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DIST. 18 REGION

W.P. No.

CONT. No.

W. O. No. 70-11006

STR. SITE No.

HWY. No. 17N

LOCATION CPR RELOCATION
FEASIBILITY Study

No. of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

41 K-6

MEMORANDUM

To: Mr. J. L. Forster,
Regional Director,
Northwestern Region,
THUNDER BAY, Ontario.

FROM: Foundation Section,
Materials & Testing Office,
Room 107, Lab. Bldg.

ATTENTION: Mr. F. Norman,
Manager, Engineering
OUR FILE REF. Services.

DATE: May 27, 1970

IN REPLY TO

JUN 15 1970

SUBJECT:

PRELIMINARY FOUNDATION REPORT
For

Proposed C.P.R. Relocation West of
People's Road to East of Black Road
(Station 280+00 to Station 610+00)
City of Sault Ste. Marie

District of Algoma
District No. 18 (Sault Ste. Marie)
W.J. 70-11006 -- W.O. 69-27

Attached, we are forwarding to you, our Preliminary Foundation Investigation Report pertaining to the above sites. Presented in this report are the results of the investigation, together with our general comments pertaining to the stability of the approaches and recommendations regarding structure foundations at various crossings.

We believe that the information contained therein will prove adequate for your immediate use. Should you require further data, or clarification of the report, please feel free to contact this Office.

AGS/MdeF
Attach.

cc: Messrs. J. L. Forster
B. R. Davis
H. A. Tregaskes
D. W. Parren
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PRINCIPAL FOUNDATION ENGINEER

Foundations Files
Gen. Files

PRELIMINARY FOUNDATION REPORT
For
Proposed C.P.R. Relocation West of
People's Road to East of Black Road
(Station 280+00 to Station 610+00)
City of Sault Ste. Marie
District of Algoma
District No. 18 (Sault Ste. Marie)
W.J. 70-11006 -- W.O. 69-27

1. INTRODUCTION:

The Foundation Section was requested to carry out a preliminary foundation investigation for the proposed C.P.R. Relocation (Stations 280+00 to 610+00), to be located in the northern outskirts of Sault Ste. Marie, Ontario. This relocation will connect with the joint Algoma Central and Hudson Bay Railroad system at a point west of People's Road, while at its eastern extremity it will merge with the existing C.P.R. line.

Specifically, the purpose of this investigation was to provide preliminary information at the following locations:

- i) the grade separations at People's Rd., Hwy. #17 North and Old Garden River Road;
- ii) in an area where relatively high fills are to be placed (vicinity of Old Garden River and Black Roads);
- iii) in an area where relatively deep cuts are to be made (Hwy. #17 North easterly to Third Line Road); and
- iv) a number of natural valley crossings.

The request for this foundation investigation was contained in a memo from Mr. F. Norman, Manager, Engineering Services, Northwestern Région, dated January 16, 1970. An investigation was subsequently carried out by this Section to determine the subsoil, bedrock and groundwater conditions along the proposed relocation.

1. INTRODUCTION: (cont'd.) ...

This report presents all the factual data obtained during this investigation. Included are recommendations pertaining to the foundation design of the structures proposed at the interchange locations. In addition, the engineering factors to be considered in the cut, fill and natural valley crossing sections, such as the stability and settlement of fills, are discussed in detail in this report.

2. DESCRIPTION OF THE SITE AND GEOLOGY:

The terrain, in the area under consideration, encompasses two distinct terraces. The higher of the two terraces, located west of Hwy. #17 North, is gently undulating in relief between elevations 760 and 780. This area has in places been deeply incised by river and creek courses which have, by erosion, formed relatively deep steep-sided valleys. The major of these is located immediately east of Old Goulais Bay Road; this valley is 65 feet deep with slopes between 2:1 and 3:1. The lower terrace, located east of Old Garden River Road, is gently undulating in relief between elevations 610 and 640. From Old Garden River Road westerly to Hwy. #17 North, the terrain gradually rises to the high terrace; the relief in this area is quite rolling with many ridges and knolls standing above the surrounding ground surface.

The major portion of the relocation is located in non-built-up areas, which are cultivated and being used for farming purposes.

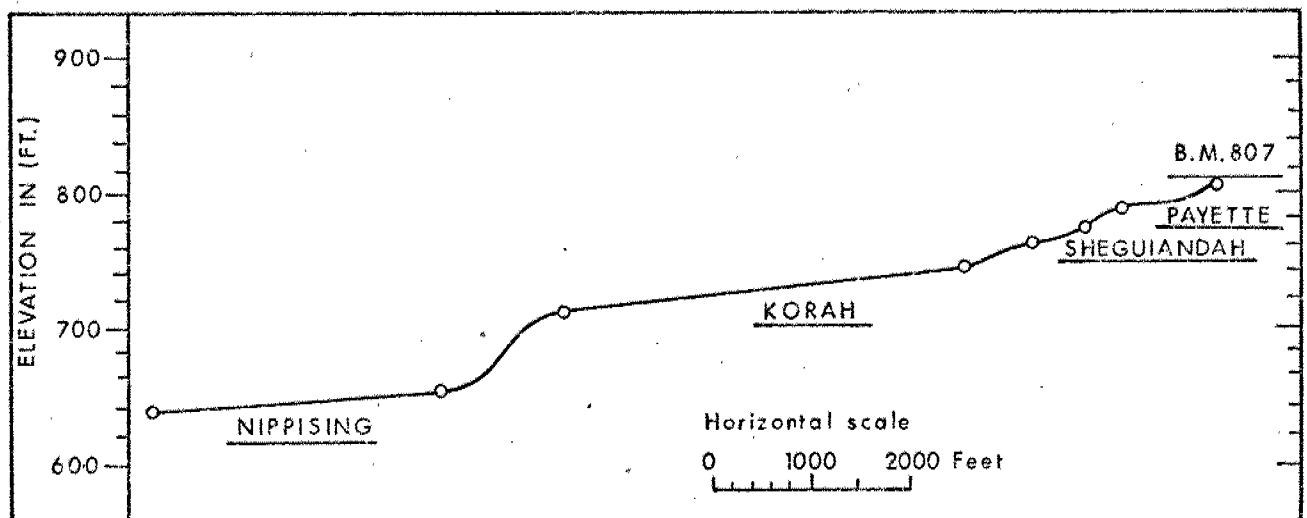
The geological history of the Great Lakes region is known to be quite complex.* The lakes are located almost wholly within the Precambrian Shield. Further, they are nearly surrounded with highlands - i.e., the general pattern is that of a syncline with the Great Lakes occupying the trough. The edge of this shield is located approximately 5 miles north of Sault Ste. Marie.

* Refer to "Geology of the Great Lakes" - Hough, J. L. - University of Illinois Press.

2. DESCRIPTION OF THE SITE AND GEOLOGY: (cont'd.) ...

In the geologic past the area was inundated by glacial Lake Algonquin, the main stage of which existed at about elevation 605. The lakeshore lay along the edge of a crystalline-rock upland, a few miles north of Sault Ste. Marie. In addition, there were a number of post-Algonquin sub-stages. During these sub-stages beaches were formed with the lake water outlets at successively lower levels. At least three such beaches have been identified in the Sault Ste. Marie area, namely, the Payette, Sheguiandah and the Korah systems; all these beaches are parallel to the original Algonquin beach. Following the Algonquin period, the general area was upwarped in a northerly direction; the maximum amount of uplifting occurs along a line located about 6 miles north of Sault Ste. Marie, here the Algonquin beach is known to be approximately 410 feet above the original glacial lake level, which was at elevation 605.

Following the aforementioned events, a low water stage, known as the Nipissing stage, existed. The deposits laid down in this, the most recent of the periods, crosses the parallel Algonquin beaches. This beach like the former beaches, was upwarped 25 to 50 feet above the present surface of Lakes Huron and Michigan. A typical profile in the Sault Ste. Marie area, showing the sequence and location of the various beaches, is given in the figure below.



2. DESCRIPTION OF THE SITE AND GEOLOGY: (cont'd.) ...

The deposits, laid down during the various glacial lake stages, were composed of stratified silts and sands completely interbedded with strata of layered clay. These deposits, which are of lacustrine origin, are of variable thickness.

The overburden is underlain by fine-grained ferruginous sandstone bedrock. Geologic references indicate that this bedrock was formed during a transitional period between the Precambrian and Cambrian eras. It is of the Bruce Series of the Upper Keweenaw System.

3. FIELD AND LABORATORY WORK:

Twenty-three boreholes were put down along the Relocation. In addition, a vane hole was put down in close proximity to one of the borings. The borings were advanced by using conventional diamond drill rigs adapted for soil sampling purposes.

Samples of the overburden were obtained, at specified intervals, in a 2" O.D. split-spoon sampler, which was hammered into the soil in accordance with the specifications for the Standard Penetration Test. In the cohesive portions of the overburden, the testing programme was supplemented by taking 2" I.D. Shelby tubes, which were manually pushed into the soil. In addition, field vane tests were carried out, where possible, to determine the undrained shear strength of the cohesive strata. Bedrock was proven in 6 of the boreholes by obtaining AXT size rock core samples.

Groundwater level observations were carried out, during the period of the investigation, in the open boreholes. Artesian groundwater conditions were encountered in two of the borings put down. Following completion of the drilling operations, the artesian flow was stopped by sealing the borings with bentonite.

3. FIELD AND LABORATORY WORK: (cont'd.) ...

The soil conditions encountered at the boring locations are presented on the Record of Borelog sheets. The location and elevation of the various boreholes were provided by personnel from the Northwestern Regional Engineering Surveys Section. The elevations in this report are referenced to a geodetic datum. The boring locations, and an estimated stratigraphical profile along the proposed relocation are shown on Drawing No. W.J. 70-1006A.

All the 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 overburden.

Bulk Densities
Natural Water Contents
Atterberg Limits
Grain-size Distributions
Undrained Shear Strengths
Consolidation Characteristics

The results of this testing are plotted on the Record of Borelog sheets and summarized on Figures 2 to 11, inclusive, contained in Appendix I of this report.

4. SUBSOIL AND BEDROCK CONDITIONS:

4.1) General:

The extent and composition of the overburden, within the area under investigation, varies markedly.

Along the lower terrace, located east of Third Line Road, the predominant stratum is composed of a soft to stiff layered clay to silty clay of marine origin. The thickness of this deposit

4. SUBSOIL AND BEDROCK CONDITIONS: (cont'd.) ...

4.1) General: (cont'd.) ...

varies from 15 feet to in excess of 175 feet; in general, it increases in an easterly direction. In some areas the cohesive stratum is overlain by up to 9 feet of loose to compact silty sand to sandy silt. The clay stratum is underlain by a competent glacial till deposit. The subsoil along this lower terrace was probably deposited during the Nipissing Stage.

Along the higher terrace, located west of Third Line Road, the overburden is composed of complexly interbedded deposits. The upper deposit, which varies randomly from 3 to 60 feet in depth, is a compact to very dense silty fine sand to silt. The surficial granular subsoil is underlain by a 20 to 60 foot thick firm to stiff layered clay to clayey silt stratum of lacustrine origin, which, in turn, is followed by a competent glacial till. In the immediate vicinity of People's Road this stratigraphical sequence is interrupted; here the cohesive stratum is composed of soft to stiff irregularly stratified silty clay, clayey silt and silt, the overall thickness of which ranges from 21 to 33 feet. The stratified cohesive subsoil is then underlain by an extensive granular deposit composed of compact to very dense silty fine sand to sandy silt. These deposits were probably laid down during either the Sheguiandah or Payette regimes.

The overburden deposits across the site are, in general, underlain by ferruginous fine -grained sandstone bedrock, the surface elevation of which is quite variable, due to the geologically complex history of this area (refer to Section #2).

The stratigraphy encountered in the borings is plotted on the Record of Borelog sheets. The stratigraphical profile, along the Relocation, has been inferred from this data and plotted on Drawing No. W.J. 70-11006A. The subsoil and bedrock, encountered from ground surface downward, is presented in the following sub-sections.

SURFICIAL DEPOSITS

4. SUBSOIL AND BEDROCK CONDITIONS: (cont'd.) ...

4.2) Surficial Deposits:

Over the majority of the area a granular surficial stratum is present. The composition of this faintly stratified stratum ranges from a reddish-brown to grey silty fine sand to sandy silt. In the vicinity of Hwy. #17 North (specifically, B.H.'s #6, 7 and 8), the subsoil is composed of a silt with a trace of clay. The thickness of this stratum is quite variable across the area; where encountered, it ranges from about 3 feet to as much as 63 feet (B.H. #14). Where the granular subsoil is most extensive, numerous random seams and layers of silty clay, up to 9 inches in thickness, are present throughout. Grain-size distribution curves, obtained on representative samples of the deposit, are plotted on Figures #2 and 3 in Appendix I.

The Standard Penetration Resistance testing, carried out within the stratum, is summarized on the Borelog sheets. The testing gave 'N' values which range from 11 to 72 blows/ft., being typically of the order of 18 blows/ft. Based on these values it is estimated that the relative density of the surficial granular subsoil varies from compact to very dense.

At those borings, put down along the existing roadways, fill was encountered. The fill, which is between 2 and 5 feet in depth, is composed of a compact silty sand and gravel. At B.H. #9, put down through an embankment located within the confines of a natural valley, 21 feet of fill was encountered. The upper 18 feet of the fill is composed of a very stiff clayey silt with sand and gravel. This is underlain by granular fill.

Along the floor of the natural valleys, between 2 and 5 feet of soft organic silt was encountered (refer to B.H.'s #1, 1A, 4, 4A, 5 and 5A). This organic material is probably a flood-plain deposit associated with the creeks located on the floor of these valleys.

COHESIVE STRATA

4. SUBSOIL AND BEDROCK CONDITIONS: (cont'd.) ...

4.3) Cohesive Strata:

4.3.1) Silty Clay, Clayey Silt and Silt (Stratified) -
(People's Road and Vicinity - B.H.'s #1, 1A,
2, 2A and 18):

The surficial deposits at the aforementioned borehole locations are underlain by a complexly stratified basically cohesive stratum of lacustrine origin. The overall thickness of the stratum varies from 16 to 35 feet. The composition of the individual stratifications, comprising the subsoil, varies from silty clay to clayey silt to silt. The thickness of the randomly oriented individual layers ranges from approximately 1/4 inch to up to 6 inches; the more plastic of these are generally the most predominant as well as thickest. In addition, random layers of silty sand were encountered. One such layer, encountered in B.H. #1, was about 3 feet thick. Grain-size distribution testing was carried out on samples obtained from the overall deposit. The results of the tests, on individual layers, are plotted on Figure #4; these curves indicate the variation in gradation within the layers.

The range in the engineering properties of the various layers is summarized in the following table:

4. SUBSOIL AND BEDROCK CONDITIONS: (cont'd.) ...

4.3) Cohesive Strata: (cont'd.) ...

4.3.1) Silty Clay, Clayey Silt and Silt (Stratified) -
(People's Road and Vicinity - B.H.'s #1, 1A,
2, 2A and 18): (cont'd.) ...

		Cohesive Layers (Clayey Silt to Silty Clay)			Non-Cohesive Layers (Silt)	
		<u>Range</u>	<u>(Average)</u>		<u>Range</u>	<u>(Average)</u>
Bulk Density (p.c.f.)	(γ)	115 - 118	(117)		-	
Liquid Limit (%)	(W_L)	34 - 50	(43)	*	21.5 - 25	(22)
Plastic Limit (%)	(W_P)	19 - 23	(21)	*	18 - 21.5	(19)
Natural Water Content (%)	(W)	46 - 82	(48)		26 - 41	(33)
Liquidity Index	(I_L)	0.8 - 2.0	(1.3)	*	1.0 - 2.0	(1.5)
<u>Compressibility Characteristics -</u>						
Void Ratio	(e_o)	Tests (1.1 and 1.5		-	
Compression Index	(C_c)		0.4 and 0.8		-	
Degree of Preconsolidation (p.s.f.)	($P_c - P_o$)		1,400 and 900		-	
<u>Undrained Shear Strengths (p.s.f.)</u> (C_u)						
In Situ Field Vane Tests		350 - 1,600			-	
Laboratory Tests		400 - 1,300				

* Atterberg Limit results carried out, where possible.

4. SUBSOIL AND BEDROCK CONDITIONS: (cont'd.) ...

4.3) Cohesive Strata: (cont'd.) ...

4.3.1) Silty Clay, Clayey Silt (Stratified) -
(People's Road and Vicinity - B.H.'s #1, 1A,
2, 2A and 18): (cont'd.) ...

The Atterberg limit test results, given in the table, are also summarized on the Plasticity Chart, Figure #6. The testing indicates that the cohesive layers are inorganic with a plasticity in the low to intermediate range.

The field and laboratory undrained shear strength results are plotted on the Record of Borelog sheets. The results indicate that the consistency of the cohesive zones varies randomly from soft to stiff.

The consolidation characteristics of the cohesive zones were determined by carrying out two laboratory consolidation tests, the results of which are shown as Void Ratio vs. Pressure plots on Figure #8. Referring to the figure, it can be seen that the clay is slightly preconsolidated in excess of the existing overburden pressure.

4.3.2) Clay to Clayey Silt (Layered) -
(Station 320+00 Easterly):

On the higher terrace, from People's Rd. easterly to Third Line Rd., the surficial deposits are underlain by a reddish-brown to grey layered clay to clayey silt stratum. The thickness of the individual layers vary randomly from 3 to 6 inches. The overall thickness of this deposit ranges from 8 feet (B.H. #5) to 111 feet (B.H. #3). Numerous seams of silt and sand up to 4 inches thick are present at random intervals throughout. In addition, at B.H.'s #3 and 15, a deposit of silty fine sand to sandy silt (up to 27 feet in depth), is sandwiched within this cohesive stratum. The results of grain-size distribution testing, carried out on representative samples of the stratum, are plotted on Figure #5.

4. SUBSOIL AND BEDROCK CONDITIONS: (cont'd.) ...

4.3) Cohesive Strata: (cont'd.) ...

4.3.2) Clay to Clayey Silt (Layered) -
(Station 320+00 Easterly): (cont'd.) ...

On the lower terrace, from Third Line Road easterly, another layered cohesive stratum was encountered. The composition of the individual layers, whose thickness is anywhere from 1/2 to 6 inches, ranges from clay to silty clay. The thickness of this stratum varies from 15 feet at B.H. #17 to in excess of 172 feet at B.H. #13 - i.e., increases in an easterly direction. The upper 2 to 6 feet of the cohesive subsoil has been 'desiccated' forming a crust. In addition, random seams of silt and sand are present throughout, as discussed in the previous paragraph. The results of the grain-size distribution testing, carried out on representative samples obtained from the stratum, are plotted on Figure #5 .

It is believed that the cohesive stratum encountered on the high terrace, and that on the low terrace, were laid down during different stages of the Algonquin regime (refer to Section #2). The respective engineering properties of the two cohesive sheets are presented, for comparison purposes, in tabular form.

4. SUBSOIL AND BEDROCK CONDITIONS: (cont'd.) ...

4.3) Cohesive Strata: (cont'd.) ...

4.3.2) Clay to Clayey Silt (Layered) -
(Station 320+00 Easterly): (cont'd.) ...

		Clay to Clayey Silt (Layered) High Terrace (Sta. 320+00 to Sta. 450+00)		Clay to Silty Clay (Layered) Low Terrace (Sta. 470+00 to Sta. 600+00)	
		<u>Range</u>	<u>(Average)</u>	<u>Range</u>	<u>(Average)</u>
Bulk Density (p.c.f.)	(γ)	109 - 123	(114)	97 - 118	(106).
Liquid Limit (%)	(W_L)	29 - 61	(42)	35 - 66	(43)
Plastic Limit (%)	(W_P)	18 - 24	(21)	16 - 25	(22.5)
Natural Water Content (%)	(W)	26 - 56	(37)	31 - 78	(48)
Liquidity Index	(I_L)	0.6 - 1.3	(0.9)	0.6 - 1.4	(1.1)
<u>Compressibility Characteristics -</u>					
Void Ratio	(e_o)	0.75 - 1.2	} Tests	2.1 - 2.4	} Tests
Compression Index	(C_c)	0.27 - 0.57		1.6 - 2.5	
Degree of Preconsolidation (p.s.f.)	($P_c - P_o$)	2,000 - 2,400		0 - 600	
<u>Undrained Shear Strengths</u> (p.s.f.)					
		(C _u)			
In Situ Field Vane Tests		750 ->2,000		375 - 2,000	
Laboratory Tests		750 - 1,600		350 - 1,600	

4. SUBSOIL AND BEDROCK CONDITIONS: (cont'd.) ...

4.3) Cohesive Strata: (cont'd.) ...

4.3.2) Clay to Clayey Silt (Layered) -
(Station 320+00 Easterly): (cont'd.) ...

The Atterberg limit test results, given in the table, are also summarized on the Plasticity Chart, Figure #6. The testing indicates that the cohesive strata have a plasticity which falls basically into the same range, namely, from low to high, being on the average, intermediate. The liquidity indices of the clay on the lower terrace is, however, consistently higher than that on the higher; this would indicate that this sheet is a more compressible and sensitive subsoil.

The field and laboratory undrained shear strength results are plotted on the Record of Borelog sheets. The results indicate that the cohesive stratum, encountered on the upper terrace, has a consistency which varies from firm to very stiff, being typically in the stiff range. The cohesive deposit on the lower terrace, however, has a consistency which varies from soft, immediately below the desiccated crust, to stiff with depth. Typical stress-strain curves for the cohesive strata are plotted on Figure #7. Failure generally occurred at low strains, namely, between 3 and 5 percent.

The consolidation characteristics of the cohesive strata were determined by carrying out a series of laboratory consolidation tests, the results of which are shown as Void Ratio vs. Pressure plots, on Figures #8 and #9. Referring to the table, it can be seen that the cohesive stratum on the lower terrace is: i) much less preconsolidated in excess of existing overburden pressure, and ii) is more compressible, than that on the higher terrace.

4. SUBSOIL AND BEDROCK CONDITIONS: (cont'd.) ...

4.3) Cohesive Strata: (cont'd.) ...

4.3.2) Clay to Clayey Silt (Layered) -
(Station 320+00 Easterly): (cont'd.) ...

In addition to the more routinely employed tests previously described, an additional laboratory programme was carried out to determine the engineering properties of the compressible clay (encountered along the lower terrace) in terms of effective stresses. This was done by carrying out a series of isotropically consolidated - undrained triaxial compression tests, in which the excess pore water pressure build-up due to applied load was monitored throughout (CIU test). The results of this testing are summarized on Figure #10.

This testing indicates that the subsoil behaves quite differently once the preconsolidation pressure is exceeded ($P_c \approx 11.5$ p.s.i. from consolidation test). This is substantiated by the effective stress parameters obtained above and below this value, namely,

	<u>Stresses Below P_c</u>	<u>Stresses Above P_c</u>
C' (Effective Cohesive Intercept)	300 p.s.f.	0
ϕ' (Effective Angle of Friction)	$12\frac{1}{2}^\circ$	$23\frac{1}{2}^\circ$

As discussed in Section #2, this clay was deposited in a marine environment; following weathering and leaching processes it developed a 'metastable' or 'bonded' type of structure, which is extremely sensitive to disturbance. Once such a clay is stressed to a level beyond the existing preconsolidation pressure this bonding is destroyed and the clay loses its structured orientation and deforms plastically. This no doubt explains the loss of the apparent cohesion once this level of stress is exceeded - i.e., the subsoil behaves as a basically frictional material.

4. SUBSOIL AND BEDROCK CONDITIONS: (cont'd.) ...

4.3) Cohesive Strata: (cont'd.) ...

4.3.2) Clay to Clayey Silt (Layered) -
(Station 320+00 Easterly): (cont'd.) ...

The build-up of excess pore water pressure was also considerable upon load application; when the soil was stressed to a level in excess of the preconsolidation pressure. This was represented by a pore pressure coefficient 'A'* which was consistently greater than 1.0, where, in the laboratory test

$$\Delta u = A (\sigma_1 - \sigma_3)$$

Δu - excess pore water pressure (p.s.f.)

$(\sigma_1 - \sigma_3)$ - deviator stress (p.s.f.)

'A' - Dimensionless parameter

'A' values, greater than 1.0, are indicative of very sensitive soft clays.

* After Skempton, A. W., 1954 -
"The Pore Pressure Coefficients 'A' and 'B'" -
Geotechnique, 4:143-47.

GLACIAL TILL

4. SUBSOIL AND BEDROCK CONDITIONS: (cont'd.) ...

4.4) Lower Deposits:

4.4.1) Silty Fine Sand to Sandy Silt:

From Old Goulais Bay Road (approximate Station 340+00) westerly, the cohesive strata are underlain by an extensive deposit of compact to very dense ('N' values between 12 and 68 blows/ft.) silty fine sand to sandy silt. The borings put down in the area were terminated within this deposit; at B.H. #2 it was proven for a depth of in excess of 100 feet. Numerous seams and layers of silty clay, up to 6 inches in thickness, are present throughout. Grain-size distribution curves, obtained on the deposit, are plotted on Figure #2, referred to in Sub-section 4.2).

4.4.2) Glacial Till:

East of Old Goulais Bay Road the cohesive strata are underlain by a glacial till. The thickness of this deposit, where fully penetrated, varies from 2 feet to 16 feet. The glacial till is basically granular in nature, that is, a heterogeneous mixture of silt, sand and gravel, with a trace of clay. There are, however, random zones within the deposit where the matrix is cohesive, namely, it is composed of a clayey silt binding sand and gravel. The range in the grain-size gradation of this subsoil is indicated by the curves plotted on Figure #11. Where the deposit is most extensive, the lower portion is often quite bouldery; the boulders encountered were up to 6 inches in size.

Based on the standard penetration resistance testing carried out within the deposit, it is estimated that the relative density of the granular portions range from compact to very dense, being generally very dense. The cohesive portions have a consistency in the very stiff to hard range.

4. SUBSOIL AND BEDROCK CONDITIONS: (cont'd.) ...

4.5) Bedrock:

Bedrock was proven at 6 of the boring locations by obtaining between 3 and 10 feet of AXT size rock core samples. The surface of the bedrock is quite variable, ranging from elevation 517 (B.H. #12) to elevation 702.5 (B.H. #9). The bedrock would appear to have an anticlinal structure in the vicinity of Third Line Road, because, from this point, it slopes away steeply in both an easterly and westerly direction.

The bedrock is composed of a fine-grained, reddish-brown ferruginous sandstone with mottled whitish interbeds. Occasional shaley bands, up to 6 inches in thickness, are also present at random intervals. In general, bedrock is sound throughout; however, some signs of fracturing and jointing were observed in the upper 2 to 3 feet at a few of the boring locations.

