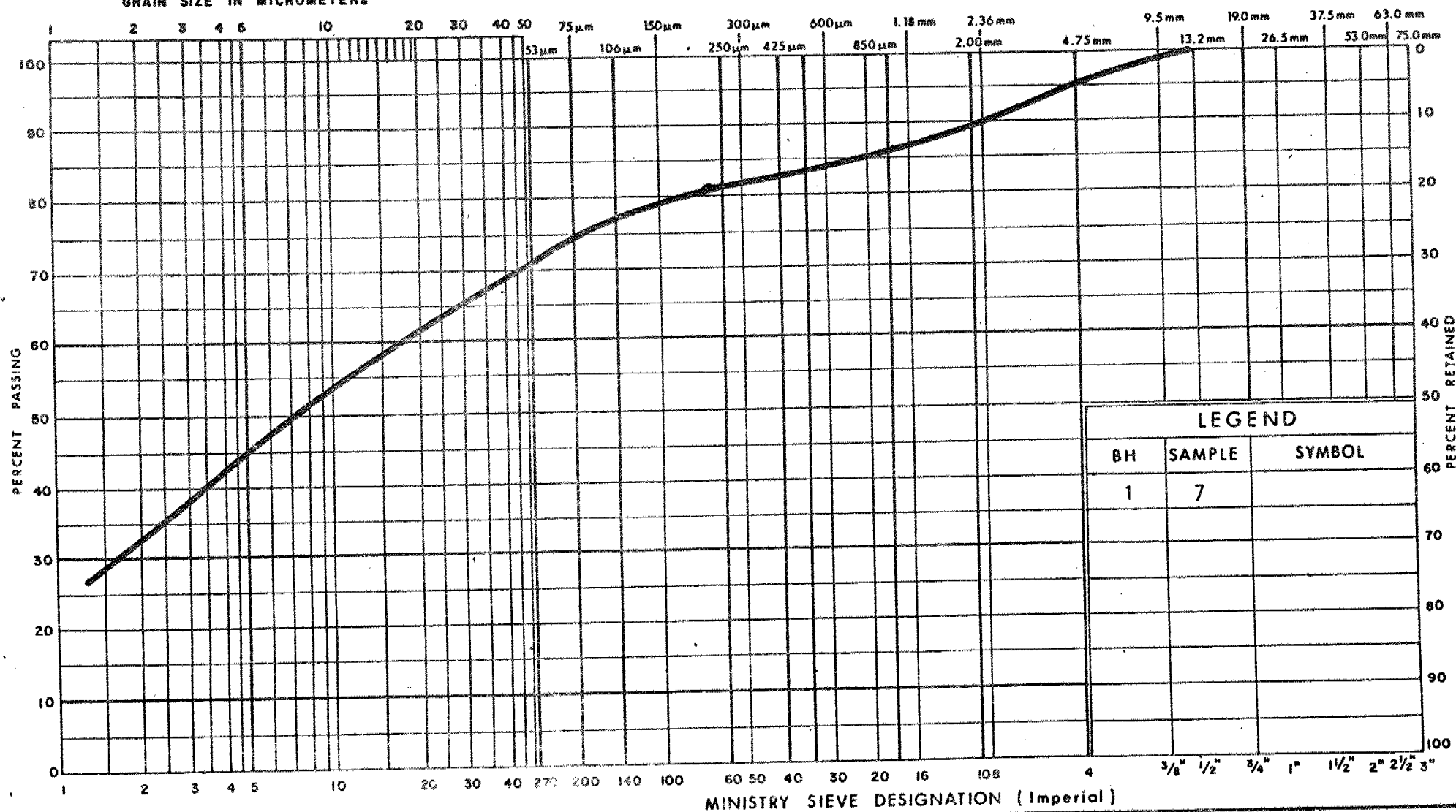
Medium

Coarse

Fine

Coarse

GRAIN SIZE IN MICROMETERS

[illegible]

Ontario

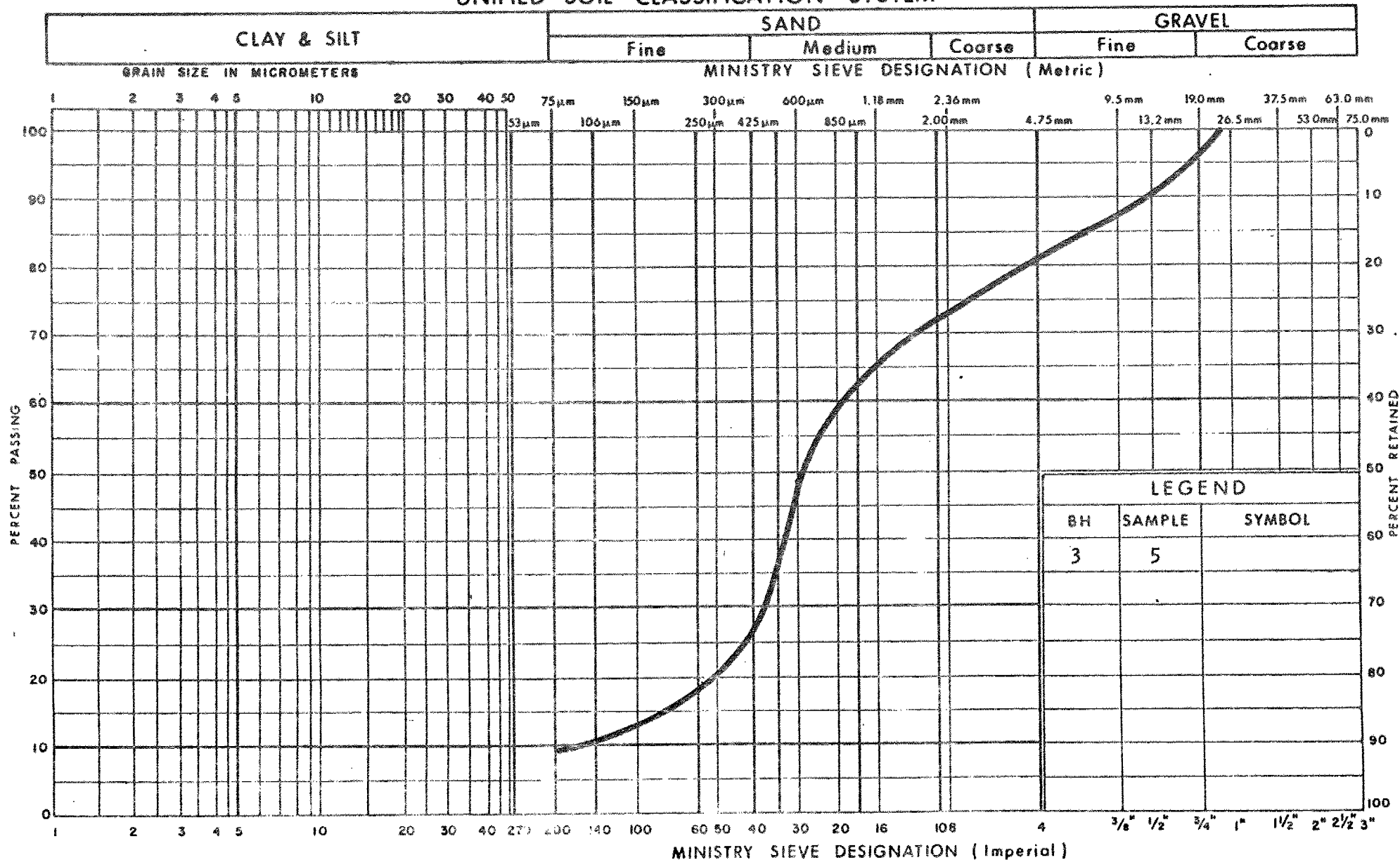
**Ministry of
Transportation and
Communications**

GRAIN SIZE DISTRIBUTION
SANDY SILTY CLAY (TILL)

FIG No 3

W P 152-75-06

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION
GRAVELLY SAND

FIG No 4

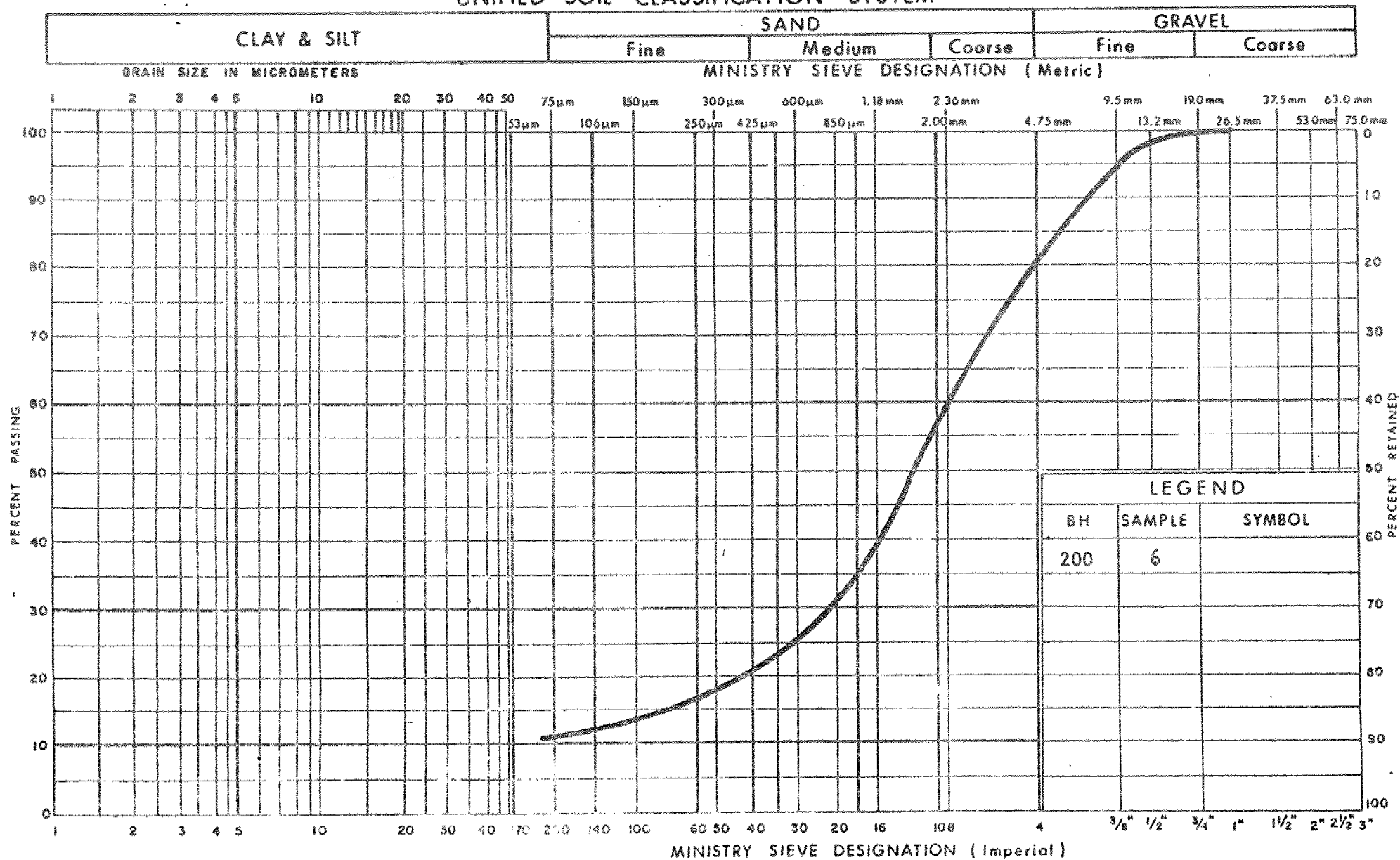
W P 152-75-06



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UNIFIED SOIL CLASSIFICATION SYSTEM



