FOUNDATION TECHNICAL MEMORANDUM

For

QUEEN STREET EBL OVERPASS ON HIGHWAY 401
MTO WEST REGION 59 STRUCTURE REHABILITATIONS
SITE 6-51-1, CONTRACT 7
GWP 3084-11-00
TOWNSHIP OF TILBURY NORTH
KENT COUNTY, ONTARIO

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Peto MacCallum Ltd.
CONSULTING ENGINEERS

FOUNDATION TECHNICAL MEMORANDUM
For
Queen Street EBL Overpass, Highway 401
MTO West Region 59 Structure Rehabilitations
Contract 7, GWP 3084-11-00
Geographical Township of Tilbury North
Kent 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 Queen Street East Bound Lanes (EBL) Overpass. The Foundation Engineering recommendations from the existing overpass 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 overpass structure is anticipated and that the rehabilitation will be completed in a single stage using median crossovers.

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 noted.

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2. PROJECT SITE BACKGROUND AND GEOLOGY

The Queen Street Overpass on Highway 401 is located in the Geographic Township of Tilbury North, Kent County, Ontario. A key plan is shown in Figure 1.

The existing overpass is a single span reinforced concrete rigid frame structure that carries two lanes of Highway 401 Eastbound traffic. Currently, there is a residential community south of the overpass structure and at the north of the structure there is mixed industrial and agricultural developments.

Physiographically, the site is located on the Essex Clay Plain of the St. Clair Clay Plain, which consists of a flat and relatively deep deposit of typically very stiff clayey silt and silty clay till. The bedrock underlying the Highway 401 alignment throughout the Geographical Township of Tilbury North comprises mostly of the black bituminous shale of the Kettle Point Formation containing grey shale and 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. Foundation Report on Highway 401 Line 'B' & Queen Street Crossings at Tilbury, Lot 22, Con. IV, Township of Tilbury East & North, W.J. F-59-2, W.P. 161-58, Materials and Research Section, Department of Highways Ontario, June 22, 1959. GEOCRES NO. 40J08-002.

2. General Plan - Tilbury North Township Bridge No. 1, Queen St. Overpass, WP 161-58, TWP 105-51-1-1A, Department of Highways Ontario, dated January 1960.

4. SITE RECONNAISSANCE

As part of the current foundation engineering assessment study, a site reconnaissance of the Queen Street EBL Overpass (Photograph 1) was carried out on October 20, 2013. A photographic record of the site visit is attached in Appendix B.

The adjacent slopes of the abutments were observed to be vegetated and were restrained by retaining wall structures (Photographs 2 and 3). No erosion of the slope faces was observed. No obvious major cracks were observed on the abutment walls except for some minor cracks. Open weep holes were observed in the abutment walls (Photographs 2 and 3). Concrete deteriorations and rebar exposure was observed on the wingwalls, deck and barriers, which will require rehabilitation.

5. PREVIOUS FIELD INVESTIGATION AND SUMMARIZED SUBSURFACE CONDITIONS

The site is located on Highway 401 in the Geographic Township of Tilbury North, Ontario. The general subsurface conditions presented in this section are based on the Foundation Report, GEOCRES 40J08-002, dated June 22, 1959.

The foundation report includes the borehole location plan (Drawing No. F59-2A), Record of Borehole and Penetration sheets (1 to 4) and summary of the Field and Laboratory tests.

The subsurface investigation was carried out in the period between January 5 and 16, 1959. The investigation comprised three boreholes, 1 to 3, including adjacent dynamic cone penetration tests (DCPT) and one separate DCPT, test hole 4. An additional borehole was completed adjacent to borehole 3 to confirm similar subsoil conditions; however, the borehole log for the additional boreholes was not presented in the report.

The field investigation was carried out by a standard diamond drill adapted for soil sampling. Wash boring procedures were followed and samples were recovered at 1.5 m depth intervals. Samples were obtained using 50.8 mm (2 in.) I.D. thin walled Shelby tube samplers or 50.8 mm (2 in.) O.D. split barrelled spoon samplers.

The three boreholes were drilled between 12.6 and 14.2 m. The DCPTs were advanced to 6.3 to 10.7 m, where either the DCPT was terminated or met refusal. An additional borehole was investigated adjacent to borehole 3 to confirm similar subsoil conditions; however, the borehole log was not presented in the report.

In summary, a surficial layer of topsoil over hard to very soft silty clay layer was encountered at the site location.

Topsoil

A 300 mm thick surficial frozen topsoil layer was encountered in the three boreholes which extended to elevation 176.5 to 176.6.

Silty Clay

Below the topsoil layer hard to very soft silty clay deposit was encountered in the three boreholes at 0.3 m, elevation 176.5 to 176.6. The silty clay extended to borehole termination depths 12.6 to 14.2 m, elevation 162.8 to 164.1. The consistency of the silty clay diminished with depth in the boreholes. The silty clay stratum could be divided to two parts.

The upper 7.6 m silty clay was believed to be desiccated, resulting in higher stiffer condition than the silty clay encountered at depth below 7.6 m. The upper 3.7 to 4.3 m silty clay was subjected to oxidation giving its brown color. The color changes to predominately grey below the oxidized layer. Laboratory shear strength tests obtained an average 95.8 kPa (2000 psf), representative of the upper 7.6 m silty clay layer. Further, the layer appeared to be saturated and preconsolidated, which was confirmed by the consolidation test results. The coefficient of volume compressibility was 7.3×10^{-5} m^2/kN (0.007 sq.ft/ton) and the coefficient of consolidation was 0.013 m^2/day (0.14 sq.ft/day) for the upper 7.6 m silty clay layer. N values recorded ranged between 9 and 45 which represent the consistency of stiff to hard for this portion of silty clay, however, the N value of 9 was mostly recorded in the boundary of upper portion with the lower one.

This upper silty clay contained approximately 54% clay, 23% silt, 17% sand and 6% gravel sized particles. The Atterberg liquid limits ranged from 25.0 to 35.7 and plastic limits ranged between 14.2 and 18.7 for the silty clay samples. The plasticity index ranged from 10.7 to 16.3. The Atterberg liquid and plastic limits averaged 30 and 18, respectively. The unit weight of the upper silty clay samples varied from 19.6 to 20.9 kN/m^3. Moisture content determinations ranged from 15.1 to 22.8%. The average unit weight and moisture content for this upper silty clay were approximately 20.3 kN/m^3 and 20%, respectively.

Below 7.6 m, typically soft to stiff silty clay stratum was encountered. This softer stratum was explored to a depth of 23.5 m, elevation 153.3, in the additional borehole adjacent to borehole 3. Laboratory shear strength tests showed that the strength decreases with depth and reaches a constant of 38.3 kPa below about 11.3 m, elevation 165.5. The compression index obtained was 0.16 and coefficient of consolidation was 8.1 x 10^{-3} m^2/day (0.0875 sq.ft/day), indicating that the soil is normally consolidated. N values in the lower soft to stiff silty clay stratum recorded typically ranged between 2 and 10, with N values of 12, 16 and 14 recorded in boreholes 1, 2 and 3, respectively.

This lower silty clay layer contained approximately 55% clay, 22% silt, 17% sand and 6% gravel sized particles. The Atterberg liquid limits ranged from 25.0 to 34.3 and plastic limits ranged between 16.9 and 18.9 for the lower silty clay samples. The Atterberg liquid and plastic limits averaged 30 and 18, respectively. The plasticity index ranged from 8.1 to 15.4. In-situ vane test shear strengths obtained ranged from 88.1 to 26.8 kPa, diminishing with increasing depth. Further, unit weight of the lower silty clay samples varied from 19.2 to 20.2 kN/m^3. Moisture content determinations ranged from 21.1 to 25.7%. The average unit weight and moisture content for this lower silty clay were 19.5 kN/m^3 and 25%, respectively.