5. GROUNDWATER CONDITIONS:

Groundwater level observations have been carried out during the period of the investigation by recording the water level in the open borings. The observations are recorded on the borelog sheets and summarized on Drawing No. W. J. 70-11006A. The results of the measurements indicate that the piezometric groundwater level, within the overburden deposits, generally varies between 6 and 22 feet below existing ground surface. Within the natural valleys, however, the groundwater level is within a few feet of ground surface. Referring to the aforementioned drawing, it can be seen that there is a natural hydrostatic groundwater gradient towards the valleys. This would indicate that these valleys do, in fact, control the drainage in the area.

At B.H.'s #4 and 12 artesian conditions were encountered. When the casing at these locations was advanced through the upper cohesive deposit, down into the lower glacial till zone found

5. GROUNDWATER CONDITIONS: (cont'd.) ...

immediately above the bedrock, the water rose instantaneously in the casing. The condition stabilized itself at a height of 5 and 3 feet above ground surface at B.H.'s #4 and 12, respectively. The thin glacial till deposit, as well as the upper fractured and jointed portion of the bedrock is relatively pervious in comparison with the overlying cohesive strata. It is inferred that these relatively pervious zones are acting as a confined aquifer; such layers are probably being charged with groundwater from the surrounding terrain, which is at a higher elevation.

6. DISCUSSION AND RECOMMENDATIONS:

6.1) General:

The proposed C.P.R. Relocation, which will be approximately 6-1/2 miles in length, will run in a southeasterly to northwesterly direction in the northern outskirts of the City of Sault Ste. Marie. In the east it will connect with the existing C.P.R. (approx. Station 610+00), while in the west the connection will be with the Algoma Central and Hudson Bay Railway system (approx. Station 280+00). The proposed relocated C.P.R. will have two tracks.

The proposed alignment of the C.P.R. is shown on Drawings prepared by M. M. Dillon Limited, Consulting Engineers - (Drawings Nos. B 917-6, -7, B 1300-2, dated January, 1970). The preliminary centre-line profile grade was also provided (No. 6349-01, dated January, 1970).

On the high terrace the proposed grade of the C.P.R. will be between elevations 773 and 775. East of Hwy. #17 N, however, the grade will decrease at the rate of 1.2% to a point east of Black Road; on the lower terrace the grade will range between elevations 620 to 640.

6. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

6.1) General: (cont'd.) ...

This report will be concerned with a number of foundation engineering considerations associated with the proposed scheme; specifically:

(a) Stability and settlement considerations associated with the relatively high fills - (Max. height 30 feet) proposed in the vicinity of Old Garden River and Black Roads - (Stations 460+00 to 500+00).

(b) The stability of cuts up to 30 feet in depth; the cuts will be located east of Hwy. #17 N., between Stations 420+00 and 445+00.

(c) Three natural valley crossings, located in the western portion of the alignment.

(d) Proposed grade separations to be located at People's Rd., Hwy. #17 N. and Old Garden River Road.

In addition, two alternate locations for a 'Potential Industrial Area' have been presented. One is located immediately east of People's Rd., while the other is on the Second Range located in the eastern portion of the proposed alignment.

The subsoil, bedrock and groundwater conditions, encountered along the C.P.R. Relocation, which were discussed in the previous sections, are shown on Drawing No. W.J. 70-11006A.

The detailed recommendations, pertaining to each of the aspects listed above, will be discussed separately in the sub-sections to follow. Summarized comments on the feasibility of adopting the proposed alignment and profile grade, will be presented in Section #7.

6. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

6.2) Stability and Settlement Considerations for Fill Section -
Between Stations 460+00 and 500+00:

6.2.1) General:

To reach the proposed C.P.R. profile grade, between the aforementioned stations, it will be necessary to place between 20 and 30 feet of fill. These fills will be underlain by between 36 and 117 feet of soft to firm compressible clay to silty clay (layered) stratum.

The presence of this compressible cohesive stratum, at a relatively shallow depth below ground surface, requires that steps must be taken to ensure the overall stability of the fill sections as well as limit the settlements to a tolerable magnitude.

6.2.2) Stability Considerations:

The critical condition for stability of an embankment on normally or slightly overconsolidated clays, as is the case with this clay stratum, generally occurs during or immediately after construction. This being the case, a total stress analysis ($\phi = 0$) provides a suitable means of assessing the stability of the fill sections. In this method of analysis, stability is governed by the applied loads and the stress-strain and undrained shear strength properties of the foundation and fill material.

Analyses have been carried out, therefore, in terms of total stresses, both manually and by the use of the electronic computer, to determine the stability of the fill sections. The geometric sections of the fills, as well as the soil properties for the fill and natural subsoil, assumed for computation purposes, are presented on Figure #1, in Appendix I of this report. The results of the analyses, presented on the aforementioned figure, are summarized in the following paragraphs.

6. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

6.2) Stability and Settlement Considerations for Fill Section -
Between Stations 460+00 and 500+00: (cont'd.) ...

6.2.2) Stability Considerations: (cont'd.) ...

The results of the stability analyses carried out, are summarized below: (a total unit weight of 125 p.c.f. was assumed for the in-place fill material).

- Fills up to 14 feet in height may be constructed with standard 2:1 slopes.
- Fills in excess of 14 feet will require berms. For instance:
 - for a fill height of 20 feet, a single mid-height berm of 50 feet will be required.
 - for a fill height of 30 feet, double berms, each approximately 60 feet in width, should be incorporated into the design. These berms should be located at equi-distances along the slope (i.e., at the third points).

A smooth transition should be effected between the varying berm sections required along the relocation.

Based on the computations carried out, the following comments are presented:

- 1) It may be advantageous to minimize the berm requirements by limiting the heights of fill to something of the order of 20 feet. This could be accomplished by lowering the profile grade proposed for the C.P.R. Relocation.

6. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

6.2) Stability and Settlement Considerations for Fill Section -
Between Stations 460+00 and 500+00: (cont'd.) ...

6.2.2) Stability Considerations: (cont'd.) ...

2) If lightweight fill, such as slag, is available from the local steel mill, consideration could be given to the utilization of such material for embankment construction.

Since the induced surcharge loading would be reduced the stability of the fill sections would be improved. The stability computations carried out, indicate the following:

- Fills less than 20 feet in height, may be constructed with standard 2:1 slopes.
- Fills 30 feet in height would require a single mid-height berm 55 feet in width.

In these computations it was assumed that the unit weight of the lightweight fill was 90 p.c.f.

3) As an alternative to the aforementioned, the C.P.R. could be trestled either completely or partially over this problem area.

All the proposals discussed are feasible with respect to stability of the fills. The ultimate choice will, however, be based on economic considerations as well as the comments presented regarding the foundation conditions.

6.2.3) Settlement Considerations:

The underlying highly compressible cohesive stratum will undergo excessive settlements due to consolidation, over a long-term period, under the weight of the approach embankments. Settlement computations were, therefore, carried out, the results of which are summarized on Figure #1 in the Appendix.

6. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

6.2) Stability and Settlement Considerations for Fill Section - Between Stations 460+00 and 500+00: (cont'd.) ...

6.2.3) Settlement Considerations: (cont'd.) ...

The range in consolidation settlement, predicted for various heights of fill, are summarized in the following table:

<u>Height of Fill</u>	<u>Fill Material</u>	<u>Berm Requirements</u>	<u>Estimated Consolidation Settlement</u>
30 ft.	Locally Available ($\gamma = 125$ p.c.f.)	Double - Each 60' in Width	4 ft. - 4 years 7 ft. (Max.) - 25 years
30 ft.	Lightweight ($\gamma = 90$ p.c.f.)	Single 50' in Width	$2\frac{1}{2}$ to 3 ft. - 4 years 5 to $5\frac{1}{2}$ ft. (Max.) - 25 years
20 ft.	Locally Available ($\gamma = 125$ p.c.f.)	Single 50' in Width	$2\frac{1}{2}$ to 3 ft. - 4 years 5 to $5\frac{1}{2}$ ft. (Max.) - 25 years
20 ft.	Lightweight ($\gamma = 90$ p.c.f.)	Nil	1.5 to 2 ft. - 4 years 3 to 4 ft. (Max.) - 25 years
14 ft.	Locally Available ($\gamma = 125$ p.c.f.)	Nil	1.5 to 2 ft. - 4 years 3 to 3.5 ft. - 25 years

It is considered that the estimated settlements may occur at a faster rate than that theoretically computed, because of the presence of the occasional permeable silt layers within the cohesive stratum, which would accelerate the drainage in the lateral direction. In view of this, it would, therefore, be advantageous to construct the embankments first and leave them in place for as long a period as possible, prior to placing the tracks (say, for 18 to 24 months).

6. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

6.3) The Stability of Cuts - Stations 420+00 to 445+00:

Between the aforementioned stations, the C.P.R. will be in cut; the maximum depth of the cut will be of the order of 30 feet. Over the majority of this area the cuts will be carried out within the surficial compact silt deposit. In the eastern portion, however, they will extend through the silt down into the firm to stiff cohesive stratum. East of Station 420+00 the cuts will be as much as 18 to 20 feet below the groundwater level recorded at the time of the investigation.

No stability problems are anticipated for cuts with standard 2:1 slopes, provided suitable drainage measures are adopted in those areas where cut sections extend below the groundwater level.

In order to control the seepage forces and consequent erosion that may occur below the groundwater level, it is recommended that a sand blanket, with a minimum thickness of 18 to 24 inches, be placed on the side slopes. This blanket should extend to an elevation approximately one foot above the observed high groundwater level. The blanket should be composed of a material which will act as a proper filter with respect to the natural silty subsoil. Both the blanketed and upper portion of the cut slopes should be sodded, staked and wire-meshed as per current D.H.O. methods (Standard No. DD-403).

Adequately designed interceptor ditches should be constructed at the top of the cut sections in order to prevent spill-over of surface run-off onto the surface of the cut slopes. In addition, it is recommended that an interceptor drainage ditch with a 6" diameter perforated sub-drain, should be constructed at the toe of the cut slopes. The perforations of the sub-drain pipe should be oriented downwards and covered in all directions with suitable granular material. The pipe should be located at least 5 feet below ground surface in order to provide adequate frost protection.

6. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

6.4) Natural Valley Crossings - Western Portion of the Alignment:

The C.P.R. Relocation will cross three natural valleys which are underlain by compressible cohesive subsoil. It is proposed to construct earth fills within the confines of the valley banks. The drainage course, along the valley floor, would be maintained by having culverts located within the fill.

The feasibility of employing earth fills will be dependent on the following co-related factors:

- i) the depth of the valley - i.e., the height of fill required; and
- ii) the overall thickness and strength-compressibility characteristics of the subsoil.

Stability and settlement analyses were carried out, based on the contemplated height of fill at each crossing; these are presented in the following table:

RECOMMENDATIONS - NATURAL VALLEY CROSSINGS

Location of Valley	Est. Thickness of Cohesive Deposit Beneath Valley Floor -	-- E M B A N K M E N T S --			Remarks
		Height of Fill Proposed - (2:1 Slopes)	Stability - (Length of Mid-height Berm Required)	Consolidation Settlements - (Beneath the Max. Height of Fill)	
Sta. 300+00 to 302+00 B.H.'s 1 & 1A West of People's Rd.)	15 to 20 ft. (Soft to Firm)	31 ft. (Approx.)	30 ft. (Berms will not be required for fills less than 20 ft. in height)	4" to 5" in 3 months 9" in 12 to 18 months - (Max.)	The surficial organic silt deposit, encountered on the valley floors, should be completely sub-excavated.
Sta. 355+00 to 360+00 B.H.'s 4 & 4A East of Old Goulais Bay Road)	40 ft. (Firm to Stiff)	67 ft. (Approx.)	>100 ft. (Berms will not be required for fills less than 35 ft. in height)	3/4' to 1' in 1 year 1 1/2' to 2' in 4 to 6 years (Max.)	
Approx. Sta. 372+00 B.H.'s 5 & 5A West of Hwy. #17 N)	6 to 7 ft. (Firm to Stiff)	28 ft. (Approx.)	Nil	2" to 4" (Recompression) will take place during or immediately following the construction period.	

cont'd. 27

6. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

6.4) Natural Valley Crossings - Western Portion of the Alignment: (cont'd.) ...

Based on the stability and settlement computations, carried out at the respective valley crossings, the following conclusions can be drawn:

a) At the first and last valley crossings, listed in the table, it would be possible to construct an earth fill with an associated culvert. If a flexible type of culvert is proposed, sufficient camber should be provided to accommodate the anticipated differential settlements. In any event, it would be advantageous to allow the fills to remain in place for as long a period as possible prior to laying the tracks. This provision would minimize maintenance requirements once the railway is in operation.

b) Excessively wide berms will be required to ensure the stability of the fill section to be placed over the deep ravine located east of Old Goulais Bay Road. Further, up to 2 feet of consolidation settlement may occur within the cohesive subsoil, due to the surcharge fill loading. These factors may preclude the economic use of fills with associated culverts. If this is the case, this valley could be bridged by a multi-span structure. The abutments, located on the valley banks, could be supported on spread footings located within the upper silty sand deposit. An allowable bearing value of up to 3.0 t.s.f. could be used in design. The intermediate piers would, however, be located within the valley gorge. These could be supported on end-bearing piles driven to bedrock (estimated pile tip elevations 668 approx.).

If a multi-span structure is adopted, detailed recommendations will be provided once final design details become available.

6. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

6.5) Proposed Grade Separations:

Structures will be required at the following locations:

- i) People's Rd. (Sta. 310+00) - Overhead
- ii) Hwy. #17 North (Sta. 392+00) - Overhead
- and
- iii) Old Garden River Rd.. (Sta. 470+00) - Subway

Preliminary recommendations pertaining to the structure foundations, as well as the stability and settlement considerations for the approach fills, will be presented in the tables which immediately follow:

FOUNDATION RECOMMENDATIONS

Overhead Structure - Reloc. C.P.R. and People's Road

Approx. Exist. Ground Elev. Approx. Grade (People's Rd.)	Predominant Overburden Strata Approx. Thickness (ft.)	R E C O M M E N D A T I O N S		Remarks
		<u>Structure</u>	<u>Embankments</u> (Height - Longitudinal and Transverse Directions - 28 ft.)	
774 (802 +) Refer to B.H.'s #2 and #2A	<u>Silty Sand to Sandy Silt</u> - - Compact (-4') <u>Silty Clay, Clayey Silt and Silt</u> - (Stratified) - Soft to Firm (22') Underlain by <u>Silty Sand to Sandy Silt</u> - Compact to Dense (Thickness of at least 110 ft.)	<u>Piers and Abutments</u> Supported on Friction piles driven into the extensive granular stratum located beneath the cohesive stratum - e.g., Herkules pile-type #800, 50 feet in length could be designed using an allowable load of 30 Tons/pile. - e.g., 12" Ø Timber piles 45 ft. in length could be designed using an allow- able load of 25 Tons/pile. <u>Note:</u> The structure elements, founded on friction piles, will be subject to differ- ential settlements.	<u>Stability</u> 1) Fills up to 17' (with 2:1 slopes) will be stable. 2) Fills in excess of 17' will require berms in all directions; - mid-height berm of 50 ft. will be required for a fill height of 28 ft. (F.S. ≥ 1.3). <u>Probable Consolidation Settlement</u> 1) 17' fill (2:1 slopes) - 3/4' in 1 to 1½ yrs. 1' to 1.5' in 5 to 6 yrs. - (Max.) 2) 28' fill with a berm length of 50' at mid-height - 1' to 1.5' in 1 to 1½ yrs. 2' to 2.5' in 5 to 6 yrs. (Max.)	- Since the structure elements will settle differ- entially, it should be of the simply- supported type. - Consideration should be given to constructing the approach fills prior to construction of the structure foundations, in order to minimize the post-construc- tion settlements.

FOUNDATION RECOMMENDATIONS

Overhead Structure - Reloc. C.P.R. and Hwy. #17 North

Approx. Exist. Ground Elev. (Approx. Grade of Hwy. #17 N.)	Predominant Overburden Strata Approx. Thickness (ft.)	R E C O M M E N D A T I O N S		Remarks
		Structure	Embankments (Height - Longitudinal Direction - 28 ft.) (Height - Transverse Direction - 21 ft.)	
780 (801 ±) Refer to B.H. #6	Fill Material - (5 ft.) <u>Silt</u> - Compact (18') <u>Clay to Silty Clay</u> (Layered) - Firm to Stiff (28.5') Underlain by Glacial Till - (Dense to Very Dense) (Thickness of at least 15 ft.)	<u>Abutments</u> Spread footings, founded within the approach fills, in a zone composed of well compacted G.B.C. 'A' material, using an allow- able bearing value of 2.0 t.s.f. in design. (Refer to 'Remarks' column) <u>Piers</u> Spread footings, founded at about elev. 778 in the silt stratum, allowable bearing value up to 2.0 t.s.f. Alternatively, the abut- ments and piers could be founded on end-bearing piles driven to practical refusal within glacial till. - estimated tip elev. 720. <u>Note:</u> Differential settlements between the spread foot- ing supported abutments and piers are anticipated.	<u>Stability</u> Fills up to 28' (with 2:1 slopes) will be stable (F.S. ≥ 1.3) <u>Probable Consolidation Settlement of Approach Fills</u> - 21' fill (2:1 slopes) - 2" in 6 to 9 months 3" to 5" in 2 to 3 yrs. (Max.)	If the abutments and piers are supported on spread footings, consideration should be given to constructing the approach fills prior to construction of the structure foundations in order to minimize the post-construc- tion settlements

FOUNDATION RECOMMENDATIONS

Subway Structure - Reloc. C.P.R. and Old Garden River Road

Approx. Exist. Ground Elev. (Prop. Grade of C.P.R.)	Predominant Overburden Strata Approx. Thickness (ft.)	R E C O M M E N D A T I O N S		Remarks
		<u>Structure</u>	<u>Embankments</u> (Height - Longitudinal and Transverse Directions - 28 ft.)	
655 (634 ⁺) Refer to B.H. #10	Fill Material - (5 ft.) <u>Clay to Silty</u> <u>Clay</u> (Layered) - Firm to Stiff (36 ft.) <u>Glacial Till</u> - Very Dense (11 ft.) Underlain by Bedrock - Sound	<u>Abutments and Piers</u> End-bearing piles driven to bedrock surface. - estimated tip elev. 603. - designed for max. capacity of the pile section chosen at pier locations. <u>Note:</u> Capacity of piles supporting abutments may have to be reduced in order to allow for negative skin frictional effects. (A reduction of 20% will be used in max. pile capacity.)	<u>Stability</u> 1) Fills up to 16' - (with 2:1 slopes) will be stable. 2) Fills in excess of 16' will require berms in all directions. - Mid-height berm of 70 ft. will be required for a fill height of 28' - (F.S. \geq 1.3) <u>Probable Consolidation</u> <u>Settlement of Approach</u> <u>Embankments:</u> 1) 16' fill (2:1 slope) - 1.5' in 4 yrs. 3' in 25 yrs. (Max.) 2) 28' fill with a berm length of 75' at mid-height - 2.5' to 3' in 4 yrs. 4.5' to 5.5' in 25 yrs. (Max.)	Consideration should be given to constructing the approach fills prior to construction of the structure foundations, in order to minimize the post-construction settlements.

6. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

6.5) Proposed Grade Separations: (cont'd.) ...

The subsoil conditions encountered at Old Goulais Bay Rd. (Station 340+00 - refer to B.H. #14) are quite favourable when compared to those at People's Rd., since the soft stratified cohesive deposit was not encountered at the former location. Old Goulais Bay Rd. would, therefore, be preferred as a site for a grade separation. If this location was adopted the Foundation Section could provide preliminary recommendations pertaining to foundation considerations.

7. CONCLUSIONS:

Cohesive subsoil deposits, of quite variable consistencies and thicknesses, are present along the alignment. The presence of these deposits is of major importance when assessing the economic feasibility of the proposed alignment and profile grade for the Relocated C.P.R.

At the toe of the scarp connecting the high and low terraces (Sta's 460+00 to 500+00) up to 30 feet of fill is to be placed on a soft, compressible, layered, clay deposit.

Under this height of fill:

- i) excessive consolidation settlements are expected within the foundation subsoil; and
- ii) berms will be required to ensure the stability of the sections.

In order to maintain the settlement and berm lengths within reasonable limits, it has been recommended that the C.P.R. profile grade be lowered in this area so that the heights of fill are limited to 20 feet.

7. CONCLUSIONS: (cont'd.) ...

As discussed in Sub-section 6.4), it may be beneficial to bridge the deep ravine, located east of Old Goulais Bay Road (Sta. 339+00), with a multi-span structure, since the berm requirements and settlements expected are excessive.

The subsoil conditions encountered at Old Goulais Bay Rd. are more favourable from a foundation point of view than those at People's Rd. If practical, therefore, it may be beneficial to locate the grade separation, required in this general area, along the former roadway rather than the latter.

It should be stressed that this report is of a preliminary nature. A complete foundation investigation will be required at all the sites, when design details become available for the alignment of the Relocation.

8. MISCELLANEOUS:

The field work, performed during the period of February 4 to 19, 1970, was under the immediate supervision of Mr. R. Hendry, Student Technician (Field) and Mr. B. T. Darch, Senior Foundation Engineer.

The equipment was owned and operated by Canadian Longyear Ltd., North Bay, Ontario.

This report was written by Mr. Darch. This project was carried out under the general supervision of Mr. M. Devata, Supervising Foundation Engineer, who reviewed this report.

June, 1970

APPENDIX I

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 1

FOUNDATION SECTION

JOB 70-11006

LOCATION CPR Relocation Sta. 301 + 20

ORIGINATED BY RH

W.O. 69-27

BORING DATE Feb. 10 and 11, 1970

COMPILED BY VK

DATUM Geodetic

BOREHOLE TYPE Washboring-NX, BX Casing

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		SHEAR STRENGTH P.S.F.					w_p — w — w_L WATER CONTENT %				
							400 800 1200 1600 2000					15 30 45				
744.3	Ground Level															
0.0	Organic silt															
740.3	Black Soft														743.	
4.0	Clayey silt & silty clay		1	SS	2										WL in open BH Feb. 11/70	
734.3	Stratified														org. 0.2%	
10.0	layer of silty sand		2	SS	2											
731.5			3	SS	2											
12.8	Occ. seams of sand up to 4" thick throughout		4	TW	PM										0 6 55 39	
724.3	Grey to Reddish Brown Soft to firm		5	TW	PM										0 0 60 40	
20.0	Silty fine sand to sandy silt, trace of clay		6	SS	12										0 11 82 7	
	Random stratification		7	SS	13											
			8	SS	12											
	occasional seams and layers of silty clay up to 6" thick throughout.		9	SS	9										0 14 81 5	
			10	SS	12											
			11	SS	14											
			12	SS	11											
	Compact to very dense		13	SS	8										0 88 10 2	
			14	SS	11											
			15	SS	10											
			16	SS	11											
			17	SS	27											
662.3			18	SS	58										0 12 84 4	
82.0	End of Borehole															

DEPARTMENT OF HIGHWAYS- ONTARIO

MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 1A

FOUNDATION SECTION

JOB 70-11006

LOCATION CPR Relocation Sta. 301 + 80 o/s 30' Lt.

ORIGINATED BY RH

W.O. 69-27

BORING DATE Feb. 11, 1970

COMPILED BY VK

DATUM Geodetic

BOREHOLE TYPE Washboring-NX Casing

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.					WATER CONTENT %				
												w_p — w — w_L				
							400	800	1200	1600	2000					
744.3	Ground Level															
0.0	Organic silt Black					740									GR. SA. SI. CL.	
739.3	Soft															
5.0	Silty clay, clayey silt & silt (stratified) (stratifications of random thickness) Grey to reddish brown		1	SS	8	730									Org. 1.8%	
			2	TW	PM											
			3	SS	3											
			4	SS	2											
			5	TW	PM											
724.8	Soft		6	TW	PM										115	
723.3	Silty fine sand. Loose		7	SS	7											
21.0	End of Borehole					720										

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 2 A

FOUNDATION SECTION

JOB 70-11006

LOCATION CPR Relocation Sta. 309 + 85 o/s 50' Rt.
(at Peoples Rd)

ORIGINATED BY CS

W.O. 69-27

BORING DATE Feb. 12, 1970

COMPILED BY VK

DATUM Geodetic

BOREHOLE TYPE Washboring-NX Casing

CHECKED BY *AK*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.					w_p — w — w_L WATER CONTENT % 15 30 45				
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE 500 800 1200 1600 2000									
774.2	Ground Level															
772.2	Silty sand with grav. fill Compact															
2.0	Silty fine sand to sandy silt.															
767.7	Compact		1	SS	21	770										
6.5	Silty clay, clayey silt & silt (stratified) (stratification of random thickness) Occ. partings & seams of sand up to 1/4" thick throughout.		2	SS	10										0 8 86 6	
			3	SS	4										▼ 762.	
			4	TW	PM	760								117	0 1 54 45 0 5 86 9	
			5	SS	2											
	Grey & reddish brown		6	SS	2										0 1 94 5	
			7	SS	2	750										
746.0	Soft to firm		8	SS	6										WL in open BH Feb. 12/70	
745.2	Silty fine sand															
29.0	End of Borehole					740										

DEPARTMENT OF HIGHWAYS- ONTARIO

MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 4

FOUNDATION SECTION

JOB 70-11006

LOCATION

CPR Relocation Sta. 357 + 20 o/s 40' Rt.

