FOUNDATION TECHNICAL MEMORANDUM

For

CNR OVERHEAD EBL AND WBL ON HIGHWAY 402
MTO WEST REGION 59 STRUCTURE REHABILITATIONS
SITES 19-527-1 AND 19-527-2, CONTRACT 4
GWP 3102-10-00
GEOGRAPHICAL TOWNSHIP OF STRATHROY-CARADOC
MIDDLESEX COUNTY, ONTARIO

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Reference 2. Foundation Investigation Report for C.N.R. Overhead E.B.L. and W.B.L., W.P.s 40-66-13/14, Site Nos. 19-527 A/B, Hwy. 402, District 2, London, Foundation Investigation Report, Contract No. 79-51, Pages 3-19, dated January, 1979.

Reference 3. Memorandum for C.N.R. Overhead, East Approach Embankment, Site No. 19-527, Highway 402, District 2, London, Foundation Design Section, Room 315, Central Building, dated September 18, 1985.

Reference 4. General Plan Drawing, E.B.L. Bridge, Hwy 402, CNR Overhead, 5.8 miles West of Hwy 2, DWG 1, Sheet 213, Site No. 19-527A, Dist. 2, Cont No. 79-51, WP No. 40-66-13, dated March 1978.

Reference 5. Foundation Layout Drawing, E.B.L. Bridge Hwy 402, CNR Overhead, DWG 3, Sheet 215, Site No. 19-527A, Dist. 2, Cont No. 79-51, WP No. 40-66-13, dated March 1978.

Reference 6. General Plan Drawing, W.B.L. Bridge, Hwy 402, CNR Overhead, 5.8 miles West of Hwy 2, DWG 1, Sheet 233, Site No. 19-527B, Dist. 2, Cont No. 79-51, WP No. 40-66-14, dated March, 1978.

Reference 7. Foundation Layout Drawing, W.B.L. Bridge Hwy 402, CNR Overhead, DWG 3, Sheet 235, Site No. 19-527B, Dist. 2, Cont No. 79-51, WP No. 40-66-14, dated March 1978.

Appendix B – Site Photographs

Peto MacCallum Ltd.
CONSULTING ENGINEERS

FOUNDATION TECHNICAL MEMORANDUM
For
CNR Overhead EBL/WBL, Highway 402
MTO West Region 59 Structure Rehabilitations
Sites 19-527-1/2, Contract 4, GWP 3102-10-00
Geographical Township of Strathroy-Caradoc
Middlesex 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) 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 Highway 402 Canadian National Railway (CNR) Overhead EBL (Eastbound Lanes) and WBL (Westbound Lanes). The Foundation Engineering recommendations from the existing 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 MMM Group's Minutes of Meeting Report, dated May 1, 2015, it is understood that the CNR Overhead EBL and WBL on Highway 402 will be both rehabilitated in two stages maintaining a single 3500 mm lane and 500 mm shoulders on each structure during each stage.

The purpose of the technical memorandum is to summarize the subsurface and groundwater conditions and foundation recommendations based on available reports at the overhead structure 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 CNR EBL/WBL Overhead structures on Highway 402 are located at approximately 243.8 m (800.0 ft.) west of the 20th sideroad, in the Geographic Township of Strathroy-Caradoc, Middlesex County, Ontario. A key plan is shown in Figure 1.

The existing Highway 402 overhead structures pass over the single CNR track and a service road parallel to the railway on twin structures that carry two lanes of traffic in each direction. The surrounding areas around the site location are generally flat farming lands on both sides of Highway 402.

Physiographically, the site is situated in the region known as the Caradoc Sand Plains. The Caradoc Sand Plains comprise large water-laid alluvial beach deposits. This plain was formed when the early Thames River discharged into Glacial Lake Warren forming a sand gravel deltaic deposit. Clay plains occur in association with the sand plains and represent the sediment that was deposited in deeper water further off than the alluvial beach deposits (sand plains). The limestone, dolostone or shale bedrock in the area belongs to the Hamilton Group of Middle Devonian period. The bedrock surface at the site location is between elevation 160.0 to 167.6 (525.0 to 550.0 ft.) (Map 1564, Bedrock Topography Series: Strathroy Area, Southern Ontario, Ontario Department of Mines) some 74.0 to 80.0 m (243.0 to 262.0 ft) below ground surface.

3. SOURCE OF INFORMATION

The following foundation reports and drawings, provided in Appendix A, were available for review and provided information for the overhead structures, subsoil information and original foundation recommendations.

Reference 1. Foundation Investigation Report for W.P. 40-66-13/14, Site 19-527, Hwy. 402, District 2, London, CNR Overhead EBL/WBL, 5.8 Miles West of Hwy 2, Soil Mechanics Section, Geotechnical Office, West Bldg., dated April 30, 1976. GEOCRES No.: 40I13-47

Reference 2. Foundation Investigation Report for C.N.R. Overhead E.B.L. and W.B.L., W.P.s 40-66-13/14, Site Nos. 19-527 A/B, Hwy. 402, District 2, London, Foundation Investigation Report, Contract No. 79-51, Pages 3-19, dated January, 1979.

Reference 3. Memorandum for C.N.R. Overhead, East Approach Embankment, Site No. 19-527, Highway 402, District 2, London, Foundation Design Section, Room 315, Central Building, dated September 18, 1985.

Reference 4. General Plan Drawing, E.B.L. Bridge, Hwy 402, CNR Overhead, 5.8 miles West of Hwy 2, DWG 1, Sheet 213, Site No. 19-527A, Dist. 2, Cont No. 79-51, WP No. 40-66-13, dated March 1978.

Reference 5. Foundation Layout Drawing, E.B.L. Bridge Hwy 402, CNR Overhead, DWG 3, Sheet 215, Site No. 19-527A, Dist. 2, Cont No. 79-51, WP No. 40-66-13, dated March 1978.

Reference 6. General Plan Drawing, W.B.L. Bridge, Hwy 402, CNR Overhead, 5.8 miles West of Hwy 2, DWG 1, Sheet 233, Site No. 19-527B, Dist. 2, Cont No. 79-51, WP No. 40-66-14, dated March, 1978.

Reference 7. Foundation Layout Drawing, W.B.L. Bridge Hwy 402, CNR Overhead, DWG 3, Sheet 235, Site No. 19-527B, Dist. 2, Cont No. 79-51, WP No. 40-66-14, dated March 1978.

4. SITE RECONNAISSANCE

As part of the current foundation engineering assessment study, site reconnaissance of the CNR Overhead EBL and WBL structures was carried out on July 27, 2016.

The site photographs present the conditions of the CNR EBL and WBL structures including visible portions of the abutments, wing walls and piers and abutment slope assessment based on visible areas, apparent areas of soil erosion and abutment slope cover.

Surficial cracks were observed on the east and west abutment walls and the associated north and south wing walls with each abutment of the CNR Overhead EBL and WBL structures (Photographs 1, 2, 3, 4, 8, 11, 12, 13, 14, 17 and 19). A local concrete spalling was observed on the north wingwall of the east abutment of the CNR Overhead EBL structure (Photograph 10). Weep holes were not observed in the east and west abutment walls for the CNR Overhead EBL and WBL structures.

The front slopes of the abutments were covered with crushed rock (Photographs 1, 4, 8, 11, 14 and 17). Weed growth through the crushed rock was observed in front slopes of the abutments. However, effect of erosion was not observed on the front slopes. The adjacent slopes of the east and west abutments and the median (between the two structures) slopes between the abutments for the structures were observed to be vegetated and the effect of erosion was not observed on the slope faces (Photographs 2, 3, 9, 10, 12, 13, 18 and 19). A corrugated steel pipe (C.S.P.) was observed coming out of the north slope adjacent to west abutment of WBL structure (Photograph 13).

Surficial cracks were observed on the piers and the crash walls of the EBL and WBL structures. The ground surface around the piers and crash walls were vegetated. The effect of erosion was not observed at Pier Nos. 2 and 3 of EBL structure and Piers Nos. 1 to 3 of WBL structure (Photographs 4, 6, 7, 14, 15 and 16). Slight erosion was observed at the toe of northerly column of Pier No. 1 of EBL structure (Photograph 5).

During the site reconnaissance on July 27, 2016, there was no observation of the French drains and perforated pipe at the east approach and no stability problem was observed at the site location.

5. PREVIOUS FIELD INVESTIGATION AND SUMMARIZED SUBSURFACE CONDITIONS

A Foundation Investigation Report, dated April 30, 1976 (Reference 1) was originally prepared for the CNR Overhead EBL/WBL structures. The description of the subsurface conditions from Reference 1 was superseded by the Foundation Investigation Report, dated January, 1979 (Reference 2) for the contract purpose.

The general subsurface conditions presented in this section are based on the Foundation Report, dated January, 1979 (Reference 2).

The foundation investigation comprised ten (10) boreholes (1 to 10) and eight (8) dynamic cone penetration tests (DCPT) adjacent to boreholes 1 to 4 and 7 to 10, which were investigated from February 16 to 26, 1976. The sampled boreholes were drilled to depths of 8.1 to 38.3 m (26.5 to 125.5 ft.), elevation 203.8 to 234.0 (668.5 to 767.8 ft.).

Reference 1 includes the borehole location plan (Drawing No. 406613 & 14-A), Record of Borehole sheets (1 to 10) and the grain size distribution test results Figure No. 1. Reference 2 includes Record of Borehole sheets (1 to 10) and the grain size distribution test results Figure No. 1, however, the Contract Drawings (Drawing 19-527A-2 and 19-527B-2) are not included in Reference 2.

Boreholes 1, 3, 5, 7 and 9 were investigated at or near the east abutments, piers, and west abutment of WBL structure and boreholes 2, 4, 6, 8 and 10 were investigated at the east abutments, piers and west abutment of EBL structure.

Based on Reference 2, the boreholes were drilled by employing continuous flight auger machines, mounted either on a muskeg vehicle or on an all-terrain vehicle and equipped with 83 mm (3 ¼ in.) I.D. hollow stem augers that was advanced into the soil without the use of a plug. A split spoon was washed down to below the bottom of the augers in order to minimize the hydraulic disturbance to the soil during the removal of the rods from the hollow stem augers.

5.1 General

Generally, a loose to very dense silt layer overlaid alternating layers of stiff to hard clayey silt and compact to very dense sand.

5.1.1 Silt

A loose to very dense 3.0 to 4.6 m (10.0 to 15.0 ft.) thick surficial deposit of silt layer was encountered in all of the ten boreholes, which extended to 3.0 to 4.6 m (10.0 to 15.0 ft.), elevation 237.3 to 239.0 (778.5 to 784.0 ft.). N values ranged between 5 and over 100. Lower N values of 5 to 10 were recorded within the upper portion of the silt layer in boreholes 3, 4, 6, 7, 9 and 10.

Grain size distribution results of five selected samples indicated 2 to 7% sand, 84 to 96% silt and 2 to 14% clay sized particles. The Atterberg liquid limit and the corresponding plastic limit of one selected sample from borehole 2 was 20 and 18, respectively, and the plasticity index value was 2, indicating the silt was non-plastic. Moisture content determinations of the samples ranged from 18 to 21%.

5.1.2 Clayey Silt

Discontinuous 1.4 to 18.1 m (4.5 to 59.5 ft.) thick layers of clayey silt were encountered in boreholes 3 to 10. An upper clayey silt encountered below the surficial silt layer in boreholes 4 to 10 at 3.0 to 3.7 m (10.0 to 12.0 ft.), elevation 238.0 to 239.0 (780.7 to 784.0 ft.) extended to 4.6 to 5.5 m (15.0 to 18.0 ft.), elevation 236.4 to 237.4 (775.7 to 779.0 ft.). A second layer of clayey silt encountered below sand layer in boreholes 3 to 10 at 6.7 to 9.4 m (22.0 to 31.0 ft.), elevation 232.6 to 234.9 (763.1 to 770.7 ft.) extended to 8.2 to 12.5 m (27.0 to 41.0 ft.), elevation 229.5 to 233.4 (753.1 to 765.7 ft.). A lower clayey silt layer encountered in boreholes 3, 4, and 7 to 9 at 18.9 to 20.1 m (62.0 to 66.0 ft.), elevation 221.9 to 223.1 (728.0 to 732.1 ft.) extended to the termination depths ranging from 20.3 to 38.3 m (66.5 to 125.5 ft.), elevation 203.8 to 221.8 (668.5 to 727.6 ft.). N values of clayey silt were increasing with depth ranging from 12 to over 100, indicating stiff to hard consistency.

Grain size distribution results of two selected clayey silt samples indicated 0 and 1% sand, 62 and 80% silt, and 38 and 19% clay sized particles, respectively. The Atterberg liquid limits were 17 to 29, and the corresponding plastic limits were 11 to 17. The plasticity values were 3 to 12. Moisture content determinations ranged from 13 to 21%.

The shear strength values obtained from laboratory unconfined tests performed on two selected clayey silt samples from borehole 5 were approximately 121 kPa (2533 psf) and 107 kPa (2233 psf), respectively, confirming very stiff consistency.

5.1.3 Sand

A 3.5 (11.5 ft.) thick sand layer was encountered below the surficial silt layer in boreholes 1 and 2 at 4.6 m (15 ft.), elevation 237.5 and 237.3 (779.3 and 778.5 ft.) and extended to the termination depth of 8.1 m (26.5 ft.), elevation 234.0 and 233.8 (767.8 to 767.0 ft.).

Two 1.5 to 12.0 m (5.0 to 39.5 ft.) thick sand layers were encountered in boreholes 3 to 10. The upper sand layer was encountered at 4.6 to 5.5 m (15.0 to 18.0 ft.), elevation 236.4 to 237.5 (775.7 to 779.1 ft.) and extended to 6.7 to 9.4 m (22.0 to 31.0 ft.), elevation 232.6 to 234.9 (763.1 to 770.7 ft.).

The lower sand layer was encountered in borehole 3 to 10 at 8.2 to 12.5 m (27.0 to 41.0 ft.), elevation 229.5 to 233.4 (753.1 to 765.7 ft.). The lower sand layer extended to 18.9 to 20.1 m (62.0 to 66.0 ft), elevation 221.9 to 223.1 (728.0 to 732.1 ft) in boreholes 3, 4 and 7 to 9 and to borehole termination depths 12.6 to 20.3 m (41.5 to 66.5 ft.), elevation 221.3 to 229.4 (726.2 to 752.5 ft.) in boreholes 5, 6 and 10.

N values of sand ranged from 15 to over 100, indicating compact to very dense compactness condition.

Grain size distribution results of eleven selected sand samples from boreholes 1, 2, 4, 5, 7 and 10 indicated 0 to 26% gravel, 68 to 92% sand, and 6 to 23% silt and clay sized particles; and grain size distribution results of one selected sand samples from borehole 4 indicated included 34% sand, 62% silt, and 4% clay sized particles. Moisture content determinations ranged from 9 to 21%.

