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DEPARTMENT OF HIGHWAYS ONTARIO  
MEMORANDUM

To: Mr. B. R. Davis,  
Bridge Engineer,  
Bridge Office,  
Admin. Bldg.

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

ATTENTION: Mr. S. McCombie

DATE: April 9, 1969

OUR FILE REF:

IN REPLY TO

APR 14 1969

SUBJECT:

FOUNDATION INVESTIGATION REPORT  
For  
-- Structure #6 --  
Proposed Overpass at the Crossing of  
Q.E.W. (N.B.L.) and Hwy. #20, Q.E.W.  
And Q.E.W. Extension Complex  
District No. 4 (Hamilton)  
W.J. 69-F-2-6 -- W.P. 168-64-13

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

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

MD/MdeF  
Attach.

cc: Messrs. B. R. Davis (2)  
H. A. Tregaskes  
D. W. Farren  
G. K. Hunter (2)  
H. Greenland  
W. S. Melnyshyn  
T. J. Kovich  
B. A. Singh

Foundations Files  
Gen. Files

M. Devata

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

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FOUNDATION INVESTIGATION REPORT  
For

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Proposed Overpass at the Crossing of  
Q.E.W. (N.B.L.) and Hwy. #20, Q.E.W.  
And Q.E.W. Extension Complex  
District No. 4 (Hamilton)  
W.J. 69-F-2-6 -- W.P. 168-64-13

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1. INTRODUCTION:

The Foundation Section was requested to carry out an investigation at the proposed structure locations associated with the Hwy. #20, Q.E.W. and Q.E.W. Extension complex, planned in the vicinity of Niagara Falls, Ontario. Nine structures are proposed within this interchange. The request for this foundation investigation was contained in a memo from Mr. W. S. Melinyshyn, Regional Bridge Location Engineer, Central Region, dated January 19, 1969. An investigation was subsequently carried out by this Section to determine the subsoil conditions at the structure sites.

This report presents information on the subsoil and groundwater conditions encountered at the proposed location for the overpass structure at the crossing of the Q.E.W. (Northbound Lane) and Hwy. #20. Also included are recommendations pertaining to foundation design, as well as stability of cut slopes.

Foundation Reports have already been, or will be submitted for other structure locations within this interchange complex.

2. DESCRIPTION OF THE SITE AND GEOLOGY:

The proposed overpass structure at the crossing of the Q.E.W. (N.B.L.) and Hwy. #20 is located in the vicinity of the existing Niagara Falls traffic circle; the site is within the western limits of the City of Niagara Falls, Ontario.

The area, with the exception of the traffic

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

circle, which is founded on an embankment approximately 4 to 5 feet high, is generally flat lying at about elevation 633. The surrounding terrain is primarily a grass-covered agricultural area.

Geographically the site is situated within the physiographic region known as the "Haldimand Clay Plain". The Haldimand Clay Plain can be described as falling into a series of parallel belts. The first, in which this site is situated, is the highest ground adjoining the Niagara Escarpment. Here recessional moraines were built by the ice lobe that occupies the basin of Lake Ontario. As moraines, these ridges have a much subdued relief due to having been built under water. The intervening troughs are floored with lacustrine silt or clay deposited in Lake Warren, which inundated the area during the Wisconsin glacial stage. The overburden, which is generally less than 50 feet in thickness in this area, is underlain by dolomite bedrock of the Lockport Formation, Silurian Period.

The drainage in the immediate area is controlled by the Chippawa Power Canal, located approximately 1/4 mile south-east of the structure site. This canal is cut into the underlying dolomite bedrock, the normal water level being at about elevation 552.

3. FIELD AND LABORATORY WORK:

Five sampled boreholes, Nos. 60 to 64, inclusive, each accompanied by a dynamic cone penetration test, were put down during the course of the investigation. In addition, Borehole No. C-5, put down in the vicinity of the structure site in September 1965, is also included. This borehole was part of the preliminary foundation investigation carried out for this complex (Report No. 65-F-98). The borings associated with the most recent investigation were put down with a diamond drill rig adapted for soil sampling purposes.

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

Samples of the overburden were obtained using a 2" O.D. split-spoon sampler, which was hammered into the soil in accordance with the specifications for the Standard Penetration Test. The same method was used to advance the dynamic cone penetration tests. Bedrock was proven, at B.H.'s #61 and 64, by obtaining 12 and 5 feet, respectively, of AXT size rock core. The groundwater level conditions across the site were determined during the course of the investigation, by recording the water level in the open boreholes.

The location and elevation of all borings were surveyed by personnel from the Central Region Engineering Surveys Section, and are shown on Drawing 69-F-2-6A, together with estimated stratigraphical profiles and sections at the proposed crossing. All elevations given in the report are referenced to a Geodetic datum.

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

Natural Moisture Contents

Atterberg Limits

Grain-Size Distributions

The results of this testing are plotted on the Record of Borelog sheets, and are summarized on Figures 1 to 5 inclusive, in Appendix I of this report.

4. SUBSOIL CONDITIONS:

4.1) General:

The surficial deposit across the site is a stiff to hard, mottled brown silty clay to clayey silt, between 6 and 7 feet

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

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

in thickness. This deposit is underlain by a dense to very dense granular stratum ranging from 27 to 36 feet in thickness. The stratum varies transitionally from a silt, in the upper portion, to a sandy silt to silty sand with depth. This stratum is, in turn, underlain by a thin competent glacial till deposit followed by dolomite bedrock. The above pattern is disrupted in certain areas in which trenches were excavated for installation of utilities and subsequently backfilled.

The boundaries of the various deposits, as determined at the boring locations, are shown on the accompanying borelog sheets. The stratigraphical profiles and sections, shown on Drawing 69-F-2-6A, are inferred from this data.

From ground surface downwards, the various soil types encountered, are as follows:

4.2) Fill Material:

B.H. #63 was put down in the vicinity of an existing storm sewer (refer to Drawing 69-F-2-6A). This boring extended approximately 25.5 feet into material placed as backfill in the sewer trench. The fill is primarily composed of a firm to stiff clayey silt to silty clay, with some sand. This material is basically inorganic with a plasticity in the low to intermediate range. A seven-foot thick zone of loose silt to sandy silt (fill) was sandwiched within the cohesive fill; this was encountered at about elevation 623. Grain-size distribution curves, for samples of the more cohesive portions of the fill, are plotted on Figure #1.

4.3) Clayey Silt to Silty Clay:

The surficial cover across the site, with the exception of areas in which fill is present, is composed of a stiff to hard, mottled brown silty clay to clayey silt, with a trace of sand. The deposit is approximately 7 to 8 feet thick. A grain-size curve, for a sample obtained from this deposit, is given on Figure #1.

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

4.3) Clayey Silt to Silty Clay: (cont'd.) ...

