

DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 40PI-65

DIST. 4 REGION

W.P. No.

CONT. No.

W. O. No. 80-36153
74-11024

STR. SITE No. N/A

HWY. No. 99

LOCATION EMBANKMENT FAILURE N.B.L.

WEST OF LYNDEN STA. 52+00 TO 53+00

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:



RECORD OF BOREHOLE No 1

W@ 80-36153 LOCATION STA: 52+08; O/S 13' RT ORIGINATED BY PP
DIST 4 HWY 99 BOREHOLE TYPE CONT. FLIGHT AUGER (H.S.) COMPILED BY PP
DATUM GEODETIC DATE SEPTEMBER 22 1982 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT <u>2</u>					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		
697.5	SHOULDER SURFACE													
0.0	FILL SAND & GRAVEL		1	SS	12									
			2	SS	10									
	SILTY CLAY		3	SS	6		690							
	SOME SAND		4	SS	16									
			5	SS	9									
			6	SS	25		680							
			7	SS	25									
675.7	MATERIAL		8	SS	31									
22.0			9	SS	14									
	SILTY CLAY		10	SS	14		670							
	SOME SAND		11	SS	12									
	STIFF		12	SS	14									
665.5														
32.0	END OF BOREHOLE						660							



RECORD OF BOREHOLE No 2

W# 80-36153 LOCATION STA: 52+46; 9/S 5' RT ORIGINATED BY PP
DIST 4 HWY 99 BOREHOLE TYPE CONT. FLIGHT AUGER (H.S.) COMPILED BY PP
DATUM GEODETIC DATE SEPTEMBER 23 1982 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH		W _p	W	W _L		
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE	WATER CONTENT (%) 10 20 30				
							20 40 60 80 100							
							400 800 1200 1600 2000							
700.0	PAVEMENT SURFACE													
0.0	ASPHALT													
	FILL		1	SS	32									
	SAND		2	SS	15									
	GRAVEL		3	SS	12									
	SILTY CLAY		4	SS	13									
	SOME SAND		5	SS	15									
			6	SS	14		690							
			7	SS	10									
			8	SS	18									
			9	SS	17									
682.7	MATERIAL		10	SS	31									
17.3	WOOD FRAGMENTS & ORGANICS		11	SS	18									
			12	SS	12		680							
			13	SS	11									
			14	SS	13									
	SILTY CLAY		15	SS	12									
	SOME SAND		16	SS	7									
			17	SS	6		670							
			18	SS	5									
	FIRM		19	SS	6									
	TO		20	SS	5		660							
	STIFF		21	SS	5									
			22	SS	6									
651.5														
48.5	END OF BOREHOLE						650							



RECORD OF BOREHOLE No 3

W 0 80-36153

LOCATION STA: 52+46; 9/S 7' LT

ORIGINATED BY PP

DIST 4 HWY 99

BOREHOLE TYPE CONT. FLIGHT AUGER (H.S.)

COMPILED BY PP

DATUM GEODETIC

DATE SEPTEMBER 24 1982

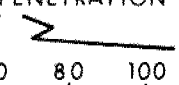
CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	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		W _p	W	W _L		
699.5	PAVEMENT SURFACE													
0.0	ASPHALT													
	FILL SAND & GRAVEL		1	SS	22									
			2	SS	21									
	SILTY CLAY		3	SS	20									
	SOME SAND		4	SS	13									
			5	SS	15									
			6	SS	10		690							
685.5	MATERIAL		7	SS	24									
14.0			8	SS	23									
	SILTY CLAY		9	SS	14									
			10	SS	8									
	SOME SAND		11	SS	9		680							
			12	SS	7									
			13	SS	8									
	FIRM		14	SS	5									
	TO		15	SS	5		670							
	STIFF		16	SS	5									
			17	SS	5									
			18	SS	6		660							
656.5														
43.0	END OF BOREHOLE													



RECORD OF BOREHOLE No 4

W@ 80-36153 LOCATION STA: 50+89; 9/5 13' 2T ORIGINATED BY PP
DIST 4 HWY 99 BOREHOLE TYPE CONT. FLIGHT AUGER COMPILED BY PP
DATUM GEODETIC DATE SEPTEMBER 27 1982 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH						
								20 40 60 80 100						
						<input type="radio"/> UNCONFINED	+ FIELD VANE							
						<input checked="" type="radio"/> QUICK TRIAXIAL	x LAB VANE							
692.0	SHOULDER SURFACE													
0.0	<u>FILL</u> <u>SAND</u> <u>GRAVEL</u>		1	SS	26									
			2	SS	28									
	SILTY CLAY		3	SS	17									
	SOME SAND		4	SS	19									
			5	SS	15									
	<u>MATERIAL</u>		6	SS	23									
			7	SS	23									
	ASPHALT		8	SS	28									
668.0	SOME ORGANICS		9	SS	32									
240			10	SS	20									
	SILTY CLAY		11	SS	17									
	SOME SAND		12	SS	22									
	STIFF													
	TO													
655.0	V. STIFF BROWN		13	SS	16									
37.0	END OF BOREHOLE													
	GREY													