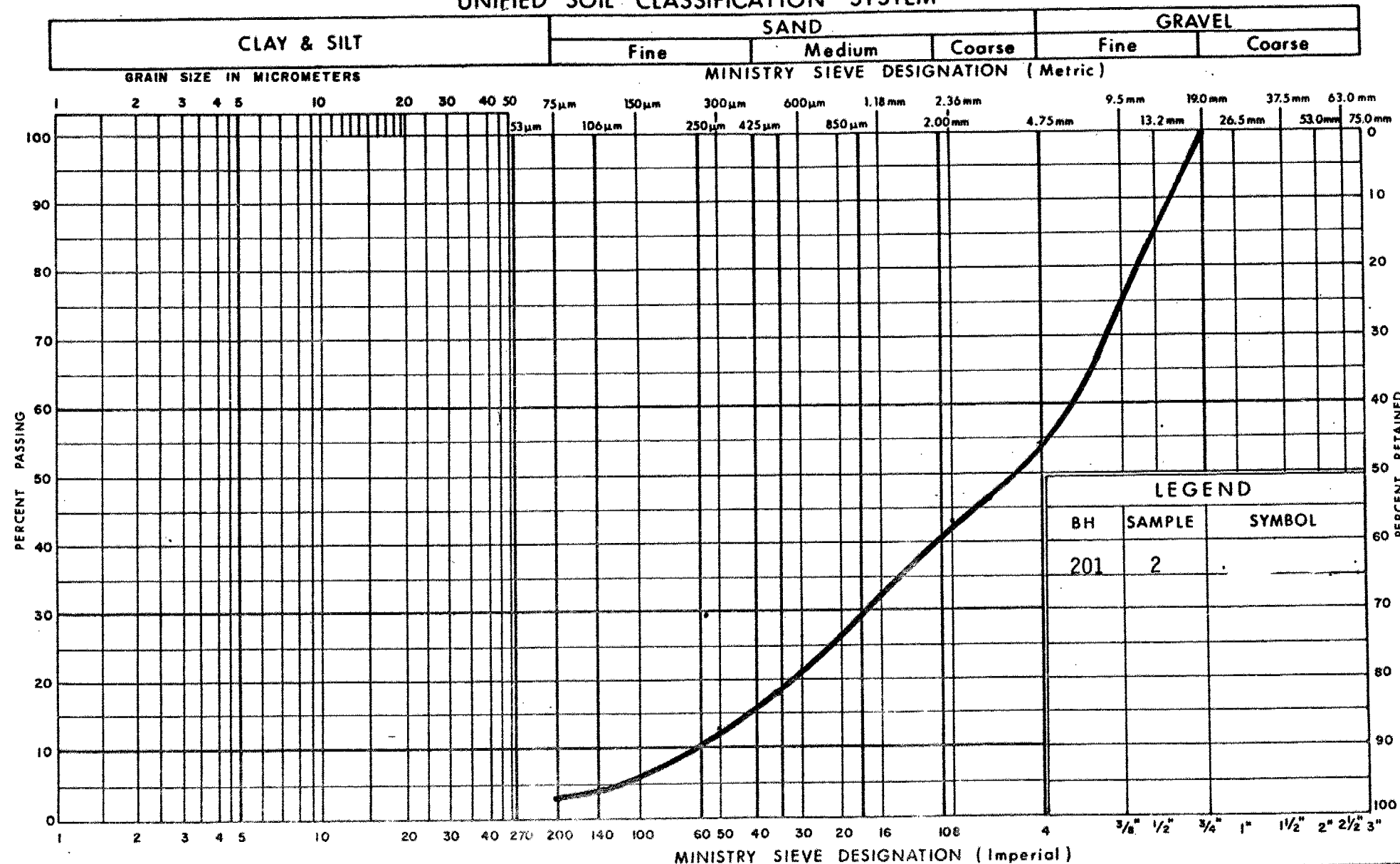
Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
SAND (Some Gravel)

FIG No 5

W P 152-75-06

UNIFIED SOIL CLASSIFICATION SYSTEM



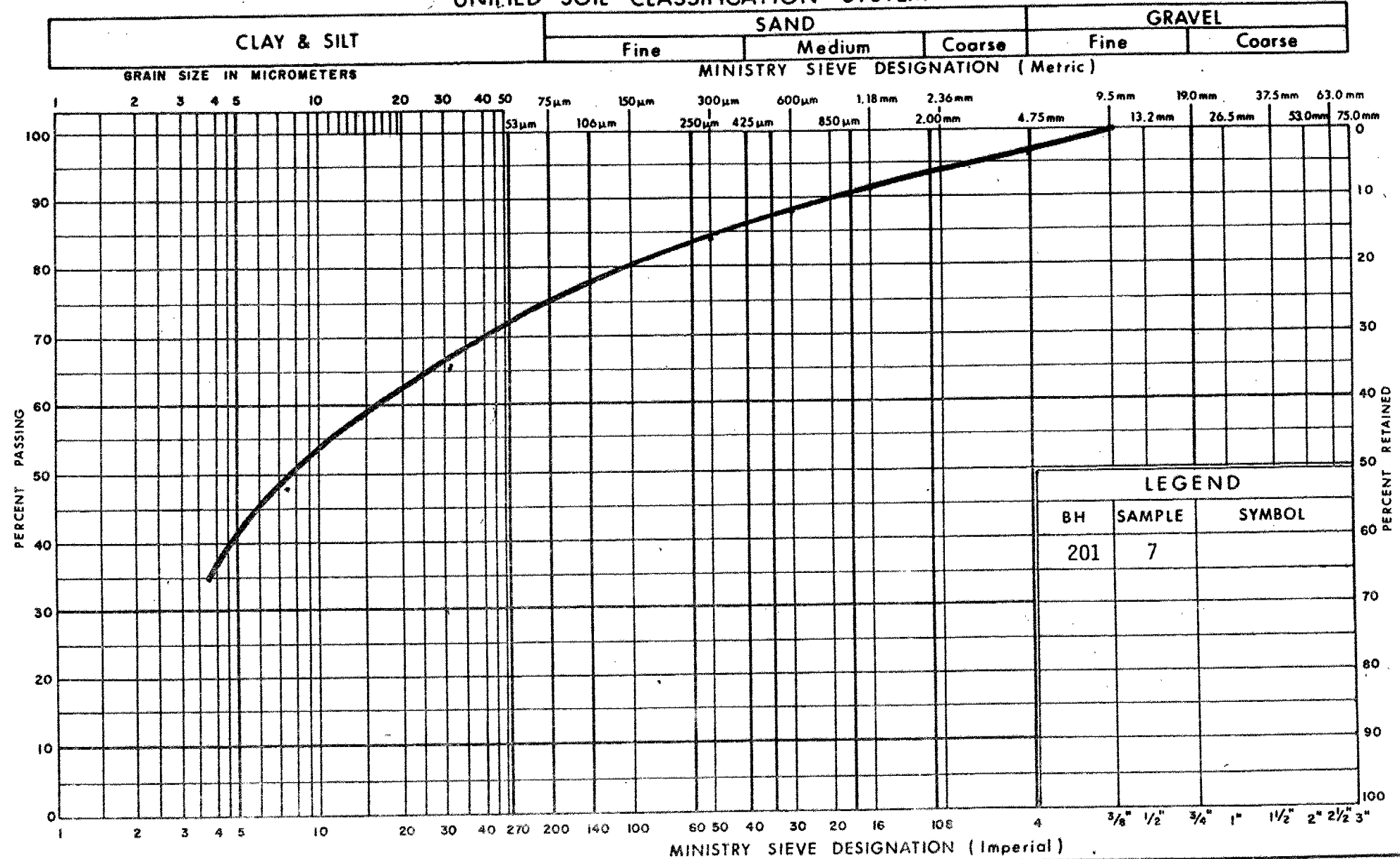
Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
SANDY GRAVEL

FIG No 6

W P 152-75-06

UNIFIED SOIL CLASSIFICATION SYSTEM



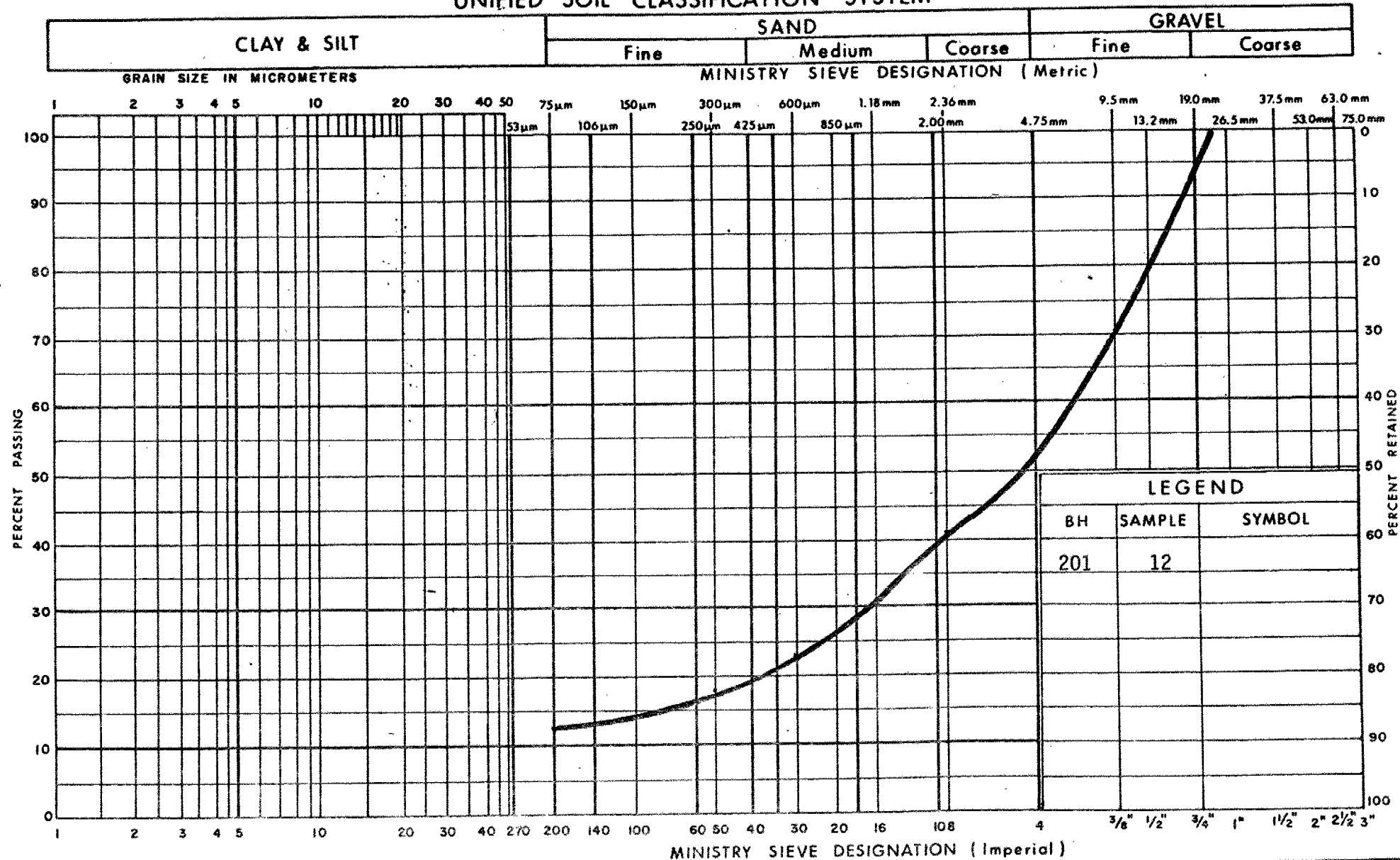
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Communications

GRAIN SIZE DISTRIBUTION
SANDY SILTY CLAY (TILL)

FIG No 7

W P 152-75-06

UNIFIED SOIL CLASSIFICATION SYSTEM

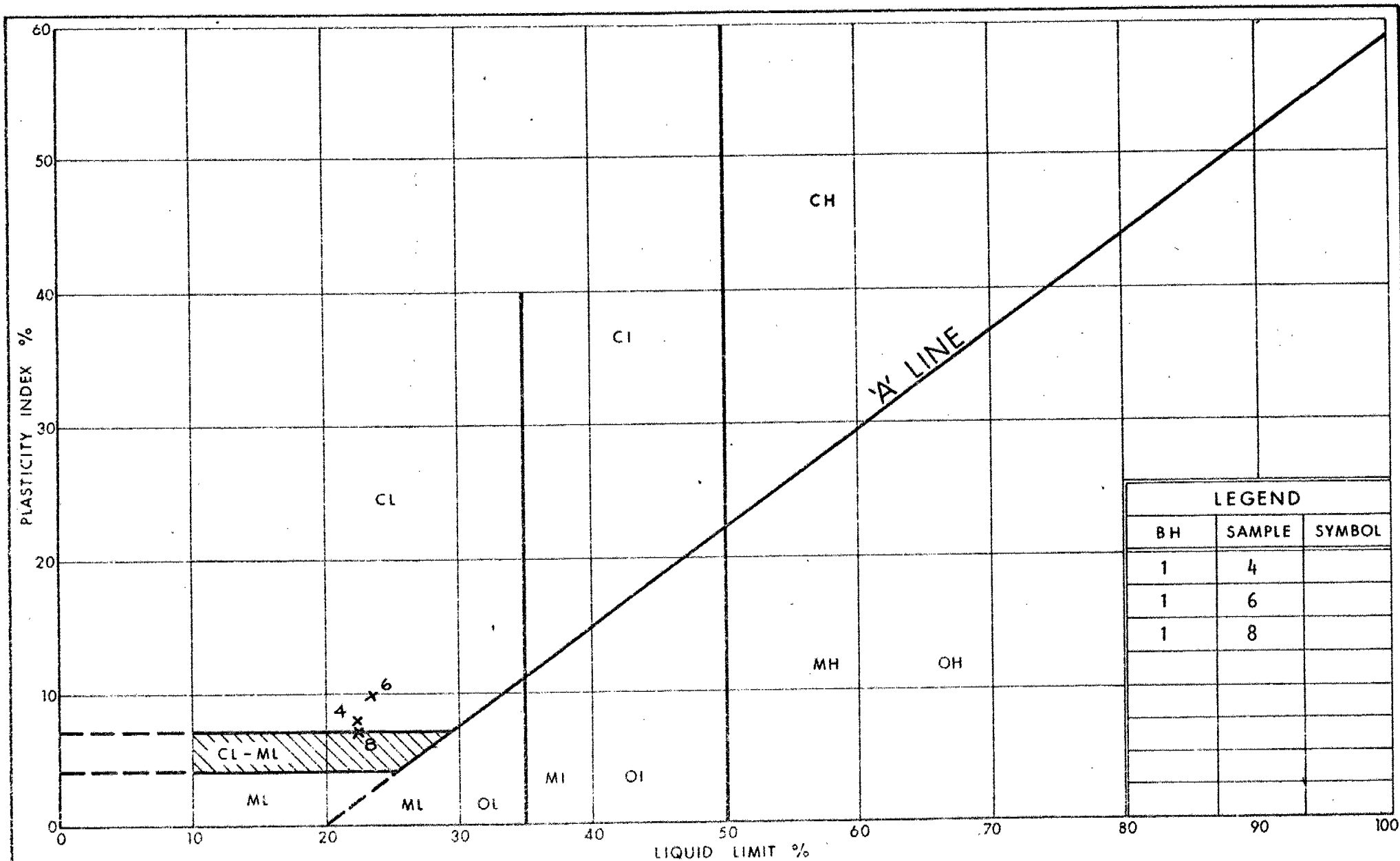


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GRAIN SIZE DISTRIBUTION
SANDY GRAVEL

