

GEOCRES No. 413-57DIST. 18 REGION _____W.P. No. 263-90-01

CONT. No. _____

W. O. No. _____

STR. SITE No. _____

HWY. No. 17LOCATION Embankment Failure4 km W of Thessalon Lake St./Hwy 17BNo of PAGES - Westaby 13.7 km

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. _____

REMARKS: _____



Ministry
of
Transportation

Ron Nickelson

FILE No. _____ DATE _____

REMARKS N.W. Region Property Section

Linda Swistowski

807-473-2059

SURVEYS+PLANS - 807-473-2077 (BRAD: CUNNINGHAME,
MIKE CHAMBERLAIN)
FAX 473-2167 (CRYSTAL)

BILL FERGASON (EQUIPMENT DISPATCHER) (MIKE LAVENE)

STOCK ROOM 71 OLD GARDEN RIVER ROAD - VEHICLE 24 OCT.

GENERAL ENQUIRY (705) 942-8120

PATROL YARD (Thessalon) 842-3012

CANADIAN SOIL DRILLING (JAMIE ARCHER)

-- (905) 832-3247

RON NICKELSON (PATROL SUPERVISOR) 705-785-3452

**ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION**

WP 263-90-01 DIST 62
HWY 17 STR SITE 48E-46C

Embankment Failure - 0.9 km West Hopper Road
4 Km West of Thessalon (Lake Street)

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GEOCRES 41J-57

DATE NOV 15 1995

FOUNDATION INVESTIGATION REPORT
FOR
Sta. 13+900 to Sta. 14+000
Embankment Failure - 0.9 Km West Hopper Road
4 Km West of Thessalon (Lake Street)
WP 263-90-01, Twp. of Lefroy
District 62, Sault. Ste. Marie

This report was written in response to a request by the Northwestern Region Geotechnical Section concerning fill stabilization along Highway 17.

The longitudinal limits that pertain to this investigation and recommendation extend from Sta. 13+900 to Sta. 14+000 along Hwy. 17. Failures of the slope have occurred running 88 m and 15 m in length on the north and south sides respectively.

A foundation investigation was carried out at the above site consisting of seven boreholes of 7.6 to 15.2 m in length and three cone penetration tests. Boreholes were conducted both on the shoulders of the highway on top of the embankment and along the length of the failed zones at the toe. Where penetration was difficult through the rockfill, boreholes were relocated. This report contains factual information obtained from this investigation pertaining to roadway embankments along Hwy. 7.

Site Description

The site is located approximately 10 km west of the Town of Thessalon along Hwy. 17 in the Township of Lefroy, District of Algoma. The existing highway road is an asphalt covered 2-3 lane road with gravel shoulders. A truck climbing third lane extends along the westbound lane.

The topography consists of a maximum fill of 10 m along the highway. The existing embankment is comprised of rockfill with slopes protected from erosion and stabilization considerations by large boulders. The overall failure area is within the confines of a low wet area covered with cattails. This drainage basin is also located on the south side of the highway. Immediately east is an entrance to an old barn. In the transverse direction of the highway the ground surface dips into a valley for approximately 200 m. Bedrock outcrops lie at the crest of the valley further west of Hwy. 17.

Subsurface conditions

The highway embankment consists of a rockfill composed of boulders mixed with Silt, Sand and Gravel. At some locations the fill was not penetrable with conventional augering techniques. Casing and rock coring was not conducted on the embankment due to concerns with undermining the existing fill by washing out the fines. Sublayers of Clayey Silt, trace Organics and Organics was encountered, particularly approaching the surface of the native materials. The fill was encountered to depths of 4.4 m to 6.6 m, however this depended on the embankment which extended to 10 m heights. Underlying the rockfill was a 0.9 m to 2.9 m of Clayey Silt, trace Sand. Having a stiff to hard consistency. As

this material makes up the native subsoils, the Clayey Silt was encountered from the surface in boreholes conducted at the toe of the Hwy. embankments. One borehole to the south west did not contain this layer. At greater depths the clay content increased with a 1.3 to 8 m Silty Clay, trace Sand encountered. This layer, of similar composition as the above, had a stiff to hard consistency. Underlying the cohesive strata above was a non-cohesive Silty Sand, some Gravel which extended down to 0.7 - 4.4 m. It has a very dense state of denseness, with auger refusal being encountered in each borehole at the bottom of the Silty Sand. Auger refusal occurred throughout the site within either boulders or bedrock. Rock coring techniques were required to penetrate beyond this depth. Only one borehole encountered bedrock however. Boreholes were terminated from depths of 7.6 - 15.2 m with refusal encountered at elevations of 196 m to 189 m. Large bedrock outcrops can be seen just west of the site consisting of the same colour and composition.

The locations of borings are shown on Dwg. No 2639001-A in the attached appendix of this report. The field and laboratory test results are plotted on the record of borehole logsheets.

Specific descriptions of the material encountered are given below.

Boulders with a mixture of Silt, Sand and Gravel (ROCKFILL)

The fill comprised of boulders with a mixture of Silt, Sand and Gravel. Upon approaching the depths of the native materials, interbedded layers of Clayey Silt, trace Organics and Organics was encountered.

Some boreholes located at the crest of the highway had to be moved a few times in order to penetrate the fill. Generally the fill was made up of rockfill with a mixture of fines filling the voids. Large boulders are placed along the slope and within the fill itself. Augering through the fill created cavities as the fines were removed and disturbed. Within the boreholes drilled at the crest of the embankment the fill had a thickness of 4.4 m to 6.6 m. The maximum embankment height is 10 metres.

Results of grain size distribution tests carried out on select samples indicate that the material contains 25 - 54 % Gravel, 40 - 57 % Sand, 5 - 25 % Silt and 1 - 8 % Clay. Figure 1 illustrates grain size distribution curves for this material based on representative samples within this layer.

Standard penetration tests conducted in this layer gave 'N' values ranging from 6 - 120 Blows/0.3 m due to the presence of borders, 'N' values varies considerably.

Clayey Silt, trace Sand

Underlying the rockfill the native subsoil consisted of a Clayey Silt, trace Sand with a 0.9 m to 2.9 m thickness. For those boreholes located at the toe of the Hwy. 17 embankments, a 0.5 - 1 m thickness of Organics was encountered at the surface. As a swamp existed at the toe on both north and south sides this is as expected.

Results of grain size distribution tests carried out on select samples indicate that the material contains 0 % Gravel, 2 - 16 % Sand, 48 - 81 % Silt and 17 - 36 % Clay. Figure 2 illustrates grain size distribution curves for this material based on representative samples within this layer.

The results from the field laboratory tests performed on this deposit are summarized as follows:

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	26.5 - 34	4
Liquid Limit (W_L)	28.5 - 33	4
Plastic Limit (W_P)	19.5 - 22	4
Plastic Index (I_p)	7.5 - 13.5	4
Undrained Shear Strength (kPa)	> 100	3

Figure 3 illustrates the plotted plasticity chart for this material based on representative samples. It indicates that the material is of a low plasticity. The field vane shear strengths were very high greater than 100 kPa. Based on this the consistency is considered Stiff to Hard.

Standard penetration tests conducted in this layer gave 'N' values ranging from 2 to 10 Blows/0.3 m.

Silty Clay, trace Sand

The above cohesive deposit becomes progressively more plastic with a greater percentage of Clay. This layer had a thickness of 1.3 to 8m.

Results of the grain size distribution tests carried out on select samples indicate the material contains primarily Silt and Clay. Figure 4 illustrates grain size distribution curves for this material based on representative samples within this layer.

The results from the field laboratory tests performed on this deposit are summarized as follows:

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	33 - 44.5	6
Liquid Limit (W_L)	32 - 45	6
Plastic Limit (W_P)	14.5 - 20	6
Plastic Index (I_p)	15.5- 26.5	6
Undrained Shear Strength (kPa)	36 - >100	7

Figure 5 illustrates the plotted plasticity chart for this material based on representative samples. It indicates that the material is of an intermediate plasticity. The field vanes shear strengths varied between 59 to > 100 Blows/0.3 m and can be considered to have a stiff to hard consistency.

Standard penetration tests conducted in this layer gave 'N' values ranging from 0 to 7 Blows/0.3 m.

The results of tow consolidation tests carried out on select samples indicate initial void ratios (e_0) of 0.886 and 0.97558 and a compression indices (C_c) of 0.313 and 0.4827.

Silty Sand, trace Gravel

In turn underlying the entire site was a Silty Sand, trace Gravel of 0.7 to 4.4 m thickness.

Grain size distribution tests carried out on select samples indicated 9 - 65 % Gravel, 26 - 53 % Sand, 8 - 38 % Silt, 1 - 4 % Clay. Figure 6 illustrates the grain size distribution curves for this material. A large amount of auger grinding indicated the presence of cobbles and boulders.

Standard penetration tests conducted in this layer gave 'N' values of 39 Blows/0.3 m to > 120 Blows/0.3 m, indicating a dense to very dense state.

Boulders/Bedrock

All boreholes were drilled until auger refusal was encountered. In one select borehole on each side of Hwy. 17 rock coring was conducted to confirm the bedrock elevation. To the north 3.6 m of rock was drilled having low RQD's and recoveries. This material was described as a boulder till and is considered as part of the overburden. Further penetration was not warranted for this project. To the south 1.6 m of rock core was drilled with the material described as a strong Gabbro for the first 0.5 m and then a strong Quartzite for the remainder. This rock type confirms the geological information available in the area. The rock was found to be medium strong, unweathered to slightly weathered. Please see the appendix for descriptions provided by the MTO Petrographer.

Groundwater Conditions

Observations of the groundwater level was carried out by measuring the water levels in open boreholes during the course of the investigation.

Water levels were generally found to be near the surface of the native ground level at an elevation of 200.5 to 201.8 m. As a swampy area was found near the toe of the embankments with an organic layer this was as expected.