RECORD OF BOREHOLE No 5

W# 80-36153 LOCATION STA: 53+43; 9/s 13' 2T ORIGINATED BY PP
DIST 4 HWY 99 BOREHOLE TYPE CONT. FLIGHT AUGER COMPILED BY PP
DATUM GEODETIC DATE SEPTEMBER 27 1982 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	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		W _p	W	W _L		
704.5	SHOULDER SURFACE													
0.0	FILL SAND GRAVEL													
	SILTY CLAY (3" ASPHALT AT 11')		1	SS	30		700							
	MATERIAL		2	SS	11									
691.0 13.5							690							
	SILTY CLAY		3	SS	10									
	SOME SAND		4	SS	5									
	FIRM BROWN TO GREY		5	SS	11		680							
	STIFF		6	SS	11									
672.5 32.0							670							

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

MEMORANDUM

TO: Mr. C.R. Robertson, (2)
District Engineer,
District #4, Hamilton.

FROM: Soil Mechanics Section,
Geotechnical Office,
West Building, Downsview.

ATTENTION: Mr. H. Potts.

DATE: July 30th, 1974.

OUR FILE REF.

IN REPLY TO

August 8/74

SUBJECT:

FOUNDATION INVESTIGATION REPORT

For

The Embankment Failure at Highway 99,
West of Lynden (Sta. 52+50 to 54+00),
District #4, Hamilton.

W.O. 74-11024

W.P. Nil.

Attached we are forwarding to you our detailed foundation investigation report on the subsoil conditions existing at the abovementioned site.

We believe that the factual data and recommendations contained therein will prove adequate for your design requirements. Should additional information be required, please do not hesitate to contact our Office.

M. Devata

M. Devata,
Supervising Engineer.

MD/mj

c.c. E.J. Orr
R.S. Pillar
B.J. Giroux
D. Gunther
G.A. Wrong
P. Lewycky
Files
Documents

Attach**

RECEIVED

AUG -9 1974

Ministry of
Transportation & Communications
DISTRICT No. 4 = HAMILTON

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6. DISCUSSION AND RECOMMENDATIONS.
7. MISCELLANEOUS.

FOUNDATION INVESTIGATION REPORT
For
The Embankment Failure at Highway 99,
West of Lynden (Sta. 52+50 to 54+00),
District #4, Hamilton.
W.O. 74-11024 W.P: Nil.

1. INTRODUCTION:

Following a request from Mr. J.L. Tansley, Assistant Highway Maintenance Supervisor, Hamilton District, a site inspection was made by Mr. M. Devata, and Mr. P. Payer of the Soil Mechanics Section. Subsequently a field and laboratory investigation was undertaken by this Section to determine the subsoil and groundwater conditions existing at the above-mentioned failure location. The purpose of this investigation is to determine the causes of embankment failure and suggest remedial measures. The details of this investigation are presented in this Report.

2. DESCRIPTION OF SITE:

The site is located approximately 9 miles west of Lynden, on Highway #99, Brant County, which is composed of an undulating to hilly terrain, mainly under cultivation.

The failure has occurred in the embankment on the north side of the westbound lane of Highway #99, between Sta. 52+50 and Sta. 54+00. At this location the roadway is located on a hillside (sloping to the north) overlain by fill material which was placed at approximately a 2:1 slope.

3. FIELD AND LABORATORY WORK:

Six sampled boreholes, as well as one dynamic cone penetration test, were put down during the course of the field investigation. All borings were advanced by a bombardier mounted CME 55 (continuous flight auger machine) with the exception of B.H.#6 which was advanced with a diamond drill rig, both of which were adapted for soil sampling.

At required depths disturbed samples were taken by driving a 2" O.D. split-spoon sampler into the soil in accordance with the specifications for the Standard Penetration Test. The testing programme was periodically supplemented by taking undisturbed samples in 2" I.D. Shelby tubes, which were advanced into the ground hydraulically. In addition, field vane tests were carried out where possible, to determine the undrained shear strength of the cohesive material.

Groundwater level observations were carried out during the period of investigation and for a period of four weeks after the investigation, in the open boreholes and by means of piezometers (B.H.#1, 2 & 6).

All samples were subjected to a careful visual examination in the field, and subsequently in the laboratory. Following this examination, laboratory testing was carried out on selected representative samples to determine the following engineering properties of the material.