FIG No 8

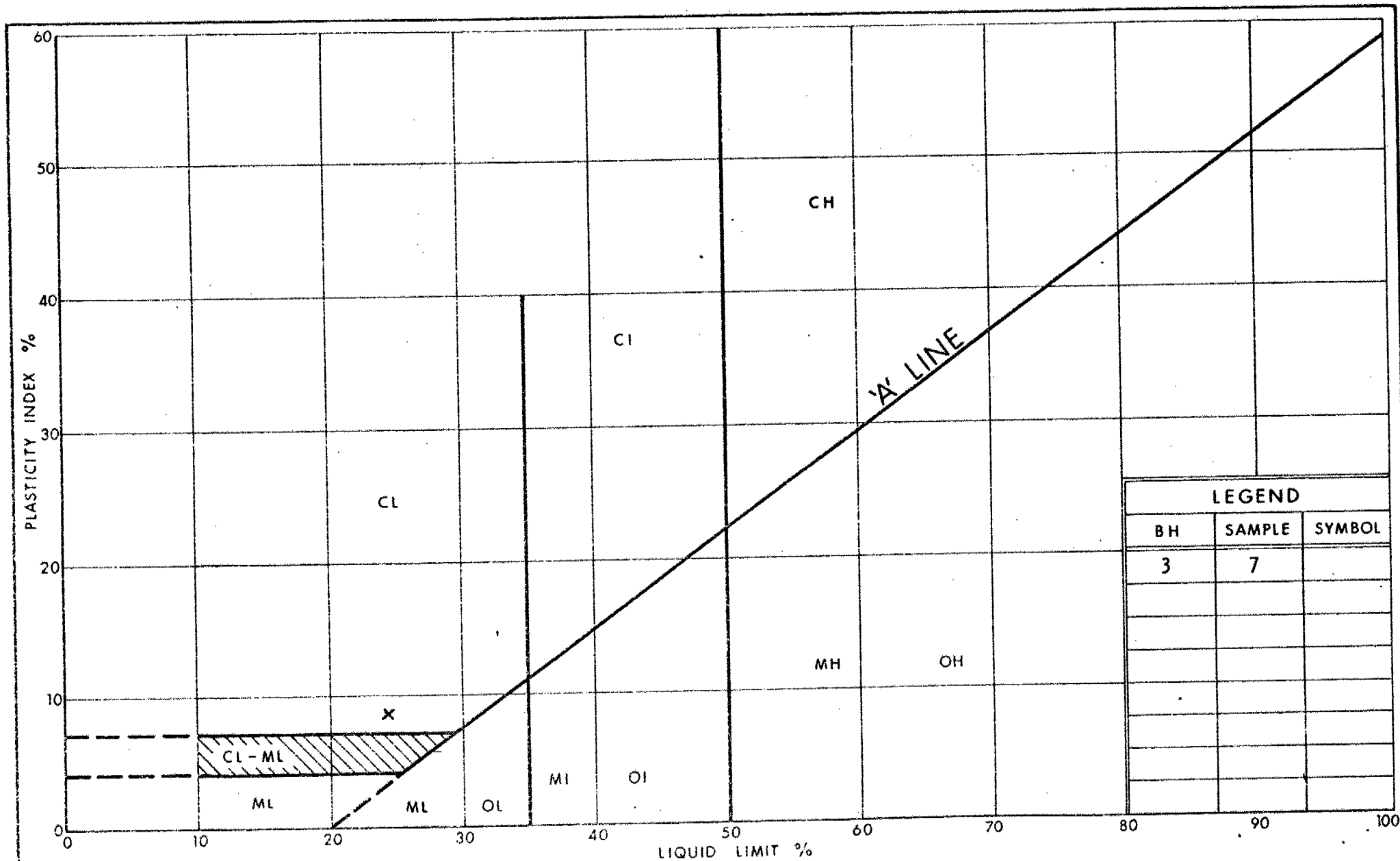
W P 152-75-06



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Communications

PLASTICITY CHART SILTY CLAY (TILL)

FIG No 9
W P 152-75-06



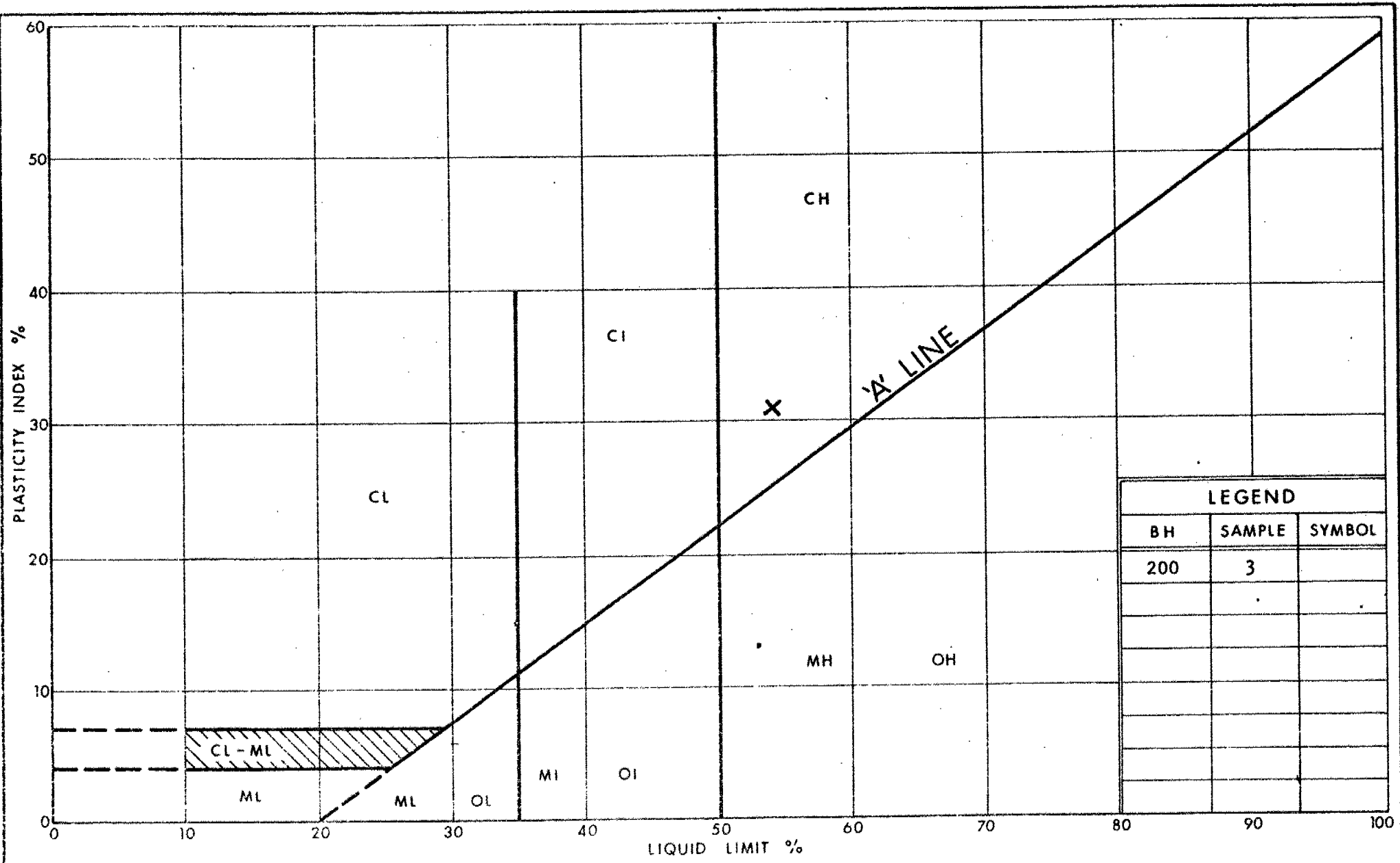
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Communications

PLASTICITY CHART SILTY CLAY (TILL)

FIG No 10

W P 152-75-06



LEGEND		
BH	SAMPLE	SYMBOL
200	3	

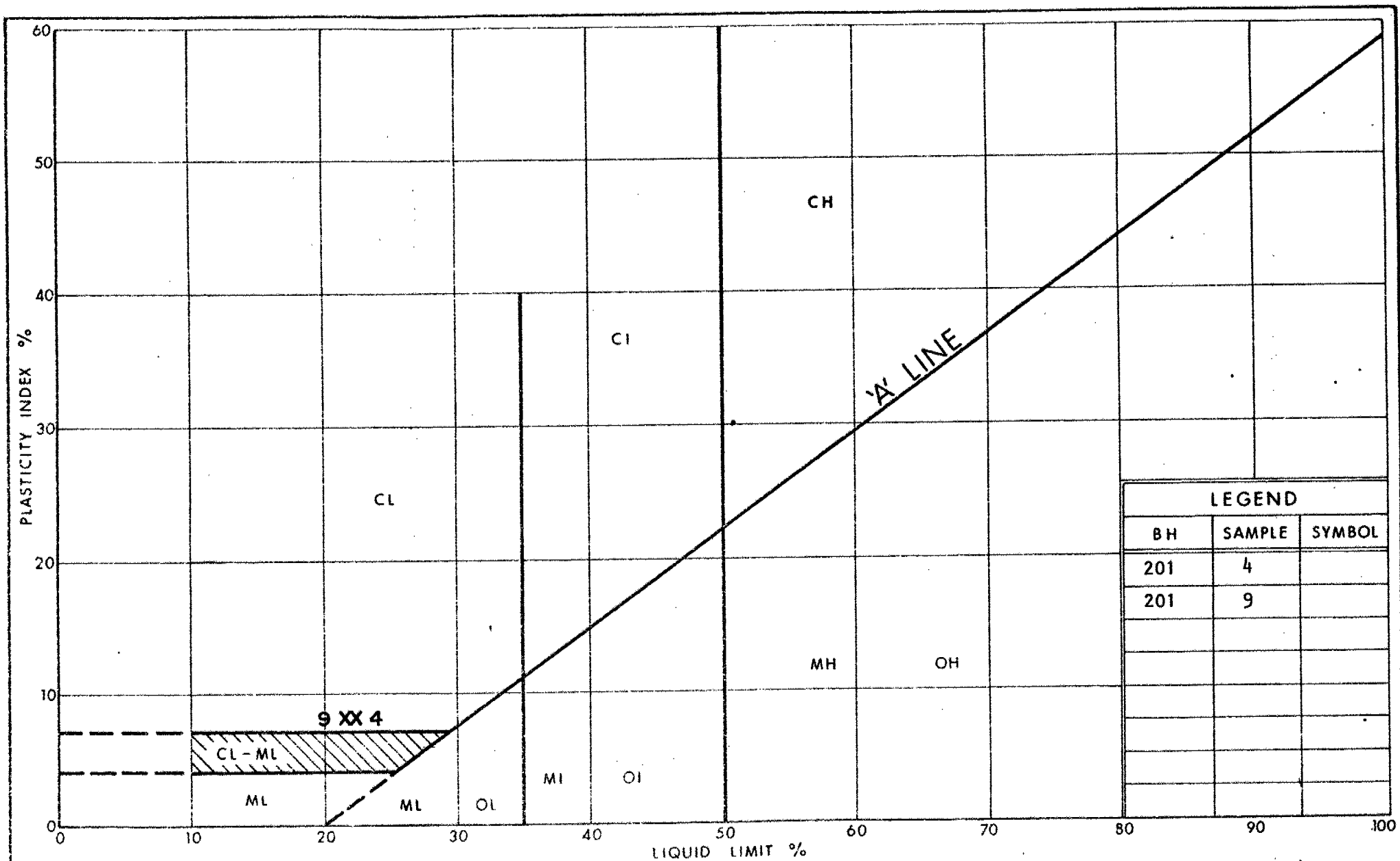


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PLASTICITY CHART SILTY CLAY

FIG No 11

W P 152-75-06



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Transportation and
Communications

PLASTICITY CHART SANDY SILTY CLAY (TILL)

FIG No 12

W P 152-75-06

memorandum

CONT 84-01



To: Mr. G. C. E. Burkhardt,
Head, Structural Section,
Central Region

Date: 81 11 04

From: Pavement & Foundation Design Section

Re: Structures over Red Hill Creek
W. P. 's 152-75-06 and 152-75-07
Site No.'s 36-1336-142 and 36-1336-271
District 4 (Hamilton)

Attached please find your copies of the Foundation Investigation Reports for the above-mentioned projects, prepared by Site Investigation Services Limited. The description of the encountered subsurface conditions appears to be adequate for your purposes. Recommendations pertaining to the design and construction of these structures are contained in Mr. K. G. Selby's memorandum of 81 09 08.