Groundwater

Groundwater was not encountered in the three boreholes during and upon completion of augering. The water level of Lake St. Clair at the time of original investigation was at approximate elevation 175.0.

The groundwater table could not be established due to the impermeable nature of the silty clay stratum. However, the moisture content determinations indicated that the the silty clay samples recovered were fully saturated and that it was assumed the groundwater table was at or slightly below the existing ground surface.

6. FOUNDATION

6.1 Previous Foundation Discussions and Recommendations

Based on the field investigation and laboratory tests, the report recommended that spread footings should be founded on the upper hard to stiff silty clay stratum at about elevation 175.0 (574 ft) or below for a footing width of 2.2 to 3.0 m (7 to 10 ft). An allowable bearing pressure of 240 kPa (2.5 tsf) and a safety factor of 3 were recommended for the spread footings design. Based on the borehole 1 to 3 elevations, it was inferred that footing at elevation 175.0 (574 ft), approximately 1.8 to 1.9 m below ground surface, would have sufficient earth protection from frost action. It was recommended that the footing should not be founded below elevation 172.2 to avoid overstressing and excessive settlement of the thick soft clay stratum.

It was estimated that the long-term settlements under the footings will be in the order of 150 mm (6 in.) as a result of the application of 240 kPa (2.5 tsf) abutment footing pressure and 172 kPa (1.8 tsf) of approximately 8.5 m fill embankment load. Due to the slow rate of consolidation of the silty clay, it was anticipated that a settlement of 76 mm (3 in.) would occur in the period of 50 years. Differential settlement was estimated in the order of 25 mm (1 in.) to 38 mm (1.5 in.). Further, it was anticipated that if a single span structure was considered then little differential settlement was to be anticipated since the abutments would settle the same amount. However, if a multi-span structure was considered, then the amount of differential settlement should be considered because the footings under the centre pier would not be affected by the fill adjacent to the abutments causing the differential settlement.

It was estimated that the maximum height of fill would be 8.5 m (28 ft) based on the original proposed grade line of Queen Street. No approach fill stability problem was anticipated at the site location.

It was inferred that the amount of seepage inflow during footing excavations will be of minor quantities because water-bearing sand seams or artesian water conditions were not encountered during the field investigation. No ground water problem was anticipated with respect to shallow footing excavation.

Based on the drawing, titled 'Tilbury North Township Bridge 1 - General Plan', dated January 1960, the footings were to be founded at approximate elevation 175.0 (574 ft). Further, it was indicated that retaining walls were to be constructed to retain the adjacent earth slopes. The footing founding elevation of the retaining walls was shown at approximate elevation 175.0. The original ground slopes were shown to be cut back and were to be graded at 2H:1V at the bridge site location. Drainage system was shown under the pavement in the drawing.

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 and Type	Elevation of Footings (m)	Previous Safe Bearing Resistance (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	175.0 (574 ft)	2.5	240	360	350	525
West Abutment on Spread Footing						

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

The Queen Street EBL Overpass on Highway 401 is located in the Geographic Township of Tilbury North, Kent County, Ontario. The existing overpass is a single span reinforced concrete rigid frame structure that carries two lanes of Highway 401 Eastbound traffic.

From a geotechnical point of view, at the present time, foundation work for the Queen Street EBL Overpass structure is not expected provided that the dead load on the overpass does not increase or decrease by more than 10%.

It is understood that rehabilitation of the bridge structure is anticipated and that rehabilitation will be completed in a single stage using median crossovers.

Further, it is suggested that the weep holes in 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 and retaining walls.

8. CLOSURE

This Technical Memorandum was prepared by Mr. Nazibur Rahman, P.Eng with the assistance of Mr. Mansoor Khorsand, EIT and was reviewed by Mr. Robert Ng, PhD, P.Eng. Mr. Brian 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.
Project Engineer, Geotechnical Services

Robert Ng, MBA, PhD, P.Eng.
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

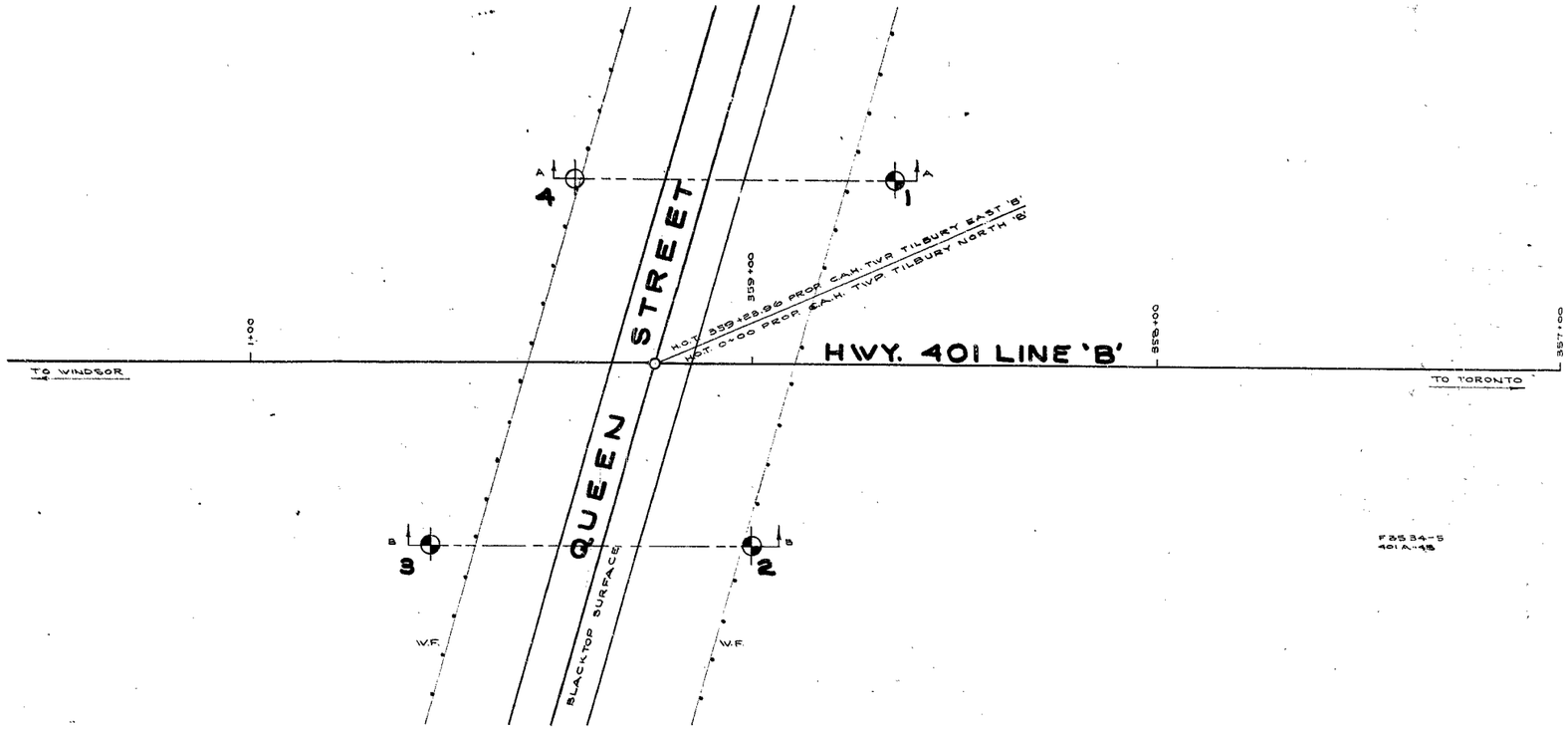
Figure 1 – Key Plan

APPENDIX A

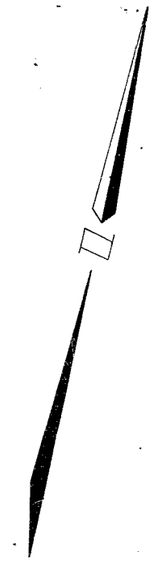
Foundation Report at Queen St. Overpass (GEOCRES 40J08-002)