Bulk Densities

Natural Water Contents

Atterberg Limits

Grain-size Distributions

Undrained Shear Strengths

Consolidation Characteristics

Organic Contents

Undrained Shear Strengths

Shear Strength Parameters in Terms of Effective Stress

The results of the field and laboratory investigation are plotted on the Record of Borehole sheets and summarized on Figures #1 to #3, inclusive, contained in the Appendix of this Report.

4. SUBSOIL CONDITIONS:

4.1) General.

Fairly uniform conditions were encountered at the site. The subsoil consists of a cohesive fill material underlain by natural material of similar characteristics to that of the fill material.

4.2) Fill Material - Clayey Silt with a Trace of Sand and Organics.

(The Fill material was placed at this site along Hwy. #99, to form the existing grade-line.) This material was encountered in all borings immediately beneath the ground surface. The upper 4 feet of B.H.'s #1 and #3 which were put down on the existing roadway, consists basically of a compact sand and gravel with some silty clay and a trace of organics. The remaining fill material (to a depth of approximately 25' from ground surface) consists of clayey silt with traces of sand and organics.

The Standard Penetration Tests were carried out within this deposit. The testing gave "N" values which range from 4 blows/foot to 63 blows/foot. Based on these results it is estimated that the fill material has been subjected to variable degree of compaction.

Typical grain-size distribution curves for the samples of this fill stratum are plotted in an envelope form on Fig. #1 in the Appendix.

Results of the Atterberg Limit test performed on samples recovered in this material were plotted on the Record of Borehole Sheets, as well as the plasticity chart, Fig. #2. They are also tabulated below, together with the shear strength parameters in terms of effective stresses (c' & ϕ').

	<u>Range</u>
Liquid Limit (W_L)%	24-47
Plastic Limit (W_P)%	17-27
Natural Moisture Content(W)%	14-30
c'	0-259 p.s.f.
ϕ'	29.5°-33°

4.3) Silty Clay to Clayey Silt, with a Trace of Sand.

The natural subsoil consists of silty clay to clayey silt, with a trace of sand and is present immediately below the fill material.

Standard penetration testing was carried out within this deposit. The results are plotted on the Record of Borehole sheets. The testing gave "N" values which range from 7 blows/foot to 21 blows for one foot.

Results of the Atterberg Limit test performed on the samples recovered in this material were plotted on the Record of Borehole Sheets, as well as on the plasticity chart, Fig. #3. These are tabulated below, together with other laboratory testing results.

	<u>Range</u>
Liquid Limit (W_L)	24-51
Plastic Limit (W_P)%	18-24
Natural Moisture Content (W)%	20-51
Undrained Shear Strength (C_u) p.s.f.	
Insitu vane test	500-2,000
Unconfined compression	650-900
Shear Strength Parameters in <u>Terms of Effective Stress</u>	
C' =	83-328 p.s.f.
ϕ =	27.5° - 30°

5. GROUNDWATER CONDITIONS:

Groundwater level observations were carried out during the period of the investigation and for a period of four weeks after the investigation, in the open boreholes and by means of piezometer tubes (B.H.'s #1, 2 & 6). These observations have been recorded on the Record of Borehole sheets and summerized on Drawing No. 74-11024A. The results of the measurements indicate that the groundwater level is approximately 5 to 10 feet below the natural ground surface (elev. 682 to elev. 652).

From the results of the piezometer reading in B.H.#2, there is evidence of perched water tables within the fill material.

6) DISCUSSION AND RECOMMENDATIONS:

The pavement directly over the perimeter of the failure zone has cracked and separated from the unaffected section of the roadway (the failure zone extends approximately to the centreline) - and within the failure area the pavement was settled slightly. It was observed that the guard rails within the failure zone had moved laterally away from the centreline of the roadway (as compared to those not in the affected area) which is assumed to be directly related to the embankment failure.

The observations of the continuous sampling in Borehole #1 have indicated relatively uniform strength pattern throughout the fill material (and into the natural subsoil). If the failure was deepseated, then, in the critical areas bounded by the surface of the failure envelope, the clayey silt should have been remoulded due to shear deformation, this would have led to some reduction in strength in these zones. Since this was not found to be the case, it is inferred that the instability must have been attributed to something other than a rotational type of failure within the parent subsoil or the lower regions of the fill material.

Using the average shear properties from the laboratory testing, the slope stability analyses proved the factor of safety of the slope to be approximately 1.3.

From the observations made, it can be concluded that the instability of the embankment was primarily attributed to action of seepage forces through the fissures in the fill material, which causes the lateral movement of the embankment material. It should be noted that such failures are of a progressive nature and will take place during the time of spring thaw of every year and also during the periods of heavy precipitation. In order to prevent such failures, an adequate drainage system will be necessary. If these measures are not carried out, further lateral movement of the embankment material can be anticipated.

