

ONTARIO DEPARTMENT OF HIGHWAYS
Toronto, Ontario

REPORT

on

FOUNDATION INVESTIGATION

PROPOSED CROSSING
HIGHWAY 401 AND FLEMING CREEK
TOWNSHIP OF ALDBOROUGH, DISTRICT NO. 2
BRIDGE NO. 12
WP 289-59

H.G. ACRES & COMPANY LIMITED
Consulting Engineers
Niagara Falls, Canada

July, 1960

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Toronto, Ontario

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TOWNSHIP OF ALDEBOROUGH, DISTRICT NO. 2
BRIDGE NO. 12
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Introduction

The present plans for Highway 401 require the construction of a bridge to carry Highway 401 over Fleming Creek, approximately one mile northwest of Rodney, Ontario. As shown on Plate I, it has been proposed that Fleming Creek be diverted in order to reduce the bridge skew angle to 25 degrees. The bridge approach embankments will be built to an average height of 10 feet above the existing ground surface.

The F.E. Johnston Drilling Company Limited was retained to perform the soil drilling and field sampling, and Mr. J.A. MacLeod and Mr. P. Jorgensen of H.G. Acres & Company Limited supervised this work.

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Field work commenced on March 22, and was discontinued due to wet ground on March 26. Drilling was resumed on July 5, and completed on July 7, 1960.

The results of the field and laboratory work are contained in the following report:

Exploratory Work

The exploratory work consisted of drilling and sampling six holes and driving one penetration cone. Hole No. 870-1 was drilled to a depth of 100 feet. Holes Nos. 870-3 to 870-7 inclusive were drilled to average depths of 50 feet. The locations of all holes are shown on Plate I.

The drilling was performed by a Penndrill power auger. Samples of clay were obtained with 2-inch diameter thin-walled tubes, and a 2-inch diameter split-spoon sampler was used where sandy or extremely stiff soil was encountered.

The program of work is briefly outlined in Appendix A, and the drilling reports are given on Plates II to VIII inclusive.

Site Conditions and Soil Properties

The site of the proposed bridge is located in a valley which has been cut into the flat countryside by the meandering Fleming Creek. The bottom of

- 3. -

the valley is relatively level at elevation 684 feet while the elevation of the surrounding country is between 700 and 710 feet. The bottom of the creek-bed is at elevation 680 feet. During the initial period of field work the creek was flowing full and actually flooded above elevation 684 feet.

The soil encountered in the exploratory work is a clay till similar to that found at the sites of the following nearby projects:

WP 94-59

WP 97-59

WP 95-59

WP 99-59

The fill is described in the attached drilling reports, Plates II to VIII inclusive, and the soil stratigraphy, which is shown on Plate I, can be seen to consist of clay till to a depth of at least 100 feet.

(a) - Clay Till - To a depth of 10 feet the clay was found to be remarkably uniform. The average liquid limit is 31 per cent and the average plastic limit is 16 per cent. The natural water content varies between 17 and 20 per cent, with an average value of approximately 18 per cent.

The clay was found to be very stiff, as evidenced by the fact that the field vane was unable

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to fail the soil in shear; the limit of the vane equipment corresponds to a soil shear strength of 1.25 tons per square foot. The average natural undrained shear strength determined from laboratory compression tests is generally greater than 1.4 tons per square foot to a depth of at least 40 feet below the ground surface. The results of the laboratory tests are summarized in Appendix B and these data are shown graphically on Plate XII.

The results of three consolidation tests are shown on Plates IX to XI inclusive, and these results are compared on Plate XIII. The clay appears to be normally consolidated or lightly overconsolidated, but this conclusion on the consolidation history of the samples is subject to considerable doubt because the degrees of curvature of the compressibility curves are small and the graphical prediction of the preconsolidation pressures is consequently very difficult. No consolidation tests on samples obtained from above elevation 690 feet were performed because the soil was extremely stiff and, therefore, effectively incompressible.

(b) - Groundwater Conditions - Groundwater levels were found from 2 to 5 feet below the ground

- 5 -

surface. In the vicinity of the creek the groundwater level was the same as the water level in the creek.

Design Considerations

(a) - Bearing Capacity

Bridge Foundations - The soil at the bridge site is stiff and relatively incompressible. The most practical foundation type for the bridge is, therefore, spread footings; to calculate the allowable bearing pressures the following data were used:

Safety factor against ultimate failure equal to 3;

Average value of undrained shear strength equal to 1.40 tsf; and

Bearing capacity factor N_c equal to 6.0.

In view of the conservative value for shear strength which has been chosen, it is considered justifiable to use a constant N_c value when considering footings of different widths and depths. For centrally-loaded footings, located at depths equal to 3 and 6 feet, the allowable total bearing pressures " q_a " are equal to 3.0 and 3.2 tons per square foot respectively. For centrally-loaded footings which are subjected to horizontal forces, the allowable total bearing pressure must be reduced by the factor $\frac{1}{1 + 1.4}$,

where α is the inclination of the resultant of the net vertical load and the horizontal load*. These calculations are summarized on Plate XIV.

For eccentrically-loaded footings the width of the footing is reduced for purposes of calculations to an effective width which is equal to twice the shortest distance from the edge of the footing to the point of intersection of the resultant applied force and the base of the footing, as shown on Plate XIV. The allowable total bearing pressure, " q_a ", given on Plate XIV, is then used as an allowable average bearing pressure over the effective width of the eccentrically loaded footing \bar{B} .

Embankment - The maximum bearing pressure of the embankment on the foundation is approximately 0.8 tons per square foot. The average undrained shear strength of the subsoil is greater than 1.4 tons per square foot and, therefore, the safety factor against ultimate foundation failure due to embankment loading is greater than 6.

(b) - Settlement - The settlement of the bridge abutments will be influenced by the direct

* Reference: Veiledning ved løsning av
fundamenteringsoppgaver by
N. Janbu, L. Bjerrum and B. Kjaernsli.
Norwegian Geotechnical Institute
Publication No. 16, 1956.

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loads of the bridge and by the loads of the approach embankments. Although the stresses transferred to the soil at the bases of the bridge abutments are much larger than those due to the embankments, the areas on which the bridge loads are applied are small and, therefore, these stresses quickly dissipate with depth below the footings. To make a prediction of possible settlement of the bridge footings, it has been assumed that the bridge abutments will settle the same amount as a strip loading which has a width equal to that of the approach embankments and which applies a pressure of 1.5 tons per square foot to the subsoil. This is considered to be a liberal estimate of the loading conditions. No consideration has been taken of the skewness of the bridge as it is only 25 degrees, and because the expected foundation settlements are small.

The consolidation characteristics of the clay till are shown on Plates IX to XI inclusive and are compared on Plate XIII. To estimate the elastic settlements, an apparent modulus of elasticity, E , equal to 200 tons per square foot, was chosen. The depth of compressible subsoil was assumed to be 100 feet.

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The calculated settlements are as follows:

Elastic settlement	0.1 feet
Consolidation settlement	0.2 feet
Total ultimate settlement	0.3 feet

Most of the elastic settlement will occur during the period of construction of the bridge and embankment, and the time taken for 50 per cent of the total ultimate settlement to take place is estimated to be 10 years.

Conclusions

(a) - On the basis of the drilling done at the site, the general soil profile consists of homogeneous clay till to a depth of at least 100 feet. The groundwater surface is located from 2 to 5 feet below the ground surface.

(b) - The soils are stiff and relatively incompressible. Their properties are summarized on Plates XII and XIII.

(c) - The 12-foot high embankments approaching the bridge can be safely supported on the natural soils at the site. The ultimate expected settlements are less than 0.3 feet.

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(d) - Allowable total bearing pressures from 2 to 3 tons per square foot can be used for design of the bridge footings, depending upon the inclination of the resultant applied load. For eccentrically loaded footings, the width of the footing must be reduced for purposes of calculation as outlined previously in this report. A summary of the bearing capacity calculations is given on Plate XIV.

(e) - The maximum ultimate settlement of the bridge abutments has been estimated to be 0.3 feet and 50 per cent of this settlement is expected to take place within 10 years.

Recommendations

It is recommended that the bridge be supported on spread footings. Allowable bearing pressures are given on Plate XIV.