General Plan– Tilbury North Township Bridge No. 1, Queen Street Overpass, dated January 1960

59-F-2
W.P. # 161-58
Hwy. # 401
Queen St.
Crossing At
Tilbury

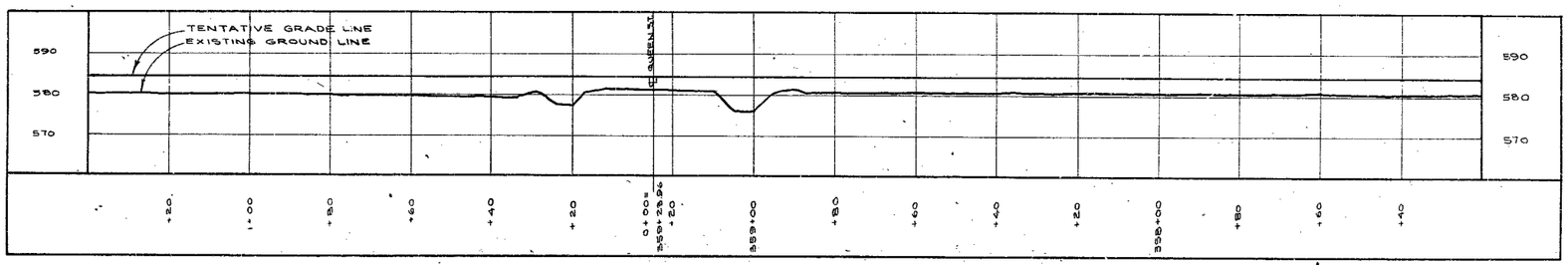


PLAN



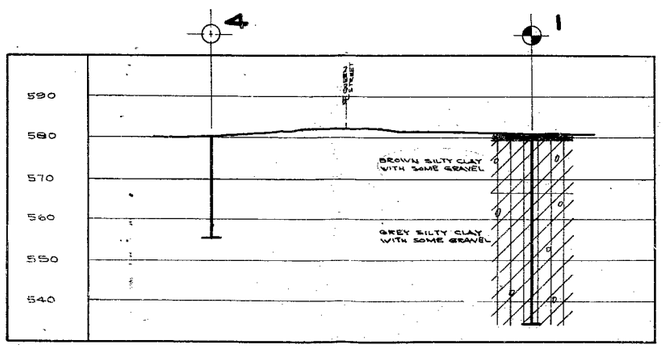
LEGEND	
BORE HOLE	●
PENETRATION HOLE	⊕
BORE & PENETRATION HOLE	⊕

HOLE NO.	ELEVATION	STATION	DISTANCE FROM ℄
1	580.5'	358+65	45' RT.
2	580.5'	359+00	45' LT.
3	580.0'	00+55	45' LT.
4	580.0'	00+20	45' RT.

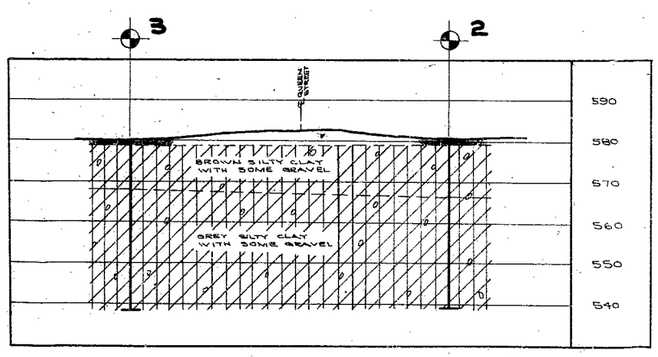


PROFILE

F 3534-9
401 A-47



A-A



B-B

— NOTE —

THE BOUNDARIES BETWEEN SOIL STRATA HAVE BEEN ESTABLISHED ONLY AT BORE HOLE LOCATIONS. BETWEEN BORE HOLES THE BOUNDARIES ARE ASSUMED FROM GEOLOGICAL EVIDENCE AND MAY BE SUBJECT TO CONSIDERABLE ERROR.

DEPARTMENT OF HIGHWAYS-ONTARIO
MATERIALS & RESEARCH SECTION

QUEEN STREET PROPOSED CROSSING

SHOWING POSITIONS & ELEVATIONS OF HOLES

HWY 401 DISTRICT 1 COUNTY ESSEX & KENT
TOWNSHIP TILBURY EAST & NORTH LOT 22 CON. 4
LOCATION AT TILBURY

DRAWN BY: T. MELLORS	CHECKED BY:	V.P. 161-59
DATE MARCH 12/59	APPROVED BY:	DRAWING NO. F 59-2A
SCALE 1" = 20'		

23-60-111 L

ONTARIO
DEPARTMENT OF HIGHWAYS

Memo to Mr. A. M. Toye, *Date* June 22, 1959.

Bridge Engineer. *Subject* Re: FOUNDATION REPORT -

From Materials & Research Section. W.P. 161-58 - W.J. F-59-2.

Attention: Mr. S. McCombie.

Hwy. 401 Line 'B' & Queen Street Crossing,
at Tilbury,
Lot 22, Con. IV, Twp. of Tilbury E. & N.

Enclosed herewith is our report on the subsoil conditions existing at the above noted site. The field work consisted of three sampled borings carried out to a maximum depth of 77 feet. The subsoil stratigraphy consists of a deep deposit of lacustrine, silty clay containing a minor percentage of fine to medium gravel. The upper 25 feet of this deposit was found to be in a stiff, preconsolidated state. The lower zone of the deposit was found to be normally consolidated. The stiff consistency of the upper layer is the result of desiccation and oxidation.

For your convenience, the principal recommendations outlined in this report, are summarized as follows:-

(1) Spread footing support can be obtained at a shallow depth at this site. A safe permissible bearing capacity of 2 1/2 tons/sq. ft. can be applied at or below elevation 574' (i.e., six feet below ground surface).

(2) Settlement resulting from the consolidation of the subsoil due to footing and embankment loads at the abutment location, has been estimated as six inches. Movement of the order of three inches can be expected within the first fifty years. If a single-span structure is to be used, differential movement should not exceed one inch.

cont'd. /2 ...

Recommendations: (cont'd.) ...

(3) If a multi-span structure is decided upon, the general layout should be reviewed by the Foundation Section to determine the magnitude of differential settlement expected between abutment and adjacent piers.

(4) The subsoil has sufficient strength to safely support the proposed embankment loadings.

(5) Ground water conditions are such that no problems need be anticipated with respect to excavations for footings. No artesian conditions were noted in any of the borings.

If any questions arise with respect to the contents of this report, please contact our office.

LGS/MdeF
Encl.

L. G. Soderman,
PRINCIPAL FOUNDATIONS & SOILS ENGINEER.

cc: Messrs. A. M. Toye
H. A. Tregaskes
D. G. Ramsay
H. Orlando
G. U. Howell
J. Roy
Dr. P. Karrow

Foundation Section.

Gen. Files.

FOUNDATION REPORT

on

Hwy. 401 Line 'B' & Queen Street Crossing,
at Tilbury,
Lot 22, Con. IV, Twp. of Tilbury E. & N.

Plan No: F-3534-5

Profile No: F-3534-9

Chainage: Sta. 359+23.96

Distribution:

Mr. A. M. Toye, Bridge Engineer.	(2)
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Dr. P. Karrow, Department of Mines.	(1)
Foundation Section.	(1)
Gen. Files.	(1)

W.J. F-59-2

W.P. 161-58.