It is recommended that the following remedial measure be carried out in order to control the seepage forces. counterfort drains having a minimum base width of 2 feet and a depth of 4 feet should be constructed, extending transversely and directly under the roadway within the failure zone. The spacing of these drains should not exceed 30 feet. The material to be used for construction of the counterfort drains should consist of a free draining granular material such as Granular 'A'.

NO COMPLETION ON DRAINS -

7. MISCELLANEOUS:

The boring programme was carried out during the period of June 6th, to June 11th, 1974. Equipment used on the site was owned and operated by P.V.K. and Sons Drilling Co. The field work was supervised by Mr. P. Christensen, Student Technician, who also prepared this Report. The Report was reviewed by Mr. M. Devata, Supervising Engineer.

P. Christensen

P. Christensen,
for Student Technician.

M. Devata

M. Devata, P. Eng.,
Supervising Engineer.

PC/mj
July, 1974.



A P P E N D I X

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 1

JOB 74-11024

LOCATION Station 52+39 (Hwy. 99); 15.5' Rt.

ORIGINATED BY PC

W.P. --

BORING DATE June 6, 1974

COMPILED BY HS & PC

DATUM Geodetic

BOREHOLE TYPE Auger

CHECKED BY

SOIL PROFILE			SAMPLES			ft/m	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT (0.3 m)	LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w $w_p \quad w \quad w_L$ WATER CONTENT %	BULK DENSITY γ	REMARKS
ELEV. DEPTH ft.	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT (0.3 m)					
698.3	Ground Level									P.C.F. GR. SA. SI. CL.
0.0	Sand with some gravel & silty clay, trace of organics - Compact.	X	1	SS	24					T/m ³
694.3	Fill Material - clayey silt with a trace of sand and organics Brown	X	2	SS	24					0.95% O.C.
4.0		X	3	SS	19	690				
		X	4	SS	8	210.2				
		X	5	SS	23					
		X	6	SS	24					
		X	7	SS	22					0.56% O.C.
		X	8	SS	32					0.6% O.C.
		X	9	SS	38					
		X	10	SS	24	680				
		X	11	SS	21	207.3				
		X	12	SS	63					
		X	13	SS	25					
		X	14	SS	31					
673.3		X	15	SS	22					
25.0		Silty clay to clayey silt with a trace of sand		16	SS	21	670			
667.8	Brown		17	SS	13	204.2				669.3
30.5	Grey		18	SS	12					204.0
	Firm to very stiff		19	TW	PH					1.92
			20	SS	--	660				W.L. @ elev. 658.8
658.3						201.2				658.8
40.0	End of Borehole									P ₁

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 2

JOB 74-11024 LOCATION Station 52+37 (Hwy. 99):16' Rt.
 W.P. -- BORING DATE June 7, 1974
 DATUM Geodetic BOREHOLE TYPE Auger

ORIGINATED BY PC
 COMPILED BY HS & PC
 CHECKED BY ap./.

SOIL PROFILE				SAMPLES			ft/m ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT (0.3 m)	LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w w_p ——— w ——— w_L WATER CONTENT % 20 40 60	BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH ft.	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT (0.3 m)	SHEAR STRENGTH P.S.F. kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					
m. 212.8 698.3	Ground Level										
0.0 0.0	Fill Material - clayey silt with some sand and a trace of organics										

FOUNDATIONS OFFICE

ORIGINATED BY PC

COMPILED BY HS & PC

CHECKED BY J.L.

SOIL PROFILE			SAMPLES		Ft/m ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT (0.3 m)	LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w w_p — w — w_L WATER CONTENT % 20 40 60	BULK DENSITY γ P.C.F.	REMARKS	
ELEV. DEPTH ft.	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE						BLWS/FOOT (0.3 m)
m. 213.6	700.8	Ground Level								
0.0	0.0	sand with some gravel and silty clay, trace of organics. brown compact Fill Material - clayey silt with a trace of sand and organics								
212.4	696.8		1	SS	30	213.4				
1.2	4.0		2	SS	35					
			3	SS	16					
			4	SS	25	690				
			5	SS	24	210.3				
			6	SS	18					
			7	SS	24	680				
206.1	676.3	Brown	8	SS	17	207.3				
7.5	24.5	silty clay to clayey silt with a trace of sand firm to stiff	9	SS	15					
			10	SS	16	670				
			11	SS	9	204.2				
			12	SS	11					
201.9	662.3	Grey	13	TN	PH					
			14	SS	11					
11.7	38.5	End of Borehole				660				
						201.2				
							50			
							kPa	100		

ORIGINATED BY PC

COMPILED BY HS & PC

CHECKED BY

20
15 \diamond 5 % STRAIN AT FAILURE
10

ORIGINATED BY PC

COMPILED BY HS & PC

CHECKED BY

15 $\frac{20}{10}$ 5 % STRAIN AT FAILURE

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 6

JOB 74-11024

LOCATION Station 52+46 (Hwy. 99); 50' Rt.

