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DIST. 4 REGION

W.P. No. 70-68-05

CONT. No.

W. O. No. 71-11021

STR. SITE No.

HWY. No. B. S. E

LOCATION MOHAWK INTERCHANGE  
UNDERPASS

No. of PAGES -

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

Ontario  
Department of Transportation and Communications

XXXXXXXXXXXXXXXXXXXX

MEMORANDUM

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: June 28, 1971

OUR FILE REF.

IN REPLY TO

JUL 9 1971

SUBJECT:

40 P1-49

FOUNDATION INVESTIGATION REPORT

For

The Murray - Mohawk Interchange  
Underpass of Proposed Brantford  
Expressway #2, City of Brantford  
District No. 4 (Hamilton)

W.O. 71-11021 -- W.P. 70-68-05

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.

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

cc: Messrs. B. R. Davis  
P. G. Allen  
D. W. Farren  
W. Sonnenberg  
H. Greenland  
A. P. Watt (2)  
J. Roy  
B. J. Giroux  
B. A. Singh

Foundations Files ✓  
Gen. Files

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FOUNDATION INVESTIGATION REPORT  
for the Murray - Mohawk Interchange  
Underpass of Proposed Brantford Expressway #2  
City of Brantford District #14  
W.O. 71-11021 --- W.P. 70-68-05

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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 creek diversion, in conjunction with the proposed Brantford Expressway #2.

The request was submitted in a memo dated March 17, 1971.

The Murray - Mohawk Interchange Underpass, discussed forthwith is one of the proposed structures along this portion of the expressway. A limited scale investigation was already implemented along the proposed line in 1968 for the Functional Planning Study. One of the boreholes, drilled at that time has been incorporated in this report (W.O. 68-F-64; B.H. #1).

The field and laboratory investigations were supervised by this section, the results of which are presented in the following sections, together with recommendations pertaining to foundations and embankment stabilities.

2. DESCRIPTION OF THE SITE AND GEOLOGY:

The site of the proposed underpass is located immediately west of the existing Murray St. and north of the Mohawk Canal, and it is occupied by a residential section of the city of Brantford. During the field investigation the houses, with one or two exceptions were all privately owned and inhabited.

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

Several underground utilities and overhead wires interfered with the drilling operations, so that borehole locations had to be shifted accordingly.

Geologically, the area lies at the north limit of the physiographic region known as the "Norfolk Sand Plain". The subsoil in this terrain is believed to be deposited as a delta in glacial lakes Whittlesey and Warren. The sands and silts at our particular location is, however, reduced to seams and layers, overlain by deposits of stratified silts and clays.

3. FIELD AND LABORATORY INVESTIGATIONS:

Some five sampled boreholes and six dynamic cone penetration tests were performed during the recent fieldwork. Boreholes were advanced by a hollow stem (C.M.E.) auger, down to approximate depths of 80-85 ft. Some holes were farther advanced below these depths by washboring techniques, using a conventional diamond rig, adapted for soil sampling purposes. - Samples were taken by means of thin walled Shelby tubes and Split Spoon samplers. Shelby tubes were usually pushed 18 inches into the "undisturbed" soils, while Split Spoons were taken by performing Standard Penetration Tests. At those elevations where the consistency of the cohesive layers permitted field vane shear tests were carried out on undisturbed and remoulded samples.

Each soil sample was visually examined and identified. Further tests were done in the laboratory consisting of Atterberg Limits, grain size analyses and natural moisture contents. The

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

undrained shear strengths of the cohesive layers were tested by unconfined and triaxial compressions. A limited number of consolidation tests were also carried out for settlement prediction purposes.

The locations and elevations of the boreholes, together with the stratigraphical profile are shown on Drawing #71-11021A, while the results of the laboratory and field tests are plotted on the accompanying borelogs.

4. SOIL CONDITIONS:

4.1) General:

Subsoils were found to consist of a surficial layer of clayey silt and silty sand fill, followed by a deep deposit of stratified clayey silts, which in turn was underlain by silts, clayey silts and sandy silts (Glacial Till). A brief description of the various strata is as follows.

4.2) Fill:

From ground elevation extending to depths of 15-19 ft. fill materials were found. In B.H.'s #2 and #3 at the north end of the proposed bridge, the fill consisted of slightly plastic clayey silts and silts with occasional layers of sand. The consistency of the cohesive portion of the fill ranges from fine to very stiff, with penetration "N" values of 6 to 18 blows per ft. In the rest of the boreholes the fill was observed to be sandy silts, silty sands and gravelly sands of compact relative density.

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

4.3) Irregularly Stratified Silts, Clayey Silts and Silty Clays: (cont'd) ...

Underlying the fill, a deposit of irregularly stratified cohesive layer was encountered, extending to elevation 586-610 ft., some 54-86 ft. below ground level. The predominant portion of the material is clayey silt to silt, with plastic limits averaging about 18% and liquid limits about 25%. Numerous seams and layers were found within the entire depth of the deposit, seams being identified to be reddish-brown coloured silty clays, grey dilatante silts and layers of sand. The average value of the plastic limits of the clayey silts were 20% and the liquid limits around 30%. The silt and sand portion of the stratum exhibited an unstable structure, and they became quick in the casing under the unbalanced hydrostatic head. Laboratory undrained and field vane shear strength values showed some discrepancy, the vane results being unreasonably higher than the laboratory unconfined and quick triaxial results. The disagreement was believed to be caused by the heterogeneous nature of the material and the presence of silt and sand seams and layers. The mean value of the undrained shear strength of the overall layer was estimated to be 1350 p.s.f. The bulk density of the soils varies between 120 p.c.f. and 131 p.c.f., depending upon the percentage silt contents of the samples.