INTRODUCTION:

Presented in this report are the results of a subsoil investigation carried out at a structure location where proposed Hwy. 401 Line 'B' underpasses Queen Street in Tilbury, Lot 22, Con. IV, Township of Tilbury East & North (Station 359+23.96, Profile No. F-3534-9). This report contains the field and laboratory findings and recommendations for the foundation of the proposed structure.

The field work commenced on Jan. 5, 1959 and was completed on Jan. 16, 1959.

DESCRIPTION OF THE SITE & GEOLOGY:

The site and its surrounding areas are generally flat farmlands presently under cultivation. At the time of the investigation, the area was covered by ice and snow.

Physiographically, the site under consideration is located on the Essex Clay Plain of the St. Clair Clay Plains, inundated by Glacial Lakes Whittlesey and Warren. According to available geological information, these extensive plains covering a large area of South-Western Ontario, are covered by deep deposits of clay, underlain by limestone or shale bedrock. At this site, the upper zone of the clay stratum was found to be desiccated and exists in a stiff condition for a depth of approximately 25 feet.

cont'd. /2 ...

DESCRIPTION OF FIELD & LABORATORY WORK:

Field work consisted of 3 sampled boreholes carried out by a standard diamond drill adapted for soil sampling. Conventional wash boring procedures were followed and samples were recovered at depth intervals of 5 feet. Samples were obtained by means of 2" I.D. thin-walled shelby tube samplers or a 2" O.D. split barrelled spoon sampler. The dimensions of this spoon sampler and the energy used in driving it conform to requirements of the Standard Penetration Test. In addition, dynamic cone penetration tests adjacent to each sampled borehole, one separate dynamic cone penetration test and in-situ vane shear tests were carried out. Immediately after the investigation, an additional boring was made adjacent to B.H. No. 3 to confirm the similar subsoil conditions that were encountered in other sites recently investigated in this area. Borehole log for this additional boring is not presented in this report and has been kept for reference.

Upon receipt in the laboratory, samples were visually examined and identified. Routine index tests were performed on selected representative samples. Laboratory test results have been presented in the borehole logs and detailed in tabular form.

The location plan and subsoil profile are presented in Drawing No. F-59-2A.

SUBSOIL CONDITIONS:

Subsoil conditions at this site are similar to other sites recently investigated in this area. Reference to the borehole logs shows that the site is underlain by a stiff silty clay crust followed by the thick stratum of soft to medium silty clay.

cont'd. /3 ...

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

In each of the sampled boreholes, the frozen topsoil was found to be underlain by a 25-foot stiff crust of silty clay extending from Elevations 580' to 555'. Underneath the stiff crust the stratum of soft to medium silty clay was encountered. This stratum was explored to a depth of 77 feet below the ground surface (i.e. Elev. 503') in the additional boring adjacent to B.H. No. 3. In general, the soil types encountered are as follows:-

1. Stiff Silty Clay -

The stiff condition of this upper crust is believed to be the result of desiccation. The upper 12' to 14' has been subjected to oxidation resulting in its present brownish colour. Below the oxidized zone the colour is predominantly grey. The material contains approximately 23% silt, 17% sand and 6% fine to medium gravel throughout. The average unit weight and moisture content were found to be 130 p.c.f. and 20%, respectively. Liquid and plastic limits averaged 30% and 18%. Laboratory shear strength tests show an average of 2000 p.s.f. to be representative for the 25-ft. layer. Judging from its moisture content and Atterberg limits, the stiff silty clay appears to be saturated and preconsolidated. This is borne out by the consolidation test results.

2. Soft to Medium Silty Clay -

Underneath the stiff clay crust the thick stratum of soft to medium silty cla was encountered. The colour is predominantly grey. It contains approximately 22% silt, 17% sand and 6% fine to medium gravel throughout. The average unit weight

cont'd. /4 ...

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

2. Soft to Medium Silty Clay - (cont'd.) ...

and moisture content were found to be 125 p.c.f. and 25%, respectively. Liquid and plastic limits averaged 30 and 18%. Laboratory tests show that the shear strength of the silty clay decreases with depth and reaches a constant value of 800 p.s.f. below approximately Elev. 543'. A plot of shear strength versus depth has been presented and is included in this report under Appendix I. The silty clay is fully saturated and laboratory consolidation test results indicate that it is normally consolidated.

Laboratory and field test results have been summarized in Table No. I. and are included in this report under Appendix I.

WATER CONDITIONS:

No ground water was encountered throughout the depths of boring during the investigation. The water level of Lake St. Clair is presently at approximately Elev. 574'.

Due to the impermeable nature of the subsoil strata, it was not possible to accurately establish the elevation of the ground water table during the boring programme. The samples obtained were fully saturated, and the ground water table has been assumed at or slightly below the existing ground surface. In view of the fact that no water-bearing sand seams or artesian water conditions were encountered during the time of boring, the amount of seepage inflow during footing excavations will be of minor quantities, only.

cont'd. /5 ...

FOUNDATION CONSIDERATIONS:

The upper stiff clay crust is competent to provide adequate foundation support for the proposed structure. Laboratory and field test results are such that spread footing support can be obtained in the stiff silty clay at Elev. 574' or below. At this elevation or below, for footings of 7' to 10' in width, an allowable bearing pressure of 2 1/2 t.s.f. incorporating a safety factor of 3, can be used for spread footing design. Footings founded at Elev. 574' are believed to have sufficient protection from frost action. To avoid overstressing and excessive settlement in the thick stratum of soft clay, footings should not be founded below Elev. 565'.

Long-term settlements under the footings, as a result of the application of 2 1/2 t.s.f. abutment footing pressure and 1.8 t.s.f. embankment load due to approximately 28 feet of fill, have been estimated as of the order of 6 inches. This is due to the fact that the stresses caused by the applied loads will influence the thick stratum of soft to medium silty clay for a considerable depth. In view of the slow rate of consolidation expected of clay, settlement will continue over several decades. For a period of 50 years a total settlement of the order of 3 inches may be anticipated. Differential settlements may be taken as of the order of 1" to 1 1/2". In view of the relatively uniform subsoil conditions at the site, little differential settlements of any consequence need be anticipated of a single-span structure since each abutment will virtually settle the same amount. This

cont'd. /6 ...

FOUNDATION CONSIDERATIONS: (CONT'D) ...

amount of settlement is significant, however, for a multi-span structure where centre piers are incorporated, since long-term differential movement between the abutment and the piers would result due to the fact that consolidation of the footings under the piers would be unaffected by the fill adjacent to the abutments. It appears that if a multi-span design is contemplated, consideration should be given to the amount of differential settlement the structure can tolerate.

Under the proposed grade line of Queen Street, the maximum height of fill is approximately 28 ft. The subsoil can safely support this embankment loading. The proposed grade line of Hwy. 401 does not present any approach fill stability problem.

No excessive seepage problems with respect to shallow footing excavations are anticipated.

CONCLUSIONS & RECOMMENDATIONS:

(1) The site is underlain by a stiff clay crust followed by deep deposits of soft to medium silty clay.

(2) Subsoil conditions are such that spread footing support can be obtained in the upper stiff clay crust at Elev. 574' or below. At this elevation, or below, for footings of 7' to 10' in width, an allowable bearing pressure of 2 1/2 t.s.f. can be used for spread footing design. Footings founded at Elev. 574' are believed to have sufficient protection from frost action. To avoid overstressing and excessive settlement in the thick stratum of soft clay, it is recommended that footings should not be founded below Elev. 565'.

cont'd. /7 ...

CONCLUSIONS & RECOMMENDATIONS: (cont'd.) ...