Please contact this office if you require any further information or clarification concerning these projects.



P. Payer,
Foundations Engineer

cc: R. D. Gunter
F. Norman
D. E. Thrasher (2)
K. Bassi
B. J. Giroux
R. Hore

R. Fitzgibbon (cover only)
J. Anderson (cover only)
T. J. Kovich (cover only)

memorandum



To: Mr. F. Chan,
Structural Section,
Central Region

Date: 81 09 08

From: Pavement & Foundation Design Section,
Room 315, Central Building

Re: Structures over Red Hill Creek,
Burlington, Ontario W. P.'s 152-75-06/07
Site Nos. 36-1336-142 and 36-1336-271
District 4 (Hamilton)

We have received a preliminary report from Site Investigation Service Ltd. who have recently completed the fieldwork for the foundation investigation for the above-mentioned project. Based on this report, we are providing you with recommendations pertaining to the design and construction of the widening of the existing bridge over Red Hill Creek and the new bridge to be built over the creek on the future Ramp N-W. A copy of the Consultant's letter, which is dated August 25, 1981, has already been given to you.

Site 36-1336-142

The widened portions of this structure should be supported on 310x110 steel H piles driven to approximate el 59 at which depth design loads of up to 800 kN per pile should be achieved. These piles should be fitted with reinforced tips and pile driving in the field should be controlled in accordance with M. T. C. Standards SS 103-10 and SS 103-11. The new portions of the piers and abutments should be rigidly connected to the existing portions by dowelling. Design loads to be imposed on the existing and new piers in the future should not exceed what is being taken now by the existing piers and abutments since we do not know the details of the installation of the existing piles.

For purposes of the O.H.B.D.C., the following recommendations apply to the 310x110 steel H piles driven as specified above:

Factored Capacity at U. L. S. = 1600 kN per pile
Capacity at S. L. S. Type II = 800 kN per pile

Earth pressures should be computed in accordance with Section 6.6.1.2.2 of the Code. All pile caps should have a minimum cover of 1.3 m for frost protection.

Site 36-1336-271

A new two span structure is proposed for this site. The proposed abutments and pier may be supported either on spread footings or on piled foundations depending on the economics of these two methods. For spread footings, a net design pressure of 400 kPa can be achieved at or below el. 73. For piled foundations 310x110 steel H piles fitted with reinforced tips should achieve a design load of 800 kN per pile if driven to el. 60. Pile driving should be controlled in the field in accordance with M. T. C. Standards SS 103-10 and SS 103-11. Footings and pile caps should have a minimum cover of 1.3 m for frost protection. For purposes of the O.H.B.D.C., the following values are recommended:

310x110 steel H piles driven as specified above

Factored capacity at U. L. S. = 1600 kN per pile
Capacity at S. L. S. Type II = 800 kN per pile

Spread footings at el. 73.0 or lower

Factored bearing capacity at U. L. S. = 600 kPa
Capacity at S. L. S. Type II = 400 kPa

Earth pressures should be computed in accordance with Section 6.6.1.2.2 of the Code.


for K. G. Selby,
Senior Foundations Engineer

cc: W. Lin

MINISTRY OF TRANSPORTATION & COMMUNICATIONS

1201 WILSON AVENUE

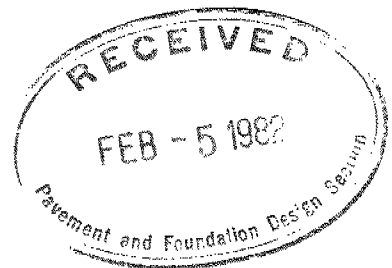
DOWNSVIEW, ONTARIO

REPORT ON SOIL CONDITIONS
STRUCTURE OVER REDHILL CREEK

SITE 36-1336-142

W.P. 152-75-06

PREPARED BY:
SITE INVESTIGATION SERVICES LIMITED
677 CROWN DRIVE
PETERBOROUGH, ONTARIO
K9J 6W2
(705) 743-6850



JOB #2573

OCTOBER, 1981

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STRUCTURE OVER REDHILL CREEK - SITE 36-1336-142

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STRUCTURE OVER REDHILL CREEK - SITE 36-1336-142

1.0 INTRODUCTION

An evaluation of soil conditions has been completed in Hamilton, Ontario where the proposed Beach Strip Arterial Road crosses Redhill Creek. This report describes the site conditions and discusses some considerations for the design of the structure foundations and approaches. A more general summary of soil conditions and design considerations was submitted to Mr. K. Selby, P. Eng. in a letter dated August 25, 1981. The study was completed under the terms of agreement No. 4242-9081-45.

The northerly part of the structure area is underlain by relatively deep deposits of fill and organic soils. Consequently the structure will have to be supported by piles. Alternative types of pile support are considered in the report. These include the possible use of piles below an existing bridge structure that extends below a substantial part of the new structure.

Recommendations and discussions included in this report are provided for the guidance of the structural design engineers for preparing design drawings and cost estimates. In no case should they be construed as specific instructions for contractors. Interpretations of soil profiles have been completed for similar reasons. While these interpretations are believed to be a good representation of soil conditions, some irregularities should be expected. Tender documents and project cost allowances should allow for such irregularities and actual soil strata limits should be confirmed by observations during construction.

2.0 FIELD WORK

Four boreholes were drilled at the site to evaluate soil conditions. The locations of borings and a general soil profile are shown on Fig. No. 1 (Contract Dwg. 1527506-A). More detailed soil profile and field test data summaries are provided on the attached Records of Boreholes.

Boreholes 1 and 3 were completed in March 1981 using a raft mounted diamond drill and wash boring procedures. These two borings are part of a series of borings for an alternative structure located west of the currently proposed structure. Boreholes #200 and #201 were completed on August 12 to 18, 1981 using a truck-mounted CME 75 power drill equipped with 82 mm internal diameter hollow stem augers.

STRUCTURE OVER REDHILL CREEK - SITE 36-1336-142

2.0 FIELD WORK (cont.)

Soil samples were obtained with 50 mm "split spoon" samplers driven using standard penetration test procedures. Additional indication of soil variability and density were obtained by driving 50 mm dynamic cone probes with the hammer energy similar to that used for the standard penetration test (63.5 kg hammer falling 760 mm).

3.0 SOIL CONDITIONS3.1 General

The site area outside the limits of the creek channel is underlain by fill, generally consisting of sand and gravel, that extends roughly to the streambed level. In the south abutment area at borehole #201 the fill is underlain directly by layered gravelly sand while at the north abutment area, at borehole #200 the layered inorganic sand stratum is separated from the fill by 4.4 m of interbedded silt and organic silt soils. Deep deposits of partly organic sediments also exist at borehole #3.

The layered sand and gravelly sand soils are underlain by till-textured soils consisting of silty clay that contains a trace to some sand and gravel. In the south abutment area the boundary between the gravelly sand stratum and the till-textured soils occurs near elevation 72 m or roughly 5 m below the existing road grade. In the north abutment area the transition occurs about 13 m below road grade.

All boreholes were terminated in the till-textured silty clay soils between elevation 57.95 m and elevation 56.58 m.

3.2 Fill

Fill encountered behind existing abutments and retaining walls consists primarily of relatively clean gravelly sand and sandy gravel. There are occasional silty lenses.

Standard penetration resistances of 12 to 48 blows per 0.3 m are indicative of compact to dense soil.

STRUCTURE OVER REDHILL CREEK - SITE 36-1336-142

3.0 SOIL CONDITIONS (cont.)3.3 Partly Organic Sediments

Soils immediately below creek bed level at boreholes #1, #3 and #200 consist of relatively soft or loose layered sediments ranging from sand to peat. At boreholes #3 and #200 (north abutment area) these sediments are 4.23 to 4.96 m thick while at the south abutment at borehole #1 these sediments are only 1.23 meters thick. No organic sediments were noted at borehole #201.

The proportion of organic sediments in this stratum is less than 40 percent and most of that can be classified as slightly to moderately organic. Highly organic very compressible silt or peat layers are rare and thin.

Penetration resistances of 3 to 6 blows per 0.3 m in this zone indicate loose and soft soils.

3.4 Sand Stratum

A northward dipping stratum of layered sand and gravelly sand, encountered in boreholes #3, #200 and #201, consists primarily of relatively clean fine to coarse sand and gravelly sand. There are some silty seams, however, and a 2.4 m thick silty seam at borehole #3 is a till-textured mixture of gravel, sand and silt. Particle sizes of typical soils from the sand stratum are provided on Figures 4, 5, 6 and 8.

Penetration resistances of 12 to 32 blows per 0.3 m in the sand indicate compact to dense soil. A low resistance of 3 blows per 0.3 m in the upper part of the stratum at borehole #3 is attributed to disturbance during sampling and a resistance in excess of 100 blows per 0.3 m is attributed to the influence of coarse gravel particles.

3.5 Silty Clay (Glacial till)

All borings penetrated the till-textured silty clay stratum that is classified as very stiff to hard on the basis of standard penetration resistances of 11 to more than 100 blows per 0.3 m. Generally the hardness increases with depth and all borings were terminated in extremely hard soil in which penetration resistances exceeded 100 blows per 0.3 m.

STRUCTURE OVER REDHILL CREEK - SITE 36-1336-142

3.0 SOIL CONDITIONS (cont.)

Occasional thin sand and gravel seams were encountered within the till-textured silty clay soils.

The silty clay has a low plasticity, with liquid limits of less than 25 percent, and generally contains a trace to some sand and gravel. Particle analyses on typical soils from this stratum are summarized on Figures 2, 3 and 7.

3.6 Groundwater

Groundwater levels were at or close to the water level of the adjacent creek and bay at the time of drilling. A similar close relationship is expected to prevail as water levels in the creek and bay fluctuate. There was no evidence of artesian conditions in any of the boreholes.

STRUCTURE OVER REDHILL CREEK - SITE 36-1336-142

4.0 DESIGN AND CONSTRUCTION CONSIDERATIONS4.1 General

The proposed structure crosses Redhill Creek at an angle and the total bridge length exceeds 50 meters. The new three span structure overlaps a significant portion of an existing three span structure and the retaining walls adjacent to that structure.

It is our understanding that an attempt will be made to incorporate as much of the existing structure foundation as possible into the new structure. Available records indicate that all of the existing bridge and retaining walls are supported on steel H-piles. Comments related to incorporating the existing foundations in the new structure are included in this section of the report. The driving of new piles and the possible use of spread footings for part of the structure are also discussed.

4.2 Use of Existing Foundations

Contract drawings for the existing structure indicate that the bridge abutment and piers are founded on 310 X 79 steel H-piles with a design capacity of 450 kN and that the retaining walls are supported on 200 X 54 steel H-piles with a design capacity of 270 kN per pile.

The existing structures have performed well and should continue to do so provided that new loads do not exceed significantly the existing actual loads. The feasibility of increasing the loads on existing piles would require a thorough analysis of pile driving and load test records. Subsoil conditions are relatively good and it may be feasible to increase the loads. In the absence of appropriate data and analyses the loads applied to the piles by the existing structures should be assumed for the serviceability state Type II design. An ultimate limit state load of 2.0 times the serviceability state limit load could be assumed for preliminary design purposes.

4.0 DESIGN AND CONSTRUCTION CONSIDERATIONS (cont.)

The existing piles have already settled under load and little or no added settlement is expected when the load from the new structure is applied. This will create a differential settlement condition where existing piled sections abut newly piled sections. Reinforcing or joint arrangements should make allowance for differential movements of up to 15 mm. The differential settlement condition will also effect sections where new piles are added to supplement existing piles. The old piles will attract higher than normal loadings and the new piles may not develop their full load carrying capacity. This will create some short term stresses in the concrete that will differ from the normal condition.

4.3 New Piles

New piles required can consist of driven steel H-piles provided that the pile tips are reinforced to prevent damage on cobbles and to increase the effective end area.

Piles driven to refusal on the very hard soils below elevation 60 meters, approximately, are expected to develop full capacities in combined end bearing and adhesion. For design based on Ontario Highway Bridge Design Code criteria the following capacities can be assumed for 310 X 110 steel H-piles:

Factored capacity at Ultimate Limit State	1600 kN per pile
Capacity at Serviceability Limit State, Type II	800 kN per pile

Settlements for the Serviceability State conditions should be well within the 25 mm limit.

Silty clay till soils above elevation 60 meters are very stiff to hard and assistance such as pre-augering may be required to achieve full penetration of piles to or near elevation 60 meters. Full allowable capacities might be achieved for piles that meet refusal above elevation 60 meters but field load tests would be required for confirmation.

