FOUNDATION TECHNICAL MEMORANDUM

For

FLEMING CREEK BRIDGES EBL AND WBL ON HIGHWAY 401
MTO WEST REGION 59 STRUCTURE REHABILITATIONS
SITE 5-114-1 AND 5-114-2, CONTRACT 7
GWP 3084-11-00
TOWNSHIP OF ALDBOROUGH
ELGIN COUNTY, ONTARIO

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CONSULTING ENGINEERS

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For
Fleming Creek Bridges EBL and WBL, Highway 401
MTO West Region 59 Structure Rehabilitations
Contract 7, GWP 3084-11-00
Geographic Township of Aldborough
Elgin County, Ontario

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1. INTRODUCTION

The Foundation Engineering Services for the present project involve the detail foundation investigation and design for the rehabilitation of 59 structures in MTO West Region along Highways 4, 6, 401, 402 and 403. Ten (10) Group Work Projects (GWP's) are contemplated to be completed between 2014 and 2020.

This technical memorandum summarizes the factual results of geotechnical data based on the review and compilation of existing subsurface information from relevant reports in the MTO GEOCRES Library for the Fleming Creek Bridges EBL (Eastbound Lanes) and WBL (Westbound Lanes). The Foundation Engineering recommendations from the existing bridge foundation reports are summarized with reference to the "Canadian Highway Bridge Design Code" (CHBDC) and follow in general the "Guidelines for Professional Engineers providing Geotechnical Engineering Services".

From the Minutes of Meeting Report, dated July 24, 2014, it is understood that rehabilitation of the bridge structure is anticipated and that the rehabilitation will be completed in two stages to maintain one lane of traffic.

The purpose of the Technical Memorandum is to summarize the subsurface and groundwater conditions and foundation recommendations based on available reports at the bridge location for the design project team's reference.

The elevations in this report are expressed in meters, unless otherwise indicated.

2. PROJECT SITE BACKGROUND AND GEOLOGY

The Fleming Creek Bridges on Highway 401 are located approximately 1.5 km northwest of Rodney in the Geographic Township of Aldborough, Elgin County, Ontario. A key plan is shown in Figure 1.

The existing bridges are single span reinforced concrete rigid frame structures; each carrying two lanes of traffic. The Fleming Creek is flowing from southwest to northeast direction at the site location.

Physiographically the site is located in Bothwell Sand Plains region, which is the delta of the Thames River in glacial Lake Warren. Soils consist of a shallow surface layer of sand underlain by lacustrine clay in this area. The topography is generally level with occasional knolls and ridges of sand and gravel. Most of the land at and near the site is in pasture or woods indicating a region of low grade soil. The bedrock underlying the Highway 401 alignment throughout the Geographical Township of Aldborough East mostly comprises of shale with limestone bands of the Hamilton Formation.

3. SOURCE OF INFORMATION

The following foundation report and drawing, appended in Appendix A, were available for review and provided information for the bridge structure, subsoil information and original foundation recommendations.

1. Report on Foundation Investigation, Proposed Crossing Highway 401 and Fleming Creek, Township of Aldborough, District No. 2, Bridge No. 12, WP 289-59 by H.G. Acres & Company Limited Consulting Engineers for Ontario Department of Highways, dated July, 1960, GEOCRES NO. 40I12-002. (Reference 1).

2. General Arrangement, Fleming Creek Bridge (Aldborough Township, District No. 12), The King's Highway 401 Line "A", District No. 2, Co. Elgin, Township of Aldborough, Lot C or I, Con. VI, TWP 110-114-1-A, W.P 289-59, Bridge Office Toronto, Department of Highways, Ontario, dated February 17, 1965 (revision date).

4. SITE RECONNAISSANCE

As part of the current foundation engineering assessment study, a site reconnaissance of the Fleming Creek EBL and WBL structures was carried out on October 20, 2013. A photographic record of the site visit is attached in Appendix B.

The site photographs present current visual conditions of the abutments of the WBL and EBL structures including the appearance of the structure, visual slope stability and soil erosion/scour features.

The exposed ground in front of the east and west abutment walls of the Fleming Creek EBL and WBL structures was affected by scouring (Photographs 1 and 3 to 5). The adjacent slopes of the bridge structures were vegetated. However, some rock protection was placed on the top of the east median slope ground (Photograph 2). Surficial cracks of the abutment and retaining walls were observed.

The weep drains in the abutment and retaining walls were open and wet. The creek was relatively dry with water only covering a portion of the creek bed. At the time of site reconnaissance, the depth of the water was about 0.1 m deep, where encountered.

5. PREVIOUS FIELD INVESTIGATION AND SUMMARIZED SUBSURFACE CONDITIONS

The site is located in Highway 401 Geographic Township of Aldborough, Elgin County Ontario. The general subsurface conditions presented in this section are based on the Foundation Report, GEOCRES 40I12-002 dated July, 1960.

The purpose of the original Foundation Investigation (Reference 1) was to explore the subsurface and the groundwater conditions at the site location where a bridge was proposed to carry the Highway 401 over the Fleming Creek. At the time, it was proposed that the Fleming Creek be diverted in order to reduce the bridge skew angle to 25 degrees. It was indicated that the proposed bridge approach embankments would be built to an average height of 3.0 m (10 ft.) above the existing ground surface.

The foundation investigation comprised six boreholes and one dynamic cone penetration test (DCPT), which was carried out between March 22 and 26, and between July 5 and 7, 1960. The boreholes were drilled to 12.4 to 30.5 m and the cone penetration test was penetrated to 5.2 m.

The F.E Johnston Drilling Company Limited was retained to perform the soil drilling and field sampling. The six boreholes were drilled using a Penndrill power auger drill machine. Clay samples were obtained with a 50 mm (2 in.) diameter thin-walled tubes and sandy or extremely stiff soil was sampled by a 50 mm (2 in.) diameter split-spoon sampler.

Boreholes 870-1, 870-4, 870-5 and 870-7 were drilled accompanied with cone penetration test (hole no. 870-2) at the EBL bridge abutment and approach locations. Boreholes 870-3 and 870-6 were drilled at the WBL bridge abutment locations.

The subsurface encountered at the EBL and WBL site locations was quite uniform. Generally, clay till was encountered from surface to the termination depth of the boreholes.

5.1 SUBSURFACE CONDITION

5.1 Sand

A local deposit of sand was encountered surficially, elevation 209.1, in borehole 870-7 and extended to 0.9 m, elevation of 208.2.

5.2 Clay Till

Clay till was encountered surficially in boreholes 870-1 and 870-3 to 870-6, elevation 208.5 to 213.5 and below sand in borehole 870-7 at 0.9 m, elevation 208.2. The clay till extended to 12.4 to 30.5 m, elevation 178.0 to 198.1, where boreholes were terminated.

Generally, to a depth of 3.0 m, the clay till encountered was found to be uniform. The clay till was in very stiff consistency. The field vane, whose limit corresponded to soil shear strength of 119.7 kPa (1.25 tsf), was unable to fail the clay till in shear. The average natural undrained shear strength determined from laboratory shear test was generally greater than 134.1 kPa (1.4 tsf) to a depth of at least 12.2 m (40 ft.). In borehole 870-7, medium sand seams were encountered within this upper clay till layer. N values recorded ranged from 10 (borehole 870-7) to 37.

Below 3.0 m, very stiff to hard clay till was encountered. N values ranged from 17 to 85. Laboratory undrained shear strengths obtained for clay till ranged from 100.5 to 216.4 kPa (1.05 to 2.26 tsf) and laboratory remoulded undrained shear strength obtained for clay till ranged from 78.5 to 129.3 kPa (0.82 to 1.35 tsf) with a range of sensitivity between 1.1 and 2.2. The Atterberg liquid limits ranged from 30.1 to 33.3 and plastic limits 15.6 to 17.4 for the selected clay till samples. The plasticity index ranged from 14.5 to 15.9. Moisture content determinations ranged from 17.0 to 19.6%.

Three consolidation tests were carried out and the clay appeared to be normally consolidated or lightly overconsolidated. Because the degrees of curvature of the compressibility curves were small and the graphical prediction of the preconsolidation pressures was consequently difficult, the conclusion of the consolidation state of the samples was doubted. No consolidation tests were carried out on samples obtained from above elevation 210.3 (690 ft.) because the soil obtained was extremely stiff and incompressible.

5.3 Groundwater

Groundwater was observed in boreholes 870-1 and 870-6 at 0.8 m (2.5 ft.) and 1.5 m (5.0 ft.), elevation 207.7 (681.5 ft.) and 207.0 (679.2 ft.).

In the vicinity of the creek the groundwater level was the same as the water level in the creek. At the time of the site reconnaissance the water level was about 0.1 m deep, where encountered. The creek water level is subject to seasonal fluctuations and rainfall patterns.