Groundwater levels are subject to seasonal fluctuations and may therefore fluctuate accordingly.

Discussions and Recommendations

General

The failure of the existing paved shoulders along the east and west bound lanes along Hwy. 17 between stations 13+900 to Sta. 14+000 indicated the need for a foundation investigation to determine its cause. The alignment of the guide-rail indicated lateral and vertical movement.

The failed shoulder along the west bound passing lane is 88 m in length and is located on a rockfill of approximately 10 m in height. The overall failure area is within the confines of a low wet area covered with cattails. On the south side of the highway, immediately east of an entrance to an old barn, the shoulder has failed for a length of 15 metres and projects 1.0 m into the embankment.

The failed areas have received a hot mix patch approximately 3 to 4 years ago. The recommendations made in this report are expected to be part of the permanent repair carried out when a capital construction project is underway in the area.

Settlement and Stability Considerations

Stability and settlement analysis was carried out due to the presence of the compressive clay layers. The results indicated that relatively shallow slip planes were more critical than those of a deep seated nature. Settlement did not appear to play a part in the failures observed.

An effective stress analysis was applied for calculations of slope stability of the embankment fills using the Limit Equilibrium Method of stability developed by Sarma (1973, Stability Analysis of Embankment and Slopes, Geotechnique, Vol. 23, No. 3). Checking both deep seated and shallow failures for rockfill embankments of 1.25H:1V slopes, a factor of safety of 1.4 and 1.1 respectively was calculated (Figure 7 and 8). As the minimum Factor of Safety utilized by this office is 1.3, subsequent analysis indicated the need to place a 2 m midheight berm to increase this value for shallow failures to an acceptable level. (Figure 9)

Consolidation settlement calculations indicated that for an embankment of this size the clay layer would settle by 140 mm with 85 % taking place within 5 years. As the Hwy. EBL/WBL and WBPL have been in existence for a greater period of time it is assumed that consolidation has taken place to a large degree. Comparisons between samples taken at the toe and beneath the fill indicated that the water content has decreased, compression indices have decreased and coefficients of volume compressibility have increased. This confirms the above indicating that consolidation has taken place to some degree. Therefore settlement concerns can be eliminated.

In addition to the requirements of a berm, observations in the field indicated that these failures may be aggravated due to the construction and composition of the embankment.

Drilling through the rockfill embankment showed it to be composed of large boulders with fines filling the voids. Auger drilling, when successfully penetrating the boulders caused cave-ins, with boreholes expanding in diameter beneath the pavement surface upon disturbance of the silty fines. It is believed that disturbance from traffic and possible infiltration of surface water is causing a loss of fines beneath the pavement. A lack of "Chinking" between the large rock fill particles during construction is causing them to re-align. In addition, while only 0.5 m of organics was encountered at the toe of the embankment, if any organics or loose materials were not effectively removed from under the fill this could cause the rockfill to sink within this weak zone additionally.

It is therefore recommended to place crushed stone on the rockfill, together with a geotextile underneath the subgrade material in order to prevent the mitigation of fines. Recompact the upper granular fines, reshaping the base materials and restoring the cross fall would be required. In addition, management of runoff should be considered to channel away any surface water and prevent infiltration and washing out of fines.

Summary

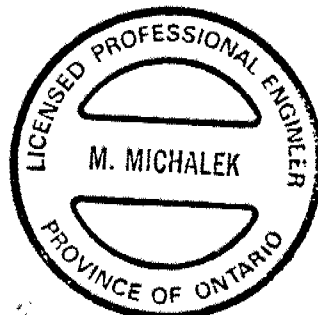
To summarize, the failure of the slopes appears to be a combination of shallow slip planes and the infiltration of fines into the voids of the rockfill. The recommendations are to place a 2 m midheight berm together with the placement of crushed stone on the rockfill with a geotextile underneath the subgrade material.


Differential settlements may be caused within the existing embankment due to the varying thickness of the underlying clay deposits. It should be noted that some failures may have to be tolerated unless the entire embankment can be reconstructed.

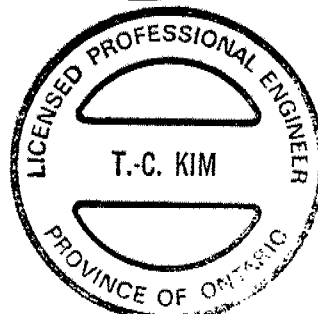
Miscellaneous

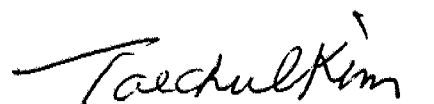
The fieldwork for this investigation was carried out under the supervision of M. Michalek, Jr. Foundation Engineer and D. Daneff, Geotechnical Engineer. The equipment was owned and operated by Canadian Soils Limited, Toronto.

The report was written by M. Michalek under the general supervision of T. Kim, Senior Foundation Engineer.