ORIGINATED BY PC

W.P. --

BORING DATE June 11, 1974

COMPILED BY HS & PC

DATUM Geodetic

BOREHOLE TYPE Wash Boring (Jr. Diamond Drill)

CHECKED BY J. J.

SOIL PROFILE			SAMPLES			Ft/m	DYNAMIC PENETRATION RESISTANCE			LIQUID LIMIT ——— w_L			BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT (0.3 m)		BLOWS / FOOT (0.3 m)			PLASTIC LIMIT ——— w_p				
m.	ft.						SHEAR STRENGTH P.S.F.			w_p ——— w ——— w_L			Y	P.C.F. GR. SA. SI. CL.
							O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE			WATER CONTENT % 20 40 60				
208.4	683.8	Ground Level												
0.0	0.0	Fill Material - clayey silt with a trace of sand and organics												
			1	SS	29	680								
			2	SS	22	207.3								0.69% O.C.
			3	SS	34									
			4	SS	27									
			5	SS	24	670							1.22% O.C.	Dry
203.4	667.3	Brown												
5.0	16.5	End of Borehole												
						</								

OFFICE REPORT ON SOIL EXPLORATION

GRAIN SIZE DISTRIBUTION

UNIFIED SOIL CLASSIFICATION SYSTEM

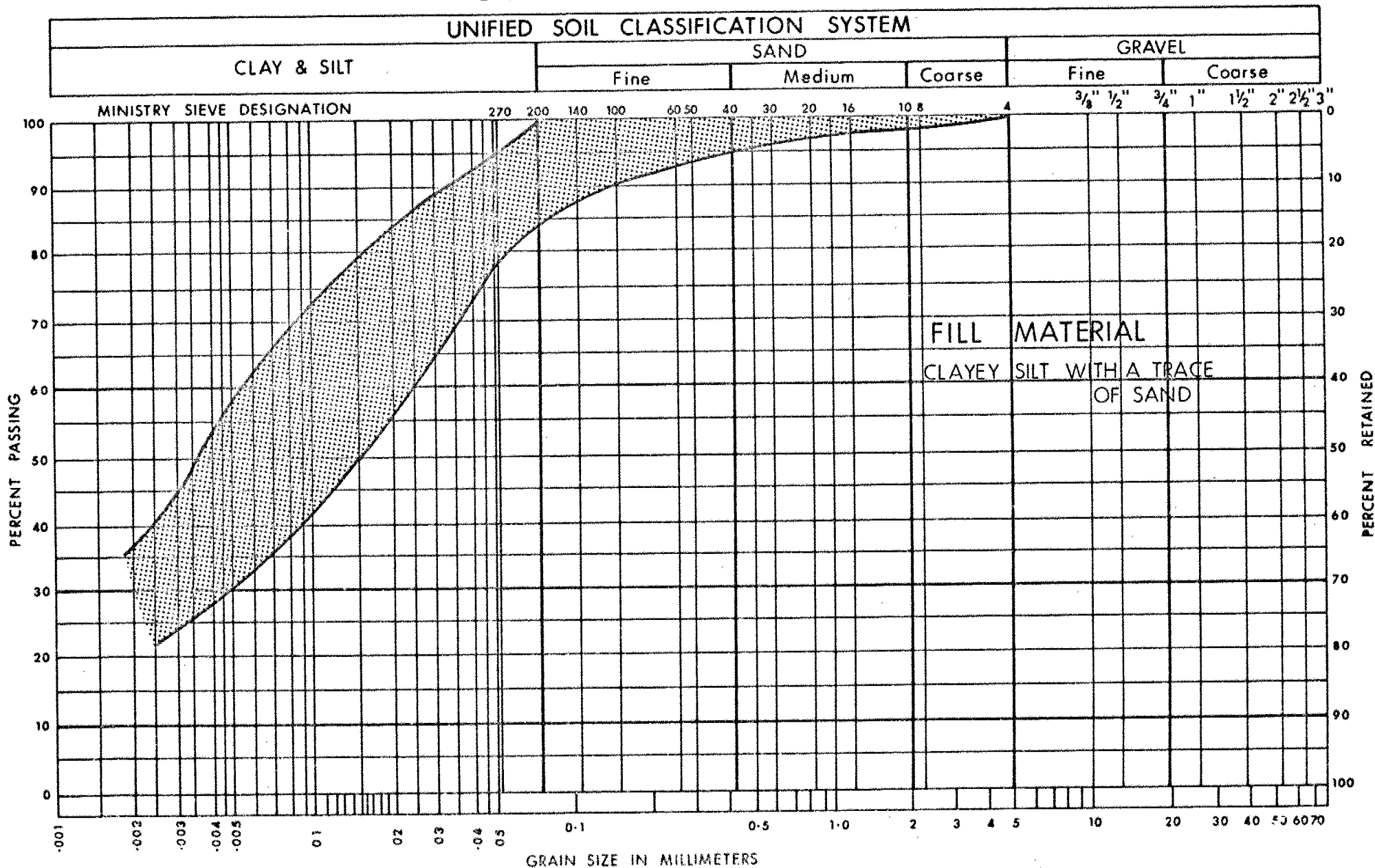


FIG. 1

W.O. 74-11024

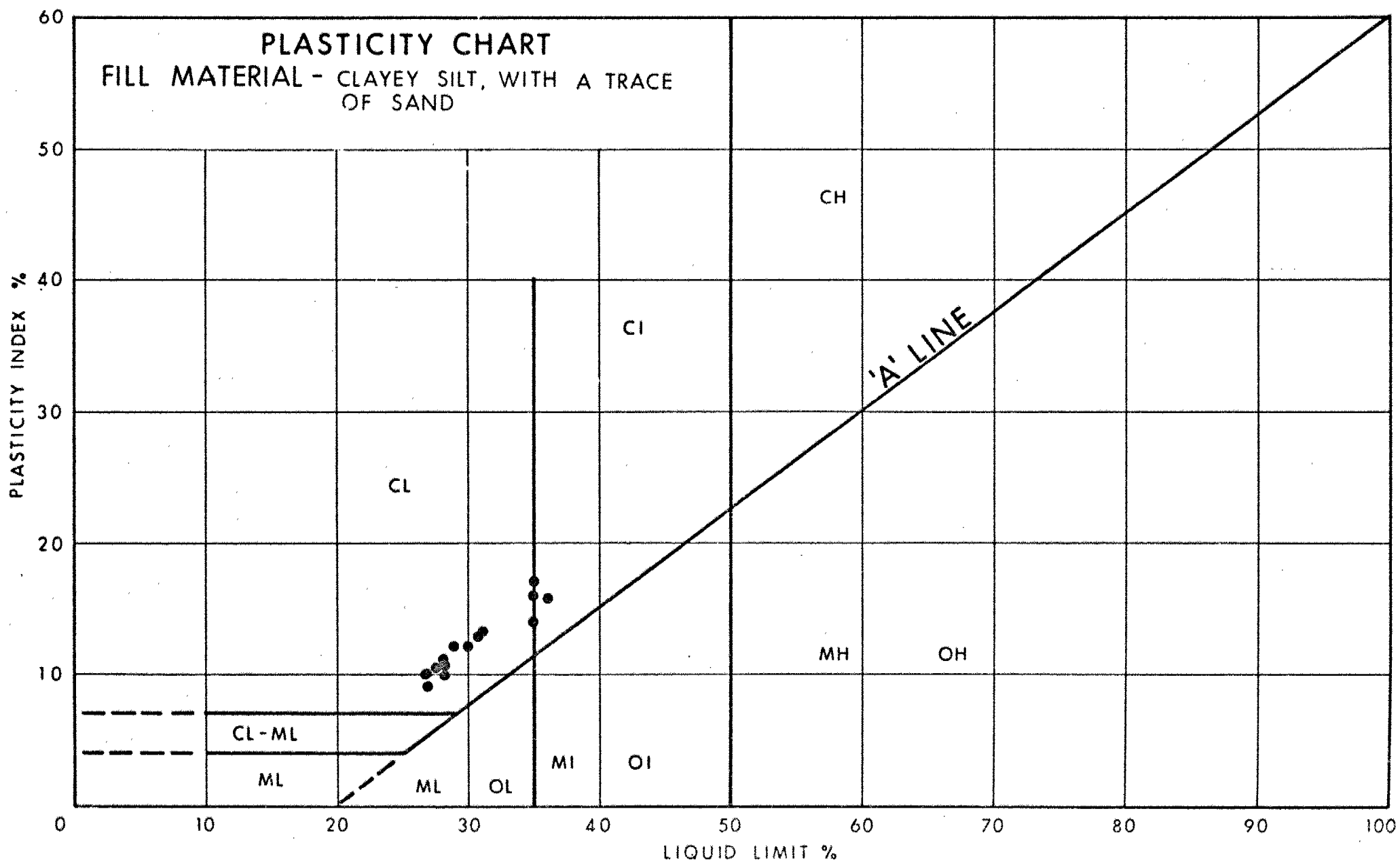


FIG. 2

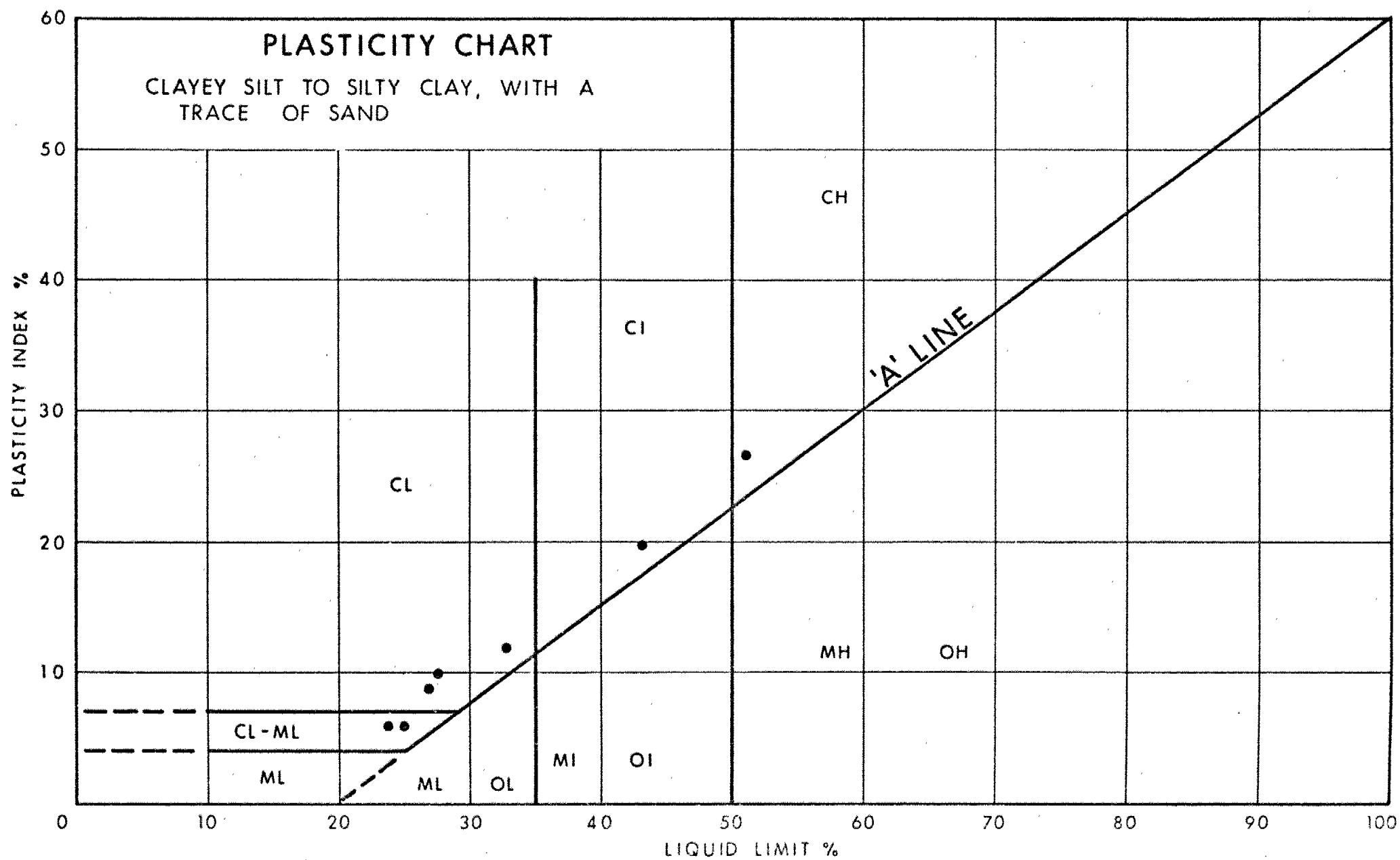


FIG. 3

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

PENETRATION RESISTANCE

'N'-STANDARD PENETRATION RESISTANCE : - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE : - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL. THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

<u>CONSISTENCY</u>	<u>c LB./SQ.FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
VERY SOFT	0 - 250	VERY LOOSE	0 - 4
SOFT	250 - 500	LOOSE	4 - 10
FIRM	500 - 1000	COMPACT	10 - 30
STIFF	1000 - 2000	DENSE	30 - 50
VERY STIFF	2000 - 4000	VERY DENSE	> 50
HARD	> 4000		

TERMS TO BE USED IN DESCRIBING SOILS:-

TRACE < 10% , SOME 10-25% , WITH 25-40% , > 40% SILTY, SANDY, GRAVELLY, CLAYEY ETC.