ORIGINATED BY BTD

W.O. 69-27

BORING DATE

Feb. 14 - 16, 1970

COMPILED BY VKDATUM Geodetic

BOREHOLE TYPE

Washboring-NX, BX Casing - AXT Rock CoreCHECKED BY JK

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		SHEAR STRENGTH P.S.F.					w_p — w — w_L WATER CONTENT %					
							400	800	1200	1600	2000		15	30	45		
709.1	Ground Level																Art. Head
707.1	Organic silt Black Soft		1	TW	PM												714.
2.0	Silty clay to clay (layered)		2	TW	PM												Art. Head
	layers of random thickness		3	TW	PM												708.
			4	TW	PM	700											WL in open BH Feb. 16/70
	occ. seams of silt up to 1/2" thick throughout		5	TW	PM												
			6	TW	PM												
			7	TW	PM	690											
	Grey to reddish brown		8	TW	PM												
	Firm to stiff		9	TW	PM	680											
			10	TW	PM												
670.1																	
668.8	Glacial Till Hard		11	SS	100/4"	670											668
40.3	Sandstone Bedrock (fine grained-ferruginous)																Art. condition
664.1	Reddish-brown. Sound		12	AXT	100%												encountered
45.0	End of Borehole					660											

DEPARTMENT OF HIGHWAYS- ONTARIO
 MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 4 A

FOUNDATION SECTION

 JOB 70-11006 LOCATION C.P.R. Relocation Sta. 357 + 80 Ø
 W.O. 69-27 BORING DATE Feb. 17, 1970
 DATUM Geodetic BOREHOLE TYPE Washboring-NX Casing

 ORIGINATED BY BTD
 COMPILED BY VK
 CHECKED BY HK

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.					WATER CONTENT %				
							400 800 1200 1600 2000					w_p — w — w_L				
709.1	Ground Level															
707.1	Organic silt Black Soft		1	SS	2										P.C.F. GR. SA. SI. CL.	
2.0	Silty clay to clay (layered) (layers of random thickness)		2	TW	PM		+4			+4					708.	
			3	TW	PM	700	+3			+4					WL in open BH Feb.17/70	
	occ. seams of silt up to 1/4" thick throughout		4	TW	PM		+3			+4						
			5	TW	PM	690	+4			+6						
	Grey to reddish brown		6	TW	PM		+3			+2						
	Firm to stiff		7	SS	4	680	+2			+3						
674.1							+3									
35.0	End of Borehole						+4									
						670										

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 5

FOUNDATION SECTION

JOB 70-1106 LOCATION C.P.R. Relocation Sta. 372 + 50 Ø ORIGINATED BY BTD

W.O. 69-27 BORING DATE Feb. 13 & 14, 1970 COMPILED BY VK

DATUM Geodetic BOREHOLE TYPE Washboring, BX, NX, Casing CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT ——— w _L PLASTIC LIMIT ——— w _p WATER CONTENT ——— w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.					w _p ——— w ——— w _L WATER CONTENT %				
							400	800	1200	1600	2000	15	30	45		
746.7	Ground Level														GR. SA. SI. CL.	
745.2	Organic silt (Black) Soft														WL in open	
1.5	Silty clay to clay (layered) occ. seams of silt		1	SS	3										WH Feb. 14/70	
738.7	Firm		2	TW	PM	740		s8						116	▼ 740.	
8.0	Sandy silt, trace of clay (Brown)		3	SS	13										0 36 59 5	
733.7	Compact		4	TW	PM											
13.0	Het. mix. of clay, silt, sand & gr. (Giac. Till) V. dense or hard		5	SS	163	730										
			6	SS	100 3/4"											
	Bouldery Zone		8	SS	138										15 34 40 11	
725.2	Boulders up to 5" in size.		9	SS	100 1/4"											
21.5	End of Borehole					720										

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 5A

FOUNDATION SECTION

JOB 70-11006

LOCATION C.P.R. Relocation Sta. 372 + 60 o/s 40' Lt.

ORIGINATED BY BTD

W.O. 69-27

BORING DATE Feb. 15, 1970

COMPILED BY VK

DATUM Geodetic

BOREHOLE TYPE Washboring-NX Casing

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT ——— w _L PLASTIC LIMIT ——— w _p WATER CONTENT ——— w				BULK DENSITY γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.					w _p ——— w ——— w _L WATER CONTENT %					
746.7	Ground Level																
745.2	Organic silt (Black)		1	SS	2	740										▼ 740. WL in open BH Feb. 15, 70	
1.5	Silty clay to clay (layered) occ. seams of silt		2	TW	PM				+6								
738.2	Firm		3	TW	PM				+7								
8.5	Sandy silt, trace of clay		4	SS	15												
732.7	Brown Compact		5	SS	19												
14.0	End of Borehole					730											

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 6

FOUNDATION SECTION

JOB 70-11006 LOCATION CPR Relocation Sta. 393 + 00 ♂ (at Hwy.17) ORIGINATED BY BTD
W.O. 69-27 BORING DATE Feb. 7 & 8, 1970 COMPILED BY VK
DATUM Geodetic BOREHOLE TYPE Washboring-NX, BX Casing AXT Rock Core CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.					w_p — w — w_L WATER CONTENT %					
783.8	Ground Level						400	800	1200	1600	2000	15	30	45		GR. SA. SI. CL.	
0.0	Sand & gravel (Fill) Brown																
778.8	Compact		1	SS	17	780											
5.0	Silt, trace of clay (random stratification) occ. seams of clayey silt up to 2" thick throughout Reddish brown to grey		2	SS	30												
			3	SS	20												0 1 92 7
			4	SS	14	770											
			5	SS	19												
			6	SS	13												
760.8	Compact																
23.0	Clay to silty clay (layered) (layers of random thickness) occ. seams of silt & sand up to 2" thick throughout Reddish brown to grey		7	TW	PM	760											
			8	TW	PM					+4						123	0 2 78 20
			9	TW	PM	750											
			10	TW	PM					+3						118.5	
			11	SS	10	740											0 1 69 30
732.5	Firm to stiff		12	TW	PM												
51.3	Het. mix. of silt, sand & gravel, trace of clay (Glacial Till) Grey Dense to very dense		13	SS	31	730										9 82 (9)	
717.8	Bouldery Zone (Boulders up to 6" in size.)		14	AXT	20%	720											
66.0	End of Borehole																
						710											

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 7

FOUNDATION SECTION

JOB 70-11006

LOCATION CPR Relocation Sta. 426 + 00 o/s 260' Rt.

ORIGINATED BY RH

W.O. 69-27

BORING DATE Feb. 17 & 18, 1970

COMPILED BY VK

DATUM Geodetic

BOREHOLE TYPE Washboring-NX, BX Casing - AXT Rock Core

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.					WATER CONTENT %				
							○ UNCONFINED		+ FIELD VANE			w_p ——— w ——— w_L				
						● QUICK TRIAXIAL	x LAB. VANE									
760.9	Ground Level					400	800	1200	1600	2000	15	30	45		GR. SA. SI. CL.	
0.0	Silty topsoil															
1.0	Silt, trace of clay (random stratification) occ. seams of clayey silt up to 1" thick throughout		1	SS	98										0 0 94 6	
			2	SS	80										747.	
			3	SS	12	750									WL in open BH Feb. 18/70	
			4	SS	15										0 2 93 5	
			5	SS	16											
			6	SS	11	740										
	Brown		7	SS	13											
			8	SS	11	730										
	Compact		9	SS	12											
720.9																
40.0	Silty clay to clayey silt (layered) (layers of random thickness)		10	TW	PM	720										
			11	TW	PM											
	occ. seams of silt & sand up to 1/2" thick		12	SS	6	710										
	Grey to reddish brown															
699.2	Stiff to very stiff		13	TW	PM	700										
61.7	Het. mix. of silt, sand & gravel, trace of clay (Glacial Till) Very dense		14	AXT	40%											
	Bouldery Zones															
	Boulders up to 6" in size.					690										
685.7																
75.2	Sandstone Bedrock (fine grained-ferruginous)		15	AXT	80%	680										
	Reddish brown															
675.9	Sound		16	AXT	80%											
85.0	End of Borehole					670										

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 8

FOUNDATION SECTION

JOB 70-11006

LOCATION CPR Relocation Sta. 438 + 15 o/s 115' Lt.

ORIGINATED BY RH

W.O. 69-27

BORING DATE February 18 & 19, 1970

COMPILED BY VK

DATUM Geodetic

BOREHOLE TYPE Washboring-NX Casing-AXT Rock Core

CHECKED BY *HK*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.					WATER CONTENT % w_p — w — w_L				
							400	800	1200	1600	2000					
760.6	Ground Level															
0.0	Silty topsoil					760										
1.0	Silt, trace of clay (random stratifications)		1	SS	44											
	occ. seams of clayey silt up to 1" thick throughout		2	SS	91											
			3	SS	72	750										
	Brown to grey		4	TW	PM											
	Very dense to compact		5	SS	15	740										
735.6			6	TW	PM											
25.0	Silty clay to clayey silt (layered)		7	SS	5	730										
	(layers of random thickness)		8	SS	10											
	occ. seams of silt & sand up to 1" thick throughout		9	SS	10	720										
	Grey to reddish brown		10	SS	11											
712.6	Stiff to very stiff															
48.0	Het. mix. of silt, sand & gravel (Glacial Till)					710										
	Very dense															
	Bouldery Zone															
703.6	Boulders up to 8" in size		11	AXT	Nil Rec.											
57.0	End of Borehole					700										

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 9

FOUNDATION SECTION

JOB 70-11006

LOCATION CPR Relocation Sta. 448 + 40 @ (at 3rd Line Rd.)

ORIGINATED BY BTD

W.O. 69-27

BORING DATE February 4 - 6, 1970

COMPILED BY VK

DATUM Geodetic

BOREHOLE TYPE Washboring-NX Casing-AXT Rock Core

CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — W _L PLASTIC LIMIT — W _P WATER CONTENT — W			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.					W _P — W — W _L 15 — 30 — 45				
							○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB. VANE	600	800	1200	1600	2000			
732.8	Ground Level															
0.0	Clayey silt, pockets of sand & gravel (fill)		1	SS	24	730									0 3 87 10	
	Brown		2	SS	24	720										
714.8	Very stiff		3	SS	38											
18.0	Sand & gravel (Fill)															
711.8	Brown Compact		4	SS	11	710										
21.0	Clayey silt to silty clay (layered)															
	Brown		5	SS	23											
704.8	Very stiff															
28.0	Het. mix. of silt, sand & gr. (Glac. Till)		6	SS	42											
702.5	Dense fractured	7	AXT	50%	700											
30.3	Sandstone Bedrock (fine grained-ferruginous)	8	AXT	100%												
	Interbeds of argillaceous shale.	9	AXT	100%												
692.5	Sound															
40.3	End of Borehole					690										

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 10

FOUNDATION SECTION

JOB 70-11006

LOCATION CPR Relocation Sta. 470+30 Ø (at Old Garden River Rd.) ORIGINATED BY BTB

W.O. 69-27

BORING DATE Feb. 4-6, 1970

COMPILED BY VK

DATUM Geodetic

BOREHOLE TYPE Washboring-NX Casing-AXT Rocke Core

CHECKED BY *HL*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.					w_p ——— w ——— w_L WATER CONTENT % 15 30 45				
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE 400 800 1200 1600 2000									
655.0	Ground Level															
0.0	Sand, trace of gravel, trace of organic matter														▽ 653.	
650.0	(Fill) Brown Loose		1	SS	5										Excess water pressure head	
5.0	Desiccated Crust		2	SS	12											
	Stiff		3	SS	7											
	Clay to silty clay (layered) (layers of random thickness)		4	TW	PM										117.5 2 6 82 10	
			5	TW	PM										▽ 639.	
			6	TW	PM										WL in open BH Feb. 6/70	
	occ. seams of silt & sand up to 2" thick throughout		7	TW	PM											
	Reddish brown to grey		8	TW	PM											
			9	TW	PM											
614.0	Firm to stiff		10	TW	PM											
41.0	Het. mix. of silt, sand & gravel, trace of clay (Glacial Till)		11	SS	102										46 38 15 1	
	Brown Very dense		12	SS	116/6"										▽ 604.	
603.0	Boulders up to 5" size															
52.0	Sandstone Bedrock															
599.5	Sound		13	AXT	80%										Excess hydrostatic head encountered	
55.5	End of Borehole															

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 11

FOUNDATION SECTION

JOB 70-11006

LOCATION CPR Relocation Sta. 478 + 00 Ø

ORIGINATED BY RH

W.O. 69-27

BORING DATE Feb. 7 & 8, 1970

COMPILED BY VK

DATUM Geodetic

BOREHOLE TYPE Washboring-NX, BX Casing

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.					WATER CONTENT %				
							400 800 1200 1600 2000					w_p ——— w ——— w_L 15 30 45				
646.4	Ground Level															
0.0	Silty fine sand to sandy silt															
641.4	Reddish Brown. Compact		1	SS	12										0 40 56 4	
5.0	Desiccated Zone		2	SS	9	640									641.	
	Stiff		3	TW	PM										WL in open	
	Clay to silty clay (layered)		4	TW	PM	630	+6								BH Feb.8/70	
	occ. seams of silt & sand up to 2" thick throughout		5	TW	PM		+8									
			6	TW	PM	620										
			6	SS	4											
	Reddish brown to grey		7	TW	PM		+6							97.5		
			8	TW	PM	610										
	Soft to firm		9	TW	PM		+5							111.5	0 0 88 12	
			10	TW	PM	600										
			11	TW	PM		+9									
594.4			12	AXT	-	590										
52.0	Het. mix. of silt, sand & gl. trace of clay (glacial till) V. Dense		13	AXT	40%											
	Boulder Zone		14	AXT	20%	580										
578.9	Sandstone Bedrock		15	AXT	100%											
68.0	End of Borehole					570										

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF VANE HOLE No. 11A

FOUNDATION SECTION

JOB 70-11006 LOCATION CPR Relocation Sta. 478 + 80 ORIGINATED BY RH

W.O. 69-27 BORING DATE February 9, 1970 COMPILED BY VK

DATUM Geodetic BOREHOLE TYPE Washboring-NX Casing CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		SHEAR STRENGTH P.S.F.					w_p — w — w_L WATER CONTENT %				
							400	800	1200	1600	2000				P.C.F.	GR. SA. SI. CL.
646.4	Ground Level															
0.0	Silty fine sand to sandy silt Reddish brown. Compact															
	Desiccated Zone Stiff					640										▼ 641.
	Clay to silty clay (layered) occ. seams of silt & sand up to 2" thick throughout Reddish brown to grey					630	+12 +11 +7 +5									WL in open BH Feb. 9/70
618.4	Soft to firm					620	+10 +8 +6 +4									
28.0	End of Borehole					610										

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 13

FOUNDATION SECTION

JOB 70-11006 LOCATION CPR Relocation Sta. 530 + 15 o/s 50' Rt. ORIGINATED BY HM

W.O. 69-27 BORING DATE Feb. 17 and 18, 1970 COMPILED BY VK

DATUM Geodetic BOREHOLE TYPE Washboring-NX Casing CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — w _L PLASTIC LIMIT — w _p WATER CONTENT — w			BULK DENSITY γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		SHEAR STRENGTH P.S.F.					w _p — w — w _L				
							○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB. VANE								
631.1	Ground Level					400	800	1200	1600	2000	20	40	60	P.C.F.	GR.SA.SI.CL.	
0.0	Sandy topsoil		1	SS	17	630									0 94 (6)	
0.5	Fine sand, trace of silt (Brown)		2	SS	20											
622.1	Compact		3	SS	16											
9.0	Desiccated Zone		4	SS	10	620									619.	
	Clay to silty clay (layered) (layers of random thickness)		5	TW	PM		x s3							109.5	WL in open BH Feb.18/70	
			6	TW	PM		+									
			7	TW	PM	610										
	occ. seams of silt and sand up to 1" thick throughout		8	TW	PM			x s5						102		
	Reddish brown to grey		9	SS	23	600										
			10	SS	10										0 0 76 21	
	soft to stiff		11	TW	PM	590			+ 6							
			12	TW	PM		+3									
			13	TW	PM	580										
			14	TW	PM	570								111.0		
	Numerous layers of silt up to 5" thick		15	TW	PM	560			+3							
			16	TW	PM	550				+ 6						
			17	TW	PM	540								122	0 1 89 10	
			18	TW	PM											
59.1						460										

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 14

FOUNDATION SECTION

JOB 70-11006 LOCATION CRP Relocation Sta.339+20 ♂ (at Old Golais Bay Rd.) ORIGINATED BY BTB

W.O. 69-27 BORING DATE Feb. 14-16, 1970 COMPILED BY VK

DATUM Geodetic BOREHOLE TYPE Washboring-NX, BK Casing CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT ——— w _L PLASTIC LIMIT ——— w _p WATER CONTENT ——— w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		SHEAR STRENGTH P.S.F.					WATER CONTENT %				
							○ UNCONFINED	● QUICK TRIAXIAL	+ FIELD VANE	x LAB. VANE	w _p	w	w _L			
770.8	Ground Level					400	800	1200	1600	2000	20	40	60		GR. SA. SI. CL.	
0.0	Sand & gravel (Fill)															
767.8	Compact															
3.0	Sandy silt, trace of clay (random stratification)		1	SS	111/10"											
			2	SS	17											
			3	SS	11	760										
			4	SS	10											
			5	SS	20											
	occ. layers of silty clay up to 9" thick throughout		6	TW	PM	750										
			7	TW	PM											
	Reddish brown to grey brown		7A	SS	20											
			8	SS	17	740										
			9	TW	PM											
			9A	SS	23											
			10	SS	17	730										
			11	SS	14											
	Compact		12	SS	16	720										
			13	SS	14											
			14	SS	13	710										
704.1			15	SS	9											
66.7	Clay to silty clay (layered) (layers of random thickness)		16	SS	18	700										
			17	TW	PM											
	layers of silty sand up to 3" thick throughout		18	TW	PM	690										
	Reddish brown		19	TW	PM											
680.7	Stiff															
90.1	Silty fine sand, seams of silty clay up to 1" thick		20	SS	63	680										
668.8																
102.0	End of Borehole		21	SS	55	670										

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 15

FOUNDATION SECTION

JOB 70-11006

LOCATION CPR Relocation Sta. 324 + 50 o/s 170' Lt.

ORIGINATED BY BTB

W.O. 69-27

BORING DATE Feb. 10 & 11, 1970

COMPILED BY VK

DATUM Geodetic

BOREHOLE TYPE Washboring-NX, BX Casing

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.					w_p — w — w_L WATER CONTENT %					
781.6	Ground Level						400	800	1200	1600	2000	10	20	30		GR. SA. SI. CL.	
0.0	Silty fine sand to sandy silt		1	SS	11	780										0 74 (26)	
	Reddish brown		2	SS	15												772.
			3	SS	22	770											WL in open BH Feb. 11/70
			4	SS	28												0 4 94 2
	Compact		5	SS	20												
760.6			6	SS	5	760											
21.0	Silty clay to clayey silt, trace of sand (layered)		7	TW	PM											0 13 84 3	
	occ. seams of silt & sand up to 3-4" thick		8	SS	7	750											
	Reddish brown to grey																
744.1	Firm to stiff		9.10	TW	PM												
37.5	Silty fine sand to sandy silt, layers of silty clay up to 1/2" thick throughout		11	SS	16	740										0 42 (58)	
	Reddish brown		12	SS	15												
	Compact																
732.6																	
49.0	Silty clay to clayey silt, trace of sand (layered) occasional seams of silt & sand		13	SS	4	730										0 1 91 8	
	Reddish brown to grey		14	TW	PM												
	Stiff		15	TW	PM	720											
719.6																	
62.0	Silty fine sand to sandy silt (random stratification)		16	SS	44												
	occ. seams of silty clay up to 1" thick throughout		17	SS	162	710											0 17 (83)
	Grey		18	SS	69												
	Dense to very dense					700											
694.6			19	SS	47												
87.0	End of Borehole					690											

DEPARTMENT OF HIGHWAYS- ONTARIO

MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 16

FOUNDATION SECTION

JOB 70-11006

LOCATION GPR Relocation Sta. 475 + 00 o/s 70' Rt.

ORIGINATED BY BTB

W.O. 69-27

BORING DATE Feb. 13 & 14, 1970

COMPILED BY VK

DATUM Geodetic

BOREHOLE TYPE Washboring-NX Casing

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.					w_p — w — w_L WATER CONTENT %				
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE									
646.7	Ground Level						400	800	1200	1600	2000	20	40	60		GR. SA. SI. CL.
0.0	Silty sand Brown															
643.2	Loose															
3.5	Desiccated Zone		1	SS	6											
			2	TW	PM	640			+7							
	Clay to silty clay (layered) (layers of random thickness)		3	TW	PM				+3		x					▼ 639. WL in open BH Feb. 14/70
			4	TW	PM	630										0 0 94 6 (silt seam)
	occ. seams of silt & sand up to 2" thick throughout		5	TW	PM				+6							
			6	TW	PM	620			+5							
	Reddish brown to grey		7	TW	PM				+6							
	Firm to stiff		8	TW	PM	610			+6		x s8				109	
607.7									+6							
39.0	Het. mix. of silt, sand & gravel, trace to some clay (Glacial Till)		9	SS	21											
	Grey															
599.7	Compact or very stiff		10	SS	30											28 46 (26)
47.0	End of Borehole															

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 17

FOUNDATION SECTION

JOB 70-11006

LOCATION CPR Relocation Sta. 465 + 40 o/s 110' Lt.

ORIGINATED BY BTD

W.O. 69-27

BORING DATE Feb. 14 & 15, 1970

COMPILED BY HK

DATUM Geodetic

BOREHOLE TYPE Washboring-NX Casing

CHECKED BY SK

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — w_L			BULK DENSITY γ P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT					PLASTIC LIMIT — w_p					WATER CONTENT — w
							SHEAR STRENGTH P.S.F.					WATER CONTENT %					
659.5	Ground Level																
0.0	Clayey topsoil																
1.0	Desiccated crust																
	Stiff		1	SS	8												
			2	TW	PM												
	Clay to silty clay (layered)		3	SS	7												
			4	TW	PM	650											
	Reddish brown to grey Firm		5	TW	PM												
644.5																	
15.0	Het. mix. of silt, sand & gravel, trace of clay (Glacial Till)		6	SS	24												
			7	SS	26	640											
	Bouldery zone Boulders up to 6" in size		8	AXT	no rec.												
			9	AXT	20%	630											
626.5																	
33.0	End of Borehole																
						620											

DEPARTMENT OF HIGHWAYS- ONTARIO

MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 18

FOUNDATION SECTION

JOB 70-11006

LOCATION GRP Relocation Sta. 299 + 80 o/s 20' Lt.

ORIGINATED BY RH

W.O. 69-27

BORING DATE Feb. 17 & 18, 1970

COMPILED BY VK

DATUM Geodetic

BOREHOLE TYPE Washboring-NX Casing

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.					w_p — w — w_L WATER CONTENT % 15 30 45				
770.9	Ground Level															
0.0	Silty fine sand to sandy silt Reddish brown					770										
762.9	Compact		1	SS	25											
8.0	Silty clay, clayey silt & silt (stratified) (stratification of random thickness)		2	TW	PM	760				x 3.5				118	0 0 90 10 760. WL in open BH Feb. 18/70	
			3	TW	PM											
			4	TW	PM	750				+ 4						
	numerous sand seams up to 1/4" thick below el. 745.		5	SS	15					+ 3					0 4 95 1	
			6	SS	8	740										
	Grey to reddish brown		7	SS	9					+ 5						
	Firm to stiff		8	SS	4	730										
727.9																
43.0	Silty fine sand (random stratification)		9	SS	38											
	Grey to reddish brown		10	SS	28	720										
			11	SS	58											
709.4	Compact to very dense		12	SS	23	710									0 39 (61)	
61.5	End of Borehole															

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 19

FOUNDATION SECTION

JOB 70-11006 LOCATION CRR Relocation Sta. 371+50 o/s 80' Lt. ORIGINATED BY HM

W.O. 69-27 BORING DATE Feb. 16, 1970 COMPILED BY VK

DATUM Geodetic BOREHOLE TYPE Washboring NX Casing CHECKED BY *AK*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — w_L			BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT					PLASTIC LIMIT — w_p				
							SHEAR STRENGTH P.S.F.					WATER CONTENT — w				
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE					w_p — w — w_L				
							400	800	1200	1600	2000	WATER CONTENT % 15 30 45				
770.2	Ground Level					770										
0.0	Silty fine sand to sandy silt (random stratification)		1	SS	56											
	Reddish brown		2	SS	66											
760.7	Very dense		3	SS	10	760										
9.5	Clay to silty clay (layered)(layers of random thickness)		4	TW	PM				+8							
			5	TW	PM			+4								
	occ. seams of silt & sand up to 1/2" thick throughout		6	TW	PM	750		x3	+12							
			7	TW	PM			+8								
	Reddish brown		8	TW	PM	740			+4							
	Firm to stiff								+8							
734.2			9	TW	PM											
36.0	Het. mix. of clay, silt, sand & gr. (Glac. Till)		10	SS	26											
730.4	Very stiff to hard		11	SS	95/3"											
39.8	End of Borehole					730										

755.