APPENDIX AProgram of Work

- March 23, 1960 - Penndrill arrived at the site and drilling of hole No. 870-1 was commenced.
- March 25, 1960 - Hole No. 870-1 was completed to a depth of 100 feet.
- March 26, 1960 - Hole No. 870-2 (cone penetration test) was completed to a depth of 17 feet. Site abandoned due to flooding by Fleming Creek.
- July 5, 1960 - Hole No. 870-3 was completed to a depth of 41 feet.
- July 6, 1960 - Holes Nos. 870-4 and 870-5 were completed to average depths of 50 feet. Hole No. 870-6 was started.
- July 7, 1960 - Holes Nos. 870-6 and 870-7 were completed to average depths of 53 feet.

Summary of Time

Work Type	No. of Holes	Total Length Feet	Total Time Days
Soil Drilling and Sampling	6	350	6-1/2
Cone Penetration Tests	1	17	1/2

APPENDIX BSummary of Laboratory Tests

Hole No.	Sample No.	Elevation Feet	Water Content %	Liquid Limit %	Plastic Limit %	Su _n Tsf	e _f %	Su _r Tsf	St
870-1	2	674	18.2	-	-	1.54	20	-	--
	3	669	17.3	30.1	15.6	1.66	20	-	--
	4	654	17.9	31.3	15.8	1.43	20	1.35	1.1
	7	639	18.2	30.9	16.1	1.40	20	1.11	1.3
	9	614	18.8	31.4	16.8	1.26	20	0.97	1.3
	11	594	19.6	33.3	17.4	1.18	20	0.82	1.4
870-3	2	675	18.8	-	-	1.37	20	1.08	1.3
	4	665	18.4	-	-	1.88	20	0.87	2.2
	6	645	18.2	-	-	1.50	20	0.89	1.7
870-5	2	690	17.0	-	-	2.22	20	-	-
	3	680	17.6	-	-	2.04	20	-	-
	4	670	17.2	-	-	2.26	20	-	-
870-7	1	671	17.5	-	-	1.48	20	-	-
	2	661	18.7	-	-	1.05	20	-	-
	3	636	18.1	-	-	-	-	-	-

e_f - Failure StrainSu_r - Remoulded undrained shear strengthSu_n - Natural undrained shear strength

St - Sensitivity

APPENDIX C

List of Plates

- Plate I - Exploratory Holes, Plan and Section.
- Plate II - Drilling Report, Hole No. 870-1.
- Plate III - Drilling Report, Hole No. 870-2.
- Plate IV - Drilling Report, Hole No. 870-3.
- Plate V - Drilling Report, Hole No. 870-4.
- Plate VI - Drilling Report, Hole No. 870-5.
- Plate VII - Drilling Report, Hole No. 870-6.
- Plate VIII - Drilling Report, Hole No. 870-7.
- Plate IX - Consolidation Test, Hole No. 870-1,
Sample Elevation 654 feet.
- Plate X - Consolidation Test, Hole No. 870-1,
Sample Elevation 639 feet.
- Plate XI - Consolidation Test, Hole No. 870-1,
Sample Elevation 614 feet.
- Plate XII - Summary of Drilling and Test Results
Comparison of All Tests.
- Plate XIII - Consolidation Test - Comparison
of All Tests.
- Plate XIV - Allowable Total Bearing Pressures
for Strip Footings.

H. G. ACRES & COMPANY LIMITED — CONSULTING ENGINEERS
 NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Ontario Department of Highways

JOB No. 870

PROJECT Highway 401, Fleming Creek Bridge (WP-289-59)

HOLE No. 870-1

SITE Township of Aldborough, Lot 1, Ontario

SHEET No. 1 OF 2

CONTRACTOR: F.E. Johnston Drilling
 Company Limited

STARTED 1:00 P.M. March 23, 1960
 FINISHED 5:30 P.M. March 25, 1960

METHOD SOIL Penndrill 4" Auger

CASING DIAM.

OF
 DRILLING:

ROCK

CORE DIAM.

LOCATION: LATITUDE 43° 53' 49.5"
 DEPARTURE 45' Left
 BEARING
 INITIAL DIP 90 Degrees
 OTHER DIPS

ELEVATIONS: DATUM G.S.C.
 DRILL PLATFORM
 GROUND SURFACE 684.0
 ROCK SURFACE
 BOTTOM OF HOLE 584.0
 WATER TABLE 681.5

DEPTH	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE					PENETRATION TEST See Plate II
			NO.	TYPE *	SIZE	DEPTH	RET'D	
					Inches	Feet	Inches	Blows
0.0	Clay till	Brown and grey, moist, stiff with scattered pebbles which are partially rounded and composed of black shale and limestone	1	BO	1-7/8	5.0		
						5.5		6
						6.0		15
						6.5	13	22
5.0	Clay till	Grey, firm, moist, very stiff and tenacious with scattered pebbles 1/16" to 1/4"	2	BO	1-7/8	10.0		
						10.5		6
						11.0		14
						11.5	12	24
100.0		End of hole						
			3	BO	1-7/8	15.0		
						15.5		6
						16.0		15
						16.5		21
						17.0	13	25
				BZ	1-7/8	20.0		
						20.5		6
						21.0		14
						21.5	0	19
			4	BO	1-7/8	30.0		
						30.5		7
						31.0		13
						31.5	15	19

SAMPLING METHOD

* A — SPLIT TUBE
 B — THIN WALL TUBE
 C — PISTON SAMPLER
 D — CORE BARREL

E — AUGER
 F — WASH

SHIPPING CONTAINER

N — IN. T
 O — TUBE
 P — WATER CONTENT TIN
 Q — GLASS JAR

R — CLOTH BAG
 S — PLIOfILM BAG
 Z — DISCARDED

INSPECTOR J. MacLeod

APPROVED

D. H. Macdonald

LOGGED BY J. MacLeod

DATE July, 1960

H. G. ACRES & COMPANY LIMITED - CONSULTING ENGINEERS
 NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Ontario Department of Highways
 PROJECT Highway 401, Fleming Creek Bridge (WP-280-59)
 SITE Township of Aldborough, Lot 1, Ontario

JOB No. 870
 HOLE No. 870-1
 SHEET No. 2 OF 2

DEPTH	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTION, WATER LOSS OR GAIN, ETC.	SAMPLE					PENETRATION TEST
			NO	TYPE	SIZE	DEPTH	RET'D	
					Inches	Feet	Inches	Blows
			5	BO	1-7/8	35.0		
		<u>Note: * Penetration Test</u>				35.5		15
						36.0		23
		This is the number of				36.5	18	30
		blows of a 140-lb.						
		weight falling 30	6	BO	1-7/8	40.0		
		inches required to				40.5		10
		advance the sampler to				41.0		18
		distance indicated.				41.5		23
						42.0	21	30
			7	BO	1-7/8	45.0		
						45.5		9
						46.0		16
						46.5		23
						47.0	14	30
			8	BO	1-7/8	55.0		
						55.5		9
						56.0		15
						56.5		23
						57.0	18	31
				BZ	1-7/8	65.0		
						65.5		6
						66.0		16
						66.5		22
						67.0	0	29
			9	BO	2.0	70.0		
						70.5		14
						71.0		24
						71.5		30
						72.0	16	35
			10	BO	2.0	80.0		
						80.5		18
						81.0		28
						81.5	16	29
			11	BO	2.0	90.0		
						90.5		15
						91.0		25
						91.5	16	40
			12	BO	2.0	100.0		
						100.5		23
						101.0		40
						101.5	16	45

DRILLING REPORT

JOB No. 870

HOLE No. 870-2

SHEET No 1 OF 1

CONTRACTOR: F.E. Johnston Drilling STARTED 8:00 A.M. March 26, 1960

Company Limited..... FINISHED 11:00 A.M. March 26, 1960

METHOD	SOIL	D.H.O. Cone Penetration Test	CASING DIAM.
--------	------	------------------------------	--------------

OF
DRILLING: ROCK CORE DIAM.