M. Michalek, P. Eng.
Jr. Foundation Engineer

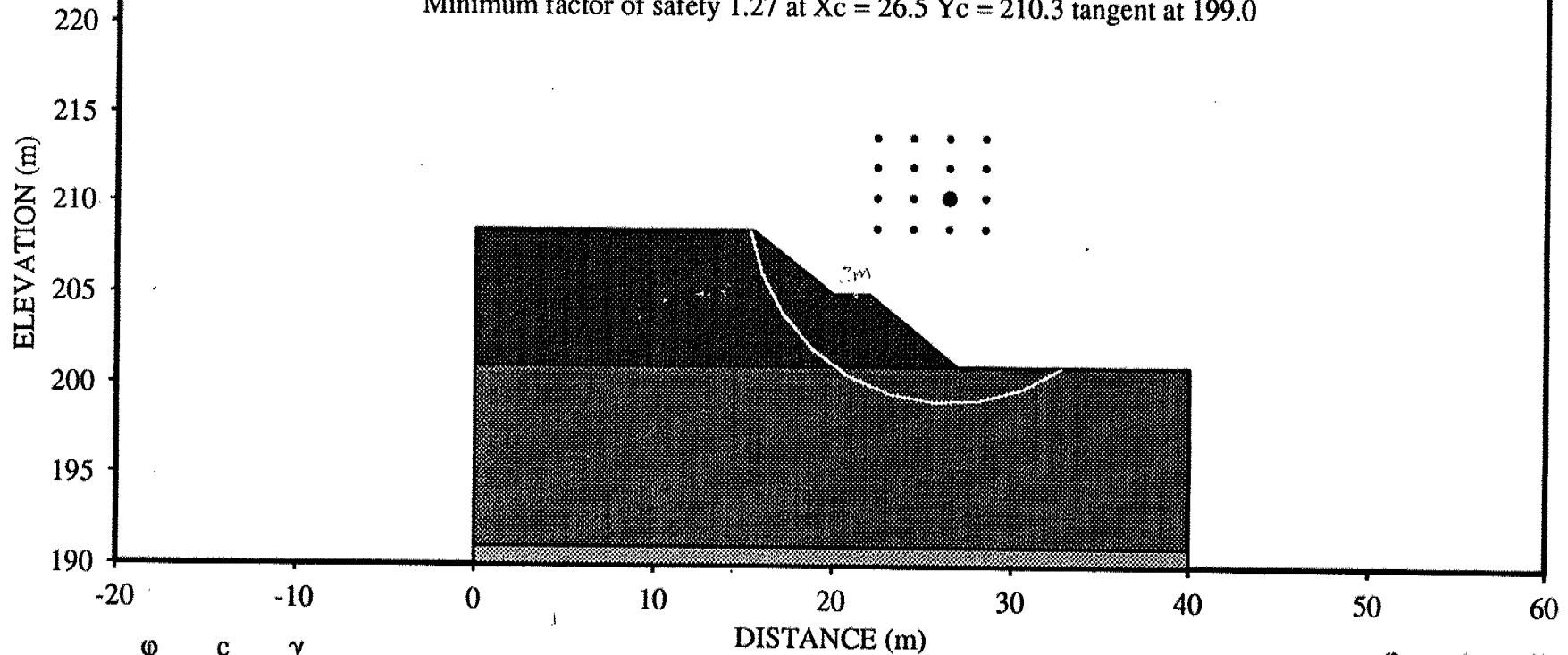



T. C. Kim, P. Eng.
Sr. Foundation Engineer

APPENDIX

WP 263-90-01

Minimum factor of safety 1.27 at $X_c = 26.5$ $Y_c = 210.3$ tangent at 199.0

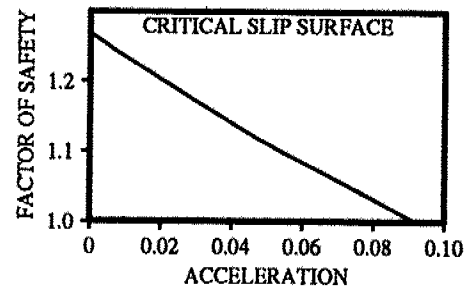


ϕ	c	γ	
40.0	0.0	18.1	Rock Fill

	ϕ	c	γ
Silty Clay	28.0	0.0	18.1
Silty Sand	32.0	0.0	18.9

CRITICAL ACCELERATIONS

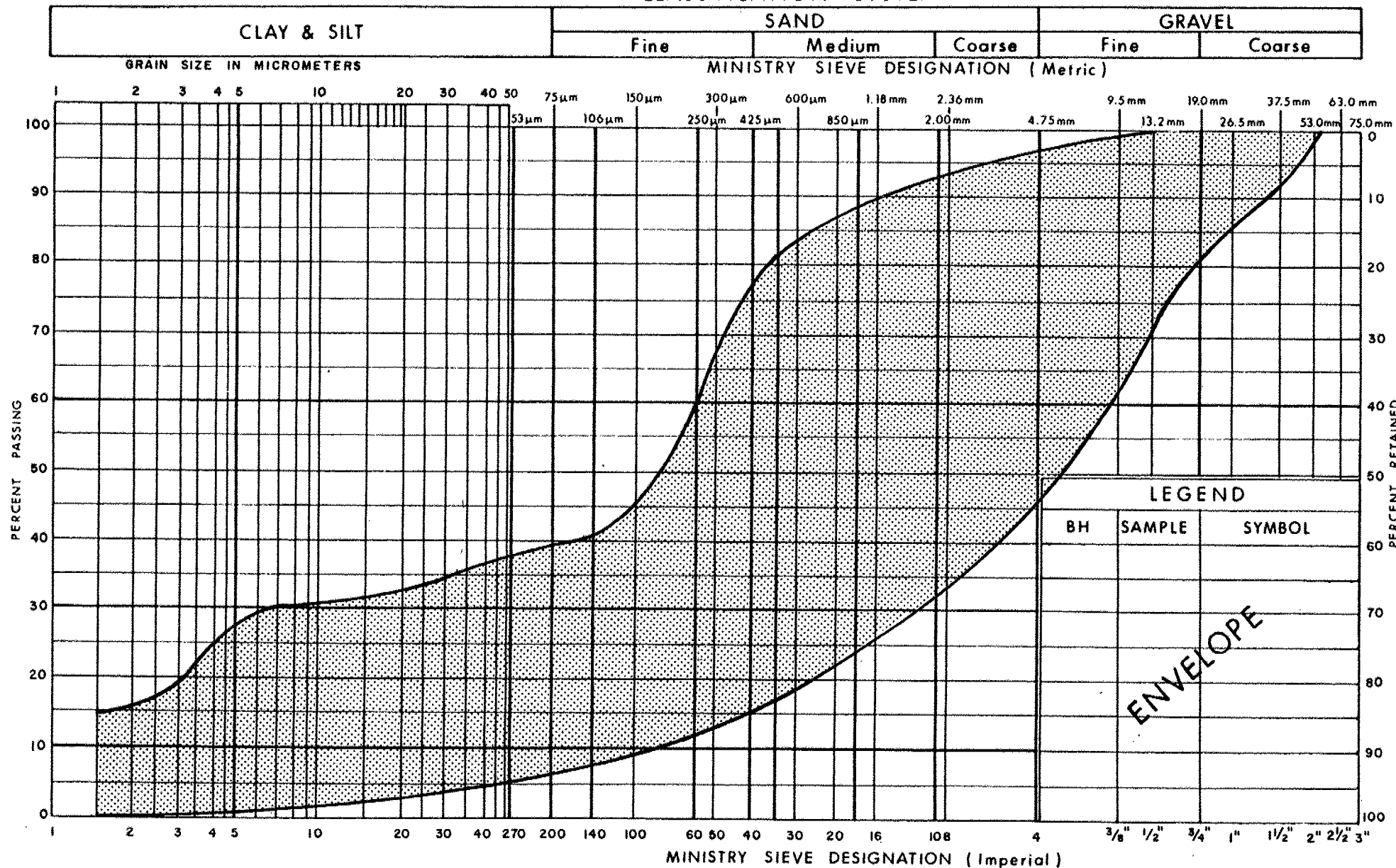
0.173	0.139	0.116	0.110
0.162	0.125	0.101	0.108
0.153	0.111	0.092	0.114
0.147	0.102	0.095	0.102



FACTORS OF SAFETY

1.598	1.455	1.350	1.352
1.536	1.388	1.294	1.361
1.482	1.325	1.266	1.398
1.444	1.285	1.282	1.284

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

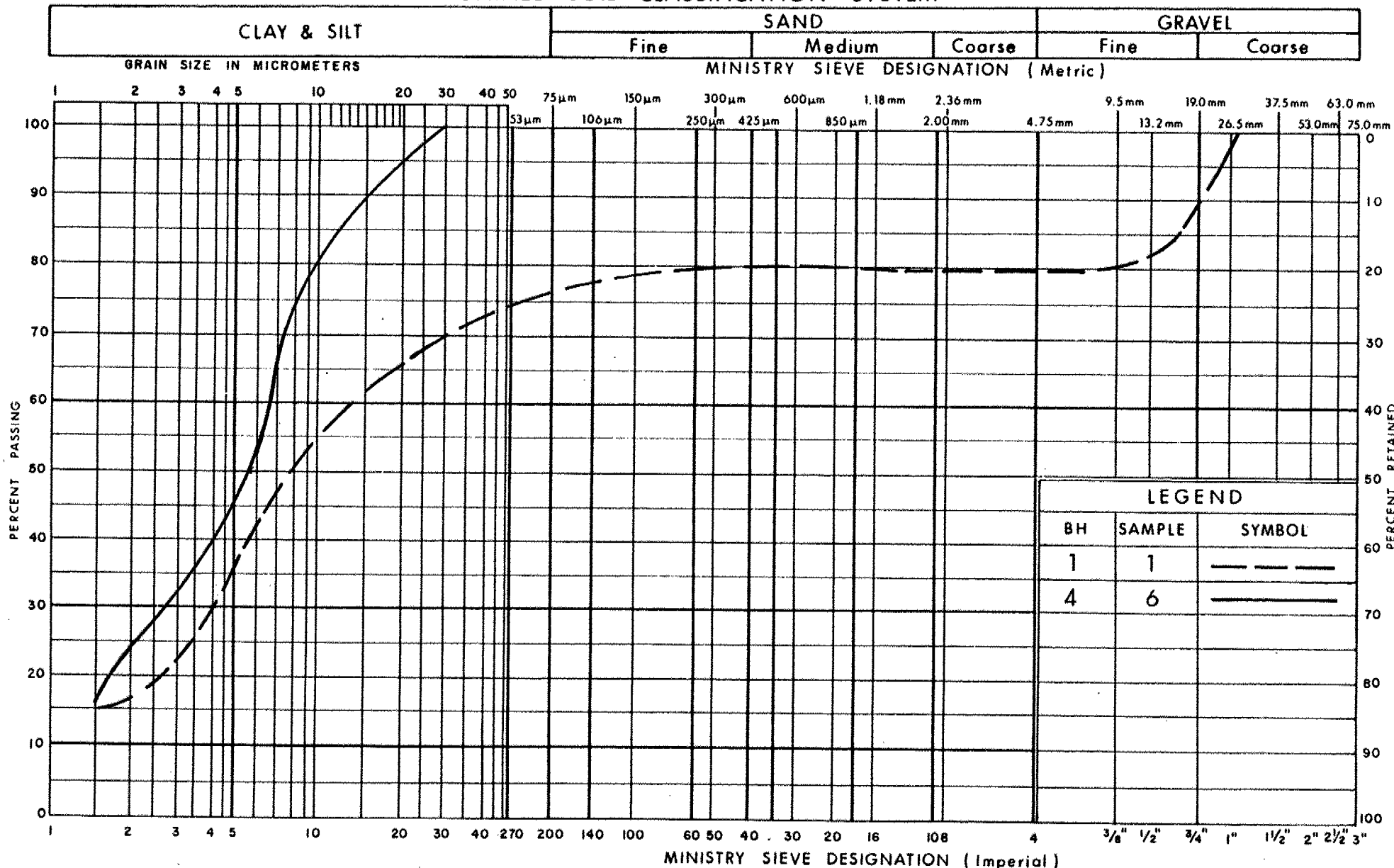
GRAIN SIZE DISTRIBUTION

BOULDERS WITH A MIXTURE OF SILT, SAND & GRAVEL (ROCKFILL)