5.1.4 Groundwater

The following groundwater levels were observed in the boreholes during the field investigation:

BOREHOLE NO.	GROUND SURFACE ELEVATION m (ft.)	GROUNDWATER ELEVATION m (ft.)	DEPTH BELOW GROUND SURFACE m (ft.)
1	242.1 (794.3)	241.8 (793.2)	0.3 (1.1)
2	241.9 (793.5)	241.7 (793.0)	0.2 (0.5)
3	242.0 (794.1)	241.7 (793.0)	0.3 (1.1)
4	242.0 (794.0)	241.7 (792.9)	0.3 (1.1)
5	242.1 (794.3)	241.7 (793.0)	0.4 (1.3)
6	241.6 (792.7)	241.5 (792.2)	0.2 (0.5)
7	242.0 (793.8)	241.6 (792.7)	0.3 (1.1)
8	242.0 (794.0)	241.7 (792.9)	0.3 (1.1)
9	241.9 (793.7)	241.6 (792.6)	0.3 (1.1)
10	242.0 (794.0)	241.7 (792.9)	0.3 (1.1)

Reference 2 indicated that the shallow water levels encountered in all the boreholes were due to the extensive ponding caused by the prolonged thaw in February during the field work. It was assumed that the water levels were lower during other seasons of the year.

6. FOUNDATION

6.1 Previous Foundation Recommendations

The foundation recommendations presented in Reference 1 were provided for twin structures to carry Highway 402 over the double CNR tracks and a service road parallel to the railway. The approach embankments of the overhead structures were to be approximately 10.1 m (33 ft.) in height, and the spans were to be 17.7 (58 ft.), 28.0 (92 ft.), 26.5 (87 ft.) and 17.7 m (58 ft.).

Based on the site reconnaissance at the crossing, it was observed that the CNR Overhead EBL and WBL structures are crossing over a single CNR track and the service road.

The previous foundation recommendations presented in the following sections are based on the Foundation Investigation Report, dated April 30, 1976 (Reference 1).

6.1.1 Structure Foundations

6.1.1.1 Perched Abutments

It was recommended that perched abutments be supported on steel tube piles with the dimensions of 323 mm (12 ¾ in.) O.D. and 6 mm (1/4 in.) wall thickness. A design load of 222.4 kN (25 tons) per pile was recommended when the piles were driven to elevation 237.7 (780.0 ft.) at the east abutments and elevation 239.3 (785.0 ft.) at the west abutments.

As an alternative, it was also recommended that the design load of 533.8 kN (60 tons) be achieved at approximately 230.1 (755.0 ft.), if pile driving was to be controlled by employing the Hiley Dynamic Pile Driving Formula.

However, it was deemed that the timber piles are not suitable for the perch abutment, due to the difficulties of driving the timber piles through the approach fills placed at the footages of the perched abutments.

6.1.1.2 Piers

Based on Reference 1, three foundation types were suggested as options for supporting the piers, including spread footings, tube piles and timber piles.

- The spread footings were recommended to support the piers at elevation 239.6 (786.0 ft.). A design load of 287.3 kPa (3 tsf) was recommended and 25 mm (1 in.) settlement was assumed. It was recommended that a dewatering scheme employing sheet piling be required for the use of spread footings and the depth of sheet piling below the groundwater level should be equal to twice the required depth of excavation below the same groundwater level.

- Tube piles were suggested as an alternative to support the piers. Pile driving was to be controlled by employing the Hiley Dynamic Pile Driving Formula. A design load of 533.8 kN (60 tons) was to be achieved at approximately elevation 230.1 (755.0 ft.)

- Timber piles were recommended with a design load of 311.4 kN (35 tons) and the pile tip at elevation 234.7 (770.0 ft.)

6.1.1.3 H-Piles

Based on Reference 1, it was also recommended using steel H-piles to support the abutments and the piers with a design load equal to their allowable structural capacity, which would be achieved at approximately elevation 207.3 (680.0 ft.).

6.1.1.4 Settlements

Reference 1 suggested that the greatest settlements were to be anticipated under the approach fills. It was anticipated that the settlements would occur during the construction, due to the non-cohesive materials of the upper 18.3 m (60 ft.) of the subsoil. It was stated that the differential settlement would be less than 25 mm (1 in.) after the deck was placed.

6.1.2 Approach Embankments

Based on Reference 1, it was anticipated that there were no stability problems if 2:1 side slope of 10.1 m (33.0 ft.) high embankment approaches was to be employed. It was recommended removing the cobbles exceeding a 76 mm (3 in.) diameter from the fill that was placed under side of the perched abutments, where the piles were to be driven through.

A memorandum, dated September 18, 1985 (Reference 3) reported that settlements were observed on the EBL and WBL of the east approach from the overhead to about 182.9 m (600.0 ft.) easterly after the road was opened to the public. Based on the investigations carried out by the Regional Geotechnical Sections, the major cause of the settlements was the presence of a saturated sand layer and its inability to drain. It was observed that the sand layer was placed

on top of the silty clay fill material to raise the embankment to the subgrade level. Up to 0.9 m (3.0 ft.) of this sand material was found saturated with water below the lean concrete base.

The MTC concluded that only the removal of the saturated sand and complete rebuilding would provide a 100% solution to the problem. In view of the expense involved, it was suggested that if the drainage of the sand layers could be effected and maintained then it may be possible that future settlements would be substantially reduced or prevented and the pavement would require patching only.

The recommended drainage system would consist of 0.6 m (2.0 ft) wide French drains extending to 1.5 m (5.0 ft.) on each side of the affected pavements. A 152 mm (6.0 in.) perforated pipe would be placed in the trench backfilled with Granular 'A' and connected to a frost free outlet. In areas where the settlement was severe, transverse French drains were recommended to be provided and connected to side drains.

Finally, it was recommended that the treatment should be applied initially as an experiment on one or two areas where the settlements were the most severe and extended if significant improvements occur.

There was no information available for our review whether this drainage treatment was attempted and what degree of success was achieved.

During the site reconnaissance on July 27, 2016, there was no observed evidence of the presence of the French drain or perforated pipe at the east approach embankment. No stability problem was observed at the site location.

6.1.3 Other Considerations

All pile caps and spread footings should be protected by a minimum 1.2 m (4.0 ft.) cover against frost action.

6.1.4 Drawings

Based on the General Arrangement Drawings of CNR Overhead EBL and WBL structures (References 4 and 6), the proposed twin four-span structures were to carry Highway 402 over double CNR tracks and a service road. The plan view also indicated that two additional future tracks were to be constructed. Only a single CNR track and the Service Road were observed during July 27, 2016 site reconnaissance survey.

Reference 4 indicated that the west and east perched abutments of EBL Overhead structure were founded at elevation 246.9 (810.0 ft.) and 247.0 (810.5 ft.), and Reference 6 indicated that both west and east perched abutments of WBL Overhead structure were founded at elevation 247.0 (810.5 ft.). The approach grades were raised approximately 9.4 (31.0 ft.) to 10.1 m (33.0 ft.) from the ground levels. Compacted boulder-free fill (maximum 50 mm (2 in.) size) was to be placed underneath the perched abutment footings prior to driving piles. Based on Foundation Layout drawings, References 5 and 7, the bottom of the pile caps of Pier Nos. 1, 2 and 3 was to be founded at elevation 242.0, 239.9 and 240.5 (794.0, 787.0 and 789.0 ft.), respectively.

Based on Foundation Layout Drawings for EBL and WBL Overhead structures (References 5 and 7), the pile caps for abutments and piers were to be founded on 323.9 mm O.D. x 6.35 mm wall thickness (12 ¾ in. O.D. x ¼ in. wall thickness) steel pipe piles. A design load of 553.8 kN (60 tons) was specified for the steel tube piles driven in accordance with SS 3-11 and after installation and inspection filled with 20 MPa (3000 psi) concrete. The following table summarizes the pile data based on References 5 and 7.

LOCATION AND PILE TYPE		FACE	NO.	BATTER (H:V)	LENGTH m (ft.)	PILE CUT-OFF ELEVATION m (ft.)	TOP OF PILE CAP ELEVATION m (ft.)
Eastbound Lanes Steel Tube Pipe (323.9 mm O.D. x 6.35 mm Wall Thickness) (12¾ in. O.D. x ¼ in. Wall Thickness)	West Abutment	Front	7	1:3	18.9 (62.0)	247.19 (811.00)	247.65 (812.50)
		Rear	3	Vertical	17.7 (58.0)		
		Rear	2	1:3	18.9 (62.0)		
	Pier No. 1	West	6	1:3	13.4 (44.0)	242.32 (795.00)	242.93 (797.00)
		East	6	1:3	13.4 (44.0)		
	Pier No. 2	North	2	1:3	11.3 (37.0)	240.18 (788.00)	240.79 (790.00)
		South	2	1:3	11.3 (37.0)		
		West	6	1:5	11.0 (36.0)		
		East	6	1:5	11.0 (36.0)		
	Pier No. 3	West & East	16	1:3	12.5 (41.0)	240.79 (790.00)	241.40 (792.00)
	East Abutment	Front	7	1:3	18.9 (62.0)	247.35 (811.50)	247.80 (813.00)
		Rear	2	1:3	18.9 (62.0)		
		Rear	4	Vertical	17.7 (58.0)		
Westbound Lanes Steel Tube Pipe (323.9 mm O.D. x 6.35 mm Wall Thickness) (12¾ in. O.D. x ¼ in. Wall Thickness)	West Abutment	Front	7	1:3	18.9 (62.0)	247.35 (811.50)	247.80 (813.00)
		Rear	3	Vertical	18.0 (59.0)		
		Rear	2	1:3	18.9 (62.0)		
	Pier No. 1	West	6	1:3	13.4 (44.0)	242.32 (795.00)	242.93 (797.00)
		East	6	1:3	13.4 (44.0)		
	Pier No. 2	North	2	1:3	11.3 (37.0)	240.18 (788.00)	240.79 (790.00)
		South	2	1:3	11.3 (37.0)		
		West	6	1:5	11.0 (36.0)		
		East	6	1:5	11.0 (36.0)		
	Pier No. 3	All	16	1:3	12.5 (41.0)	240.79 (790.00)	241.40 (792.00)
	East Abutment	Front	7	1:3	18.9 (62.0)	247.35 (811.50)	247.80 (813.00)
		Rear	2	1:3	18.9 (62.0)		
		Rear	4	Vertical	18.0 (59.0)		

Based on the General Plan drawings, References 4 and 6, a 152 mm (6 in.) C.S.P. was to be installed behind the east and west abutments of EBL and WBL Overhead structures. During the site visit on July 27, 2016, the C.S.P. was observed at the north side slope of west abutment of the CNR WBL structure. It should be noted that the embankment slopes were heavily vegetated and the presence of C.S.P may exist at other locations which were not identified during our site reconnaissance survey. The drawings indicated that crushed rock protection was specified on the abutment front slopes. The crushed rock protection was observed during our site reconnaissance survey.

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 previously referenced reports and drawings and the updated geotechnical reaction at SLS and factored geotechnical resistance at ULS are provided.

FOUNDATION DESIGN PARAMETERS

FOUNDATION LOCATIONS	PREVIOUS WORKING STRESS VALUES	PREVIOUS EQUIVALENT LIMIT STATE DESIGN VALUES		LIMIT STATE DESIGN VALUES UPDATED TO CURRENT INDUSTRY PRACTICE	
	SAFE BEARING RESISTANCE (Tons)	BEARING RESISTANCE (kN)		BEARING RESISTANCE (kN)	
		SLS	FACTORED ULS	SLS	FACTORED ULS
West abutments	60	534	640	534	640
Piers 1, 2 and 3					
East abutments					

Notes:

1. Working Stress design values. The Ultimate Limit State design values are based on the working stress. No field verification was available for review.
2. Resistance Factor = 0.4 for deep foundation (CFEM 4th edition).
3. Assumed Factor of Safety is 3 (CFEM 4th edition).
4. There is sufficient pile length to reach the recommended founding elevation 230.1 (755.0 ft.) at all foundation locations. It was considered that the design load would be achieved provided the piles were driven employing the Hiley Dynamic Pile Driving Formula.

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

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 CNR Overhead EBL and WBL structures is not expected provided that the total dead load on the overhead structures do not increase or decrease by more than 10%.

It is understood that the CNR Overhead EBL and WBL on Highway 402 will be rehabilitated in two stages maintaining a single 3500 mm lane and 500 mm shoulders in both stages.

Temporary support system may be required during the rehabilitation of the overhead structures. The construction for temporary support system should conform to OPSS 404 and 539. The contractor is responsible for the selection, detailed design and performance of the roadway protection scheme. The contractor should monitor the movement of the roadway protection system.

The slopes adjacent to both abutments are visually stable without signs of erosion. However, the embankments which are greater than 8.0 m in height were constructed with a 2H:1V slope but not benched as per current practice (OPSD 202.010).

8. CLOSURE

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

We trust that 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

Brian R. Gray, MEng, P.Eng.
Principal Consultant

Robert Ng, MBA, PhD, P.Eng.
MTO Designated Principal Contact

NR/RN/BRG:nk

TABLE 1

LIST OF STANDARD SPECIFICATIONS REFERENCED IN REPORT

DOCUMENT	TITLE
OPSS 404	Construction Specification for Support Systems
OPSS 539	Construction Specification for Temporary Protection Systems
OPSD 2020.10	Slope Flattening Using Surplus Excavated Material On Earth or Rock Embankment
OPSD 3090.101	Foundation Frost Depth for Southern Ontario

Figure 1 – Key Plan

APPENDIX A

Appendix A – Previous Foundation Investigation Reports (GEOCRES 40I13-47)

Reference 1. Foundation Investigation Report for W.P. 40-66-13/14, Site 19-527, Hwy. 402, District 2, London, CNR Overhead EBL/WBL, 5.8 Miles West of Hwy 2, Soil Mechanics Section, Geotechnical Office, West Bldg., dated April 30, 1976. GEOCRES No.: 40I13-47

Reference 2. Foundation Investigation Report for C.N.R. Overhead E.B.L. and W.B.L., W.P.s 40-66-13/14, Site Nos. 19-527 A/B, Hwy. 402, District 2, London, Foundation Investigation Report, Contract No. 79-51, Pages 3-19, dated January, 1979.

Reference 3. Memorandum for C.N.R. Overhead, East Approach Embankment, Site No. 19-527, Highway 402, District 2, London, Foundation Design Section, Room 315, Central Building, dated September 18, 1985.

Reference 4. General Plan Drawing, E.B.L. Bridge, Hwy 402, CNR Overhead, 5.8 miles West of Hwy 2, DWG 1, Sheet 213, Site No. 19-527A, Dist. 2, Cont No. 79-51, WP No. 40-66-13, dated March 1978.

Reference 5. Foundation Layout Drawing, E.B.L. Bridge Hwy 402, CNR Overhead, DWG 3, Sheet 215, Site No. 19-527A, Dist. 2, Cont No. 79-51, WP No. 40-66-13, dated March 1978.

Reference 6. General Plan Drawing, W.B.L. Bridge, Hwy 402, CNR Overhead, 5.8 miles West of Hwy 2, DWG 1, Sheet 233, Site No. 19-527B, Dist. 2, Cont No. 79-51, WP No. 40-66-14, dated March, 1978.

