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DIST. 4 REGION

W.P. No. 70-68-07

CONT. No.

W. O. No.

STR. SITE No.

HWY. No. B.S.E

LOCATION THREE RETAINING

WALLS - BRANTFORD EXPRESSWAY

NO OF PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

Ontario
Department of Transportation and Communications

FOUNDATIONS FILES

~~XXXXXXXXXXXXXXXXXXXX~~

MEMORANDUM

40 P1-51

ORIGINALS FILED

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

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

ATTENTION: Mr. S. McCombie

DATE: July 16, 1971

OUR FILE REF.

IN REPLY TO

JUL 30 1971

SUBJECT:

FOUNDATION INVESTIGATION REPORT
For

Three Retaining Walls
Prop. to be Built in Conjunction
With the Brantford Expressway #2
City of Brantford District #4
W.O. 71-11024 -- W.P. 70-68-07

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.

AGS/MdeF
Attach.

cc: Messrs. B. R. Davis
F. G. Allen
D. W. Farren
W. Zonnenberg
H. Greenland
A. P. Watt
J. Roy
B. J. Giroux
B. A. Singh

(2)

A. G. Stermac
A. G. Stermac
PRINCIPAL FOUNDATION ENGINEER

M. M. Dillon (2) -
- London Office - A. Kobelak
- Galt Office - D. McKinnon

Foundations Files ✓
Gen. Files

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FOUNDATION INVESTIGATION REPORT
For
Three Retaining Walls
Prop. to be Built in Conjunction
With the Brantford Expressway #2
City of Brantford District #4
W.O. 71-11024 -- W.P. 70-68-07

1. INTRODUCTION:

The Foundation Section was requested by Mr. A.P. Watt, Regional Bridge Planning Engineer, Southwestern Region, to carry out foundation investigations at the sites of several crossings, retaining walls and the Eastward Canal culvert, in conjunction with the proposed Brantford Expressway #2. The request was submitted in a memo, dated March 17, 1971.

This report contains the results of the investigations along three proposed retaining walls. It is to be noted, that recommendations for two other walls proposed to be built integral with the Eastward culvert, were already given in the report numbered 71-11022.

Walls, included in this report are arbitrarily numbered Walls #3, 4 and 5. Following is a brief outline of the investigations and soil properties, with recommendations concerning foundations, earth pressures and dewatering of excavations.

2. DESCRIPTION OF THE SITE AND FIELD INVESTIGATION:

The site of proposed wall #3 is grass and bush covered, and the line crosses the existing municipal services easement and the abandoned railway embankment.

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

The location of wall #4 is in between the existing Greenwich Ave. and the Mohawk Canal, and at the present the site is used as a parking area by Massey-Ferguson employees.

Wall #5 will be built south of Abel Ave., where the land is occupied by single family units.

A total of 12 boreholes and 7 dynamic cone penetration tests were carried out at the locations of the proposed retaining walls. One continuous hollow stem auger and one conventional diamond drill, adapted for soil sampling purposes were used for the field work. The locations and elevations of the boreholes are marked on Drawing No. 71-11024A.

Soil samples were taken at regular intervals, together with field vane tests within the cohesive strata. All the samples were visually examined and identified upon recovery, and again in the laboratory. Standard laboratory tests of moisture contents, Atterberg limits and grain-size analyses were performed on representative soil specimens. Undisturbed samples were subjected to undrained shear strength tests, by means of unconsolidated quick triaxial and unconfined compression tests. Field and laboratory test results are marked on the accompanying borelogs.

3. SOIL CONDITIONS:

3.1) General:

The surficial stratum along wall #4 was found to be mixed ash and cinder fill. At the locations of wall #3 and 5 the uppermost layers consist of silty sands and gravelly

3. SOIL CONDITIONS: (cont'd) ...

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

sands; which were also present under the fill along proposed wall #4. The main body of the overburden within the entire area was identified to be stratified silts, clayey silts and silty clays, followed by glacial till-like deposits, right above the bedrock surface.

The description of the various strata follows:

3.2) Mixed Fill:

The southern bank of the Mohawk Canal is built up by fill material, consisting predominantly of the waste product of the Massey-Ferguson plant. The ash and cinder are mixed with some sand and gravel, but the colour of the layer is dark brown and black. Standard penetration resistances within this 9 - 12 foot thick layer generally range from 2 blows per foot to 8 blows per foot, thus the relative density is very loose to loose. Due to the organic content and insufficient compaction, this layer is considered to be a poor engineering material.

3.3) Granular Deposits:

The granular deposits were identified to be gravelly sands to silty sands, the thickness of which varied between 5 feet and 13 feet, except at the location of wall #3, where the granular layers were found to be up to 45 feet thick. Grain-size analyses, carried out on samples of these deposits resulted in 0 - 40% gravel, 3 - 35% silt and clay, the remainder falling within the sand size grains. Typical

3. SOIL CONDITIONS: (cont'd) ...

3.3) Granular Deposits: (cont'd) ...

grain-size curves are presented on Figure #1 in the Appendix.

Penetration 'N' values showed considerable variations, which might partially be caused by the presence of large size gravels. The relative density determined by 'N' values ranged from loose to very dense. The granular soils were all found to have quick dilatancy, thus they will exhibit instability under unbalanced hydrostatic heads. Quick conditions were observed in the casings during drilling operations, below the water level.

3.4) Silts, Clayey Silts and Silty Clays: (Stratified layers)

Underlying the granular deposit, silts and clayey silts were encountered. The upper 5 - 15 ft. portion of these soils usually had no stratifications, under which irregular seams and layers of silt and clayey silt were noted. Within the seams some random, thin, reddish-brown coloured silty clay layers were also observed. The silt portion of the stratum had very slight plasticity and, due to the lack of cohesive strength, it showed considerable dilatancy. Moisture contents were measured to be above the liquid limits, especially at the upper zones. The stratification of the lower portion of the stratum is horizontal, at some places seams are quite regular, in other locations they were noted to be in a random order with various thicknesses and frequency. In the stratified layers the moisture contents lie between the plastic limits and liquid limits. In Figure #2 several

3. SOIL CONDITIONS: (cont'd) ...

3.4) Silts, Clayey Silts and Silty Clays: (cont'd) ... grain-size curves are plotted of the various seams, showing that among the layers, there are almost pure silts, but also clays of high plasticity.

The undrained shear strengths of the deposit were determined by field and laboratory tests. Results of these tests versus elevations, at the locations of each retaining wall, are delineated on Figures #3, 4 and 5. The average undrained shear strength under proposed wall #3 was estimated to be 1,300 PSF, while under walls #4 and 5 1,250 PSF.

The bulk density of the layer varies between 135 PCF and 117 PCF, with an estimated average of 125 PCF.

3.5) Silts and Clayey Silts with Some Sand and Gravel:

In the majority of boreholes, underlying the stratified layers a somewhat heterogeneous deposit was found. Due to the non-uniform nature of the soils, they were identified to be clayey silts to silts with some gravel, and silts to sandy silts with some gravel. Representative grain-size curves of these deposits are presented on Figure #6.

Relatively high penetration 'N' values were obtained in this stratum, which, together with the heterogeneous grain-size distribution indicated the glacial origin of the layer. In the non-cohesive materials some quick conditions and "blow-out-s" occurred during drilling.

3. SOIL CONDITIONS: (cont'd) ...

3.6) Bedrock:

Some boreholes were driven or augered to refusal. Those elevations where definite bouncing of the drill rods was observed were considered to be the upper surface of the Lockport dolomite bedrock. Since the bedrock was proved during previous investigations, no diamond drilling was believed to be warranted at this time. The elevation of the bedrock along proposed wall #3 was estimated to be at 580-582 feet; along wall #4: 573 - 577 feet , and along wall #5 between 574 - 580 feet.