LOCATION: LATITUDE CH. 537+00 ELEVATIONS: DATUM GSC

DEPARTURE 45' Left

ELEVATIONS: DATUM GSC
DRILL PLATFORM

BEARING

DRILL PLATFORM

BEARING

GROUND SURFACE 684.0

INITIAL DIP 90 Degrees

ROCK SURFACE

OTHER DIPS

BOTTOM OF HOLE 667.0

WATER TABLE	681.5
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DEPTH:	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	S A M P L E					PENETRATION TEST
			NO.	TYPE *	SIZE	DEPTH	RET'D	* Blows
						Feet		
						0		
						1		14
						2		4
						3		4
						4		4
						5		10
		<u>Note: D.H.O. Penetration Test</u>				6		14
						7		14
		This is the number of				8		15
		blows of a 140-lb.				9		35
		weight falling 30"				10		70
		required to advance				11		81
		the cone one foot.				12		92
						13		104
						14		130
						15		165
						16		192
						17		214

SAMPLING METHOD

* A — SPLIT TUBE
B — THIN WALL TUBE
C — PISTON SAMPLER
D — CORE BARREL

E - AUGER
F - WASH

E - AUGER
F - WASH

SHIPPING CONTAINER

N - INSERT
O - TUBE
P - WATER CONTENT TIN
Q - GLASS JAR

R - CLOTH BAG
S - PLIOFILM BAG
Z - DISCARDED

INSPECTOR J. MacLeod

APPROVED

D. H. MacDonald.

LOGGED BY J. MacLeod

DATE _____

July, 1960

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H. G. ACRES & COMPANY LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT	Ontario Department of Highways	JOB No.	870
PROJECT	Highway 401, Fleming Creek Bridge (WP 289-59)	HOLE No.	870-3
SITE	Township of Aldborough, Lot 1, Ontario	SHEET No.	1 OF 2
CONTRACTOR:	F.E. Johnston Drilling Company Limited	STARTED	2:00 P.M. July 5, 19 60
		FINISHED	5:30 P.M. July 5, 19 60
METHOD OF DRILLING:	SOIL Penndrill, 4-inch Auger	CASING DIAM.	
	ROCK	CORE DIAM.	
LOCATION:	LATITUDE Ch. 536+00	ELEVATIONS:	DATUM G.S.C.
	DEPARTURE 50 feet right		DRILL PLATFORM
	BEARING		GROUND SURFACE 684.8
	INITIAL DIP 90 degrees		ROCK SURFACE
	OTHER DIPS		BOTTOM OF HOLE 644.1
			WATER TABLE

DEPTH Feet	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE					PENETRATION TEST See Plate II
			NO.	TYPE	SIZE Inches	DEPTH Feet	RET'D Inches	
0.0	Clay till	Brown, weathered, silty containing angular pebbles, very stiff.	1	AQ	2	5.0		
						5.5		3
						6.0		6
						6.5	15	8
7.0	Clay till	Grey, moist, containing angular pebbles, very stiff.	2	BO	2	9.0		
						9.5		5
						10.0		8
						10.5	16	12
			3	BO	2	14.0		
						14.5		5
						15.0		9
						15.5	18	14
			4	BO	2	19.0		
						19.5		4
						20.0		6
						20.5		11
						20.75	21	7
			5	BO	2	29.0		
						29.5		7
						30.0		11
						30.5	18	17

SAMPLING METHOD

* A — SPLIT TUBE
 B — THIN WALL TUBE
 C — PISTON SAMPLER
 D — CORE BARREL

E — AUGER
 F — WASH

SHIPPING CONTAINER

N — INSERT
 O — TUBE
 P — WATER CONTENT TIN
 G — GLASS JAR

R — CLOTH BAG
 S — PLIOFILM BAG
 Z — DISCARDED

INSPECTOR P. Jorgensen

LOGGED BY P. Jorgensen

APPROVED *D. H. MacDonald*

DATE July, 1960

H. G. ACRES & COMPANY LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Ontario Department of Highways JOB No. 870

PROJECT Highway 401, Fleming Creek Bridge (WP 289-59) HOLE No. 870-4

SITE Township of Aldborough, Lot 1, Ontario SHEET No. 1 OF 2

CONTRACTOR: F.E. Johnston Drilling Company Limited STARTED 9:00 A.M. July 6, 19 60
 FINISHED 12:00 A.M. July 6, 19 60

METHOD OF DRILLING: SOIL Penndrill, 4-inch Auger CASING DIAM. _____
ROCK CORE DIAM. _____

LOCATION: LATITUDE Ch. 536+51 ELEVATIONS: DATUM G.S.C.
 DEPARTURE 45 feet left DRILL PLATFORM _____
 BEARING _____ GROUND SURFACE 685.1
 INITIAL DIP 90 degrees ROCK SURFACE _____
 OTHER DIPS _____ BOTTOM OF HOLE 634.5
 WATER TABLE _____

DEPTH Feet	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE					PENETRATION TEST See Plate II Blows
			NO	TYPE *	SIZE Inches	DEPTH Feet	RET'D Inches	
0.0	Clay till	Brown-grey, weathered, containing angular pebbles, very stiff.	1	BO	2	4.0 4.5 5.0 5.5 5.75	18	5 6 10 6
7.5	Clay till	Grey, containing angular pebbles, very stiff	2	BO	2	9.0 9.5 10.0 10.5 10.75	21	5 8 15 10
			3	BO	2	19.0 19.5 20.0 20.6	18	5 9 17
			4	BO	2	29.0 29.5 30.0 30.1	13	5 24 7

SAMPLING METHOD

* A — SPLIT TUBE
 B — THIN WALL TUBE
 C — PISTON SAMPLER
 D — CORE BARREL

E — AUGER
 F — WASH

SHIPPING CONTAINER

N — INSERT
 O — TUBE
 P — WATER CONTENT TIN
 Q — GLASS JAR

R — CLOTH BAG
 S — PLOFILM BAG
 Z — DISCARDED

INSPECTOR P. Jorgensen
 LOGGED BY P. Jorgensen

APPROVED D. H. MacDonald.
 DATE July, 1960

DRILLING REPORT

SHEET No. 2 OF 2

H. G. ACRES & COMPANY LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Ontario Department of Highways JOB No. 870

PROJECT Highway 401, Fleming Creek Bridge (WP 289-59) HOLE No. 870-5

SITE Township of Aldborough, Lot 1, Ontario SHEET No. 1 OF 2

CONTRACTOR: F.B. Johnston Drilling Company Limited STARTED 1:00 P.M. July 6, 19 60
 FINISHED 3:15 P.M. July 6, 19 60

METHOD OF DRILLING: SOIL Penndrill, 4-inch Auger CASING DIAM. _____
ROCK CORE DIAM. _____

LOCATION: LATITUDE Ch. 535+23 ELEVATIONS: DATUM G.S.C.
 DEPARTURE 7 feet left DRILL PLATFORM _____
 BEARING _____ GROUND SURFACE 700.6
 INITIAL DIP 90 degrees ROCK SURFACE _____
 OTHER DIPS _____ BOTTOM OF HOLE 649.9
 WATER TABLE _____

DEPTH Feet	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE					PENETRATION TEST See Plate II
			NO	TYPE*	SIZE Inches	DEPTH Feet	RET'D Inches	
0.0	Clay till	Brown, weathered, containing many angular pebbles, very stiff	1	AQ	2	4.0 4.5 5.0 5.5	18	5 12 16
7.0	Clay till	Grey, silty, containing angular pebbles, very stiff	2	BO	2	9.0 9.5 10.0 10.5	18	6 8 15
19.0	Clay till	Same as above, but more moist and tenacious.	3	BO	2	19.0 19.5 20.0 20.5 20.7	20	5 9 13 5
			4	BO	2	29.0 29.5 30.0 30.5 30.75	19	7 13 15 10
			5	BO	2	49.0 49.5 50.0		9 16

SAMPLING METHOD

* A — SPLIT TUBE
 B — THIN WALL TUBE
 C — PISTON SAMPLER
 D — CORE BARREL

E — AUGER
 F — WASH

SHIPPING CONTAINER

N — INSERT
 O — TUBE
 P — WATER CONTENT TIN
 Q — GLASS JAR

R — CLOTH BAG
 S — PLIOFILM BAG
 Z — DISCARDED

INSPECTOR P. Jorgensen

LOGGED BY P. Jorgensen

APPROVED

DATE

A. H. MacDonald

July, 1960

DRILLING REPORT

JOB No. 870

HOLE No. 870-5

SHEET No. 2 OF 2

[illegible]

H. G. ACRES & COMPANY LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT: Ontario Department of Highways JOB No. 870
 PROJECT: Highway 401, Fleming Creek Bridge (WP 289-59) HOLE No. 870-6
 SITE: Township of Aldborough, Lot 1, Ontario SHEET No. 1 OF 2

CONTRACTOR: F.E. Johnston Drilling Company Limited STARTED 4:30 P.M. July 6, 19 60
 FINISHED 11:00 A.M. July 7, 19 60

METHOD OF DRILLING: SOIL Penndrill, 4-inch Auger CASING DIAM.
 ROCK CORE DIAM.