4.4) Silts, Clayey Silts and Sandy Silts with Traces of Gravel:

Around elevation 586 ft. and 610 ft. subsoils gradually change to become clayey silts to silts and silty

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

4.4) Silts, Clayey Silts and Sandy Silts with Traces of Gravel: (cont'd) ...

sands to sandy silts. The majority of the samples contained some gravel, which together with the higher penetration 'N' values indicated the glacial origin of this portion of the soil strata. The grain size curves embraced a great range of soil particles as shown on Fig. #1, where the envelope of 8 grain size analyses is plotted. Some of the samples had very slight plasticity, indices ranging from 3 to 7; some of the samples, however, were not plastic at all. Penetration resistances were measured to vary between 16 blows/ft. and well above 100 blows/ft., indicating compact to very dense relative densities and hard consistencies. Between elevation 568 ft. and 576 ft. some 86 to 106 ft. below ground level, a distinct refusal of further penetration was obtained. Above elevations were assumed to be the upper surface of the Lockport dolomite bedrock.

4.5) Groundwater Conditions:

Groundwater levels were measured in the boreholes during the field investigations. The water levels reached equilibrium within usually a day or so, and these levels are plotted on the borelog sheets. The elevations of groundwater were recorded between 653 ft. and 664 ft., some 10 - 15 ft. below ground surface. The water level in the Mohawk Canal was at elevation 652.2 ft. during the field work, so that there is some seepage from the higher grounds towards the river.



5. DISCUSSION AND RECOMMENDATIONS:

5.1) General:

It is proposed to construct a four-span structure, to carry Murray St. over the expressway, over the T.H. & B. Railway Tracks and the Eastward Canal Culvert. The bridge will be located slightly to the west of the existing Murray St. and north of the Mohawk Canal, the latter which will be abandoned and filled. The grade of the expressway at the crossing is designed to be around elevation 661-662 ft.

5.2) Foundations:

Based on the undrained shear strengths of the underlying soils, the maximum net safe bearing pressure on the footings was computed to be  $Q_s = 1.3$  t.s.f. If the bridge can be designed economically with footing loads not in excess of above safe loads, then spread footings should be constructed, the base of the footings being placed some 4 ft. below finished ground, for frost protection.

The most economical footings for the perched type abutments appear to be the ones supported on end bearing steel H piles. Pile caps may be formed within the approach embankments and piles should be driven to refusal on bedrock. The elevation of bedrock ranges from 569 ft. to 577 ft. Safe design loads equal to the structural strength of the pile section used may be applied on these piles.

As an alternative to spread footings, the entire bridge - abutments as well as piers - can be supported on end bearing steel H piles driven to bedrock as mentioned above.

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

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

Considerations might 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 will support safe loads of 20 tons per pile. A pile loading test, carried out prior to construction would be necessary, in order to obtain reliable bearing values on friction piles.

5.3) Settlements:

The approach embankment at the north end of the bridge will be around 10 - 12 ft. high and at the south end some 16 - 18 ft. Consolidation settlements with the compressible layers are anticipated under the new fills. Settlement computations were carried out, assuming the height of the fill to be 18 ft. Laboratory consolidation tests were used for the computations, with a reduction factor of  $\mu=0.8$  (Skempton - Bjerrum, 1957). The calculations resulted in long term settlements of 5 inches, under the south abutment and proportionally smaller settlements are anticipated under the north abutment.

Considering piles foundations, the settlements of the compressible layers will act as negative skin friction upon the vertical surface, surrounding the group of piles. The magnitude of this additional stress will not likely exceed 1300 p.s.f.

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

5.4) Approach Slope Stability:

The stability of the approach embankments were checked by an electronic computer. Analyses were carried out by Bishop's method, using strength parameters in terms of total stresses, and assuming failures along circular arcs. The most critical location of the approach fill was taken to be at the existing Mohawk Canal, where the height of the fill will be almost 30 ft. It is suggested that, prior to construction of the fill, all organic material and debris be replaced by acceptable soils in the present creekbed.

According to the calculations, embankments up to 30 ft. in height will remain stable without constructing berms, provided the fills are built with 2 horizontal to 1 vertical slope.

5.5) 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 slope.

Excavations below the water level, within the clayey silts 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.

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

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

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 Fig. #2. 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 equal to or greater than the distance of the water level above it, to prevent "boiling".

It appears, however, that the bottom of the excavations will be either in the cohesive soils or just a short distance above the cohesive layers. In the latter event, due to the relatively impervious nature of these materials, sheet pile penetration can be reduced, according to the formula given on Fig. #3. 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. DISCUSSION AND RECOMMENDATIONS: (cont'd) ...

5.6) Foundations in the Vicinity of Utilities:

Several existing utilities cross the sites of the proposed bridge.

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 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) 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 of April 7-16, 1971 was supervised by Mr. H. Stankaitis, Engineering Technician. Equipment used was owned and operated by P.V.K. Drilling Company, Burford, Ontario.

6. MISCELLANEOUS: (cont'd) ...

This report was written by Mr. A.K. Barsvary, Senior Foundation Engineer, and reviewed by Mr. K.G. Selby, Supervising Foundation Engineer.

June, 1971

APPENDIX I

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 1 (7; 68-F-64)

FOUNDATION SECTION

JOB 71-11021

LOCATION Co-ords. 672,810 N; 799,370 E.