6. FOUNDATION

6.1 Previous Foundation Recommendations

6.1.1 Bearing Capacity

The foundation report (Reference 1) recommended based on stiffness and incompressibility of the encountered clay till soil, the most practical type of footing for this bridge was spread footing. It recommended the safety factor against ultimate failure equal to 3. It recommended the bearing capacity factor of N_c equal to 6.0, and average value of undrained shear strength equal to 134.1 kPa (1.4 tsf). The report indicated that it was justifiable to use a constant N_c value when considering footings of different widths and depths because a conservative shear strength value was recommended.

Further, the report recommended a total allowable bearing pressure (q_a) of 287.3 kPa (3.0 tsf) and 306.4 kPa (3.2 tsf) for centrally-loaded footings located at 0.9 and 1.8 m, respectively. For centrally-loaded footings which are subjected to horizontal forces, the allowable total bearing pressures must be reduced by the factor 1/(1+1.4) or 0.4.

The report recommended for eccentrically-loaded footings that the the width of the footing should be reduced for purposes of calculation to an effective width which is equal to twice the shortest distance from the edge of the footing to point of intersection of the resultant applied force and the base of footing.

6.1.2 Embankment

Based on report, the maximum bearing pressure of the embankment on the foundation was approximately 76.6 kPa (0.8 tsf) and the average of undrained shear strength of the subsoil was greater than 134.1 kPa (1.4 tsf). The report indicated that the natural soil would be able to support 3.6 m (12 ft.) high embankments. It was expected that the ultimate settlement would be less than 92 mm (0.3 ft.).

6.1.3 Settlements

It was expected the settlement of the abutments would be influenced by the direct loads of the bridge and by the loads of approach embankments. It was considered that the areas on which the bridge loads would be applied were small and these stresses would dissipate quickly with depth below the footings although the stresses transferred to the soil at the bases of the bridge abutments would be much larger than those due to the embankments. In order to predict the possible settlement of the bridge footings, it was assumed that the bridge abutments would settle the same amount as a strip loading which has a width equal to that of approach embankments and applied a pressure of 143.6 kPa (1.5 tsf) to the subsoil. No consideration was taken of the 25 degrees skew of the bridge, and because the expected foundation settlements are small.

An apparent elastic modulus, E, of 19,152 kPa (200 tsf) and a depth of compressible subsoil of 30.5 m (100 ft.) were assumed to estimate elastic settlements. The following settlements were estimated:

Elastic Settlement	30.5 mm (0.1 ft.)
Consolidation Settlement	61.0 mm (0.2 ft.)
Total Ultimate Settlement	91.4 mm (0.3 ft.)

It was expected that most part of the elastic settlement would happen during the period of construction of the bridge and embankment and that 50% of the total ultimate settlement would occur within 10 years.

Based on the General Arrangement drawing (Reference 2), the footings were to be founded at about elevation 204.1 (669.5 ft.). The original ground at the approaches was to be increased by 3.7 m. It was shown that the adjacent slopes would be graded at 2H:1V slopes. Further, the drawing provided a site plan that showed the intended flow diversion of the Fleming Creek. The new bed of the creek was proposed to be at elevation 206.2 (676.5 ft.).

6.2 Assessment of Foundation Parameters

Based on the previous investigation and subsurface conditions encountered, the following table summarizes the foundation design parameters that were recommended in the previous report and the updated geotechnical reaction at SLS and factored geotechnical resistance at ULS are provided.

FOUNDATION DESIGN PARAMETERS

Foundation Type	Elevation of Footings (m)	Previous Working Stress Values (tsf)[1]	Previous Equivalent Limit State Design Values		Limit State Design Values Updated to current industry practices[2]	
			SLS Geotechnical Reaction (kPa)	ULS Geotechnical Resistance Factored (kPa)	SLS Geotechnical Reaction (kPa)	ULS Geotechnical Resistance Factored (kPa)
East Abutment on Spread Footing	204.1 (669.5 ft.)	2 to 3	190 to 285	285 to 425	350	525
West Abutment on Spread Footing		2 to 3	190 to 285	285 to 425	350	525

Notes: 1. Working stress design values. The Ultimate Limit State design values are based on the working stress. No field verifications were made.
2. Resistance Factor = 0.5 for shallow foundation (CFEM 4th edition)
Assumed Factor of Safety is 3 (CFEM 4th edition)

The seismic site coefficient for the conditions at this site is 1.0 (soil profile Type 1, Canadian Highway Bridge Design Code (CHBDC) 2006 Edition, clause 4.4.6).

The bearing resistance for inclined loads should be reduced in accordance with the requirements of clause 6.7.4 of the CHBDC. The foundation frost penetration depth at the site is 1.2 m according to OPSD 3090.101.

7. DISCUSSION

From a geotechnical point of view, at the present time, foundation work for the Fleming Creek Bridge EBL and WBL structures is not expected provided that the total dead load on the bridge does not increase or decrease by more than 10%.

It is understood that rehabilitation of the bridge structures is anticipated and that rehabilitation will be completed in two stages to maintain one lane of traffic.

Further, it is suggested that the weep holes out of the abutment walls should be maintained and cleaned at a regular basis to prevent any clogging of the holes. Regular maintenance of the weep holes will keep the water flowing from behind the abutment walls and will mitigate hydrostatic pressure to build-up behind the abutment walls.

8. CLOSURE

This Technical Memorandum was prepared by Mr. N. Rahman, P.Eng with the assistance of Mr. M. Khorsand, EIT and was reviewed by Mr. R. Ng, PhD, P.Eng. Mr. B. R. Gray, MEng, P.Eng., MTO Designated Principal Contact conducted an independent review of the report.

We trust this memo is sufficient for your immediate needs. Please do not hesitate to contact us if you have any inquiries and/or comments.

Yours very truly,

Peto MacCallum Ltd.

Nazibur Rahman, P.Eng.
Engineer, Geotechnical Services

Robert Ng, MBA, PhD, P.Eng.Project
Senior Project Engineer

Brian R. Gray, MEng, P.Eng.
MTO Designated Principal Contact

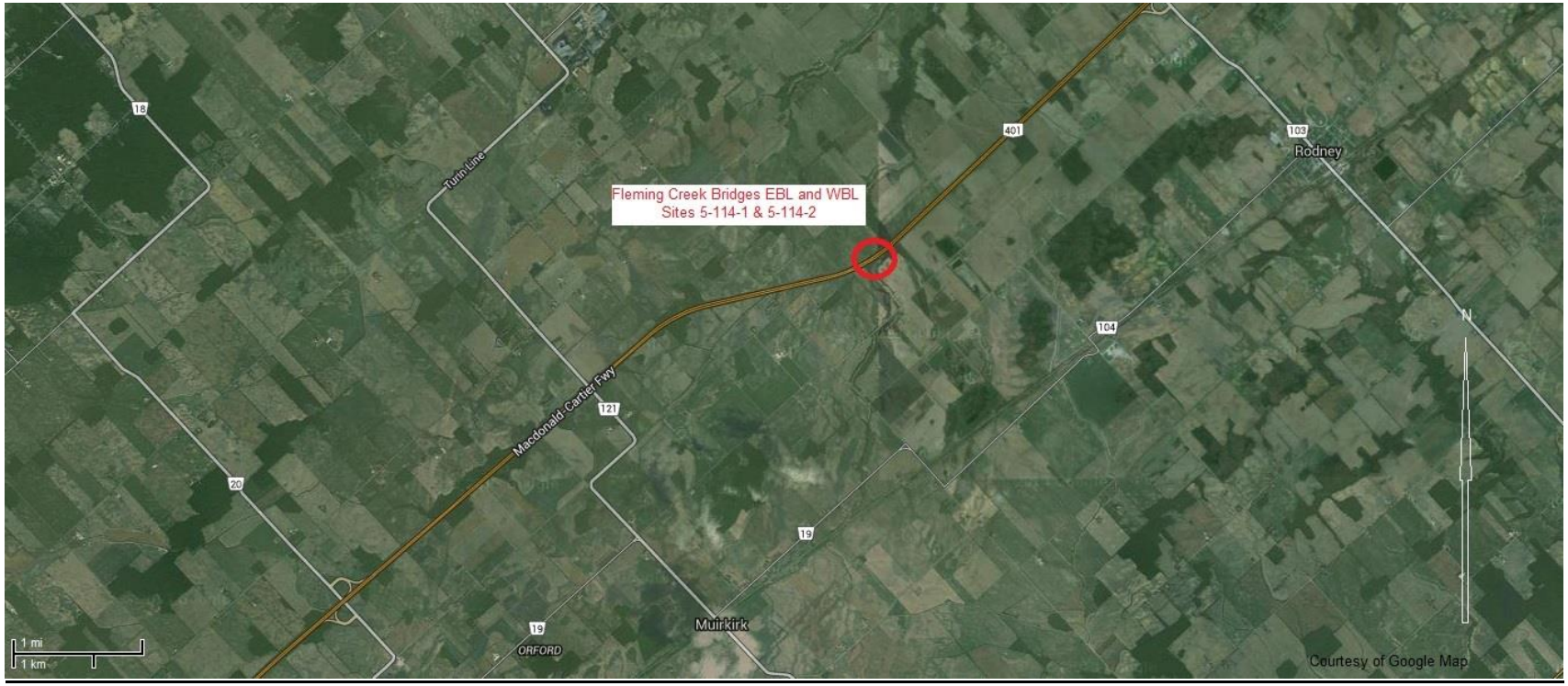
NR/RN/BRG:nr-mi-jk

TABLE 1

LIST OF STANDARD SPECIFICATIONS REFERENCED IN REPORT

DOCUMENT	TITLE
OPSD 3090.101	Foundation Frost Depth for Southern Ontario

Figure 1 – Key Plan



APPENDIX A

Foundation Investigation Report at Fleming Creek (GEOCRES No. 40I12-002)