Reference 7. Foundation Layout Drawing, W.B.L. Bridge Hwy 402, CNR Overhead, DWG 3, Sheet 235, Site No. 19-527B, Dist. 2, Cont No. 79-51, WP No. 40-66-14, dated March 1978.

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

MEMORANDUM

TO: A.P. Watt (2)
Regional Structural Planning Engineer
Southwestern Region, London

FROM: Soil Mechanics Section
Geotechnical Office
West Bldg.

ATTENTION:

DATE: April 30, 1976

OUR FILE REF.

IN REPLY TO

SUBJECT:

FOUNDATION INVESTIGATION REPORT
For
W.P. 40-66-13/14
Hwy. 402, District 2, London
CNR Overhead EBL/WBL
5.8 Miles West of Hwy 2

Site #19-527

Attached we are forwarding to you our detailed Foundation Investigation Report on the subsoil conditions existing at the above mentioned site.

We believe that the factual data and recommendations contained therein will prove adequate for your requirements. Should additional information be required, please do not hesitate to contact our Office.

K.G. Selby
Supervising Engineer

KGS/bp

cc: R.S. Pillar
C.S. Grebski
B.J. Giroux
G.A. Wrong
A. Wittenberg
J.R. Roy
D.P. Collins
R. Hore
J. Anderson)
A. Crowley) Memo only
G. Sloan)
Files

FOUNDATION INVESTIGATION REPORT

For

W.P. 40-66-13/14
Hwy. 402, District 2, London
CNR Overhead EBL/WBL
5.8 Miles West of Hwy 2

1. INTRODUCTION

This report is to provide information for the design and construction of proposed twin structures at the above site.

The subsoil information is based on ten sampled boreholes and eight dynamic cone penetration tests. The boring operation was carried out using hollow stem augers which were advanced into the soil without the use of a plug. A spilt-spoon, from which the ball had been removed, was then washed down to just below the bottom of the augers, where it was driven in the conventional manner. In this way the disturbance of the soil layer to be sampled is minimized as it is not subjected to an unbalanced hydrostatic head during the removal of the rods from the hollow stem augers.

2. SITE DESCRIPTION

The proposed location is in the sixth concession of the Twp. of Caradoc approx. 800 ft. west of the 20th. sideroad. The railway, which has twin sets of tracks,runs on a low embankment approx. three feet above the surrounding land. The area is gently rolling and exhibits a poorly developed pattern of drainage. The surrounding fields are engaged in a cash crop type of agriculture.

Physiographically, the area in which the site is located is referred to as the'Caradoc Sand Plain'.

3. SUBSOIL

3.1 General

The subsoil consists of alternating layers of cohesive and non cohesive

material. The first of these is ten to fifteen feet in thickness and consists primarily of silt with some clayey silt in the upper portion. Beneath this is a layer of approx. five feet of clayey silt which disappears in the area south of the railway tracks. Next a layer of five to fifteen feet of fine sand is found which is underlain by five to seven feet of clayey silt. This layer is in turn underlain by approx. 30 ft. of fine sand. Beneath this and extending to a depth of over 125 ft. is found another clayey silt layer.

Locations of boreholes and the inferred subsoil stratigraphy are shown in Dwg. 406613 & 14-A.

3.2 Silt

This layer is from ten to fifteen feet in depth. Its upper portion contains enough clay to make it slightly cohesive in places. Relative density generally increases with depth. The upper portion has a loose relative density with Standard Penetration 'N' values as low as five. In contrast the relative density of the lower portion varies from compact to very dense with Standard Penetration 'N' values ranging to in excess of 100 blows per foot. Moisture content ranges from 18 to 20 percent.

3.3 Clayey Silt

The soil profile contains three distinct layers of clayey silt.

The upper clayey silt layer, which is found between layers of silt and sand is approx. five feet in thickness over most of the site. It was not however encountered in boreholes one, two or three located on the south side of the railway tracks. This layer exhibits a very stiff consistency with shear strengths estimated to be between 2000 and 3000 p.s.f. Moisture content was found to be approx. 20 percent.

The second clayey silt layer consists of five to ten feet of material sandwiched between two fine sand layers. Moisture content varies from 17 to 21 percent. Standard Penetration 'N' values are generally between 14 and 30 indicating a stiff to very stiff consistency.

The third clayey silt layer extends from a depth of approximately 60 ft. to in excess of 125 ft. where the deepest borehole was terminated. It may be subdivided into two portions. Between the depths of 60 and 105 ft. Standard Penetration 'N' values range from 16 to 60 and moisture content is 20 percent or above. Below 105 ft. Standard Penetration Test 'N' values are well in excess of 100 blows per foot and the moisture content ranges from 13 to 19 percent.

3.4 Fine Sand

There are two distinct fine sand layers both of which are sandwiched between layers of clayey silt. The upper layer varies in thickness from five to fifteen feet while the lower layer ranges from 25 to 30 ft. Silt content for both layers generally ranges from 10 to 25 percent but is higher in isolated pockets and along the layer boundaries. Grain size distribution for the fine sand is shown as an envelope in Fig. 1. Standard Penetration 'N' values range from 15 to in excess of 100 blows per foot but are generally in excess of 30. This would indicate a dense to very dense relative density with occasional compact pockets. Laboratory tests indicate a moisture content of approx. 20 percent.

3.5 Groundwater

Field work was carried out during a prolonged thaw in February which produced extensive ponding in surface depressions. Water levels in the boreholes throughout this period remained within a foot of the ground surface. It may be assumed that this water level would be somewhat lower during other seasons of the year.

4. DISCUSSION AND RECOMMENDATIONS

4.1 Discussion

It is proposed that Hwy. 402 pass over the double CNR tracks plus a service road parallel to the railway tracks on twin four span structures. The bridges would have approach embankments approx. 33 ft. in height and would consist of spans of 58,92,87 and 58 ft.

4.2 Perched Abutments

Perched abutments may be supported on steel tube piles (12 3/4" X 1/4"). A design load of 25 tons per pile may be used if these piles are driven to

elev. 780 for the south abutments and 785 for the north abutments.

Alternately if the driving of these piles is controlled by Hiley Formula it is estimated they will achieve a design load of 60 tons at approximate elev. 755.

4.3 Piers

(a) The piers may be supported on spread footings at elev. 786. A design load of 3 tons per sq. ft. may be used assuming a settlement of one inch.

(b) As an alternative the piers may be supported on tube piles. The driving of these piles should be controlled by the Hiley Formula. A design load of 60 tons will be achieved at approx. elev. 755.

(c) The piers may be supported on timber piles. These piles would, however, be unsuitable to use for perched abutments as difficulties in driving them through the approach fills could be expected. A design load of 35 tons should be used for these piles with a tip elev. of 770.

4.4 H-Piles

The structure may be supported on steel H-piles with a design load equal to their allowable structural capacity. This capacity should be achieved at approx. elev. 680.

4.5 Settlements

Settlements will be greatest under the approach fills. Due to the non-cohesive nature of most of the upper 60 ft. of the subsoil, settlement will occur primarily during construction. Differential settlement after the deck is placed will be less than 1 inch.

4.6 Dewatering

The use of spread footings will require a dewatering scheme employing sheet piling. The sheet piling should be driven so that its depth below the

groundwater level is equal to twice the required depth of excavation below the same groundwater level.

4.7 Frost Protection

All pile caps or spread footings should be protected by a minimum four feet of cover against frost action.

4.8 Approach Embankments

No stability problems are anticipated with embankment fills (33 ft.) if 2:1 slopes are employed. Cobbles exceeding a 3 inch. diameter should be removed from fill placed at locations through which piles have to be driven.

REGISTERED PROFESSIONAL ENGINEER
P. J. STUART
PROVINCE OF ONTARIO

Peter Stuart, P. Eng.
Project Engineer

K.G. Selby, P. Eng.
Supervising Engineer

KGS/bp

APPENDIX

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

ENGINEERING SERVICES BRANCH – GEOTECHNICAL OFFICE – SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 1

WP 40-66-13 & 14 LOCATION Co-ords. 15,606,624 N; 1,261,084 E. ORIGINATED BY PJS

DIST 2 HWY 402 BORING DATE February 23, 1976 COMPILED BY MK

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger & Cone Test CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT	LIQUID LIMIT W_L / PLASTIC LIMIT W_P / WATER CONTENT W	UNIT WEIGHT	REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	ELEV	20 40 60 80 100 SHEAR STRENGTH: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	W_P — W — W_L WATER CONTENT % 10 20 30	γ	% GR SA SI CL
794.3	Ground Level									
0.0	Silt, some clayey silt layers		1	SS	17					
			2	SS	37	790				
	Compact to Dense		3	SS	41					0 2 84 14
			4	SS	27					
779.3			5	SS	53	780	100/6"			
15.0	Fine sand, some silt		6	SS	61					0 85 (15)
			7	SS	38					
	Dense to Very Dense					770				
767.8			8	SS	49					
26.5	End of Borehole									

OFFICE REPORT ON SOIL EXPLORATION

20
15 ◇ 5 % STRAIN AT FAILURE
10

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 2

WP 40-66-13 & 14 LOCATION Co-ords. 15,606,638 N; 1,260,960 E. ORIGINATED BY PJS

DIST 2 HWY 402 BORING DATE February 23, 1976 COMPILED BY MK

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger & Cone Test CHECKED BY

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH: o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE	LIQUID LIMIT W_L / PLASTIC LIMIT W_P / WATER CONTENT W (W_P W W_L) / WATER CONTENT % (10 20 30)	UNIT WEIGHT γ	REMARKS % GR SA SI CL
793.5	Ground Level									
0.0	Silt, some clayey silt layers		1	SS	30	790				
			2	SS	31			o		
	Dense		3	SS	47	780				
778.5										
15.0	Fine sand, some silt		4	SS	100/7"					
			5	SS	152			o		0 78 (22)
	Very Dense					770				
767.0			6	SS	78					
26.5	End of Borehole									

OFFICE REPORT ON SOIL EXPLORATION

15 ◇ 20/10 5 % STRAIN AT FAILURE

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

ENGINEERING SERVICES BRANCH – GEOTECHNICAL OFFICE – SOIL MECHANICS SECTION

RECORD OF BOREHOLE Nº 3

WP 40-66-13 & 14 LOCATION Co-ords. 15,606,678 N; 1,261,024 E. ORIGINATED BY PJS

DIST 2 HWY 402 BORING DATE February 24, 1976 COMPILED BY MK

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger & Cone Test CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER ELEV
794.1	Ground Level					
0.0	Silt, some clayey silt layers		1	SS	5	
			2	SS	21	
	Loose to Dense		3	SS	20	
779.1			4	SS	33	
15.0	Fine sand, some silt		5	SS	81	
			6	SS	100/8"	
	Compact to Very Dense		7	SS	15	
763.1			8	SS	65	
31.0	Clayey Silt		9	SS	85	
	Very Stiff to Hard		10	SS	30	
753.1						
41.0	Fine sand, some silt		11	SS	73	
	with silt pockets		12	SS	60	
			13	SS	51	
	Very Dense		14	SS	61	
732.1						
42.0	Clayey silt					
727.6	Hard		15	SS	57	
66.5	End of Borehole					

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE

LIQUID LIMIT w_L PLASTIC LIMIT w_P WATER CONTENT w (w_P — w — w_L) WATER CONTENT %

UNIT WEIGHT γ

REMARKS

% GR SA SI CL

790 780 770 760 750 740 730

20 15 5 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 4

WP 40-66-13 & 14 | LOCATION Co-ords. 15,606,692 N; 1,260,901 E. | ORIGINATED BY PJS

DIST 2 HWY 402 | BORING DATE February 25, 1976 | COMPILED BY MK

DATUM Geodetic | BOREHOLE TYPE Hollow Stem Auger & Cone Test | CHECKED BY GD.

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV
794.0	Ground Level					
0.0	Silt, some clayey silt layers		1	SS	9	
			2	SS	46	
784.0	Loose to Dense					
10.0	Clayey Silt		3	SS	23	
			4	SS	15	
779.0	Very Stiff					
15.0	Fine sand, some silt		5	SS	48	
			6	SS	100/9"	
	Dense to Very Dense					
768.0						
26.0	Clayey Silt		7	SS	38	
			8	SS	16	
761.0	Very Stiff					
33.0			9	SS	59	
	Fine sand, some silt					
	with silt pockets		10	SS	55	
			11	SS	28	
	Dense to Very Dense		12	SS	56	
			13	SS	74	
728.0						
66.0			14	SS	57	
	Clayey Silt					
	Very Stiff to					
	Hard		15	SS	16	
			16	SS	34	
			17	SS	100/7"	
690.0						
104.0						

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE

LIQUID LIMIT W_L | PLASTIC LIMIT W_P | WATER CONTENT W

WATER CONTENT % (10 20 30)

UNIT WEIGHT γ

REMARKS	% GR	SA	SI	CL
	0	7	87	6
	0	88	(12)	
	0	34	62	4
	0	88	(12)	

15 20 10 5 % STRAIN AT FAILURE

Continued

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

ENGINEERING SERVICES BRANCH – GEOTECHNICAL OFFICE – SOIL MECHANICS SECTION

RECORD OF BOREHOLE Nº 4 Continued

WP 40-66-13 & 14 LOCATION Co-ords. 15,606,692 N; 1,260,901 E. ORIGINATED BY PJS

DIST 2 HWY 402 BORING DATE February 25, 1976 COMPILED BY MK

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger & Cone Test CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT		UNIT WEIGHT	REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	ELEV	20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT W WATER CONTENT % 10 20 30	γ	% GR SA SI CL
690.0	continued									
104.0	Clayey Silt									
	Very Stiff to Hard		18	SS	150/6"	680				
			19	SS	120/6"					
668.5			20	SS	100/6"	670				
125.5	End of Borehole									

15 20 10 5 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE Nº 5

WP 40-66-13 & 14 LOCATION Co-ords. 15,606,776 N; 1,260,996 E. ORIGINATED BY PJS

DIST 2 HWY 402 BORING DATE February 20, 1976 COMPILED BY MK

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH PSF (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w / WATER CONTENT %	UNIT WEIGHT γ	REMARKS % GR SA SI CL
794.3	Ground Level									
0.0	Silt, some clayey silt layers									
			1	SS	15					
			2	SS	116					
	Compact to Very Dense		3	SS	63					0 6 88 6
782.3										
12.0	Clayey Silt		4	TW	PH					
776.3	Very Stiff		5	TW	PH					
18.0	Fine sand, some silt		6	SS	87					0 77 (23)
	Very Dense		7	SS	161					
766.3										
28.0	Clayey Silt		8	SS	17					
761.3	Very Stiff									
33.0	Fine sand, some silt with silt pockets		9	SS	72					
			10	SS	76					0 83 (17)
	Very Dense		11	SS	37					
			12	SS	61					
			13	SS	87					
732.8			14	SS	117					
61.5	End of Borehole									