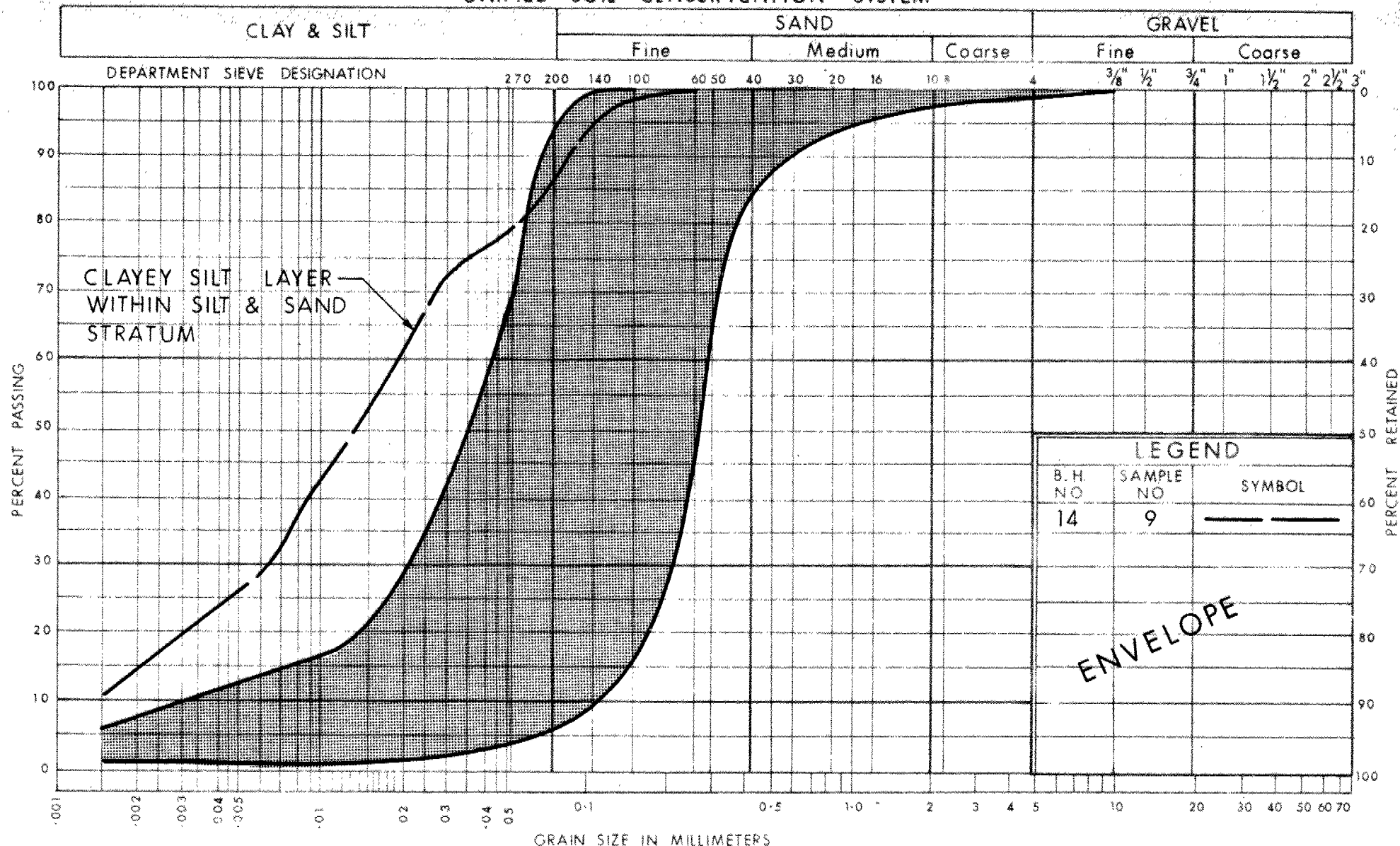
WL in open BH Feb. 16/70

111

11 52 30 7

OVERSIZE DRAWING

UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

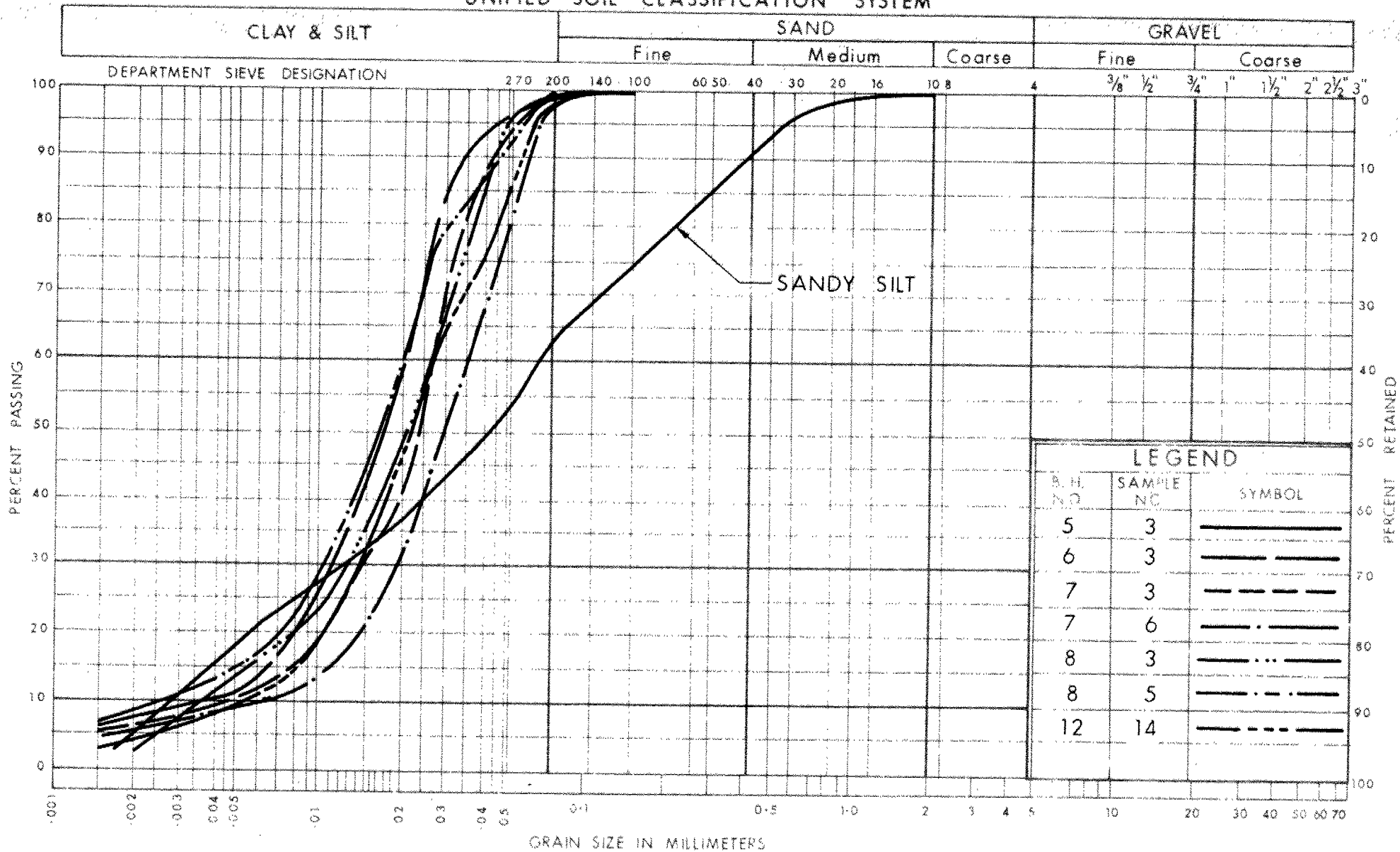
GRAIN SIZE DISTRIBUTION
SILTY FINE SAND TO SANDY SILT

W.O. No. 69-27

JOB No. 70-11006

FIG. NO. 2

UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

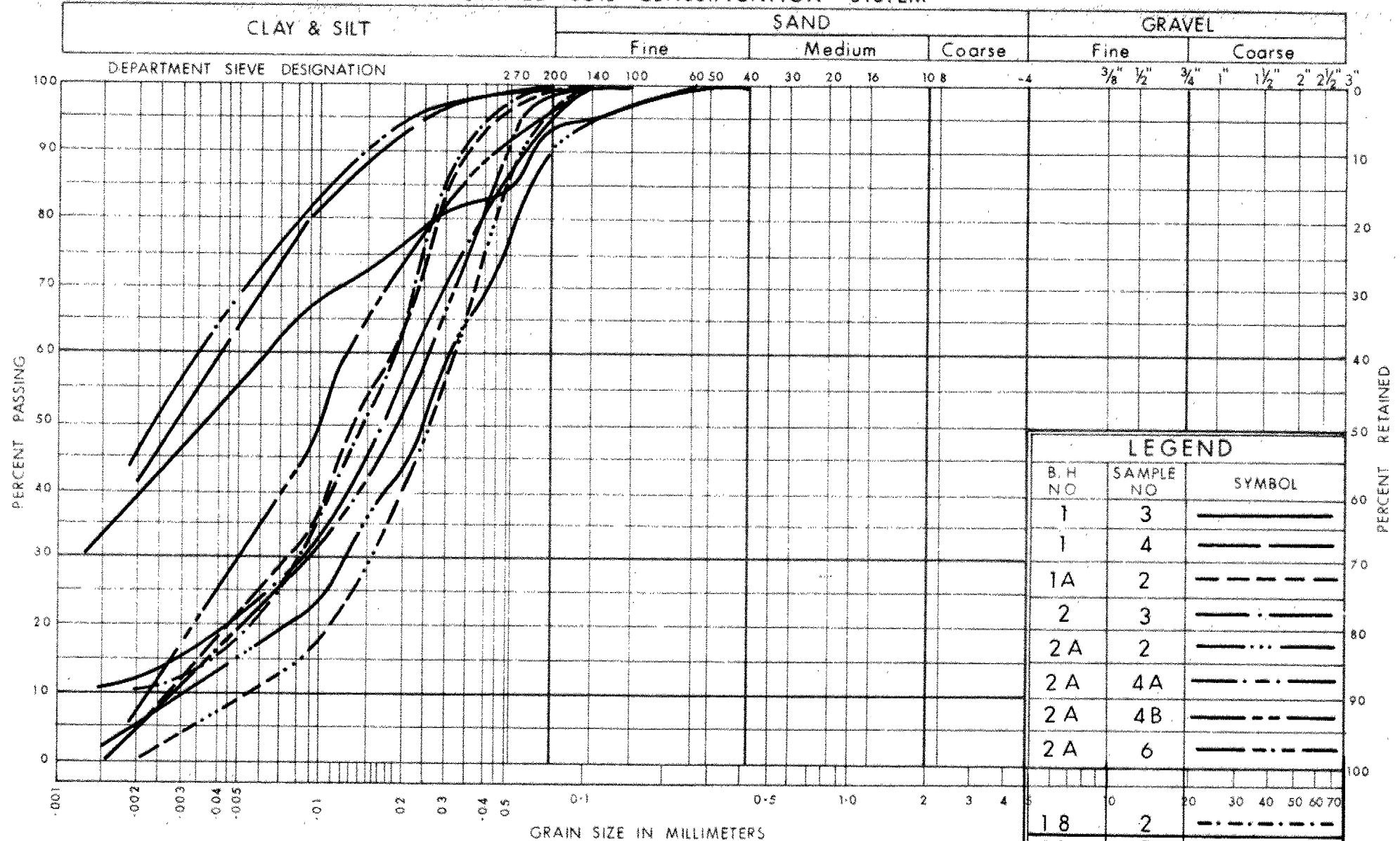
GRAIN SIZE DISTRIBUTION SILT

W.O. No. 69-27

JOB No. 70-11006

FIG. NO. 3

UNIFIED SOIL CLASSIFICATION SYSTEM



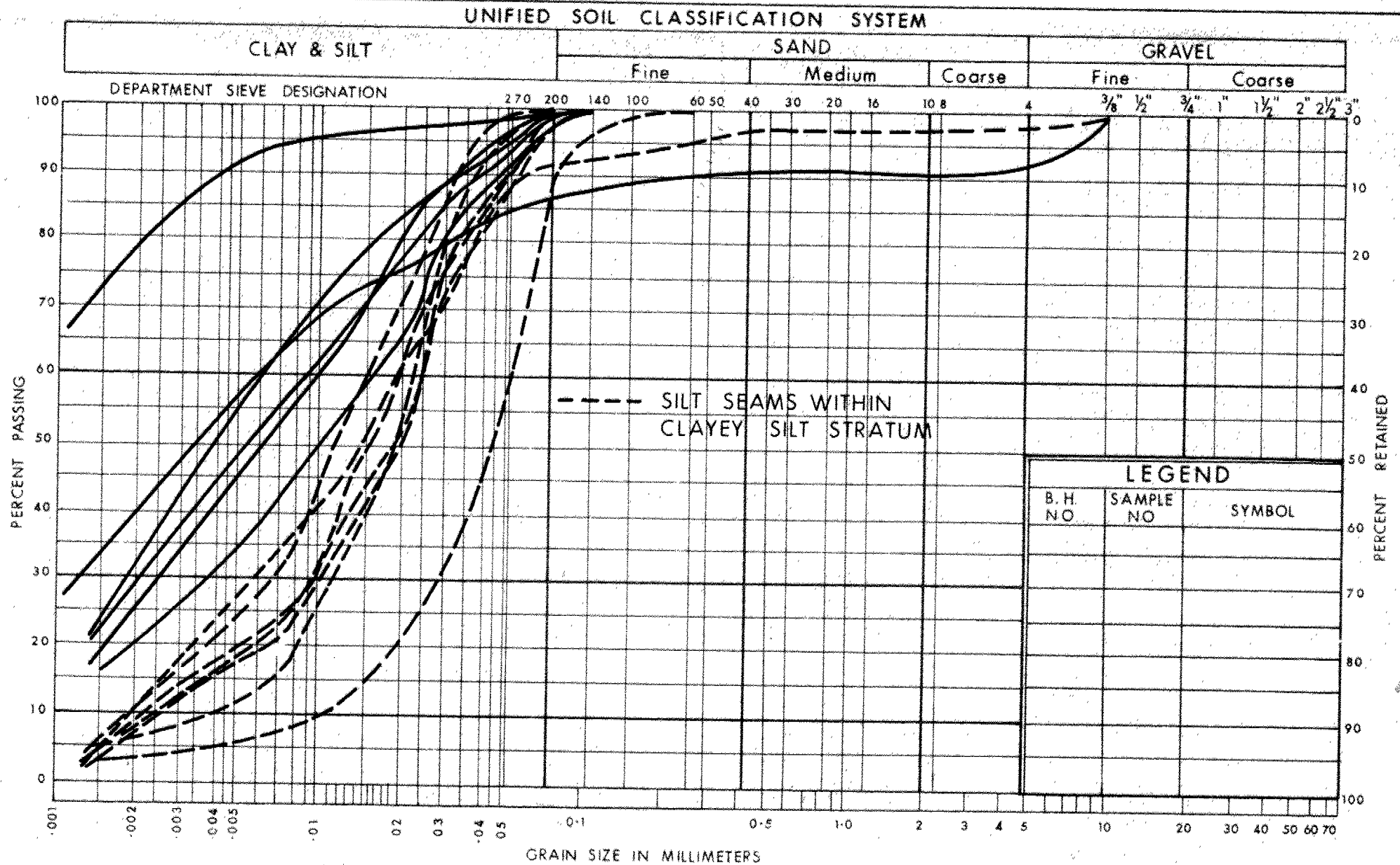
DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

GRAIN SIZE DISTRIBUTION
SILTY CLAY, CLAYEY SILT & SILT (Stratified)

W.O.No. 69-27

JOB No. 70-11006

FIG. NO. 4



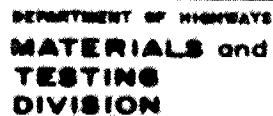
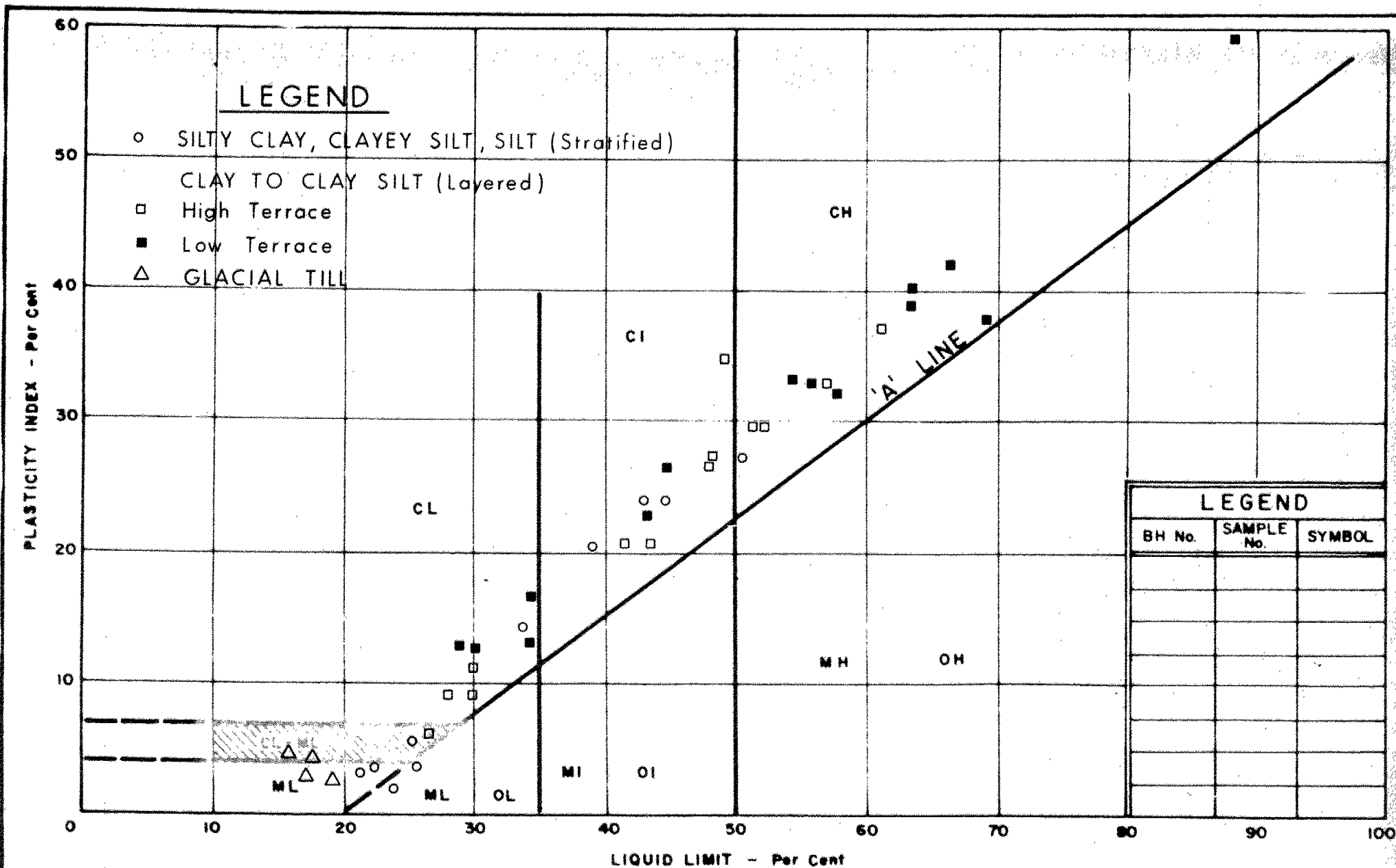
DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

GRAIN SIZE DISTRIBUTION
CLAY TO CLAYEY SILT (Layered)

W.O. No. 69-27

JOB No. 70-11006

FIG. NO. 5



PLASTICITY CHART

W.O. NO. 69-27

JOB No. 70-11006

FIG. NO. 6

TYPICAL STRESS-STRAIN CURVES

QUICK TRIAXIAL TEST

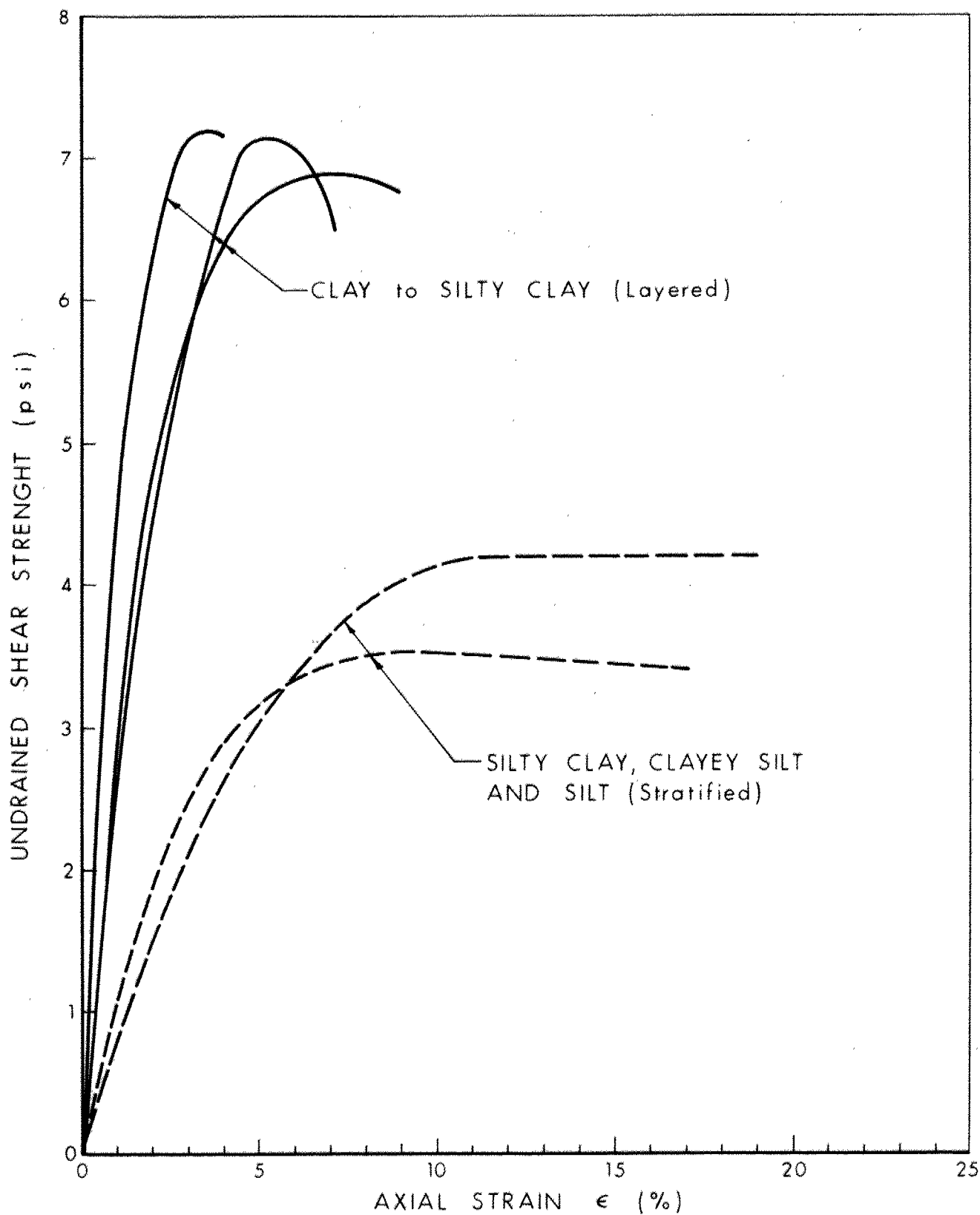


FIG. NO 7

VOID RATIO-PRESSURE CURVES

JOB NO. 70-11006

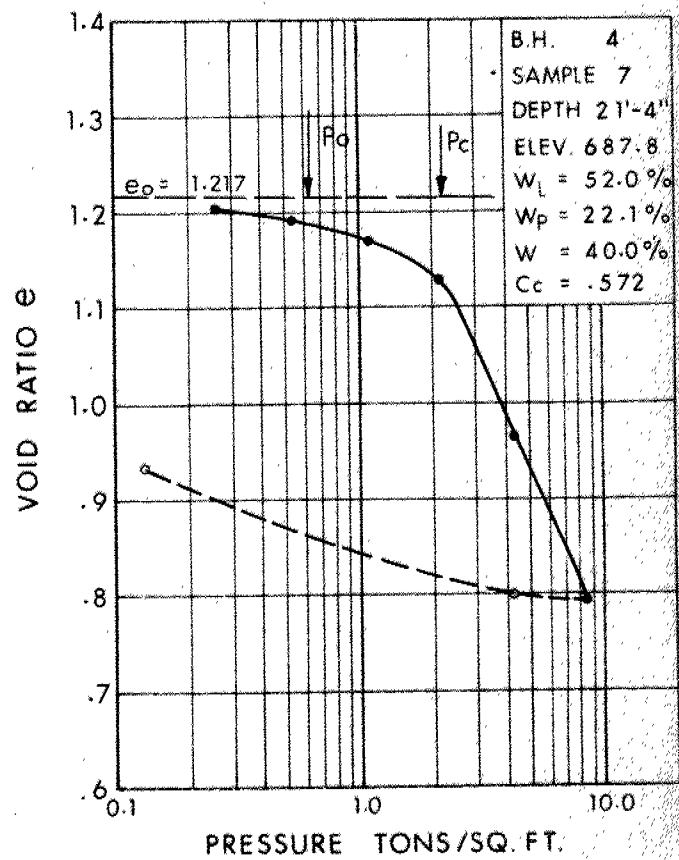
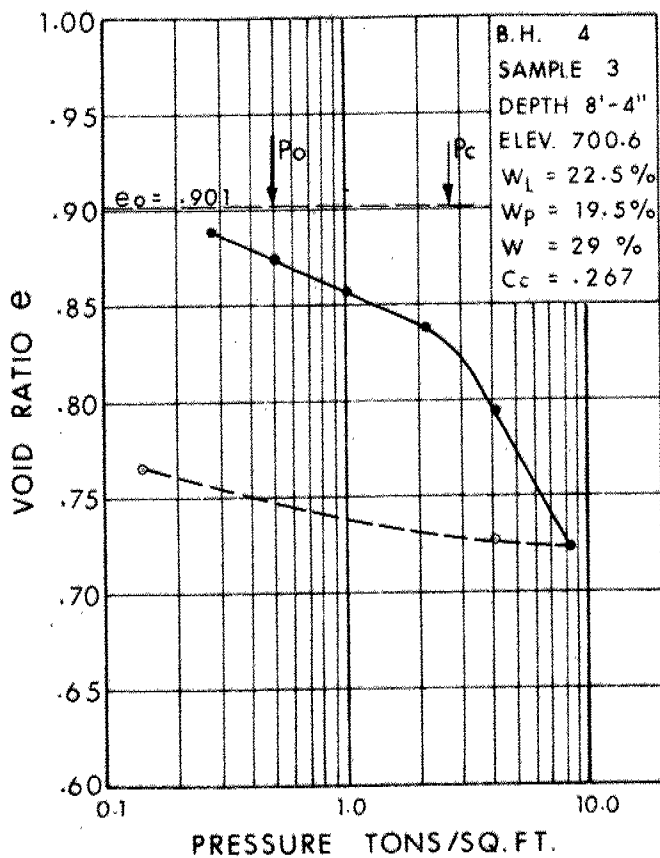
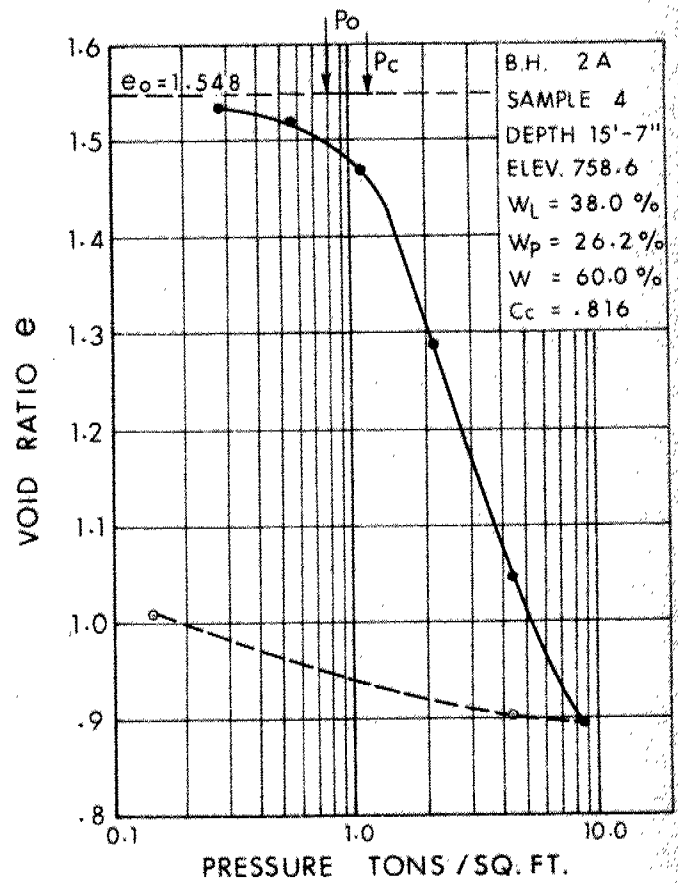
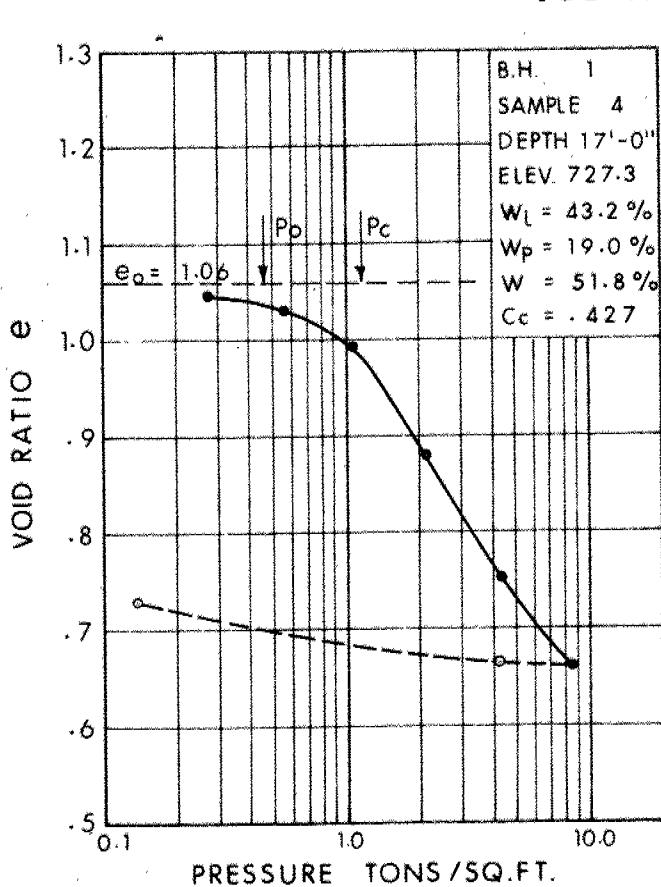