FIG No 1

W P 263-90-01

UNIFIED SOIL CLASSIFICATION SYSTEM

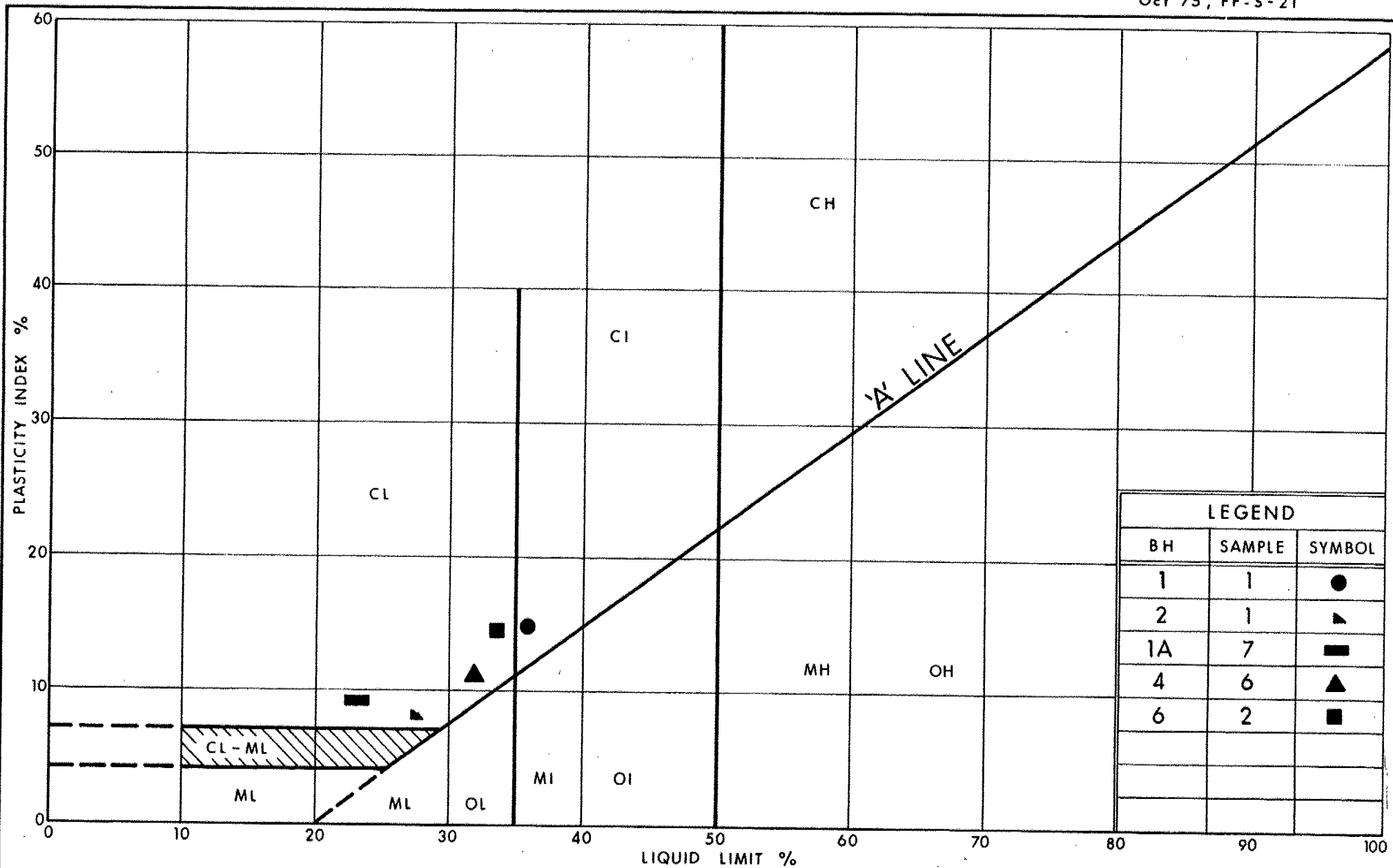


Ministry of
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GRAIN SIZE DISTRIBUTION
CLAYEY SILT, TRACE SAND

FIG No 2

W P 263-90-01



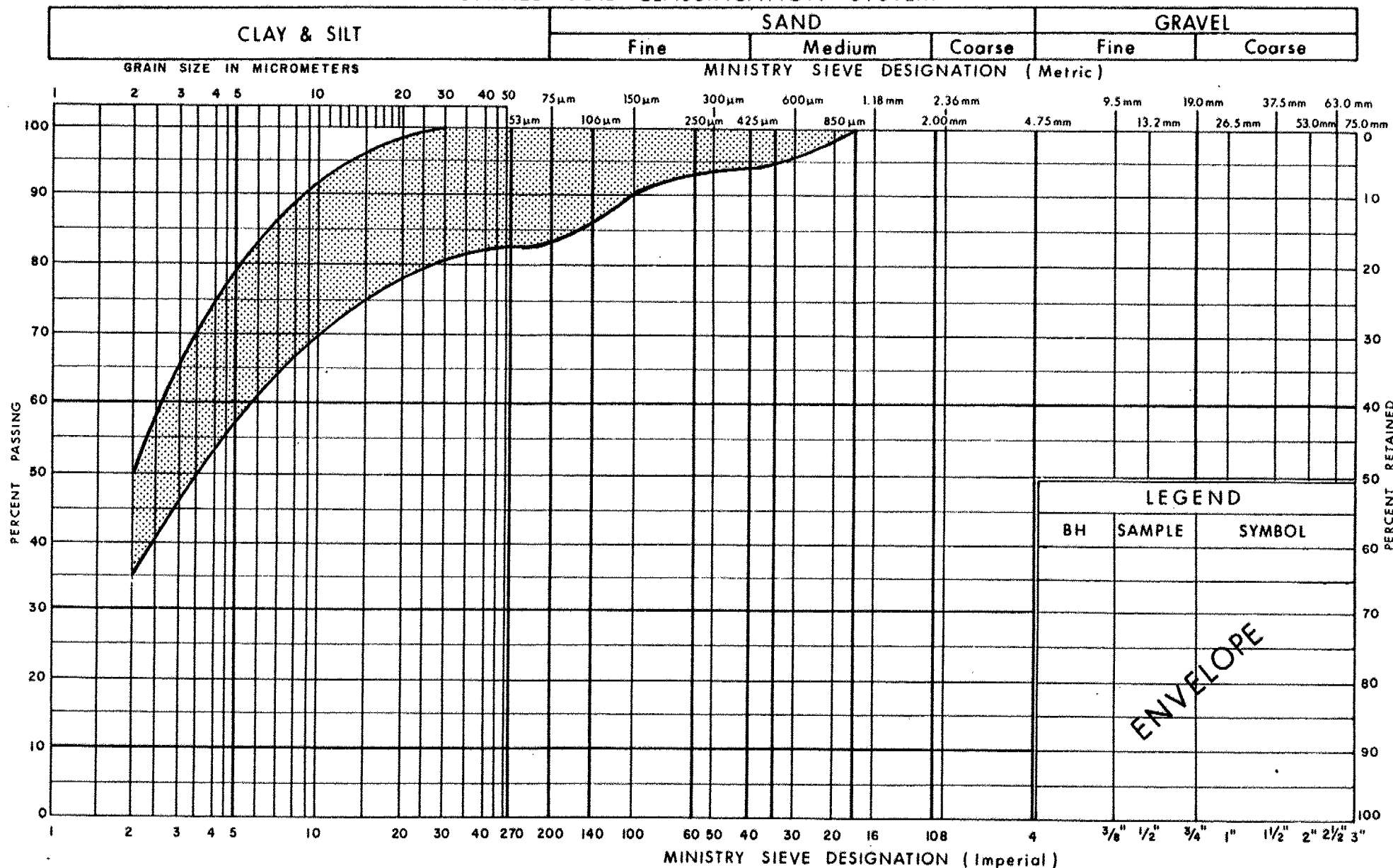
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Transportation

PLASTICITY CHART CLAYEY SILT, TRACE SAND

FIG No 3

W P 263-90-01

UNIFIED SOIL CLASSIFICATION SYSTEM



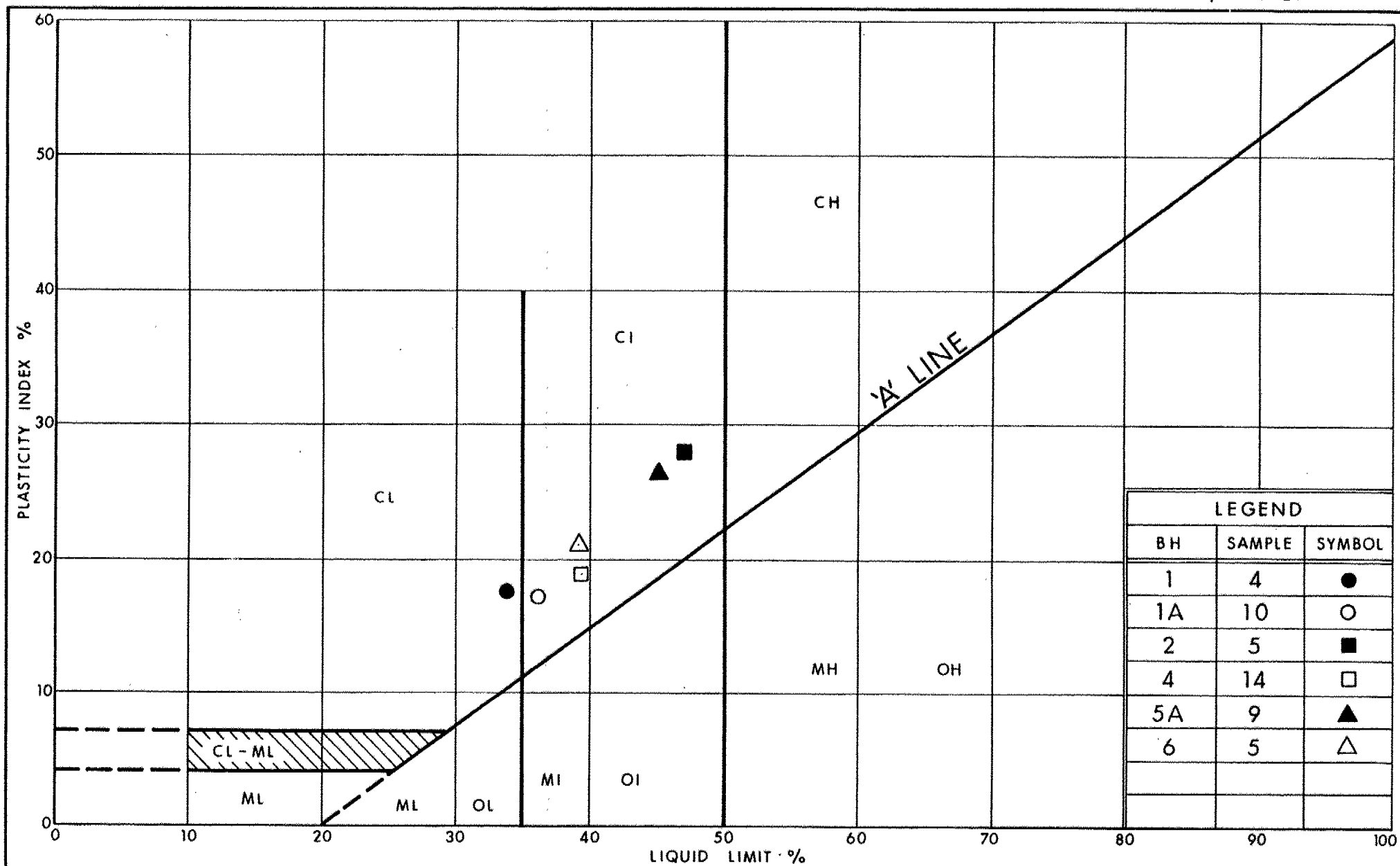
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GRAIN SIZE DISTRIBUTION
SILTY CLAY, TRACE SAND