STRUCTURE OVER REDHILL CREEK - SITE 36-1336-142

4.0 DESIGN AND CONSTRUCTION CONSIDERATIONS (cont.)4.4 Footings

Very stiff to hard silty clay till extends close to streambed level at boreholes #1 and #201. Theoretically conventional footings could be placed on the till. We recommend, however, that pile support be maintained for all abutment and pier extensions.

4.5 Abutments and Wingwalls

All existing fill and organic sediments within 3 meters of the abutments should be removed and the end of the excavation should be tapered at 5:1 or flatter. All replacement fill and backfill adjacent to the walls should consist of clean free-draining sand and gravel (MTC granular 'B'). The fill should be compacted in 300 mm maximum lifts to 100 percent of standard proctor density (ASTM D 698 standard). Compaction equipment should be restricted to hand operated tampers and rollers. Large self-propelled rollers can create high lateral pressures through wedging effects.

Earth pressures for abutments and retaining walls should be computed in accordance with section 6.6.1.2.2 of the Ontario Highway Bridge Design Code. All pile caps should have a minimum of 1.3 meters of earth cover for frost protection.

4.6 Existing Hydro Tower

Foundations for the extended south abutment may encroach on the foundation of the existing hydro tower located near the south west corner of the new footing. Details of the tower foundation should be fully evaluated to ensure that no detrimental interference occurs.

4.7 Approach Fills

The road grade will be increased by about one meter relative to existing grades. The added fill load will cause some settlement to occur north of the bridge where the existing fill is underlain by several meters of looser partly organic soil. Where more compressible organic pockets exist the settlements could exceed 100 mm.

STRUCTURE OVER REDHILL CREEK - SITE 36-1336-142

4.0 DESIGN AND CONSTRUCTION CONSIDERATIONS (cont.)

General embankment stability will not be affected appreciably by the small increase in fill height. However, the added fill will increase lateral loads on existing retaining walls by the ratio of the square of the new fill depth over the square of the existing fill depth.

4.8 Scour Protection

We understand that the existing bridge has a concrete base that extends across the entire channel width. This base should be extended below the new structure to prevent erosion from occurring at a transition within the structure area. Alternative forms of protection such as a riprap covered channel might be considered.

Submitted by:

SITE INVESTIGATION SERVICES LIMITED



R. Marttila, P. Eng.

RM/lp

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

Fine

Medium

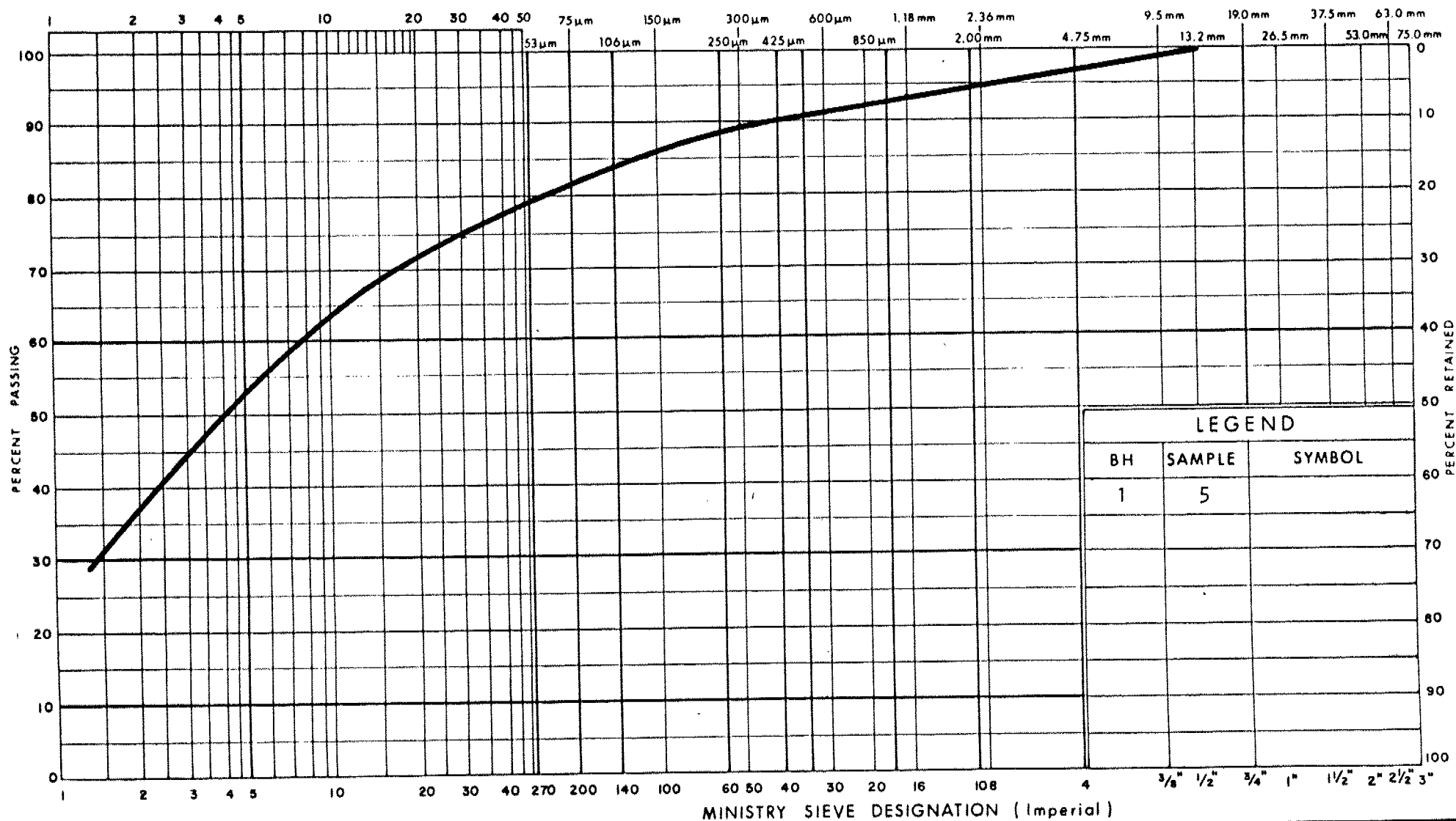
Coarse

Fine

Coarse

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)



LEGEND

BH	SAMPLE	SYMBOL
1	5	

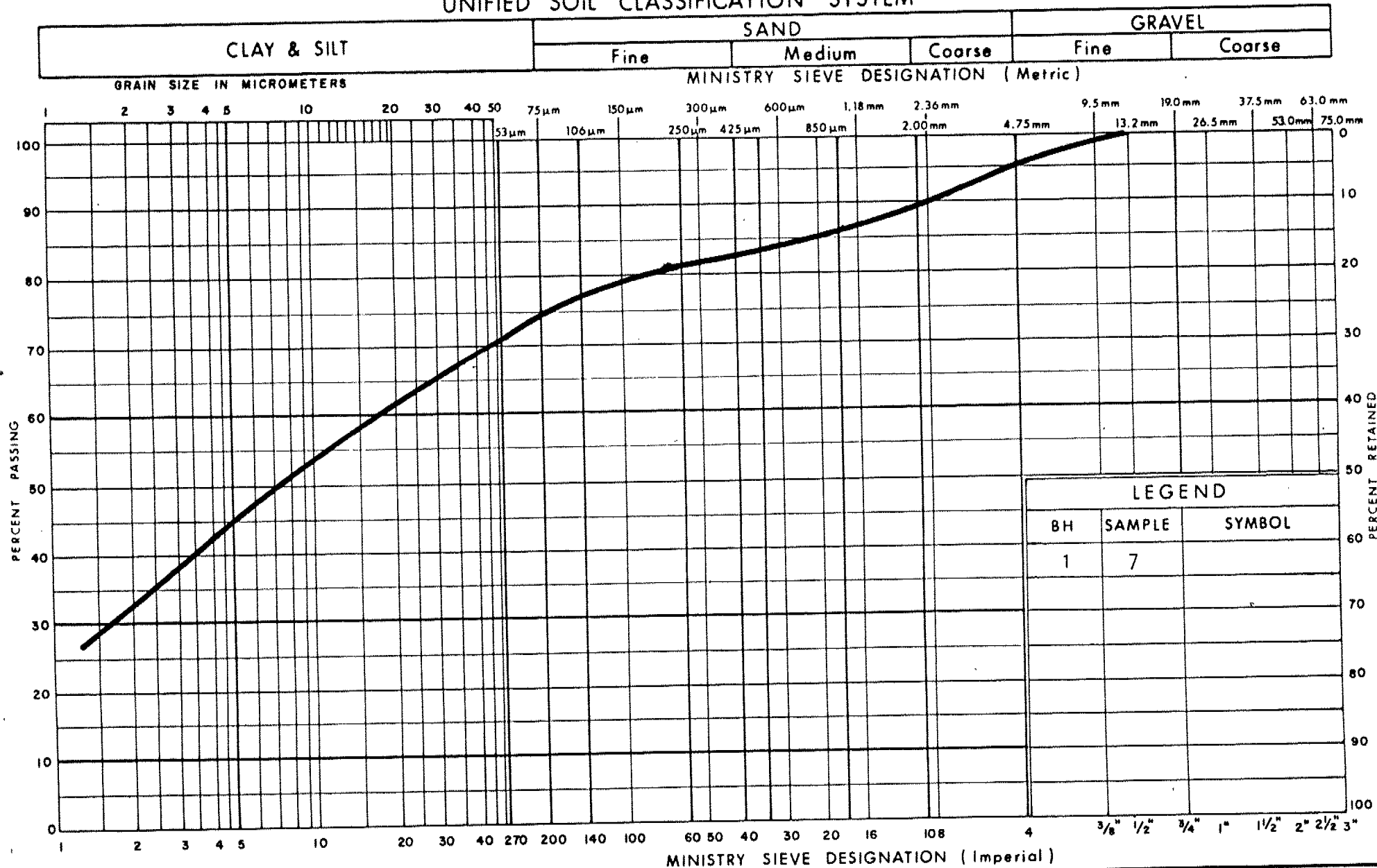
GRAIN SIZE DISTRIBUTION
SILTY CLAY (TILL)

FIG No 21
W P 152-75-104



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UNIFIED SOIL CLASSIFICATION SYSTEM



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Communications

GRAIN SIZE DISTRIBUTION
SANDY SILTY CLAY (TILL)

FIG No 32

W P 152-75-104 06

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

GRAIN SIZE IN MICROMETERS

Fine

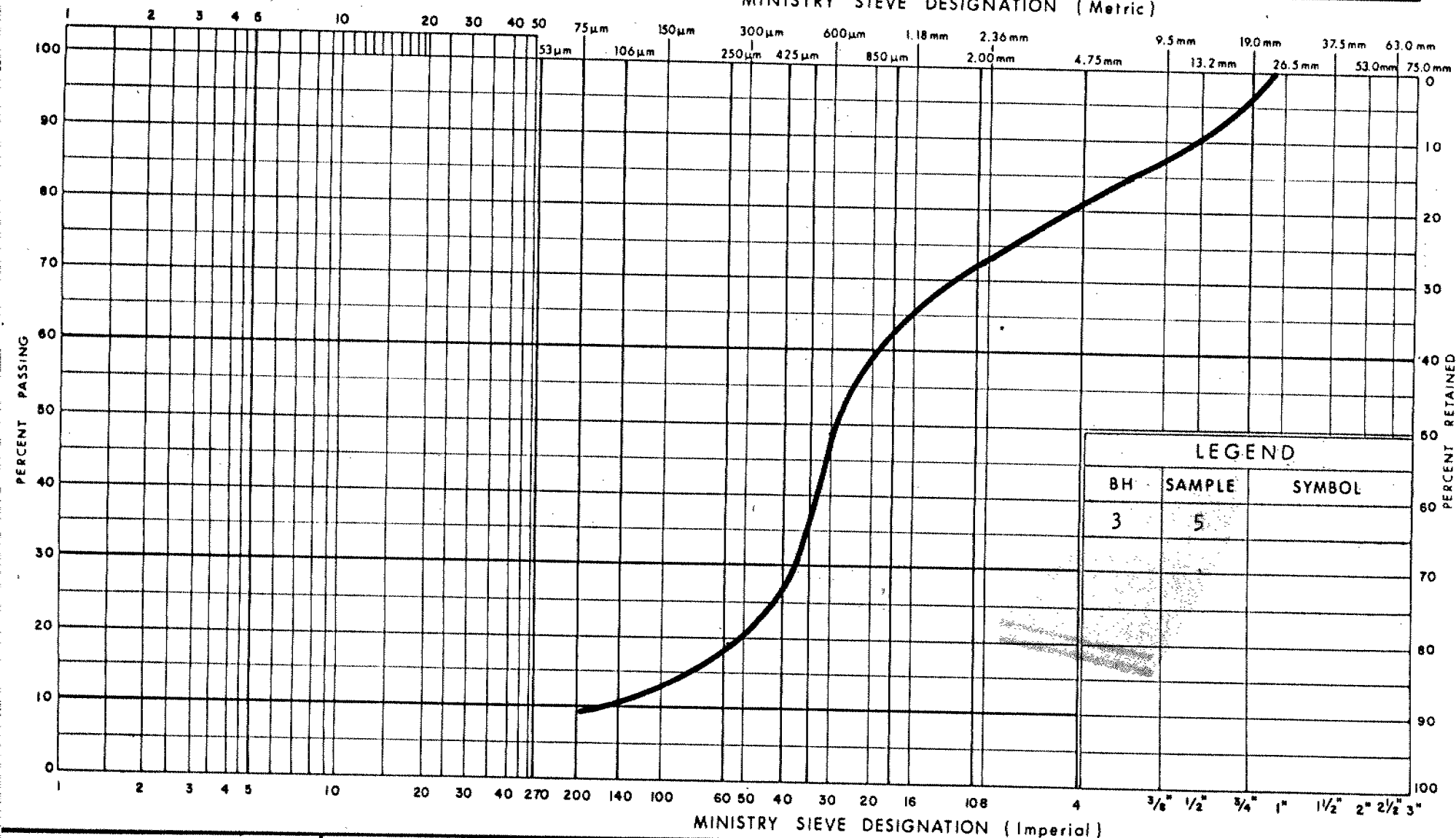
Medium

Coarse

Fine

Coarse

MINISTRY SIEVE DESIGNATION (Metric)