FIG. 8

VOID RATIO-PRESSURE CURVES

JOB NO. 70-11006

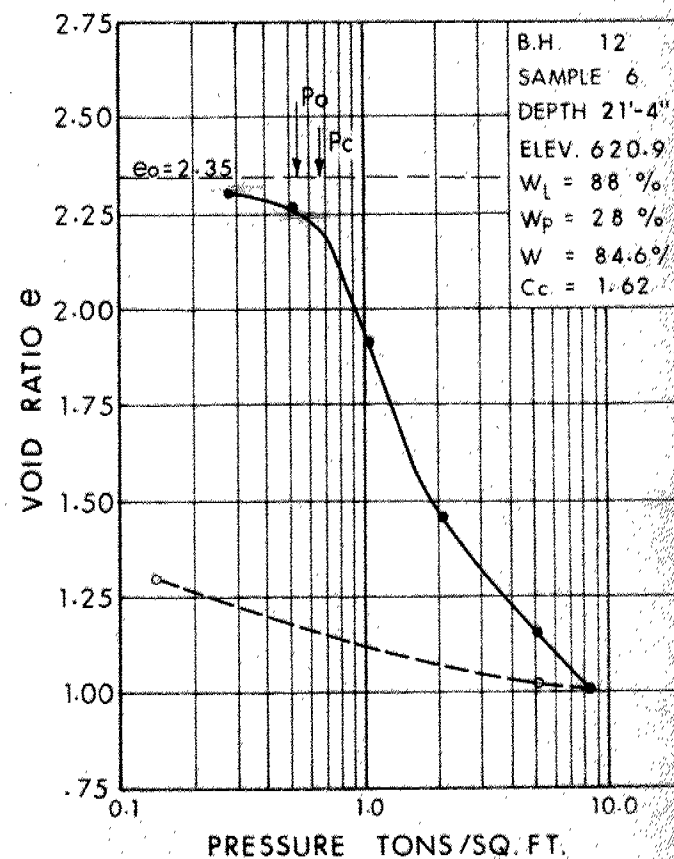
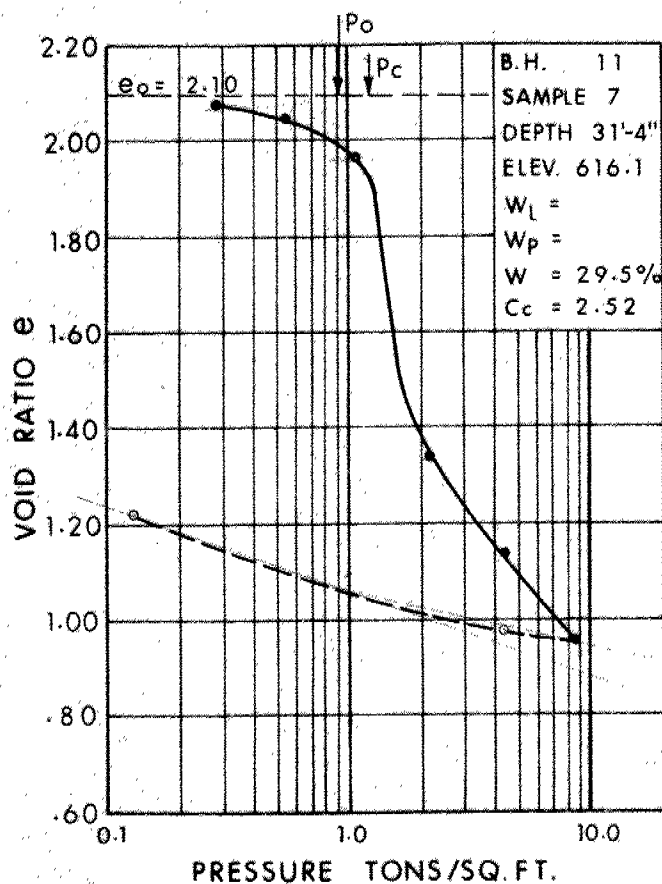
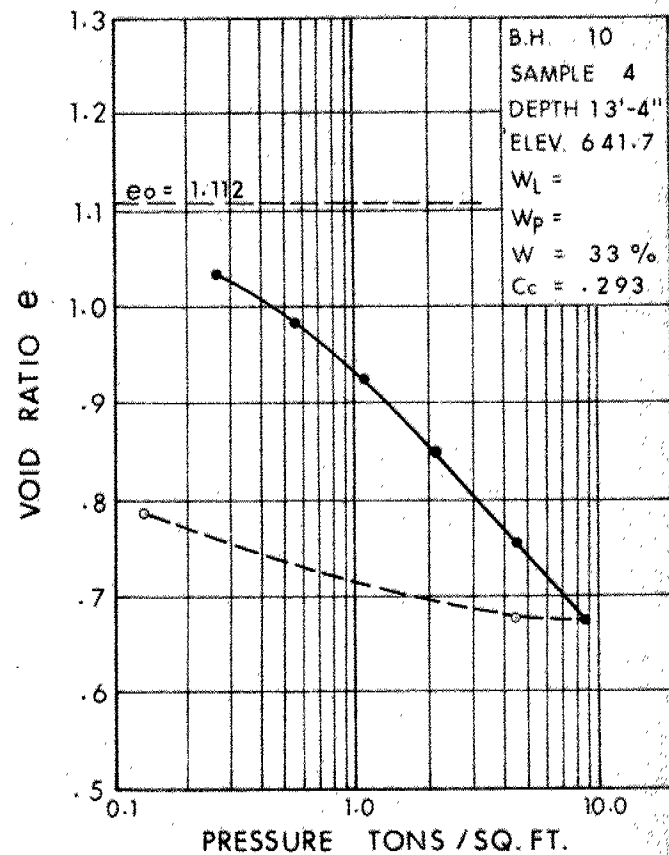
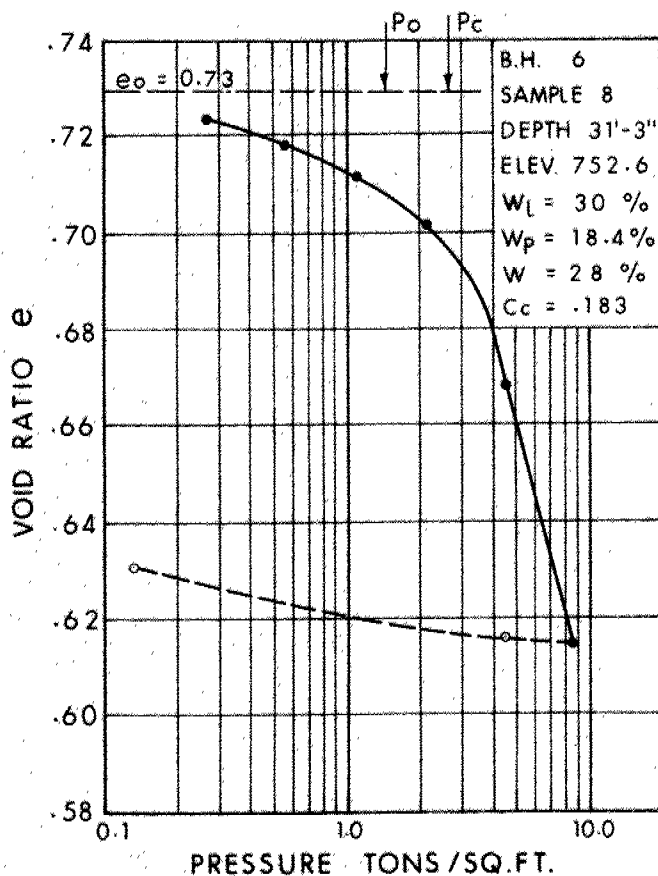
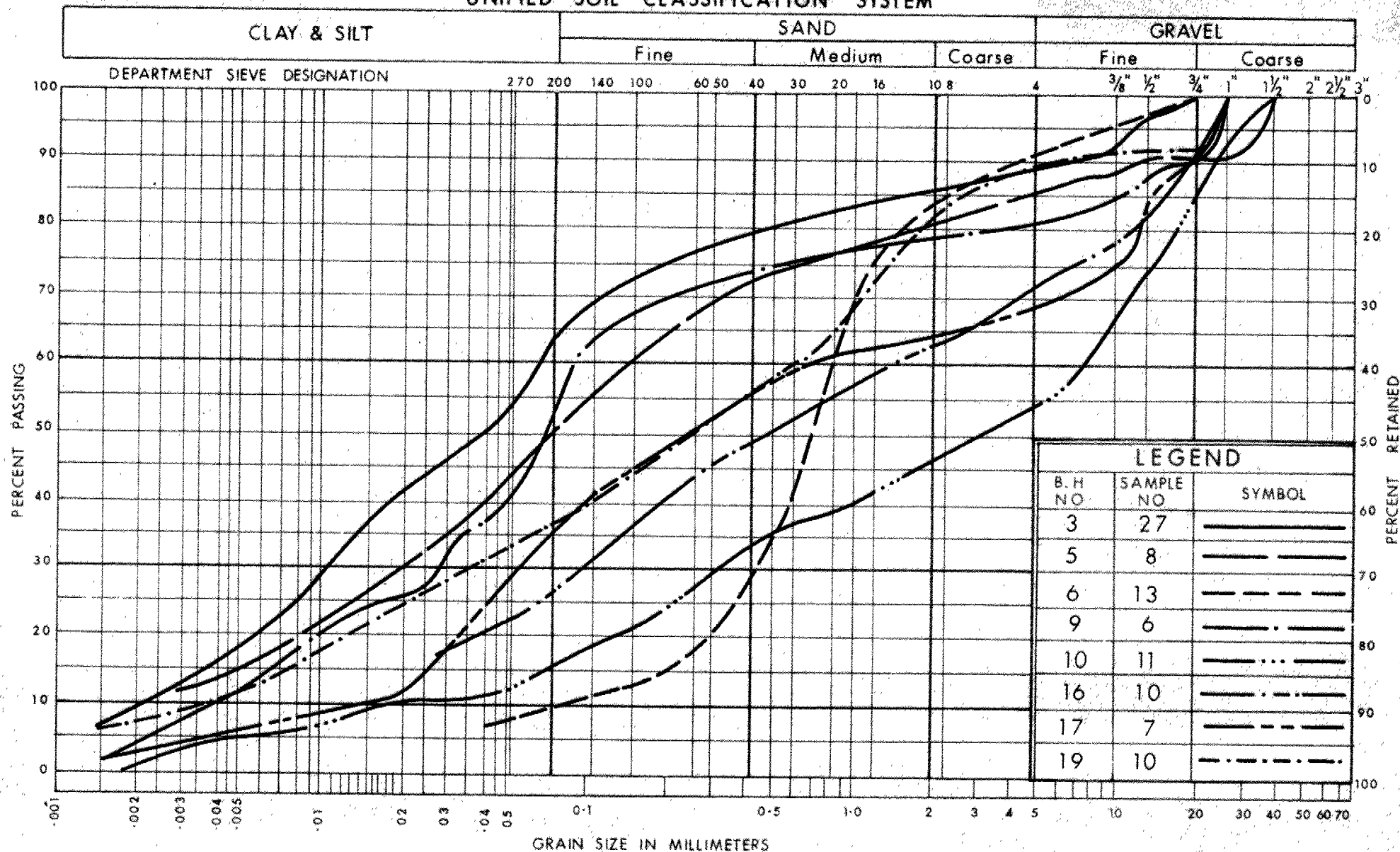


FIG. 9

UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT OF HIGHWAYS
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DIVISION

GRAIN SIZE DISTRIBUTION GLACIAL TILL

HET. MIX. OF SILT, SAND & GRAVEL TRACE TO SOME CLAY

W.O.No. 69-27

JOB No. 70-11006

FIG. NO. 11

ABBREVIATIONS USED IN THIS REPORT

PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE 'N' - 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>'N' BLOWS / FT.</u>	<u>c LB. / SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
VERY SOFT	0 - 2	0 - 250	VERY LOOSE	0 - 4
SOFT	2 - 4	250 - 500	LOOSE	4 - 10
FIRM	4 - 8	500 - 1000	COMPACT	10 - 30
STIFF	8 - 15	1000 - 2000	DENSE	30 - 50
VERY STIFF	15 - 30	2000 - 4000	VERY DENSE	> 50
HARD	> 30	> 4000		

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.B.	SCRAPER BUCKET SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE
S.T.	SLOTTED TUBE SAMPLE		
	P.H. SAMPLE ADVANCED HYDRAULICALLY		
	P.M. SAMPLE ADVANCED MANUALLY		

SOIL TESTS

Qu	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V.	FIELD VANE
Qcu	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Qd	DRAINED TRIAXIAL	S	SENSITIVITY

ABBREVIATIONS 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_r	DEGREE OF SATURATION
w_L	LIQUID LIMIT
w_p	PLASTIC LIMIT
I_p	PLASTICITY INDEX
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

MEMORANDUM

To: Mr. R. G. Gascoyne,
District Engineer,
District #18,
SAULT STE. MARIE, Ont.

From: Foundation Section,
Materials & Testing Office,
Room 107, Lab. Bldg.

ATTENTION:

DATE: September 4, 1970

OUR FILE REF.

IN REPLY TO

SUBJECT:

Proposed C.P.R. Relocation
(Sta. 280+00 to Sta. 610+00)
Dist. #18 (Sault Ste. Marie)
W.J. 70-11006 -- W.O. 69-27

A meeting of the Technical Advisory Committee on the Sault Ste. Marie Expressway was held in the City Council Chambers on July 30, 1970. At this meeting, it was requested to reassess our foundation recommendations with regard to stability of embankments between Station 460+00 and Station 500+00, in the light of recently provided information, namely:

i) That the relocation of the C.P.R. will be for a single trackage (crest width 22 ft.) except for structures which would be double trackage. At the time of the preparation of the foundation report, it was understood that the entire relocation would have two tracks (crest width 40 ft.).

ii) In our foundation report it was assumed that all fills along the relocation would have slopes of 2:1. The recent information indicates that fills up to 15 ft. in height will have $1\frac{1}{2}$:1 slopes, while fills in excess of 15 ft. in height will be constructed with 2:1 slopes (letter from Mr. J. L. Mitchell, P.Eng., Project Manager, M. M. Dillon Ltd., London, Ontario, dated August 5, 1970).

The effects of these revisions, with respect to the original recommendations, will be elaborated upon in the paragraphs to follow.

During the meeting, Mr. J. L. Mitchell of M. M. Dillon Ltd. expressed the opinion that the values assumed for the undrained shear strength of the cohesive subsoil in the stability computations in the area between Station 460+00 and Station 500+00 are very conservative and, consequently, berm lengths recommended in our Preliminary Foundation Report W.J. 70-11006 for various fill sections, are generally excessive.

This memo presents all the results of our review of subsoil conditions, together with our recommendations with respect to stability and settlement of embankments between the aforementioned limits, taking into account all the available up-to-date information.

September 4, 1970

Re: Proposed C.P.R. Relocation - W.J. 70-11006 -- W.O. 69-27 ...

Discussion and Recommendations:

The area where fills up to 30 ft. in height are required is situated between Station 460+00 and Station 500+00, east and west of Old Garden River Road. The respective physical properties of the subsoil at these locations are described in our foundation report. In order to assess the problems more accurately, the fill area can be subdivided into two distinct regions, namely: east of Old Garden River Road (Station 470+00 to Station 500+00) and west of Old Garden Road (Station 460+00 to Station 470+00). The undrained shear strength plots with respect to elevation, are shown on Fig. #11 and #12 for the respective regions, which are appended to this memorandum.

i) Station 470+00 to Station 500+00 (East of Old Garden River Road)

Based on the results presented on Fig. 11, it is our opinion that the undrained shear strength values used for stability analyses in our Preliminary Foundation Report are realistic, and represent the average conditions. It should be noted that a very limited number of laboratory tests have been carried out to determine the undrained shear strength of the cohesive subsoil. Our experience indicates that the laboratory strength values are generally lower than the in-situ field strengths for these cohesive layered deposits. In this high fill area, only 3 boreholes have been carried out for a total distance of 3,000 ft., which averages one borehole for every 1,000 ft. distance. Based on the aforementioned facts, we conclude that the undrained shear strength values chosen for our stability analyses in the Preliminary Foundation Report cannot be considered overly conservative.

A number of stability analyses have been carried out in terms of total stresses, taking into account the new information recently obtained with the following assumptions:

Fill Material - Granular Type

Bulk Density	$\gamma = 125 \text{ p.c.f.}$
Angle of Shearing Resistance	$\phi = 30^\circ$
Slopes for the Fill	$1\frac{1}{2}:1$ and $2:1$
Crest Width of the Fill	22 ft.

September 4, 1970

Re: Proposed C.P.R. Relocation - W.J. 70-11006 -- W.O. 69-27 ...

i) Station 470+00 to Station 500+00 (East of Old Garden River Road) -
(cont'd.) ...

Subsoil -

Elev. 643 - Elev. 639	: C_u = 1000 p.s.f.)	} Ref. Fig. 11
Elev. 639 - Elev. 628	: C_u = 400 p.s.f.)	
Elev. 628 - Elev. 600	: C_u = 550 p.s.f.)	

In addition, settlement analyses have been carried out for various fill heights incorporating $1\frac{1}{2}:1$ and $2:1$ slopes. As a result of these analyses, our stability requirements and estimated consolidation settlements are as follows:

Height of Fill	$1\frac{1}{2}:1$ Slopes		$2:1$ Slopes	
	Berm Requirements	Consolidation Settlements	Berm Requirements	Consolidation Settlements
14'	Nil	12"to18"- 4 yrs. 24"to30"- 25 yrs.- (Max.)	Nil	14"to20"- 4 yrs. 30"to36"- 25 yrs.- (Max.)
20'	Single - Mid-Height 55 ft.	24"to30"- 4 yrs. 54"to60"- 25 yrs.- (Max.)	Single - Mid-Height 50 ft.	24"to30"- 4 yrs. 54"to60"- 25 yrs.- (Max.)
30'	Double - Berms at $1/3$ Height- 65 ft.	30"to36"- 4 yrs. 66"to72"- 25 yrs.- (Max.)	Double - Berms at $1/3$ Height- 60 ft.	30"to36"- 4 yrs. 66"to72"- 25 yrs.- (Max.)

The fact that the width of the embankment will be 22 ft. instead of 40 ft. will mean the placement of less fill. The magnitude of consolidation settlement induced in the foundation subsoil, will be slightly less than that predicted in our original foundation report. It should be noted that the stability requirements of a single-track railway embankment will not alter the berm requirements quoted in our report, for $2:1$ slopes.

September 4, 1970

Re: Proposed C.P.R. Relocation - W.J. 70-11006 -- W.O. 69-27 ...

ii) Station 460+00 to Station 470+00 (West of Old Garden Road) -

At this location, a total of two boreholes (B.H. #10 and #17) have been carried out. These borings revealed that the subsoil conditions are more favourable than those at the east of the Old Garden River Road. As a result of this, we have carried out stability analyses for this region using the following assumptions:

Fill Material - Granular Type

Angle of Shearing Resistance $\phi = 30^\circ$
Bulk Density $\gamma = 125 \text{ p.c.f.}$
Slopes $1\frac{1}{2}:1$ and $2:1$

Subsoil -

Elev. 658 - Elev. 644 : $C_u = 900 \text{ p.s.f.}$
Elev. 644 - Elev. 635 : $C_u = 550 \text{ p.s.f.}$ } Ref. Fig. 12
Elev. 635 - Elev. 620 : $C_u = 1050 \text{ p.s.f.}$

Maximum Height of Fill = 28 ft.

In addition, settlement analyses have also been carried out for various fill heights. The stability requirements and estimated settlements are as follows:

Height of Fill	$1\frac{1}{2}:1$ Slopes		$2:1$ Slopes	
	Berm Requirements	Consolidation Settlements	Berm Requirements	Consolidation Settlements
22'	Nil	3"to 6"-18 mos. 8"to 12"-10 yrs.- (Max.)	-	-
23'	-	-	Nil	4"to 6"-18 mos. 10"to 12"-10 yrs. (Max.)
28'	Single - Mid-Height 40 ft.	6"to 8"-18 mos. 12"to 18"-10 yrs.- (Max.)	Single - Mid-Height 40 ft.	6"to 8"-18 mos. 12"to 18"-10 yrs. (Max.)

Mr. R. G. Gascoyne,
District Engineer,
District #18 - Sault Ste. Marie, Ont.

5
September 4, 1970

Re: Proposed C.P.R. Relocation - W.J. 70-11006 -- W.O. 69-27 ...

The various recommendations outlined in this memo are for preliminary design purposes, based on limited number of boreholes. It will be necessary to carry out additional boreholes in the field when the final design details are available. Recommendations given in this memo are, therefore, to be regarded as conditional only, and as such, are subject to revision at a later date when and if new information becomes available. This memo should be included with our Foundation Report W.J. 70-11006.

If you have any further queries, or if any of the foregoing requires clarification, please do not hesitate to call us.