790 780 770 760 750 740

20 15 ◇ 5 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

ENGINEERING SERVICES BRANCH – GEOTECHNICAL OFFICE – SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 6

WP 40-66-13 & 14 LOCATION Co-ords. 15,606,778 N; 1,260,876 E. ORIGINATED BY PJS

DIST 2 HWY 402 BORING DATE February 26, 1976 COMPILED BY MK

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	LIQUID LIMIT W_L / PLASTIC LIMIT W_P / WATER CONTENT W (W_P — W — W_L) WATER CONTENT %	UNIT WEIGHT γ	REMARKS % GR SA SI CL
792.7	Ground Level									
0.0	Silt, some clayey silt layers.		1	SS	10	790				
	Compact to Very Dense		2	SS	30					
780.7			3	SS	52					
12.0	Clayey Silt		4	SS	18	780				
775.7	Very Stiff		5	SS	25					
17.0	Fine sand, some silt		6	SS	100/8"					
770.7	Very Dense					770				
22.0	Clayey Silt		7	SS	14					
765.7	Stiff									
27.0			8	SS	31					
	Fine sand, some silt		9	SS	100/10"	760				
	with silt pockets		10	SS	100/10"					
			11	SS	112	750				
	Dense to Very Dense		12	SS	76					
			13	SS	63	740				
			14	SS	76					
						730				
726.2			15	SS	106					
66.5	End of Borehole									

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

ENGINEERING SERVICES BRANCH – GEOTECHNICAL OFFICE – SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 7

WP 40-66-13 & 14 LOCATION Co-ords. 15,606,830 N; 1,260,937 E. ORIGINATED BY PJS

DIST 2 HWY 402 BORING DATE February 19, 1976 COMPILED BY MK

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger & Cone Test CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV
793.8	Ground Level					
0.0	Silt, some clayey silt layers.		1	SS	6	
	Loose to Very Dense		2	SS	45	
781.8			3	SS	54	
12.0	Clayey Silt		4	SS	12	
775.8	Stiff to Very Stiff		5	SS	17	
18.0	Fine Sand Some Silt		6	SS	90	
765.8	Very Dense		7	SS	130	
28.0	Clayey Silt		8	SS	21	
760.8	Very Stiff					
33.0	Fine sand, some silt with silt pockets		9	SS	48	
			10	SS	69	
	Dense to Very Dense		11	SS	40	
	sand with gravel		12	SS	85	
728.8						
65.0	Clayey Silt		13	SS	49	
	Very Stiff to Hard		14	SS	16	
689.8			15	SS	100/6"	
104.0						

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE

120/10"

LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT W

WATER CONTENT % (10 20 30)

UNIT WEIGHT γ

REMARKS	% GR	SA	SI	CL
	0	2	96	2
	0	0	62	38
	0	78	(22)	
	0	91	(9)	
	26	68	(6)	

20 15 ◇ 5 10 % STRAIN AT FAILURE

Continued

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE Nº 7 Continued

WP 40-66-13 & 14 LOCATION Co-ords. 15,606,830 N; 1,260,937 E. ORIGINATED BY PJS

DIST 2 HWY 402 BORING DATE February 19, 1976 COMPILED BY MK

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT	LIQUID LIMIT W_L / PLASTIC LIMIT W_P / WATER CONTENT W	UNIT WEIGHT	REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	ELEV	20 40 60 80 100 SHEAR STRENGTH: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	W_P — W — W_L WATER CONTENT % 10 20 30	γ	% GR SA SI CL
689.8	continued									
104.0	Clayey Silt Very Stiff to Hard		16	SS	112/6"	680		○		0 1 80 19
677.8			17	SS	111/6"			○		
116.0	End of Borehole									

OFFICE REPORT ON SOIL EXPLORATION

20
15 ◇ 5 % STRAIN AT FAILURE
10

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

ENGINEERING SERVICES BRANCH – GEOTECHNICAL OFFICE – SOIL MECHANICS SECTION

RECORD OF BOREHOLE Nº 8

WP 40-66-13 & 14 LOCATION Co-ords. 15,606,839 N; 1,260,843 E. ORIGINATED BY PJS

DIST 2 HWY 402 BORING DATE February 16, 1976 COMPILED BY MK

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger & Cone Test CHECKED BY

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV
794.0	Ground Level					
0.0	Silt, some clayey silt layers. Compact to Very Dense		1	SS	29	
			2	SS	104	
782.0			3	SS	35	
12.0	Clayey Silt		4	SS	16	
776.0	Stiff		5	SS	12	
18.0	Fine sand, some silt		6	SS	32	
	Dense to Very Dense		7	SS	100/9"	
766.0						
28.0	Clayey Silt		8	SS	18	
760.0	Very Stiff					
34.0	Fine sand, some silt with silt pockets. Compact to Very Dense		9	SS	73	
			10	SS	61	
			11	SS	19	
			12	SS	59	
			13	SS	53	
728.0						
66.0	Clayey silt					
722.5	Very Stiff		14	SS	20	
71.5	End of Borehole					

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

790 780 770 760 750 740 730

120/10"

LIQUID LIMIT w_L
PLASTIC LIMIT w_P
WATER CONTENT w
w_P w w_L
WATER CONTENT %

UNIT WEIGHT γ

REMARKS

% GR SA SI CL

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

ENGINEERING SERVICES BRANCH – GEOTECHNICAL OFFICE – SOIL MECHANICS SECTION

RECORD OF BOREHOLE Nº 9

WP 40-66-13 & 14 LOCATION Co-ords. 15,606,874 N; 1,260,935 E. ORIGINATED BY PJS

DIST 2 HWY 402 BORING DATE February 18, 1976 COMPILED BY MK

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger & Cone Test CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w (w_P w w_L) / WATER CONTENT %	UNIT WEIGHT γ	REMARKS % GR SA SI CL
793.7	Ground Level					ELEV				
0.0	Silt, some clayey silt layers		1	SS	6	790	160			
			2	SS	107					
	Loose to Very Dense		3	SS	51					
781.7										
12.0	Clayey Silt		4	SS	13	780				
	Stiff		5	SS	12					
775.7										
18.0	Fine sand, some silt		6	SS	59					
	Dense to Very Dense		7	SS	45	770				
766.7										
27.0	Clayey Silt									
	Very Stiff		8	SS	20					
760.7						760				
33.0	Fine sand, some silt		9	SS	26					
	with silt pockets		10	SS	55					
			11	SS	22	750				
	Compact to Very Dense		12	SS	59					
			13	SS	69	740				
731.7										
62.0	Clayey Silt					730				
727.2	Hard		14	SS	49					
66.5	End of Borehole									

20
15 ⊹ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 10

WP 40-66-13&14 LOCATION Co-ords. 15,606,894 N; 1,260,788 E. ORIGINATED BY PJS

DIST 2 HWY 402 BORING DATE February 17, 1976 COMPILED BY MK

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger & Cone Test CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER ELEV
794.0	Ground Level					
0.0	Silt, some clayey silt layers.		1	SS	6	790
			2	SS	61	
	Loose to Very Dense		3	SS	47	
782.0						
12.0	Clayey Silt		4	SS	15	780
776.0	Very STiff		5	SS	33	
18.0	Fine Sand Some Silt		6	SS	29	
	Dense to Very Dense		7	SS	112	770
766.0						
28.0	Clayey Silt		8	SS	22	
761.0	Very Stiff					
33.0	Fine Sand, trace of silt with silt pockets		9	SS	27	760
752.5	Compact to Dense		10	SS	50	
41.5	End of Borehole					

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

100/10"

LIQUID LIMIT W_L
PLASTIC LIMIT W_P
WATER CONTENT W
W_P W W_L
WATER CONTENT %
10 20 30

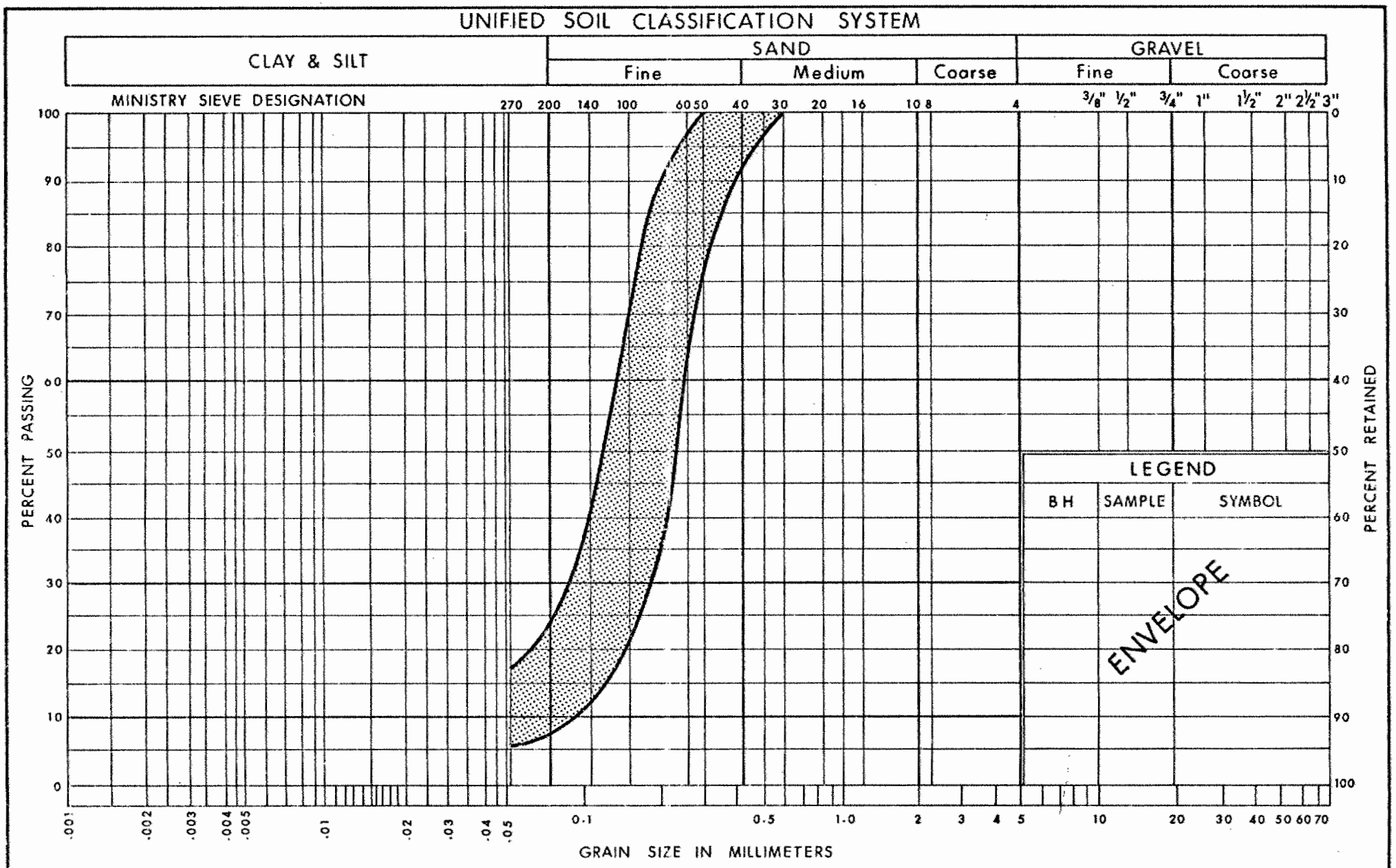
UNIT WEIGHT γ

REMARKS

% GR	SA	SI	CL
0	5	93	2
0	89	(11)	
0	92	(8)	

20
15 ☼ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION



Ministry of Transportation and Communications
Ontario
ENGINEERING SERVICES BRANCH

GRAIN SIZE DISTRIBUTION
FINE SAND, SOME SILT
(UPPER & LOWER LAYERS)

FIG No 1

W P 40-66-13 & 14

FF-A-24(a) (Rev. Jan. 73)

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

PENETRATION RESISTANCE

'N' = STANDARD PENETRATION RESISTANCE :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL. THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

CONSISTENCY	c LB./SQ.FT.	DENSENESS	'N' BLOWS / FT.
VERY SOFT	0 - 250	VERY LOOSE	0 - 4
SOFT	250 - 500	LOOSE	4 - 10
FIRM	500 - 1000	COMPACT	10 - 30
STIFF	1000 - 2000	DENSE	30 - 50
VERY STIFF	2000 - 4000	VERY DENSE	> 50
HARD	> 4000		

TERMS TO BE USED IN DESCRIBING SOILS:-

TRACE < 10% , SOME 10-25% , WITH 25-40% , > 40% SILTY, SANDY, GRAVELLY, CLAYEY ETC.

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.T.	SLOTTED TUBE SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE

P.H. SAMPLE ADVANCED HYDRAULICALLY

P.M. SAMPLE ADVANCED MANUALLY

SOIL TESTS

U	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
UU	UNCONSOLIDATED UNDRAINED TRIAXIAL	F.V.	FIELD VANE
CIU	CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL	C	CONSOLIDATION
CID	" " DRAINED "	S	SENSITIVITY
CAU	" ANISOTROPIC UNDRAINED "		
CAD	" " DRAINED "		

FF-A-24(b) (Rev. Jan. 73)

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

SOIL PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
S_r	DEGREE OF SATURATION
w_L	LIQUID LIMIT
w_P	PLASTIC LIMIT
I_P	PLASTICITY INDEX
w_S	SHRINKAGE LIMIT
I_L	LIQUIDITY INDEX $= \frac{w - w_P}{I_P}$
I_C	CONSISTENCY INDEX $= \frac{w_L - w}{I_P}$
e_{max}	VOID RATIO IN LOOSEST STATE
e_{min}	VOID RATIO IN DENSEST STATE
I_D	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY D_r IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
m_v	COEFFICIENT OF VOLUME CHANGE $= \frac{-\Delta e}{(1+e)\Delta\sigma'}$
c_v	COEFFICIENT OF CONSOLIDATION
C_c	COMPRESSION INDEX $= \frac{\Delta e}{\Delta \log_{10} \sigma'}$
T_v	TIME FACTOR $= \frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION INTERCEPT
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
	IN TERMS OF EFFECTIVE STRESS $\tau_f = c' + \sigma' \tan \phi'$
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
	IN TERMS OF TOTAL STRESS $\tau_f = c_u + \sigma \tan \phi$
μ	COEFFICIENT OF FRICTION
S_t	SENSITIVITY

GENERAL

π	= 3·1416
e	BASE OF NATURAL LOGARITHMS 2·7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

STRESS AND STRAIN

u	PORE PRESSURE
σ	NORMAL STRESS
σ'	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ε	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNGS MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