General Arrangement – Fleming Creek Bridge (Aldborough Township No. 12)

#60-F-202

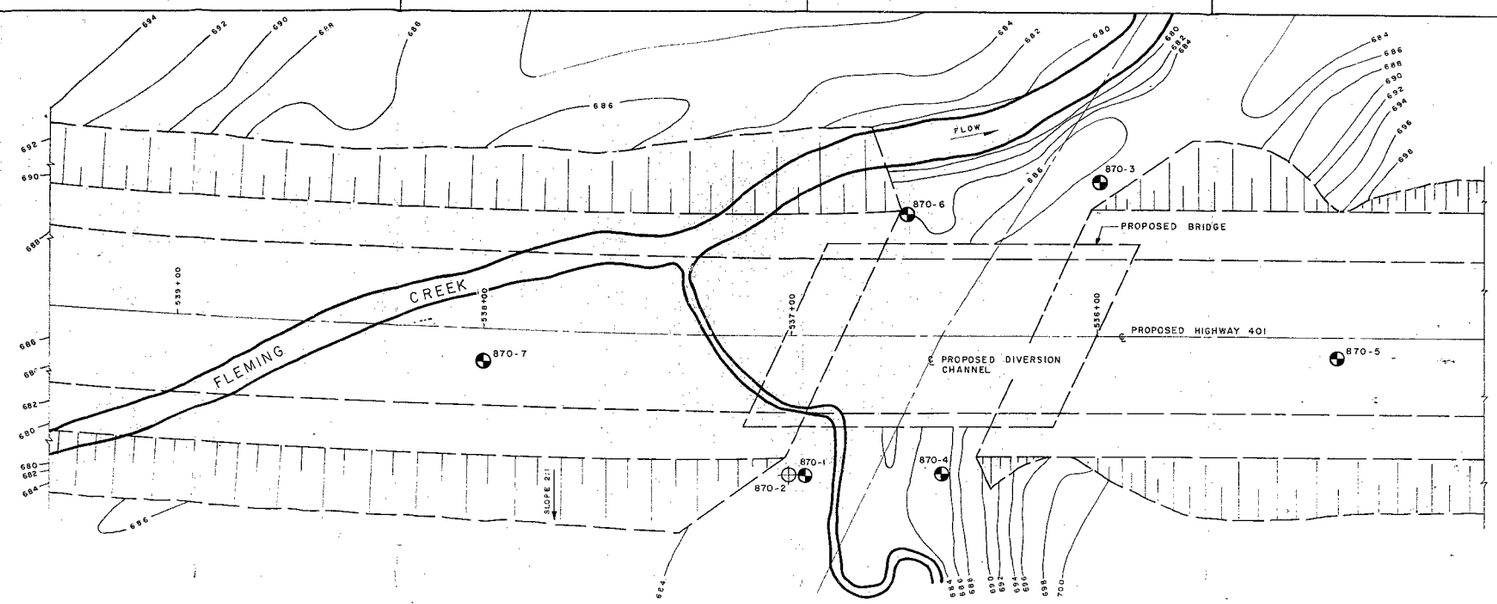
WP #289-59

HWY 401

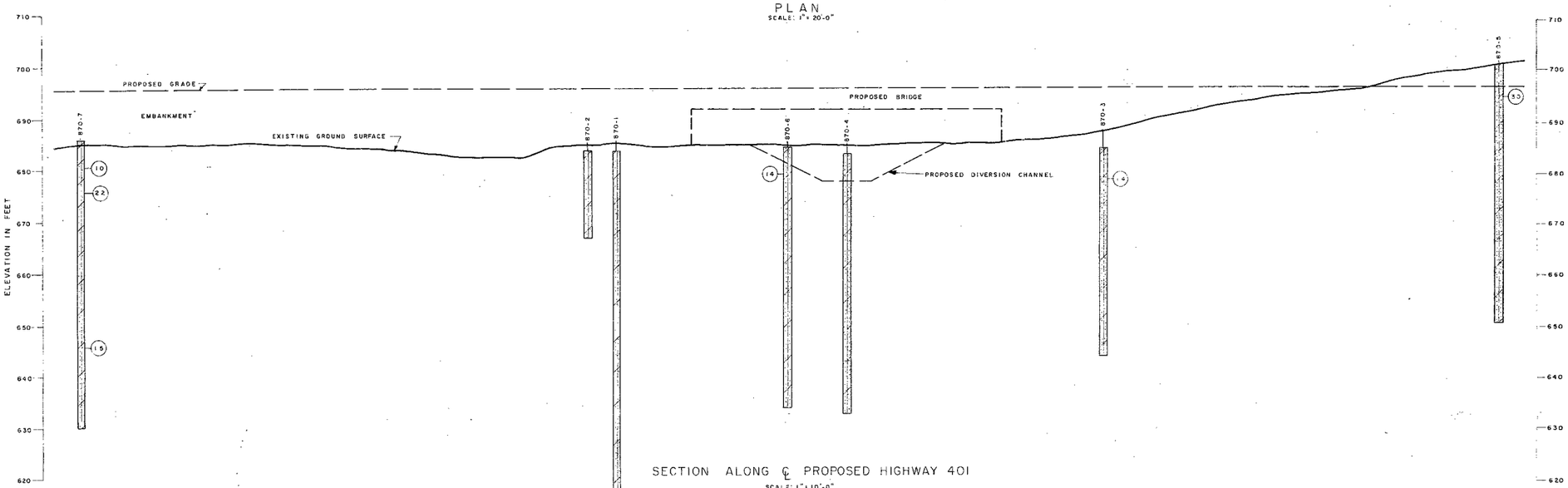
CROSSING

FLEMING CR.

ALDBOROUGH TWP.



PLAN
SCALE: 1"= 20'-0"

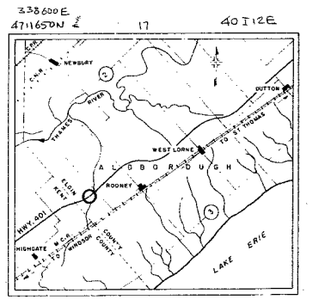


SECTION ALONG ℄ PROPOSED HIGHWAY 401
SCALE: 1"= 10'-0"

LEGEND

- ORGANIC SOIL
- CLAY
- SILT
- FINE SAND
- COARSE SAND
- GRAVEL
- BEDROCK

- WATER TABLE
- EXPLORATORY DRILL HOLE
- 2-IN. DIA. PENETRATION CONE TEST HOLE.



KEY PLAN
SCALE 1 IN. = 4 MI.

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 - 1	

SK-870-C-1

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

ONTARIO DEPARTMENT OF HIGHWAYS
Toronto, Ontario

REPORT

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HIGHWAY 401 AND FLEMING CREEK
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WP 289-59

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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

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.

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

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

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

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 Nc 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 Nc 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 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 $\overline{B}$.

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

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

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 IA 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.

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.

(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 A

Program 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 B

Summary 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 Strain

Su_n - Natural undrained shear strength

Su_r - Remoulded 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 OF DRILLING: SOIL Penndrill 4" Auger — CASING DIAM.
ROCK — CORE DIAM.