(3) Long-term settlements under the footings resulting from the application of 2 1/2 t.s.f. footing pressure and 1.8 t.s.f. embankment load, over a period of 50 years have been estimated as of the order of 3 inches. Differential settlement may be taken as of the order of 1" to 1 1/2". In view of the relatively uniform subsoil conditions at the site, little differential settlements need be anticipated of a single-span structure since each abutment will virtually settle the same amount. If a multi-span design is contemplated, consideration should be given to the amount of differential settlement the structure can tolerate.

(4) The proposed grade line of either Queen Street or Hwy. 401 presents no approach fill stability problems.

(5) No ground water problems with respect to shallow footing excavations are anticipated.

AKLoh

A. K. Loh,
FOUNDATIONS ENGINEER.

APPENDIX I.

FORM CE—ML—222
FEB 59
IM-58-5869

SUMMARY OF FIELD & LABORATORY TESTS

JOB F-59-2
W.P. 161-58

HOLE NO.	SAMP NO.	SAMPLE DEPTH (FEET)	MATERIAL DESCRIPTION	PENETN RESIST. BLOWS FT	MOIST. CONT. %	PLASTIC LIMIT %	LIQUID LIMIT %	SHEAR STRENGTH p.s.f.	UNIT WEIGHT p.c.f.	REMARKS
1	T1	5'-7'	Stiff brown silty clay	37	18.1	18.7	35.7	2880	129.0	
	T2	10'-12'	" " " "	45	18.6	-	-	2430	127.0	Approximately 6% fine to medium gravel throughout
	T3	15'-17'	Stiff grey silty clay	14	22.3	17.5	31.6	-	125.0	
	T4	19'-21'	" " " "	9	22.8	16.8	29.9	-	125.7	
	T5	23'-25'	Medium grey silty clay	-	22.7	14.7	29.0	-	124.9	
	T6	27'-29'	" " " "	12	22.5	-	-	-	124.0	
	T7	31'-33'	" " " "	6	-	-	-	-	-	
	T8	35'-37'	" " " "	9	-	-	-	-	-	
	T9	43'-45'	" " " "	7	-	-	-	-	-	
	S10	45'-46'6"	Soft to med. grey silty clay	2	-	-	-	-	-	
2	T1	5'-7'	Stiff brown silty clay	15	-	-	-	-	-	
	T2	10'-12'	" " " "	37	18.6	17.4	33.7	3380	128.5	Approximately 6% fine to medium gravel throughout
	T3	15'-17'	Stiff grey silty clay	21	15.1	14.3	25.0	2550	132.0	
	T4	19'-21'	" " " "	16	19.7	14.2	29.6	-	-	
	T5	23'-25'	Medium grey silty clay	18	20.8	-	-	-	126.0	
	T6	27'-29'	" " " "	16	21.1	16.9	25.0	936	127.4	
	T7	31'-33'	" " " "	9	-	-	-	-	-	
	S8	35'-36'6"	" " " "	10	-	-	-	-	130.8	
	S9	40'-41'6"	" " " "	9	-	-	-	-	122.4	
3	S1	5'6-7'	Stiff brown silty clay	14	21.3	-	-	2620	129.0	
	S2	10'6"-12'	" " " "	18	18.2	16.4	29.2	3120	133.0	Approximately 7% fine to medium gravel throughout
	S3	15'6"-17'	Stiff grey silty clay	11	20.8	17.2	29.8	1770	131.0	
	S4	19'6"-21'	" " " "	9	21.4	-	-	1520	130.0	
	S5	23'6"-25'	Medium grey silty clay	9	21.9	17.4	29.7	1060	129.0	
	S6	27'6"-29'	" " " "	6	22.3	-	-	994	128.5	
	S7	31'6"-33'	" " " "	10	23.3	-	-	850	127.1	
	S8	40'-41'6"	" " " "	14	23.1	17.4	28.9	865	126.5	
	T9	45'-47'	Soft to med. grey silty clay	11	25.7	-	-	388	125.5	
	T10	50'-52'	" " " " " "	11	25.6	-	-	504	124.5	
	T11	55'-57'	" " " " " "	-	25.1	18.9	34.3	-	124.5	
	T12	65'-66'	Soft to med. grey silty clay with med. sand layers	-	-	-	-	-	-	

SUMMARY OF FIELD & LABORATORY TESTS

JOB F-59-2
W.P. 161-58

HOLE NO.	SAMP NO.	SAMPLE DEPTH (FEET)	MATERIAL DESCRIPTION	PENET'N RESIST. BLOWS FT	MOIST CONT. %	PLASTIC LIMIT %	LIQUID LIMIT %	SHEAR STRENGTH p.s.f.	UNIT WEIGHT p.c.f.	REMARKS
	S13	75'-77'	Soft to med. grey silty clay with sand layers	18	-	-	-	-	-	
		28'	Stiff grey silty clay	-	-	-	-	1760	-	)
		38'	" " " "	-	-	-	-	1840	-	)
		43'	" " " "	-	-	-	-	1280	-	) In-situ vane test.
		53'	Soft to med. grey silty clay	-	-	-	-	560	-	)
		58'6"	" " " " " "	-	-	-	-	720	-	)

Note: Laboratory test results of B.H. No. 3 presented were taken from an additional boring adjacent to B.H. No. 3.

T1 denotes thin-walled shelby samples.
S1 denotes split spoon sample.

Consolidation characteristics:-

Depth 0'-25' :- Coefficient of volume compressibility 0.007 sq.ft./ton.
Coefficient of consolidation 0.14 sq.ft./day.

Depth 25' & below :- Compression index 0.16
Coefficient of consolidation 0.0875 sq.ft./day
Preconsolidation pressure submerged unit weight x depth (normally consolidated)

FORM OB-ML-1

H.D.R.

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & RESEARCH BRANCH - FOUNDATIONS SECTION - DOWNSVIEW

OFFICE REPORT ON SOIL EXPLORATION

DRILL RIG 54-6 OPERATION BORE & PENETRATION JOB F-59-2 W.P. 161-59 BORING 1 STA. 358+65 45' RT.

CASING B X (standard samplers to fit unless noted) DATUM GEODETIC DATE REPORT FEB. 1959

SAMPLER HAMMER WT. 250 LBS. DROP 19 INCHES COMPILED BY H.S. CHECKED BY V.K. DATE BORING 7 JAN. 1959

ABBREVIATIONS

V - INSITU VANE SHEAR TEST
M - MECHANICAL ANALYSIS
U - UNCONFINED COMPRESSION
Q_c - TRIAXIAL CONSOLIDATED QUICK
Q - TRIAXIAL QUICK
S - TRIAXIAL SLOW
WL - WATER LEVEL IN CASING
WT. - WATER TABLE IN SOIL
K - PERMIABILITY
C - CONSOLIDATION
CA. - CASING
γ - UNIT WEIGHT

SAMPLE TYPES

C.S. - CHUNK
D.O. - DRIVE OPEN
D.F. - DRIVE FOOT VALVE
T.O. - THIN WALLED OPEN
S.S. - SLEEVE SAMPLE
P.S. - PISTON SAMPLE
W.S. - WASHED SAMPLE
R.C. - ROCK CORE