LOCATION: LATITUDE Ch. 536+62 ELEVATIONS: DATUM G.S.C.
 DEPARTURE 39 feet right DRILL PLATFORM
 BEARING GROUND SURFACE 684.2
 INITIAL DIP 90 degrees ROCK SURFACE
 OTHER DIPS BOTTOM OF HOLE 633.2
 WATER TABLE 679.2

DEPTH Feet	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE					PENETRATION TEST See Plate II
			NO.	TYPE	SIZE Inches	DEPTH Feet	RETD Inches	
0.0	Clay till	Brown, containing loam, sand and pebbles.	1	AQ	2	4.0		
						4.5		2
						5.0		5
						5.5	3	9
7.5	Clay till	Grey, moist, and tenacious, containing angular pebbles, very stiff.	2	BO	2	9.0		
						9.5		6
						10.0		12
						10.5		16
						10.75	14	10
			3	BO	2	14.0		
						14.5		5
						15.0		12
						15.5		18
						15.75	13	10
			4	BO	2	24.0		
						24.5		5
						25.0		12
						25.5		16
						25.75	9	11

SAMPLING METHOD

* A — SPLIT TUBE
 B — THIN WALL TUBE
 C — PISTON SAMPLER
 D — CORE BARREL

E — AUGER
 F — WASH

SHIPPING CONTAINER

N — INSERT
 O — TUBE
 P — WATER CONTENT TIN
 Q — GLASS JAR

R — CLOTH BAG
 S — PLIOFILM BAG
 Z — DISCARDED

INSPECTOR: P. Jorgensen
 LOGGED BY: P. Jorgensen

APPROVED: *D. H. MacDonald*
 DATE: July, 1960

H. G. ACRES & COMPANY LIMITED — CONSULTING ENGINEERS
 NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Ontario Department of Highways

JOB No. 870

PROJECT Highway 401, Fleming Creek Bridge (WP 289-59)

HOLE No. 870-6

SITE Township of Aldborough, Lot 1, Ontario

SHEET No. 1 OF 2

DEPTH Feet	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTION, WATER LOSS OR GAIN, ETC.	S A M P L E					PENETRATION TEST	
			NO	TYPE	SIZE Inches	DEPTH Feet	RET'D Inches	Blows	
			5	BO	2	34.0			
						34.5			7
						35.0			13
						35.5			19
						35.75	12		10
			6	BO	2	49.0			
						49.5			8
						50.0			15
						50.5			23
51.0		End of hole.				51.0	14		28

H. G. ACRES & COMPANY LIMITED — CONSULTING ENGINEERS
NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Ontario Department of Highways JOB No. 870
 PROJECT Highway 401, Fleming Creek Bridge (WP 289-59) HOLE No. 370-7
 SITE Township of Aldborough, Lot 1, Ontario SHEET No. 1 OF 2
 CONTRACTOR: F.E. Johnston Drilling Company Limited STARTED 1:00 P.M. July 7 1960
 FINISHED 4:30 P.M. July 7 1960
 METHOD OF DRILLING: SOIL Perndrill, 4-Inch Auger CASING DIAM. _____
ROCK CORE DIAM. _____
 LOCATION LATITUDE Ch. 538+00 ELEVATIONS: DATUM _____ G.S.C. _____
 DEPARTURE 12 feet left DRILL PLATFORM _____
 BEARING _____ GROUND SURFACE 686.0
 INITIAL DIP 90 degrees ROCK SURFACE _____
 OTHER DIPS _____ BOTTOM OF HOLE 630.0
 WATER TABLE _____

DEPTH Feet	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE					PENETRATION TEST See Plate II Blows
			NO.	TYPE *	SIZE Inches	DEPTH Feet	RET'D Inches	
0.0	Sand	Brown sandy loam with some clay.						
3.0	Clay Till	Brown, sandy, containing bands of medium sand, wet.		AZ		4.0		
						4.5		4
						5.0		5
						5.5		5
8.0	Clay Till	Grey, moist, containing angular pebbles, very stiff		AZ		9.0		
						9.5		5
						10.0		8
						10.5	2	14
			1	BO		14.0		
						14.5		6
						15.0		11
						15.5		15
						15.75	11	11
			2	BO		24.0		
						24.5		6
						25.0		14
						25.5		16
						25.75	11	9

SAMPLING METHOD

* A — SPLIT TUBE
 B — THIN WALL TUBE
 C — PISTON SAMPLER
 D — CORE BARREL

E — AUGER
 F — WASH

SHIPPING CONTAINER

N — INSERT
 O — TUBE
 P — WATER CONTENT TIN
 Q — GLASS JAR

R — CLOTH BAG
 S — PLIOFILM BAG
 Z — DISCARDED

INSPECTOR P. Jorgensen

LOGGED BY P. Jorgensen

APPROVED

D. H. MacDonald

DATE

July, 1960

SK-870-LS-10A

PLATE VIII A

H. G. ACRES & COMPANY LIMITED — CONSULTING ENGINEERS
 NIAGARA FALLS, CANADA

DRILLING REPORT

CLIENT Ontario Department of Highways

JOB No. 870

PROJECT Highway 401, Fleming Creek Bridge (WP 289-59)