GRAIN SIZE DISTRIBUTION

GRAVELLY SAND

FIG No

43

W P

152-75-104 06



Ministry of
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UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

Fine

Medium

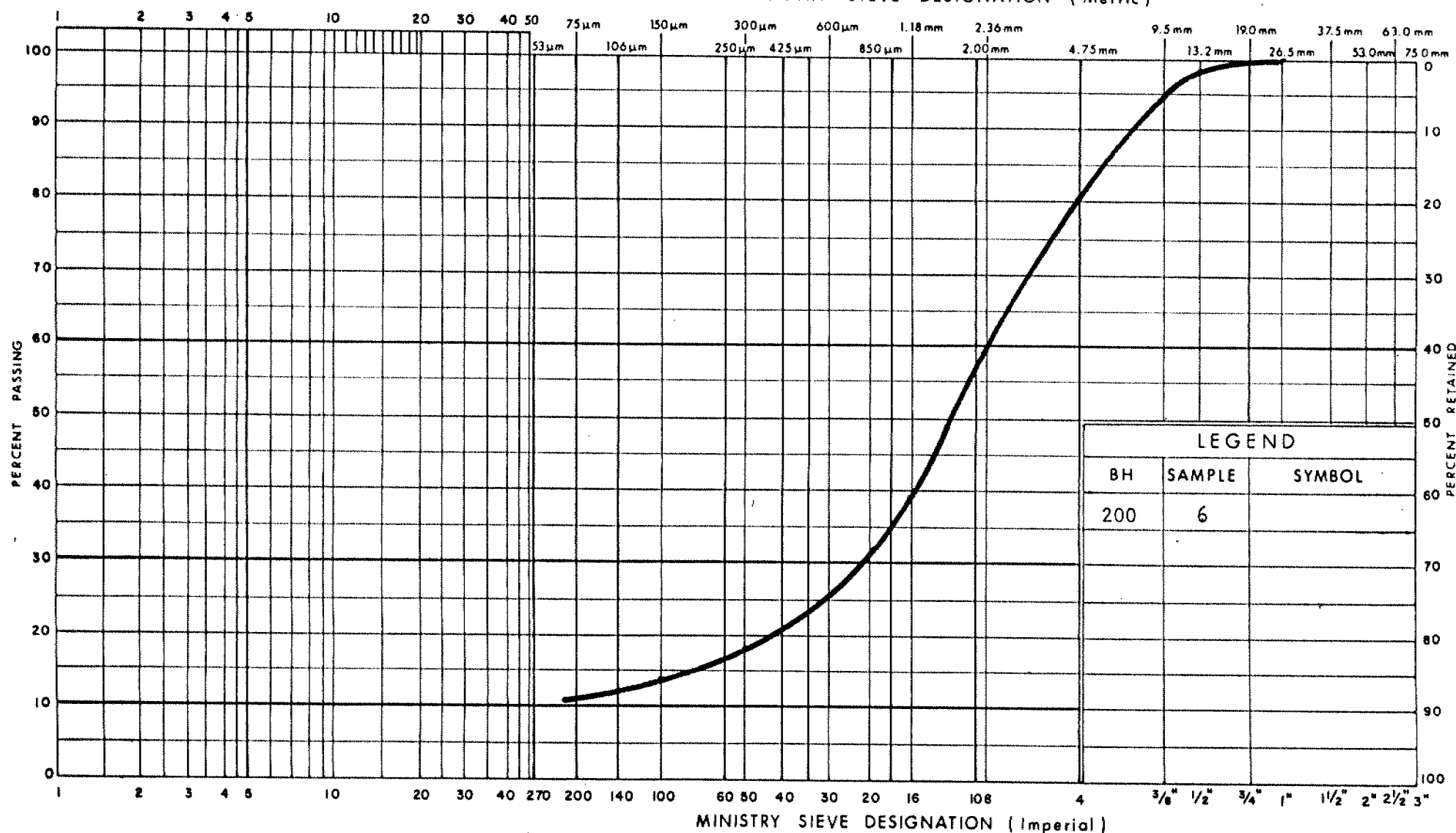
Coarse

Fine

Coarse

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)



Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
SAND (Some Gravel)

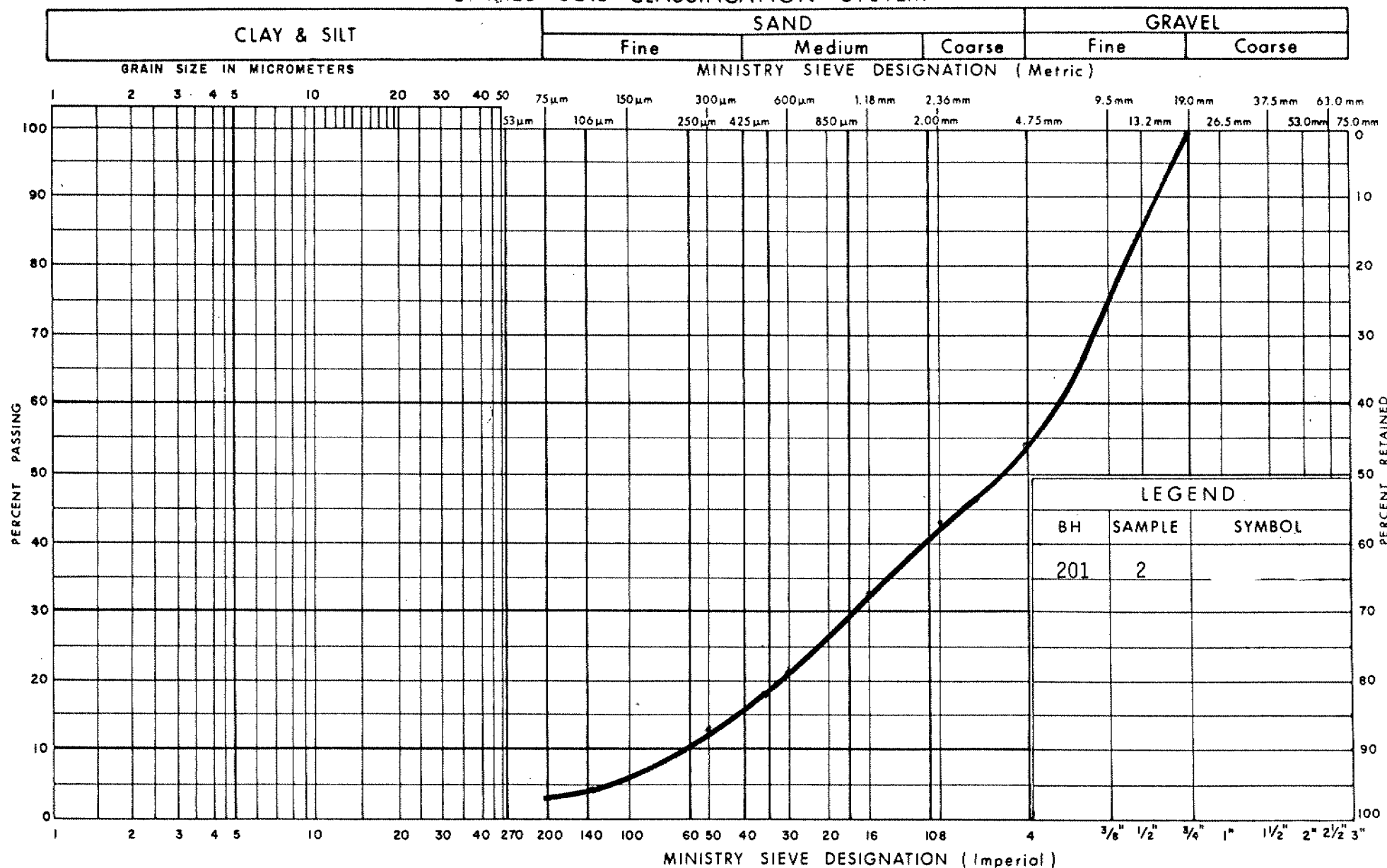
FIG No

54

W P

152-75-10406

UNIFIED SOIL CLASSIFICATION SYSTEM

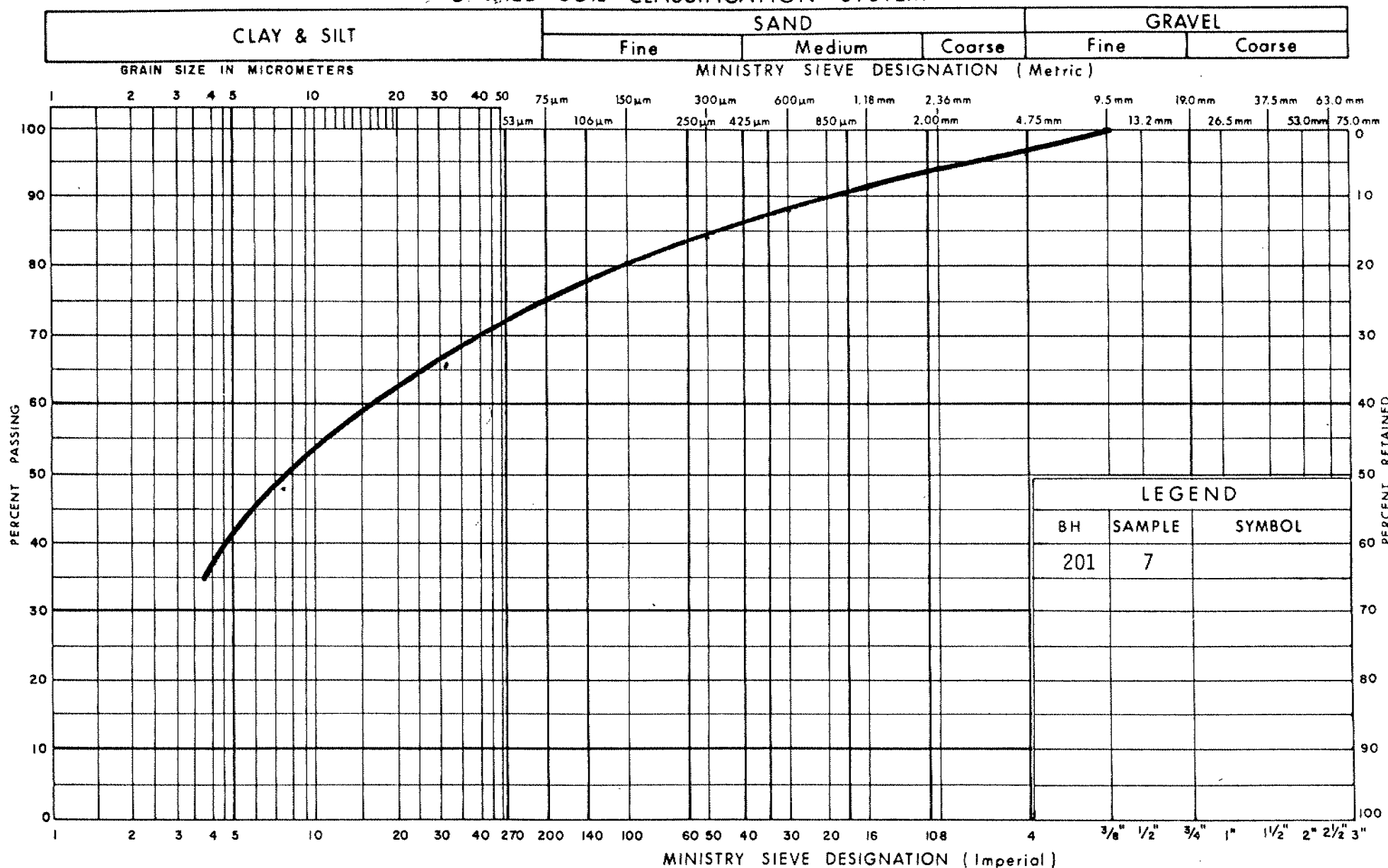


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Transportation and
Communications