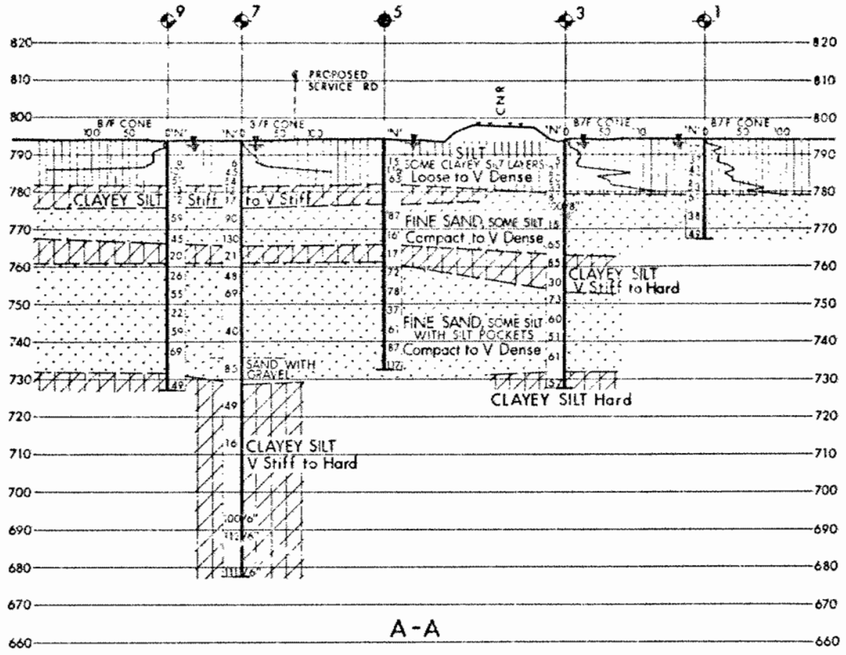
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_o	COEFFICIENT OF EARTH PRESSURE AT REST

FOUNDATIONS

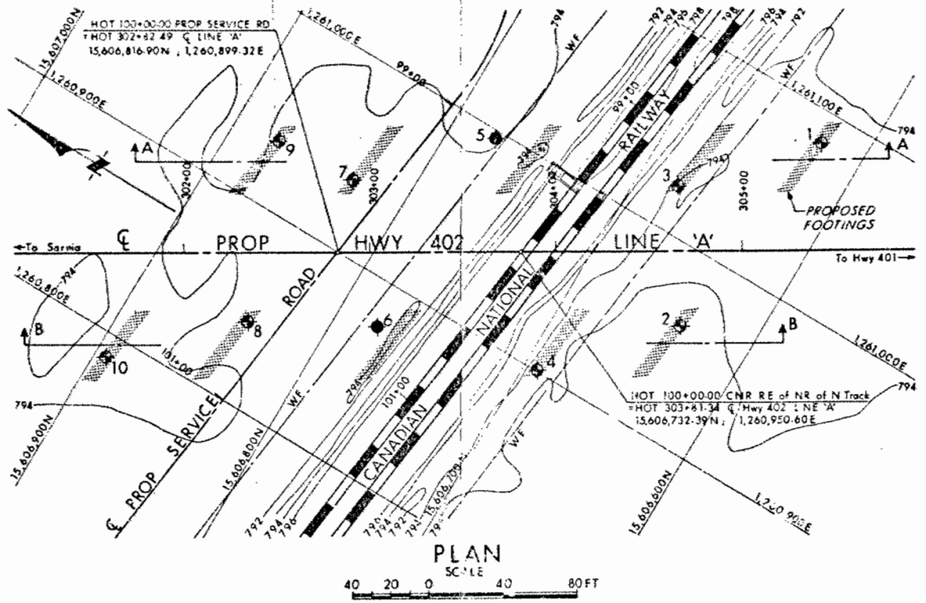
B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
k_s	MODULUS OF SUBGRADE REACTION

SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL



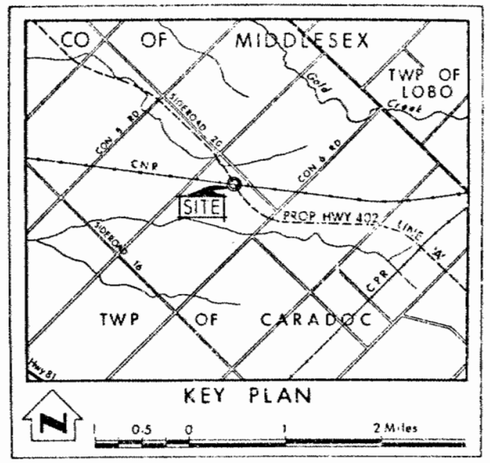
A-A



PLAN

SCALE

40 20 0 40 80 FT

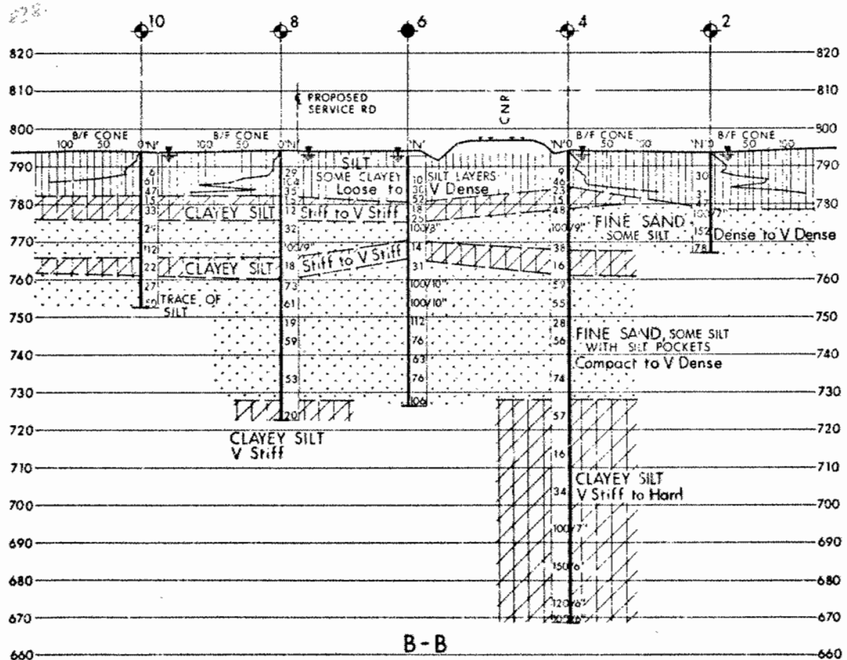


KEY PLAN

LEGEND

- Bore Hole
- Dynamic Cone Penetration Resistance Test B/F CONE - Blows/Ft. Cone Test (350 ft.lbs energy/blow)
- Bore Hole & Cone Test
- Water Levels established at time of field investigation. Feb 1976

NO.	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
1	794.3	15,606,624	1,261,084
2	793.5	15,606,638	1,260,960
3	794.1	15,606,678	1,261,024
4	794.0	15,606,692	1,260,901
5	794.3	15,606,776	1,260,996
6	792.7	15,606,778	1,260,976
7	793.8	15,606,830	1,260,937
8	794.0	15,606,839	1,260,843
9	793.7	15,606,874	1,260,935
10	794.0	15,606,894	1,260,788



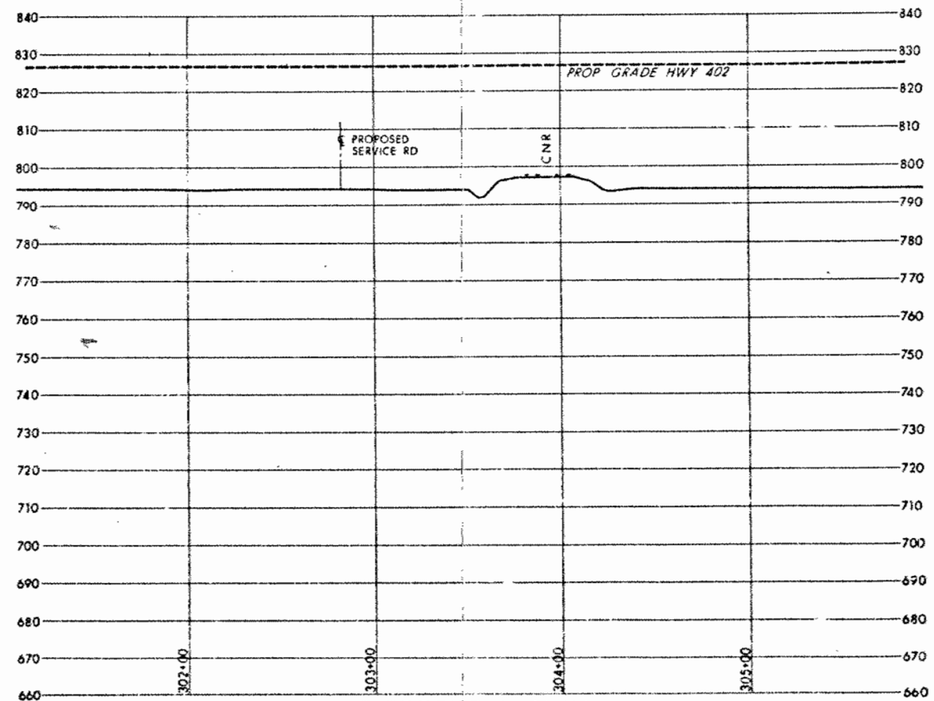
B-B

SECTIONS

SCALE

HOR 40 20 0 40 80 FT

VERT 20 10 0 20 40 FT



℄ PROFILE LINE 'A'

SCALE

HOR 40 20 0 40 80 FT

VERT 20 10 0 20 40 FT

— NOTE —

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

REVISIONS		
DATE	BY	DESCRIPTION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

CANADIAN NATIONAL RAILWAY

(5.8 Miles West of Hwy 2)

HIGHWAY NO Prop 402 LINE 'A' DIST NO 2

CO MIDDLESEX

TWP CARADOC LOT CON

BORE HOLE LOCATIONS & SOIL STRATA

SUBMITTED	CHECKED	W.P. NO 40-66-13 & 14
DRAWN	CHECKED	W.O. NO
DATE April 21, 1976		SITE NO 19-527
APPROVED		CONT NO

DRAWING NO 406613 & 14-A

BRIDGE DRAWING NO

REF No E-5383-1, July 1975

DOCUMENT MICROFILMING IDENTIFICATION

Reference 2

G.I.-30 SEPT. 1976

GEOCRES No. 40I13-47

DIST. 2 REGION

W.P. No. 40-66-13/14

CONT. No. 79-51

W. O. No.

STR. SITE No. 19-527

HWY. No. 402

LOCATION C.N.R Overhead Structures

No of PAGES - —

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION REPORT

CONTRACT NO 79-51

Ontario

Ministry of Transportation and Communications

INDEX

NOTE: For purposes of the contract these reports supercede all other foundation reports prepared by or for the Ministry in connection with the above mentioned projects.

EXPLANATION OF TERMS USED IN REPORT

'N' VALUE: AN INDICATOR OF SUBSOIL QUALITY. IT IS OBTAINED FROM THE STANDARD PENETRATION TEST (CSA STD. A119.1). SPT 'N' VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 2 INCH O.D. SPLIT-BARREL SAMPLER TO PENETRATE 12 INCHES INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WEIGHING 140 POUNDS, FALLING FREELY A DISTANCE OF 30 INCHES. FOR PENETRATIONS OF LESS THAN 12 INCHES 'N' VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. 'N' VALUES CORRECTED FOR OVERBURDEN PRESSURE ARE DENOTED THUS $\bar{N}$.

DYNAMIC CONE PENETRATION TEST (CSA STD. A119.3): CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (2" O.D. 60 CONE ANGLE) DRIVEN BY 350 FT-LB IMPACTS ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 12 INCH ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOIL QUALITY: SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSITY.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH AS FOLLOWS:

S_u (PSF)	0 - 250	250 - 500	500 - 1000	1000 - 2000	2000 - 4000	>4000
	VERY SOFT	*SOFT*	*FIRM*	*STIFF*	*VERY STIFF*	*HARD*

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF SPT 'N' VALUES AS FOLLOWS:

'N' (BLOW/FT)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	*LOOSE*	*COMPACT*	*DENSE*	*VERY DENSE*

ROCK QUALITY: ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND/OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH DRILLED IN THAT CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE NATURALLY FRACTURED CORE PIECES, 4"+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINTING AND BEDDING:

SPACING	2"	2" - 12"	1' - 3'	3' - 10'	> 10'
JOINTING	*VERY CLOSE*	*CLOSE*	*MOD. CLOSE*	*WIDE*	*VERY WIDE*
BEDDING	*VERY THIN*	*THIN*	*MEDIUM*	*THICK*	*VERY THICK*

ABBREVIATIONS & SYMBOLS

LABORATORY TESTING

TRIAXIAL TESTS ARE DESCRIBED IN TERMS OF WHETHER THEY ARE CONSOLIDATED (C) OR NOT (U)
ISOTROPICALLY (I) OR NOT (A)
AND SHEARED DRAINED (D) OR UNDRAINED (U)
WITH PORE PRESSURE MEASUREMENTS (BAR OVER SYMBOLS)
EG. $\overline{CIU}$ = CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENT
UNLESS OTHERWISE SPECIFIED IN REPORT ALL TESTS ARE IN COMPRESSION

FIELD SAMPLING

S S	SPLIT SPOON
W S	WASH SAMPLE
S T	SLOTTED TUBE SAMPLE
B S	BLOCK SAMPLE
C S	CHUNK SAMPLE
T W	THINWALL OPEN
T P	THINWALL PISTON
O S	OSTERBERG SAMPLE
F S	FOIL SAMPLE
R C	ROCK CORE
P H	T.W. ADVANCED HYDRAULICALLY
P M	T.W. ADVANCED MANUALLY

EARTH PRESSURE TERMS

μ	COEFFICIENT OF FRICTION
δ	ANGLE OF WALL FRICTION
k_o	COEFFICIENT OF EARTH PRESSURE AT REST
k_A	COEFFICIENT OF ACTIVE EARTH PRESSURE
k_p	COEFFICIENT OF PASSIVE EARTH PRESSURE
i	ANGLE OF INCLINATION OF SURCHARGE
ω	SLOPE ANGLE-BACKFACE OF WALL
β	ANGLE OF SLOPE
N_γ, N_q, N_c	BEARING CAPACITY FACTORS
D_f	DEPTH OF FOOTING
B,L	FOOTING DIMENSIONS

INDEX PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	UNIT WEIGHT OF SUBMERGED SOIL
G_s	SPECIFIC GRAVITY OF SOLIDS
e	VOIDS RATIO
e_o	INITIAL VOIDS RATIO
e_{max}	e IN LOOSEST STATE
e_{min}	e IN DENSEST STATE
D_r	RELATIVE DENSITY = $\frac{e_{max} - e}{e_{max} - e_{min}}$
n	POROSITY
w	WATER CONTENT
w_L	LIQUID LIMIT
w_p	PLASTIC LIMIT
w_s	SHRINKAGE LIMIT
I_p	PLASTICITY INDEX = $w_L - w_p$
I_L	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
I_c	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
A_c	ACTIVITY = $\frac{I_p \text{ of soil}}{\% < 2\mu m \text{ Soil Fraction}}$
Om	ORGANIC MATTER CONTENT
S_r	DEGREE OF SATURATION
S	SENSITIVITY = $\frac{S_u \text{(undisturbed)}}{S_u \text{(remoulded)}}$