4. GROUNDWATER CONDITIONS:

Groundwater level observations were carried out in the boreholes, and the equilibrium water levels recorded on the borelogs. The water levels were found to be between el. 652 feet and 656 feet, within the granular strata.

5. DISCUSSION AND RECOMMENDATIONS:

5.1) General:

Wall #3 is proposed to be built at the north side of the expressway embankment between approx. Station 168 + 30 and Station 173 + 40. Wall #4 will provide lateral support for the expressway at the south side between Station 161+ 80 and Station 171 + 40. Wall #5 is designed to retain the north slope of Ramp E (N/S/W) at the TH & B Railway line. The exact ground elevations at the low side of the walls are not known, but it is assumed, that the future ground levels will

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

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

be at or near the existing ones. According to the preliminary plans, the height of wall #3 will range between 17 feet and 25 feet, wall #4 between 20 feet and 34 feet and wall #5 between 7 feet and 24 feet.

Soil conditions at the locations of the retaining walls are shown on the stratigraphical profiles on Drawing No. 71-11024A.

5.2) Foundations:

Soil conditions beneath the proposed walls appear to be unfavourable for shallow foundations. Along wall #3, however, between elevations 645 feet and 650 feet the sands and silts exhibited somewhat higher strengths, so that spread footings might be considered within this zone. 3 TSF safe loads may be assumed on spread footings between the above elevations.

Depending upon the finished ground level at the low side of the wall, the suggested zone might prove to be too deep, for the economical design of the spread footings. In this case retaining wall #3, together with walls #4 and 5 should also be supported on end-bearing steel H-piles, driven to refusal on bedrock. The bedrock surface is expected to be reached along wall #3 between elevation 580 feet and elevation 582 feet, beneath wall #4 around elevation 573 feet and 577 feet and at wall #5 between elevations 574 feet and 580 feet. Safe loads equal to the full structural strength of

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

5.2) Foundations: (cont'd) ...

the particular H section used may be employed on piles, supported on bedrock. Considerations may also be given to constructing footings, supported on timber friction piles. Rough computations indicated, that 12 inch diameter timber piles, having 45 ft. embedded lengths in undisturbed, original soils, will support safe loads of 20 Ton/pile. A pile loading test prior to construction would be recommended in order to obtain reliable bearing values on friction piles.

5.3) Earth Pressures:

The lateral earth pressures, that will act on the walls can be estimated using a value of coefficient of active earth pressures $K_a = 0.35$. In calculating the factor of safety against sliding along the base, for walls lying within the sands and silts, a coefficient of friction $\tan \phi = 0.4$; within the cohesive strata (clayey silt, layers of silt, clayey silt and silty clay) an adhesion value of $C_{ADH} = 1,250$ PSF may be employed. The surface of the cohesive material should be roughened before the concrete base is placed.

For retaining walls supported on piles, the entire vertical and horizontal load should be assumed to be carried on piles. No frictional resistance and no adhesion should be considered to act along the base slab.

Backfill of the retaining walls should be carried out according to D.H.O. Standard # SD 4-58.

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

5.4) Dewatering of Excavations:

The prevailing groundwater levels during the field investigation, are marked on the soil profiles. Seasonal fluctuation of the water surface is anticipated within one calendar year.

Footing excavations above the water level will involve no problems, and all the soils encountered will be stable for a limited time with 1 horizontal to 1 vertical slopes.

Excavations below the water level, within the clayey silts and silty clays, are expected to cause no special problems on account of the low permeability of these soils. Conventional open pumping will suffice for the removal of the accumulated seepage water. Excavations within the sands and silts, however, will require some dewatering scheme, since these soils will become unstable and will 'boil' under the uplift pressure of the unbalanced hydrostatic head. In order to prevent 'quick' conditions of the soils, oversize excavations may be constructed as shown on Figure 7. This method would involve an initial gradual pumping, with final pumping confined to the shallow ditches around the bottom of the excavation. The side slopes should be cut as steep as possible, and the rate of pumping should be such, that the sides of the excavations do not slough in.

Excavations within the above-mentioned cohesionless deposits may also be carried out with vertical walls within the protection of interlocking sheet piles. Sheet piling should be driven to a distance below the bottom of the excavation

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

5.4) Dewatering of Excavations: (cont'd) ...

equal to, or greater than the distance of the water level above it, to prevent 'boiling'.

It appears, however, that the bottom of some of the footing excavations will be just a short distance above the cohesive layers. In this event, due to the relatively impervious nature of these materials, sheet pile penetrations can be reduced, according to the formula given on Figure #8. The formula may be used only in those cases where the length of the sheeted excavation is at least 4 times larger than the excavation width.

5.5) Foundations in the Vicinity of Utilities:

Several existing utilities cross the sites of the proposed retaining walls.

The locations of these sewers and utilities must be taken into consideration when decisions are made regarding the type of foundation to be employed - i.e., spread footings or piles. Our recommendations pertaining to spread footings are, of course, valid only for footings placed in undisturbed original ground. 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) Where 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

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

5.5) Foundations in the Vicinity of Utilities: (cont'd) ...
should be prebored to a depth of 6 feet below the pipe bottom.
The size of the augered hole need only be slightly larger than
the pile section.

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

6. MISCELLANEOUS:

The field work carried out during the period
May 6 - May 20, 1971, was supervised by Messers. K. Williams
and M. Logan, Engineering students.

Equipment used was owned and operated by P.V.K.
Drilling Co., Burford, Ontario. Mr. A.K. Barsvary, Senior
Foundation Engineer was in charge of the entire project.
He also wrote this report.

Mr. K.G. Selby, Supervising Foundation Engineer
reviewed the report.

July, 1971

APPENDIX I

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 10

FOUNDATION SECTION

JOB 71-11024

LOCATION Co-ord's 672,825 N.; 800,132 E.

ORIGINATED BY H.S.

W.P. 70-68-07

BORING DATE April 19 - 20, 1971

COMPILED BY A.K.B.

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		20	40	60	80	100	w _p ——— w ——— w _L					
							SHEAR STRENGTH P.S.F.					WATER CONTENT %					
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE										
668.0	Ground level.						1000	2000				10	20	30		GR, SA, SI, CL	
0.0	Silty sand with some gravel.	[Pattern]				660										32 43 (25) 0 12 (88)	
	Dense.		1	SS	38												
656.0	Brown.		2	SS	30												
12.0	Clayey silt to silt.	[Pattern]				650											
	Stiff.		3	SS	9												
	Grey.		4	TW	PM												
640.0			5	SS	9	640											
28.0	Irregular seams of silt, clayey silt & silty clay.	[Pattern]	6	TW	PM											121 122 128	
			7	SS	8												
			8	TW	PM	630											
			9	SS	10												
	Stiff to hard.		10	TW	PM												
	Grey and brown.		11	SS	8	620											
			12	TW	PM												
606.5			13	SS	32	610											
61.5	End of borehole.		14	SS	26												

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 17

FOUNDATION SECTION

JOB 71-11024 LOCATION Co-Ord's 672,922 N.; 800,734 E. ORIGINATED BY M.L.
W.P. 70-68-07 BORING DATE May 4 - 5, 1971 COMPILED BY A.K.B.
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 %				
							1000		2000		10 20 30				
658.6	Ground level.														GR, SA, SI, CL
0.0	Gravelly sand. Compact.		1	SS	17	650									0 74 (26)
649.1			2	SS	38										
9.5	Silt.		3	SS	32										
639.6	Very stiff.		4	SS	24	640									0 5 92 3
			5	SS	25										
19.0	Irregular seams of silt, clayey silt and silty clay. Stiff to hard. Grey and brown.		6	SS	11										
			7	TW	PM	630									111 126
			8	SS	16										
			9	TW	PM										
			10	SS	21	620									129
			11	SS	17										
			12	SS	23										
			13	SS	41	610									0 1 49 50
			14	SS	29										
			15	SS	29										
588.6						600									0 1 74 25
70.0	Clayey silt with some sand. Glacial Till.		16	SS	62										
582.1			17	SS	111										
76.5	End of borehole. Probable Bedrock.					590									0 3 76 21

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 18

FOUNDATION SECTION

JOB 71-11024

LOCATION Co-Ord's 672.817 N.; 800,527 E.