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.T.	SLOTTED TUBE SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE

P.H. SAMPLE ADVANCED HYDRAULICALLY

P.M. SAMPLE ADVANCED MANUALLY

SOIL TESTS

U	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
UU	UNCONSOLIDATED UNDRAINED TRIAXIAL	F.V.	FIELD VANE
CIU	CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL	C	CONSOLIDATION
CID	" " DRAINED "	S	SENSITIVITY
CAU	" " ANISOTROPIC UNDRAINED "		
CAD	" " DRAINED "		

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

SOIL PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
S_v	DEGREE OF SATURATION
w_L	LIQUID LIMIT
w_p	PLASTIC LIMIT
I_p	PLASTICITY INDEX
w_s	SHRINKAGE LIMIT
I_L	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
I_c	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
e_{max}	VOID RATIO IN LOOSEST STATE
e_{min}	VOID RATIO IN DENSEST STATE
I_D	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY D_r IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
m_v	COEFFICIENT OF VOLUME CHANGE = $\frac{-\Delta e}{(1+e)\Delta\sigma}$
c_v	COEFFICIENT OF CONSOLIDATION
C_c	COMPRESSION INDEX = $\frac{\Delta e}{\Delta \log_{10} \sigma}$
T_v	TIME FACTOR = $\frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION INTERCEPT
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
μ	COEFFICIENT OF FRICTION
S_t	SENSITIVITY

GENERAL

π	= 3.1416
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

STRESS AND STRAIN

u	PORE PRESSURE
σ	NORMAL STRESS
σ'	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ϵ	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_0	COEFFICIENT OF EARTH PRESSURE AT REST

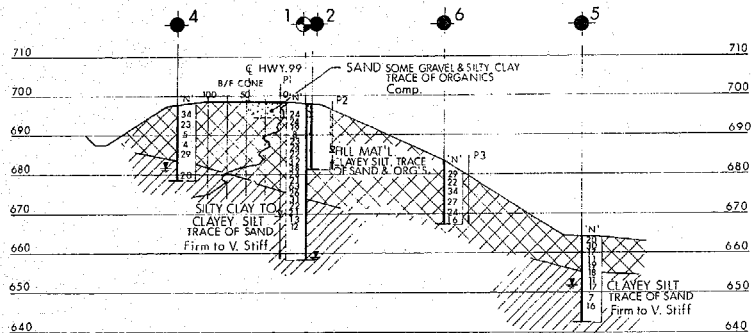
FOUNDATIONS

B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
k_s	MODULUS OF SUBGRADE REACTION

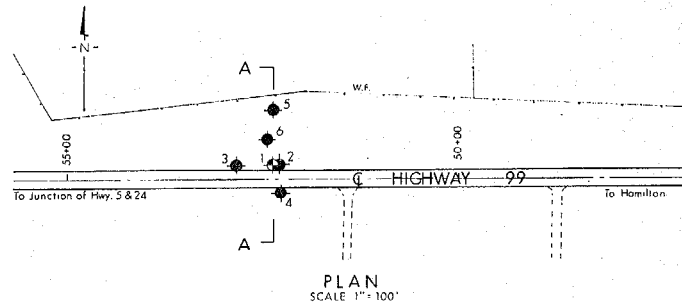
SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL

OVERSIZE DRAWING



SECTION A-A
SCALE 1" = 20'

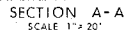






PLAN
SCALE 1" = 100'

LEGEND

	B.H. NO.	ELEV.	STA.	OFFSET
• Bare & Cone Penetration Test	1	698.3	52+39	15.5' RT.
• Bare Hole	2	698.3	52+37	16' RT.
• Water Levels established at time of field investigation, JUNE 1974	3	700.8	52+86	15' RT.
	4	697.8	52+28	18.5' LT.
• Piezometer with Water Level	5	664.3	52+39	86' RT.
	6	683.8	52+46	50' RT.

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS	EMBANKMENT FAILURE AT HWY. 99 STA. 52+50 TO STA. 54+00	
GEOTECHNICAL OFFICE SOIL MECHANICS SECTION		
DATE 26 JULY 1974	W.O. NO. 74-11024	DWG. NO. 74-11024 A



	B.H. No.	ELEV.	STA.	OFFSET.
 Bar & Cone Penetration Test	1	698.3	52+39	15'-3" RT.
 Bar Hole	2	698.3	52+37	16" RT.
Water Level established at time of field investigation, JUNE 1974	3	700.8	52+86	15' RT.
	4	697.8	52+28	18'-5" LT.
 Piezometer with Water Level	5	664.3	52+39	86" RT.
	6	683.8	52+46	50" RT.

MINISTER OF TRANSPORTATION AND COMMUNICATIONS

GEO TECHNICAL OFFICE
SOIL MECHANICS SECTION

EMBANKMENT FAILURE AT HWY. 99

STA. ~~52+50~~ TO STA. ~~54+00~~

52-162

53000

DATE 26 JULY 1974

W.O. NO. 74-11024

DWG. NO. 74-11024 A