LOCATION: LATITUDE 0H. 536+95
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 NO.	SAMPLE TYPE *	SAMPLE SIZE Inches	SAMPLE DEPTH Feet	SAMPLE RET'D Inches	PENETRATION TEST See Plate II 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 — TIN
O — TUBE
P — WATER CONTENT TIN
Q — GLASS JAR
R — CLOTH BAG
S — PLIOFILM BAG
Z — DISCARDED

INSPECTOR J. MacLeod
LOGGED BY J. MacLeod
APPROVED D. H. MacDonald
DATE July, 1960

SK-370-LS-4a
Plate II A
FORM NO. 91-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-280-59) — HOLE No. 870-1

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

DEPTH	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE NO	SAMPLE TYPE	SAMPLE SIZE (Inches)	SAMPLE DEPTH (Feet)	SAMPLE RET'D (Inches)	PENETRATION TEST (Blows)
			5	BO	1-7/8	35.0		
		Note: * Penetration Test				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

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-280-59) — HOLE No. 870-2

SITE Township of Alborough, Lot 1, Ontario — SHEET No. 1 OF 1

CONTRACTOR: F.E. Johnston Drilling Company Limited — STARTED 8:00 A.M. March 26, 1960 — FINISHED 11:00 A.M. March 26, 1960

METHOD OF DRILLING: SOIL D.H.O. Cone Penetration Test — CASING DIAM.

ROCK — CORE DIAM.

LOCATION: LATITUDE Ch. 537+00 — DEPARTURE 45' Left — BEARING — INITIAL DIP 90 Degrees — OTHER DIPS

ELEVATIONS: DATUM GSC — DRILL PLATFORM — GROUND SURFACE 684.0 — ROCK SURFACE — BOTTOM OF HOLE 667.0 — WATER TABLE 681.5

DEPTH	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE NO.	SAMPLE TYPE *	SAMPLE SIZE	SAMPLE DEPTH	SAMPLE RET'D	PENETRATION TEST * Blows
						Feet		
						0		
						1		14
						2		4
						3		4
						4		4
						5		10
		Note: D.H.O. Penetration Test				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

SHIPPING CONTAINER
N — INSERT
O — TUBE
P — WATER CONTENT TIN
Q — GLASS JAR
R — CLOTH BAG
S — PLIOFILM BAG
Z — DISCARDED

INSPECTOR J. MacLeod

LOGGED BY J. MacLeod

APPROVED D. H. MacDonald

DATE July, 1960

Plate III

SK-870-LS-5

FORM NO. 91-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. 870-3

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	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE NO.	SAMPLE TYPE *	SAMPLE SIZE	SAMPLE DEPTH	SAMPLE RET'D	PENETRATION TEST See Plate II
Feet					Inches	Feet	Inches	Blows
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
Q — GLASS JAR
R — CLOTH BAG
S — POLYFILM BAG
T — DISCARDED

INSPECTOR P. Jorgensen
LOGGED BY P. Jorgensen
APPROVED D. H. MacDonald
DATE July, 1960

SK-870-LS-6a

Plate IV a

FORM NO. 914

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. 2 OF 2

DEPTH	SOIL TYPE	DESCRIPTION, COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC	SAMPLE					PENETRATION TEST
			NO	TYPE	SIZE	DEPTH	RET'D	
Feet					Inches	Feet	Inches	Blows
			6	BO	2	39.0		
						39.5		6
						40.0		8
						40.5		14
40.7		End of hole				40.7	24	5

SK-870-LS-6b

Plate IV b

FORM NO. 91-B

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; DEPARTURE 45 feet left; BEARING; INITIAL DIP 90 degrees; OTHER DIPS

ELEVATIONS: DATUM G.S.C.; DRILL PLATFORM; GROUND SURFACE 685.1; ROCK SURFACE; BOTTOM OF HOLE 634.5; WATER TABLE

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

DEPTH	SOIL TYPE	DESCRIPTION: COLC , CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE					PENETRATION TEST
			NO.	TYPE	SIZE	DEPTH	RET'D	
Feet					Inches	Feet	Inches	Blows
			5	BO	2	39.0		
						39.5		7
						40.0		12
						40.5	18	20
			6	BO	2	49.0		
						49.5		6
						50.0		10
50.6		End of hole.				50.6	19	16

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.E. 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; DEPARTURE 7 feet left; BEARING; INITIAL DIP 90 degrees; OTHER DIPS

ELEVATIONS: DATUM G.S.C.; DRILL PLATFORM; GROUND SURFACE 700.6; ROCK SURFACE; BOTTOM OF HOLE 649.9; WATER TABLE

DEPTH	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC	SAMPLE NO	SAMPLE TYPE *	SAMPLE SIZE	SAMPLE DEPTH	SAMPLE RET'D	PENETRATION See TEST Plate II
Feet					Inches	Feet	Inches	Blows
0.0	Clay till	Brown, weathered, containing many augular pebbles, very stiff	1	AQ	2	4.0		
						4.5		5
						5.0		12
						5.5	18	16
7.0	Clay till	Grey, silty, containing augular pebbles, very stiff	2	BO	2	9.0		
						9.5		6
						10.0		8
						10.5	18	15
19.0	Clay till	Same as above, but more moist and tenacious.	3	BO	2	19.0		
						19.5		5
						20.0		9
						20.5		13
						20.7	20	5
			4	BO	2	29.0		
						29.5		7
						30.0		13
						30.5		15
						30.75	19	10
			5	BO	2	49.0		
						49.5		9
						50.0		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 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. 870-5

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

DEPTH	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC	SAMPLE					PENETRATION TEST
			NO	TYPE	SIZE	DEPTH	RET'D	
Feet					Inches	Feet	Inches	Blows
						50.5		22
50.7		End of hole.				50.7	14	10

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; DEPARTURE 39 feet right; BEARING; INITIAL DIP 90 degrees; OTHER DIPS

ELEVATIONS: DATUM G.S.C.; DRILL PLATFORM; GROUND SURFACE 684.2; ROCK SURFACE; BOTTOM OF HOLE 633.2; WATER TABLE 679.2

DEPTH	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE NO.	SAMPLE TYPE *	SAMPLE SIZE	SAMPLE DEPTH	SAMPLE RET'D	PENETRATION TEST See Plate II
Feet					Inches	Feet	Inches	Blows
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

SK-870-LS-9a — Plate VII a — FORM NO. B1-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. 870-6

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

DEPTH	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC	SAMPLE					PENETRATION TEST
			NO	TYPE	SIZE	DEPTH	RET'D	
Feet					Inches	Feet	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. 870-7

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 19 60
FINISHED 4:30 P.M. July 7 19 60

METHOD OF DRILLING: SOIL Peandrill, 4-Inch Auger — CASING DIAM.
ROCK — CORE DIAM.

LOCATION: LATITUDE Ch. 538+00; DEPARTURE 12 feet left; BEARING; INITIAL DIP 90 degrees; OTHER DIPS

ELEVATIONS: DATUM G.S.C.; DRILL PLATFORM; GROUND SURFACE 686.0; ROCK SURFACE; BOTTOM OF HOLE 630.0; WATER TABLE

DEPTH	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE NO.	SAMPLE TYPE*	SAMPLE SIZE	SAMPLE DEPTH	SAMPLE RET'D	PENETRATION TEST See Plate II
Feet					Inches	Feet	Inches	Blows
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-L5-10A
PLATE VIII A