FIG No 4

W P 263-90-01



LEGEND		
BH	SAMPLE	SYMBOL
1	4	●
1A	10	○
2	5	■
4	14	□
5A	9	▲
6	5	△



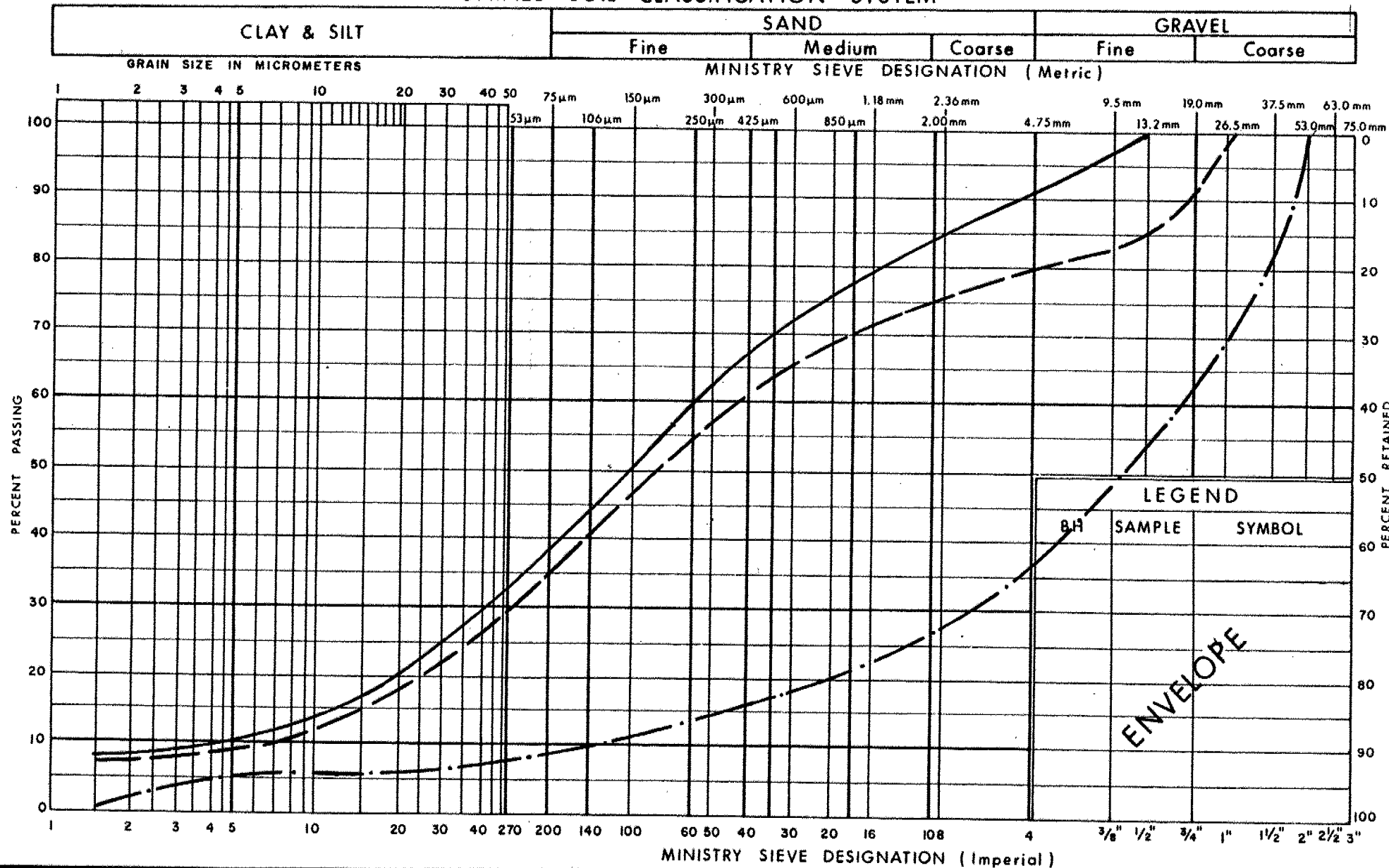
Ministry of
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PLASTICITY CHART SILTY CLAY, TRACE SAND