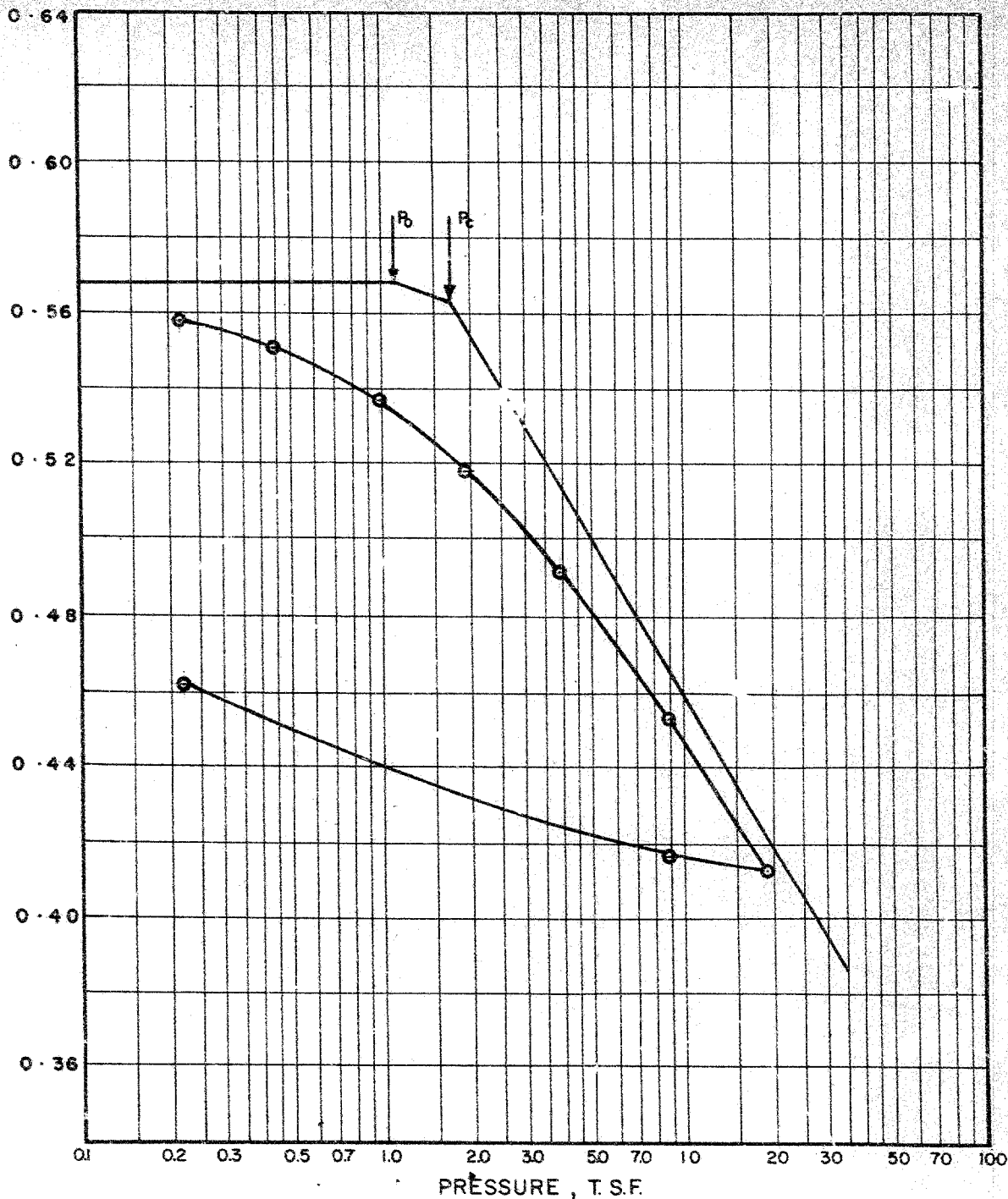
HOLE No. 870-7

SITE Township of Aldborough, Lot 1, Ontario

SHEET No. 2 OF 2

DEPTH Feet	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTION, WATER LOSS OR GAIN, ETC.	S A M P L E					PENETRATION TEST Blows
			NO	TYPE	SIZE Inches	PTH feet	RET'D Inches	
				BZ	2	34.0		
						34.5		8
						35.0		14
						35.5		20
						36.0	0	25
				BZ	2	39.0		
						39.5		8
						40.0		15
						40.5	0	24
				AZ	2	40.0		
						40.5		5
						41.0	5	10
			3	30	2	49.0		
						49.5		10
						50.0		15
						50.5		20
						50.75	5	16
				BZ	2	54.0		
						54.5		10
						55.0		17
						55.5		23
56.0		End of hole.				56.0	0	24

VOID RATIO



OVERBURDEN PRESSURE -- $P_0 = 1.1$ TSF
 CONSOLIDATION PRESSURE -- $P_c = 1.7$ TSF

NATURAL WATER CONTENT = 18.50 %
 LOADING INTERVAL - 25 MIN.

SAMPLE No. 870 - 80 - 4

TEST DATE APRIL 5, 1960

TEST No. 870 - 9 - 1

TESTED BY R. G.

H. G. ACRES & COMPANY LIMITED
 CONSULTING ENGINEERS
 NIAGARA FALLS CANADA

CONSOLIDATION TEST

HOLE No. 870 - 1 SAMPLE ELEV. 654'

DEPARTMENT OF HIGHWAYS OF ONTARIO

APPROVED

DATE: JULY, 1960

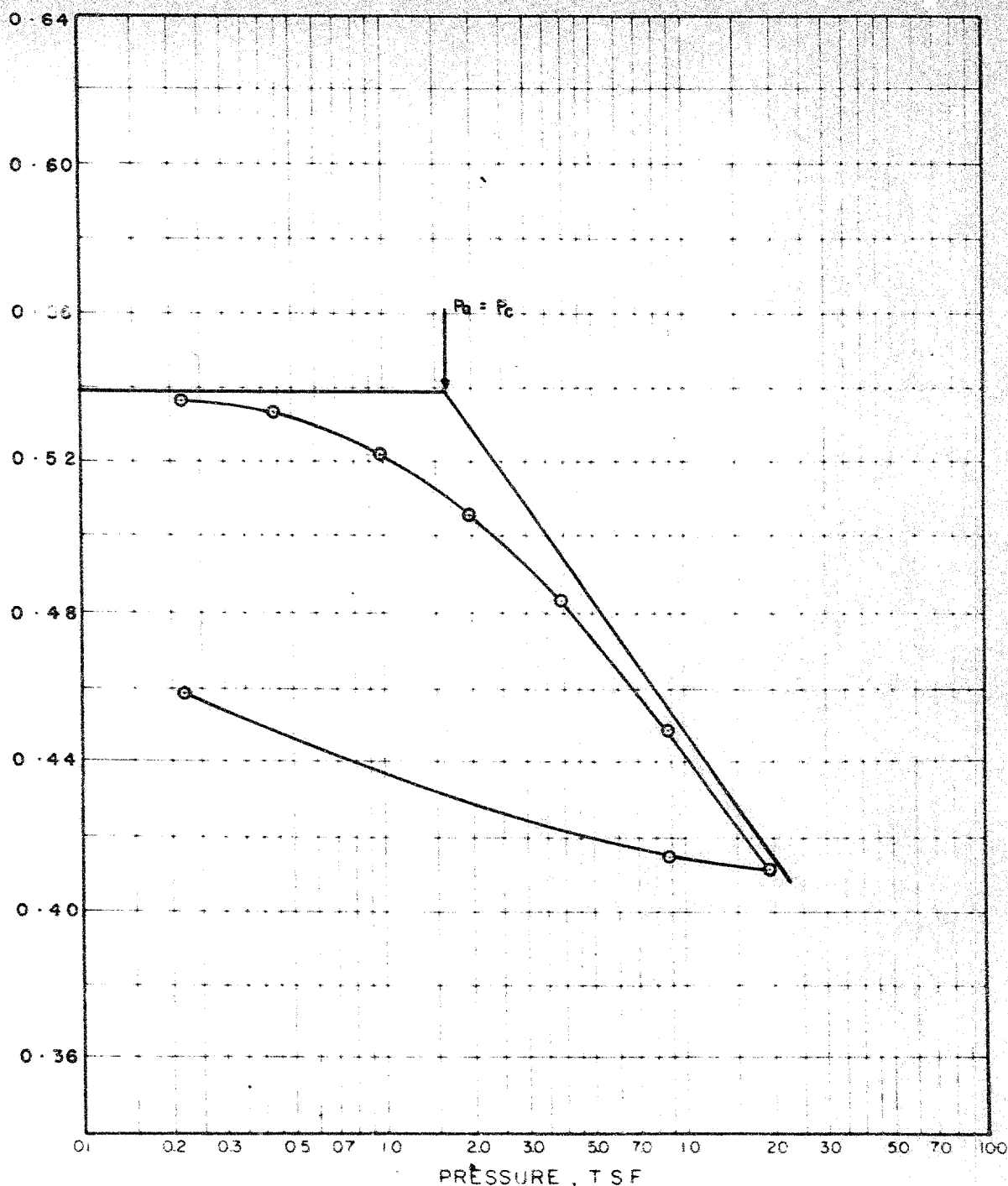
HWY. 401, FLEMING CREEK BRIDGE (WP - 289-59)

H.G. ACRES & COMPANY LTD.

JOB No. 870

PLATE IX

VOID RATIO



OVERBURDEN PRESSURE - $P_0 = 1.6$ TSF
 CONSOLIDATION PRESSURE - $P_c = 1.6$ TSF

NATURAL WATER CONTENT = 19.10 %
 LOADING INTERVAL - 25 MIN.

SAMPLE No 870 - B0 - 7
 TEST No 870 - 9 - 3

TEST DATE APRIL 5, 1960
 TESTED BY R. G.