GRAIN SIZE DISTRIBUTION
SANDY GRAVEL

FIG No 65
W P 152-75-10406

UNIFIED SOIL CLASSIFICATION SYSTEM

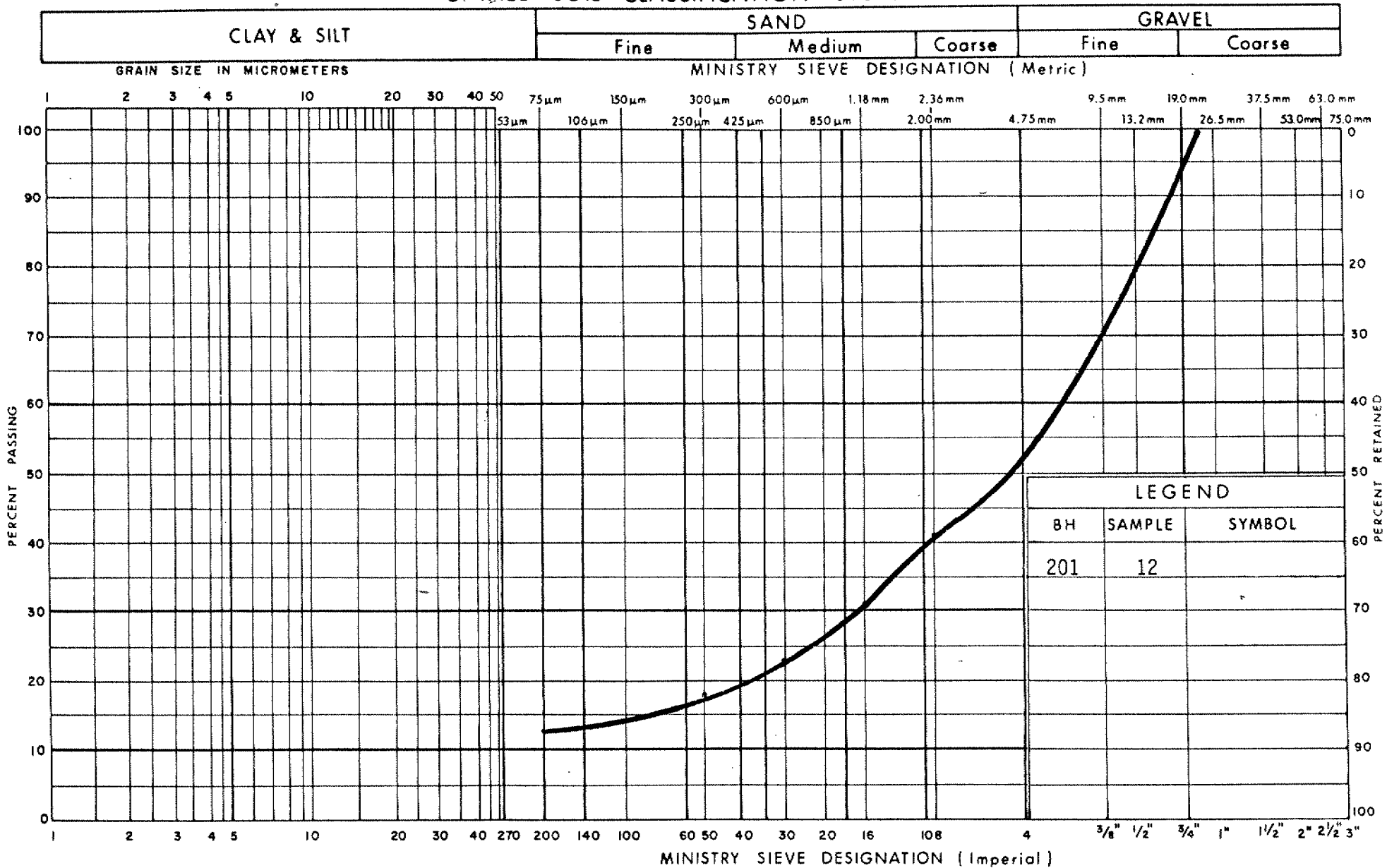


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Communications

GRAIN SIZE DISTRIBUTION
SANDY SILTY CLAY (TILL)

FIG No 76
W P 152-75-10406

UNIFIED SOIL CLASSIFICATION SYSTEM

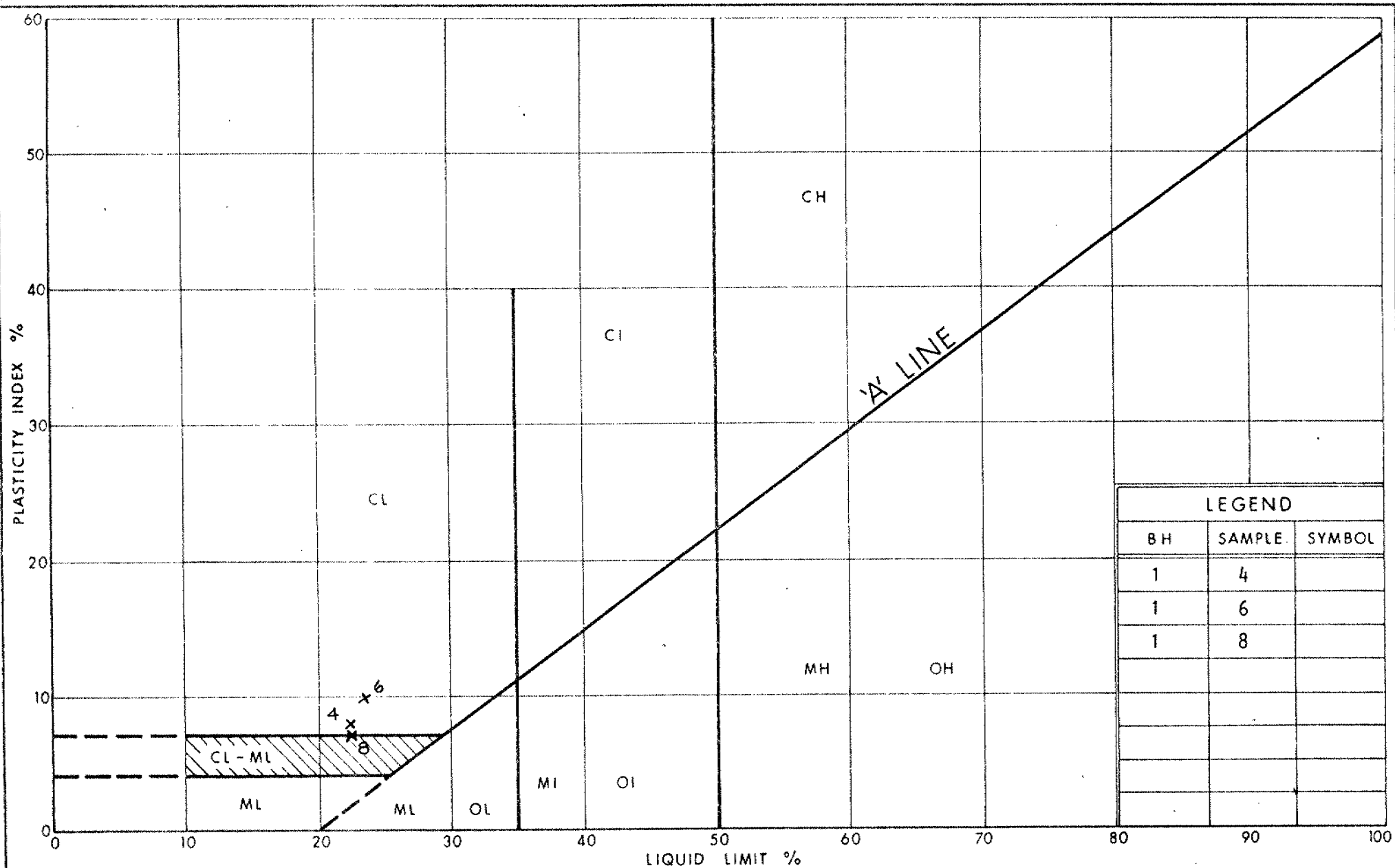


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 GRAIN SIZE DISTRIBUTION
SANDY GRAVEL

 FIG No 87
W P 152-75-10406

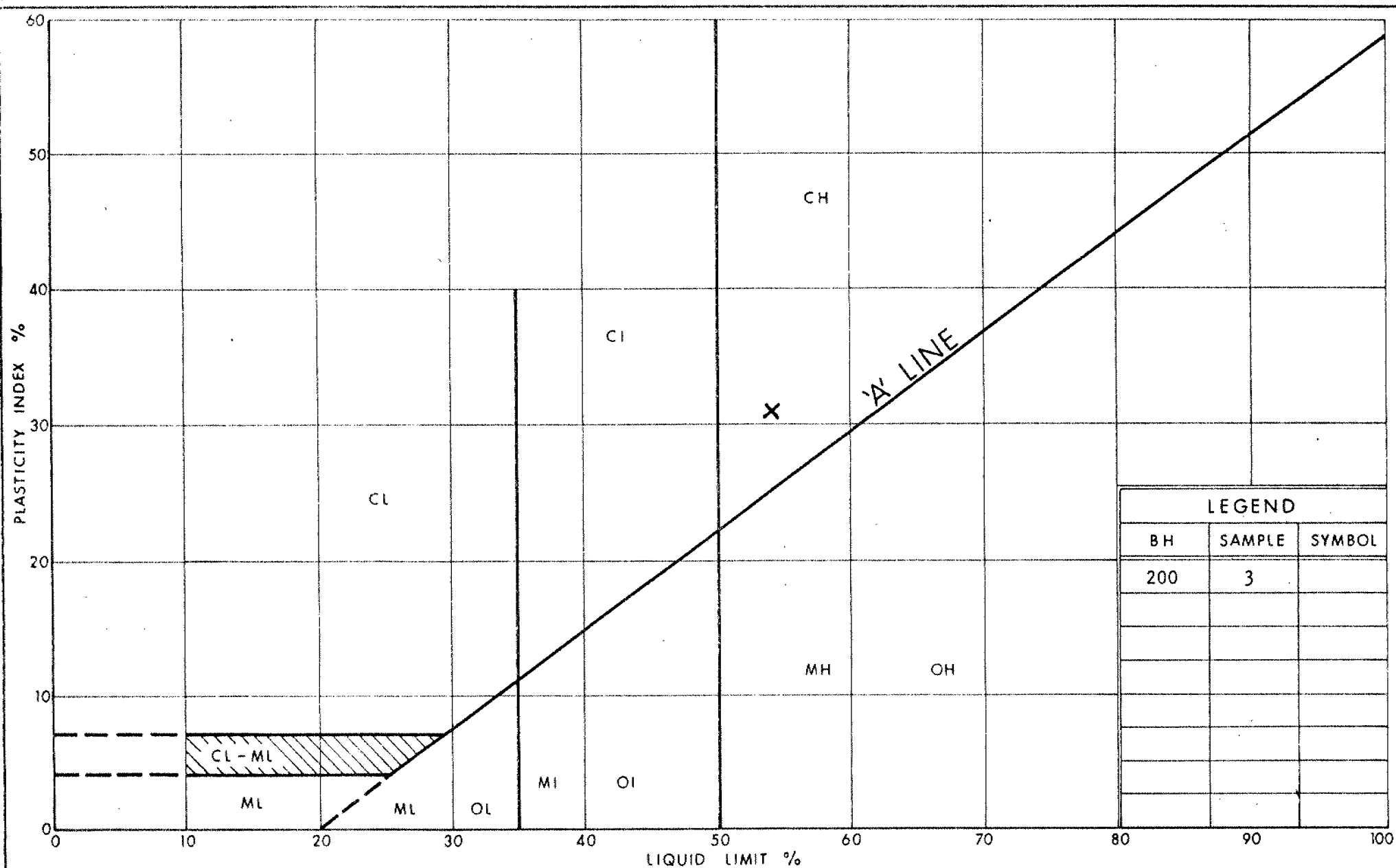


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Communications

PLASTICITY CHART SILTY CLAY (TILL)