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

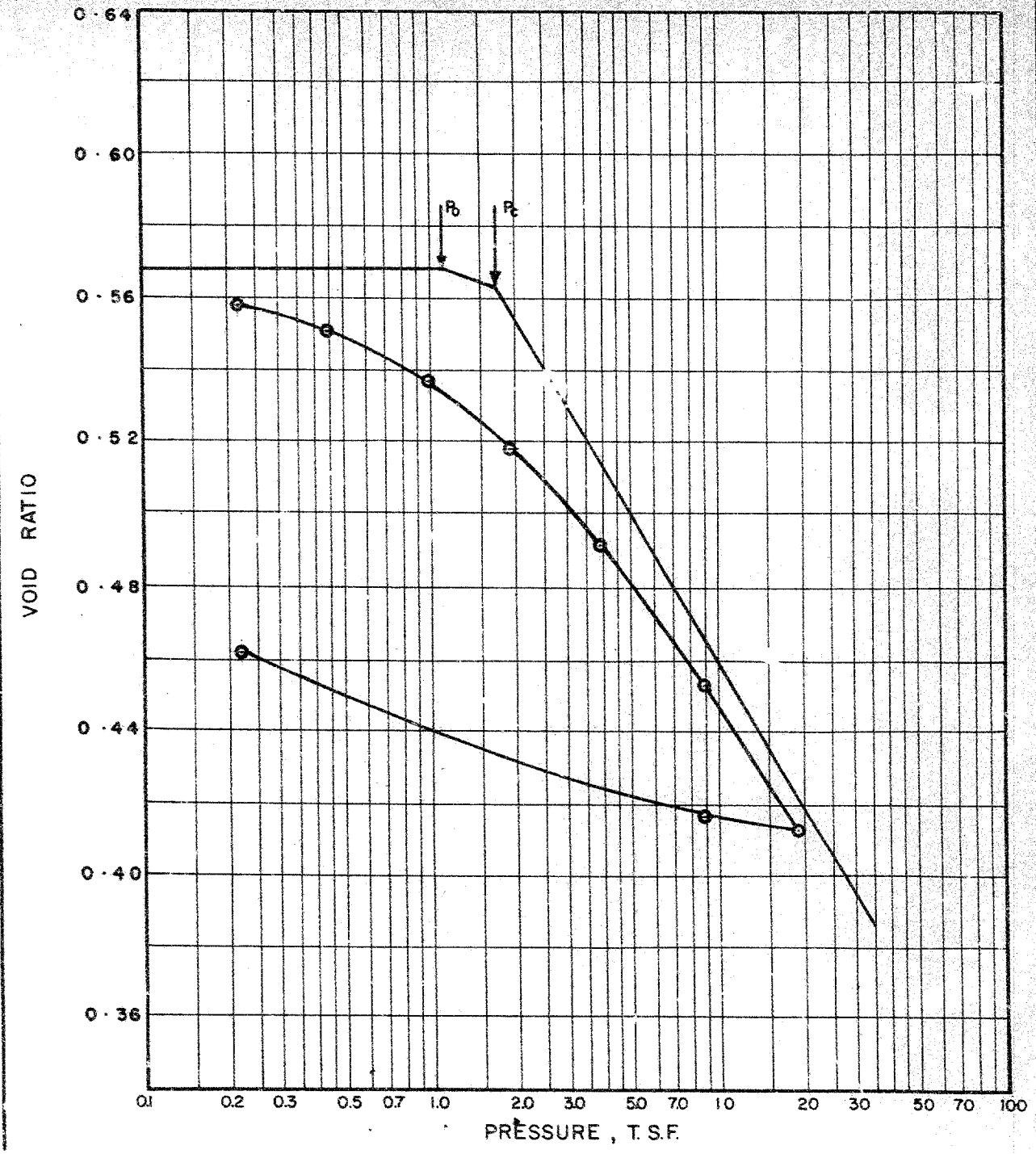
DRILLING REPORT

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	SOIL TYPE	DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.	SAMPLE					PENETRATION TEST
			NO	TYPE	SIZE	PTH	RET'D	
Feet					Inches	Feet	Inches	Blows
				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	BO	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



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 - BO - 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

DEPARTMENT OF HIGHWAYS OF ONTARIO

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

CONSOLIDATION TEST

HOLE No. 870 - 1 SAMPLE ELEV. 654'

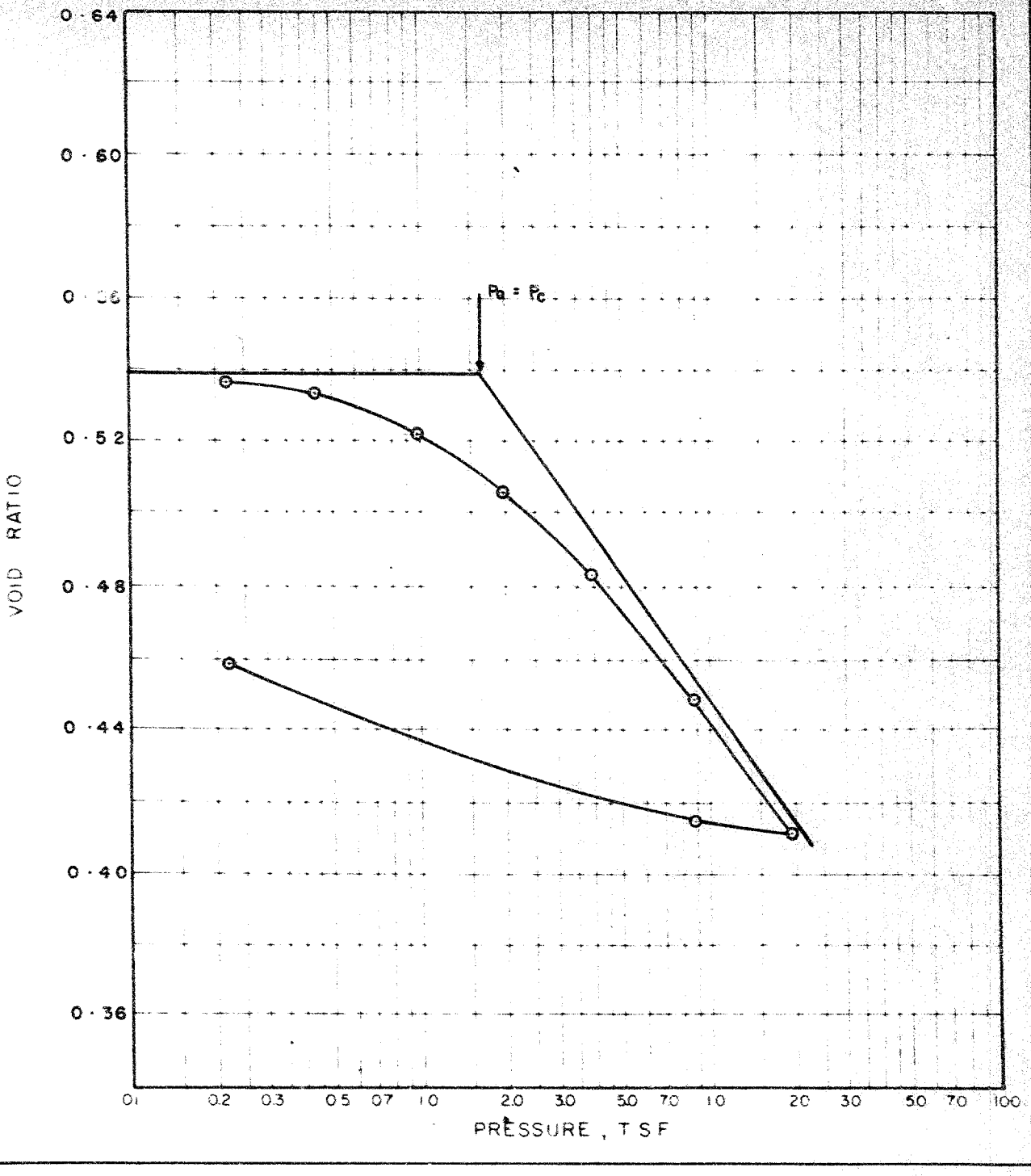
APPROVED

H.G. ACRES & COMPANY LTD.

DATE: JULY, 1960

JOB No. 870

PLATE IX



OVERBURDEN PRESSURE — P_o = 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

CONSOLIDATION TEST

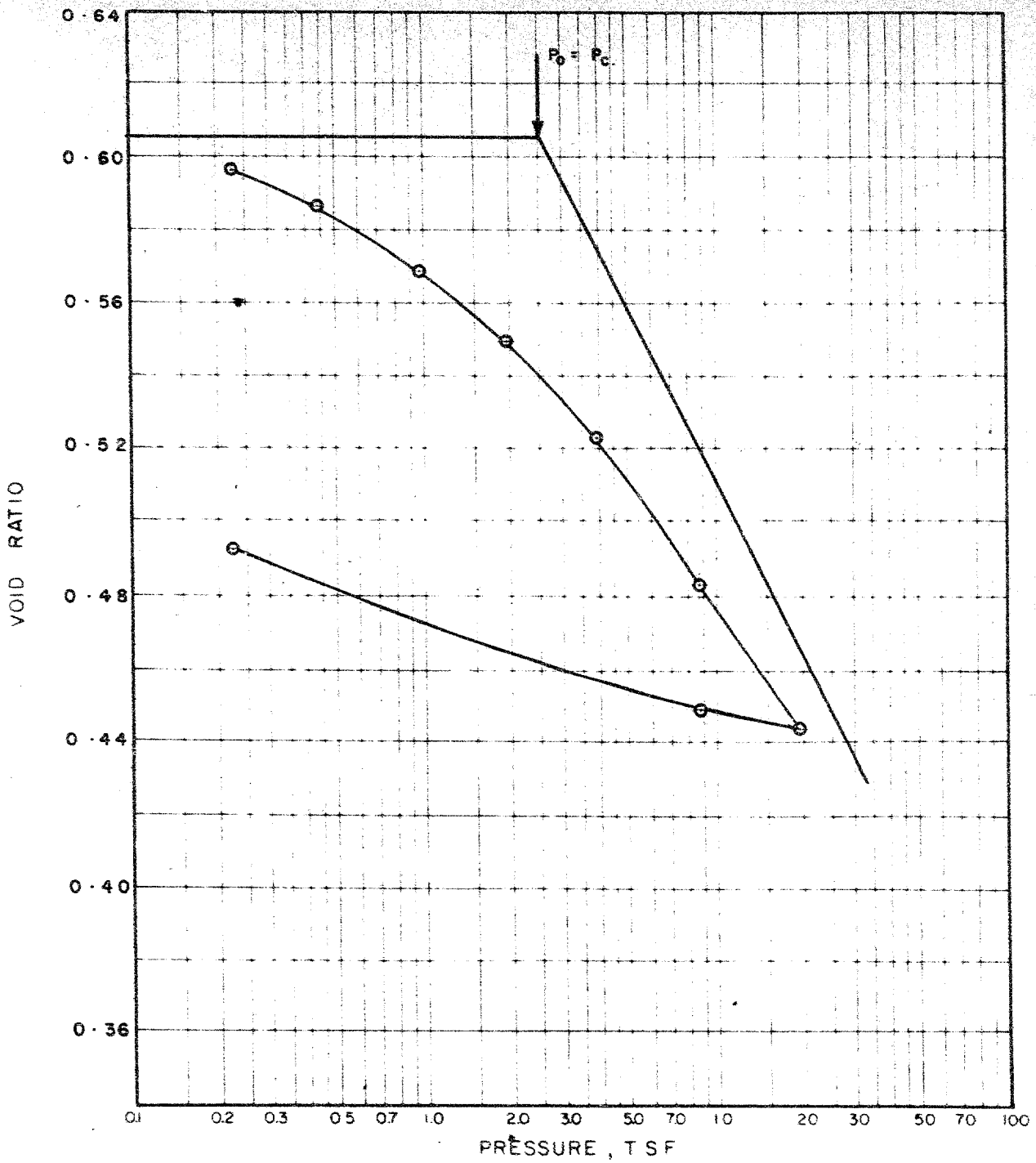
HOLE No 870-1 SAMPLE ELEV 639'