MD/MdeF

M. Devata

M. Devata
SUPERVISING FOUNDATION ENGR.
For:
A. G. Stermac
PRINCIPAL FOUNDATION ENGR.

cc: Messrs. R. G. Gascoyne (2)
B. R. Davis
H. A. Tregaskes
D. W. Farren
H. W. Hurrell
I. C. Campbell
P. Lester
R. Morgenroth
B. A. Singh
M. M. Dillon Ltd., London - J. L. Mitchell
Foundations Files ✓
Gen. Files

UNDRAINED SHEAR STRENGTH PROFILE OLD GARDEN RIVER ROAD EASTERLY

STATIONS 470+00 TO 500+00 BOREHOLES 11, 11A, 12 & 16

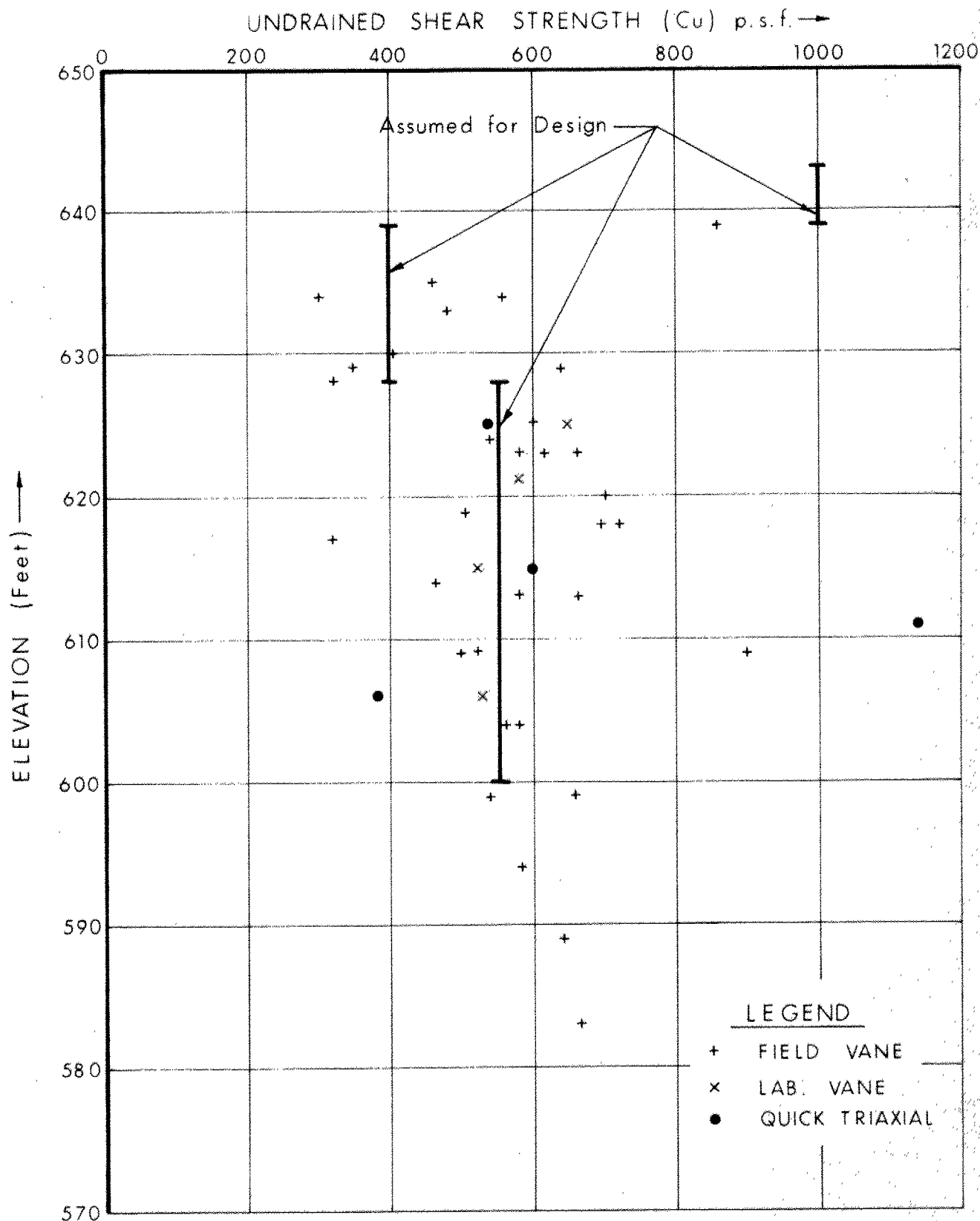


Fig. No 11

70-11006

UNDRAINED SHEAR STRENGTH PROFILE OLD GARDEN RIVER ROAD WESTERLY

STATIONS 460+00 TO 470+00 BOREHOLES 10 & 17

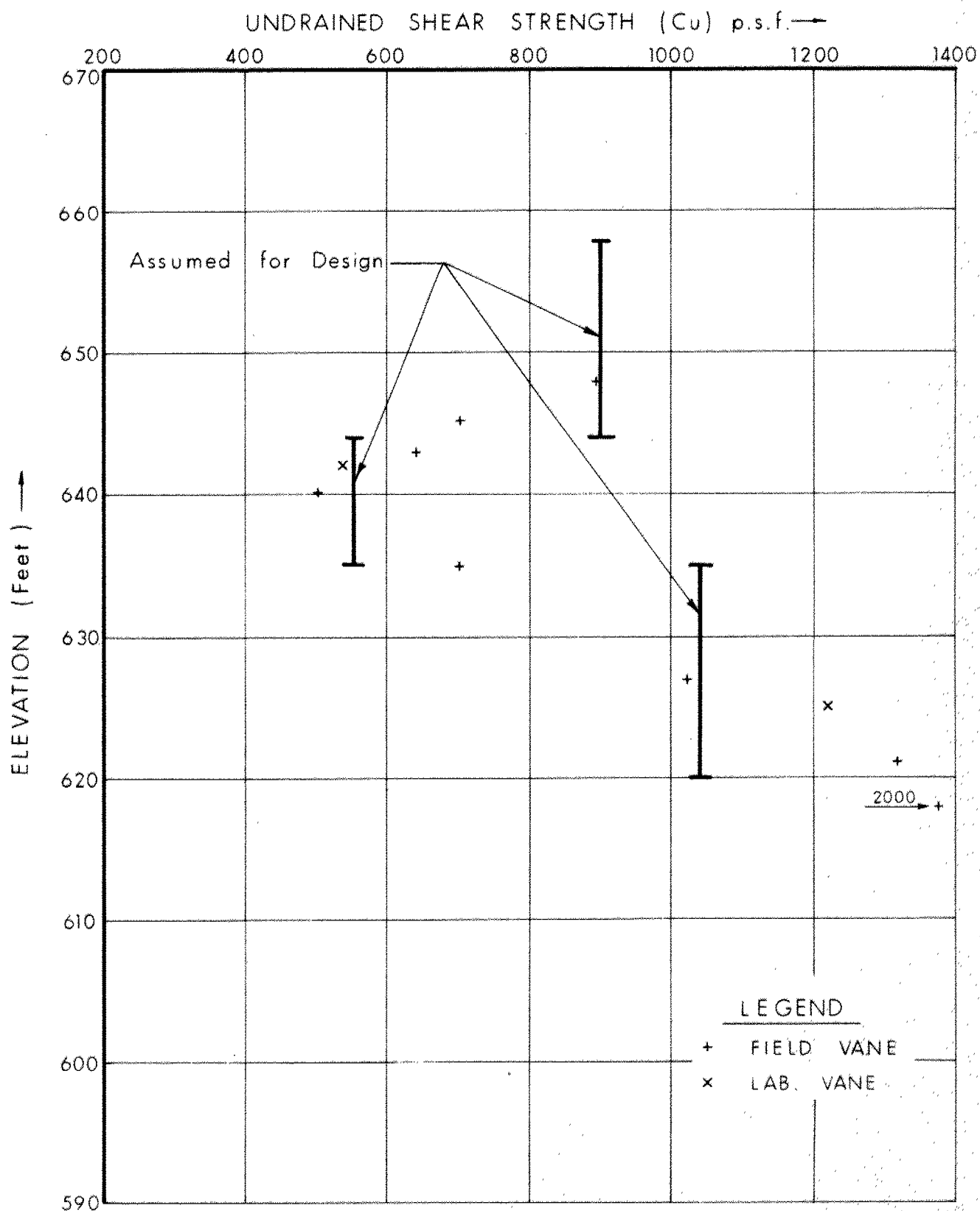


Fig. No 12

Ontario
Department of Transportation and Communications
XXXXXXXXXXXXXXXXXXXXXXX

Mr. G. R. Browning, (2)
District Engineer,
District #18,
Sault Ste. Marie, Ontario.

Foundations Office,
Design Services Branch,
Central Bldg., Downsview.
October 29, 1971.

Proposed C.P.R. Relocation, (Sta. 470+00 to
Sta. 500+00), District #18 (Sault Ste. Marie),
W.J. 70-11006 -- W.O. 69-27

Further to the letter of Mr. J. L. Mitchell, Project Manager, M.M. Dillon Ltd. of October 15, 1971, we have carried out the stability analyses for the proposed C.P.R. Relocation railway embankment at Sault Ste. Marie, Ontario (Stations 470+00 to 500+00).

The analyses have been carried out using the following assumptions:

- 1) Embankment core composed of light weight slag (-4 inch material from Algoma Steel stock piles). In-place compacted bulk density 90 p.c.f.
- 11) All stabilizing berms composed of locally available cut material. In-place compacted bulk density 115 p.c.f.
- 111) Geometric details, such as height of fill, slopes, tension cracks and soil parameters are shown on the enclosed drawing.

The computations indicated that:

- a) Fills up to 20 feet in height (with 2:1 slopes), composed of light weight slag, will be stable.
- b) Fills in excess of 20 feet in height will require stabilizing berms.

For example, a 30 foot high fill (with 2:1 slopes) will require mid-height berms 35 feet in length in order to ensure stability of the section.

Mr. G. R. Browning

- 2 -

October 29, 1971.

For preliminary estimating purposes, the values quoted in our foundation report for consolidation settlement of the foundation subsoil, due to the embankment loading, will still apply.

MD/ao


M. Devata,
SUPERVISING FOUNDATION ENGINEER.

cc: J. I. Becking
J. L. Mitchell, M. M. Dillon Ltd.
J. R. Crosby, M. M. Dillon Ltd.

Foundations Files ✓
Documents

Design Services Branch,
Foundations Office,
Downsview, Ontario.

October 25, 1971.

Mr. J. L. Mitchell, P. Eng.,
Project Manager,
M. M. Dillon Limited,
Consulting Engineers,
Box 426, Station B,
London 12, Ontario.

Dear Mr. Mitchell:

Re: Sault Ste. Marie, Ontario -
Rail Relocation Study.

70-11-006

This is to confirm and answer your letter of October 15, 1971, to Mr. M. Devata regarding the above subject.

We are most surprised and rather concerned with your statement that our memorandum of October 1, 1971, to Mr. G. R. Browning contains several inaccuracies. We have reviewed the mentioned memorandum very carefully and have failed to find any inaccuracies and must, therefore, ask you to elaborate and list them one by one. The memorandum may not contain the information you think it should but this would not mean that it contains inaccuracies.

Before we go into further elaboration of the issue may we draw your attention to what we would consider inaccuracies in your letter of October 15, 1971.

On page 1 of your letter you quote the unit weight of the slag in lbs./cu. yd. We are sure you meant lbs./cu. ft. On page 2 you quote two of our memoranda - October 1, 1971, and October 6, 1971. We have, however, never sent you a memorandum dated October 6, 1971.

It appears to us that some of the problems, if there even are any, result from certain misunderstandings which may have been brought about from conveying some of the requests by telephone rather than in written form.

To elaborate on and restate the events as we see them we would like to make the following comments:

1. In our report dated May 27, 1970, we did carry out stability analyses assuming the fill to be built of normal as well as of light-weight material. For a 30 ft. high embankment for both assumptions berms were found to be necessary, however, of different lengths. For the fill built of light-weight slag berms were assumed to be of the same material. The light-weight fill was assumed to have a unit weight of 90 lbs./cu. ft.
2. Because of some modifications in the design and because of some doubt expressed with regard to the soil parameters used in our original computations we were requested to review our findings and, if necessary, re-analyze certain sections. The results of this work are contained in our memorandum to Mr. R. G. Gascoyne dated September 4, 1970.

This time all calculations were made with the assumption that the fills will be constructed with the normal earth material having a unit weight of 125 lbs./cu. ft.

3. Samples of the slag from the Algoma Steel Mills were sent to us for analyses and the results of these contained in our memorandum to Mr. G. R. Browning dated July 22, 1971, confirmed the correctness of our original assumption regarding the unit weight of slag. Consequently, we were of the opinion and stated that the recommendations contained in our report dated May 27, 1970, were valid.
4. Upon your request we have carried out stability analyses for a 30 ft. high embankment having 30 ft. long and 5 ft. high berms. The unit weight of the embankment and berm material was taken as 115 lbs./cu. ft. We were under the impression that you stated that such an arrangement is safe because you quoted a slip circle which gave a factor of safety in excess of one. We could not assume that someone, when quoting a slip circle would not be quoting the most critical one, i.e. the one having the lowest factor of safety. To quote any other circle seems to us pointless.

Our subsequent analyses have shown that the above quoted embankment and berm arrangement was not safe and we presented our findings in the memorandum to Mr. G. R. Browning dated October 1, 1971.

5. On August 3, 1971, there was a telephone discussion concerning embankment stability but only from your letter to Mr. M. Devata dated October 6, 1971, it was realized that you requested us to analyze the embankment-berm arrangement with the embankment built of material weighing 90 lbs./cu. ft. and the berms of material weighing 115 lbs./cu. ft.

October 25, 1971.

We have now carried out these calculations and have found that this arrangement is also not sufficiently stable. The results are attached.

6. The new slag samples (-4 inch) have now been analyzed in our laboratory. The results of these tests are attached. These latter analyses have again shown that our original assumption of 90 lbs./cu. ft. was correct. We would like to point out that our assumption of 90 lbs./cu. ft. was based on the Department's past experience with light-weight materials. Manufacturers and suppliers have claimed certain unit weights but the laboratory and field tests did not support those claims.

In conclusion, we would like to suggest that in the future all requests for any work to be performed by this office be made in writing so as to avoid any possible misunderstanding.

We hope the above clarifies the issue. Should you, however, have any comments to make we would be pleased to consider them.

Yours truly,



A. G. Stermac,
PRINCIPAL FOUNDATION ENGINEER.

AGS/ao
Attach.

cc: Foundations Files ✓
Documents

G. R. Browning
J. I. Becking
J. R. Crosby, M. M. Dillon Limited.

C.P.R. RELOCATION
CONDITIONS

<u>ESTIMATED FOR COSTING</u>	<u>BY SOILS</u>
1) Fill Station 460-500 2:1 slopes over 15' Settlements tolerable	Berms equivalent 6:1 slopes Settlement 7 feet Structure recommended or lower profile by 10 feet.
2) Cuts east of Highway 17 2:1 backslope over 15' Toe tile drains	2:1 backslope. Toe tile drain. 18" to 24" of granular blanket below the groundwater table. Recommends 10 ft. lower pro- file.
3) Ravine west of Peoples Road 2:1 slopes fill	2:1 fill slope 30 ft. mid berm.
4) Ravine east of old Goules Bay Road 2:1 fill slopes Settlement tolerable	2:1 fill slope 100 ft. mid berm Settlements 2' Structure recommended
5) Structure at Highway 17 Normal conditions	Normal conditions
6) Structure at Garden River Road Normal Conditions	Piles to bedrock Approach fills require excessive berms.

Ontario
Department of Transportation and Communications
~~XXXXXXXXXXXXXXXXXXXX~~

MEMORANDUM

D R A F T

TO: Mr. G. R. Browning, (2)
District Engineer,
District #18,
Sault Ste. Marie, Ontario.

FROM: Foundations Office,
Design Services Branch,
Central Bldg., Downsview.

ATTENTION:

DATE: October 20, 1971.

OUR FILE REF.

IN REPLY TO

SUBJECT: Proposed C.P.R. Relocation, (Sta. 470+00 to
Sta. 500+00), District #18 (Sault Ste. Marie),
W.J. 70-11006 -- W.O. 69-27

Further to the letter from Mr. J. L. Mitchell, Project Manager, M.M. Dillon Limited, of October 15, 1971, we would like to request him to clarify his statement that "several inaccuracies and corrections," were contained in our memo of October 1, 1971.

In the interim we would like to clarify a number of the points presented in Mr. Mitchell's recent letter.

Department Personnel from the Sault Ste. Marie District provided this Office with samples of slag from the Algoma Steel Mills stock pile. Laboratory testing was carried out to determine the compacted bulk density of the material. The results, together with our comments with regard to the stability of fills composed of this light weight slag, were presented in a letter dated July 22, 1971. At a later date, we were advised by Mr. Mitchell that the slag samples submitted were not the minus 4-inch type of slag material proposed for the fills. He stated that the District would provide minus 4-inch slag material for further testing. The testing has now been completed; the results obtained are summarized below:

- * Bulk Unit Weight - (Loose State - Vibrated) - 83 to 86 p.c.f.
- Absorption - (of moisture) - 27 to 2.8%
- Abrasion Test - (Los Angeles 500 REVS) - 26 to 29% Loss
- Aggregate Test - Coarse - (+#4 Sieve) - 71 to 81%
- Fine - (-#4 Sieve) - 19 to 29%
- Specific Gravity (Gs) - Dry - 2.37 to 2.42
- Apparent - 2.54 to 2.60

*It should be noted that it is extremely difficult to carry out conventional Proctor compaction tests on material as coarse as this slag. Modified testing procedures (using vibratory methods) were adopted to estimate the bulk weight in the loose state.

From the aforementioned results it can be concluded that the in-place bulk weight, in a compacted state, would likely be of the order of 90 p.c.f. The recent test results agree closely with the value assumed for light weight fill in our stability analyses presented in our foundation report W.J. 70-11006, dated May 27, 1970. This being the case we consider that the berm requirements, specified in the report, for various fill heights are still applicable.

It appears from Mr. Mitchell's letter (October 6, 1971) that the slag material will only be used for the main core of the embankment and the berms will be formed of surplus cut material (bulk unit weight 115 p.c.f.). In order to assess the stability of this composite section, additional computations will have to be carried out. Prior to carrying out additional analysis we would like to have a finalized detailed geometry of the proposed embankment section of the railway. This will, no doubt, avoid any misunderstanding as well as limit the need for unnecessary work.

With regard to another comment made in Mr. Mitchell's letter, we would like to point out that the section details, as well as the unit weight of the material (unit weight 115 p.c.f.) ^{were} specified verbally, in a telephone conversation, to personnel from this Office. In addition, it was requested that we should carry out a stability analysis for a particular geometry and cylindrical failure surface which was stated to provide a stable section. We carried out the necessary stability analyses for the specified section and the results indicated that this section would be unstable. The specific details were discussed in our letter of October 1, 1971. We would like to emphasize that, at the time of the verbal conversations, no mention was made of the fact that the section to be employed would be of a composite type - i.e. a core composed of compacted light-weight slag and berms composed of compacted surplus cut material.

Based on the above-mentioned facts, we feel there are no inaccuracies for the requirements specified at early dates, and that further, no clarifications or corrections are necessary. Since this is the second time we have had to re-analyze various geometric sections we feel that a written request, with all the pertinent information, should be submitted to this Office rather than further verbal information.

Based on the laboratory testing carried out, as well, the field case history obtained on Hwy. #10 reconstruction, near Toronto, we have come to the conclusion that the in-place unit weight of slag material is never significantly less than 90 p.c.f.

In order to finalize the stability analysis for this project, prior to November 5, 1971, this Office will initiate the necessary work using the following assumptions:

- 1) Geometry of the composite fill section will be the same as that mentioned in our memo of September 4, 1970.
- 2) The slag material ($\gamma = 90$ p.c.f.) will only be used for the main core and the berms will be composed of cut material ($\gamma = 115$ p.c.f.)

These results will be submitted to you prior to your November 5, 1971, Technician Advisory Committee Meeting. In the meanwhile if the design consultant feels that the aforementioned assumptions are incorrect this Office should be notified immediately.

If you have any further queries, or if any of the foregoing requires clarification, please contact this Office.

MD/ao
Attach.

M. Devata,
SUPERVISING FOUNDATION ENGINEER.

cc: M. M. Dillon Ltd.,
London, Ontario.

RESULTS OF SLAG SAMPLES (-4 INCH)

- * Bulk Unit Weight - (Loose State - Vibrated) - 83 to 86 p.c.f.
- Absorption - (of moisture) - 2.7 to 2.8%
- Abrasion Test - (Los Angeles 500 REVS) - 26 to 29% Loss
- Aggregate Test - Coarse - (+#4 Sieve) - 71 to 81%
- Fine - (-#4 Sieve) - 19 to 29%
- Specific Gravity (Gs) - Dry - 2.37 to 2.42
- Apparent - 2.54 to 2.60

*It should be noted that it is extremely difficult to carry out conventional Proctor compaction tests on material as coarse as this slag. Modified testing procedures (using vibratory methods) were adopted to estimate the bulk weight in the loose state.



M. M. DILLON LIMITED

CONSULTING ENGINEERS

BOX 426 STATION B LONDON 12, ONTARIO / TEL. AREA 519-438-6192 / CABLE: DILLENG LONDON CANADA

OUR FILE: 6349-01
YOUR FILE:

15 October 1971

Department of Transportation & Communications
Foundation Section
Design Services Branch
Central Building
DOWNSVIEW 464, ONTARIO

Attn: Mr. M. Devata, P. Eng.
Supervising Foundations Engineer

Sault Ste. Marie, Ontario
Rail Relocation Study

Dear Sirs:

On 14 October 1971 we received a copy of your memorandum of 1 October 1971 to Mr. G. R. Browning, and note several inaccuracies which, in the interest of all concerned, require clarification and correction.

To briefly review the background, your reports of 27 May 1970 and 4 September 1970 considered fills of granular material as well as of light-weight material of 90 lbs/cu. yd. However, in the early Spring of 1971, the Technical Advisory Committee was given to understand by Algoma personnel that their minus 4 inch slag was lighter than 90 lbs/cu. yd. The Technical Advisory Committee decided that a slag sample should be taken and sent to your office for testing and further recommendations from you regarding berms for fills. This was done and you reported on 22 July 1971. Unfortunately, the slag sample submitted was not the minus 4 inch type of material proposed for the fill.

... continued

141 MAPLE STREET LONDON ONTARIO

LONDON • WINDSOR • TORONTO • OTTAWA • WINNIPEG • SUDBURY

Department of Transportation & Communications

Attn: Mr. M. Devata, P. Eng.
Supervising Foundations Engineer

-2-

15 October 1971

We discussed all of this with you on 3 August 1971. It was agreed that if samples of the material proposed for use were delivered to you, you would make further tests and recommendations. Also, you agreed to provide stability figures for a 30 foot fill of "slag" material with 2:1 side slopes and a berm of 5 ft. x 30 ft. of 115 pound surplus cut material. Not having received this information, we wrote you on 6 October 1971 again requesting this data.

(1) Your memorandum of 1 October 1971 does not answer either query. Firstly, what did your tests show for the estimated compacted weight of the minus 4 inch slag material?


Secondly, your memo of 6 October 1971 with the attached data sheet, is apparently for a granular fill of 115 pounds per cubic foot, rather than for a slag material as requested.

Thirdly, we did not specify any slip circle as being the critical one as suggested in your memo. As we are both aware, the calculations to arrive at the critical circle are so time consuming, they are best done by a computer. The circle mentioned in your memo was used by us on a preliminary trial basis to give an indication of the Factor of Safety for a slag fill with berms as mentioned above. Since this trial appeared to indicate a reasonable factor of safety, we requested that you analyze such a section by computer. Obviously, since you assumed a fill weight approximately 30 pounds heavier than the slag we proposed, you arrived at a Factor of Safety less than unity.

We are most anxious to finalize this fill section, both as to types of material and the berm requirements. In order to do this, may we please have a reply to our letter of 6 October 1971 prior to 5 November 1971 which is the date of our next Technical Advisory Committee meeting.

Yours truly,

M. M. DILLON LIMITED


J. L. Mitchell, P. Eng.
Project Manager

JLM:iv

cc: G. R. Browning (2)

J. I. Becking
T. B. Crosby



M. M. DILLON LIMITED

CONSULTING ENGINEERS

BOX 426 STATION B LONDON 12, ONTARIO / TEL. AREA 519-438-6192 / CABLE: DILLENG LONDON CANADA

OUR FILE: 6349-01

YOUR FILE:

6 October 1971

Department of Transportation & Communications
Foundation Section
Room 107 - Lab Building
DOWNSVIEW 464, ONTARIO

Attn: Mr. M. Devata, P. Eng.
Supervising Foundation Engineer

Sault Ste. Marie
Rail Relocation Study

Dear Sirs:

This is a follow up to our telephone conversations of 3 August 1971 and early September 1971 regarding proposed fills using Algoma slag.


As discussed, we are awaiting your recommendations regarding fill slopes and berms when 4 inch minus slag is used. We understand that samples of this material were delivered to your office some time ago.

Also, you were to send us the computer input data and output assuming a slag fill height of 30 feet 2:1 slopes and a berm 5 feet x 30 feet of 115 pound material.

We would appreciate receiving this data as soon as possible.

Yours truly,

M. M. DILLON LIMITED


J. L. Mitchell, P. Eng.
Project Manager

JLM:iv

cc: G. Browning, P. Eng.
J. I. Becking, P. Eng.
A. A. Jackson, P. Eng.
J. R. Crosby, P. Eng.

141 MAPLE STREET LONDON ONTARIO

LONDON * WINDSOR * TORONTO * OTTAWA * WINNIPEG * SUDBURY

Ontario
Department of Transportation and Communications
~~XXXXXXXXXXXXXXXXXXXX~~

MEMORANDUM

TO: Mr. G. R. Browning, (2) FROM: Foundations Office,
District Engineer, Design Services Branch,
District #18, Central Bldg., Downsview.
Sault Ste. Marie, Ontario.

ATTENTION:

DATE:

October 1, 1971.

OUR FILE REF.

IN REPLY TO

SUBJECT: Proposed C.P.R. Relocation,
District #18 (Sault Ste. Marie),
W.J. 70-11006 -- W.O. 69-27.

As requested by Mr. J. L. Mitchell, Project Manager, M.M. Dillon Ltd., London, Ontario, we have carried out analyses to determine the stability of a typical fill section located along the proposed C.P.R. relocation in Sault Ste. Marie, Ontario (between Stations 470+00 to 500+00). The geometric details of the typical section, as specified by Mr. Mitchell, are summarized on the drawing attached to this letter as well as in the table given below:

Embankment Fill Details:

- Height of Fill - 30 feet
- Transverse Berms - Height - 5 feet, Length - 30 feet
- Crest Width of Embankment - 12 feet
- All slopes - 2:1

Fill Parameters:

- Bulk Unit Weight - 115 p.c.f.
- Apparent Angle of Internal Friction - 30°

The results of the computations are summarized on the attached drawing. Referring to this drawing it can be seen that the centre of the circle, specified as the critical one by Mr. Mitchell (No. 1), has a factor of safety slightly greater than unity with respect to instability. Our analyses indicated, however, that lower factor of safeties exist at other centre locations. The critical centre, for this particular case, (designated as No. 2) is plotted on the drawing; this gave a factor of safety of 0.9. It is pertinent to note that the critical cylindrical failure surface cuts through the berm. This would indicate that the counter-balancing (resisting) force provided by the relatively low berm is inadequate and that a greater counter-balancing force (i.e. a higher, longer berm) would be required to ensure the stability of this 30feet high fill.

October 1, 1971.

Based on our computations and analyses we conclude that the 5 feet high - 30 feet long berms recommended would not ensure the stability of this section. Further, we consider that the berm requirements, presented in Foundation Report No. 70-11006, dated May 27, 1970, as well as a letter dated September 4, 1970, still apply as far as preliminary design considerations are concerned. We would, however, be pleased to re-assess our recommendations in the light of any detailed information that becomes available, such as a revision in the in-place compacted bulk unit weight of the fill.

If we can be of any further assistance to you on this project please contact this Office.

MD/ao
Attach.

cc: M. M. Dillon Ltd.,
London, Ontario.
Mr. J. L. Mitchell.

Foundations Office ✓
Documents

M. Devata
M. Devata,
Supervising Foundation Eng.,

MEMORANDUM

TO: Mr. G. R. Browning,
District Engineer,
District #18,
SAULT STE. MARIE, Ont.

FROM: Foundation Section,
Design Services Branch,
Room 107, Lab. Bldg.

ATTENTION:

DATE: July 22, 1971

OUR FILE REF.

IN REPLY TO

SUBJECT:

Proposed C.P.R. Relocation
Dist. #18 (Sault Ste. Marie)
W.J. 70-11006 -- W.O. 69-27

As requested by you, we have carried out laboratory tests on the lightweight slag samples supplied by your office. This slag is from the Algoma Steel Mills stock pile in Sault Ste. Marie, Ontario.

The compaction tests carried out on this material gave the following:

<u>Degree of Compaction</u>	<u>Bulk Density</u>
Loose	88.4 p.c.f.
Dense	95.2 p.c.f.

Two typical grading curves for this material are enclosed.

In the preliminary foundation report (No. W.J. 70-11006, dated June 16, 1970), a value of 90 p.c.f. has been assumed for the lightweight fill in our stability computations (refer to page 22). The design consultants felt that the Algoma Steel lightweight slag would have a much lower bulk density than what was assumed for design purposes. On the contrary, the recent laboratory results revealed that the bulk weight of the lightweight slag would range between 88 (loose state) and 95 p.c.f. (dense state), depending upon the gradation of the material.

Based on the aforementioned results, we consider that the berm requirements for various fill heights, for preliminary design purposes, are still applicable, as mentioned in our report.