The results of three Atterberg limit tests, carried out on representative samples of the soil, have been plotted on the Plasticity Chart, located in the Appendix of this report - (Figure #5). Based on this testing, it is estimated that the cohesive deposit is inorganic with a plasticity in the low to intermediate range. The natural moisture content is about 17 to 22%, which is within 1% ( $\pm$ ) of the plastic limit of the material.

4.4) Silt to Silty Sand:

Directly underlying the surficial deposit is a granular stratum, ranging between 27 and 36 feet in thickness. The upper 12 to 22 feet of the stratum is composed of a uniform brown silt, with a trace of sand and clay. Below this upper zone, however, the sand content increases markedly; in this region the deposit varies from a sandy silt to a silty sand. The granular soil is faintly stratified at random locations throughout. Grain-size distribution curves for samples, obtained with 1-1/2 inch I.D. sampling equipment, are plotted on Figures #2 and #3. The natural water content of the stratum varies from 11 to 23%, being typically about 17%.

Standard penetration tests, carried out within the stratum, gave 'N' values which range from 15 blows/ft. to 100 blows for 6 inches, being consistently greater than 35 blows/ft. Based on these results, it is estimated that the relative density of the granular stratum ranges from dense to very dense.

4.5) Heterogeneous Mixture of Clay, Silt, Sand and Gravel - (Glacial Till):

A glacial till deposit, varying anywhere from 4 to 8 feet in thickness, was encountered beneath the silt and sand stratum. The majority of the glacial till is cohesionless in nature - i.e.,

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

4.5) Heterogeneous Mixture of Clay, Silt, Sand and Gravel -  
(Glacial Till): (cont'd.) ...

has a matrix of silt and sand binding gravel sizes. There are random zones throughout, however, in which the matrix is basically composed of a clayey silt; such zones exhibit slight plasticity. This was substantiated by Atterberg limit tests carried out on a few selected samples obtained from more plastic zones within the main body of the glacial till (refer to Figure #5). A grain-size distribution curve, for a sample obtained from the glacial till, is plotted on Figure #4. The natural water content, determined from laboratory testing, was found to be typically in the 6 to 12% range.

Standard penetration resistance tests, carried out within the deposit, gave 'N' values which ranged from 33 blows/ft. to 150 blows for 5 inches, indicating that the relative density of the granular portions of the glacial till varies from dense to very dense. It is inferred that the cohesive portions of the deposit have a consistency in the "hard" range.

4.6) Dolomite Bedrock:

Bedrock was established in two of the boreholes (Nos. 61 and 64) by obtaining 12 and 5 feet of AXT rock core, respectively. In addition, the bedrock surface was inferred in B.H.'s #60 and 62 at the point where the BX casing met practical refusal to driving. The bedrock surface was encountered between elevation 596 and 599 - i.e., approximately 34 to 41 feet below existing ground surface.

The bedrock is composed of a grey dolomite. At B.H. #61 the upper 4-foot zone is slightly fractured and jointed. Below this zone in B.H. #61, and for the full depth of penetration at B.H. #64, the rock is in a sound condition.

5. GROUNDWATER CONDITIONS:

Groundwater level observations were carried out, during the period of the investigation, in the open boreholes. These



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

observations, which are recorded on the borehole logs, and summarized on Drawing 69-F-2-6A, indicate that the static groundwater level within the overburden, ranges between elevation 608 and 612 - i.e., some 21 to 27 feet below existing ground surface.

6. DISCUSSION AND RECOMMENDATIONS:

6.1) General:

It is proposed to construct an overpass structure, designated as Bridge Structure #6, at the crossing of the Q.E.W. (Northbound Lane) and Hwy. #20 (Eastbound and Westbound Lanes); this site is located on the western outskirts of Niagara Falls, Ontario. This structure is one of many associated with the Hwy. #20, Q.E.W. and Q.E.W. Extension Complex.

The proposed scheme for this particular structure is given on Drawings Nos. 9622-14-3, Sheets 1 and 2, dated March, 1969; these drawings were prepared by De Leuw, Cather, Consulting Engineers. In the vicinity of the structure, Hwy. #20 will have two paved lanes in both the E.B. and W.B. direction; in addition, there will be the associated W.-N. and E.-S. ramps. The highway lanes are 12 feet wide, while the ramps are 16 feet in width. The E.B. and W.B. lanes are separated by a 17-foot wide median. The profile grades of the Hwy. #20 lanes and the ramps, at the structure location, are approximately 615 and 614, respectively - i.e., some 18 to 19 feet below existing ground surface. The profile grade of the Q.E.W. (N.B.L.) and associated W.-N. ramp is, however, at about elevation 637 - i.e., 1 to 2 feet above existing ground surface.

The structure scheme proposed, calls for a two-span structure (70'-80' - approx.), incorporating a centre pier and closed-end abutments. It is understood the bridge deck will have a width varying from approximately 70 to 76 feet at its north and south ends, respectively. This width will allow for the two

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

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

Q.E.W. (N.B.) lanes and the associated W.-N. ramp.

The following existing buried utilities are located within the plan limits of the proposed structure:

- i) Bell telephone cable - east - west line located in the vicinity of the proposed centre pier.
- ii) storm and combined sewer - located in the vicinity of the proposed north abutment (refer to B.H. #63).

In addition, a 27" diameter east - west trending storm sewer will be placed, in the vicinity of the south abutment, prior to construction of this structure. In the vicinity of the structure the invert elevation of the sewer will be between elevation 593 and 594 - i.e., approximately 20 to 22 feet below the proposed profile grade of Hwy. #20 and the associated ramps. The approximate locations of the buried utilities are shown in plan on Drawing No. 69-F-2-6A.

The predominant deposit across the site is a compact to very dense stratum composed of silt, changing with depth to sandy silt; this stratum varies from 27 to 36 feet in thickness. This granular soil is overlain by a 6 to 7 feet thick surficial cover of silty clay to clayey silt, which has a consistency in the stiff to hard range. The silt is underlain by a thin competent glacial till, which, in turn, is followed by sound dolomite bedrock. Fill, used to backfill buried utilities, was encountered in some areas (B.H. #63). The groundwater level across the site, at the time of the investigation, was between elevations 608 and 612 - i.e., some 21 to 27 feet below existing ground surface.

6.2) Cut Slopes:

Hwy. #20 and the associated E.-S. and W.-N. ramps will be in cuts in the vicinity of this crossing, the maximum depth of

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

6.2) Cut Slopes: (cont'd.) ...

the cut will be of the order of 19 to 20 feet. At the deepest section the excavation will extend through the surficial clayey silt deposit into the underlying silt stratum. No stability problems are anticipated for cuts with standard 2:1 slopes.

Since the excavations will not extend below the groundwater level recorded during the period of the investigation, no special measures need be adopted to protect the slopes. Adequately designed interceptor ditches should, however, 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.