H G ACRES & COMPANY LIMITED
 CONSULTING ENGINEERS
 NIAGARA FALLS CANADA

DEPARTMENT OF HIGHWAYS OF ONTARIO

HWY. 401, FLEMING CREEK BRIDGE (WP-289-59)

CONSOLIDATION TEST

HOLE No 870-1 SAMPLE ELEV 639'

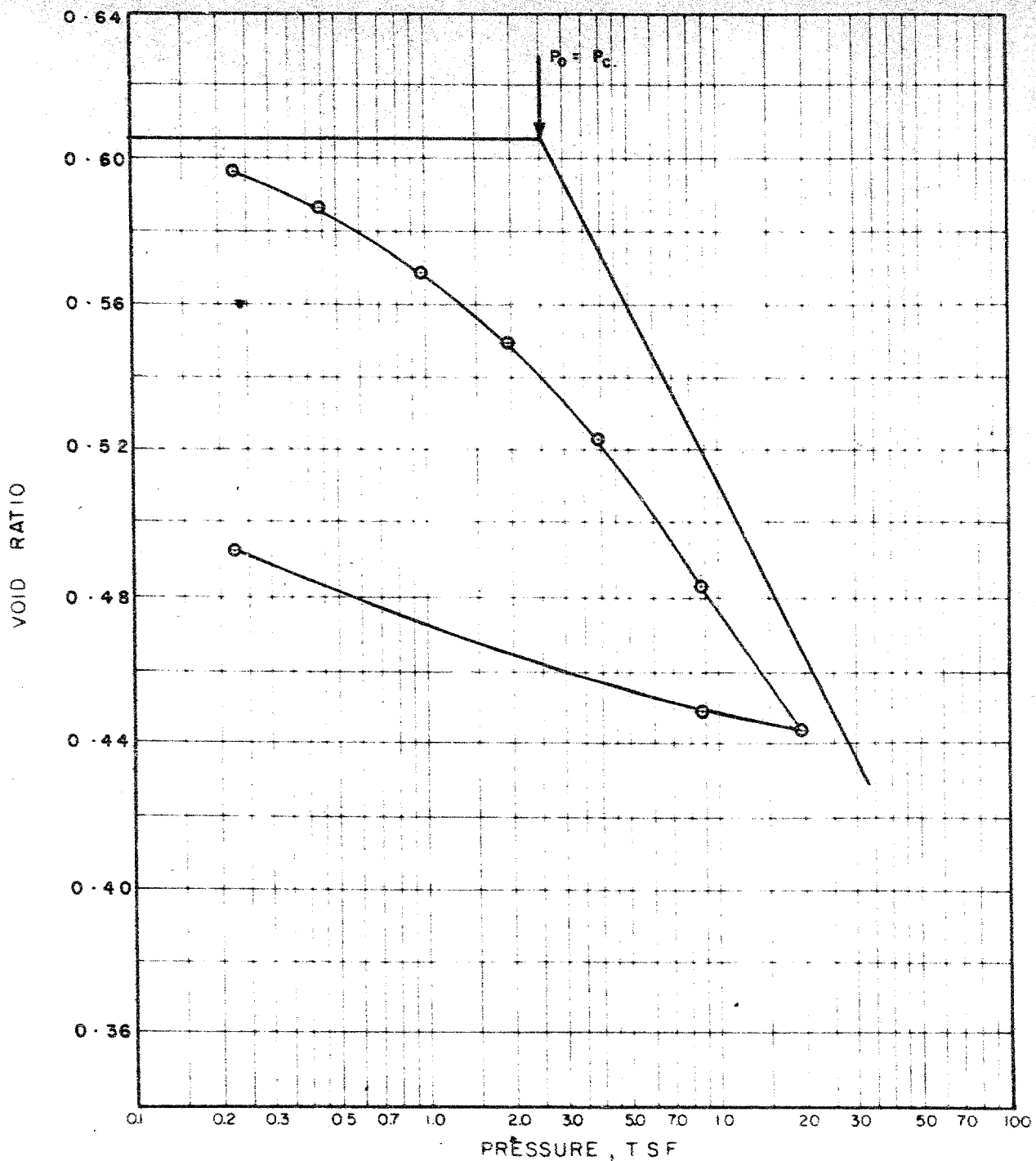
APPROVED

DATE JULY, 1960

JOB No 870

H G ACRES & COMPANY LTD

PLATE X.



OVERBURDEN PRESSURE — $P_0 = 25$ TSF
 CONSOLIDATION PRESSURE — $P_c = 25$ TSF

NATURAL WATER CONTENT = 18.69 %
 LOADING INTERVAL — 25 MIN.

SAMPLE No. 870 - B0 - 9 TEST DATE APRIL 5, 1960
 TEST No. 870 - 9 - 2 TESTED BY R. G.

H. G. ACRES & COMPANY LIMITED
 CONSULTING ENGINEERS
 NIAGARA FALLS CANADA

CONSOLIDATION TEST

HOLE No. 870-1 SAMPLE ELEV 614'

DEPARTMENT OF HIGHWAYS OF ONTARIO

APPROVED

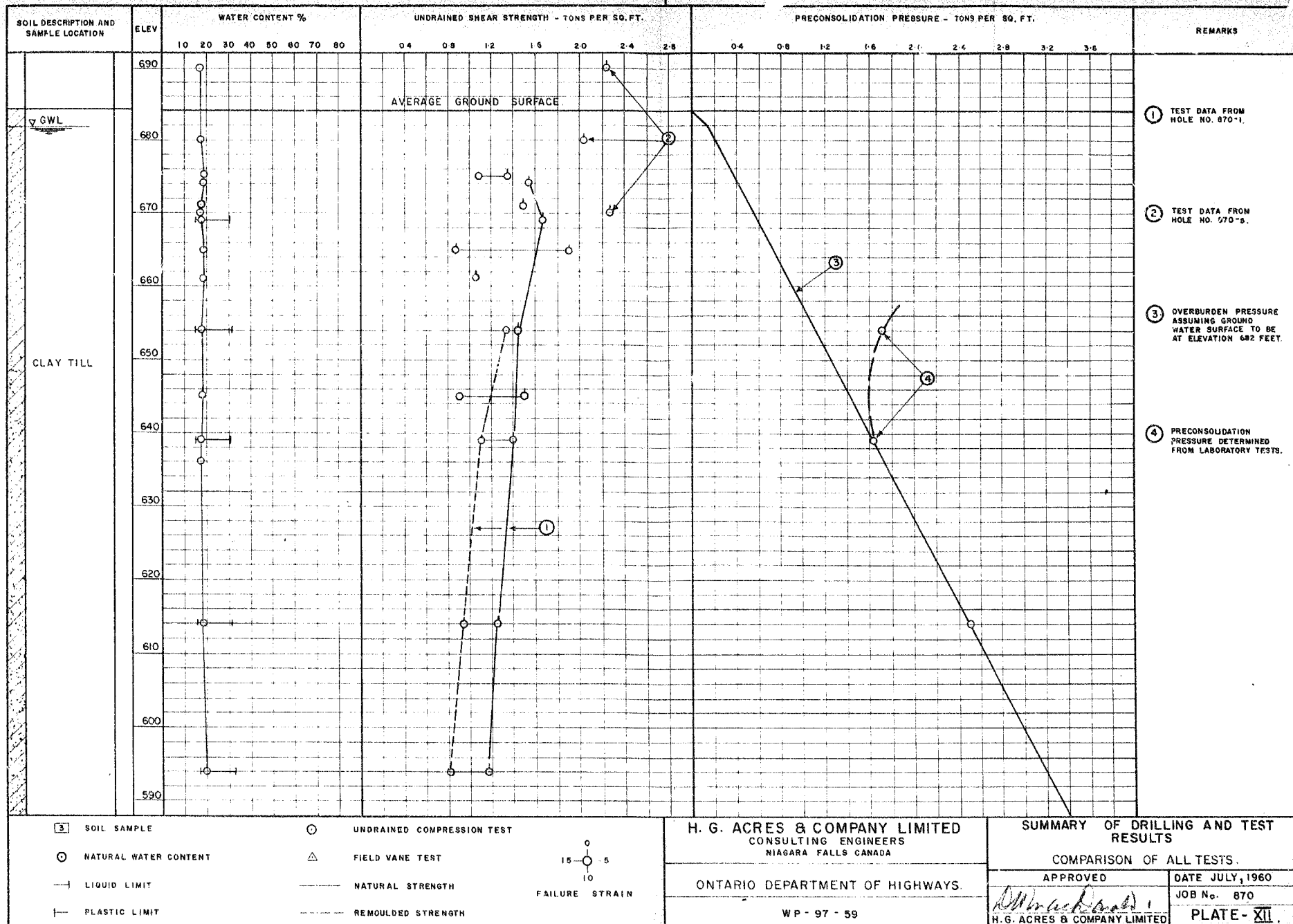
DATE JULY 1960.