STRENGTH PARAMETERS

ϕ	ANGLE OF SHEARING RESISTANCE
τ_f	PEAK SHEAR STRENGTH
τ_R	RESIDUAL SHEAR STRENGTH
c	COHESION INTERCEPT
$\sigma_1, \sigma_2, \sigma_3$	NORMAL PRINCIPAL STRESSES
u	PORE WATER PRESSURE
u_e	EXCESS u
r_u	PORE PRESSURE RATIO
q_u	UNCONFINED COMPRESSIVE STRENGTH
s_u	UNDRAINED SHEAR STRENGTH
ϵ	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO
E	MODULUS OF ELASTICITY
G	MODULUS OF SHEAR DEFORMATION
k_s	MODULUS OF SUBGRADE REACTION
m,n	STABILITY COEFFICIENTS
A,B	PORE PRESSURE COEFFICIENTS

NOTE: EFFECTIVE STRESS PARAMETERS ARE DENOTED BY USE OF APOSTROPHE ABOVE THE SYMBOL, THUS:
ϕ' = EFFECTIVE ANGLE OF SHEARING RESISTANCE;
σ' = EFFECTIVE NORMAL STRESS

HYDRAULIC TERMS

h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
j	SEEPAGE FORCE PER UNIT VOLUME
η	COEFFICIENT OF VISCOSITY
k	COEFFICIENT OF HYDRAULIC CONDUCTIVITY
k_h	k IN HORIZONTAL DIRECTION
k_v	k IN VERTICAL DIRECTION
m_v	COEFFICIENT OF VOLUME CHANGE
c_v	COEFFICIENT OF CONSOLIDATION
C_c	COMPRESSION INDEX
C_r	RECOMPRESSION INDEX
d	DRAINAGE PATH DISTANCE
T_v	TIME FACTOR
U	DEGREE OF CONSOLIDATION
OCR	OVERCONSOLIDATION RATIO

FOUNDATION INVESTIGATION REPORT

For

C.N.R. Overhead E.B.L. and W.B.L.
W.P.s 40-66-13/14, Site Nos. 19-527 A/B
Hwy. 402, District 2, London

INTRODUCTION

This report contains the results of a foundation investigation which was carried out at the site of the above mentioned projects. Fieldwork was done during the period of February 16 to 26, 1976 utilizing a continuous flight auger machine equipped with 3¼ inch I.D. hollow stem augers. The subsoil information is based on ten sampled boreholes and eight dynamic cone penetration tests. The boring operation was carried out using hollow stem augers which were advanced into the soil without the use of a plug. A split-spoon from which the ball had been removed was then washed down to just below the bottom of the augers where it was driven in the conventional manner. In this way the disturbance of the soil layer to be sampled is minimized as it is not subjected to an unbalanced hydrostatic head during the removal of the rods from the hollow stem augers.

SITE DESCRIPTION

The site is located in the sixth concession of the Township of Caradoc approximately 800 feet west of the 20th Sideroad. The railway, which has twin sets of tracks, runs on a low embankment approximately three feet above the surrounding land. The area is gently rolling and exhibits a poorly developed pattern of drainage. The surrounding fields are engaged in a cash crop type of agriculture.

Physiographically, the area in which the site is located is referred to as the 'Caradoc Sand Plain'.

SUBSURFACE CONDITIONS

General

The subsoil consists of alternating layers of cohesive and noncohesive material. The first of these is ten to fifteen feet in thickness

and consists primarily of silt with some clayey silt in the upper portion. Beneath this is a layer of approximately five feet of clayey silt which disappears in the area south of the railway tracks. Next a layer of five to fifteen feet of fine sand is found which is underlain by five to seven feet of clayey silt. This layer is in turn underlain by approximately 30 feet of fine sand. Beneath this and extending to a depth of over 125 feet is found another clayey silt layer. Reference should be made to the Record of Borehole Sheets contained in the report Appendix. Locations of boreholes and the inferred subsoil stratigraphy are shown on Drawing 19-527A-2 and 19-527B-2 of the Contract Drawings.

Silt

This layer is from ten to fifteen feet in depth. Its upper portion contains enough clay to make it slightly cohesive in places. Relative density generally increases with depth. The upper portion has a loose relative density with Standard Penetration 'N' values as low as five. In contrast, the relative density of the lower portion varies from compact to very dense with Standard Penetration 'N' values ranging to in excess of 100 blows per foot. Moisture content ranges from 18 to 20 percent.

Clayey Silt

The soil profile contains three distinct layers of clayey silt. The upper clayey silt layer, which is found between layers of silt and sand, is approximately five feet in thickness over most of the site. It was not, however, encountered in boreholes, 1, 2 or 3 located on the south side of the railway tracks. This layer exhibits a very stiff consistency with shear strengths estimated to be between 2000 and 3000 p.s.f. Moisture content was found to be approximately 20 percent. The second clayey silt layer consists of five to ten feet of material sandwiched between two fine sand layers. Moisture content varies from 17 to 21 percent. Standard Penetration 'N' values are generally between 14 and 30 indicating a stiff to very stiff consistency.

The third clayey silt layer extends from a depth of approximately 60 feet to in excess of 125 feet where the deepest borehole was terminated. It may be subdivided into two portions. Between the

depths of 60 and 105 feet Standard Penetration 'N' values range from 16 to 60 and moisture content is 20 percent or above. Below 105 feet Standard Penetration Test 'N' values are well in excess of 100 blows per foot and the moisture content ranges from 13 to 19 percent.

Fine Sand

There are two distinct fine sand layers, both of which are sandwiched between layers of clayey silt. The upper layer varies in thickness from five to fifteen feet, while the lower layer ranges from 25 to 30 feet. Silt content for both layers generally ranges from 10 to 25 percent but is higher in isolated pockets and along the layer boundaries. Grain size distribution for the fine sand is shown as an envelope in Figure 1. Standard Penetration 'N' values range from 15 to in excess of 100 blows per foot but are generally in excess of 30. This would indicate a dense to very dense relative density with occasional compact pockets. Laboratory tests indicate a moisture content of approximately 20 percent.

Groundwater

Fieldwork was carried out during a prolonged thaw in February which produced extensive ponding in surface depressions. Water levels in the boreholes throughout this period remained within a foot of the ground surface. It may be assumed that this water level would be somewhat lower during other seasons of the year.

P. Stuart, P. Eng.
Project Engineer

K.G. Selby, P. Eng.
Supervising Engineer

January, 1979

APPENDIX

RECORD OF BOREHOLE No 1

WP 40-66-13 & 14 LOCATION Co-ords. 15,606,624 N; 1,261,084 E. ORIGINATED BY PJS

DIST 2 HWY 402 BORING DATE February 23, 1976 COMPILED BY MK

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger & Cone Test CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w	UNIT WEIGHT	REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	ELEV	20 40 60 80 100 SHEAR STRENGTH: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	w_P w w_L WATER CONTENT % 10 20 30	γ	% GR SA SI CL
794.3	Ground Level									
0.0	Silt, some clayey silt layers		1	SS	17					
			2	SS	37	790				0 2 84 14
	Compact to Dense		3	SS	41					
			4	SS	27					
779.3			5	SS	53	780	100/6"			0 85 (15)
15.0	Fine sand, some silt		6	SS	61					
			7	SS	38					
	Dense to Very Dense					770				
767.8			8	SS	49					
26.5	End of Borehole									

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

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RECORD OF BOREHOLE Nº 2

WP 40-66-13 & 14 LOCATION Co-ords. 15,606,638 N; 1,260,960 E. ORIGINATED BY PJS

DIST 2 HWY 402 BORING DATE February 23, 1976 COMPILED BY MK

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger & Cone Test CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w	UNIT WEIGHT	REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	ELEV	20 40 60 80 100 SHEAR STRENGTH: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	w_P w w_L WATER CONTENT % 10 20 30	γ	% GR SA SI CL
793.5 Ground Level										
0.0	Silt, some clayey silt layers		1	SS	30	790				
	Dense		2	SS	31					
778.5			3	SS	47	780				
15.0	Fine sand, some silt		4	SS	100/7"					
	Very Dense		5	SS	152					0 78 (22)
767.0			6	SS	78	770				
26.5	End of Borehole									

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

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RECORD OF BOREHOLE Nº 3

WP 40-66-13 & 14 LOCATION Co-ords. 15,606,678 N; 1,261,024 E. ORIGINATED BY PJS

DIST 2 HWY 402 BORING DATE February 24, 1976 COMPILED BY MK

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger & Cone Test CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w	UNIT WEIGHT	REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	ELEV	20 40 60 80 100 SHEAR STRENGTH: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	w_P — w — w_L WATER CONTENT %	γ	% GR SA SI CL
794.1	Ground Level					ELEV				
0.0	Silt, some clayey silt layers		1	SS	5					
			2	SS	21					
	Loose to Dense		3	SS	20					
779.1			4	SS	33	780				
15.0	Fine sand, some silt		5	SS	81					
			6	SS	100/8"					
	Compact to Very Dense		7	SS	15	770				
763.1			8	SS	65					
31.0	Clayey Silt		9	SS	85	760				
	Very Stiff to Hard		10	SS	30					
753.1										
41.0	Fine sand, some silt		11	SS	73	750				
	with silt pockets		12	SS	60					
	Very Dense		13	SS	51	740				
			14	SS	61					
732.1										
42.0	Clayey silt					730				
727.6	Hard		15	SS	57					
66.5	End of Borehole									

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

RECORD OF BOREHOLE No 4

WP 40-66-13 & 14 | LOCATION Co-ords. 15,606,692 N; 1,260,901 E. | ORIGINATED BY PJS

DIST 2 HWY 402 | BORING DATE February 25, 1976 | COMPILED BY MK

DATUM Geodetic | BOREHOLE TYPE Hollow Stem Auger & Cone Test | CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV
794.0	Ground Level					
0.0	Silt, some clayey silt layers		1	SS	9	
784.0	Loose to Dense		2	SS	46	
10.0	Clayey Silt		3	SS	23	
779.0	Very Stiff		4	SS	15	
15.0	Fine sand, some silt		5	SS	48	
	Dense to Very Dense		6	SS	100/9"	
768.0			7	SS	38	
26.0	Clayey Silt		8	SS	16	
761.0	Very Stiff					
33.0	Fine sand, some silt with silt pockets		9	SS	59	
			10	SS	55	
			11	SS	28	
	Dense to Very Dense		12	SS	56	
728.0			13	SS	74	
66.0	Clayey Silt Very Stiff to Hard		14	SS	57	
			15	SS	16	
			16	SS	34	
			17	SS	100/7"	
690.0						
104.0						

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE

LIQUID LIMIT w_L | PLASTIC LIMIT w_P | WATER CONTENT w (w_P — w — w_L)

WATER CONTENT % (10 20 30)

UNIT WEIGHT γ

REMARKS	% GR	SA	SI	CL
	0	7	87	6
	0	88	(12)	
	0	34	62	4
	0	88	(12)	

15 20 10 5 % STRAIN AT FAILURE

Continued

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE Nº 4 Continued

WP 40-66-13 & 14 LOCATION Co-ords. 15,606,692 N; 1,260,901 E. ORIGINATED BY PJS
DIST 2 HWY 402 BORING DATE February 25, 1976 COMPILED BY MK
DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger & Cone Test CHECKED BY

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	LIQUID LIMIT W_L / PLASTIC LIMIT W_P / WATER CONTENT W (W_P — W — W_L) / WATER CONTENT % 10 20 30	UNIT WEIGHT γ	REMARKS % GR SA SI CL
690.0	continued									
104.0	Clayey Silt Very Stiff to Hard		18	SS	150/6"	680				
			19	SS	120/6"					
668.5			20	SS	100/6"	670				
125.5	End of Borehole									

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE Nº 5

WP 40-66-13 & 14 LOCATION Co-ords. 15,606,776 N; 1,260,996 E. ORIGINATED BY PJS

DIST 2 HWY 402 BORING DATE February 20, 1976 COMPILED BY MK

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV
794.3	Ground Level					
0.0	Silt, some clayey silt layers		1	SS	15	
			2	SS	116	
	Compact to Very Dense		3	SS	63	
782.3						
12.0	Clayey Silt		4	TW	PH	
776.3	Very Stiff		5	TW	PH	
18.0	Fine sand, some silt		6	SS	87	
	Very Dense		7	SS	161	
766.3						
28.0	Clayey Silt		8	SS	17	
761.3	Very Stiff					
33.0	Fine sand, some silt		9	SS	72	
	with silt pockets		10	SS	78	
	Very Dense		11	SS	37	
			12	SS	61	
			13	SS	87	
732.8			14	SS	117	
61.5	End of Borehole					

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH PSF
○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE
1000 2000

LIQUID LIMIT w_L PLASTIC LIMIT w_P WATER CONTENT w (w_P w w_L)
WATER CONTENT % 10 20 30

UNIT WEIGHT γ

REMARKS

% GR	SA	SI	CL
0	6	88	6
0	77	(23)	
0	83	(17)	

15 20 5 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 6

WP 40-66-13 & 14 LOCATION Co-ords. 15,606,778 N; 1,260,876 E. ORIGINATED BY PJS

DIST 2 HWY 402 BORING DATE February 26, 1976 COMPILED BY MK

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w (w_P — w — w_L) / WATER CONTENT %	UNIT WEIGHT γ	REMARKS % GR SA SI CL
792.7	Ground Level									
0.0	Silt, some clayey silt layers.		1	SS	10	790				
	Compact to Very Dense		2	SS	30					
780.7			3	SS	52					
12.0	Clayey Silt		4	SS	18	780				
775.7	Very Stiff		5	SS	25					
17.0	Fine sand, some silt		6	SS	100/8"					
770.7	Very Dense					770				
22.0	Clayey Silt		7	SS	14					
765.7	Stiff									
27.0			8	SS	31					
	Fine sand, some silt		9	SS	100/10"	760				
	with silt pockets		10	SS	100/10"					
			11	SS	112	750				
	Dense to Very Dense		12	SS	76					
			13	SS	63	740				
			14	SS	76					
						730				
726.2			15	SS	106					
66.5	End of Borehole									

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE Nº 7

WP 40-66-13 & 14 LOCATION Co-ords. 15,606,830 N; 1,260,937 E. ORIGINATED BY PJS

DIST 2 HWY 402 BORING DATE February 19, 1976 COMPILED BY NK

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger & Cone Test CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV
793.8	Ground Level					
0.0	Silt, some clayey silt layers. Loose to Very Dense		1	SS	6	
			2	SS	45	
			3	SS	54	
781.8						
12.0	Clayey Silt Stiff to Very Stiff		4	SS	12	
			5	SS	17	
775.8						
18.0	Fine Sand Some Silt Very Dense		6	SS	90	
			7	SS	130	
765.8						
28.0	Clayey Silt Very Stiff		8	SS	21	
760.8						
33.0	Fine sand, some silt with silt pockets Dense to Very Dense		9	SS	48	
			10	SS	69	
			11	SS	40	
	sand with gravel		12	SS	85	
728.8						
65.0	Clayey Silt Very Stiff to Hard		13	SS	49	
			14	SS	16	
			15	SS	100/6"	
689.8						
104.0						