ORIGINATED BY H.S.

W.P. 70-68-07

BORING DATE April 23 - 26, 1971

COMPILED BY A.K.B.

DATUM Geodetic

BOREHOLE TYPE Auger

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		BLOWS / FOOT					SHEAR STRENGTH P.S.F.					WATER CONTENT %			
							20	40	60	80	100	UNCONFINED + FIELD VANE QUICK TRIAXIAL x LAB. VANE								
							1000	2000				10	20	30						
656.8	Ground level.																			
0.0	Gravelly sand.		1	SS	5	650									42 54 (4)					
648.3	Compact.		2	SS	24															
8.5	Irregular seams of silt, clayey silt & silty clay. Stiff to hard. Grey and brown.		3	SS	14	640														
			4	SS	13															
			5	SS	9															
			6	SS	10															
			7	TW	PM	630														
			8	SS	9															
			9	TW	PM	620														
			10	SS	14															
			11	TW	P/6"	610														
			12	SS	20															
			603.8		13	SS	33													
			53.0	Silt some seams of clayey silt. Very stiff to hard.	14	SS	39	600												0 2 88 10
					15	SS	30													
					16	SS	21	590												
					17	SS	17													
			580.3		18	SS	92													
76.5	End of borehole.																			

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 33

FOUNDATION SECTION

JOB 71-11024 LOCATION Co-ord's 672,894 N., ⁸⁶⁴700,465 E. ORIGINATED BY K.W.
W.P. 70-68-07 BORING DATE May 12, 1971 COMPILED BY K.W.
DATUM Geodetic BOREHOLE TYPE Auger 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		BLOWS / FOOT					WATER CONTENT %				
							20	40	60	80	100	W _P — W — W _L				
							SHEAR STRENGTH P.S.F.									
							○ UNCONFINED	● QUICK TRIAXIAL	+ FIELD VANE	x LAB. VANE						
655.7	Ground level.															
0.0	Gravelly sand.															
650.2	Very dense.		1	SS	33											
5.5	Silt, some clay.		2	SS	13											
	Stiff.		3	SS	11											
			4	SS	10											
637.7			5	TW	PH											
18.0	Irregular seams of silt, clayey silt & silty clay.		6	SS	11											
	Traces of sand.		7	TW	PH											
	Stiff to hard.		8	SS	14											
			9	TW	PH											
			10	SS	21											
			11	TW	PH											
			12	SS	35											
			13	SS	35											
			14	SS	19											
			15	SS	18											
			16	SS	20											
582.7																
73.0	Silt to clayey silt, some sand (Till)		17	SS	99											
574.2	Hard.															
81.5	End of borehole.															
	Probable bedrock.															

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 35

FOUNDATION SECTION

JOB 71-11024 LOCATION Co-Ord's 672,844 N.; 800,971 E. ORIGINATED BY M.L.
W.P. 70-68-07 BORING DATE May 20, 1971 COMPILED BY K.W.
DATUM Geodetic BOREHOLE TYPE Auger. 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				
							1000 2000				WATER CONTENT % 10 20 30				
657.5	Ground level.														
0.0	Sand and gravel with traces of organics.		1	SS	19										
649.5			2	SS	37										
8.0	Irregular seams of silt, clayey silt and silty clay.		3	SS	13										
			4	SS	8										
			5	TW	PH										
			6	SS	11										
			7	SS	10										
	Stiff to very stiff.		8	SS	9										
			9	TW	PH										
			10	SS	13										
			11	TW	PH										
			12	SS	17										
			13	TW	PH										
			14	SS	27										
			15	SS	26										
			16	SS	19										
			17	SS	11										
584.5			18	SS	87/6"										
73.0	Sand and gravel. Very dense.														
577.5															
80.0	End of borehole. Probable bedrock.														

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 37

FOUNDATION SECTION

JOB 71-11024

LOCATION Co-Ord's 672,736 N.; 800,710 E.

ORIGINATED BY M.L.

W.P. 70-68-07

BORING DATE May 19, 1971

COMPILED BY K.W.

DATUM Geodetic

BOREHOLE TYPE Auger

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 _L					
663.9	Ground level.					1000	2000	10	20	30					
0.0	Sandy silt with organics. Fill.		1	SS	7	660									
655.4	Loose.		2	SS	5										
8.5	Silty and gravelly sand.		3	SS	7										
			4	SS	22										
	Dense.		5	SS	37	850								0 66 (34)	
645.9			6	SS	35									27 69 (4)	
18.0	Clayey silt to silt.		7	SS	12	640									
	Very stiff.		8	SS	17										
			9	SS	15										
627.9			10	SS	21	630									
36.0			11	TW	PH								130		
	Irregular seams of silt, clayey silt & silty clay.		12	SS	14	620									
			13	TW	PH								127.5		
	Stiff.		14	SS	17	610							130		
			15	TW	PH										
			16	SS	13	600								0 0 90 10	
			17	SS	15										
584.9			18	SS	45	590									
77.0	Sandy silt, some gravel.		19	SS	89										
	Till.														
	Very dense.		20	SS	95/6"	580								2 42 46 10	
572.9	End of borehole.														
91.0	Probable bedrock.														

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 38

FOUNDATION SECTION

JOB 71-11024 LOCATION Co-Ord's 672,687, 800,517 E.
W.P. 70-68-04 BORING DATE May 17, 1971
DATUM Geodetic BOREHOLE TYPE Auger.ORIGINATED BY K.W.
COMPILED BY K.W.
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		20	40	60	80	100	SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE					WATER CONTENT % w_p ——— w ——— w_L
664.7	Ground level.						1000		2000				10	20	30		GR. SA. SI. CL.
0.0	Ash & cinder with some sand. Fill. Black. Loose.		1	SS	8	660											17 77 (6)
			2	SS	9												
			3	SS	3												
652.2			4	SS	29												
12.5	Gravelly sand. Compact.		5	SS	21	650											
647.7			6	SS	20												
17.0	Clayey silt to silt. Stiff.		7	SS	12	640											
636.7			8	SS	34												
28.0	Irregular seams of silt, clayey silt & silty clay. Traces of sand. Stiff to very stiff.		9	SS	10	630											
			10	TW	PH											123.5	
			11	SS	9	620										125	
			12	TW	PH												
			13	SS	24	610											
			14	SS	25												
			15	SS	18	600											
			16	SS	11												
			17	SS	11	590											
			18	SS	11												
581.7			19	SS	93	580											
83.0	Silt with some clay, gravel and sand. Till		20	SS	100/12"												
573.7	Probable bedrock.																
91.0	End of borehole.																

DEPARTMENT OF HIGHWAYS- ONTARIO

MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 39

FOUNDATION SECTION

JOB 71-11024

LOCATION Co-Ord's 672,624 N.; 800,326 E.

ORIGINATED BY K.W. & M.L.

W.P. 70-68-07

BORING DATE May 18, 1971

COMPILED BY K.W.

DATUM Geodetic

BOREHOLE TYPE Auger.

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				
						1000	2000			10	20	30			
663.9	Ground level.														
0.0	Ash & cinder with some sand. Fill.		1	SS	4	660									
654.9	Black.		2	SS	26										
9.0	Gravelly sand.		3	SS	2										
649.9	Very dense.		4	SS	54	650									
14.0	Silt.		5	SS	16										
	Stiff.		6	SS	11										
638.9			7	SS	19	640									
25.0	Irregular seams of silt, clayey silt & silty clay.		8	SS	9										
	Stiff.		9	SS	8	630									
			10	TW	PH									122	
			11	SS	13	620									
			12	TW	PH									127	
			13	SS	19	610								130	
			14	TW	PH									127	
			15	SS	10	600									
595.9			16	SS	11										
68.0	Silt.		17	SS	19	590									
	Trace of clay.		18	SS	12										
	Compact.		19	SS	13	580									
577.9			20	SS	81										
86.0	Sand & clayey silt.														
573.4	Till. End of borehole.														
90.5	Probable bedrock.														