HWY. 401, FLEMING CREEK BRIDGE (WP-289-59)

R. G. MacDonald
 H. G. ACRES & COMPANY LTD.

JOB No. 870

PLATE XI



③ SOIL SAMPLE

○ NATURAL WATER CONTENT

— LIQUID LIMIT

— PLASTIC LIMIT

○ UNDRAINED COMPRESSION TEST

△ FIELD VANE TEST

— NATURAL STRENGTH

--- REMOULDED STRENGTH

0
15 — 5
10
FAILURE STRAIN

H. G. ACRES & COMPANY LIMITED
CONSULTING ENGINEERS
NIAGARA FALLS CANADA

ONTARIO DEPARTMENT OF HIGHWAYS.

SUMMARY OF DRILLING AND TEST RESULTS

COMPARISON OF ALL TESTS.

APPROVED

H. G. Acres
H. G. ACRES & COMPANY LIMITED

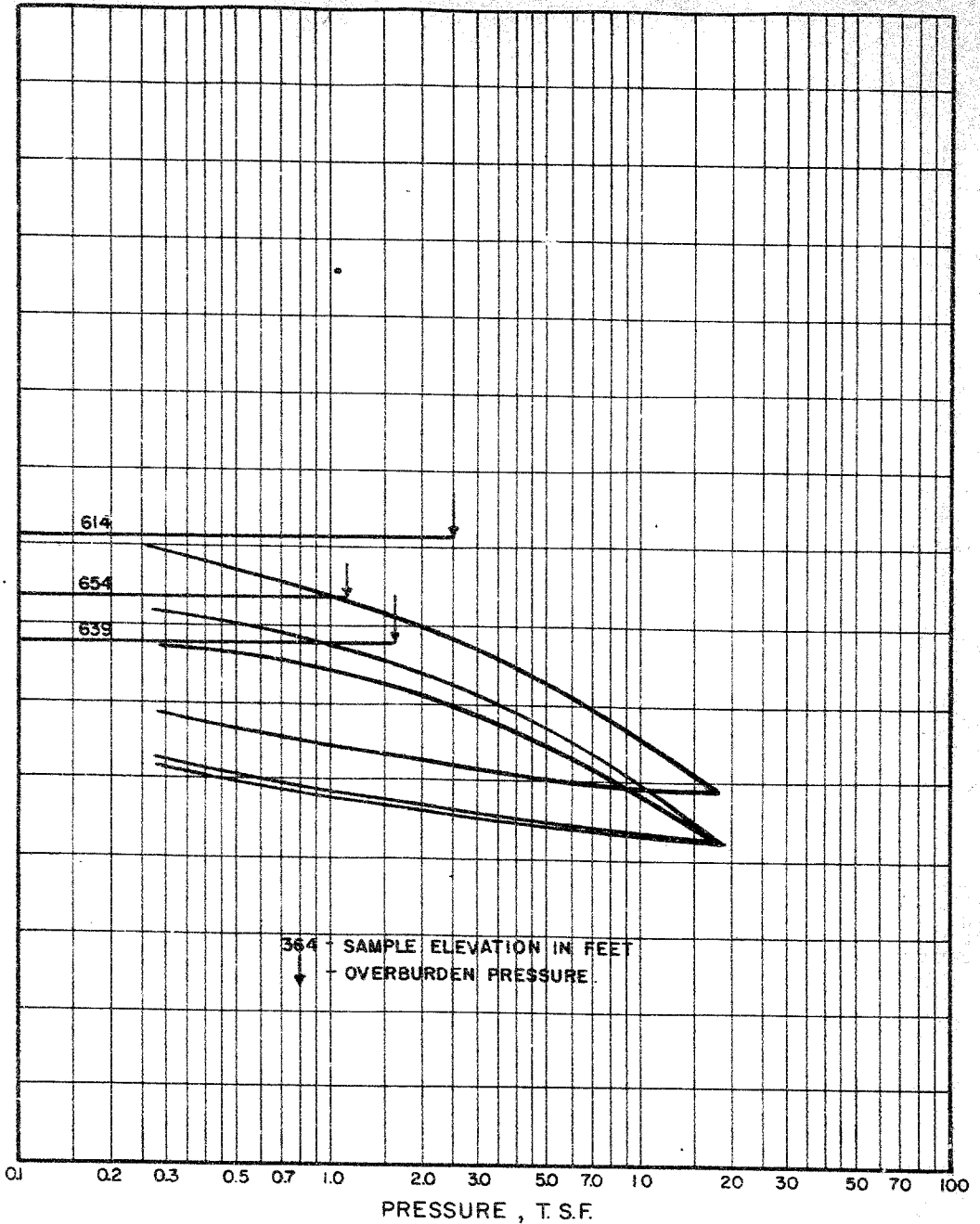
DATE JULY, 1960

JOB No. 870

PLATE - XII.

VOID RATIO

0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2



OVERBURDEN PRESSURE - P_0 = _____
CONSOLIDATION PRESSURE - P_c = _____

NATURAL WATER CONTENT _____
LOADING INTERVAL _____

SAMPLE No. _____
TEST No. _____

TEST DATE _____
TESTED BY _____

H. G. ACRES & COMPANY LIMITED
CONSULTING ENGINEERS
NIAGARA FALLS CANADA

CONSOLIDATION TEST
COMPARISON OF ALL TESTS

ONTARIO DEPARTMENT OF HIGHWAYS

WP - 289 - 59

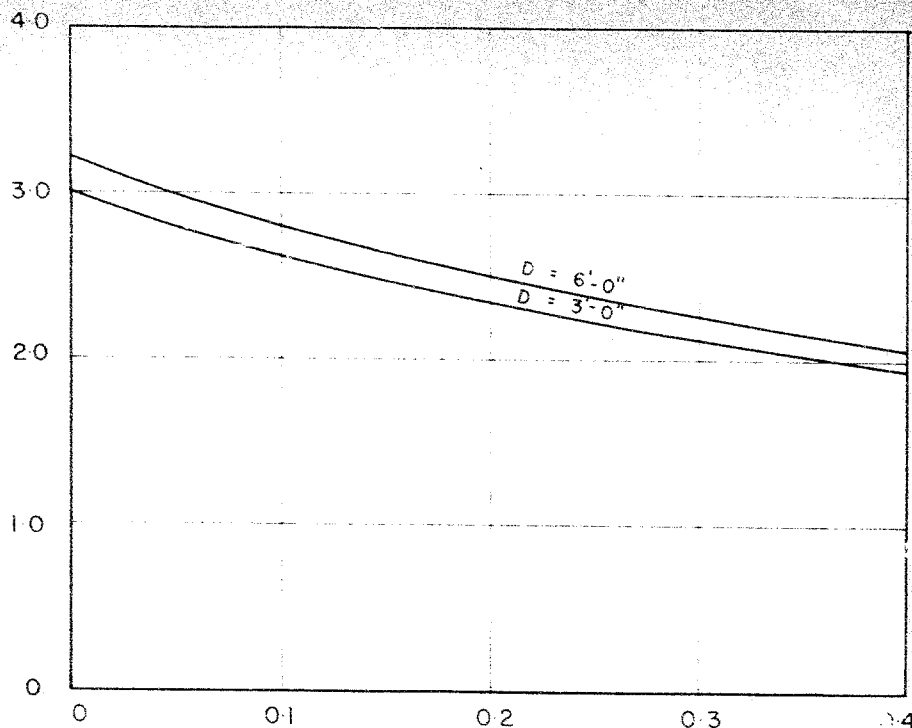
APPROVED

H. G. Acres
H. G. ACRES & COMPANY LTD.

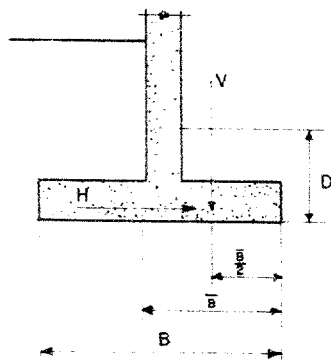
DATE: JULY, 1960.
JOB No. 870.