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

LIQUID LIMIT w_L
PLASTIC LIMIT w_P
WATER CONTENT w
w_P w w_L
WATER CONTENT % (10 20 30)

UNIT WEIGHT γ

REMARKS

% GR	SA	SI	CL
0	2	96	2
0	0	62	38
0	78	(22)	
0	91	(9)	
26	68	(6)	

790 780 770 760 750 740 730 720 710 700 690

120/10"

20
15 ☼ 5 % STRAIN AT FAILURE
10

Continued

RECORD OF BOREHOLE Nº 7 Continued

WP 40-66-13 & 14 LOCATION Co-ords. 15,606,830 N; 1,260,937 E. ORIGINATED BY PJS
DIST 2 HWY 402 BORING DATE February 19, 1976 COMPILED BY MK
DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w (w_P w w_L) / WATER CONTENT % (10 20 30)	UNIT WEIGHT γ	REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	ELEV				% GR SA SI CL
689.8	continued									
104.0	Clayey Silt Very Stiff to Hard		16	SS	11276"			○		0 1 80 19
680										
677.8			17	SS	11176"			○		
116.0	End of Borehole									

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 8

WP 40-66-13 & 14 LOCATION Co-ords. 15,606,839 N; 1,260,843 E. ORIGINATED BY PJS

DIST 2 HWY 402 BORING DATE February 16, 1976 COMPILED BY MK

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger & Cone Test CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) SHEAR STRENGTH: o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE	LIQUID LIMIT w_L, PLASTIC LIMIT w_P, WATER CONTENT w (w_P w w_L) WATER CONTENT %	UNIT WEIGHT γ	REMARKS % GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	ELEV				
794.0	Ground Level									
0.0	Silt, some clayey silt layers. Compact to Very Dense		1	SS	29					
			2	SS	104					
782.0			3	SS	35					
12.0	Clayey Silt Stiff		4	SS	16					
776.0			5	SS	12					
18.0	Fine sand, some silt Dense to Very Dense		6	SS	32					
			7	SS	100/9"					
766.0										
28.0	Clayey Silt Very Stiff		8	SS	18					
760.0										
34.0	Fine sand, some silt with silt pockets. Compact to Very Dense		9	SS	73					
			10	SS	61					
			11	SS	19					
			12	SS	59					
			13	SS	53					
728.0										
66.0	Clayey silt Very Stiff		14	SS	20					
722.5										
71.5	End of Borehole									

790 780 770 760 750 740 730

120/10"

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

RECORD OF BOREHOLE No 9

WP 40-66-13 & 14 LOCATION Co-ords. 15,606,874 N; 1,260,935 E. ORIGINATED BY PJS

DIST 2 HWY 402 BORING DATE February 18, 1976 COMPILED BY MR

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger & Cone Test CHECKED BY

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV
793.7	Ground Level					
0.0	Silt, some clayey silt layers		1	SS	6	
			2	SS	107	
	Loose to Very Dense		3	SS	51	
781.7						
12.0	Clayey Silt		4	SS	13	
	Stiff		5	SS	12	
775.7						
18.0	Fine sand, some silt		6	SS	59	
	Dense to Very Dense		7	SS	45	
766.7						
27.0	Clayey Silt		8	SS	20	
	Very Stiff					
760.7						
33.0	Fine sand, some silt with silt pockets		9	SS	26	
			10	SS	55	
			11	SS	22	
	Compact to Very Dense		12	SS	59	
			13	SS	69	
731.7						
62.0	Clayey Silt					
727.2	Hard		14	SS	49	
66.5	End of Borehole					

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE

LIQUID LIMIT —— w_L PLASTIC LIMIT —— w_p WATER CONTENT —— w

w_p — w — w_L WATER CONTENT %

160

UNIT WEIGHT γ

REMARKS

% GR SA SI CL

790 780 770 760 750 740 730

20 15 5 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE Nº 10

WP 40-66-13&14 LOCATION Co-ords. 15,606,894 N; 1,260,788 E. ORIGINATED BY PJS

DIST 2 HWY 402 BORING DATE February 17, 1976 COMPILED BY MK

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger & Cone Test CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER ELEV
794.0	Ground Level					
0.0	Silt, some clayey silt layers.		1	SS	6	
			2	SS	61	
	Loose to Very Dense		3	SS	47	
782.0						
12.0	Clayey Silt		4	SS	15	
			5	SS	33	
776.0	Very STiff					
18.0	Fine Sand Some Silt		6	SS	29	
	Dense to Very Dense		7	SS	112	
766.0						
28.0	Clayey Silt		8	SS	22	
761.0	Very Stiff					
33.0	Fine Sand, trace of silt with silt pockets		9	SS	27	
752.5	Compact to Dense		10	SS	50	
41.5	End of Borehole					

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH
○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE

100/10"

LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT W

WATER CONTENT % (10 20 30)

UNIT WEIGHT γ

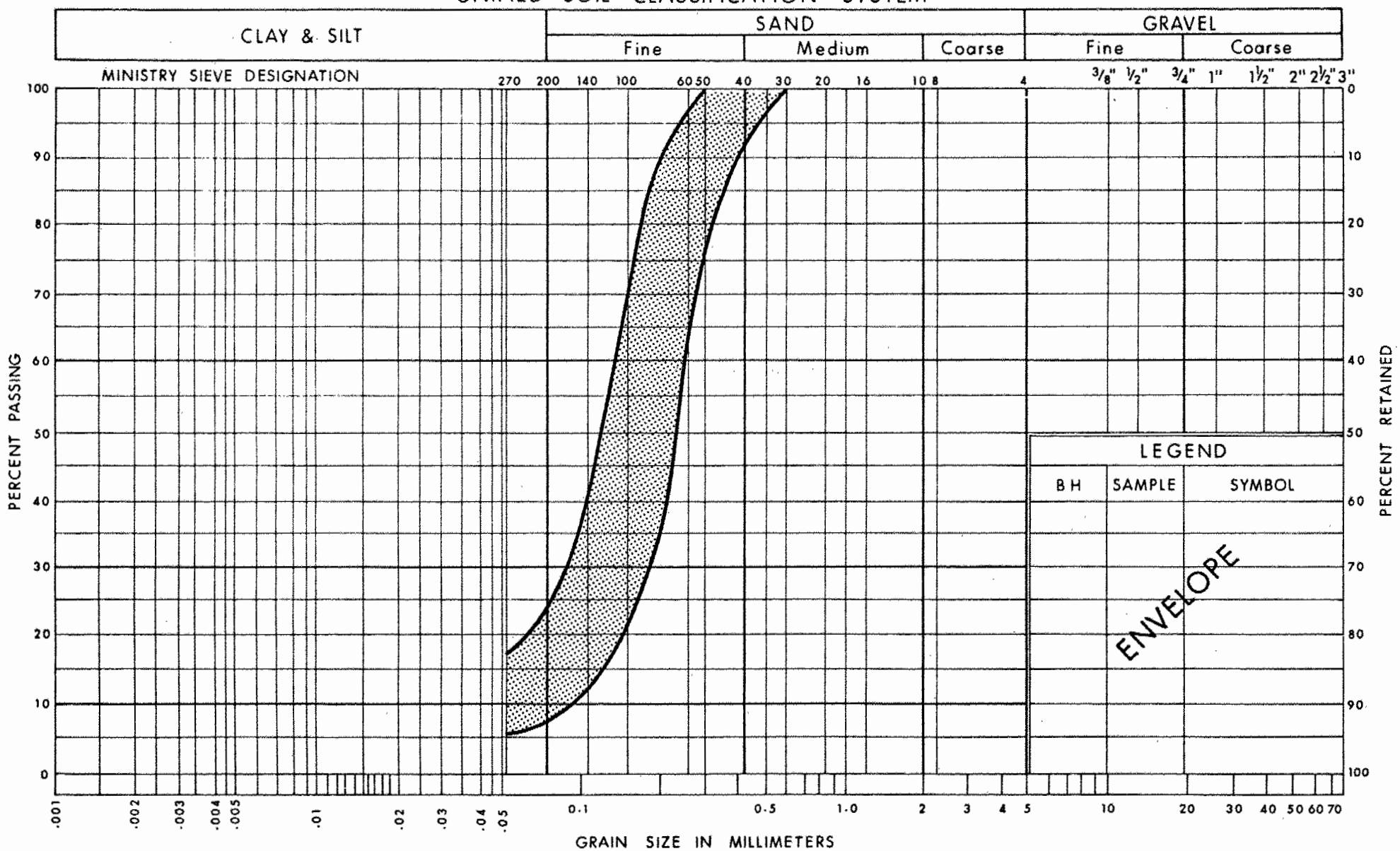
REMARKS

	% GR	SA	SI	CL
	0	5	93	2
	0	89	(11)	
	0	92	(8)	

15 20 10 5 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation and Communications
Ontario

GRAIN SIZE DISTRIBUTION
FINE SAND, SOME SILT
(UPPER & LOWER LAYERS)

FIG No 1

W P 40-66-13 & 14

19

F

memorandum

Ontario

To: M. Bond
Head, Geotechnical Section
Southwestern Region

Date: 1985 09 18

From: Foundation Design Section
Room 315, Central Building

RE: C.N.R. Overhead, East Approach Embankment
Site No. 19-527, Highway 402
District 2, London

This memo summarizes discussions and technical recommendations formulated by yourself and the writer during our visit to the above-mentioned site on 85 06 13 and subsequently by telephone.

Background

The embankments for the structure approaches were constructed to subgrade level under Contract 79-51. Fill material used was a silty clay. Original ground at the site consists of layers of compact to very dense silt followed by stiff to hard silty clay. The pavements were constructed under Contract 82-67 and consisted of a 1½ inch surface course of HL1, a 1½ inch upper course of HL4, a 7-inch middle course of concrete base and a 5-inch lower course of lean concrete base. Shortly after the road was opened to the public, settlements began to occur on the E.B.L.s and W.B.L.s of the east approach from the bridge to about six hundred feet easterly. Investigations carried out by the Regional Geotechnical Sections revealed the presence of up to three feet of sand saturated with water below the lean concrete base. It appears that this sandy material had been used to bring the embankment up to subgrade level prior to paving operations. Its saturated condition and apparent inability to drain is most undesirable just below the pavement. These factors are probably the major causes of the settlements which have occurred.

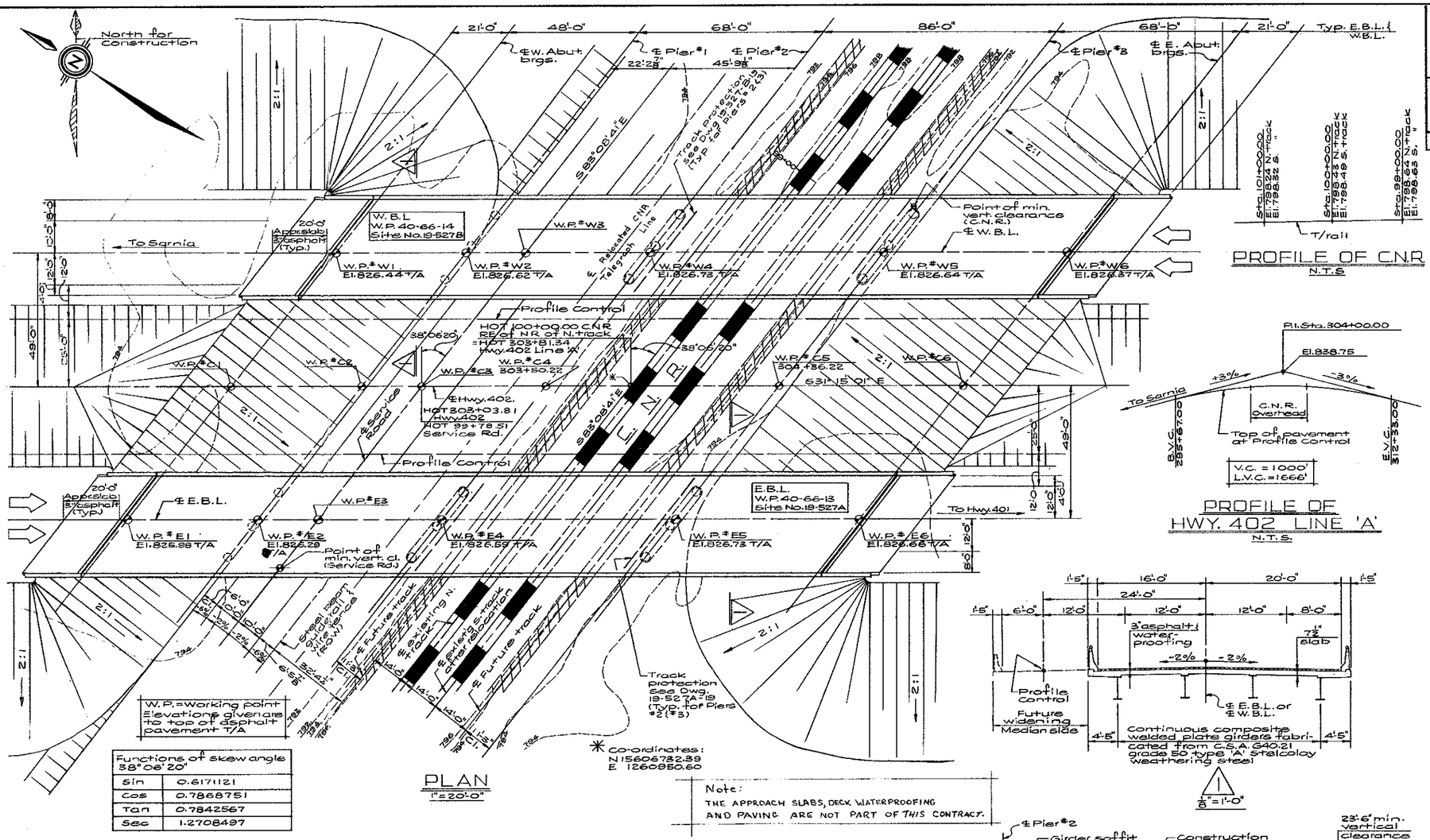
Recommendations

A review of the subsurface conditions at this site indicates that it is most unlikely that the pavement settlements are due to differential settlements of the soil below the embankments. They are almost certainly due to compression of the saturated sandy material in the upper subgrade. Only removal of this material and complete rebuilding will provide a one-hundred percent solution to the problem, however, before this extreme step is taken another approach should be tried. If drainage of the sand layers can be effected and maintained it may be possible that further settlements will be substantially reduced or prevented and the pavement will require patching only. To achieve this, french drains two feet wide and five feet deep should be constructed at each side of the pavements. A six inch perforated pipe should be placed in the trench which should be backfilled with Granular 'A'. A frost free outlet must be provided for the pipes. In those areas where settlement is severe, transverse french drains connected to the side drains should also be constructed. This treatment should be applied initially as an experiment on one or two areas where the settlements are the most severe and extended if significant improvements occur.