ORIGINATED BY VK

W.P. 70-68-05

BORING DATE August 1, 1968

COMPILED BY AKB

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 $\gamma$ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		BLOWS/FOOT	SHEAR STRENGTH P.S.F.	WATER CONTENT %				
679.6	Ground Level												
0.0													
	Silt with layers of clayey silt		1	SS	11								
			2	TW	PM	670						124	
			3	TW	PM							128	666.
	occasional seams of fine sand.		4	SS	14	660							
			5	SS	10								
			6	SS	13	650							
			7	SS	22								
	Stiff to Hard		8	SS	13	640							
			9	SS	19								
						630							
						620							
615.1			10	SS	89								0 2 90 8
64.5	End of Borehole												



DEPARTMENT OF HIGHWAYS- ONTARIO

MATERIALS &amp; TESTING OFFICE

## RECORD OF BOREHOLE No. 2

FOUNDATION SECTION

JOB 71 - 11021

LOCATION Co-ords. 672,821 N; 799,264 E.

ORIGINATED BY H.S.

W.P. 70-68-05

BORING DATE April 7-13, 1971

COMPILED BY A.K.B.

DATUM Geodetic

BOREHOLE TYPE Auger &amp; Washboring

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE				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 P.S.F.				WATER CONTENT %				
							UNCONFINED		FIELD VANE		$w_p$ — $w$ — $w_L$				
							1000	2000			10	20	30		GR. SA. SI. CL.
668.5'	Ground Level														
0.0	Clayey Silt to Silt Layers of Sand Fill? Brown V. Stiff & Compact		1	SS	15	660									
			2	SS	18										
653.0'			3	SS	13										
15.5'	Clayey Silt to Silt Irregular Seams & Layers of Silty Clay & Sandy Silt  Firm to Hard  Brownish Grey		4	SS	7	650									
			5	TW	PM										
			6	SS	12										
			7	TW	PM	640									
			8	SS	10										
			9	TW	PM	630									
			10	SS	10										
			11	TW	PM	620									
			12	SS	35										
			13	SS	49	610									
			14	SS	39										
			15	SS	32	600									
			16	SS	19										
			17	SS	40	590									
586.5'			18	SS	22										
82.0'	Clayey Silt to Silt with Traces of Sand & Gravel (Glacial Till)  Hard		19	SS	37	580									
			20	SS	76										
			21	SS	46	570									
568.8'	Probable Bedrock														
99.7'	End of Borehole														

FOUNDATION SECTION

ORIGINATED BY H.S.

COMPILED BY A.K.B.

CHECKED BY *AL*

[illegible]

DEPARTMENT OF HIGHWAYS- ONTARIO

MATERIALS &amp; TESTING OFFICE

## RECORD OF BOREHOLE No. 5

FOUNDATION SECTION

JOB 71-11021

LOCATION Co-ords. 672,689 N; 799,338 E.

ORIGINATED BY H.S.

W.P. 70-68-05

BORING DATE April 16, 1971

COMPILED BY A.K.B.

DATUM Geodetic

BOREHOLE TYPE Dynamic Cone Penetration Only

CHECKED BY *AK*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					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		20	40	60	80	100	WATER CONTENT % $w_p$ — $w$ — $w_L$				
666.5'	Ground Level															
0.0'																
						660										
						650										
						640										
						630										
						620										
						610										
	End of Cone Test					600										

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 6

FOUNDATION SECTION

JOB 71-11021

LOCATION Co-ords. 672,699 N; 799,266 E.

ORIGINATED BY H.S.

W.P. 70-68-05

BORING DATE April 13-14, 1971

COMPILED BY A.K.B.

DATUM Geodetic

BOREHOLE TYPE Auger &amp; Washboring

CHECKED BY

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — $w_L$ PLASTIC LIMIT — $w_p$ WATER CONTENT — $w$			BULK DENSITY $\gamma$ P.C.F.	REMARKS GR. SA. SI. CL.
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	SHEAR STRENGTH P.S.F.					WATER CONTENT % $w_p$ — $w$ — $w_L$			
								20	40	60	80	100			
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE							
								1000 2000							
664.4'	Ground Level														
0.0'	Sandy Silt to Sand with some Gravel & Clay		1	SS	20	660									0 25 60 15
	Compact		2	SS	10										
	Brown		3	SS	12	650									2 86 12
645.4'			4	SS	-										
19.0'	Irregularly Stratified Silts, Clayey Silts & Silty Clays, Occasional thin Seams of Fine Sand.		5	SS	9	640									0 0 92 8
	Stiff to very Stiff.		6	TW	PM										122
	Brown & Grey		7	SS	9	630									124.5
			8	TW	PM										124
			9	SS	18	620									
			10	TW	PM										
			11	SS	9	610									
			13	SS	32										
			14	SS	15	600									
64.0'	Clayey Silt to Silt with some Sand & Traces of Gravel (Glacial Till)		15	SS	36	590									14 44 32 10
	Hard		16	SS	-										
	Greyish Brown		18	SS	101										1 78 23
			19	SS	117	580									0 19 66 15
			20	SS	63										
			21	SS	66										
570.4'	Probable Bedrock														
94.0'	End of Borehole														

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 7

FOUNDATION SECTION

JOB 71-11021

LOCATION Co-ords. 672,623 N; 799,298 E.

ORIGINATED BY H.S.