6.3) Structure Foundations:

Recommendations for foundations located in undisturbed soil will be discussed in Sub-section 6.3.1). Special measures are deemed necessary for foundations located in close proximity to buried utilities. These comments will be contained in Sub-section 6.3.2).

6.3.1) Foundations in Undisturbed Soil:

As discussed previously, the subsoil at and below the profile grades of Hwy. #20 and the associated S.-E. and W.-N. ramps, is composed of a dense to very dense silt to sandy silt, which is a competent bearing stratum. It is recommended, therefore, that the pier and closed-end type abutments could be founded on spread footings, located within this stratum, at or below elevation 611, using a net safe bearing pressure of 3.0 t.s.f. in design. The footings should have adequate earth cover for frost protection purposes.

The base of the pier and abutment footing excavations will be at, or extend a few feet below the groundwater level recorded during the period of the investigation. Therefore, if scheduling

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

6.3) Structure Foundations: (cont'd.) ...

6.3.1) Foundations in Undisturbed Soil: (cont'd.) ...

permits, it would be advantageous to carry out the excavations during the dry periods of the year. If this is not possible, groundwater seepage may occur in the excavations carried out within the pervious granular subsoil. Further, the base of the excavations may "boil" because of the unbalanced hydrostatic water pressure head. A positive dewatering scheme may, therefore, be required. It is considered that the aforementioned could be controlled by carrying out an oversized excavation. Properly designed drainage trenches, extending at least 2 feet below footing level, could then be constructed around the perimeter of the excavation in order to control the groundwater. These trenches should be backfilled with granular material; provision should also be made to pump the water so collected.

Settlement of the foundation subsoil below footing level will occur due to the imposed footing loading. Because of the granular nature of the soil, the settlements will be elastic - i.e., take place during and immediately following the construction period. It is estimated that the total settlement will not exceed 1 inch, and further, the differential settlement, between the various elements, will be within tolerable limits for the type of structure contemplated.

6.3.2) Foundations in Close Proximity to Buried Utilities:

As discussed previously, both the proposed north and south closed-end abutments will likely be in the vicinity of sewers placed prior to construction of this structure. Foundations which are to be located in disturbed subsoil, should be supported on end-bearing steel H-piles driven to bedrock - (approx. tip elevation 597 to 599). The design load will be dependent on the pile section chosen. For example, 12 BP 73 steel H-piles may be designed for an allowable load of 90 tons/pile.

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

6.3) Structure Foundations: (cont'd.) ...

6.3.2) Foundations in Close Proximity to Buried Utilities

(cont'd.) ....

Where piles are to be driven adjacent to existing utilities, special precautions must be taken to ensure that no damage results. We suggest that the following procedure be adopted:

(1) When piles will be 12 feet or more from the edge of a utility, no special precautions need be taken.

(2) All piles closer than 12 feet from a utility should be prebored to a depth of 6 ft. below the pipe bottom. The size of the augered hole need only be slightly larger than the pile section.

(3) When holes are augered in non-cohesive subsoil, casing may be required to prevent the holes from caving in.

The above procedure was followed in Contracts 63-182 and 68-24 with satisfactory results.

7. MISCELLANEOUS:

The field work was carried out during the period March 3 to 7, 1969, under the supervision of Messrs. H. Szymanski and P. Payer.

This report was written by Mr. B. T. Darch, Senior Foundation Engineer, and reviewed by Mr. M. Devata, Supervising Foundation Engineer.

Equipment used was owned and operated by:

Dominion Soil Investigation Ltd., Toronto, and Peninsula Soils Investigation Company, Welland, Ontario.

April 1969.

APPENDIX I

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 60

FOUNDATION SECTION

JOB 69-F-2-6 LOCATION Co-ords. 658,739 N; 101,824 E.  
W.P. 168-64-13 BORING DATE March 6, 1969  
DATUM Geodetic BOREHOLE TYPE Washboring, BX Casing

ORIGINATED BY HS

COMPILED BY AKB

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 $\gamma$ P.C.F.	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH PS.F.					WATER CONTENT %				
												$w_p$ ——— $w$ ——— $w_L$				
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE										
637.3	Ground Level															
0.0	Clayey silt to silty clay, trace of sand (mottled brown)															
630.3	Very stiff to stiff.		1	SS	13											
7.0	Silt, trace of sand and clay.		2	SS	77	630										
	(Brown)		3	SS	110											
			4	SS	76	620										
			5	SS	30											
	Dense to very dense.		6	SS	40											
609.3			7	SS	49	610										
28.0	Sandy silt to silty fine sand. Brown		8	SS	54											
601.3	Dense		9	SS	37											
36.0	Het. mix. of clay, silt, sand & gravel (Gl. Till)		10	SS	62	600										
595.9	Very dense to hard.		11	SS	150/4"											
41.4	End of Borehole															

0 3 96 1

▼ 610.3

0 64 ( 36)

WL in open BH

DATUM            Geodetic

LOCATION

BORING DATE

BOREHOLE TYPE

## RECORD OF BOREHOLE No. 61

Co-ords. 658,792 N; 101,824 E.

March 5, 6 & 7, 1969

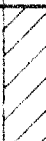
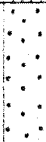
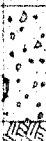
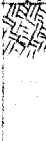
Washbore - BX Casing

FOUNDATION SECTION

ORIGINATED BY HS

COMPILED BY FP

CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT		BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT		WATER CONTENT %			
							20	40	60	80		
						SHEAR STRENGTH P.S.F.						
						○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    x LAB. VANE						
633.4	Ground Level											
0.0	Clayey silt to silty clay, trace of sand (mottled brown)					630						
625.9	Very stiff		1	SS	20							
7.5	Silt, trace of sand and clay (Brown)		2	SS	36							
	Dense to very dense		3	SS	63	620						
612.4			4	SS	68							
21.0	Sandy silt to silty fine sand. (Brown)		5	SS	50	610						
			6	SS	42							
603.9	Compact to dense.		7	SS	15							
29.5	Het. mix. of clay, silt, sand & gravel (Glacial Till) (Brown)		8	SS	33							
597.6	Dense to very dense or hard.		9	SS	83	600						
35.8	Dolomite Bedrock (Grey)		10	AXT	90%							
	Fractured to sound at elev. 594.		11	AXT	100%	590						
585.4			12	AXT	100%							
1.8.0	End of Borehole											



FOUNDATION SECTION

JOB	69-F-2-6	LOCATION	Co-ords. 658,854 N; 101,778 E.	ORIGINATED BY	HS
W.P.	168-64-13	BORING DATE	March 5 - 6, 1969	COMPILED BY	PP
DATUM	Geodetic	BOREHOLE TYPE	Washboring, BX Casing	CHECKED BY	

[illegible]

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 63

FOUNDATION SECTION

JOB 69-F-2-6

LOCATION

Co-ords. 658,936 N: 101,850 E.