FIG No 93

W P 152-75-10406

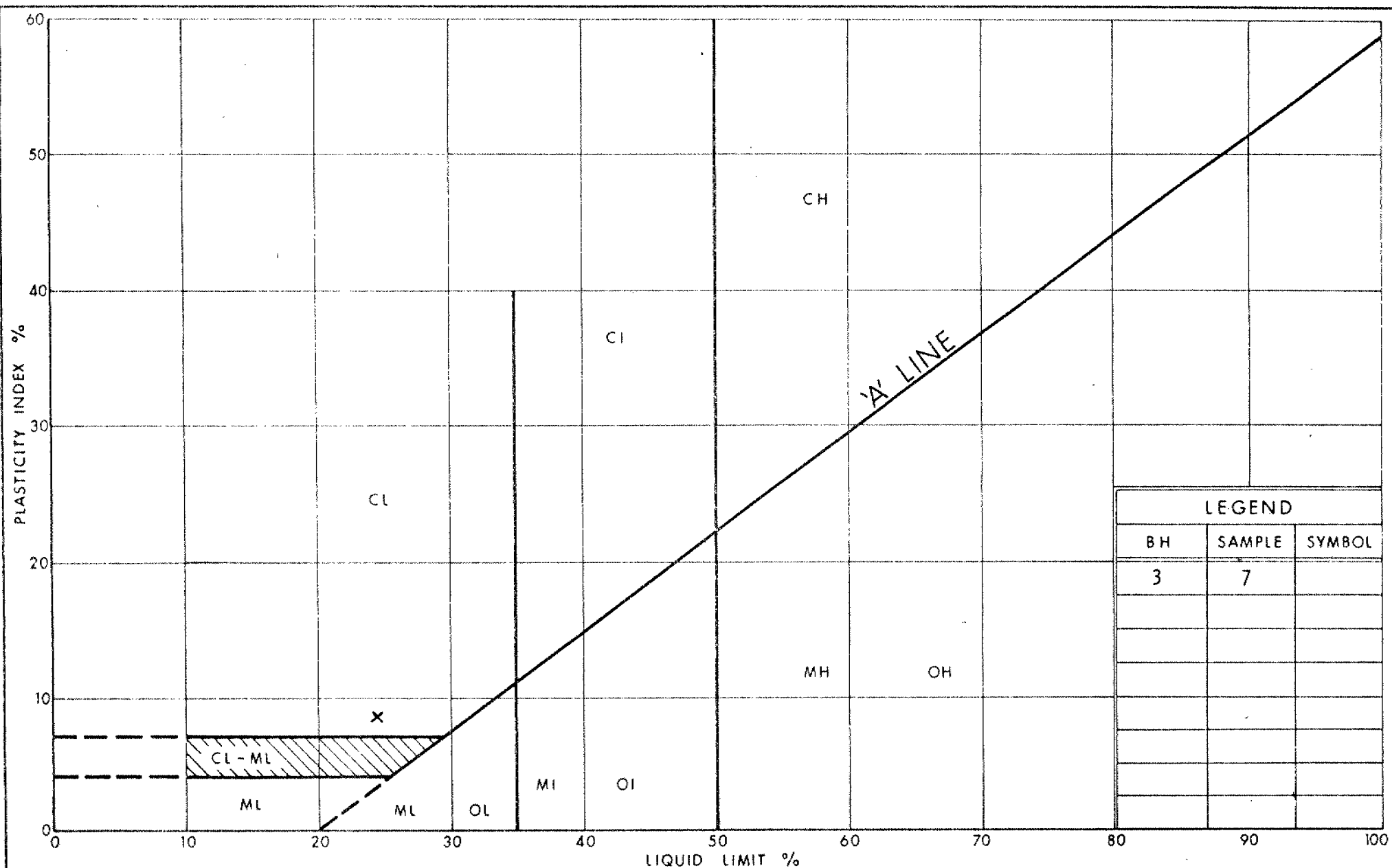


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Communications

PLASTICITY CHART SILTY CLAY

 FIG No 1110
 W P 152-75-10406

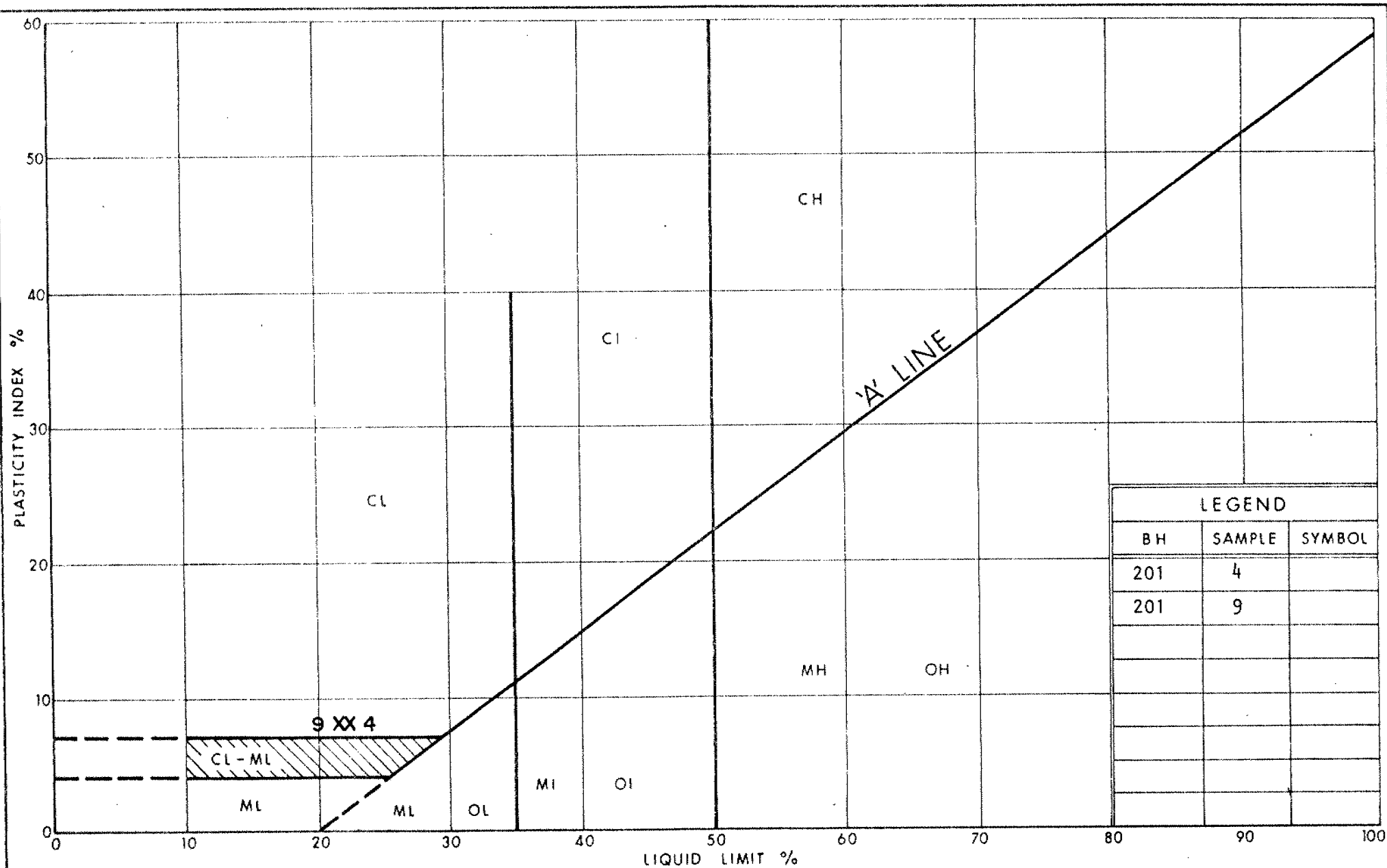


Ontario

Ministry of
Transportation and
Communications

PLASTICITY CHART SILTY CLAY (TILL)

FIG No 109
W P 152-75-10406



Ministry of
Transportation and
Communications

PLASTICITY CHART SANDY SILTY CLAY (TILL)

FIG No 1271

W P 152-75-10406

RECORD OF BOREHOLE No 1

METRIC

W P 152-75-06 LOCATION Co-ords, 4,791,260 N; 282,609 E. ORIGINATED BY P.S.
DIST 4 HWY Q.E.W. BOREHOLE TYPE Washboring, NX Casing COMPILED BY D.N.
DATUM Geodetic DATE 1981-03-26 to 1981-03-27 CHECKED BY R.E.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
74.688	Water Level																
0.0	Water						74										
73.91							73										
.770	Organic sandy silt. Some peaty material. Soft Black		1	SS	3												
72.68							72										
2.00	Silty clay, some sand trace of gravel. Trace of root fibres above 3.5 M (glacial till). Low plasticity Stiff to hard Brown		2	SS	9		71										
			3	SS	65		70										
69.18							69										
5.50	Silty clay, some sand trace of gravel (glacial till). Very stiff to hard. Light grey		4	SS	35		68										
			5	SS	32		67										
66.48							66										
8.20	Silty clay, some sand trace to some gravel (glacial till)		6	SS	41		65										
	Hard		7	SS	39		64										
	Dark grey						63										
	Reddish brown below 11.5 M		8	SS	47		62										
			9	SS	80		61										
			10	SS	110+		60										
							59										
	Some cobbles and boulders below 16.5 m			RC			58										
			11	BX	14%		57										
56.58							56										
18.10	End of Borehole																

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3

METRIC

W P 152-75-06 LOCATION Co-ords. 4,791,303 N; 282,603 E. ORIGINATED BY P.S.
DIST 4 HWY Q.E.W. BOREHOLE TYPE Washboring, NX Casing COMPILED BY D.N.
DATUM Geodetic DATE 1981-03-30 to 1981-03-31 CHECKED BY R.E.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
74.688	Water Level																
0.0	Water																
73.91																	
.770	Organic silty sand.		1	SS	3												
72.88	Loose Black																
1.80	Sand, fine to medium.		2	SS	5												
	Loose																
	Dark grey		3	SS	4												
70.28	Organic silt. Fibrous																
69.66	Soft Dark grey																
5.00	Fine sand, traces of gravel.		4	SS	3												
68.18	Loose Dark grey																
6.50	Gravelly sand, medium to coarse. Layered.		5	SS	30												
67.08	Dense Grey																
7.60	Silty sand, some gravel (Glacial till) Very dense		6	SS	100/												
64.68	Grey																
10.00	Silty clay, some sand trace of gravel. (Glacial till)		7	SS	19												
	Very stiff to hard		8	SS	32												
	Reddish to grey		9	SS	127												
			10	SS	100/												
	Bouldery below 17 M		11	SS	100/												
			12	SS	100/												
56.58																	
18.10	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 200

METRIC

W P 152-75-06 LOCATION Co-ords. 4,791,288 N; 282,641 E. ORIGINATED BY D.B.
DIST 4 HWY Q.E.W. BOREHOLE TYPE 82mm Hollow Stem Auger & Cone Test COMPILED BY D.B.
DATUM Geodetic DATE 1981-08-17 to 1981-08-18 CHECKED BY R.E.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
76.70	Ground Level													
0.0	Fill - Gravelly sand to sandy gravel, traces of silt. Compact to dense. Grey		1	SS	42									
73.13			2	SS	12									
3.57	Layers of silty clay to organic silt. Firm to stiff. Brown to dark grey.		3	SS	6									
69.69			4	SS	11									
7.01	Sand with organic silt seams. Loose		5	SS	4									
68.17			6	SS	32									
8.53	Sand, medium to coarse. Trace of silty and gravel. Dense. Brown to grey.		7	SS	---									
63.90			8	SS	30									
12.80	Silty clay, traces of sand and gravel. Low plasticity. (Glacial Till) Very stiff to hard. Reddish grey to grey.		9	SS	29									
			10	SS	78									
57.95			11	SS	69/15m									
18.75	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

+3, x⁵: Numbers refer to Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 201

METRIC

W P 152-75-06 LOCATION Co-ords. 4,791,198 N; 282,654 E. ORIGINATED BY P.S.
DIST 4 HWY Q.E.W. BOREHOLE TYPE 82mm Hollow Stem Auger COMPILED BY D.W.N.
DATUM Geodetic DATE 1981-08-12 to 1981-08-13 CHECKED BY R.E.M.

SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	'N' VALUES					
76.41	Ground Level											
0.0	Fill - mixture of silt, sand and gravel.											
75.19	Brown - grey.											
1.22	Fill - Gravel.		1	SS	48							
73.67	Dense. Brown-grey.											
2.74	Gravelly sand		2	SS	12							44 52 4 0
72.14	Compact. Grey.											
4.27	Silty clay Some sand and gravel (Glacial Till)		3	SS	22							
	Reddish below 6.09m.		4	SS	11							
	Very stiff above 9m depth.		5	SS	11							
	Hard below 9m depth.		6	SS	26							3 24 33 40
			7	SS	27							
			8	SS	30							
			9	SS	45							
			10	SS	75							
			11	SS	120							
57.66	Sandy gravel. Very dense.		12	SS	160							48 39 (13)
18.75	End of Borehole.											

OFFICE REPORT ON SOIL EXPLORATION

+3, x5; Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND/OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

MECHANICAL PROPERTIES OF SOIL

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

STRESS AND STRAIN

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

PHYSICAL PROPERTIES OF SOIL

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

memorandum



To: Mr. G.W. Henderson,
Construction Analyst,
Construction Office,
3rd Floor, 5000 Yonge St.,
CENTRAL REGION

Date: 86 01 22

From: Engineering Materials Office,
Foundation Design Section,
Central Building, Room 315

Re: Bead Strip Arterial Bridge,
Red Hill Creek, Contract #84-01,
District #4, Burlington

This is to confirm opinions expressed to you during our recent discussion regarding the foundation construction of the above-mentioned structure.

- 1) The drawings called for 1.2 m of tremie concrete to be placed immediately below the pilecaps. The purpose of this tremie concrete was twofold: to prevent blowout of the foundation base when the cofferdam was pumped out and to provide support until the pilecap concrete set.
- 2) The Contractor by using earth fill diverted the water in the creek away from the footing under construction and was able to achieve and maintain a stable base in the soil at the underside of footing level in the cofferdam. In this way he was able to dispense with the tremie concrete and place the pilecaps in the dry directly on to the soil.
- 3) The method shown on the drawings was without doubt safer and much less prone to construction problems than was the method adopted by the Contractor in which because of the existence of organic silt, silt and sand strata there was a strong possibility of 'boiling' or even 'blowout' of the soil during construction.

A handwritten signature in dark ink, appearing to read "K. G. Selby".

K. G. Selby,
Chief Foundations Engineer
(West)

KGS:ma