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 40

FOUNDATION SECTION

JOB 71-11024 LOCATION Co-Ord's 672,560 N.; 800,136 E.

ORIGINATED BY K.W.

W.P. 70-68-04 BORING DATE May 13, 1971

COMPILED BY K.W.

DATUM Geodetic BOREHOLE TYPE Auger.

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 PSF					WATER CONTENT %				
							20	40	60	80	100	UNCONFINED ○ QUICK TRIAXIAL	FIELD VANE + LAB VANE x	w_p		
664.3	Ground level.						1000	2000				10	20	30		GR. SA. SI. CL.
0.0	Cinder with some sand. Black.		1	SS	4	660										
655.3	Fill. Loose.		2	SS	5											
9.0	Gravelly sand.		3	SS	12											
650.3			4	SS	12											36 55 (9)
14.0			5	SS	12											
	Irregular seams of silt, clayey silt & silty clay.		6	SS	10											
	Stiff.		7	SS	15											
			8	TW	PH										117	
			9	SS	10										120	
			10	TW	PH											
			11	SS	2										125	
			12	TW	PH										126.5	
			13	SS	3										123	
			14	TW	PH											
			15	SS	10										123	
			16	SS	13											
			17	SS	12											
			18	SS	13											
580.8			19	SS	14											
83.5	Silt.					580										0 3 82 15
576.3	Compact.															
88.0	Sand. Very dense.															
573.3	End of Borehole.															0 92 (8)
91.0	Probable bedrock.															

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 41

FOUNDATION SECTION

JOB 71-11024 LOCATION Co-Ord's 673,024 N.; 800,920 E.

ORIGINATED BY M.L.

W.P. 70-68-07

BORING DATE May 6, 1971

COMPILED BY K.W.

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		BLOWS / FOOT					SHEAR STRENGTH P.S.F.					WATER CONTENT %		
							20	40	60	80	100	UNCONFINED					FIELD VANE		
							QUICK TRIAXIAL					LAB. VANE							
662.1	Ground level.						1000	2000				10	20	30		GR. SA. SI. CL.			
0.0	Clayey silt, traces of sand.		1	SS	9	660													
655.1	Stiff.		2	SS	14														
7.0	Silty & gravelly sand. Compact to very dense.		3	SS	17	650										0 2 73 25			
648.6			4	SS	66														
13.5	Silt. Stiff to hard.		5	SS	31														
639.1			6	SS	11	640													
23.0	Irregular seams of silt, clayey silt & silty clay. Stiff.		7	SS	12														
			8	TW	PM	630											127.5		
			9	SS	10												125		
			10	TW	PM	620											125		
			11	SS	14														
			12	TW	PM	610											130		
607.1			13	SS	45														
55.0	Silt to clayey silt, some sand & gravel. Till. Very stiff to hard.		14	SS	49	600													
			15	SS	51												0 2 83 15		
			16	SS	19	590													
			17	SS	12														
580.6				18	SS	36												8 15 63 14	
81.5	End of borehole. Probable bedrock.																		

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 42

FOUNDATION SECTION

JOB 71-11024

LOCATION Co-Ord's 673,053 N.; 801,010 E.

ORIGINATED BY M.L.

W.P. 70-68-07

BORING DATE May 10, 1971

COMPILED BY K.W.

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		BLOWS / FOOT					SHEAR STRENGTH P.S.F.					WATER CONTENT % w_p ——— w ——— w_L
							20	40	60	80	100	P.S.F.					
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE										
674.5	Ground level.						1000 2000					10 20 30				GR. SA. SI. CL.	
0.0	Silty sand to sandy silt.		1	SS	7	670										0 43 47 10	
			2	SS	17												
			3	SS	15												
	Loose to dense.		4	SS	15	660											
			5	SS	10												
			6	SS	25	650											
			7	SS	49												
643.5			8	SS	38											123 124 127 124	
31.0	Silt. Stiff.		9	SS	15	640											
639.5			10	TW	PM												
35.0	Irregular seams of silt, clayey silt & silty clay.		11	SS	22	630											
	Stiff to hard.		12	TW	PM												
			13	SS	18	620											
			14	TW	PM												
			15	SS	32	610											
			16	SS	26	600											
			17	SS	58												
			18	SS	49	590											
			19	SS	34											0 2 77 21	
			20	SS	49												
581.0																	
93.5	End of borehole. Probable bedrock.																

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 43

FOUNDATION SECTION

JOB 71-11024 LOCATION Co-Ord's 673,106 N.; 801,095 E.

ORIGINATED BY M.L.

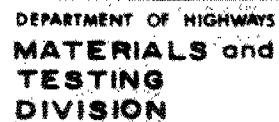
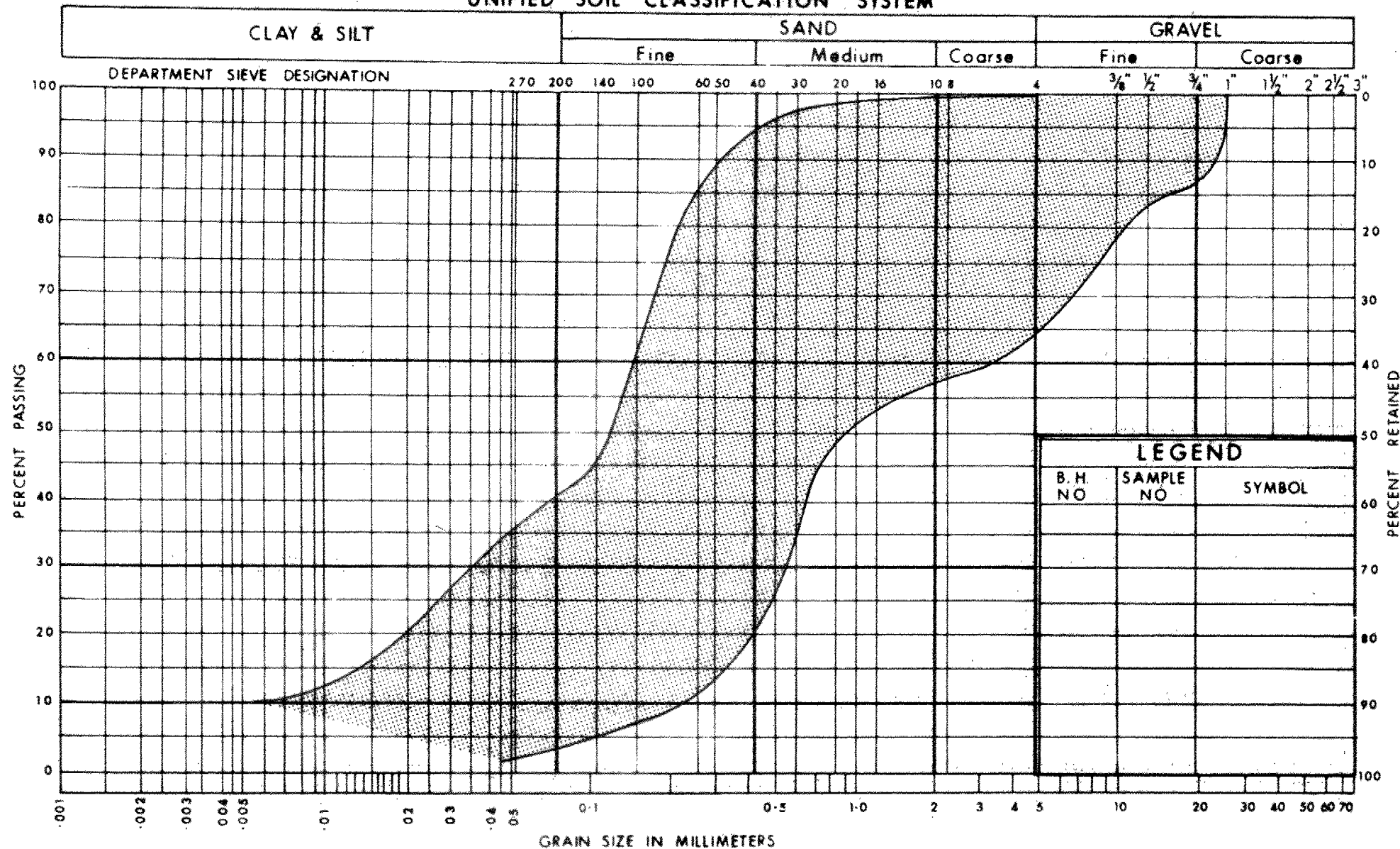
W.P. 70-68-07 BORING DATE May 12, 1971

COMPILED BY K.W.