PLATE XIII

ALLOWABLE TOTAL BEARING PRESSURE, q_a , IN TSF



INCLINATION OF LOAD, $\alpha \approx \frac{H}{V - \gamma DB}$



$$V = q_a \cdot \bar{B}$$

- V DENOTES TOTAL VERTICAL LOAD
H " HORIZONTAL LOAD.
B " WIDTH OF FOOTING
 \bar{B} " EFFECTIVE WIDTH OF ECCENTRICALLY LOADED FOOTINGS
 γ " SOIL DENSITY.
D " DISTANCE FROM GROUND SURFACE TO BASE OF FOOTINGS.

H. G. ACRES & COMPANY LIMITED
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NIAGARA FALLS CANADA.

ONTARIO DEPARTMENT OF HIGHWAYS.

WP-289-59

ALLOWABLE TOTAL BEARING PRESSURES FOR STRIP FOOTINGS.

APPROVED

DATE JULY 1960

Robert A. Donald

SCALE

JOB NO

870.

H. G. ACRES & COMPANY LIMITED

PLATE - XIV

#60-F-202

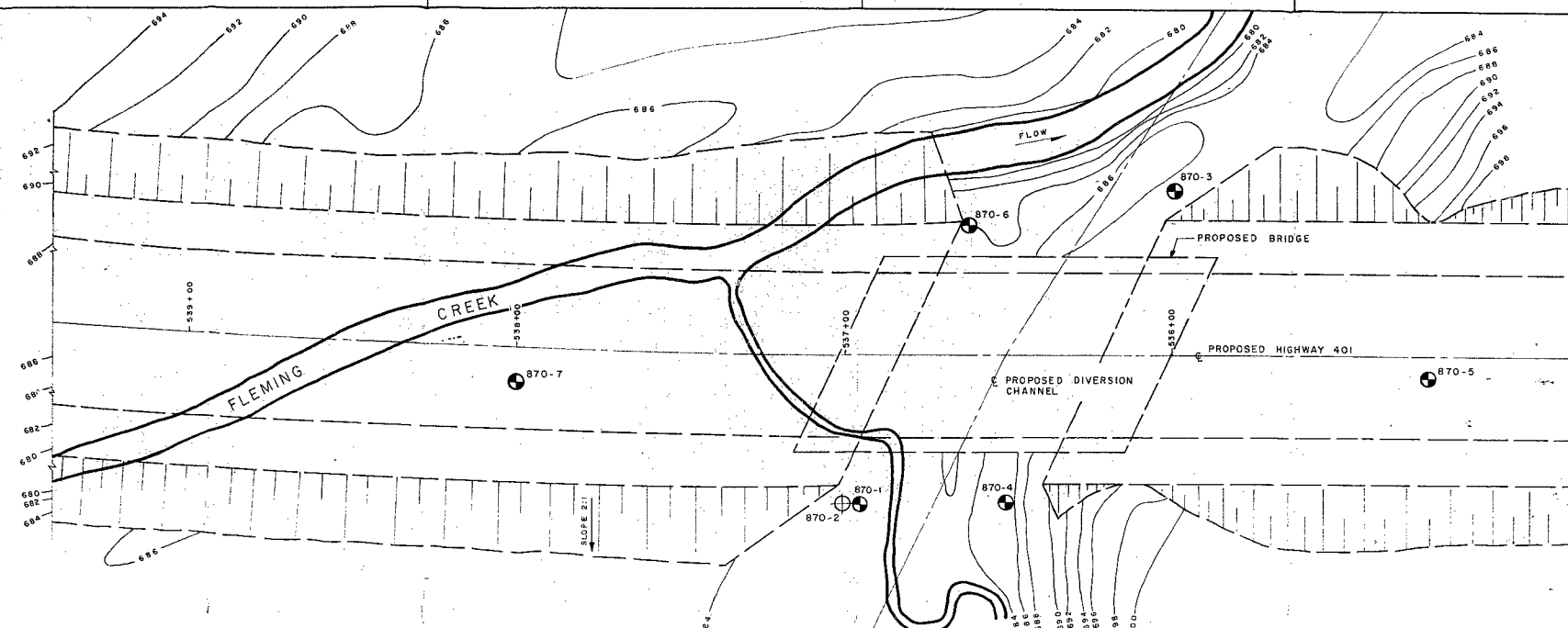
WP #289-59

HWY 401

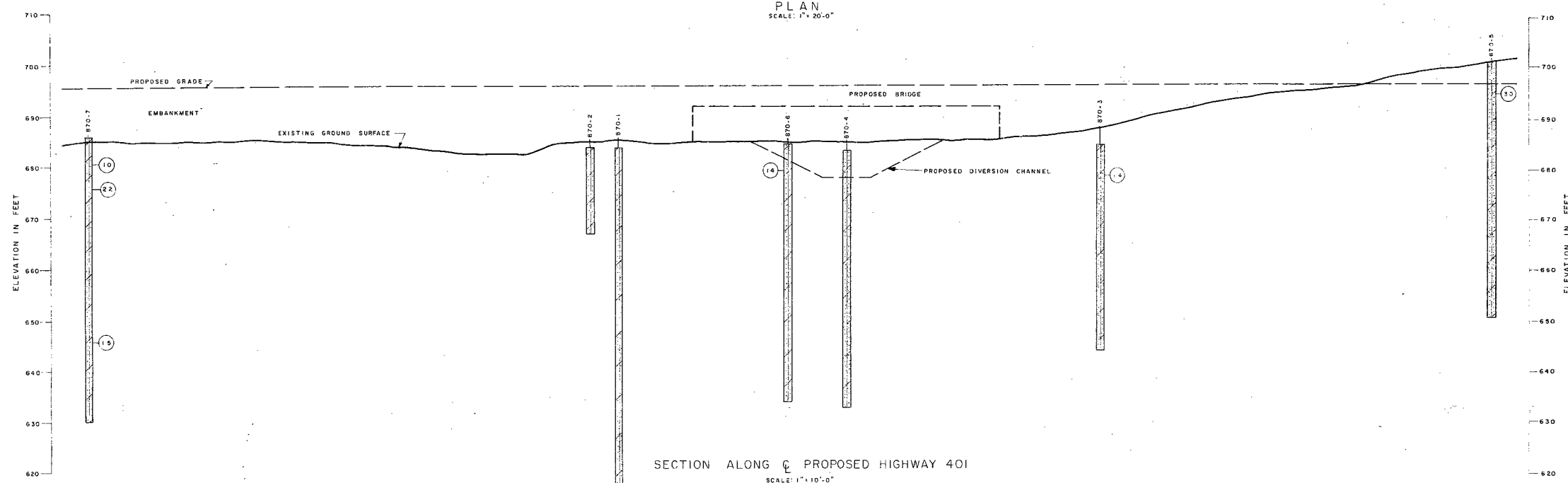
CROSSING

FLEMING CR.

ALDBOROUGH TWP.

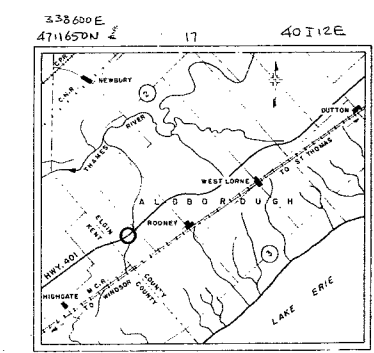


PLAN
SCALE: 1" = 20'-0"



SECTION ALONG C PROPOSED HIGHWAY 401
SCALE: 1" = 10'-0"

- LEGEND
- ORGANIC SOIL
 - CLAY
 - SILT
 - FINE SAND
 - COARSE SAND
 - GRAVEL
 - BEDROCK
 - WATER TABLE
 - EXPLORATORY DRILL HOLE
 - 2-IN. DIA. PENETRATION CONE TEST HOLE



H. G. ACRES & COMPANY LIMITED CONSULTING ENGINEERS NIAGARA FALLS CANADA	
ONTARIO DEPARTMENT OF HIGHWAYS	
WP-289-59	
EXPLORATORY HOLES PLAN AND SECTION	
APPROVED 	DATE: JULY, 1960 SCALE: AS NOTED JOB No. 870
H. G. ACRES & COMPANY LIMITED PLATE - I	