SAMPLE CONDITION

- DISTURBED
- FAIR
- GOOD
- LOST

SOIL PROFILE					SHEAR STRENGTH IN lbs/sq foot 2,000 4,000 6,000 8,000	CASING BLOWS (ACTUAL)	SAMPLES					
ELEVATION DEPTH	WATER CONDITIONS	DESCRIPTION	STRAT PLOT	ELEVATION SCALE	WATER CONTENT W% 10 20 30 40 ○ - NAT. □ - P.W. △ - L.W.		OTHER TESTS	CONDITION	TYPE	NO.	PENETRATION RESISTANCE	ELEV. RECOV. %
					PENETRATION TEST RESISTANCE BLOWS PER FOOT AT STANDARD ENERGY (4200 IN. LBS. PER BLOW) D. CONE PEN. X-------X-------X STAND. PEN. 50 100 150 200							
580.5' 0.5		GROUND LEVEL										580.5
579.5' 1.0		TOP SOIL		580		8						
						10						
						13						
						16						
						20						575.5
5.5		STIFF BROWN SILTY CLAY WITH SOME GRAVEL		575		6	γ=129.0 p.c.f.		T.O	1	37	83
						7						
						18						
						32						
						40						570.5
10.5				570		18	γ_s 127.0 p.c.f.		T.O.	2	45	75
						38						
						40						
						43						
566.0 14.5						48						565.5'
15.5				565		60	γ=125.1 p.c.f.		TO	3	14	75
						56						
						50						
						45						561.5
20.5				560		75	γ=125.7 p.c.f.		T.O.	4	9	67
						60						
						50						
						55						557.5
						57	γ=124.9 p.c.f.		T.O.	5		71
25.5		GREY SILTY CLAY WITH SOME GRAVEL		555		55						
						52						
						52						553.5
						55	γ=124.6 p.c.f.		T.O.	6	12	88
						50						
						63						
30.5				550		59						549.5
						60			T.O.	7	6	83
						64						
						71						
						71						545.5
35.5				545	PENETN STOPPED AT ELEV. 545.5	91			T.O.	8	9	83
						93						
						100						
						103						
						123						
40.5				540		123						
						107						
						100						537.5
						90			T.O.	9	7	
						90						535.5
45.5									S.S.	10	2	100
534.0' 46.5'		END OF BOREHOLE		535								
50.5				530								

END OF CASING AT ELEV. 535.5'

FORM OB-ML-12

H.D.R.

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & RESEARCH BRANCH - FOUNDATIONS SECTION - DOWNSVIEW

OFFICE REPORT ON SOIL EXPLORATION

DRILL RIG 54-6 OPERATION BORE & PENETRATION JOB F-59-2 W.P. 161-58 BORING 2 STA. 359+00 45'LT

CASING B X (standard samplers to fit unless noted) DATUM GEODETIC DATE REPORT FEB. 1959

SAMPLER HAMMER WT. 250 LBS. DROP 19 INCHES COMPILED BY H.S. CHECKED BY V.K. DATE BORING 9 JAN. 1959

ABBREVIATIONS

V - INSITU VANE SHEAR TEST
M - MECHANICAL ANALYSIS
U - UNCONFINED COMPRESSION
Q_c - TRIAXIAL CONSOLIDATED QUICK
Q - TRIAXIAL QUICK
S - TRIAXIAL SLOW
W.L. - WATER LEVEL IN CASING
W.T. - WATER TABLE IN SOIL
K - PERMIABILITY
C - CONSOLIDATION
CA. - CASING
γ - UNIT WEIGHT

SAMPLE TYPES

C.S. - CHUNK
D.O. - DRIVE OPEN
D.F. - DRIVE FOOT VALVE
T.O. - THIN WALLED OPEN
S.S. - SLEEVE SAMPLE
P.S. - PISTON SAMPLE
W.S. - WASHED SAMPLE
R.C. - ROCK CORE

SAMPLE CONDITION

- DISTURBED
- FAIR
- GOOD
- LOST

SOIL PROFILE

ELEVATION DEPTH	WATER CONDITIONS	DESCRIPTION	STRAT PLOT
580.5' 0.5		GROUND LEVEL	
579.5' 1.0'		TOP SOIL	
5.5		STIFF BROWN SILTY CLAY WITH SOME GRAVEL	
10.5			
566.5' 14.0'			
15.5		GREY SILTY CLAY WITH SOME GRAVEL	
20.5			
25.5			
30.5			
35.5			
40.5			
539.0' 41.5'		END OF BOREHOLE	
45.5			

ELEVATION SCALE: 580, 575, 570, 565, 560, 555, 550, 545, 540, 535

SHEAR STRENGTH IN LBS/□ FOOT. 2,000 4,000 6,000 8,000

WATER CONTENT W% 10 20 30 40 ○ - NAT. □ - P.W. △ - L.W.

PENETRATION TEST RESISTANCE BLOWS PER FOOT AT STANDARD ENERGY (4200 IN. LBS. PER BLOW)

D. CONE PEN. X-------X-------X STAND. PEN. ●——●——● 50 100 150 200

REFUSAL @ ELEV 559.9' 157 BLOWS FOR 7"

CASING BLOWS (ACTUAL)

5 8 10 12 13 6 9 11 20 35 26 44 58 54 64 43 60 90 112 61 49 100 127 76 108 112 125 124 131 138 131 131 138 142 148 140 152 159 161 165 END OF CASING AT ELEV. 540.5'

SAMPLES

OTHER TESTS	CONDITION	TYPE	NO.	PENETRATION RESISTANCE	ELEV. RECOV. %
					580.5' 0.5
					575.5' 5.5
		T.O.	1	15	83
					570.5' 10.5
γ=128.5 P.C.F.		T.O.	2	37	100
					565.5' 15.5
γ=132 P.C.F.		T.O	3	21	100
					561.5' 20.5
	X	T.O.	4	16	58
					557.5' 25.5
γ=126.0 P.C.F.		T.O.	5	18	79
					553.5' 30.5
γ=127.4 P.C.F.		T.O	6	16	83
					549.5' 35.5
γ=136.3 P.C.F.		T.O.	7	9	75
					545.5' 40.5
γ=130.8 P.C.F.		S.S.	8	10	83
					540.5' 45.5
γ=122.4 P.C.F.		S.S	9	9	78

FORM OB-ML-1

H.D.R.

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & RESEARCH BRANCH - FOUNDATIONS SECTION - DOWNSVIEW

OFFICE REPORT ON SOIL EXPLORATION

DRILL RIG 54-6 OPERATION BORE & PENETRATION JOB F-59-2 W.P. 161-58 BORING 3 STA. 00+55 42'LT.

CASING B"X (standard samplers to fit unless noted) DATUM GEODETIC DATE REPORT FEB. 1959

SAMPLER HAMMER WT. 250 LBS. DROP 19 INCHES COMPILED BY H.S. CHECKED BY V.K. DATE BORING 13 JAN. 1959

ABBREVIATIONS

V - INSITU VANE SHEAR TEST
M - MECHANICAL ANALYSIS
U - UNCONFINED COMPRESSION
Q_c - TRIAXIAL CONSOLIDATED QUICK
Q - TRIAXIAL QUICK
S - TRIAXIAL SLOW
W.L. - WATER LEVEL IN CASING
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T.O. - THIN WALLED OPEN
S.S. - SLEEVE SAMPLE
P.S. - PISTON SAMPLE
W.S. - WASHED SAMPLE
R.C. - ROCK CORE

SAMPLE CONDITION

- DISTURBED
- FAIR
- GOOD
- LOST

SOIL PROFILE

ELEVATION DEPTH	WATER CONDITIONS	DESCRIPTION	STRAT PLOT
580'		GROND LEVEL	
579' 1'		TOP SOIL	
		BROWN SILTY CLAY WITH SOME GRAVEL	
568' 12'		GREY SILTY CLAY WITH SOME GRAVEL	
538.5' 41.5'		END OF BOREHOLE	

ELEVATION SCALE: 580, 575, 570, 565, 560, 555, 550, 545, 540, 535

SHEAR STRENGTH IN LBS/□ FOOT * — 2,000 — 4,000 — 6,000

WATER CONTENT W% — 1.0 — 2.0 — 3.0 — 4.0 — O - NAT. □ - P.W. Δ - L.W.