MD/MdeF

cc: Messrs. G. R. Browning (2)

B. R. Davis
F. G. Allen
D. W. Farren
H. W. Hurrell
I. C. Campbell
P. Lester
R. Morgenroth
B. A. Singh
M. M. Dillon Ltd. (London) - J. L. Mitchell

M. Devata
M. Devata,
SUPERVISING FOUNDATION ENGR.
For:
A. G. Stermac,
PRINCIPAL FOUNDATION ENGR.

Foundations Files ✓

Gen. Files

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

Fine

Medium

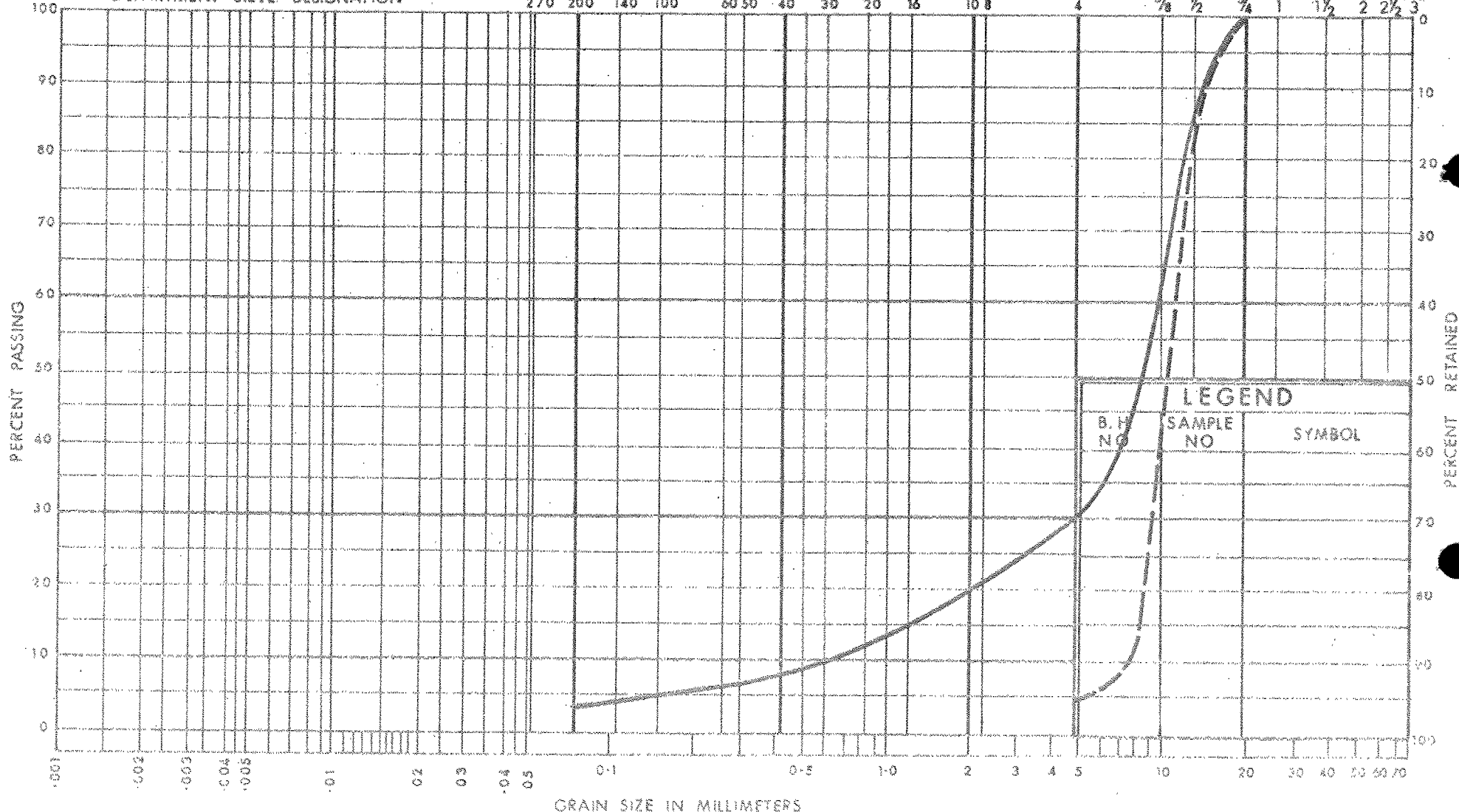
Coarse

Fine

Coarse

DEPARTMENT SIEVE DESIGNATION

270 200 140 100 60 50 40 30 20 16 10 8 4 3/8 1/2 3/4 1 1 1/2 2 2 1/2 3"



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

GRAIN SIZE DISTRIBUTION

TYPICAL CURVES

ALGOMA STEEL SLAG STOCKPILE - SAULT STE. MARIE, ONT.

W.P. No.

JOB No. 70-11006

AGS

DEPARTMENT OF HIGHWAYS ONTARIO

MEMORANDUM

To: Mr. R. G. Gascoyne,
District Engineer,
District #18,
SAULT STE. MARIE, Ont.

FROM: Foundation Section,
Materials & Testing Office,
Room 107, Lab. Bldg.

ATTENTION:

DATE: September 24, 1970

OUR FILE REF.

IN REPLY TO

SUBJECT:

Proposed C.P.R. Relocation
City of Sault Ste. Marie -
District No. 18
W.J. 70-11006 -- W.O. 69-27

As requested by you in your recent teletype, the Foundation Section reviewed the subsoil information contained in our Preliminary Foundation Report #W.J. 70-11006 and submit the following comments with regard to foundations for the potential industrial areas and also the suitability of cut material for embankment construction at the above mentioned location.

POTENTIAL INDUSTRIAL AREAS:

Two areas are designated as potential industrial areas, namely, from Station 310+00 (People's Road) easterly to Station 365+00 and, secondly, within Station 540+00 to Station 610+50.

- 1) Station 310+00 Easterly to Station 365+00 (Ref. B.H.'s #3, 4, 14, 15 and 19):

A surficial stratum of compact to dense, silty fine sand to sandy silt is present throughout the area. The thickness of the granular stratum ranges randomly from 9 to 63 ft. The granular deposit is underlain by a stiff to very stiff clay to clayey silt, which is in turn, followed by competent glacial till, then bedrock. The groundwater level at the time of the investigation, was at a depth of 10 ft. or more below existing ground surface.

Industrial buildings proposed in this area may be supported on spread footings located within the granular deposit above the prevailing water table. Footings founded in such a manner could be designed using an allowable load of 1.5 t.s.f. In the most easterly portion of this area, it may be possible to increase this value to 2.0 t.s.f. If the footings are located above the prevailing water table, no major dewatering problems are anticipated.

September 24, 1970

Re: Proposed C.P.R. Relocation - W.J. 70-11006 -- W.O. 69-27 ...

ii) Station 540+00 to Station 610+50:

Since the Department did not have permission to enter this property, no borings were carried out in this area during the time of the preliminary investigation programme. B.H. #13 (Station 530+15) was, however, put down just west of the area in question. Based on this boring, it is inferred that a surficial deposit of compact sand, about 9 ft. in thickness, is present. The granular deposit is underlain by an extensive deposit of soft to stiff layered clay. The groundwater level at the time of the investigation, was at a depth of 12 ft. below existing ground surface.

Based on the aforementioned information, the proposed industrial buildings may be founded on spread footings in the surficial sand stratum using an allowable bearing pressure of 1.0 t.s.f. Alternatively, the industrial buildings could be supported on friction piles in the cohesive subsoil. For example, a 45-ft. long #14 timber pile will have an allowable load of 15 to 20 tons. No matter which foundation scheme is adopted, some settlements can be anticipated due to the induced loading. This aspect can be discussed in detail at the time of final foundation investigation.

SUITABILITY OF CUT MATERIAL FOR EMBANKMENTS:

From Station 390+00 (Hwy. #17) easterly to Station 450+00 (Third Line Rd.), the C.P.R. relocation will be in cut, the maximum depth of which will be of the order of 30 ft. Based on our preliminary borings (B.H.'s #6, 7 and 8), it is inferred that the majority of the material excavated will be composed of a uniformly graded silt. However, in the vicinity of Third Line Rd., excavations will extend into the layered silty clay stratum. The suitability of silt as well as layered clay materials are discussed in the following paragraphs:

a) Silt:

Since the material is a fine-grained granular composition it is extremely difficult to obtain the required degree of compaction. In addition, the samples from this deposit exhibited high in-situ moisture content in the range of 20% to 25%. Our past experience elsewhere, has indicated that the optimum moisture content for such fine-grained granular soils will be of the order of 10% to 13%.

Mr. R. G. Gascoyne,
District Engineer,
District #18 - Sault Ste. Marie, Ont.

3

September 24, 1970

Re: Proposed C.P.R. Relocation - W.J. 70-11006 -- W.O. 69-27 ...

a) Silt: (cont'd.) ...

In view of the high moisture content of the silt material, it is our opinion that this material is unsuitable for high embankment construction. However, this material may be used in the following instances:

- i) In areas where fill heights are nominal, which means less than 10 ft. in height.
- ii) In areas where berms are required, this may be used for berm construction rather than the main core of the embankment.

b) Silty Clay (Layered):

This cohesive material can be compacted properly if the in-situ moisture content is at about the plastic limit of the soil. The limited laboratory testing programme carried out as part of the preliminary investigation, indicates that the in-situ moisture content is of the order of 30%, which is well above the plastic limit of the soil. In view of this, we do not recommend this material as being suitable for embankment construction. This material may be used for the berm portion where berm construction is necessary.

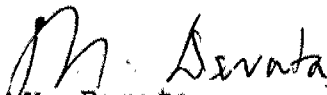
If you have any further queries, or any of the foregoing requires clarification, please contact this office.

MD/MdeF

cc: Messrs. R. G. Gascoyne (2)

B. R. Davis
H. A. Tregaskes
D. W. Farren
H. W. Hurrell
I. C. Campbell
P. Lester
R. Morgenroth
B. A. Singh
M. M. Dillon Ltd., London - J. L. Mitchell

Foundations Files
Gen. Files


M. Devata
SUPERVISING FOUNDATION ENGR.
For:
A. G. Stermac
PRINCIPAL FOUNDATION ENGR.

Ans

181

130

R G GASCOYNE DIST ENG
RM

TELETYPE
TELETYPE
TELETYPE
TELETYPE





M. M. DILLON LIMITED

CONSULTING ENGINEERS

BOX 426 STATION B LONDON 12, ONTARIO/TEL. AREA 519-438-6192 / CABLE: DILLENG LONDON CANADA

OUR FILE: 6349-01
YOUR FILE:

5 August 1970

Department of Highways, Ontario
DOWNSVIEW, ONTARIO

Attn: Mr. M. Devata, P. Eng.
Supervising Foundation Engineer

C.P.R. Relocation

Dear Sirs:

As requested at the T.A.C. meeting of 30 July 1970, we enclose the following data regarding the grading section:

- 1) C.P.R. letter of 10 November 1969 regarding grading section, together with grading plan T-14-9-4.
- 2) C.P.R. letter of 25 November 1969 regarding number of tracks.

In our original estimate we had assumed we could use $1\frac{1}{2}$:1 fill slopes for fills up to 15 ft. high and 2:1 slopes after that.

For cuts we had assumed $1\frac{1}{2}$:1 backslopes up to 15 ft. and 2:1 for over 15 ft. of cut. Also, for the cut downgrade east of Highway 17, we had assumed a wider rectangular type ditch to adequately provide for drainage. This latter provision will be required with the standard section modified accordingly.

We trust this provides you with the information required.

Yours truly,

M. M. DILLON LIMITED

J. L. Mitchell
J. L. Mitchell, P. Eng.

Project Manager

Enclosures

cc: Mr. R. G. Gascoyne

cc: Mr. J. I. Becking

JLM:iv

141 MAPLE STREET LONDON ONTARIO

LONDON * WINDSOR * TORONTO * OTTAWA * WINNIPEG * SUDBURY

C.P.R. RELOCATION - SUPPLEMENTS

A SUB-SECTION 470+00 to 500+00 - STABILITY.

SUPPLEMENT #1 - SLOPE 1 1/2:1

Cu patterns i) 1000, 400, 550 p.s.f.
ii) 1000, 400, 500⁶⁰⁰ p.s.f.

HEIGHTS OF FILL - 16', 20', 30'.

#2 - HAND COMPUTATION -

1 1/2:1, 30' FILL, DOUBLE BEAMS EACH 60'
F.S. = 1.36 (Cu = 1000, 400, 550 p.s.f.)

B SUB-SECTION 460+00 to 470+00 - STABILITY

#3 - SLOPE 1 1/2:1, Cu (900, 550, 1050 p.s.f.)
HT. OF FILL 10', 15', 20', 25', 30'.

#4 - SLOPE 2:1 Cu (900, 550, 1050 p.s.f.)
HT. OF FILL 10', 15', 20', 25', 30'.

#5 SUMMARY STABILITY ANALYSES
STA. 470+00 to 500+00.

#6 PLOT OF F.S. V.S. FILL HT.
STA. 460+00 to 470+00
i) Slope 1 1/2:1
ii) Slope 2:1

B.T.D.

TABLE OF CONTENTS

CASE 'A' - HIGH FILLS (STA. 460+00 to 500+00)

STABILITY ANALYSES

1. HT. 30' - SINGLE M.H. BERM - 120' (C_{u min.} = 400 p.s.f.) FS = 1.25
2. HT. 30' - DOUBLE BERM - 50' EACH (C_{u min.} = 400 p.s.f.) FS = 1.17
3. LIGHT WEIGHT FILL - HT. 30' - SINGLE BERM 60' (C_{u min.} = 400 p.s.f.) FS = 1.31
4. HT. 20' - SINGLE BERM 50' (C_{u min.} = 400 p.s.f.) FS = 1.34
5. HT. 16', 18', 20' (B=0) (C_{u min.} = 400 p.s.f.)
6. HT. 16' (B=0) (C_{u min.} = 450 p.s.f.) FS = 1.27

b) Effective Stresses

7. HT. 30' - BERM 90' (clay c'=0, φ'=18° - B=1.0 no p.w.p. dis.) FS = 1.89
8. HT. 30' - " " (" " " " " " full p.w.p.) FS = 2.28
9. HT. 16' - BERM 0 (c'=0, φ'=22° (no p.w.p. dis.) FS = 1.71
10. HT. 16' - " " (" " " (50% p.w.p. dis.) FS = 1.75

9. Consolidation Settlement Computations

- a) Δ of 30' FILL - 7.5'
- b) Δ of 16' FILL - 3.9'
- c) L.W.F. under Δ of 30' FILL - 5.75' } MAX IN 7 years.

CASE 'B' - DEEP RAVINE - EAST OF OLD GOULAIS BAY RD.

STABILITY - TOTAL STRESS

- a) HT. 67' - BERM > 120' (C_{u min.} = 900 p.s.f.) FS = 1.3
- b) HT. 30' - NO BERM - FS = 1.45
- HT. 35' - " " - FS = 1.3

c) CONSOLIDATION SETTLEMENT Computations

- under Δ of 67' FILL (Berm 120') ΔS = 1.75' } 3 years
- under Δ of 30' FILL (Berm 0) ΔS = - }

CASE 'C' - GULLEY CROSSING WEST OF PEOPLES RD.

TOTAL STRESS STABILITY ANALYSES

- a) HT. 30' - 50' BERM (C_{u min.} = 450 p.s.f.)
- b) HT. 30' - 30' " (C_{u min.} = 600 p.s.f.)

EFFECTIVE STRESS STABILITY ANALYSES

- a) HT. 30' - 0 BERM (φ' clay = 25°) FS = 1.67

SETTLEMENT COMPUTATIONS

HT. = 30' ΔS = 9" (18 months).

CASE 'D' - GRADE SEPARATION PEOPLES RD.

TOTAL STRESS ANALYSES

- a) HT. = 28' BERM 70' (C_u = 500 p.s.f.)
- b) HT. = 28' BERM 50' (C_u = 650 p.s.f.)

EFFECTIVE STRESS

- HT. = 28' BERM 0 (φ' clay = 25°) FS = 1.7 (P.P.W. dissipated)
- HT. = 18' " " (φ' clay = 25°) FS = 1.46 (full P.P.W. build up)

B.T. DARCH //

70-11-006

NIL

20

July 29, 1970

C.P.R. RELOCATION
SAULT STE. MARIE

MR. MITCHELL

① STABILITY IN HIGH FILL AREAS

- a) RECOMMENDATIONS IN REPORT APPLY TO AREA EAST OF BH #11 (Sta. 487+00).
- b) WEST OF OLD GARDEN RIVER ROAD (Sta. 470+00) NO MAJOR STABILITY PROBLEMS ARE ANTICIPATED.
- c) MAY BE NECESSARY TO FURTHER DIFFERENTIATE THE BERM REQUIREMENTS FROM AREA TO AREA.

② DEEP RAVINE EAST OF GOULAIS BAY ROAD

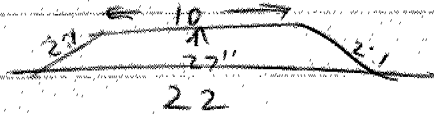
- a) STRUCTURE TOO COSTLY
- b) WILL CONSTRUCT FILLS at rate of 25' a year - 3 to 4 YEARS TO BUILD. STAGING WILL BE HELPFUL - MAY NOT REQUIRE SUCH LARGE BERMS AS RECOMMENDED IN THE REPORT.
- c) THE CULVERT CAN BE CAMBERED TO ALLOW FOR THE SETTLEMENT EXPECTED

T.A.C. Meeting

March 12/70 last meeting.

Biddell's approval and authorizing the traffic update studies.
Broken meeting sometime in Sept.

- 1) Minimum factor of safety 1.3
 - 2) are we based on minimum factor of safety.
 - 3) Divide stations 460-500 and give detailed recommendations.
 - 4) Deep Ravine Recommendations.
 - 5) cut Material as full. (send to T.T. with regard this problem)
 - 6) with single track with $1\frac{1}{2}:1$
- City Engineer - Extra Copy.
25th Nov/69



16th

B.A. #16 $C_u = 600$ p.s.f.
 $C_u = 600$ p.s.f.

Tests of Soil In Relocating CPR Started

A soil testing investigation is being carried out in the northeastern part of Sault Ste. Marie to determine the best site for the relocation of the Canadian Pacific Railway tracks and yards.

Allan Jackson, city engineer, reported that traffic consultants M. M. Dillon brought up the question of a soil study in a recent meeting with the city co-ordinating committee.

The department of highways started the soil study Feb. 3, and will pay 75 to 100 per cent of the costs, roughly estimated by Mr. Jackson at \$2,000.

The northeastern testing area is between the Third and Fourth Lines bordered by Highway 17 and the Old Garden River Road to the east.

R. G. Gascoyne, district engineer for the highways department, said about 6 testing holes have been drawn out for soil samples out of the 13 holes to be completed.

The soil samples are being taken to determine the character, strength, formation, and rock depth of the soil in the city's northern area.

The gathering of samples will be completed by the end of this week. Soil analysis will be done in Toronto at the department of highways testing lab.

A meeting to discuss the soil report will be held in two months between M. M. Dillon, officials and the committee, made up of city staff and provincial highway representatives.

Mr. Jackson said the results will determine the design standards and qualities of construction needed for the CPR relocation.

The soil study is part of the first of three study phases leading a decision on relocation of the CPR line. Completion of all the studies is not expected until 1972.

The first feasibility report started in 1969, concerns the physical determinants of the

actual moving of the CPR and its tracks.

The next step will occur in the summer of 1970 with an up-dated study of traffic throughout the city, Mr. Jackson said.

The third phase of the study involves a preliminary design of the proposed expressway to be built on land left vacant and when the CPR is moved.

New cost figures in Jan. this year estimate about \$10,429,000 for the relocation of the CPR and the construction of a cross-city expressway.

The city would pay \$2,100,000.

The controversial project has been an off and on study since 1962 when it was first recommended by the M. M. Dillon firm.

The relocation of the railway was first approved by City Council in 1962 and at that time, the cost of the project was estimated at \$3,000,000.

If the project is approved, after studies are completed in 1972, construction would take another four or five years.

SAULT STE. MARIE

Tuesday Feb. 10, 1970

MEMORANDUM

TO: Mr. A. Stermac,
Principal Foundation Engineer,
Downsview.

FROM: Engineering Services,
Northwestern Region.

ATTENTION: Mr. M. Devata,
Supt. Foundation Engineer.

DATE: January 16, 1970.

OUR FILE REF.

IN REPLY TO

SUBJECT: Sault Ste. Marie - Railway Relocation Project

I indicated to you by telephone on January 14, 1970, that we would not be in a position in this region to undertake the soils and foundation investigations connected with the above-mentioned project, and that we would refer the project to our Foundations Section.

The railway relocation is part of an overall scheme for the development of expressway and other facilities in the City of Sault Ste. Marie. It is proposed to remove the C.P.R. tracks from their present location in the central business district and to construct a new main line north of the urban area to meet up with the Algoma Central and Hudson Bay Railway two miles north of the downtown area.

At this stage, soils investigations including deep borings and stability analysis will be required on the line of the railway relocation. A letter from M. M. Dillon Ltd., the consultants commissioned to do the planning and design work, briefly outlines their requirements for soils exploration, but I am sure you will do whatever you think is necessary to achieve a safe and satisfactory design. A copy of this letter is attached together with the pertinent extracts of the minutes of a recent Technical Advisory Committee meeting.

Most of the preliminary discussions on this project have been undertaken at Technical Advisory Committee meetings between the Consultants, the City of Sault Ste. Marie and the Department. I have not been included with the Committee, therefore, there is little background information on the project that I can give you.

I would suggest you contact Mr. G. R. Crosby the Project Director, or Mr. J. L. Mitchell the Project Manager, representing M. M. Dillon Ltd. to fill you in on the project and to determine their precise requirements.

I have sent a photogrammetric plan and a profile to you under separate cover showing the proposed railway realignment.

Mr. A. Stermac

January 16, 1970.

I understand from the Consultant's most recent progress report that the soils investigation completion date is June 30, 1970.

We have some soils data on file in our regional Materials and Testing Section which might help you with your investigation, so please contact us if you think we can be of help to you.



F. Norman,
MANAGER, ENGINEERING SERVICES.

FN/mh
attach.

c.c.: J. L. Forster
R. G. Gascoyne
R. Morgenroth
J. R. Crosby

EXTRACT FROM TECHNICAL ADVISORY COMMITTEE MEETING NO. 8 ON THE
SAULT STEPHEN RAILWAY RELOCATION PROJECT

One point indicated was that the C.P.R. were now calling for 1.1% grades not over 1000' long and had pointed out that beyond this, increased operating costs must be anticipated.

He indicated that the A.C.R. had sent track data but had indicated that they were not prepared to negotiate until the C.P.R. began to move.

Mr. Crosby suggested that photogrammetric plans of 200' to the inch be sent to both the C.P.R. and A.C.R. indicating the proposal in a preliminary form so that both Railways understood what our intentions are.

Mr. Mitchell was also to send any plans of the A.C.R. to the C.P.R.

J. H. Homan
Mr. Mitchell pointed out that he had discovered several areas of bad soil conditions particularly in the vicinity of the escarpment immediately north of Black Road and felt that bore holes should be taken all the way along the proposed track line. He was, therefore, requested by the Chairman to submit a request which would go directly to Regional Headquarters at the Lakehead to Mr. Forster although it had been first indicated that they should be passed onto the Chairman.

Work was to be undertaken by the Department of Highways and it was suggested that holes to a depth of 40' in the cut and fill areas be considered using a core drill rather than an auger. It was felt, however, that in the area of low lying land between the escarpment and the Trunk Road that auger holes could be used to advantage as very little depth was required and apparently the chief problem in this area would be drainage.

N. B. Roberts,
Regional Engineer
P. C. Fuller,
Assistant Regional Engineer

Canadian Pacific

EASTERN REGION — UNION STATION, TORONTO 1, ONT.

November 25th, 1969.

File: 24023

M.M. Dillon Limited,
Consulting Engineers,
Box 426, Station B,
LONDON 12, Ontario.

Attention: Mr. J.L. Mitchell, P. Eng.,
Project Manager

M. M. DILLON LIMITED	
FILE NO. 6349-01	
REC'D. 1969 26 NOV	
JLM	
	FILE

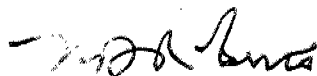
Dear Sirs:

Your letter November 21st, file 6349-01, regarding Sault Ste. Marie Railway Relocation Study.

The grading section for the major part of the relocation, except as noted in our letter of November 17th, should be for one track. Structures such as subways and overhead bridges should provide for one future track for possible future industrial development. Provision for the future track should be on the side of the main track which is most suited for industrial development.

The maximum gradient between Webbwood and Sault Ste. Marie is +1.72%, but this grade is only 400 ft. in length. However, it is in a location where trains can gain velocity before arriving at the short steep grade and, therefore, train operations are not greatly affected. There is another location where there is a +1.23% grade, 900 ft. in length. Grades in excess of those described in my letter of November 17th would result in increased operating costs.

Yours truly,



Regional Engineer.

N. B. Roberts,
Regional Engineer
P. C. Fuller,
Assistant Regional Engineer

Canadian Pacific

EASTERN REGION — UNION STATION, TORONTO 1, ONT.

November 10th, 1969.

File: 24023

M.M. Dillon Limited,
Consulting Engineers,
Box 426, Station B,
LONDON 12, Ontario.

Attention: Mr. J.L. Mitchell, P. Eng.

M. M. DILLON LIMITED LONDON	
FILE NO.	6349-01
REC'D.	1969: 11 NOV
	J.L.M.

Dear Sir:

Your file 6349-01, letter of November 6th, regarding proposed re-location of railway tracks in Sault Ste. Marie.

The following plans and pertinent data are attached for your guidance in designing and estimating the cost of the proposed trackage:

- (1) Plan T-14-9-4 showing CP Rail standard Roadbed and Ballast sections. The section to be used for the main track relocation at Sault Ste. Marie is shown on the top left-hand corner of the plan. This ballast section requires 3330 cubic yards of ballast per mile and 4570 cubic yards of sub-ballast per mile

The ballast could be $\frac{3}{4}$ " crushed slag ballast similar to that being used by the A.C.R. I understand this ballast is obtainable from Algoma Steel Co. at Sault Ste. Marie.

The sub-ballast could be granular "B" gravel in accordance with current Ontario Department of Highways specifications.

The compaction for the fill materials, and the granular "B" sub-ballast must also be in accordance with the current Ontario Department of Highways specifications.

The railway right-of-way must be properly ditched to provide adequate drainage, and graded to permit machine mowing. All earth slopes must be sodded or mulched and seeded in accordance with current Ontario Department of Highways specifications.

excavated rock surfaces shall be scaled of all material removable with a crow bar or scaling bar. Drilling and blasting must be carried out in a manner to avoid opening fissures in the rock faces.

- (2) Plan F-14-15-5 showing the standard railway right-of-way fences. Woven seven wire fence would be used in this area.