DATUM Geodetic BOREHOLE TYPE Washboring, NX Casing.

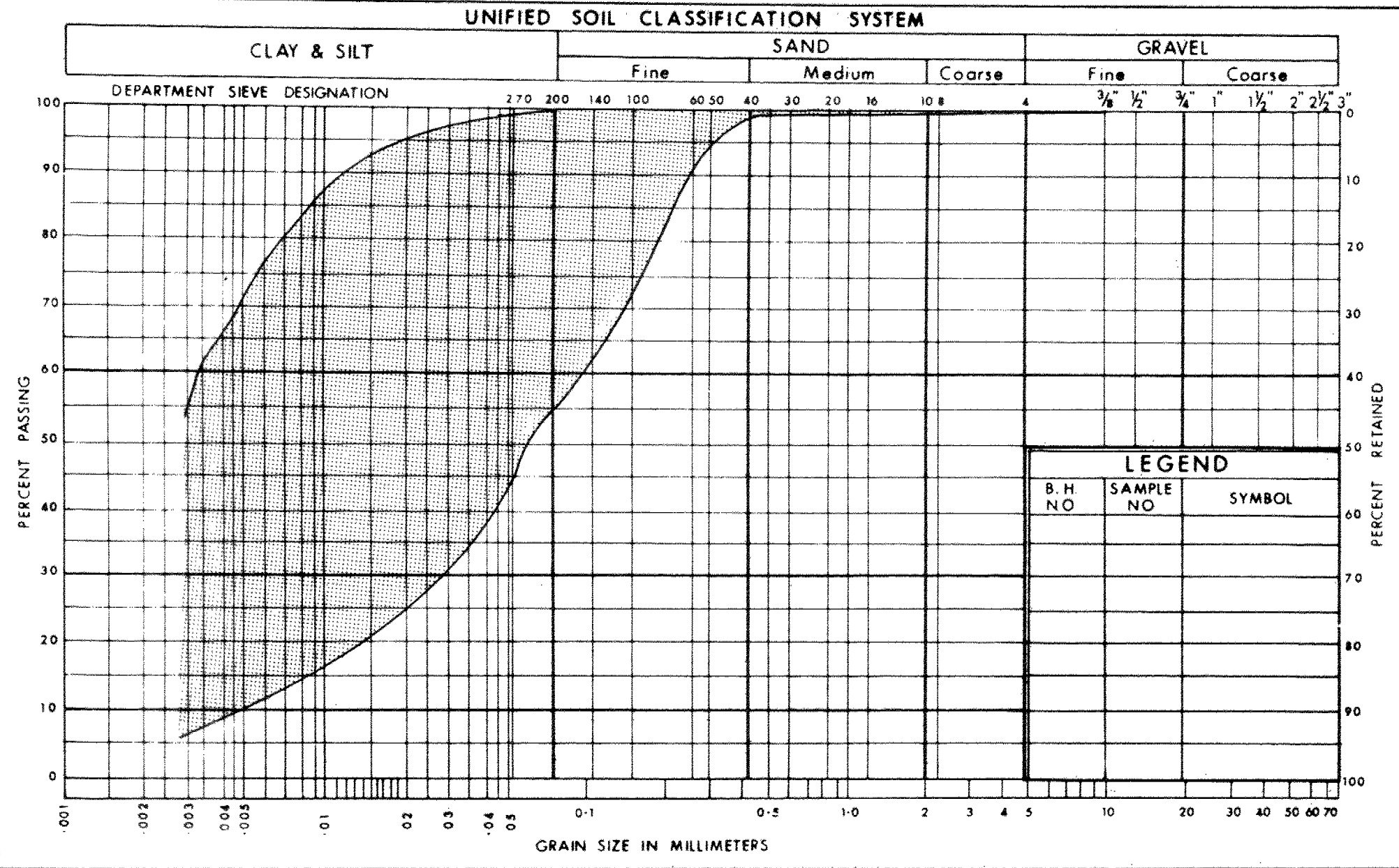
CHECKED BY

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		BLOWS / FOOT					WATER CONTENT %				
							20	40	60	80	100	w_p ——— w ——— w_L				
SHEAR STRENGTH P.S.F.																
○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE																
							1000 2000					10 20 30				
675.2	Ground level.															
0.0	Silty sand to sand with some gravel. Loose to dense.		1	SS	12	670										
			2	SS	11											
			3	SS	12											
				4	SS	9	660									
				5	SS	10										
				6	SS	9										
				7	SS	18	650									
				8	SS	35										
				9	Wash Sample											
						640										
629.7			10	SS	31	630										
45.5	Silt to clayey silt. Irregular seams of silty clay. Very stiff to hard.		11	SS	19	620										
			12	SS	21											
			13	TW	PM											
				14	SS	38	610									
				15	SS	62										
				16	SS	76										
				17	SS	64	600									
				18	SS	45										
				19	SS	17										
580.7						590										
94.5	End of borehole. Probable bedrock.															