ORIGINATED BY PP

W.P. 168-64-13

BORING DATE

March 3, 1969

COMPILED BY AKB

DATUM Geodetic

BOREHOLE TYPE

Washboring BX Casing

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT ——— W <sub>L</sub> PLASTIC LIMIT ——— W <sub>P</sub> WATER CONTENT ——— W			BULK DENSITY Y P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		20	40	60	80	100	W <sub>P</sub>	W	W <sub>L</sub>		
633.9	Ground Level															
0.0	Silty clay to clayey silt, some sand & gravel (Fill) (Grey Brown)		1	SS	6	630										
622.9	Firm		2	SS	8											
11.0	Silt to silty sand, some gravel, trace of clay (Fill) (Grey Brown)		3	SS	4											
615.9	Loose.		4	SS	9	620										
18.0	Clayey silt to silty clay, some sand (Fill) Grey Brown		5	SS	8											
608.5	Stiff		6	SS	10	610										
25.4	End of Borehole		7	SS	14											
605.8																
28.1	End of Cone Test															

0 10 62 28

0 36 52 12

FOUNDATION SECTION

ORIGINATED BY HS

COMPILED BY AKB

CHECKED BY

[illegible]

FOUNDATION SECTION

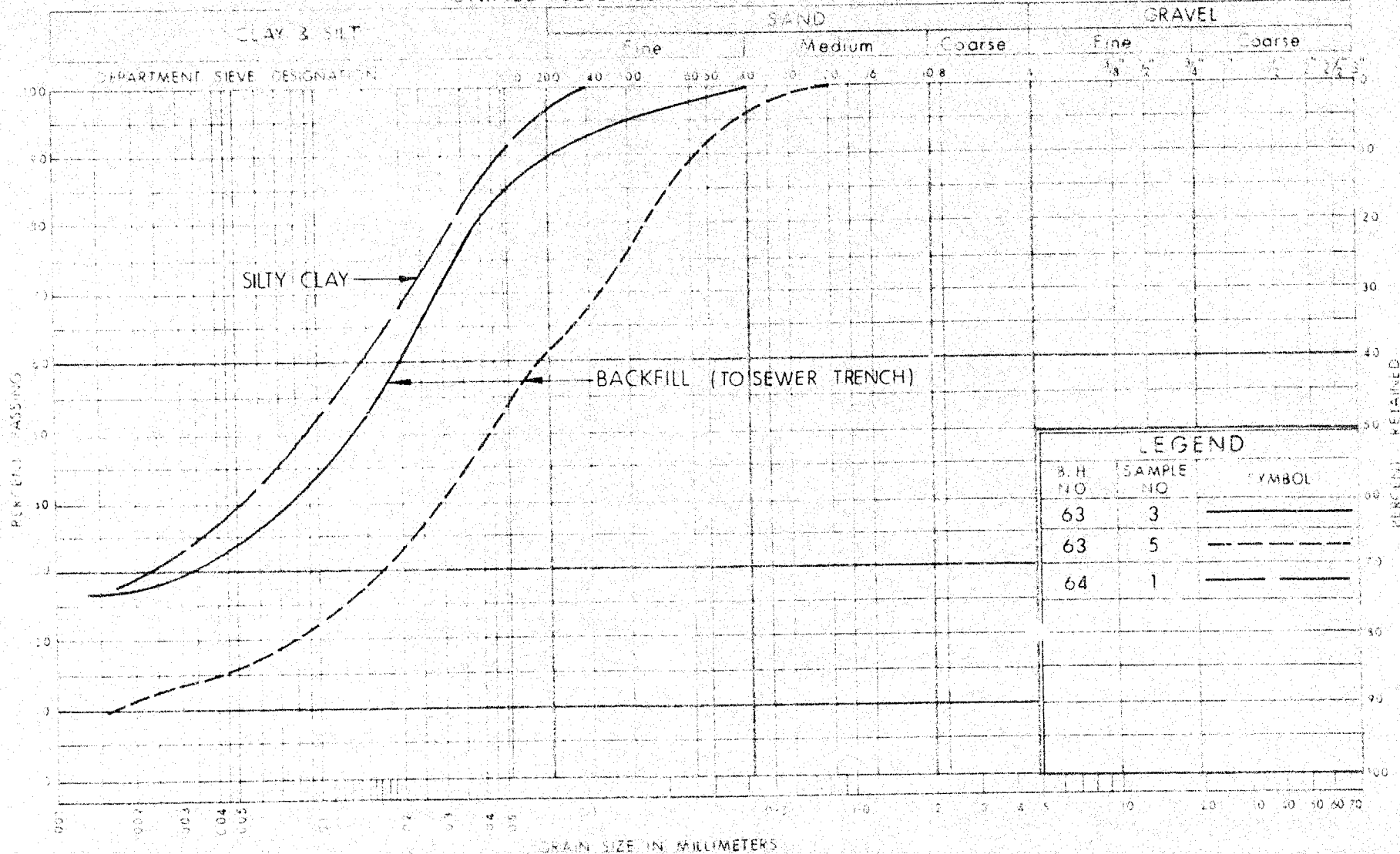
ORIGINATED BY LP

COMPILED BY LP

CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT		BULK DENSITY	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		BLOWS / FOOT		PLASTIC LIMIT				WATER CONTENT
							20	40	60	80			
							SHEAR STRENGTH P.S.F.		WATER <sup>p</sup> CONTENT %		P.C.F.	GR. SA. SI. CL.	
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE		W <sub>p</sub> — W — W <sub>L</sub>				
632.5	Ground Level								15	30	45		
0.0	Silt		1	SS	22	630							
	Compact to Dense		2	SS	85/9"								
	Seam of Sandy Silt		3	SS	64/6"							2 42 53 3	
			4	SS	73	620							
	Red-Brown		5	SS	56							0 5 92 3	
612.5			6	SS	47/3"							1 60 36 3	
20.0	Silty sand					610							
	Very dense		7	SS	68/6"							0 61 38 1	
604.5													
28.0	Gravel, sand & silt.		8	RC	30%	600						Hole caved	
	Boulders & cobbles		9	RC	-							in and dry	
597.7	from 29 feet		10	RC	-							at el.608.2	
34.8	End of Borehole												
						590							

# UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION

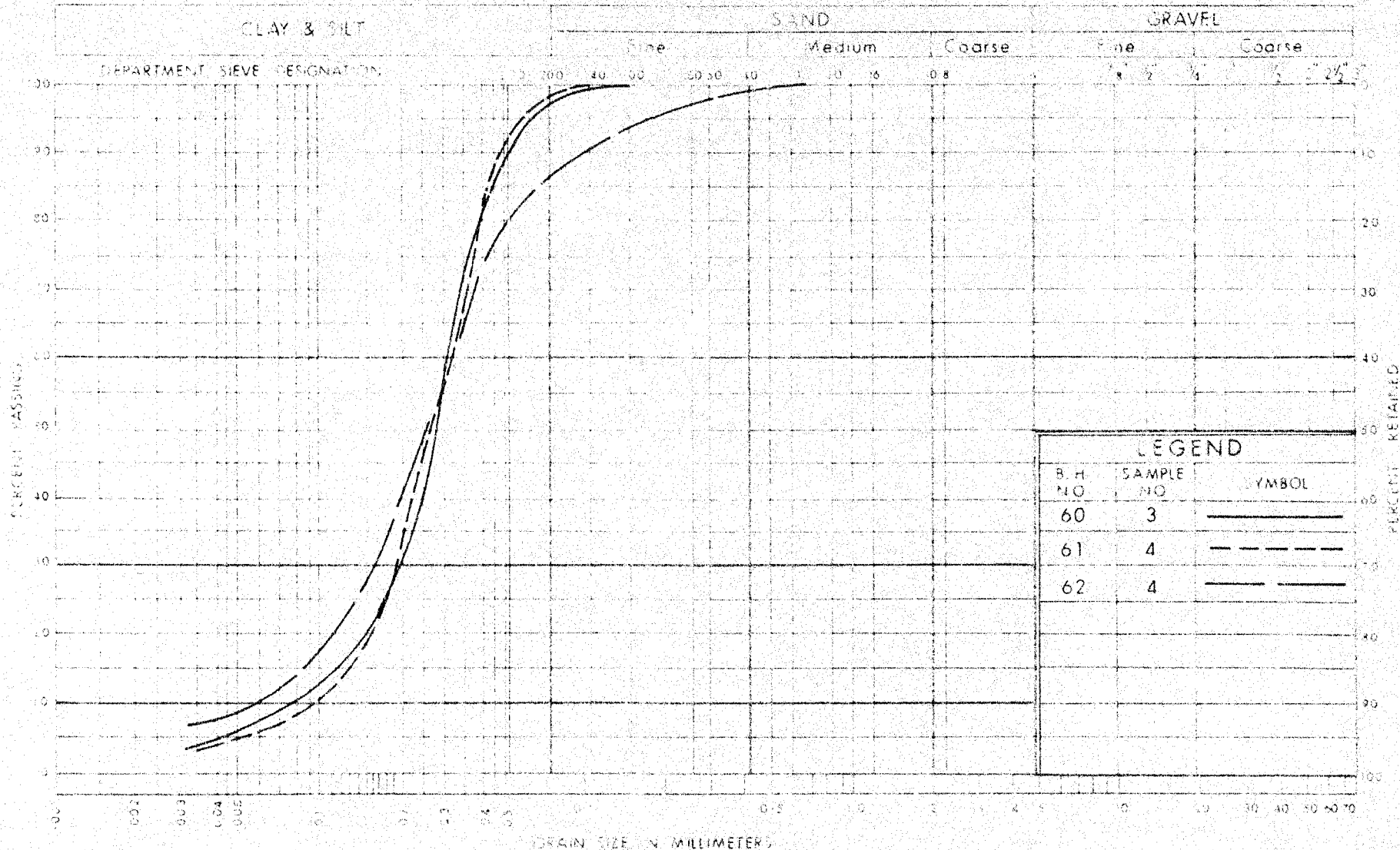
## GRAIN SIZE DISTRIBUTION

W.P. No. 168-64-13

JOB No. 69-F-2-6

FIG. 1

# UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION

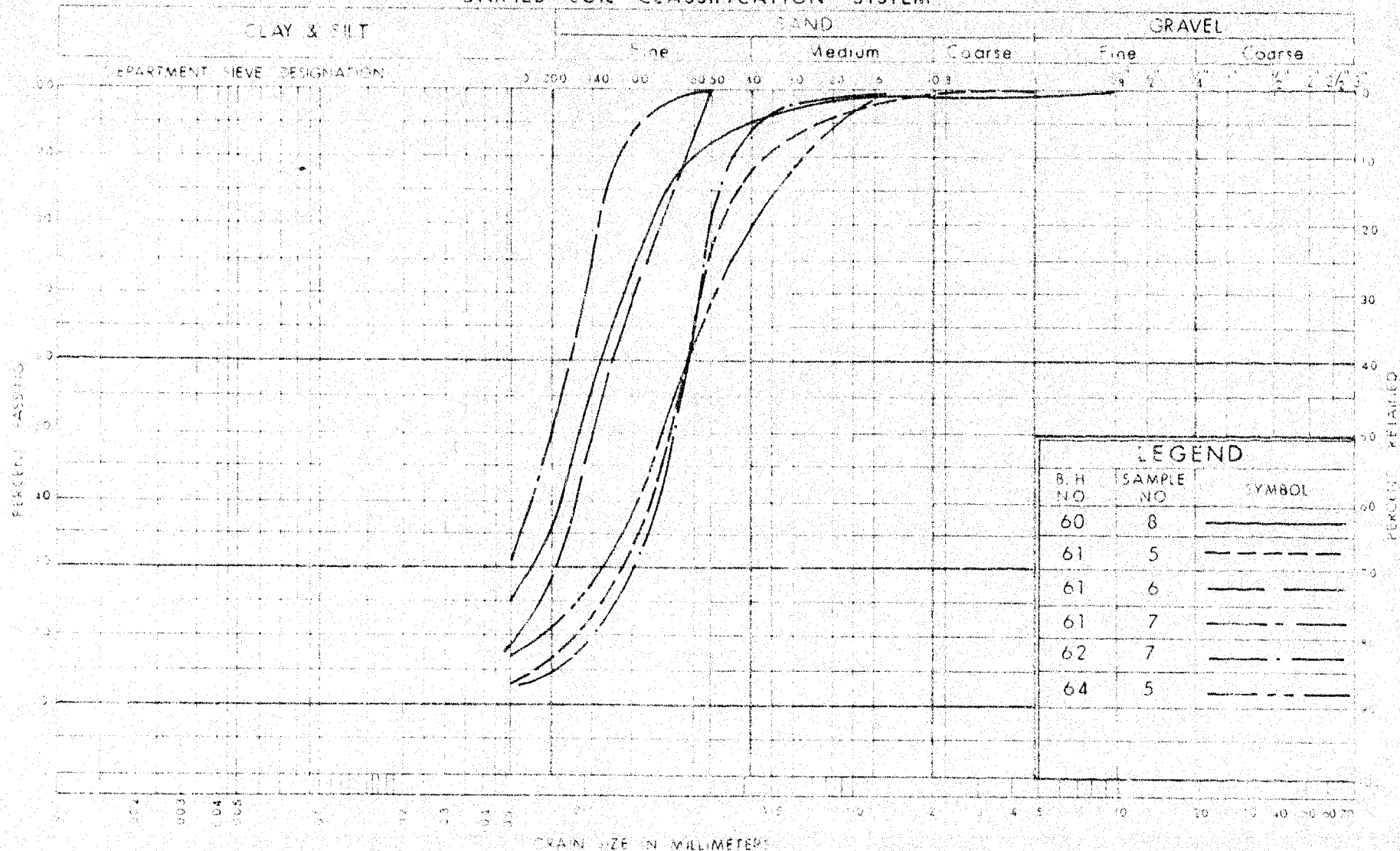