PENETRATION TEST RESISTANCE BLOWS PER FOOT AT STANDARD ENERGY (4200 IN. LBS. PER BLOW)

D. CONE PEN. X-------X-------X STAND. PEN. ●——●——● — 500 — 1,000 — 1,500 — 2,000

REFUSAL AT ELEV. 535.5
147 BLOWS FOR 6"

END OF CASING @ ELEV. 540.0'

CASING BLOWS (ACTUAL)

5 6 10 10 12 | 5 6 5 11 12 | 32 41 45 50 52 | 58 62 62 65 92 | 92 101 99 105 110 | 112 109 115 117 123 | 127 131 133 138 140 | 147 150 156 161 165

SAMPLES

OTHER TESTS	CONDITION	TYPE	NO.	PENETRATION RESISTANCE	ELEV. RECOV. %
					580'
		S.S.	1	14	89
					574.5'
					569.5'
γ=122.0 P.c.f.		S.S.	2	18	100
					564.5'
		S.S.	3	11	100
					560.5'
		S.S.	4	9	89
					556.5'
γ=138.0 P.c.f.		S.S.	5	9	100
					552.5'
		S.S.	6	6	
					548.5'
		S.S.	7	10	89
					540.0'
		S.S.	8	14	100

FORM OB-ML-1

H.D.R.

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & RESEARCH BRANCH - FOUNDATIONS SECTION - DOWNSVIEW

OFFICE REPORT ON SOIL EXPLORATION

DRILL RIG 54-6 OPERATION PENETRATION JOB F-59-2 W.P. ~~F-59-2~~ 161-58 BORING 4 STA. 00+20 45' RT.

CASING B X (standard samplers to fit unless noted) DATUM GEODETIC DATE REPORT FEB. 1959

SAMPLER HAMMER WT. 250 LBS. DROP 19 INCHES COMPILED BY H.S. CHECKED BY V.K. DATE BORING 20 JAN. 1959

ABBREVIATIONS

V - INSITU VANE SHEAR TEST
M - MECHANICAL ANALYSIS
U - UNCONFINED COMPRESSION
Q_c - TRIAXIAL CONSOLIDATED QUICK
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T.O. - THIN WALLED OPEN
S.S. - SLEEVE SAMPLE
P.S. - PISTON SAMPLE
W.S. - WASHED SAMPLE
R.C. - ROCK CORE

SAMPLE CONDITION

- DISTURBED
- FAIR
- GOOD
- LOST

SOIL PROFILE

ELEVATION DEPTH	WATER CONDITIONS	DESCRIPTION	STRAT PLOT
580'		GROUND LEVEL	

ELEVATION SCALE

WATER CONTENT W % — O - NAT. □ - P.W. Δ - L.W.

PENETRATION TEST RESISTANCE BLOWS PER FOOT AT STANDARD ENERGY (4200 IN. LBS. PER BLOW)

D. CONE PEN. X------X------X STAND. PEN. •——•——•

50 100 150 200

580 575 570 565 560 555 550

5 10 15 20 25 30

REFUSAL AT ELEV. 555'6'
150 BLOWS FOR 5"

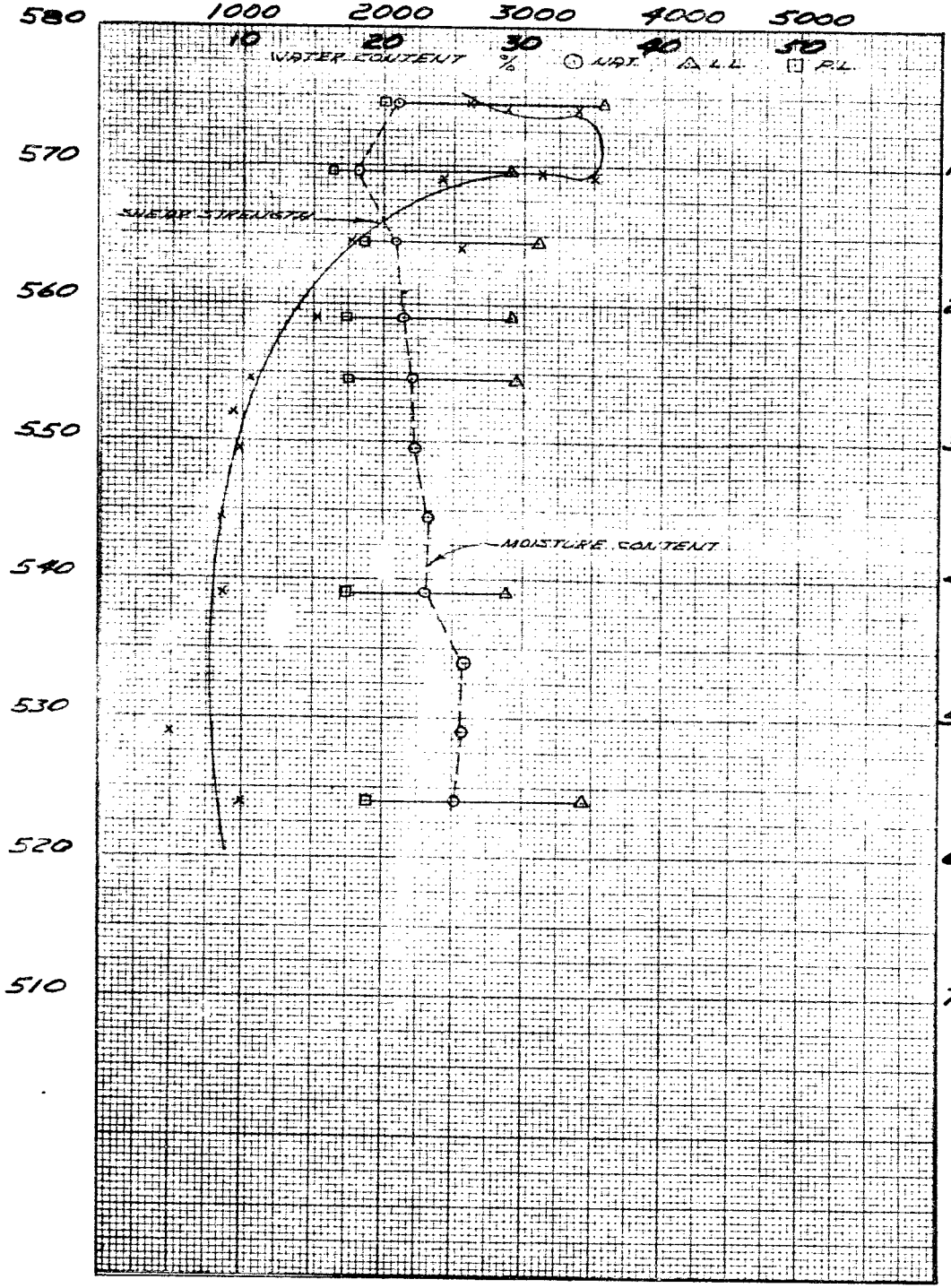
CASING BLOWS (ACTUAL)