SILTY AND GRAVELLY SANDS

FIG. 1



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

GRAIN SIZE DISTRIBUTION

IRREGULAR SEAMS OF SILTS, CLAYEY SILTS & SILTY CLAYS

W.P. No. 70-68-07

JOB No: 71-11024

FIG. 2

SHEAR STRENGTH vs. ELEVATION

RETAINING WALL No 3

Boreholes No 17, 41, 42, 43

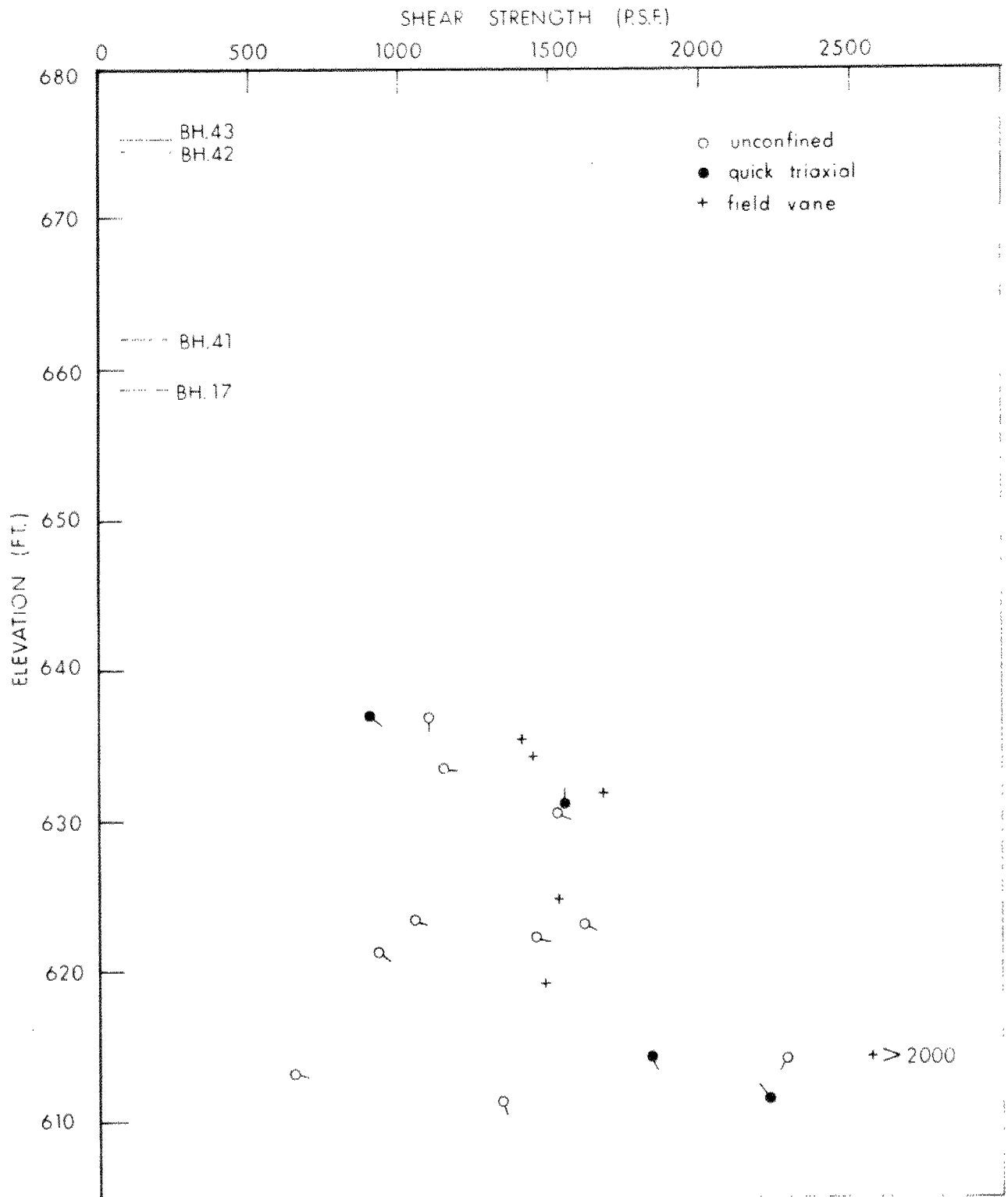