FIG No 5

W P 263-90-01

UNIFIED SOIL CLASSIFICATION SYSTEM



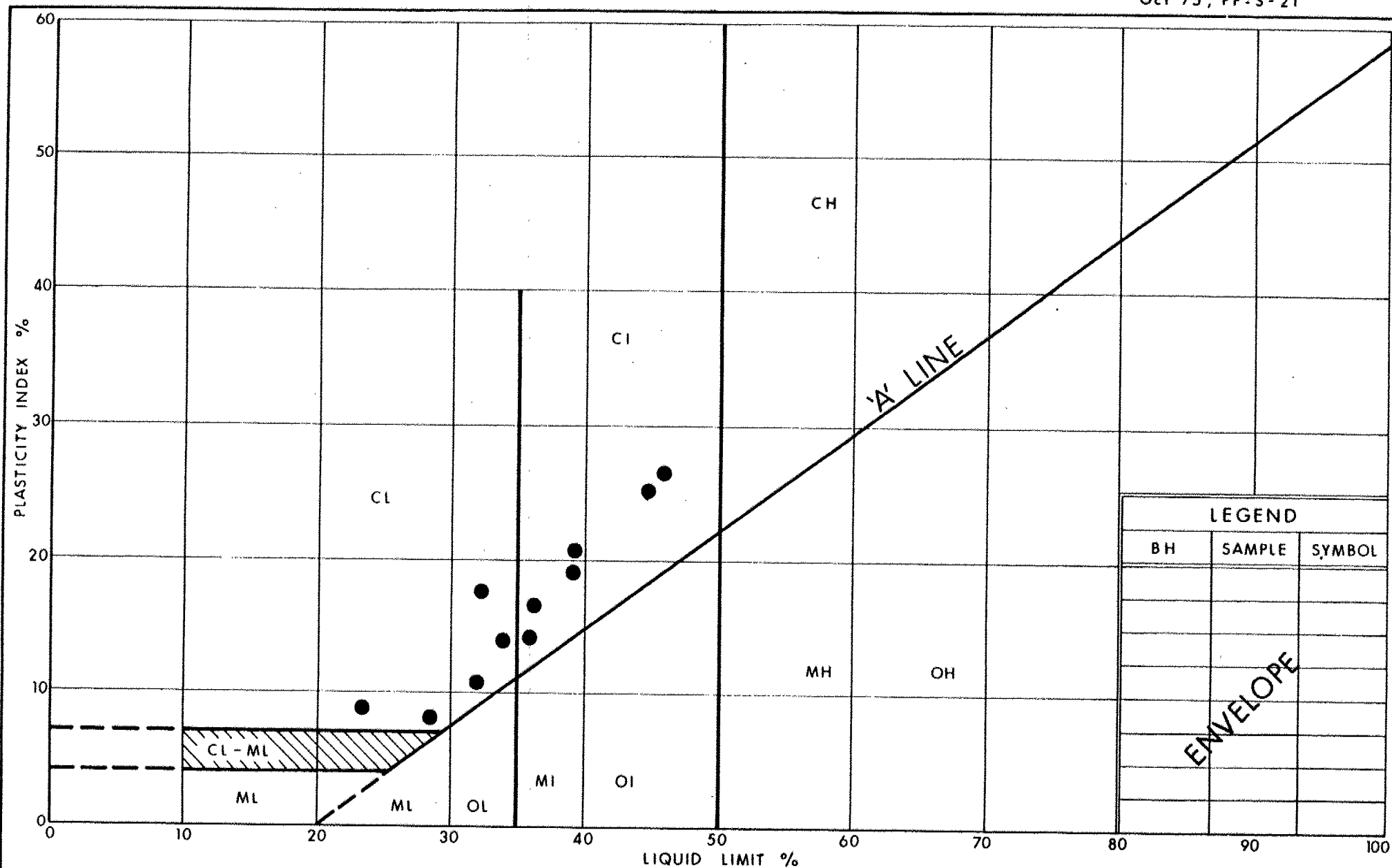
Ontario

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GRAIN SIZE DISTRIBUTION
SILTY SAND, TRACE GRAVEL

FIG No 6

W P 263-90-01



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PLASTICITY CHART SILTY CLAY TO CLAYEY SILT

FIG No 7

W P 263-90-01

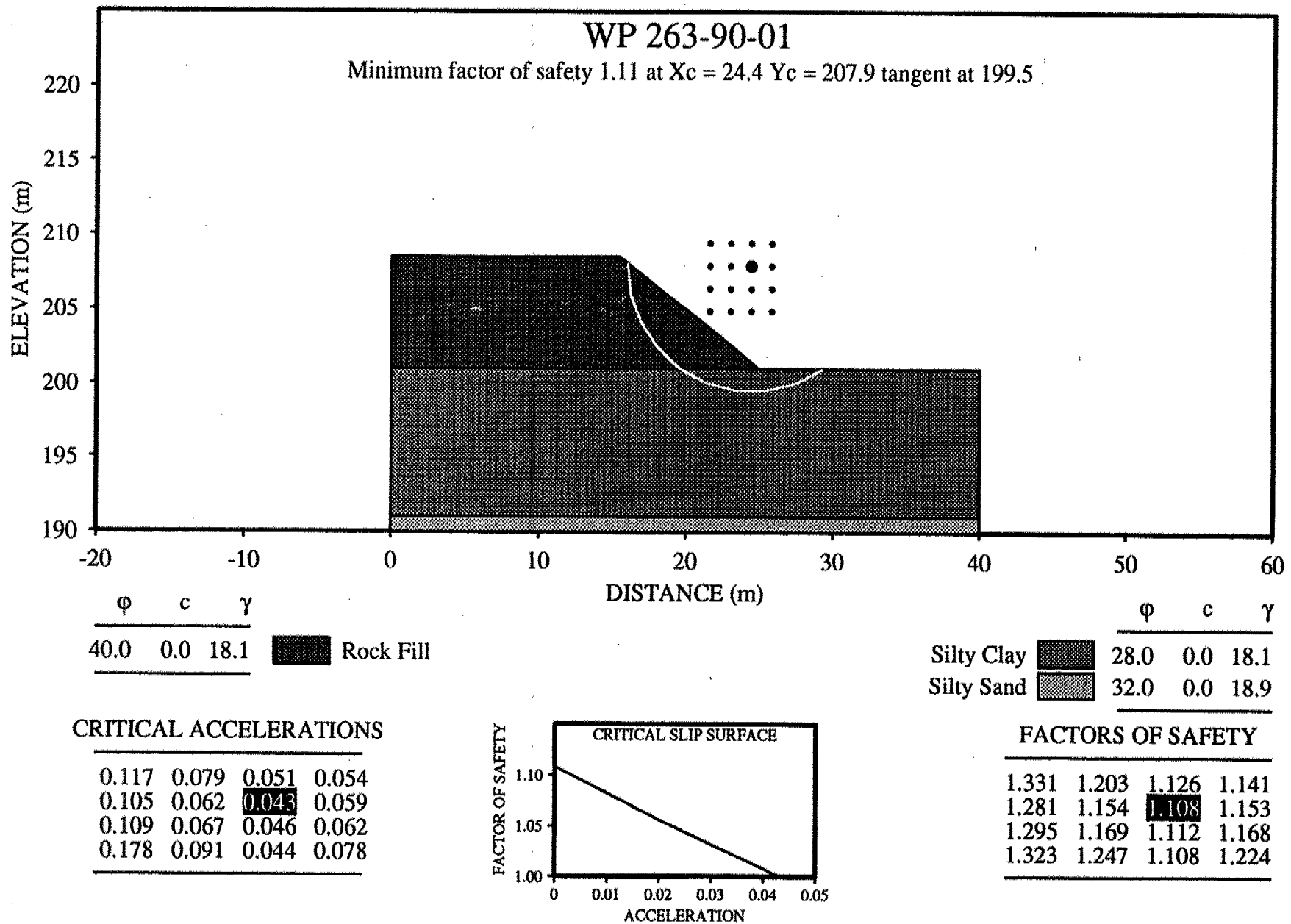


Fig - 8

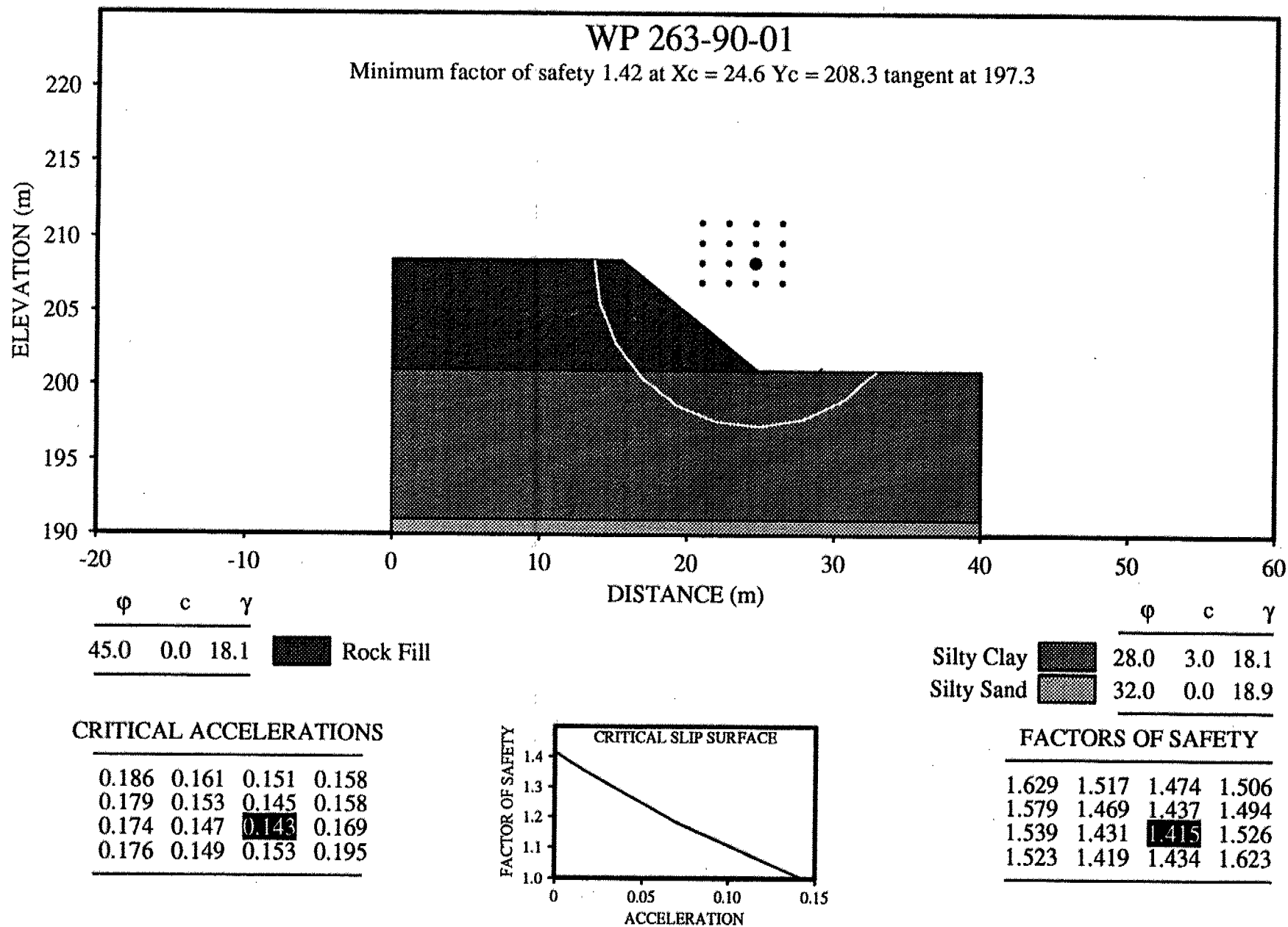


Fig - 9

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 263-90-01 LOCATION Sta.13+915 o/s 35m Lt of CL Hwy 17 ORIGINATED BY M.M.
DIST 62 HWY 17 BOREHOLE TYPE HS Auger BXL Rock Core COMPILED BY T.H.
DATUM Geodetic DATE 1994 11 02 CHECKED BY T.K.

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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
201.0	Ground Surface													
0.0	Organics													
	Clayey Silt Trace Sand Stiff		1	SS	6									
198.9			2	SS	5									
2.1			3	SS	7									
	Silty Clay Trace Sand Stiff		4	SS	2									
195.8			5	TW	PH									
5.2	Brown Grey		6	SS	22									
	Silty Sand some Gravel Compact to Very Dense		7	SS	120									
193.4	Boulders													
7.6	End of Borehole Auger refusal Probably bedrock or boulders Casing broke due to angle of rock													

RECORD OF BOREHOLE No 1A

1 OF 1

METRIC

W.P. 263-90-01 LOCATION Sta. 13+915 o/s 8.9m Lt. Cl. Hwy 17 ORIGINATED BY M.M.
DIST 62 HWY 17 BOREHOLE TYPE HS Auger COMPILED BY T.H.
DATUM Geodetic DATE 1994 11 02 CHECKED BY T.K.

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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100									
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100									
							WATER CONTENT (%) 20 40 60										
208.6	Ground Surface HWY 17																
0.0	Boulders with a mixture of Silt, Sand and Gravel (Rockfill)		1	SS	30		208										
			2	SS	14		207							54 40 5 1			
			3	SS	26		206										
			4	SS	6		205										
			6	SS	8		204										
			7	SS	8		203							3 57 25 15			
202.0			8	SS	7		202										
6.8	Clayey Silt trace Sand Hard		9	SS	6		201										
201.1				10	TW	PH		200					19.0				
7.5	Silty Clay trace Sand Hard						199										
199.8			11	SS	75		198										
8.8	Silty Sand trace Gravel Very Dense												9 53 34 4				
197.5			12	SS	120												
11.1	End of Borehole Auger Refusal Probable Bedrock or Boulders																

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 263-90-01 LOCATION STA.13+958.3 o/s 35m Lt CL Hwy 17 ORIGINATED BY M.M.
 DIST 62 HWY 17 BOREHOLE TYPE HS Auger BXL Rock Core COMPILED BY T.H.
 DATUM Geodetic DATE 1994 10 27 CHECKED BY T.K.