W.P. 70-68-05

BORING DATE April 16, 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 $\gamma$ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		20	40	60	80	100	$w_p$	$w$	$w_L$		
664.3'	Ground Level															
0.0'	Silty Sand to Sandy Silt Compact Brown		1	SS	20	660										0 90 10
			2	SS	11											
			3	SS	24	650										
646.3'			4	SS	12											
18.0'	Irregularly Stratified Silts & Clayey Silts Occasional thin Seams of Sand Stiff to very Stiff Brownish Grey		5	TW	PM	640										0 15 79 6
			6	SS	13											
			7	TW	PM	630										127 124
			8	SS	18											
			9	TW	PM	620										125
			10	SS	14											
			11	TW	PM	610										131
610.3'			12	SS	33											11 18 62 9
54.0'	Sandy Silt to Silty Sand with some Gravel & Traces of Clay Becoming Clayey Silt with Traces of Sand & Gravel (Glacial Till) Dense & Hard		13	SS	34	600										1 91 8
			14	SS	17											
			15	SS	39	590										
			16	SS	49											
			17	SS	76	580										0 4 72 24
			18	SS	95											
			19	SS	100/5"											
570.3'	Probable Bedrock															
94.0'	End of Borehole															

20  
15-5 % STRAIN AT FAILURE  
10

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 8

FOUNDATION SECTION

JOB 71-11021

LOCATION Co-ords. 672,580 N; 799,328 E.

ORIGINATED BY H.S.

W.P. 70-68-05

BORING DATE April 14-15, 1971

COMPILED BY A.K.B.

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 $\gamma$ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		20	40	60	80	100	$w_p$	$w$	$w_L$		
665.6'	Ground Level															
0.0'	Silty Sand to Gravelly Sand (Fill?)		1	SS	16	660										
			2	SS	16											
	Compact		3	SS	14											
647.6'	Brown		4	SS	35	650										18 72 10
			5	SS	23											
18.0'	Irregularly Stratified Silts, Clayey Silts & Silty Clays		6	SS	11											
	Stiff to very Stiff.		7	TW	PM	640										
			8	SS	18											
	Grey & Brown		9	SS	10	630										
			10	TW	PM											
			11	SS	16	620										0 1 77 22
			12	TW	22											
			13	SS	12	610										
			14	TW	PM											
600.6'			15	SS	11	600										6 57 28 9
65.0'	Silty Sands to Silts with Traces of Clay & Gravel. (Glacial Till)		16	SS	26											
	Compact to v. dense & hard		17	TW	PM	590										
			18	SS	47											
			19	SS	57	580										5 9 80 6
576.6'	Probable Bedrock		20	SS	100/1"											
89.0'	End of Borehole															