## GRAIN SIZE DISTRIBUTION SILT

WP No. 168-64-13

JOB No. 69-F-2-6

FIG 2

# UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION

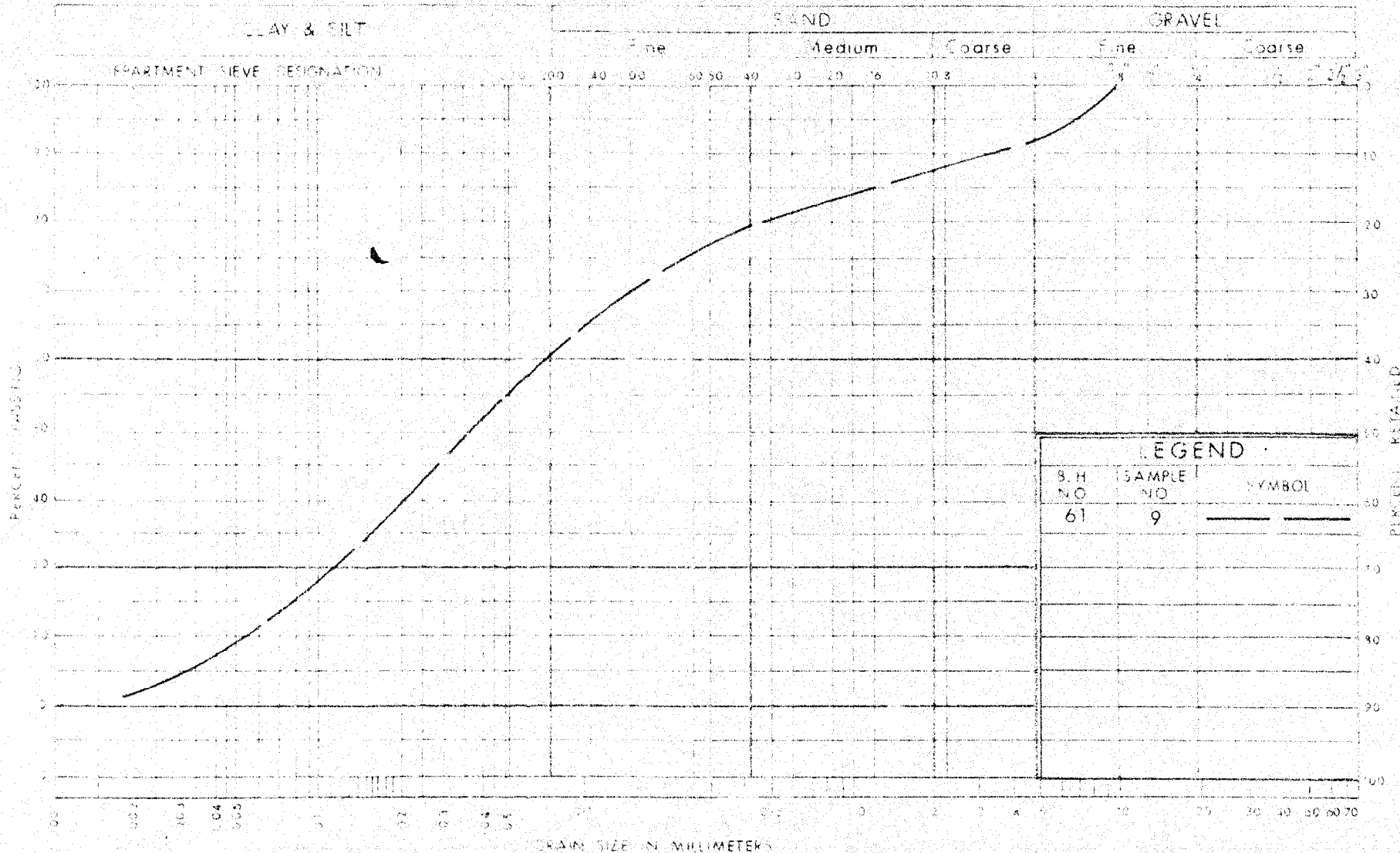
## GRAIN SIZE DISTRIBUTION SILTY SAND TO SANDY SILT