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W _p	W	W _L		
200.6	Ground Surface													
0.0	Organic					*								
	Clayey Silt trace Sand Firm		1	SS	8		200							
			2	SS	10		199							
198.5														
2.1	Silty Clay trace Sand Firm to Stiff		3	SS	6		198							
			4	SS	4		197							
			5	TW	PH		196							
			6	SS	2		195							
	Brown													
	Grey		7	SS	2		194							
			8	SS	2		193							
							192							
			9	SS	3		191							
190.5														
10.1	Silty Sand with Gravel Compact						190							
189.5			10	SS	20									20 45 32 3
11.1														
	Boulders		11	RC	REC 36%		189							RQD 0%
			12	RC	REC 33%		188							RQD 11%
			13	RC	REC 33%		187							RQD 0%
185.9							186							
14.7	End of Borehole * Water level not established													

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 263-90-01 LOCATION STA.13+995 o/s 8m Lt CL Hwy 17 ORIGINATED BY M.M.
 DIST 62 HWY 17 BOREHOLE TYPE HS Auger COMPILED BY T.H.
 DATUM Geodetic DATE 1994 10 26 CHECKED BY T.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
205.7	Ground Surface HWY 17													
0.0														
	Boulders with a mixture of Silt, Sand and Gravel (Rockfill)		1	SS	15		205							
			2	SS	57		204							
	Clayey Silt		3	SS	13		203							
			4	SS	9		202							
201.3														
4.4	Organics		5	SS	7		201							25 52 15 8
	Clayey Silt trace Gravel Very Stiff		6	SS	5		200							0 2 81 17
			7	SS	2									
199.2														
6.5			8	SS	6		199							
	Silty Clay trace Gravel Stiff to Very Stiff		9	SS	7		198							
			10	SS	5		197							
			11	SS	7		196							
	Brown													
	Grey		12	SS	5		195							
			13	SS	5		193							
191.5			14	TW	PH		192						18.0	
14.2	Silty Sand some Gravel Dense		15	SS	39		191							
190.5														

15.2 End of Borehole
 Auger Refusal, Probable Bedrock or Boulders

+3, x5: Numbers refer to
 Sensitivity

20
 15-5 (%) STRAIN AT FAILURE
 10

RECORD OF BOREHOLE No 5

1 OF 1

METRIC

W.P. 263-90-01 LOCATION Sta.13+960 o/s 6m Rt CL Hwy 17 ORIGINATED BY M.M.
 DIST 62 HWY 17 BOREHOLE TYPE HS Auger, Cone Penetration Test COMPILED BY T.H.
 DATUM Geodetic DATE 1994 11 01 CHECKED BY T.K.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT			UNIT WEIGHT γ KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					WATER CONTENT (%) w _p w w _L					
206.8	Ground Surface						20	40	60	80	100	20	40	60				
0.0	Boulders with a mixture of Silt, Sand and Gravel (Rockfill)					DRY *												
			1	SS	120													
			2	SS	120													
			3	SS	120													
202.1			4	SS	18													
4.7	End of Borehole																	
	Probable Clayey Silt																	
197.4																		
9.4	End of Cone Test																	
	Auger Refusal due to concerns over washing out of fines during casing penetration. Borehole terminated.																	

RECORD OF BOREHOLE No 5A

1 OF 1

METRIC

W.P. 263-90-01 LOCATION Sta. 13+927 o/s 8.5m Rt. CL Hwy 17 ORIGINATED BY M.M.
DIST 62 HWY 17 BOREHOLE TYPE HS Auger COMPILED BY T.H.
DATUM Geodetic DATE 1994 11 01 CHECKED BY T.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)		
208.3	Ground Surface HWY 17						20 40 60 80 100								
0.0	Boulders with a mixture of Silt, Sand and Gravel (Rockfill)		1	SS	4										
			2	SS	25										
			3	SS	10										
			4	SS	11										
			5	SS	2										
			6	SS	5										
202.4	Silty Clay trace Sand Very Stiff		7	SS	5										
			8	SS	2										
			9	TW	PH										
200.2	Brown														
8.1	Grey														
	Silty Sand trace Gravel Very Dense		10	SS	120	/30cm									
			11	SS	80	/10cm									
195.8															
12.5	End of Borehole Auger Refusal Probable Bedrock or Boulders * Water Table not Stabilized														

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 (R Q D), FOR MODIFIED RECOVERY, IS:

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

MECHANICAL PROPERTIES OF SOIL

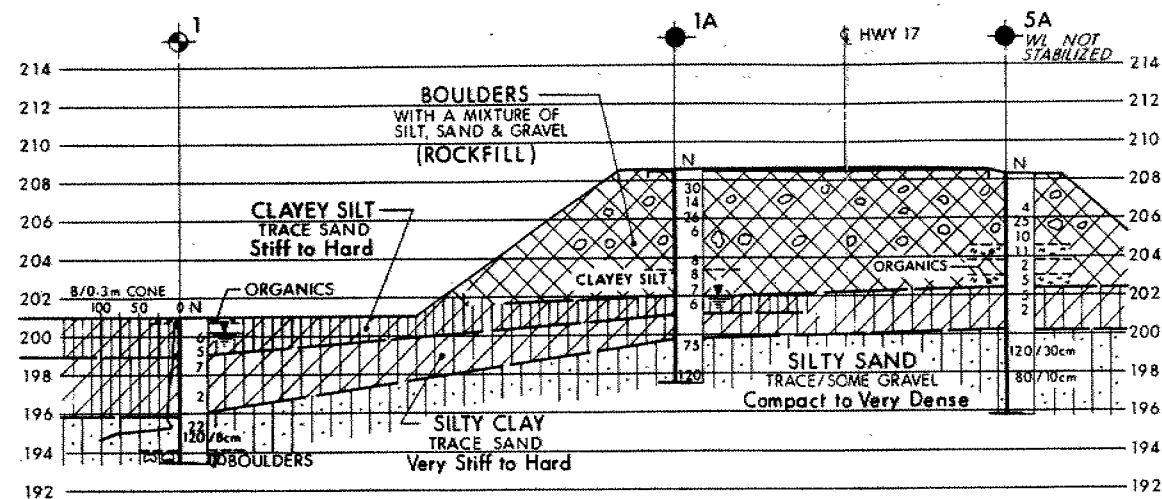
m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
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_i	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

STRESS AND STRAIN

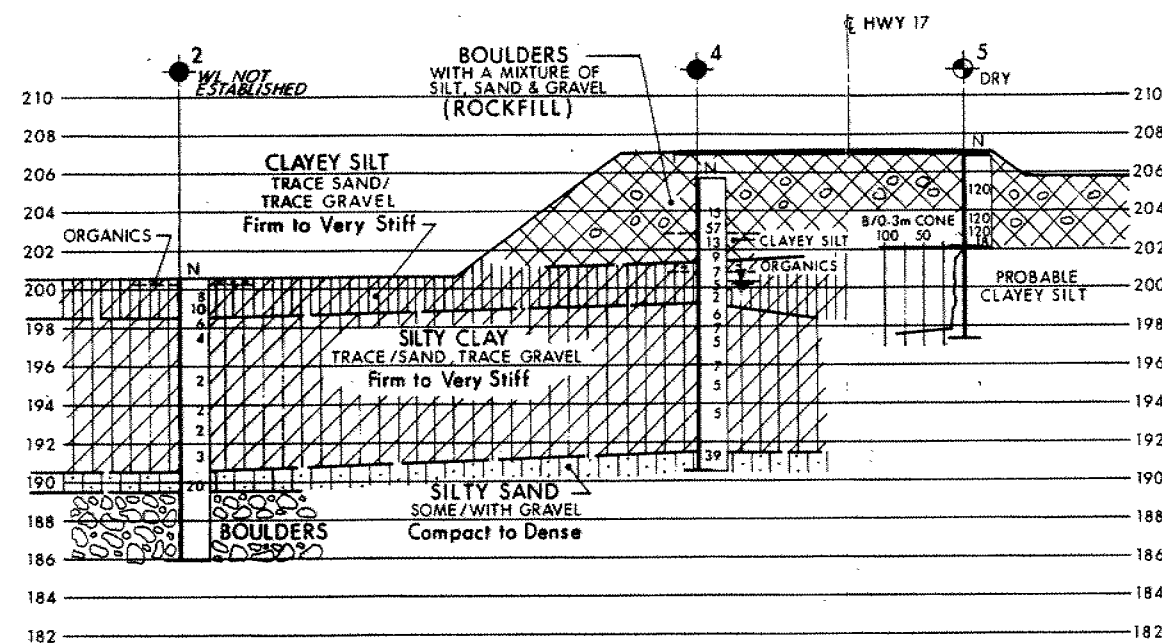
u_w	kPa	PORE WATER PRESSURE
u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS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

PHYSICAL PROPERTIES OF SOIL

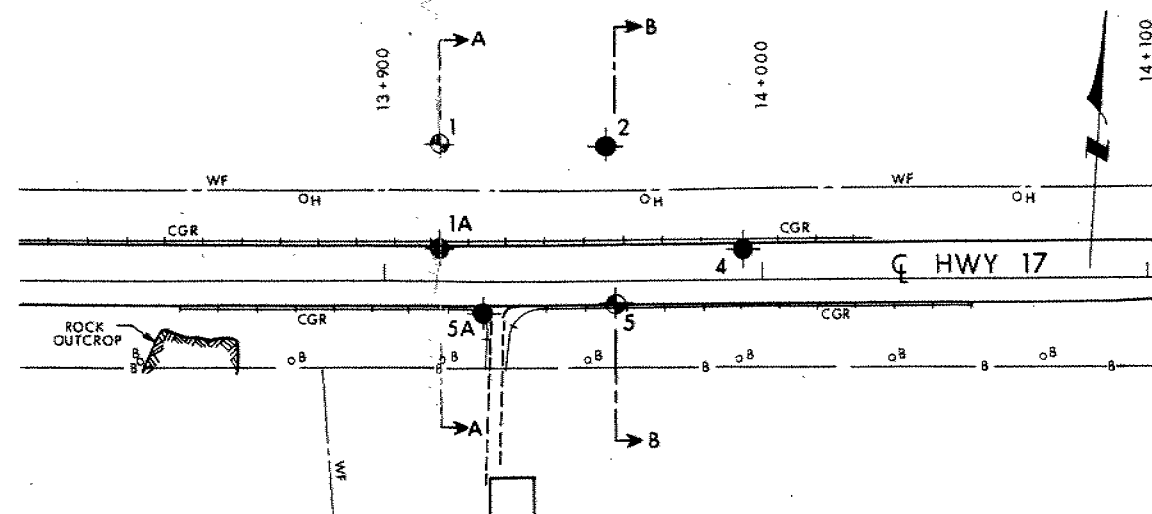
ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{\min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kn/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kn/m^3	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^2	SEEPAGE FORCE
γ'	kn/m^3	UNIT WEIGHT OF SUBMERGED SOIL						