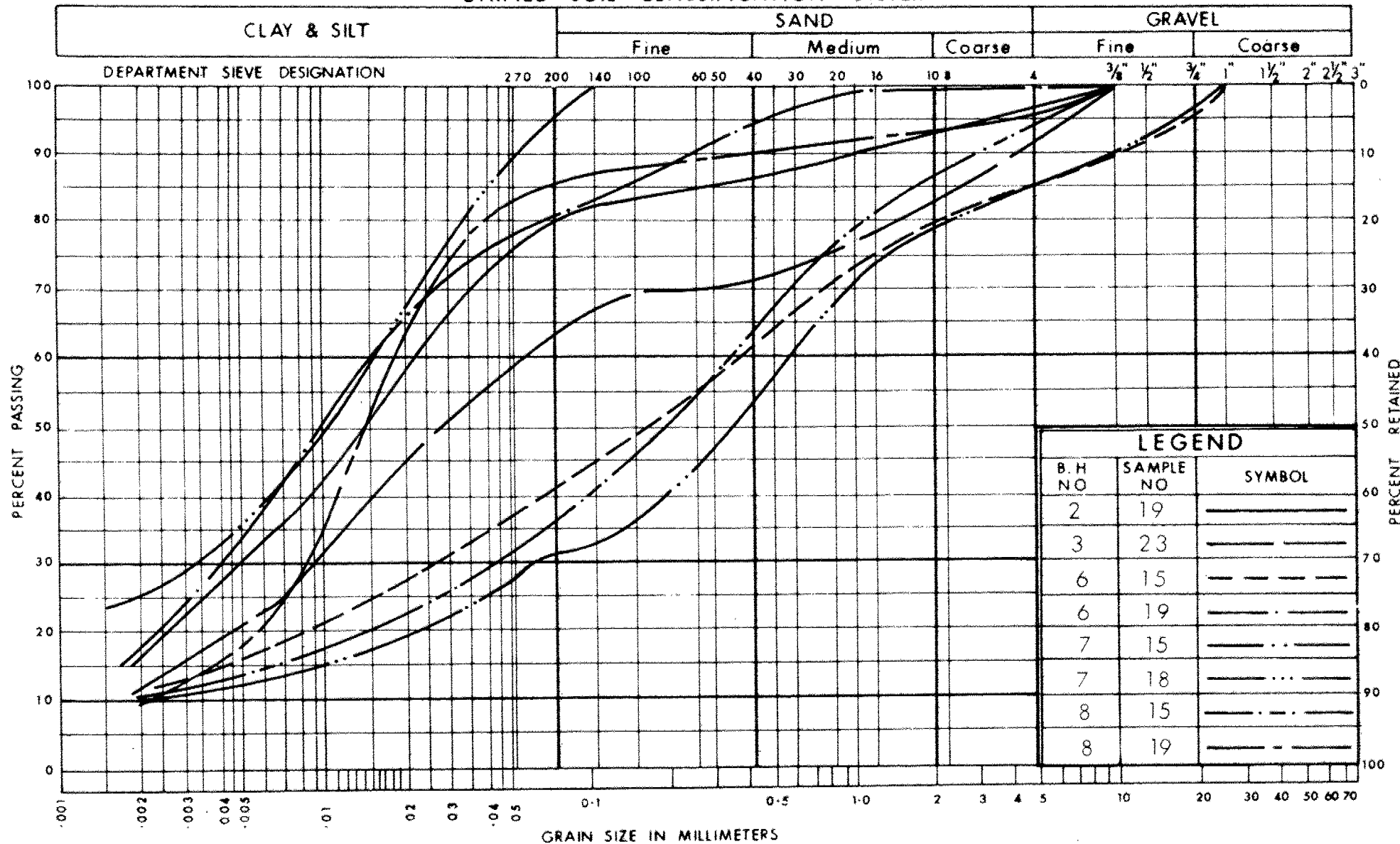
20  
15-5 % STRAIN AT FAILURE  
10



DEPARTMENT OF HIGHWAYS- ONTARIO		RECORD OF BOREHOLE No. 9		FOUNDATION SECTION	
MATERIALS & TESTING OFFICE					
JOB 71-11021	LOCATION Co-ords. 672,598 N; 799,235 E.	ORIGINATED BY H.S.			
W.P. 70-68-05	BORING DATE April 16, 1971	COMPILED BY A.K.B.			
DATUM Geodetic	BOREHOLE TYPE Dynamic Cone Penetration Only	CHECKED BY			

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE				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 P.S.F.				WATER CONTENT %				
662.0'	Ground Level														
0.0'						660									
						650									
						640									
						630									
						620									
						610									
	End of Cone Test					600									

# UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION

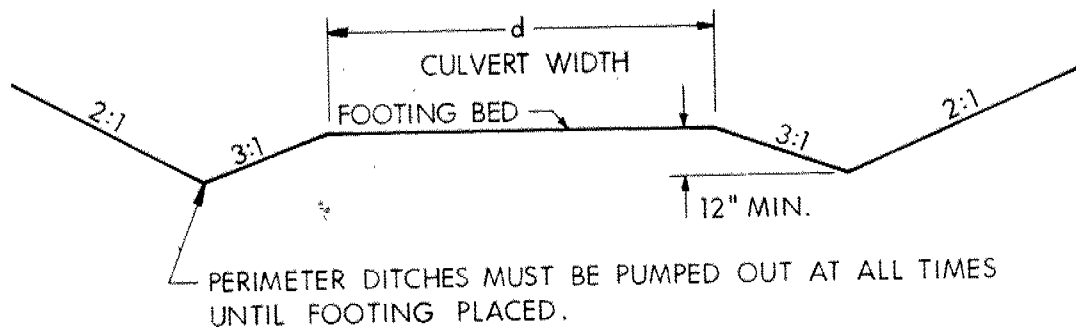
GRAIN SIZE DISTRIBUTION  
SILT CLAYEY SILT & SANDY SILT

W.P. No. 70-68-05

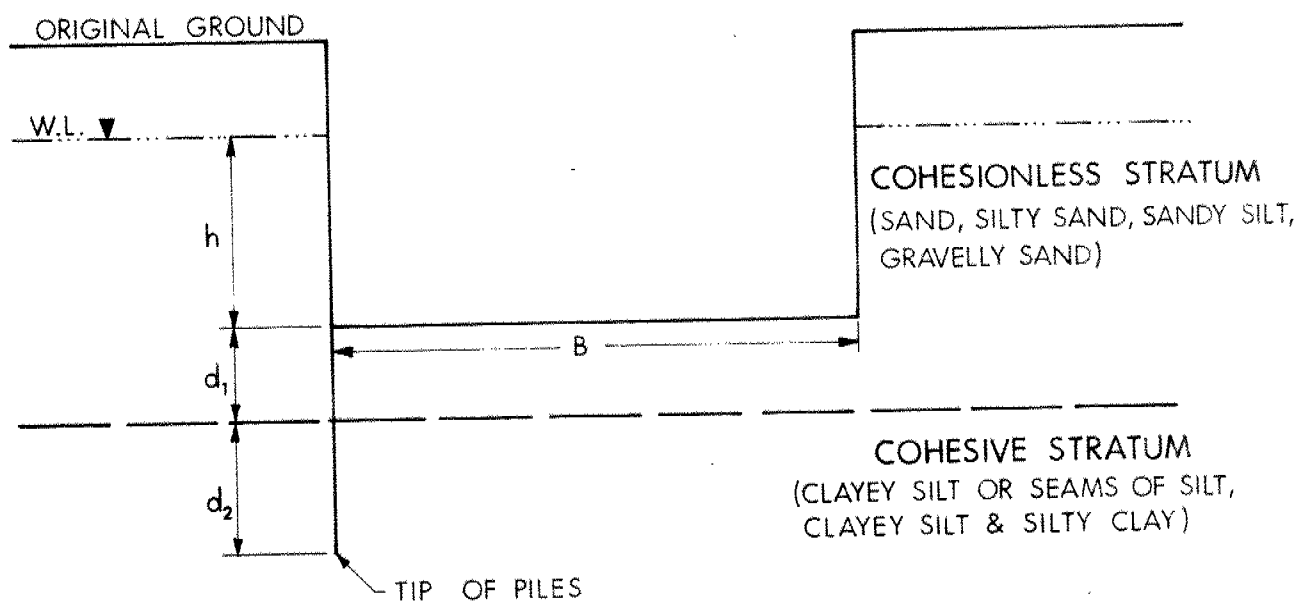
JOB No. 71-11021

FIG. NO. 1





PROPOSED OVERSIZE EXCAVATION  
FIG. 2



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

WHERE

- FS = FACTOR OF SAFETY. SHOULD BE EQUAL TO OR GREATER THAN 1.
- $\gamma$  = BULK DENSITY OF SOIL. USE 125 PCF.
- $C_{ADH}$  = ADHESION BETWEEN PILE AND SOIL. USE 800 PSF.
- $\gamma_w$  = DENSITY OF WATER (62.4 PCF)