SAMPLES

OTHER TESTS	CONDITION	TYPE	NO.	PENETRATION RESISTANCE	ELEV. RECOV. %

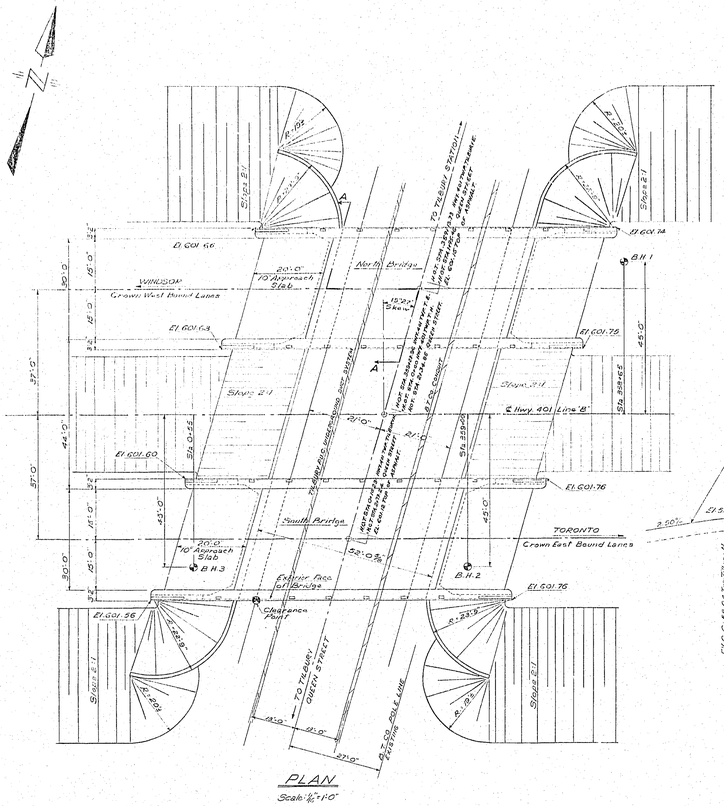
W. P. 161-58 JOB F-59-2

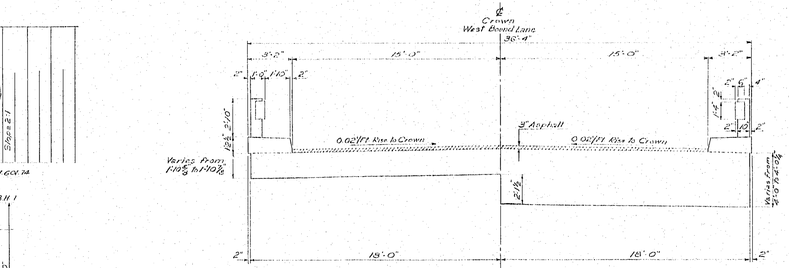
SHEAR STRENGTH IN P.S.F.

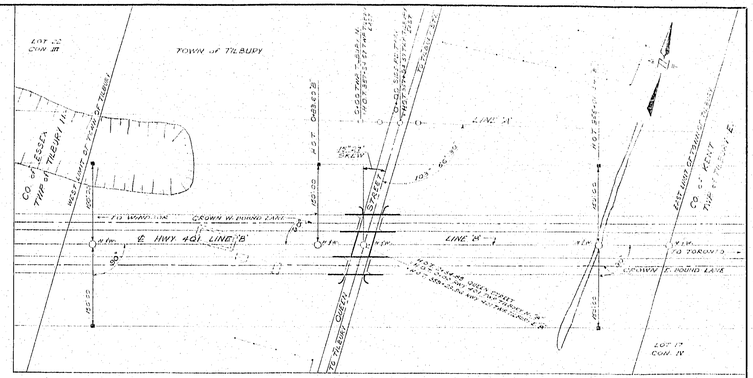


GRAPH FOR

FORM CB-ML 229
500-58 8145

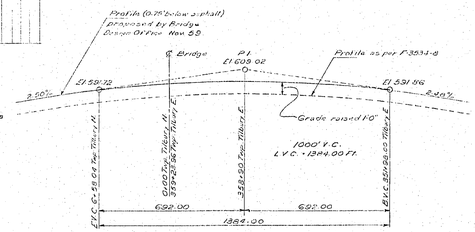


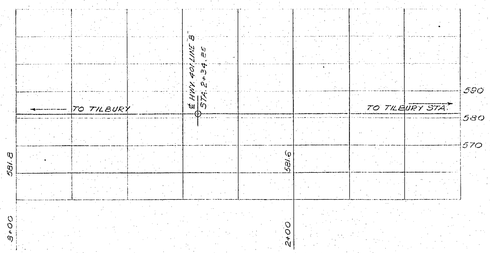


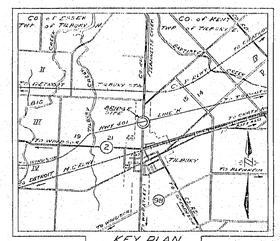


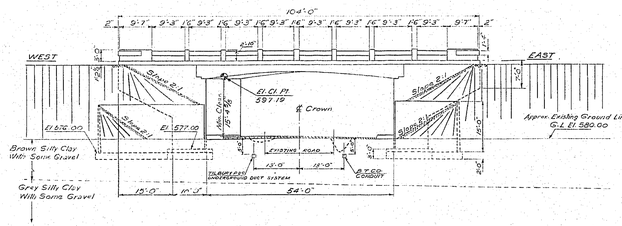
LIST OF DRAWINGS

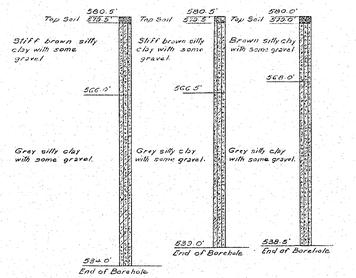
D-4422-1 General Plan
-2 Footings, Abutments & Wing Walls
-3 Reinforcing Details
-4 Retaining Walls
-5 Approach Slab
-6 Steel Table - Hard Grade
-7 Steel Table - Structural Grade











SKEW 15°27'	
Sin.	0.2663873
Cos.	0.9638638
Tan.	0.2763850
Sec.	1.0374915

NOTES:

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

To Contractor - Structure to be built in accordance with Form #6 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 strength at 28 days	Maximum size of aggregate
Footings:	2500 P.S.I.	Footings: 1½"
Structure:	3000 P.S.I.	Structure: 1"
Retaining Walls:	3000 P.S.I.	Retaining Walls: 1"

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 306 may be examined at the Bridge Office Downsview, Ontario. The Department does not guarantee the accuracy of this report or the abridged version shown on these plans.

Reinforcing Steel -

Clear Cover	Deck	2"
	Nanorails	1½"
	Abutments	3" or as specified
	Retaining Walls	3"
	Footings	3"

Construction Notes - All exposed edges to be chamfered 1"x1". Formwork supporting wing walls not to be removed until the curb concrete has reached a strength of 2400 P.S.I. Footings to be excavated to neat dimensions as shown and concrete placed against undisturbed ground.

PRINT RECORD		
NO.	FOR	DATE
30	Tender	Nov 3 58
31	Revise Fdn	59-1-16
32	Revise Fdn	8-3-61
10	Revise Fdn	12-5-61

W.P. 161 - 58

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

TILBURY NORTH TWP. BR. 1
QUEEN ST. OVERPASS

THE KING'S HIGHWAY No. 401 DIST. No. 1
CO. Essex & Kent
TWP. Tilbury N. & Tilbury E. LOT CON.

GENERAL PLAN

APPROVED

BRIDGE ENGINEER DESIGN ENGINEER

REVISIONS	DATE	BY	DESCRIPTION

REFERENCE PLANS
PROFILE F-3534-8
PLAN F-3534-7
PLAN E-3516-1
SOIL REPORT BA306

DESIGN	K.G.B.	CHECK	L.N.F.	CONTRACT NUMBERS	DESIGNATED C.S. 61-109
DRAWING	F.W.	CHECK	L.N.F.		60-111
TRACING		CHECK		LOADING	H20-S16
DATE	JAN. 1960			DRAWING NUMBER	D-4422-1

TWP #105-51-1-A

APPENDIX B

Site Photographs

Photograph 1: Looking north at the Queen Street Overpass EBL structure from about 200 m south of the overpass on Queen Street North. (October 20, 2013)

Photograph 2: Looking at the east abutment of the structure from northwest corner of the structure. The north and south slopes adjacent to the east abutment were vegetated with no signs of erosion. The slopes were retained with retaining wall structures. Weep holes were visible coming out the abutment and retaining walls. (October 20, 2013)

Photograph 3: Looking northwest at the west abutment wall of the structure from the southeast corner of the structure. The north and south slopes adjacent to the west abutment were vegetated with no signs of erosion. The slopes were retained with retaining wall structures. Weep holes were visible coming out the abutment and retaining walls. (October 20, 2013)