FIG. 3

71-11024

SHEAR STRENGTH vs. ELEVATION

RETAINING WALL NO 4

Boreholes NO 35, 37, 38, 39, 40

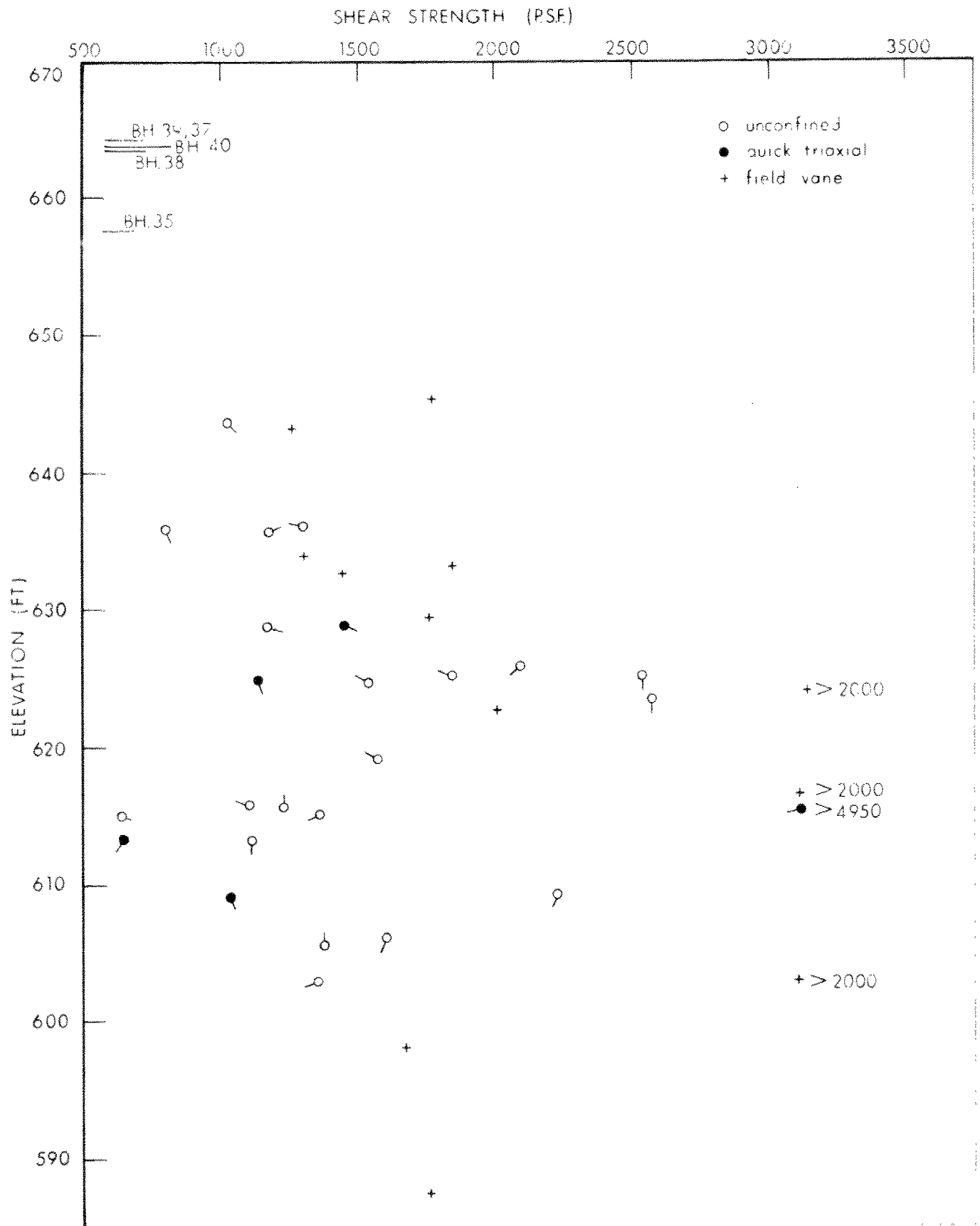


FIG. 4

71-11024

SHEAR STRENGTH vs ELEVATION

RETAINING WALL NO 5

Boreholes No 10,18,33

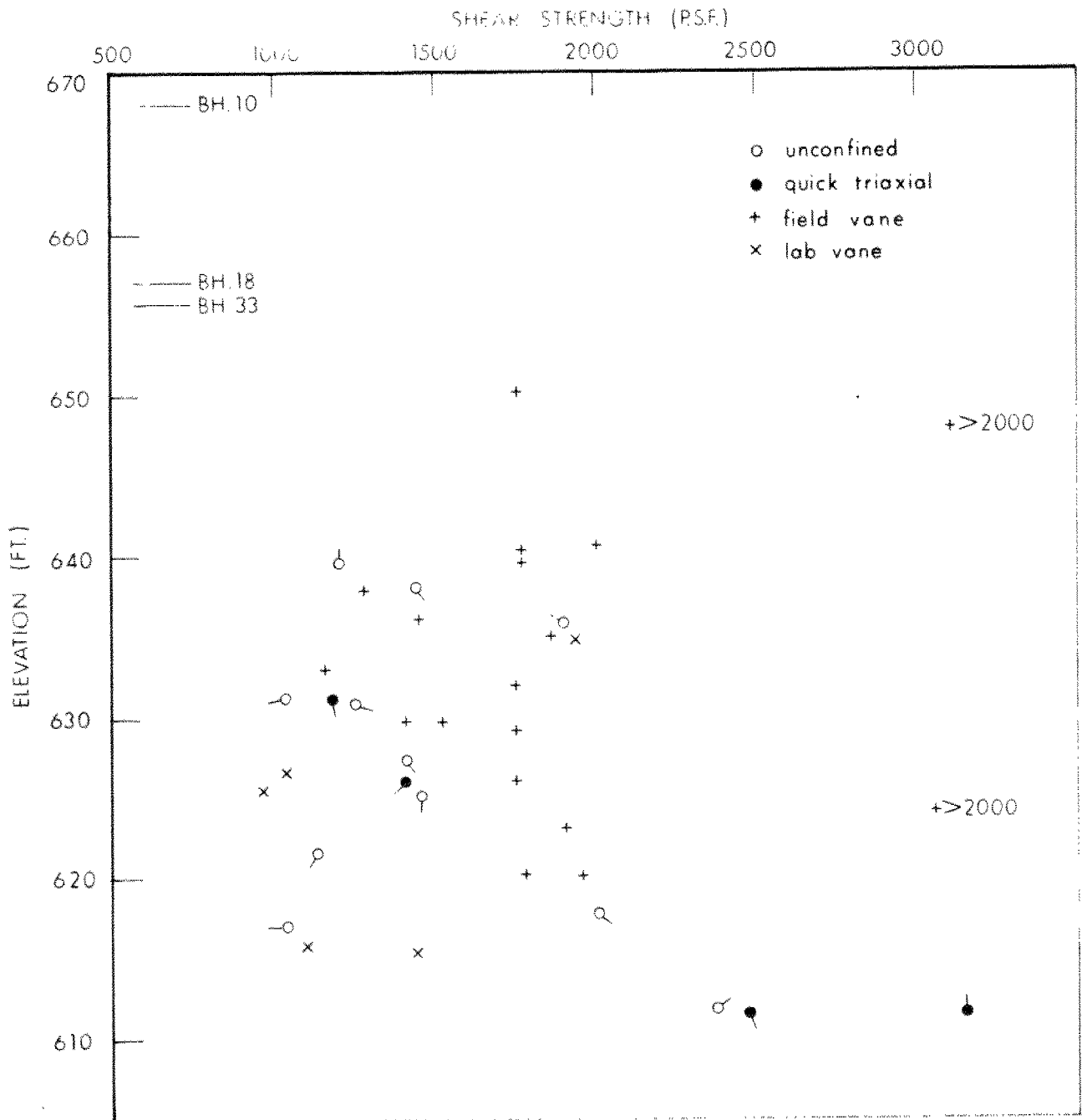
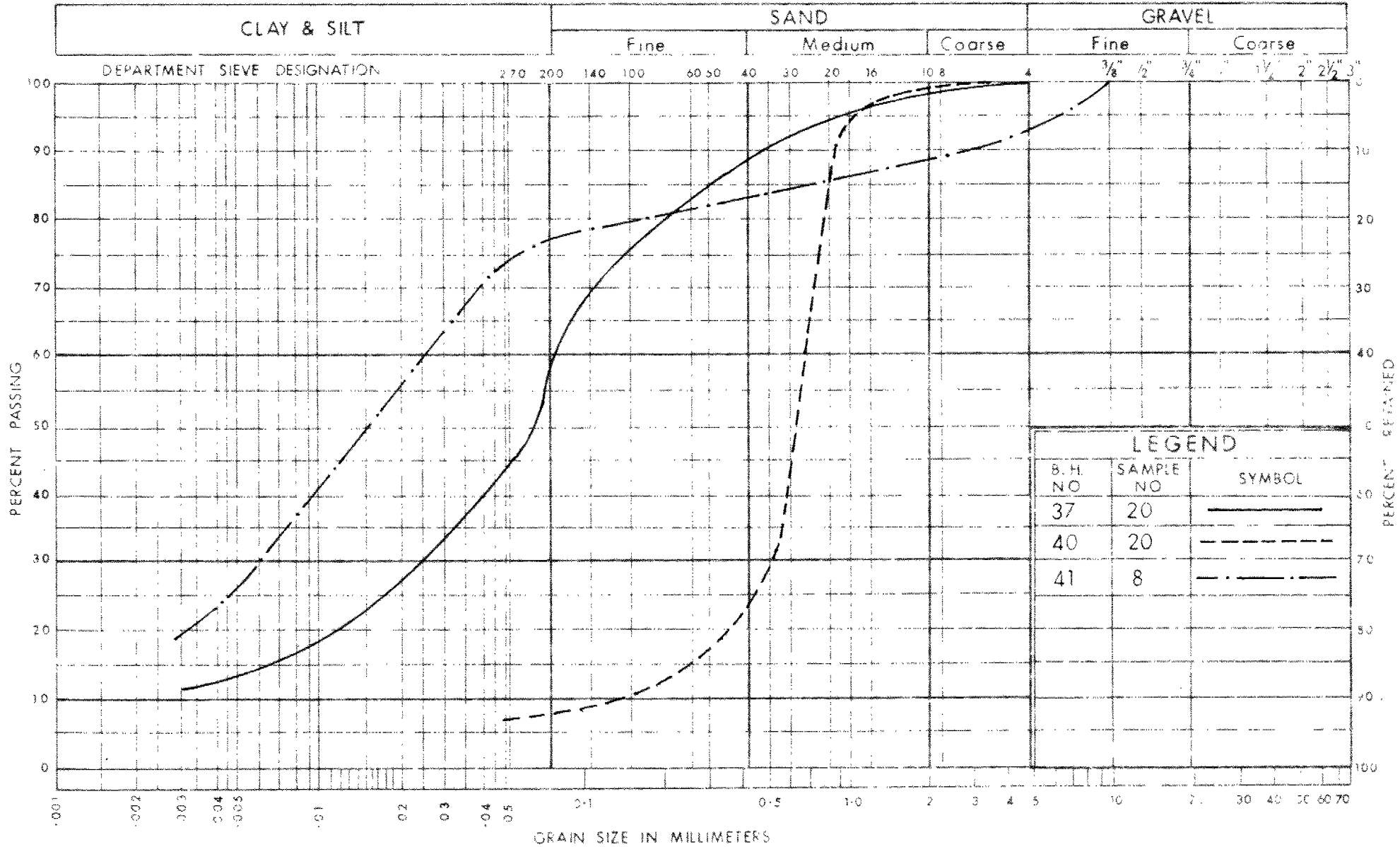