FORMULA SUGGESTED FOR THE RESTRICTION OF SHEET PILE LENGTHS

FIG. 3

71-11021

## 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

$\gamma$	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
$\phi'$	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
$\log_e \sigma$ OR $\ln \sigma$	NATURAL LOGARITHM OF $\sigma$
$\log_{10} \sigma$ OR $\log \sigma$	LOGARITHM OF $\sigma$ 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
$\sigma'$	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

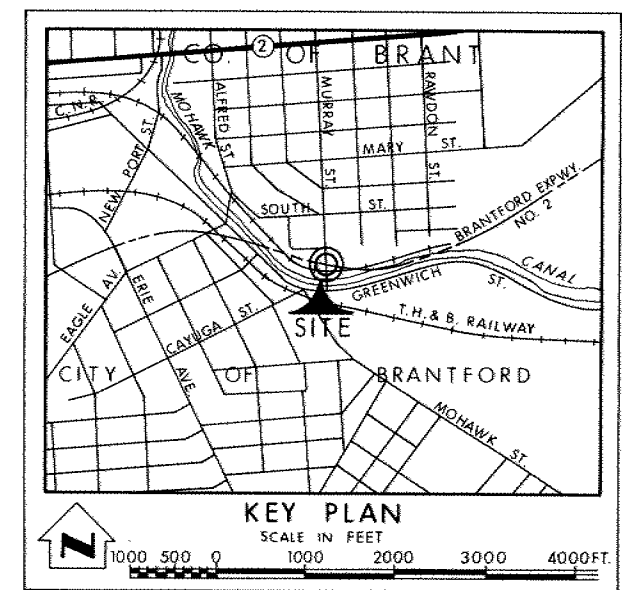
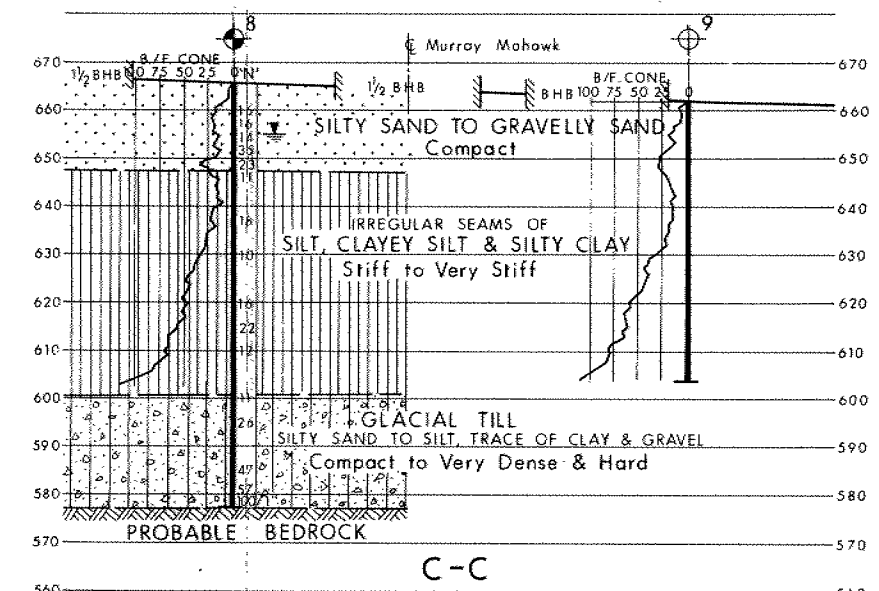
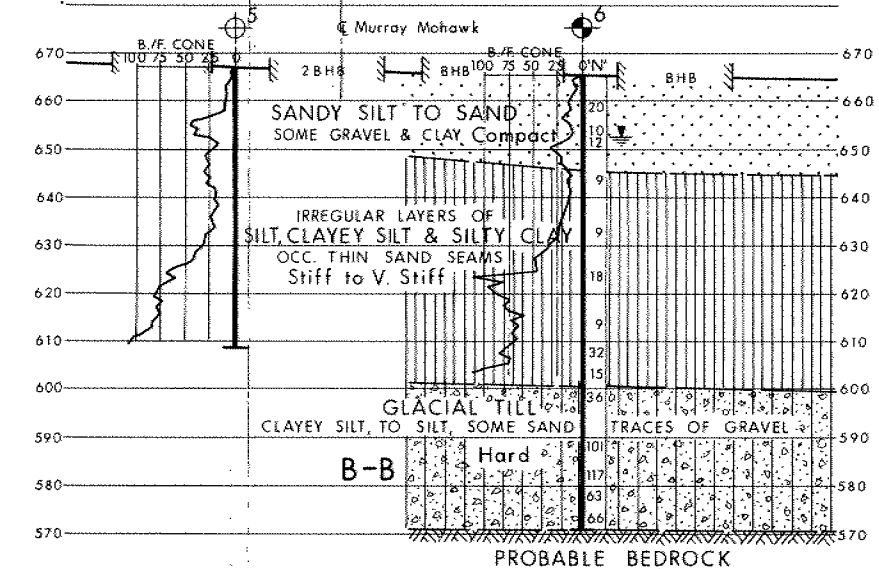
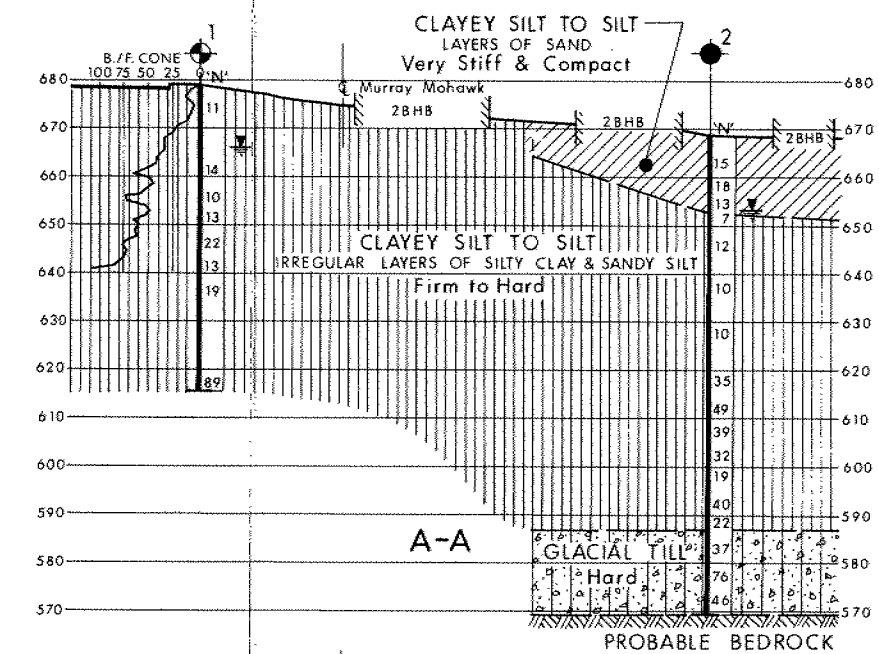
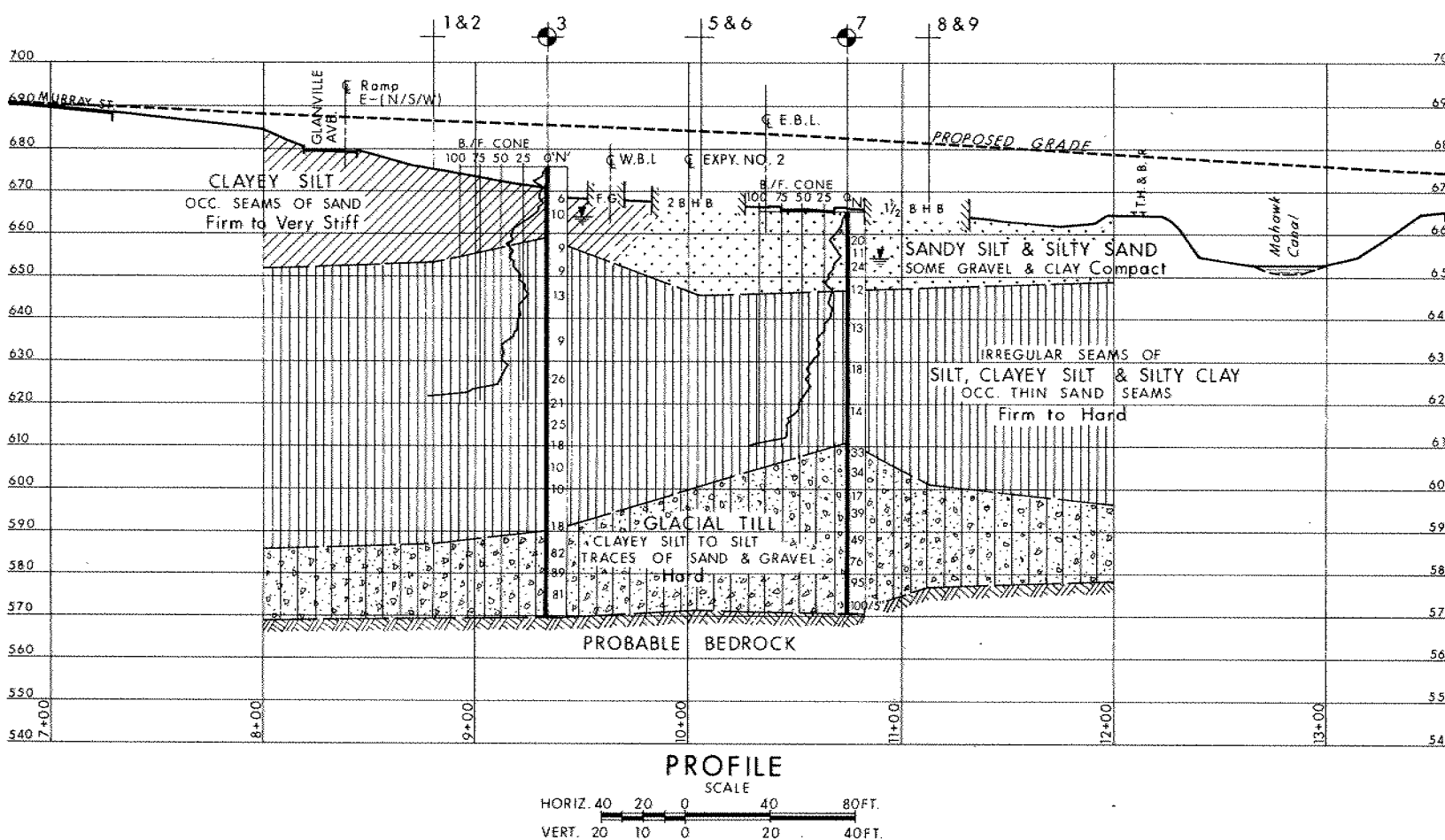
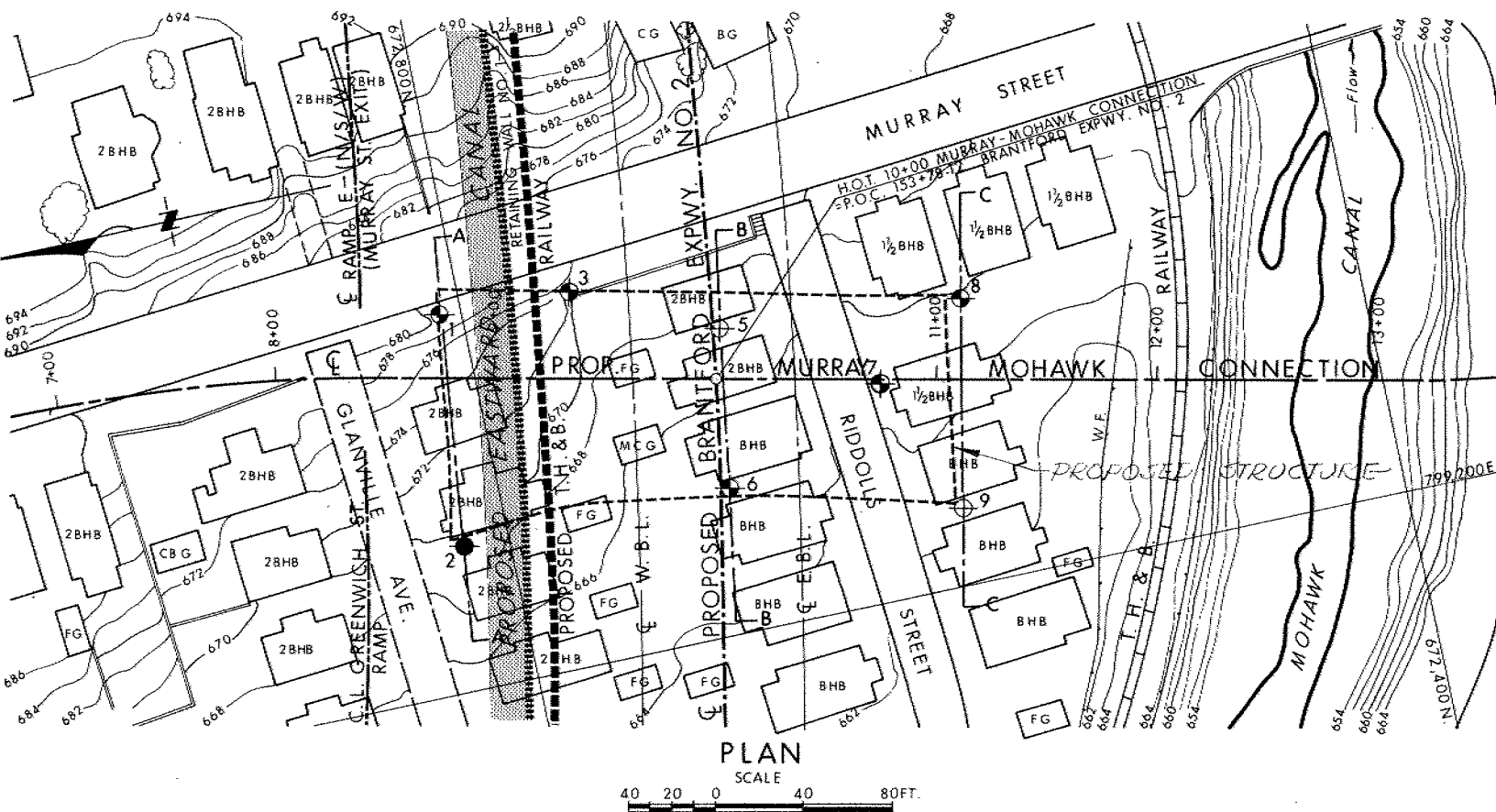
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
$\delta$	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
$K_0$	COEFFICIENT OF EARTH PRESSURE AT REST