WP No. 168-64-13

JOB No. 69-F-2-6

FIG. 2

# UNIFIED SOIL CLASSIFICATION SYSTEM

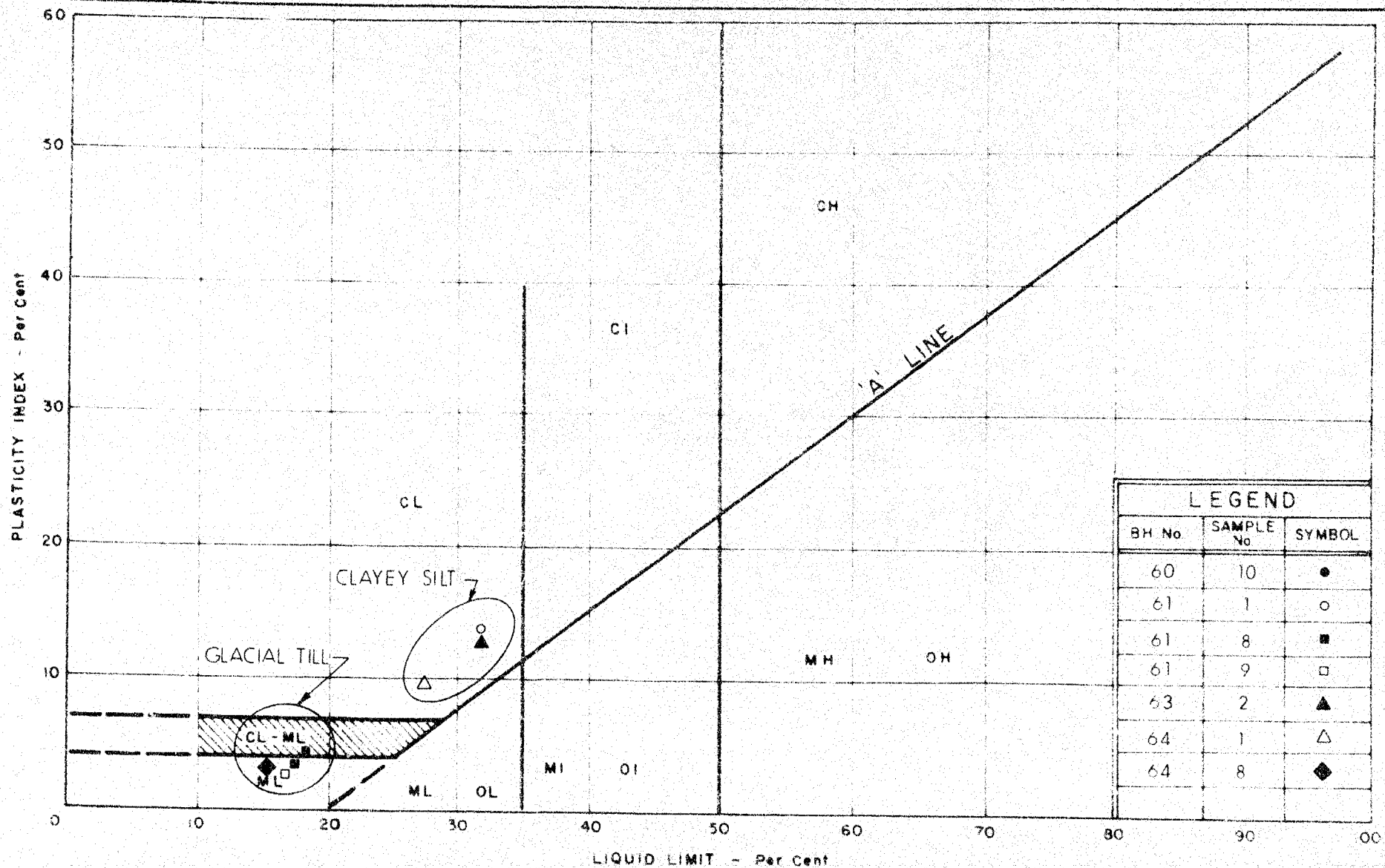


DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION

GRAIN SIZE DISTRIBUTION  
HETEROGENEOUS MIXTURE OF CLAY, SILT, SAND  
& GRAVEL (GLACIAL TILL)

W.P. No. 168-64-13  
JOB No. 69-F-2-6  
FIG. 4





DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION

## PLASTICITY CHART

WP No 168-64-13

JOB No 69-F-2-6

FIG. 5

## 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

Q <sub>u</sub>	UNCONFINED COMPRESSION	L.V	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V	FIELD VANE
Q <sub>cu</sub>	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Q <sub>d</sub>	DRAINED TRIAXIAL	S	SENSITIVITY

## ABBREVIATIONS USED IN THIS REPORT

### SOIL PROPERTIES

$\gamma$	UNIT WEIGHT OF SOIL (BULK DENSITY)
$\gamma_s$	UNIT WEIGHT OF SOLID PARTICLES
$\gamma_w$	UNIT WEIGHT OF WATER
$\gamma_d$	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
$\gamma'$	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
$\tau_f$	SHEAR STRENGTH
$c'$	EFFECTIVE COHESION INTERCEPT
$\phi'$	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
$c_u$	APPARENT COHESION
$\phi_u$	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
$\mu$	COEFFICIENT OF FRICTION
$S_t$	SENSITIVITY

### GENERAL

$\pi$	= 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
$\sigma$	NORMAL STRESS
$\bar{\sigma}$	NORMAL EFFECTIVE STRESS ( $\bar{\sigma}$ IS ALSO USED)
$\tau$	SHEAR STRESS
$\epsilon$	LINEAR STRAIN
$\gamma$	SHEAR STRAIN
$\nu$	POISSON'S RATIO ( $\mu$ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
$\eta$	COEFFICIENT OF VISCOSITY

### EARTH PRESSURE

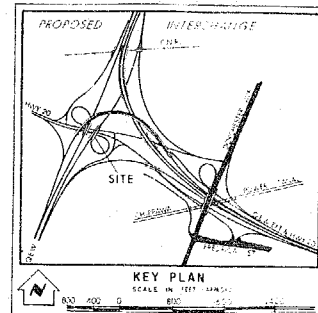
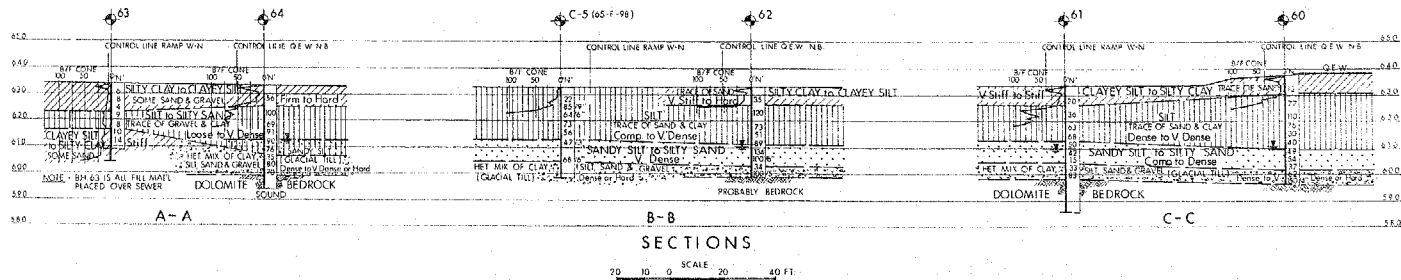
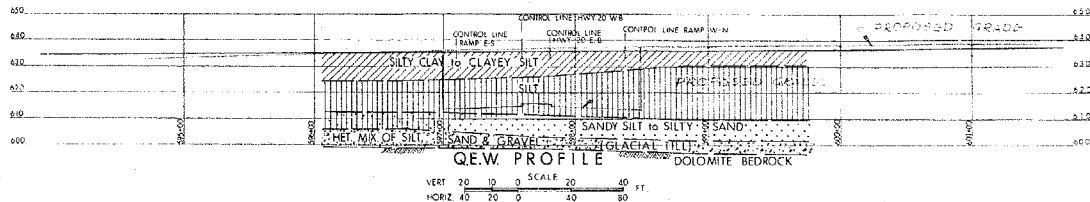
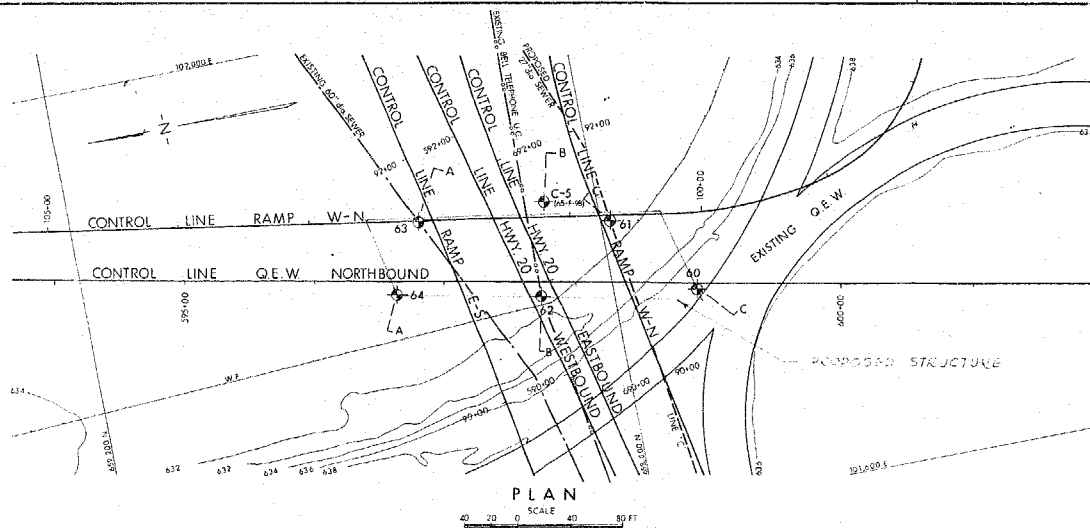
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
$\delta$	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
$K_0$	COEFFICIENT OF EARTH PRESSURE AT REST