FIG. 5

71-11024

UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

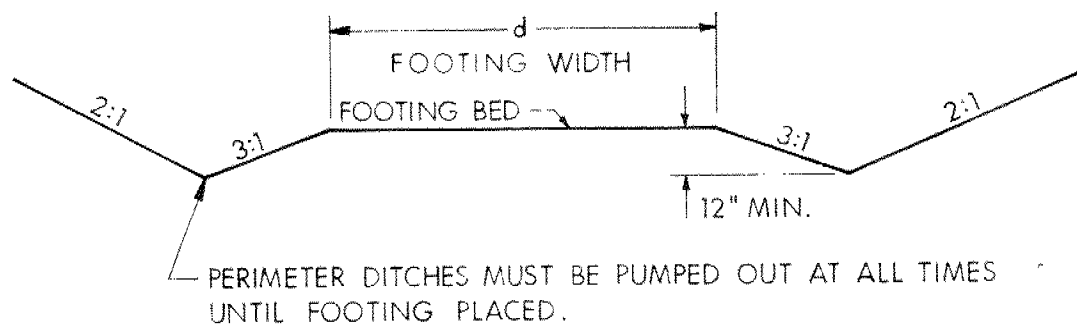
GRAIN SIZE DISTRIBUTION

GLACIAL TILL

W.P. No. 70-68-07

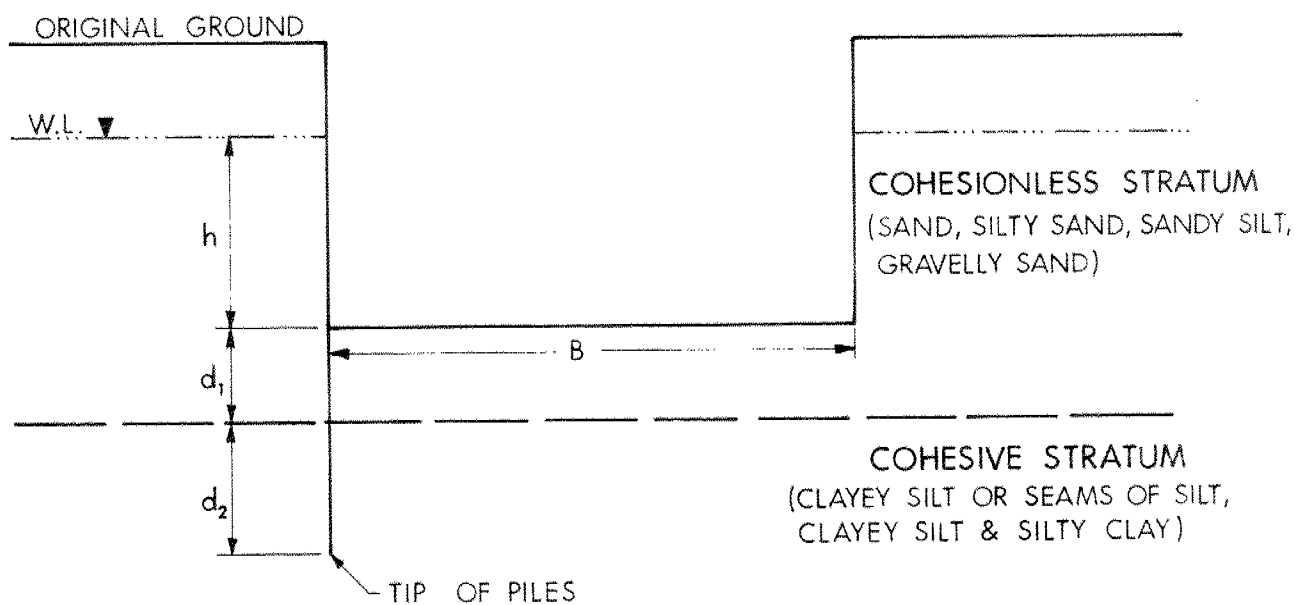
JOB No. 71-11024

FIG. 6



PROPOSED OVERSIZE EXCAVATION

FIG. 7



$$FS = \frac{[(d_1 + d_2) \times B \times \gamma] + (d_2 \times 2 \times C_{ADH})}{(h + d_1 + d_2) \times \gamma_w} \geq 1$$

WHERE

FS = FACTOR OF SAFETY. SHOULD BE EQUAL TO OR GREATER THAN 1.

γ = BULK DENSITY OF SOIL. USE 125 PCF.

C_{ADH} = ADHESION BETWEEN PILE AND SOIL. USE 800 PSF.

γ_w = DENSITY OF WATER (62.4 PCF)

FORMULA SUGGESTED FOR THE RESTRICTION OF SHEET PILE LENGTHS

FIG. 8

71-11024

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_f	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

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		

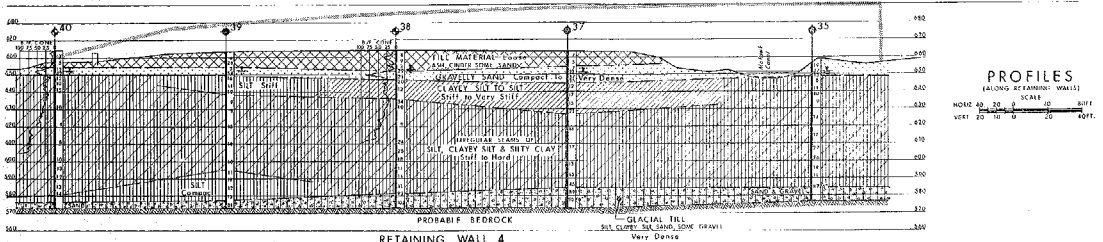
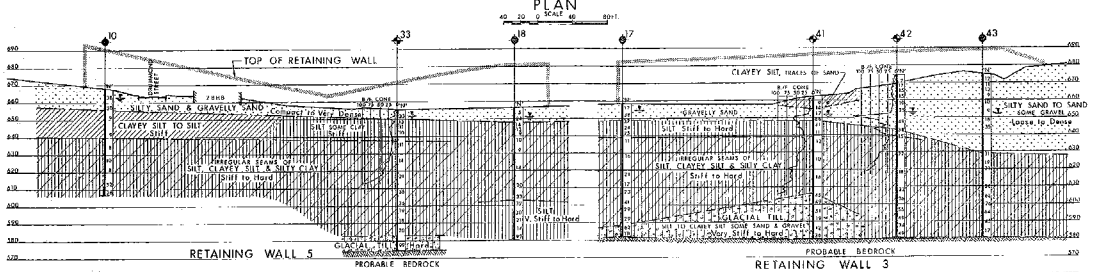
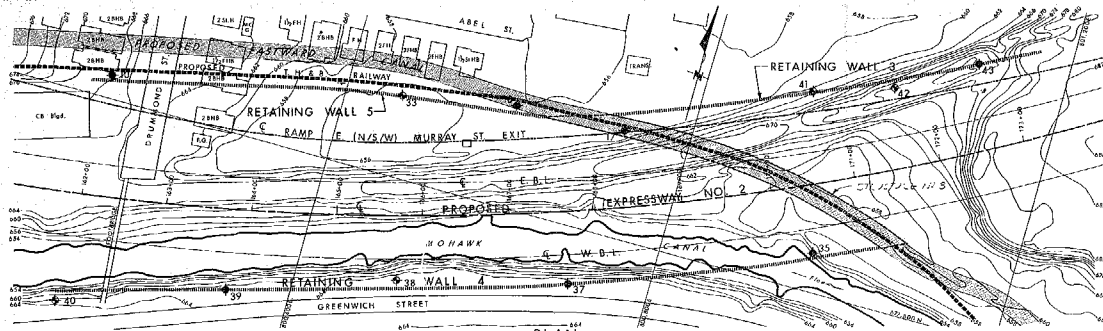
TYPE OF SAMPLE

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

OVERSIZE DRAWING



- ◆ Bore Hole
- ◆ Cone Penetration Test
- ◆ Bore Hole & Cone Test
- ↓ Water Levels established at time of field investigation APRIL & MAY, 1971

NO.	ELEVATION	CO-ORDINATES
		NORTH EAST
10	668.0	672,835 800,192
17	658.6	672,975 800,724
18	656.8	672,917 800,597
33	655.7	672,896 800,465
35	657.5	672,844 800,571
37	663.9	672,730 800,710
38	664.7	672,687 800,517
39	662.9	672,624 800,320
40	664.3	672,580 800,136
41	662.1	672,624 800,920
42	676.5	673,053 801,010
43	673.2	673,100 801,095

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.

DEPARTMENT OF TRANSPORTATION & COMMUNICATIONS
REGIONAL SERVICES BRANCH - ROADWORK SECTION

RETAINING WALLS 3, 4 & 5

FILE NO. BRANTFORD EXPWY NO. 2 SHEET NO. 4
CO. BRANT CITY OF BRANTFORD

DATE: 1971
DRAWN BY: [Signature]
CHECKED BY: [Signature]
DATE: July 14, 1971
APPROVED BY: [Signature]

BORE HOLE LOCATIONS & SOIL STRATA

BRANTFORD & CHEMUNIA TWP NO. 20-58-07
BRANTFORD & CHEMUNIA TWP NO. 21-11024
DATE: July 14, 1971
APPROVED BY: [Signature]

71-11024A
BRIDGE DRAWING NO.