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



LEGEND			
	Bore Hole		
	Cone Penetration Test		
	Bore Hole & Cone Test		
	Water Levels established at time of field investigation. APRIL, 1971		
NO.	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	679.6	672,810	799,370
2	668.5	672,821	799,264
3	675.7	672,752	799,368
5	666.5	672,689	799,338
6	664.4	672,699	799,266
7	664.3	672,623	799,298
8	665.6	672,580	799,328
9	662.0	672,598	799,235

**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.

REVISIONS	DATE	BY	DESCRIPTION

DEPARTMENT OF TRANSPORTATION & COMMUNICATIONS  
DESIGN SERVICES BRANCH — FOUNDATION SECTION

**STRUCTURE 6**  
**MURRAY MOHAWK CONNECTION**

HIGHWAY NO. BRANTFORD EXPWY. NO. 2 DIST. NO. 4  
CO. BRANT CITY OF BRANTFORD  
TWP. LOT. CON.

**BORE HOLE LOCATIONS & SOIL STRATA**

SUBWD A.B. CHECKED	W.P. NO. 70-68-05	DRAWING NO.
DRAWN BY CHECKED	JOB NO. 71-11021	71-11021A
DATE June 29, 1971	SITE NO.	BRIDGE DRAWING NO.
APPROVED	CONT. NO.	

PRINCIPAL FOUNDATION ENGINEER