DEPARTMENT OF HIGHWAYS OF ONTARIO

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

APPROVED
D H MacDonald
H G ACRES & COMPANY LTD

DATE JULY, 1960
JOB No 870
PLATE X.



OVERBURDEN PRESSURE — P_o = 2·5 TSF
CONSOLIDATION PRESSURE — P_c = 2·5 TSF
NATURAL WATER CONTENT = 18·69 %
LOADING INTERVAL - 25 MIN.

SAMPLE No 870 - BO - 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

DEPARTMENT OF HIGHWAYS OF ONTARIO

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

CONSOLIDATION TEST

HOLE No 870-1 SAMPLE ELEV 614'

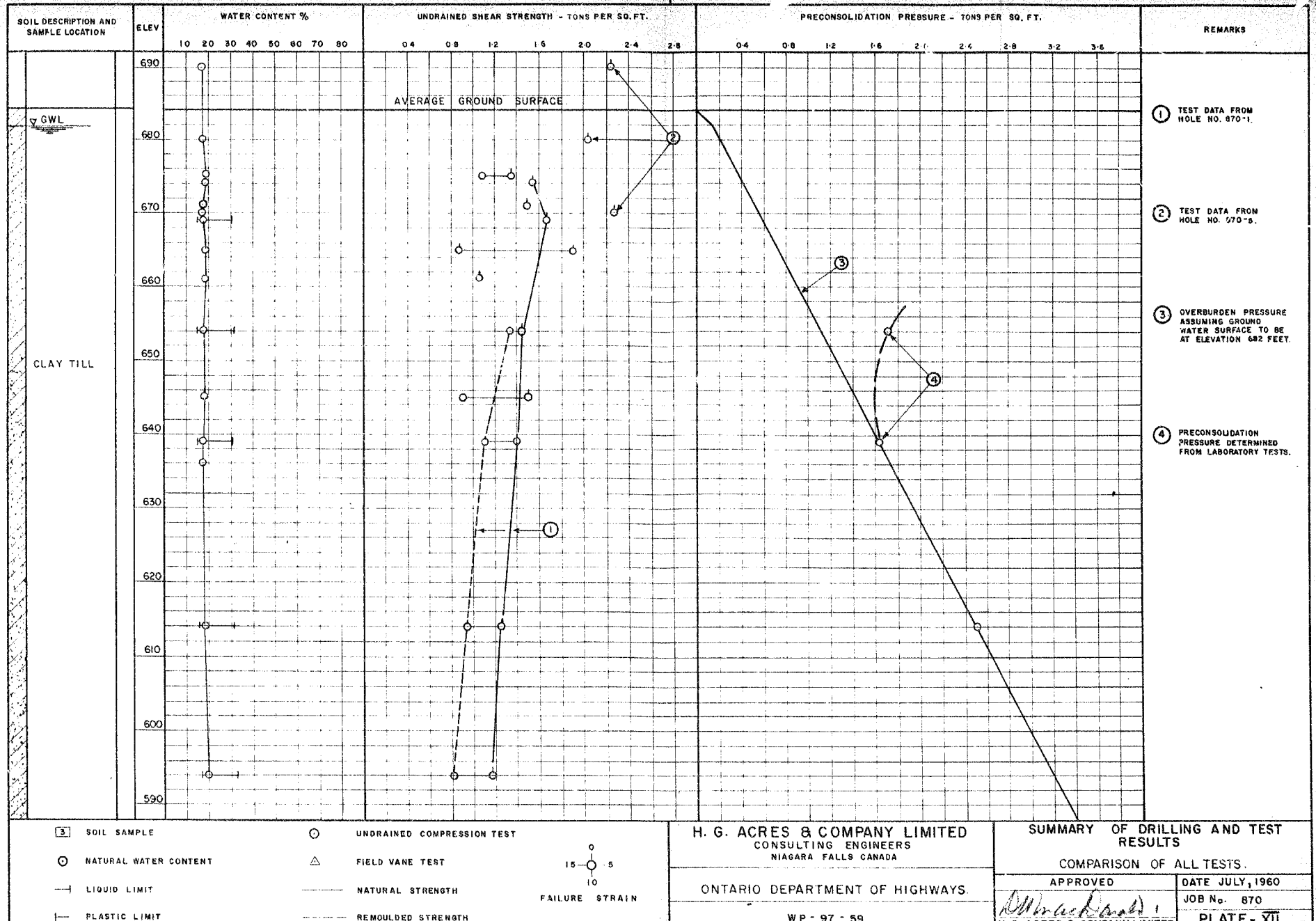
APPROVED

D. MacDonald
H G ACRES & COMPANY LTD.

DATE JULY 1960.

JOB No. 870

PLATE XI



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

ONTARIO DEPARTMENT OF HIGHWAYS.

WP - 97 - 59

SUMMARY OF DRILLING AND TEST RESULTS

COMPARISON OF ALL TESTS.