### 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 PROPERTY, 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
$\beta$	ANGLE OF SLOPE TO HORIZONTAL



LEGEND				
	Bore Hole			
	Cone Penetration Hole			
	Bore & Cone Penetration Hole			
	Water Levels established at time of field investigation, W.S. 50'			
NO.	ELEVATION	STATION	OFFSET	
C-5	632.5	658.838	101.647	
60	637.3	658.738	101.40	
61	633.4	658.782	101.602	
62	632.3	658.821	101.778	
63	633.9	658.930	101.750	
64	633.3	658.967	101.799	

**- NOTE -**  
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

DATE	BY	REVISIONS

DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & TESTING OFFICE - FOUNDATION SECTION

**BRIDGE No 6**  
Q.E.W. NORTHBOUND OVER HWY 20

KING'S HIGHWAY NO. 20 Q.E.W. INTERCHANGE DIST. NO. 4  
CO. WELLAND NIAGARA FALLS  
TWP. STAMFORD LOT COR.

**BORE HOLE LOCATIONS & SOIL STRATA**

SUBMIT B.D. CHECKED	REP. NO. 108-03-12	W.S. DRAWING NO.
DRAWN S.O. CHECKED	JOS. NO. 69-F-2-A	69-F-2-6A
DATE 1 APRIL 1969	SITE NO.	BRIDGE DRAWING NO.
APPROVED <i>[Signature]</i>	DATE NO.	

## MEMORANDUM

TO: D. Waller,  
District Construction Engineer,  
District #4,  
Hamilton.

FROM: K.G. Selby,  
Foundations Office,  
Design Services Branch.

ATTENTION:

DATE: May 18, 1972.

OUR FILE REF.

IN REPLY TO

GEOCREs N°  
30M3-95

SUBJECT: Filter Blanket on Cut Slopes  
Hwy. #20 & Q.E.W. Interchange  
Contract 71-174, W.O. 72-11058  
District #4, Hamilton.

30M3-95

GEOCREs No.

As requested by you we have carried out borings at the abovementioned site to aid in determining the upper boundary of the filter blankets to be placed on the lower portions of the cut slopes. The site was also visited by the writer in order to establish the present condition of the cut slopes, some of which have been constructed for about 12 months.

From all of our observations it appears that a perched water condition exists at many locations in this area and we recommend the following approximate upper boundaries for the filter blanket.

Dorchester North	El. 625±
Q.E.W. N.B.	El. 625±
Hwy. 20 E.B. & W.B.	El. 620±

The precise boundaries were established in the field on May 10, by the writer and Mr. I. Coghill, Project Supervisor, the elevations of which should not differ greatly from those quoted above.

The foregoing was discussed with Mr. T. Kovich, Regional Materials Engineer, who is in agreement with our recommendations.

*K. G. Selby*

K.G. Selby,  
Supervising Foundation Engineer

KGS/ht

c.c. J. Regan (Hamilton District)  
T. Kovich  
A. Rutka

File.  
Documents

#69-F-2-6

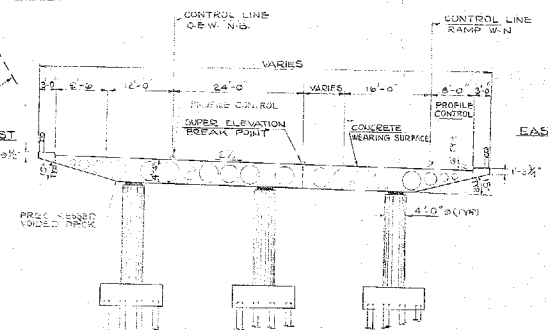
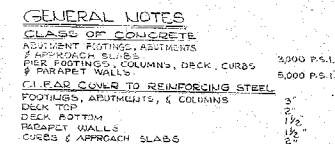
W.P. 168-64-13

Q.E.W. (N.B.L.)

AND H.W.Y. #20

Q.E.W. EXT. COMPLEX

C.N.R. OVERPASS



DEPARTMENT OF HIGHWAYS ONTARIO  
BRIDGE DIVISION

69-F-2-6

HWY. #20 O'PASS AT NORTHBOUND Q.E.W.  
KING'S HIGHWAY No. 20 E Q.E.W. DIST. No. 4  
CO. WELLAND  
CITY of NIAGARA FALLS LOT CON.

APPROVED				SITE No. 34-244		W.P. No. 768-64-13	
SEALING ENGINEER				CONTRACT No.			
DESIGN	ASB	CHECK	J. A. S.	DRAWING No.		D-6630-1	
DRAWING	D. G.	CHECK	1958				
DATE	APR. 19/61	LOADING	15.20.44				

LIST OF DRAWINGS D-6630-1, TO 16

GENERAL PLAN  
FOOTINGS - DIMENSIONS & REINFORCING  
NORTH ABUTMENT - DIMENSIONS & REINF.  
SOUTH ABUTMENT - DIMENSIONS & REINF.  
WINGWALLS - DIMENSIONS & REINF.  
DECK DIMENSIONS  
DECK REINFORCING  
WALL DETAILS  
PIER DETAILS  
APPROACH SLABS  
PARAPET WALL DETAILS  
DETAILS OF CONCRETE SLOPE PAVING  
STANDARD STEEL PARAPET RAIL  
BRIDGE ELECTRICAL DETAILS  
STANDARD DETAILS I  
STANDARD DETAILS II

— 1  
— 2  
— 3  
— 4  
— 5  
— 6  
— 7  
— 8  
— 9  
— 10  
— 11  
— 12  
— 13  
— 14  
— 15  
— 16