Three of four wooden intermediate wooden posts may be replaced by steel fence posts with the approval of the Engineer.

- (3) Sheets 1 to 12 inclusive of our Chief Engineer's estimating Bulletin No. 52.

Requirements for rail, fastenings and ties for the trackage in the Sault Ste. Marie area would be as follows:

- (a) Rail - 100 lb. main line relay, welded into 72ft. lengths.
- (b) Joint Bars - 100 lb, 6 holed new.
- (c) Bolts - 100 lb. new
- (d) Tie Plates - 100 lb. single shoulder secondhand.
- (e) Spikes - New - 6 per tie on curves and straight track for the main track. Six per tie on curves on sidings and 4 per tie on straight track on sidings.
- (f) Tie Pads - To be installed on all ties in public road crossings and on ties on bridges. Tie pads must be new.
- (g) Rail Anchors- Main track will require new anchors, at the rate of 4300 per mile.

Sidings will require secondhand anchors at the rate of 2200 per mile.
- (h) Ties - Main track ties must be No. 1 hardwood treated on curved main track, No. 1 soft wood treated on straight main track. Sidings will require No. 2 treated softwood ties.

The main track will require 3170 ties per mile, the sidings and other tracks 2640 ties per mile.

- (4) The following culvert plans:

- (a) Plan B-14-64 covering installation of corrugated metal culverts.
- (b) Specification 201 for corrugated metal pipe. Culvert pipe in this area should be galvanized with bituminous coating on asbestos binder and paved invert.
- (c) Plan B-14-57 covering corrugated structural pipe, unstrutted.

3.

(d) Plan B-14-56 covering corrugated structural plate cattle pass.

(e) Specification 272 for pipeline undercrossings.

(5) Road Crossings at Grade

Must be in accordance with current Railway Transport Committee regulations and former B.T.C. general Order E-4.

All road crossings in this area should be fully paved with asphalt with flangeway rails on both the inside and outside of the running rails.

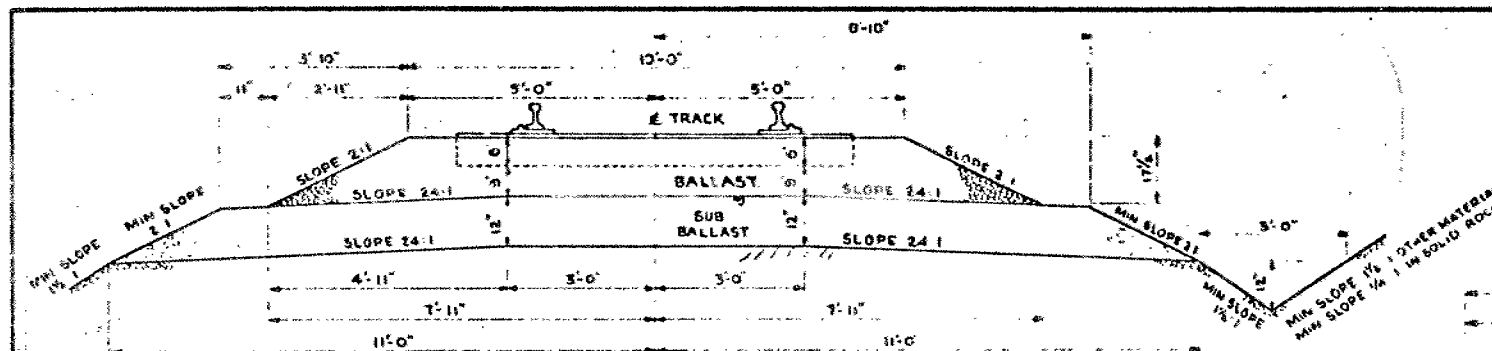
The attached data should cover the basic railway requirements in the area. However, if you require any further information, please contact Mr. Morrish of this office or myself.

We expect to meet with the A.C.R. in the near future to determine a basic plan which will be satisfactory to both railways.

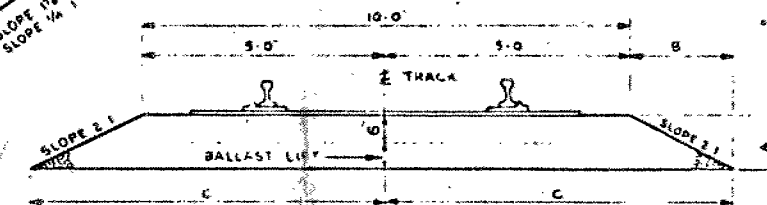
Yours truly,



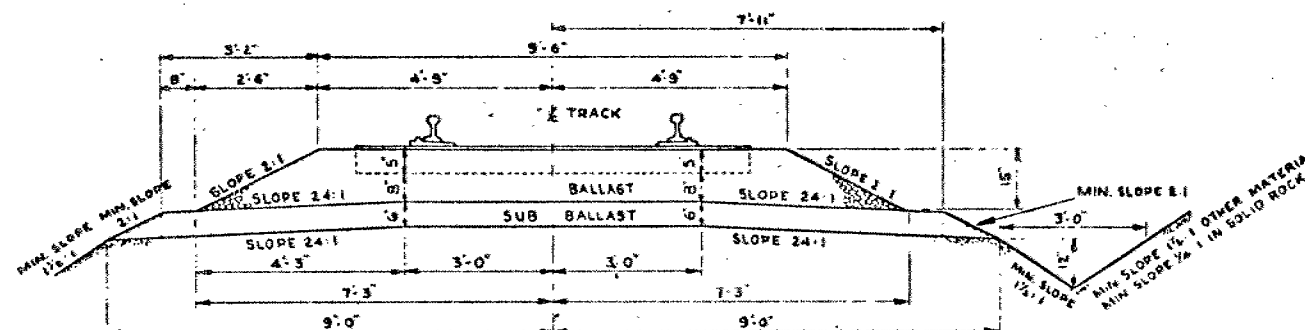
N.B. Roberts, P. Eng.
Regional Engineer.



PRIMARY & SECONDARY MAIN LINE
NEW CONSTRUCTION
3330 CU YDS. BALLAST PER MILE
4570 CU YDS. SUB BALLAST PER MILE



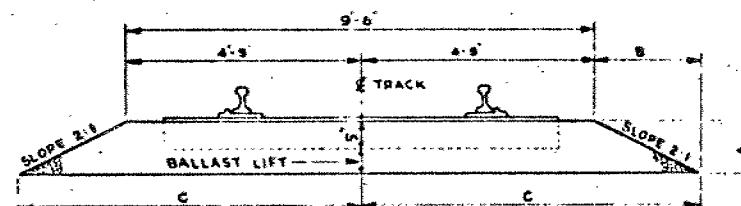
PRIMARY & SECONDARY MAIN LINE
RE-BALLASTING



BRANCH LINE
NEW CONSTRUCTION
2750 CU YDS. BALLAST PER MILE
1950 CU YDS. SUB BALLAST PER MILE

BALLAST LIFT	DIMENSIONS			CU YDS OF BALLAST PER MILE
	A	B	C	
3'	9'	1'-6"	6'-6"	1550
4'	10'	1'-8"	6'-8"	1800
5'	11'	1'-10"	6'-10"	2050
6'	12'	2'-0"	7'-0"	2300
7'	13'	2'-2"	7'-2"	2550
8'	14'	2'-4"	7'-4"	2800

NOTE:
THIS PLAN SHALL BE USED FOR CONSTRUCTION OF NEW LINES AND THE RE-BALLASTING OF EXISTING LINES.
WHERE THE LENGTH EXCEEDS 8'-0" THE WIDTH OF BALLAST SECTION MUST BE INCREASED TO SUIT.
QUANTITIES SHOWN PER MILE OF TRACK INCLUDE AN ALLOWANCE OF 15% FOR SHRINKAGE.



BRANCH LINE
RE-BALLASTING

INCHES 1 2 3 FEET
SCALE

BRANCH LINE

BALLAST LIFT	DIMENSIONS			CU YDS OF BALLAST PER MILE
	A	B	C	
3'	6'	1'-4"	6'-1"	1400
4'	7'	1'-6"	6'-3"	1600
5'	8'	1'-8"	6'-5"	1850
6'	9'	1'-10"	6'-7"	2100
7'	10'	2'-0"	6'-9"	2350

MAY 15 1955	RE-BALLASTING TABLES REVISED
APR 26 1955	APPROVED
ORIGINAL	
Canadian Pacific	
STANDARD ROADBED & BALLAST SECTIONS	
W. A. Smith	CHIEF ENGINEER
ENGINEER OF TRAIL	
CANADIAN PACIFIC RAILWAY CO. WINNIPEG, MANITOBA, CANADA	
PLAN T-14-9	THIS PLAN SUPERSEDES T-14-9-1, 2

DEPARTMENT OF HIGHWAYS - ONTARIO MATERIALS & TESTING OFFICE				RECORD OF BOREHOLE No. 2				FOUNDATION SECTION			
JOB 70-11006		LOCATION OFR Relocation Sta. 309 + 80 @ (at Peoples Rd.)		ORIGINATED BY CS							
W.O. 69-27		BORING DATE February 4 - 13, 1970		COMPILED BY VK							
DATUM Geodetic		BOREHOLE TYPE Washboring-NX, BK Casings, Cone Test		CHECKED BY LK							
SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT		PLASTIC LIMIT		WATER CONTENT	
ELEV. DEPTH	DESCRIPTION	STRAT. FLOT	NUMBER	TYPE	BLOWS/FOOT	SCALE	W _L	W _P	W	W _L	W _P
778.2	Ground Level										
772.2	Silty clay sand with some gr. (P+11). Compact		1	SS	85						
2.0	Silty fine sand to sandy silt. Brown		2	SS	85						
766.0	Compact		3	SS	5						
6.2	Silty clay, clayey silt & silt (stratified) (stratifications of random thickness)		4	SS	5						
	numerous sand lamination up to 3" thick below el. 760		5	TW	FW						
	Gray to reddish brown		6	SS	FW						
7h6.2	Soft to firm		7	TW	FW						
28.0	Silty fine sand to sandy silt (random stratification)		8	SS	14						
			9	SS	12						
			10	SS	9						
			11	SS	13						
722.2	Clay and silty clay (stratified) Firm		12	SS	14						
52.0			13	TW	FW						
717.9			14	SS	15						
56.3			15	SS	13						
713.7	Clay (varved) - Stiff		16	SS	21						
712.7			17	SS	23						
61.5	Occasional random seams of silty clay up to 1/2" thick throughout.		18	SS	20						
			19	SS	61						
	Gray to reddish brown		20	SS	31						
			21	SS	32						
	Compact to dense		22	SS	28						
			23	SS	25						
			24	SS	37						
			25	SS	44						
609.2											
165.0	End of Borehole										

DYNAMIC PENETRATION RESISTANCE
BLOWS / FOOT
20 40 60 80 100

SHEAR STRENGTH P.S.F.

○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB. VANE
400 800 1200 1600 2000

LIQUID LIMIT ——— W_L
PLASTIC LIMIT ——— W_P
WATER CONTENT ——— W

W_L W_P W
15 30 45

BULK DENSITY

P.C.F. GR. SA. SI. CL.

REMARKS

0 5 8h 11

762.

WL in open
Feb. 13/70

0 95 5 0

108

0 26 (74)

DEPARTMENT OF HIGHWAYS - ONTARIO MATERIALS & TESTING OFFICE				RECORD OF BOREHOLE No. 3				FOUNDATION SECTION			
JOB 70-P-6		LOCATION GPR Relocation Sta. 352 + 00 E		ORIGINATED BY CS							
W.O. 69-27		BORING DATE Feb. 9 - 11, 1970		COMPILED BY VK							
DATUM Geodetic		BOREHOLE TYPE Washboring-NX, BX Casing		CHECKED BY							
SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT		PLASTIC LIMIT		WATER CONTENT	
ELEV. DEPTH	DESCRIPTION	STRAIT ROT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	SHEAR STRENGTH P.S.F.	UNCONFINED	FIELD VANE	QUICK TRIAXIAL	LAB. VANE
775.4	Ground Level										
0.0	Sand Topsoil										
1.0	Silty fine sand to sandy silt (random stratification)		1	SS	35	770					
	occ. seams of silty clay up to 1/2" thick throughout		2	SS	38						
	Reddish brown		3	SS	28						
			4	SS	41						
			5	SS	54	760					
753.4	Compact to dense										
22.0	Clay to silty clay (layered) (layers of random thickness)		6	SS	18	750					
	seams of silt & sand up to 2" thick throughout		7	TW	PM						
	Reddish Brown		8	TW	PM						
			9	VW	PM	740					
			10	SS	21						
	Stiff to very stiff		11	TW	PM						
723.9											
15.5	Silty fine sand to sandy silt (random stratification)		12	SS	26	730					
	occ. seams of silty clay up to 1/2" thick throughout		13	SS	33						
			14	SS	24	720					
			15	SS	140/6"						
	Brown		16	SS	57	710					
702.4	Compact to very dense										
73.0											
	Clay to silty clay (layered) (layers of random thickness)		17	SS	62	700					
	seams of silt & sand up to 3" thick throughout		18	TW	PM						
			19	TW	PM						
			20	TW	PM	690					
			21	TW	PM						
	Reddish brown		22	SS	12	680					
			23	SS	23						
			24	SS	12	670					
			25	SS	11	660					
	Stiff to very stiff		26	SS	28	650					
			27	SS	72	640					
641.9											
131.5	Clayey silt with sand & gr. (clay fill) Hard										
636.4											
137.0	End of Borehole										

DEPARTMENT OF HIGHWAYS-ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 12

FOUNDATION SECTION

JOB 70-11006

LOCATION GR Relocation Sta. 586 + 60 E (at Black Rd.)

ORIGINATED BY

W.O. 69-27

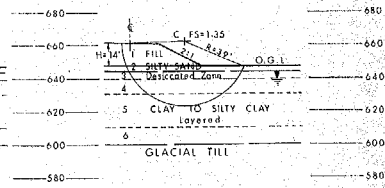
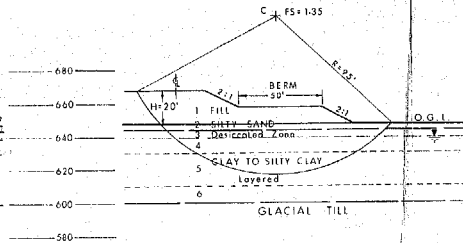
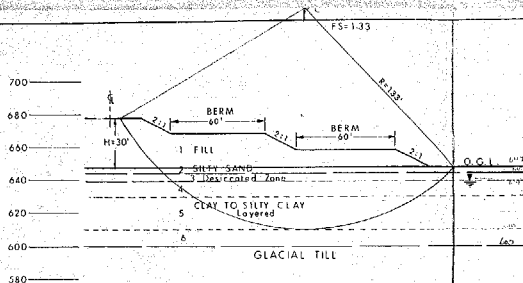
BORING DATE Feb. 4 - 6, 1970

COMPILED BY YK

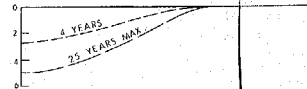
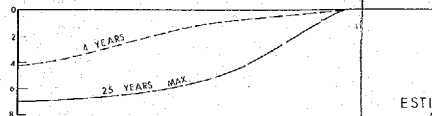
DATUM Geodetic

BOREHOLE TYPE Washboring-NK, BX Casing- AXT Rock CoreCHECKED BY YK

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			BULK DENSITY γ	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. NO.	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	SHEAR STRENGTH σ'_{sf}					WATER CONTENT %				
							UNCONFINED σ'_{sf} FIELD VANE c_u QUICK TRIAXIAL σ'_{sf} LAB VANE c_u								P.C.F.	
							400	800	1200	1600	2000	25	50	75		
612.2	Ground Level															
0.0	Sand & gravel (Fill)					610										
637.7	Brown Compact		1	SS	11	Frozen										
4.5	Desiccated Zone		2	SS	19											
	Very stiff		3	SS	10											
	Clay to silty clay (layered)		4	SS	2	620										
	(layers of random thickness)		5	TM	FM											
			6	TM	FM	620										
	occ. seams of silt and sand up to 2" thick throughout		7	TM	FM											
			8	TM	FM	610										
	Roddish brown to grey		9	TM	FM											
			10	TM	FM	600										
	Soft to firm		11	TM	FM											
			12	TM	FM	590										
502.2																
60.0	Silt, trace of clay		13	TM	FM	580										
	Grey		14	SS	20											
570.2	Loose to compact		15	SS	5	570										
72.0			16	SS	8											
	Numerous layers and seams of silt up to 6" thick		17	SS	12	560										
			18	SS	10											
	Stiff to very stiff		19	SS	-	550										
			20	TM	FM	540										
			21	SS	8											
			22	SS	14											
			23	TM	FM	530										
			24	SS	20											
520.2			25	SS	11	520										
122.0	Ext. mix of silt, sand & gravel (Clc. Fill)															
517.2	Very dense Sandstone Bedrock (fine grained)		26	AXT	100%											
512.2	Sound															
130.0	End of Borehole					510										



STABILITY FOR VARIOUS FILL HEIGHTS



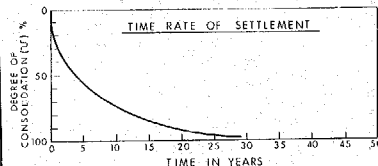
ESTIMATED SETTLEMENT IN FEET
(UNDER VARIOUS FILL HEIGHTS)

SOIL PROPERTIES

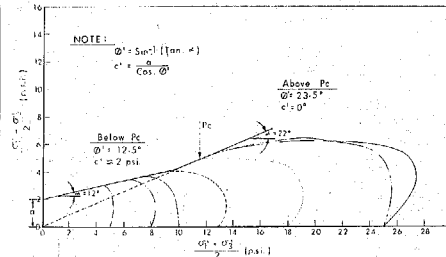
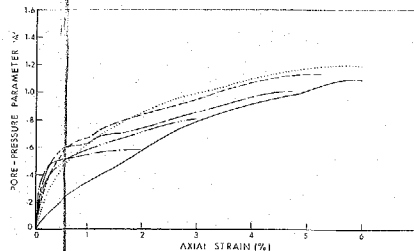
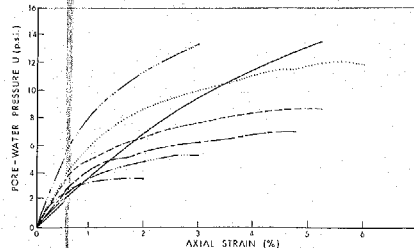
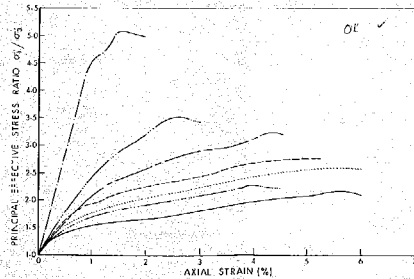
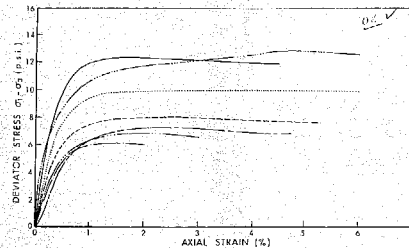
SOIL	NO.	Undrained Shear Strength C_u (psf)	Angle of Friction ϕ	Total Unit Weight γ (pcf)	Submerged Unit Weight γ_{sub} (pcf)
FILL	1	0	30°	125	65
SILTY SAND	2	0	30°	125	65
Desiccated Zone	3	1000	0	110	50
CLAY TO SILTY CLAY Layered	4	400	0	40	40
	5	500	0	40	40
	6	600	0	40	40

LEGEND

C - CRITICAL CIRCLE
FS - FACTOR OF SAFETY
H - HEIGHT OF FILL



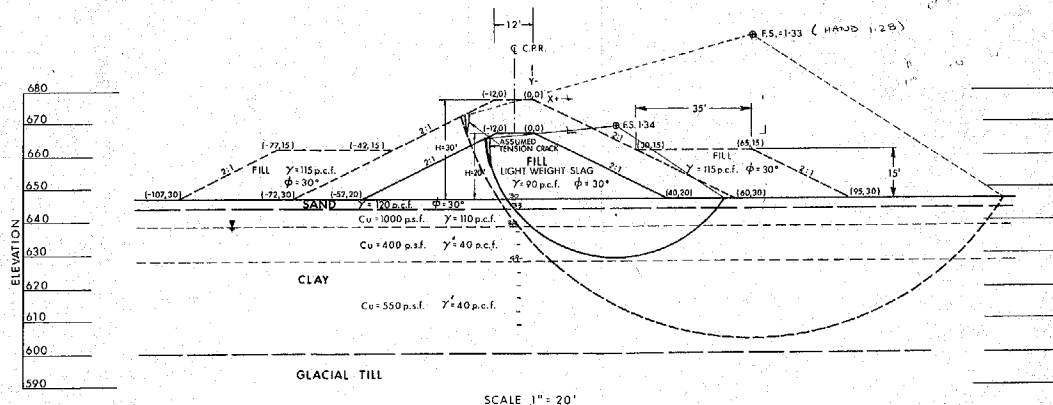
 DEPARTMENT OF HIGHWAYS MATERIALS and TESTING DIVISION ONTARIO	SUMMARIZED RESULTS OF STABILITY AND SETTLEMENT ANALYSES (FILL SECTION BETWEEN STA. 460+00 TO 500+00)	
	W/O. NO. 69-27	DIST. 18 JOB 70-11006
DATE May 30, 1970	APPROVED	Fig. No. 1



CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TESTS WITH PORE PRESSURE MEASUREMENTS

TABLE

Tests Number	30557I	30556I	30557II	30556II	30557III	30556III
Borehole Number	12	12	12	12	12	12
Sample Number	7	6	7	6	7	6
Sample Depth, (ft.)	26	21	25.5	20.5	20	25
Sample Diameter, (in.)	2	2	2	2	2	2
Sample Height, (in.)	4	4	4	4	4	4
Consolidation Press, (psi)	5	8	10	13	18	25
Back Pressure, (psi)	—	—	—	—	—	—
Consolidation Time, (days)	5	6	6	7	8	7
Rate of Strain, in./min.	.0005	.0005	.0005	.0005	.0005	.0005
Max. Deviator Stress, (psi)	5.1	3.5	3.3	2.5	2.7	2.3
Axial Failure Strain	1	2.3	2.5	2.5	4	1.5
Initial Water Cont. (%)	87.0	—	87.0	82.8	76.8	82.6
Final Water Cont. (%)	85.2	—	74.4	67.4	55.9	55.7
Wet Density, (p.c.f.)	91.7	94.5	91.7	93.6	94.8	92.4
Dry Density, (p.c.f.)	49.1	—	49.1	51.2	53.6	50.6
Liquid Limit, (%)	76.6	87.9	76.6	87.9	87.9	76.6
Plastic Limit, (%)	29.7	27.9	29.7	27.9	27.9	31.2



NOTE

FILL - EMBANKMENT CORE - LIGHT WEIGHT SLAG $\gamma = 90$ p.c.f.
 STABILIZING BERMS - LOCAL CUT MATERIAL $\gamma = 115$ p.c.f.



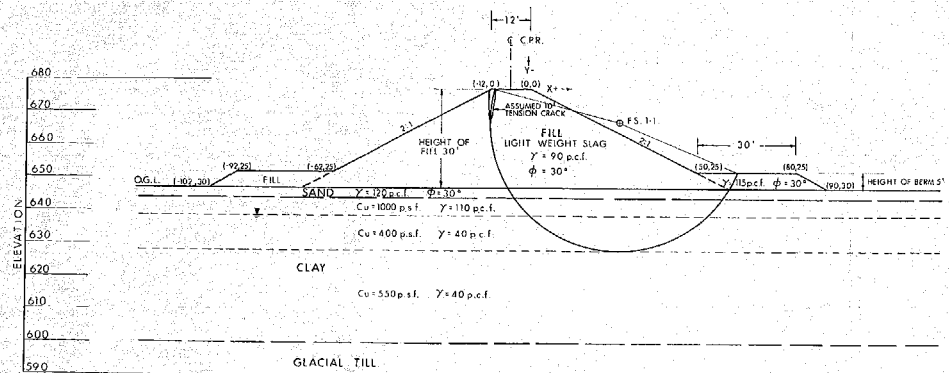
DEPARTMENT OF HIGHWAYS
**MATERIALS and
 TESTING
 OFFICE**

C.P.R. RE-LOCATION - SAULT STE MARIE
 STABILITY ANALYSIS - STA. 470+00 TO STA. 500+00

DATE 27 OCT. 1971

W.P. NO.

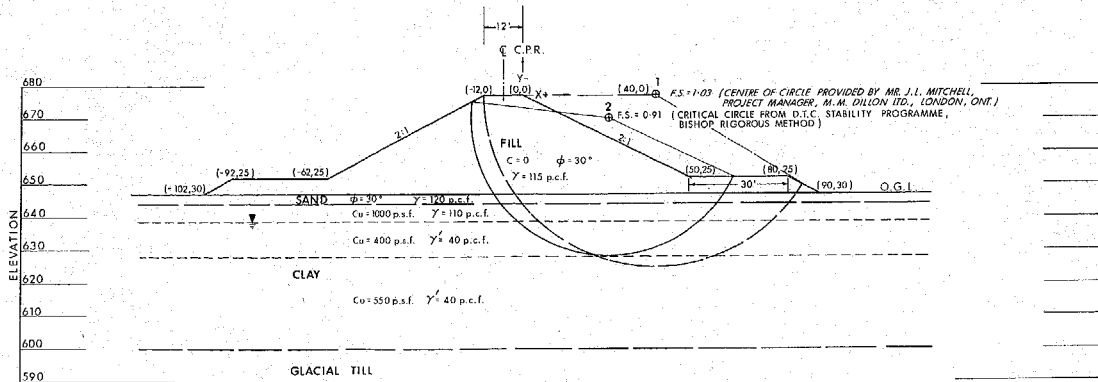
DRAWING NO. 70 - 11006



NOTE

LIGHT WEIGHT FILL (SLAG) FOR EMBANKMENT CORE ($\gamma = 90 \text{ p.c.f.}$)
 BERMS - FILL FROM LOCAL CUTS ($\gamma = 115 \text{ p.c.f.}$)

SCALE 1" = 20'



NOTE

EMBANKMENT FILL - HEIGHT 30' (SLOPES 2:1)
WITH BERMS - HEIGHT 5', LENGTH 30'

SCALE 1" = 20'



C.P.R. RE-LOCATION - SAULT STE MARIE
STABILITY ANALYSIS - STA. 470+00 TO STA. 500+00

DATE 27 SEPT. 1971

W.P. NO.

DRAWING NO. 70-11006