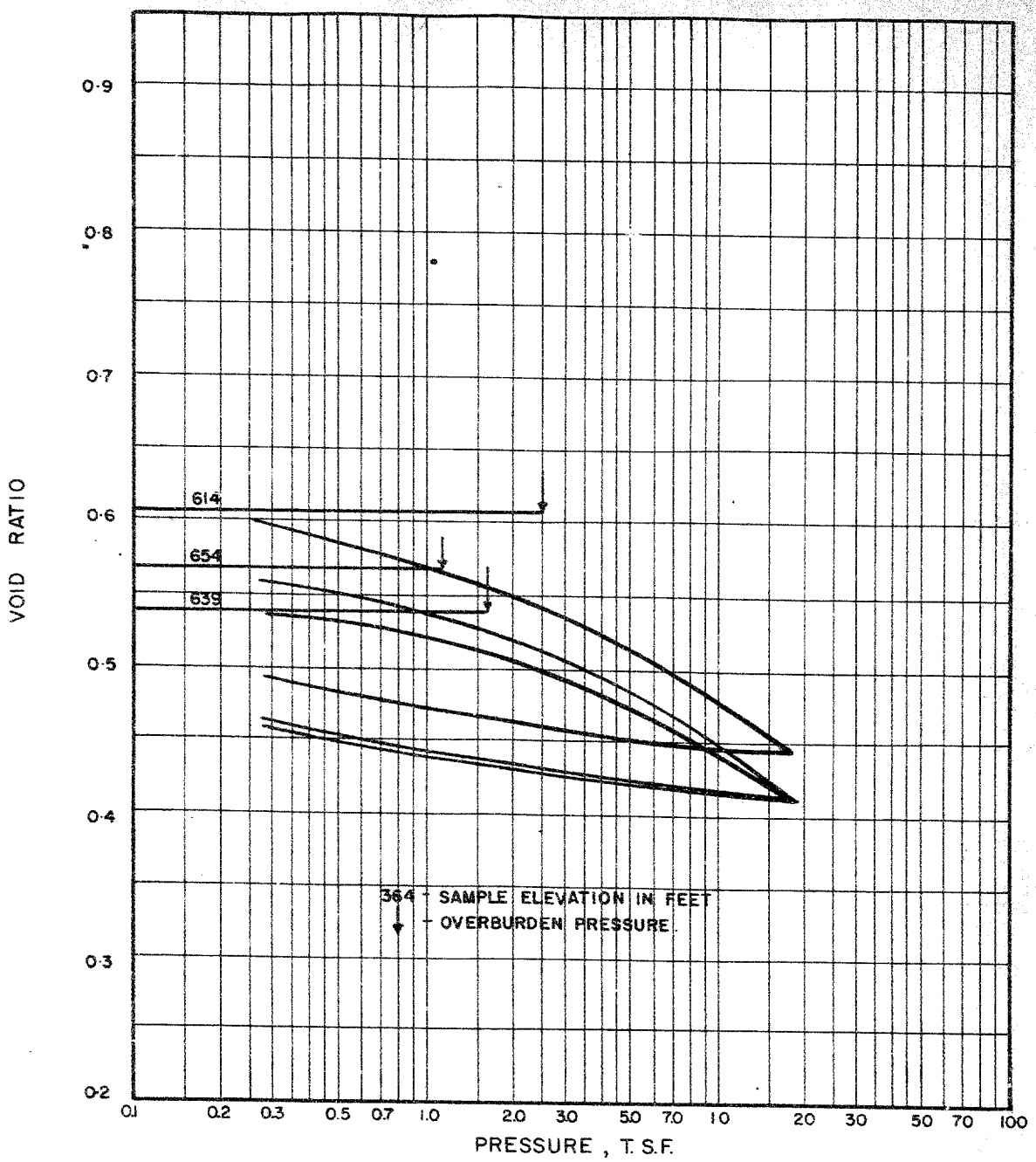
APPROVED

H.G. ACRES & COMPANY LIMITED

DATE JULY, 1960

JOB No. 870

PLATE - XII.



OVERBURDEN PRESSURE — P_o = _____ NATURAL WATER CONTENT _____

CONSOLIDATION PRESSURE — P_c = _____ LOADING INTERVAL _____

SAMPLE No. _____ TEST DATE _____

TEST No. _____ TESTED . BY _____

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

ONTARIO DEPARTMENT OF HIGHWAYS

W P - 289 - 59

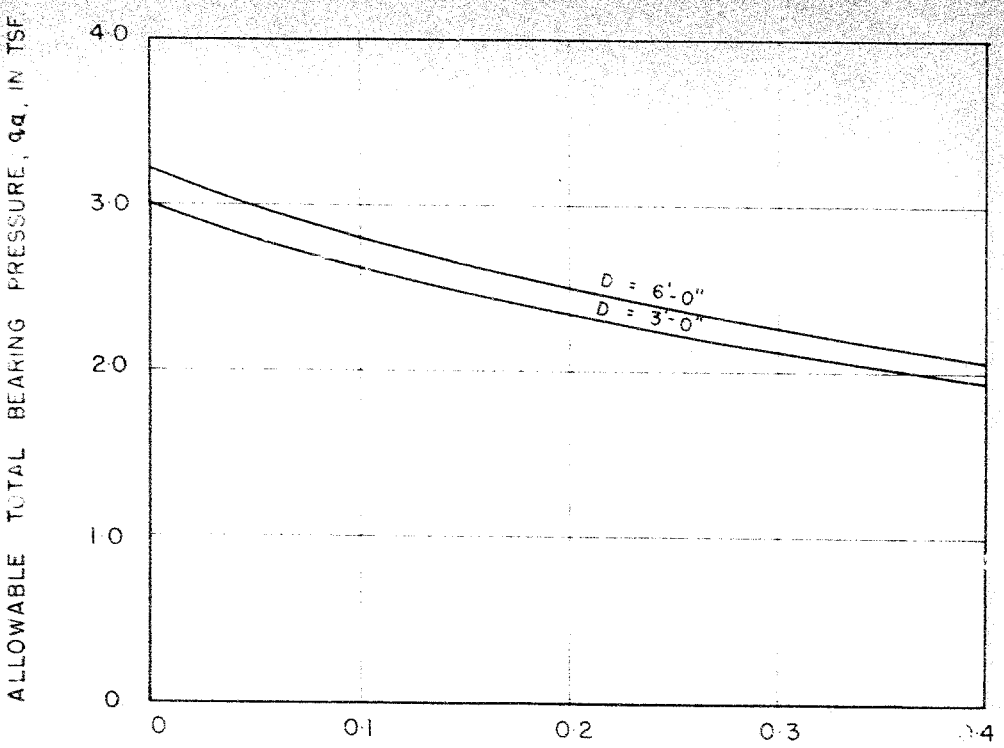
CONSOLIDATION TEST
COMPARISON OF ALL TESTS.

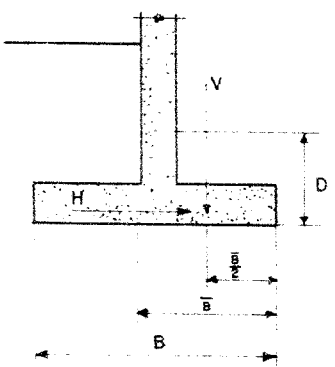
APPROVED
H.G. ACRES & COMPANY LTD.

DATE: JULY, 1960.

JOB No. 870.

PLATE XIII





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.

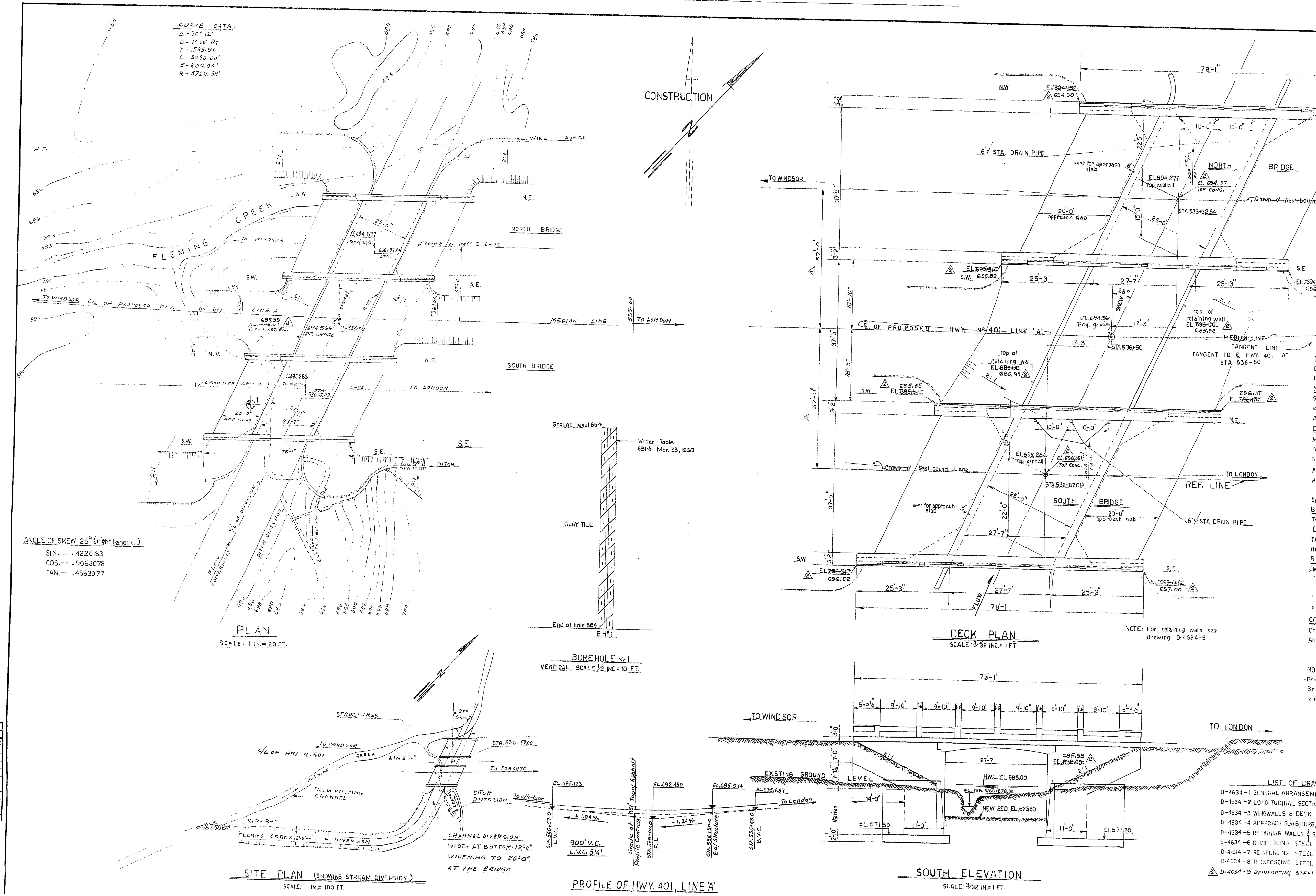
H. G. ACRES & COMPANY LIMITED
CONSULTING ENGINEERS
NIAGARA FALLS CANADA.