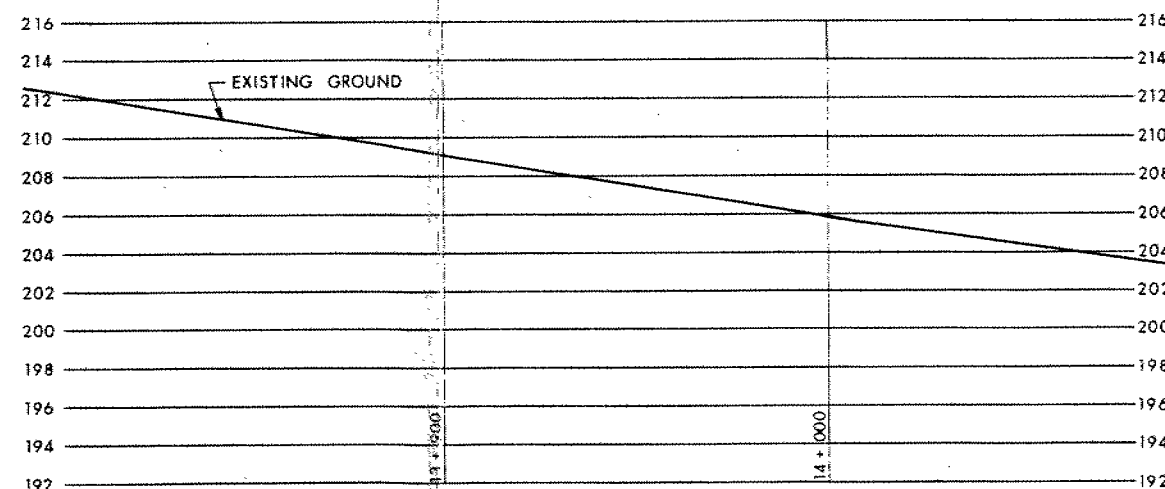
A-A



B-B
SECTIONS
SCALE
4m 0 4m



PLAN
SCALE
20m 0 20m



PROFILE HWY 17
SCALE
20m 0 20m Hor
4m 0 4m Vert

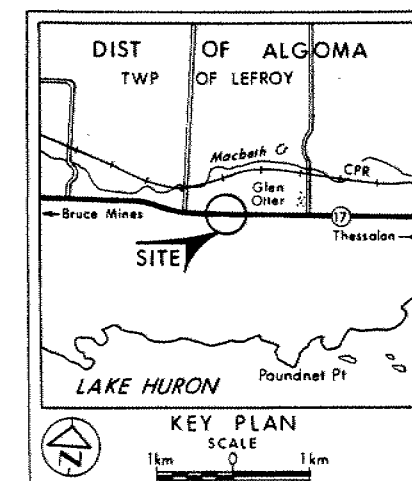
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

CONT No
WP No 263-90-01

EMBANKMENT FAILURE
STA 13+900 to STA 14+000
0.9km West of Hopper Rd
BORE HOLE LOCATIONS & SOIL STRATA



SHEET



LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊙ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation
1994 10 & 1994 11

No	ELEVATION	STATION	OFFSET
1	201.0	13+915.0	35.0m LT
1A	208.6	13+915.0	8.9m LT
2	200.6	13+958.3	35.0m LT
4	205.7	13+995.0	8.0m LT
5	206.8	13+960.0	6.0m RT
5A	208.3	13+927.0	8.5m RT

NOTE

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen Cond.



Ref Plan B-340-17-3, 1986 04

REV	DATE	BY	DESCRIPTION

Geocres No 41J-57

HWY No 17	DIST 62
SUBWD M.M. CHECKED/H.M.	DATE 1995 09 22
DRAWN D.T. CHECKED/H.M.	APPROVED
	SITE
	DWG 2639001-A

MEMORANDUM



TO: Bev MacMaster
Acting Manager of Construction
Northwestern Region

FROM: Pavements & Foundations Section
Room 223, Central Building

RE: Contract 97-208, W.P. 263-90-01
Slope Stability, Vermillion Bay Westerly
District 61, Thunder Bay

DATE: May 7, 1998

As requested, a site visit was carried out on April 27, 1998 to inspect the settlement that have occurred on Hwy. 17, west of Vermillion Bay (Township of Docker, Station 18 + 450 to 18 + 600). The site visit was conducted in collaboration with Mr. David Shaw of MTO and Mr. Jack Odson representing the Contract Administrator for the project. The memorandum summarizes our observations and recommendations to address the problems.

Site Inspection

Longitudinal cracks extending approximately 30 m long with approximately 6 m wide were observed along the centreline on westbound lane. The settlement magnitude ranged up to 10 mm on the north side in westbound lane. There is no evidence of settlement at the east bound lane.

Discussion and Recommendations


It is our understanding that the embankment was repaved sometime in October/November of 1997. At that time, the contractor placed additional rockfill on the existing slope on the north side of Hwy. 17 at this location. After the rockfill berm was placed at a certain level, a longitudinal crack developed on the eastbound lane of Hwy. 17. Rockfill placement was ceased and the pavement was patched at that time. It appears that there is some compressible organic layer underneath the existing slope. This layer is under compression due to additional load on the north slope by placing of rockfill.

Based on our observation we proposed the following recommendations:

- 1) Remove the rockfill from the berm to the lowest level of the existing rockfill berm pushing the excessive material toward north side into the swamp area.

- 2) Keep patching and monitoring the slope until the settlement is completed.
- 3) Once the settlement is completed, it is recommend that the existing subgrade material is removed and crushed stone is placed on the rockfill together with a geotextile and geogrid underneath the new subgrade material in order to prevent the migration of fines. Recompacting the new subgrade materials and restoring the pavement.

If you have any questions or require further discussion, please do not hesitate to contact this office.


Tae C. Kim, P. Eng.
Sr. Foundation Engineer

c.c. - B. Snell
D. Shaw
O. Witiw
T. Kazmierowski



TO: O. N. Warnock
Maintenance Supervisor
District # 18
Sault Ste. Marie

DATE: July 20, 1993

FROM: Geotechnical Section
Northwestern Region

Re: Pavement Failure - 0.9 km West of Hopper Road - LHRS 21270

The site was reviewed on July 15, 1993. This area received a Hot Mix patch approximately 3 to 4 years ago.

The existing paved shoulder of the Westbound Passing Lane (WBPL) has failed due to settlement of the large rock fill and underlying soils.

The alignment of the guiderail indicates lateral and vertical movement.

The failed shoulder is 88 metres in length. The cracking of the shoulder pavement also projects into the WBPL by approximately 1.5 metres for a length of 15 metres.

The failure is located on a rock fill approximately 10 metres in height. The overall failure area is within the confines of a low wet area covered with cattails. This drainage basin is also located on the south side of the highway.

On the south side of the highway, immediately east of an entrance to an old barn, the shoulder is indicating a failure 15 metres in length and projects into the shoulder approximately 1.0 metres.

Recommendation

There are three alternatives to repair the failed areas and they are:

North Side of Highway

1. Fill the existing cracks in the shoulder with Hot Mix and then pad with Hot Mix to correct cross fall deficiencies. This is a temporary measure only and can be considered a safety measure.
2. Remove the existing paved shoulder plus the WBPL full depth.

Reshape the base materials and add additional Granular 'A' as required to restore the cross fall.

Place 120 mm of HL4 in the WBPL consisting of the following:

- 40 mm average, 30 mm minimum, Lower Binder Course
- 40 mm average, 30 mm minimum, Upper Binder Course
- 40 mm average, 30 mm minimum, Surface Course
- 40 mm average, 30 mm minimum, Surface Course Shoulders

The surface course placed on the WBPL shall be keyed into the existing surface course for a depth of 40 mm x 300 mm wide.

This alternative will provide a smooth surface and should perform approximately 2 years based on past experience, before repairs are required again.

3. In order to resolve this area of continuing problems, it is recommended the Foundation Office be contacted for investigation and recommendation.

The Geotechnical Office will review previous contract documents to ascertain soil conditions and forward to the Foundation Design Office.

It should be noted that property requirements may be required to carry out a permanent solution as well as utility relocation.

South Side Highway

1. Place Hot Mix to correct cross fall deficiency.

P. J. Bound
Acting Head Geotechnical Section

PJB/lpc

memorandum

235-3696



To: T. Kazmierowski
Chief Foundation Engineer
Pavements and Foundations Section
Central Building, Room 315

Date: 94 11 16

Attn: M. Michalek

From: Soils and Aggregates Section
Engineering Materials Office
Central Building, Room 311

File No: 3162-2-4-113

Re: **Borehole Core Description**
Highway 17, Thessalon
W.P. 263-90-01

As requested by you, core from two (2) boreholes was logged. A description is appended. Bedrock is **GABBRO** and **QUARTZITE** of the Southern Province. Depth to bedrock and depth to unweathered to slightly weathered bedrock in each borehole are tabulated below:

Borehole number	Depth to bedrock in metres below ground surface	Depth to unweathered to slightly weathered bedrock in metres below ground surface
2	>14.7	>14.7
6	8.2	8.2

If you have any questions, please contact me.

D. A. Williams

David A. Williams,
Petrographer.

DAW/jlp
Attachment

ROCK CORE DESCRIPTION

WP 263-90-01

Page 1 of 1

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
2	11	11.13-12.04	36	0	11.13-14.71	OVERBURDEN (boulder till).
	12	12.04-13.41	33	11		
	13	13.41-14.71	33	0		
6	8	8.15-9.75	97	76	8.15-8.61	GABBRO (with chlorite alteration and pyrite-bearing), dark greenish grey; fine grained; strong; unweathered to slightly weathered; fractures moderate to very close spaced, dipping to near vertical, undulating to planar, smooth to rough.
					8.61-9.75	QUARTZITE (pyrite-bearing), medium dark grey to light grey to light brownish grey; medium grained; strong; unweathered to slightly weathered; fractures moderate to very close spaced, flat to near vertical, planar to undulating, smooth to rough.

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

Note: Depths are approximated where core recovery is less than 100%

Logged by: DAW, Soils and Aggregates Section