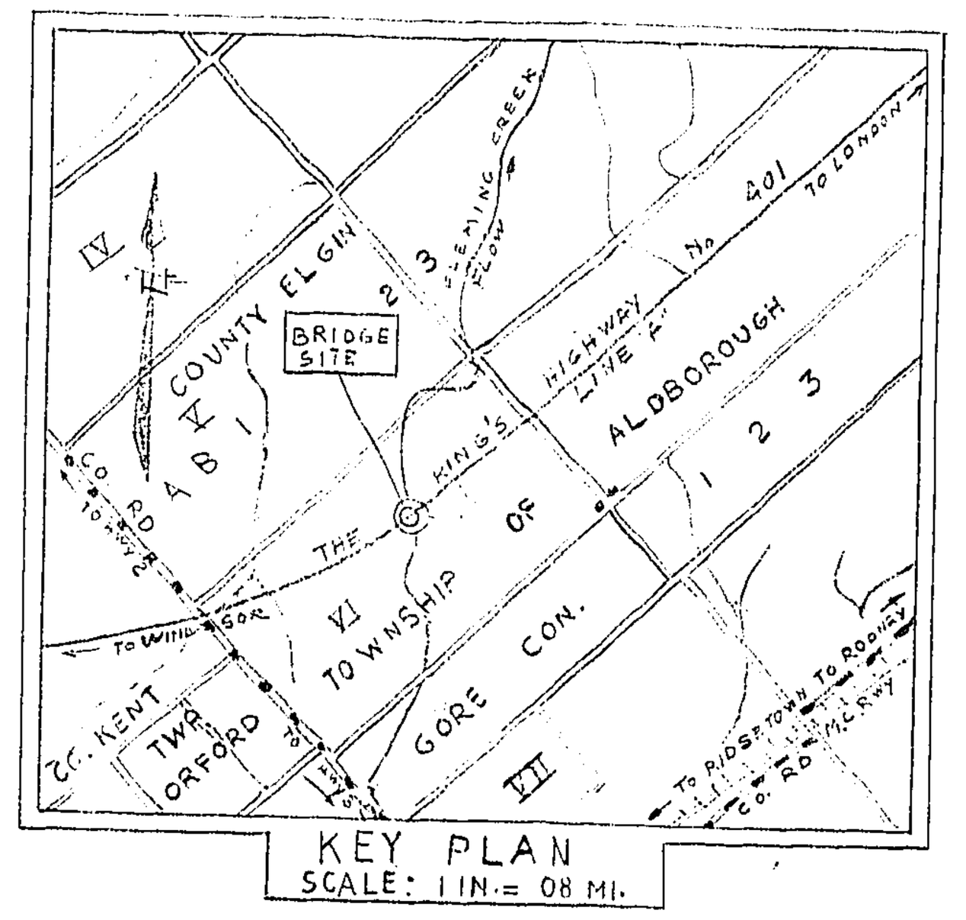
ONTARIO DEPARTMENT OF HIGHWAYS.

WP-289-59.

ALLOWABLE TOTAL BEARING PRESSURES FOR STRIP FOOTINGS.

APPROVED	DATE JULY 1960
H.G. ACRES & COMPANY LIMITED.	SCALE. / JOB NO. 870.
	PLATE- XIV





26-1

GENERAL NOTES

NOTE TO DISTRICT ENGINEER

Concrete work on this structure must not be commenced until monuments to fix control points have been erected and checked by the District Engineer.

NOTE TO CONTRACTOR

Structure to be built in accordance with Form Nº9 revised March 1957 and the Special Provisions, extra copies of which may be obtained from the District Engineer.

All construction joints must be approved by the Bridge Engineer.

CONCRETE MIX

Minimum concrete strength @ 28 days. p.s.i.

Footings	—2500 p.s.i.	–Maximum size aggregate 1½ inches
Structure	—3000 p.s.i.	– " " " ¾ "
Above Curbs	—3000 p.s.i.	– " " " ¾ "
Approach slab	—3000 p.s.i.	– " " " ¾ "

An approved admixture supplied by the Department will be added to all concrete as specified by the Engineer.

BORING DATA

The complete soil investigation report BA 1105 may be examined at the Bridge Office, DOWNSVIEW, ONT.

The Department does not guarantee the accuracy of this report or the abridged version shown on these plans.

REINFORCING STEEL

Clear cover in all concrete in contact with earth - 3 inches (Footings, Abutments)
" " " Slab 1½ inches at top and bott.
" " " Curbs —2 "
" " " Wingwalls —2 "
" " " Handrails and Posts — 1½ inches

CONSTRUCTION NOTES

Chamfer on top of curb — 2 inches
All other exposed edges to be chamfered 1 inches

NOTE
- Bridge roadways have been increased 5inch to take care of horizontal curve
- Bridge to be built parallel to reference lines, where reference lines are parallel to tangent line.

LIST OF DRAWINGS

D-4634-1 GENERAL ARRANGEMENT
D-4634-2 LONGITUDINAL SECTION & FOOTING PLAN
D-4634-3 WINGWALLS & DECK SECTIONS
D-4634-4 APPROACH SLAB, CURB, HANDRAIL & SECTIONS
D-4634-5 RETAINING WALLS & SECTION
D-4634-6 REINFORCING STEEL SCHEDULE
D-4634-7 REINFORCING STEEL SCHEDULE
D-4634-8 REINFORCING STEEL SCHEDULE
△2 D-4634-9 REINFORCING STEEL SCHEDULE

WP 289-59

DEPARTMENT OF HIGHWAYS:-ONTARIO-
BRIDGE OFFICE:-TORONTO-

FLEMING CREEK BRIDGE

(ALDBOROUGH TWP N. 12)

THE KING'S HIGHWAY No. 401 LINE "A"
CO. ELGIN — DIST. No. 2
TWP. ALDBOROUGH — LOT C or T — CON. VI

GENERAL ARRANG

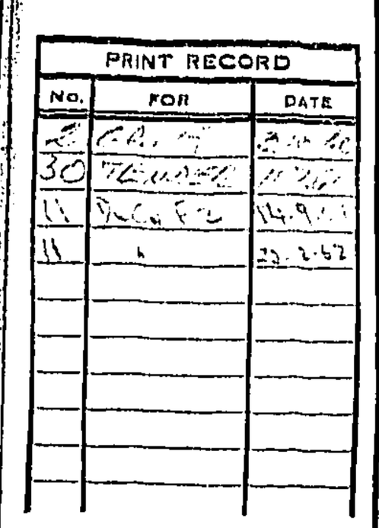
APPROVED
BRIDGE ENGINEER
62092

DESGN A.R.B. CHECK

REVISIONS:
17 FEB.65 P.K. △ ELEV. REVISED. DWG. D-4634-9 ADDED.
6/4/... J.G.G. △ DIMENSIONS REMOVED & ADDED.
7.2.62 V.B. Vertical Curve Added & Elevations Revised

REFERENCE PLANS
E-2769-1
F-3881

TWP. 110-114-1-A



APPENDIX B

Site Photographs

Photograph 1: Viewing east from the west side of the Fleming Creek Bridge WBL structure at the east abutment wall. Scouring effect of the exposed ground was evident. The weep holes in the abutment and retaining walls were open and wet. (October 20, 2013)

Photograph 2: Viewing east from the west side of the Fleming Creek Bridge WBL structure at the east median retaining wall structure. Partial vegetation and some rock protection on the slope ground were observed. The weep holes in the retaining walls were open and wet. (October 20, 2013)

Photograph 3: Viewing east from the west side of the Fleming Creek Bridge EBL structure at the east abutment wall. Surficial cracks were observed on the abutment wall. Scouring effect of the exposed ground was evident. The weep holes in the abutment and retaining walls were open and wet. (October 20, 2013)

Photograph 4: Viewing west from the east side of the Fleming Creek Bridge WBL structure at the west abutment wall. Surficial cracks were observed on the abutment wall. Scouring of the exposed ground was evident. The weep holes in the abutment and retaining walls were open and wet. (October 20, 2013)

Photograph 5: Viewing west from the east side of the Fleming Creek Bridge EBL structure at the west abutment wall. Slight scouring of the exposed ground was evident. The weep holes in the abutment and retaining walls were open and wet. (October 20, 2013)