K. G. Selby

K.G. Selby, P. Eng.
Chief Foundations Engineer
(West)

7540-1318 (10/78) KGS/mmj



DIST. No. 2
CONT No 79-51
WP No 40-66-13

C.N.R. OVERHEAD
5.8 miles west of Hwy. 2
GENERAL PLAN

SHEET 213

E.B.L. Bridge, Hwy. 402

NOTES

Class of Concrete

Deck & barrier walls ——— 4000 P.S.I.
Piers ——————— 4000 P.S.I.
Remainder ——————— 3000 P.S.I.
Or as noted on drawings

Clear Cover on Reinf. Steel

Footings ——————— 3"
Abuts. ——————— 3"
Deck ——————— 2" top; 1" bot.
Barrier walls ——————— As shown
Or as noted on drawings

Construction Notes

The Contractor shall be responsible for finishing the bearing seat dead level to the specified elevations with a tolerance of ± ⅛".

No concrete shall be placed above the abutment bearing seats until concrete in the deck has been placed.

Reinforcing Steel Grade ——— 400

Reinf. bars with the designation 'C' at the end of the bar marks shall be coated bars

Formwork

The formwork between deck and ballast walls (e.g. expanded polystyrene) shall be removed by the Contractor.

Concrete & Structural Steel Quant.

Concrete & structural steel quantities are listed below for the appropriate lump sum tender items:

Concrete in piers, abuts. & wingwalls 3000 P.S.I.	168	Cu.yd.
4000 P.S.I.	202	Cu.yd.
Concrete in deck ———	277	Cu.yd.
Concrete in barrier walls —	47	Cu.yd.
Concrete in approach slabs ———	45	Cu.yd.
Structural Steel ———	89	Tons

LIST OF DRAWINGS

B.M. 794.97
Geodetic Datum
N & W in NW Root at 2.5 Maple
505' L± 301+10 Line 'A'

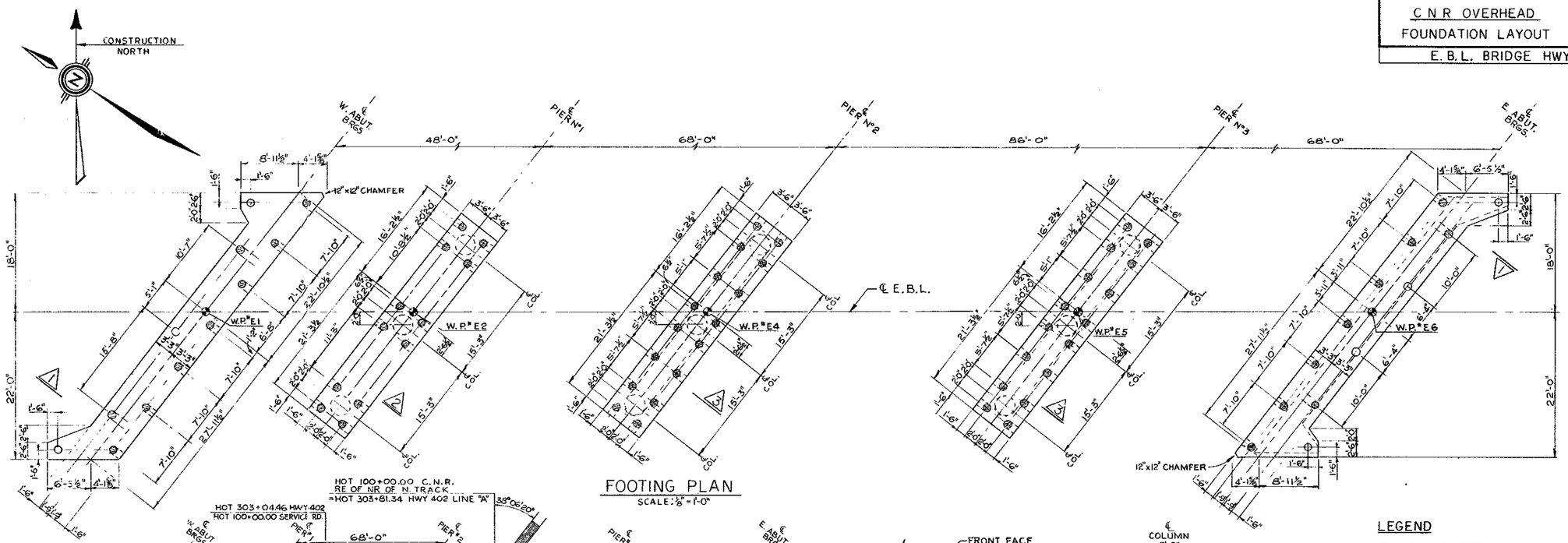
REVISIONS			
DATE	BY	DESCRIPTION	
DESIGN A.K.	CHECK J.L.K	LOADING HS-20-44	DATE Mar '78
DRAWING D.C.	CHECK A.K.	SITE No 19-527A	DWG 1

DIST Nº 2
CONT No 79-51
WP No 40-66-13

C N R OVERHEAD
FOUNDATION LAYOUT

SHEET 215

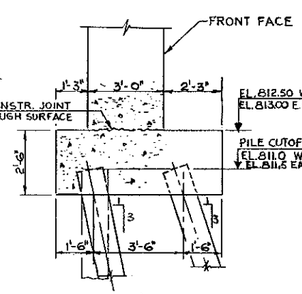
E. B. L. BRIDGE HWY 402



FOOTING PLAN
SCALE: ⅛"=1'-0"

SITE LAYOUT PLAN
N. T. S.

W. P.	STATION	CO-ORDINATES NORTH	CO-ORDINATES EAST	W. P.	STATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
W.P.ºC1	302+34.22	15606858.16	1260874.28	W.P.ºE1	301+95.79	15606865.60	1260812.45
W.P.ºC2	302+82.22	15606817.13	1260899.18	W.P.ºE2	302+43.79	15606824.56	1260837.35
W.P.ºC3	303+04.46	15606798.11	1260910.72	W.P.ºE3	302+66.03	15606805.55	1260848.89
W.P.ºC4	303+50.22	15606758.99	1260934.46	W.P.ºE4	303+11.79	15606766.43	1260872.63
W.P.ºC5	304+36.22	15606685.47	1260979.07	W.P.ºE5	303+97.79	15606692.91	1260917.24
W.P.ºC6	305+04.22	15606627.34	1261014.35	W.P.ºE6	304+65.79	15606634.77	1260952.52



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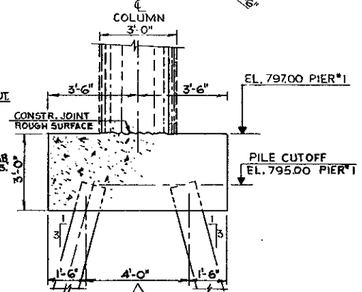
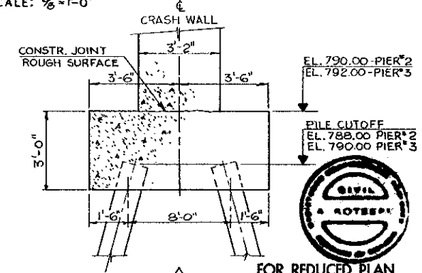


2

SCALE: ⅜"=1'-0"



3

PILE DATA				
LOCATION	FACE	Nº REQD	BATTER	LENGTH
W. ABUTMENT	FRONT	7	1:3	62'-0"
	REAR	3	VERTIC.	58'-0"
	REAR	2	1:5	62'-0"
PIER Nº 1	WEST	6	1:3	44'-0"
	EAST	6	1:3	44'-0"
PIER Nº2	NORTH	2	1:3	37'-0"
	SOUTH	2	1:3	37'-0"
	WEST	6	1:5	36'-0"
	EAST	6	1:5	36'-0"
PIER Nº 3	W. & E. FACE	16	1:3	41'-0"
E. ABUTMENT	FRONT	7	1:3	62'-0"
	REAR	2	1:5	62'-0"
	REAR	4	VERTIC	58'-0"

LEGEND

- ◉ PILES BATTERED 3:1
- ○ PILES DRIVEN VERTICALLY
- ◉ PILES BATTERED 5:1

NOTES

ALL PILE SPACING TO BE MEASURED AT UNDER SIDE OF FOOTING.

ALL PILES ARE 12¾" O.D. x 0.25" WALL THICKNESS STEEL TUBE PILES.

TUBE PILES TO BE FILLED WITH 3000 P.S.I. CONCRETE AFTER INSTALLATION AND INSPECTION.

PILES TO BE DRIVEN IN ACCORDANCE WITH SS 3-11 USING DESIGN LOAD 60 TONS/PILE.

CONCRETE QUANTITI IN TUBE PILES — 100 C. Y.

FOR REDUCED PLAN
USE SCALE BELOW
10 11 12 13
3 INCHES ON ORIGINAL PLAN

REVISIONS		
DATE	BY	DESCRIPTION

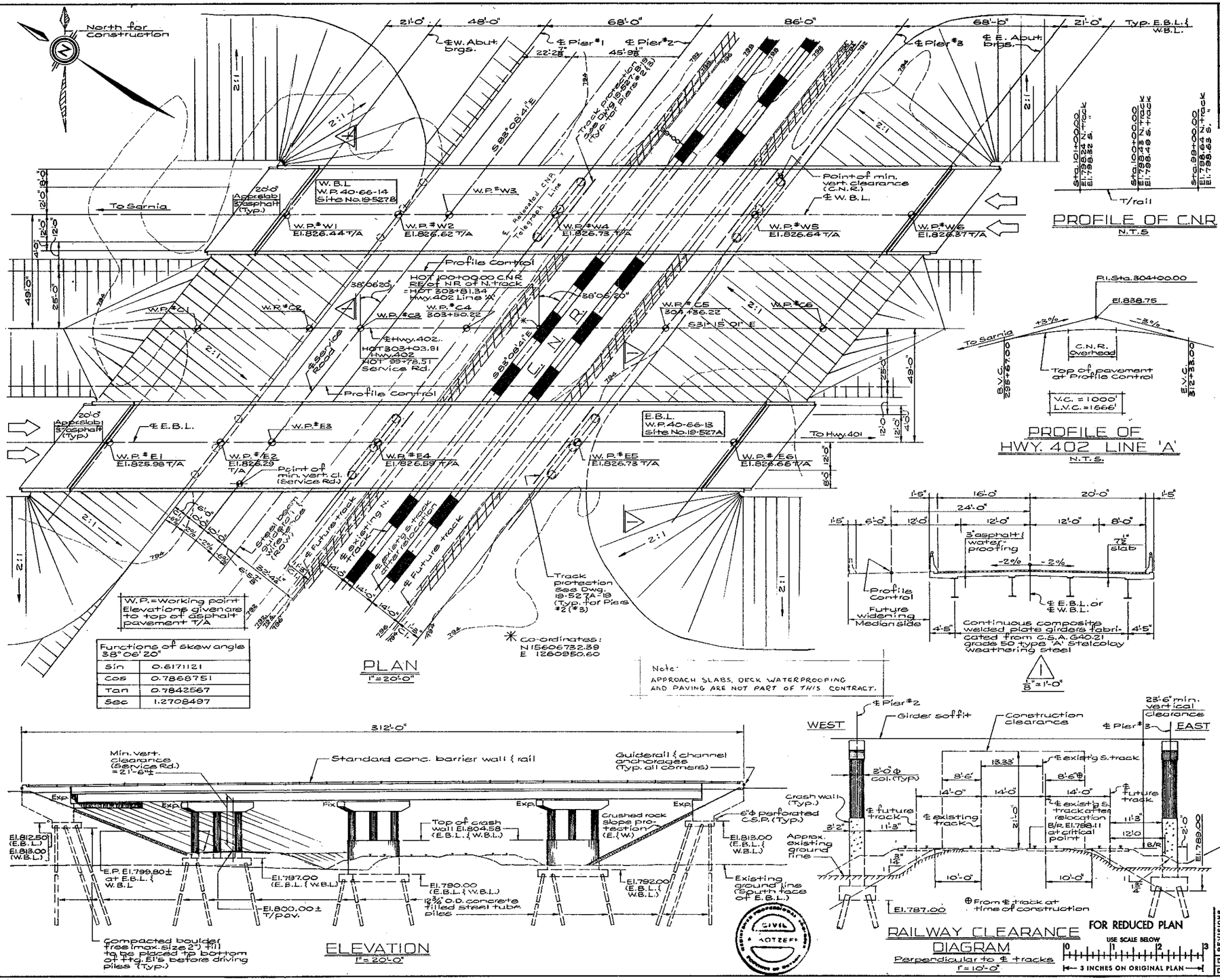
DESIGN A.K.	CHECK PKR	LOADING HS20-44	DATE MAR. 78
DRAWING Z.K.	CHECK	SITE No 19-527A	DWG 3

DIST. No. 2
CONT No 79-51
WP No 40-66-14

C.N.R. OVERHEAD
5.8 miles west of Hwy. 2
GENERAL PLAN

SHEET 233

W.B.L. Bridge, Hwy. 402



PLAN
1" = 20'-0"

Functions of skew angle 38°06'20"	
Sin	0.6171121
Cos	0.7868751
Tan	0.7842567
Sec	1.2708497

PROFILE OF C.N.R.
N.T.S.

PROFILE OF HWY. 402 LINE 'A'
N.T.S.

1/8" = 1'-0"

NOTES

Class of Concrete

Deck { barrier walls ---- 4000 P.S.I.
Piers ---- 4000 P.S.I.
Remainder ---- 3000 P.S.I.
Or as noted on drawings

Clear Cover on Reinf. Steel

Footings ---- 3"
Abuts. ---- 3"
Deck ---- 2" top; 1" bot.
Barrier walls ---- As shown
Or as noted on drawings

Construction Notes

The Contractor shall be responsible for finishing the bearing seat dead level to the specified elevations with a tolerance of ± 5".

No concrete shall be placed above the abutment bearing seats until concrete in the deck has been placed.

Reinforcing Steel Grade ---- 400

Reinf. bars with the designation 'c' at the end of the bar marks shall be coated bars

Formwork

The formwork between deck and ballast walls (e.g. expanded polystyrene) shall be removed by the Contractor.

Concrete & Structural Steel Quant.

Concrete & structural steel quantities are listed below for the appropriate lump sum tender items:

Concrete in piers, abuts. & wingwalls	3000 P.S.I.	161 Cu.yd.
	4000 P.S.I.	202 Cu.yd.
Concrete in deck		277 Cu.yd.
Concrete in barrier walls		47 Cu.yd.
Concrete in approach slabs		45 Cu.yd.
Structural Steel		89 Tons

LIST OF DRAWINGS

ELEVATION
1" = 20'-0"

RAILWAY CLEARANCE DIAGRAM
Perpendicular to ℄ tracks
1" = 10'-0"

FOR REDUCED PLAN
USE SCALE BELOW
0 1 2 3
3 INCHES ON ORIGINAL PLAN

B.M. 794.97
Geodetic Datum
N. ℄ W. in W. Root at 2'.5 Maple
505' Lt. 301+10 Line 'A'

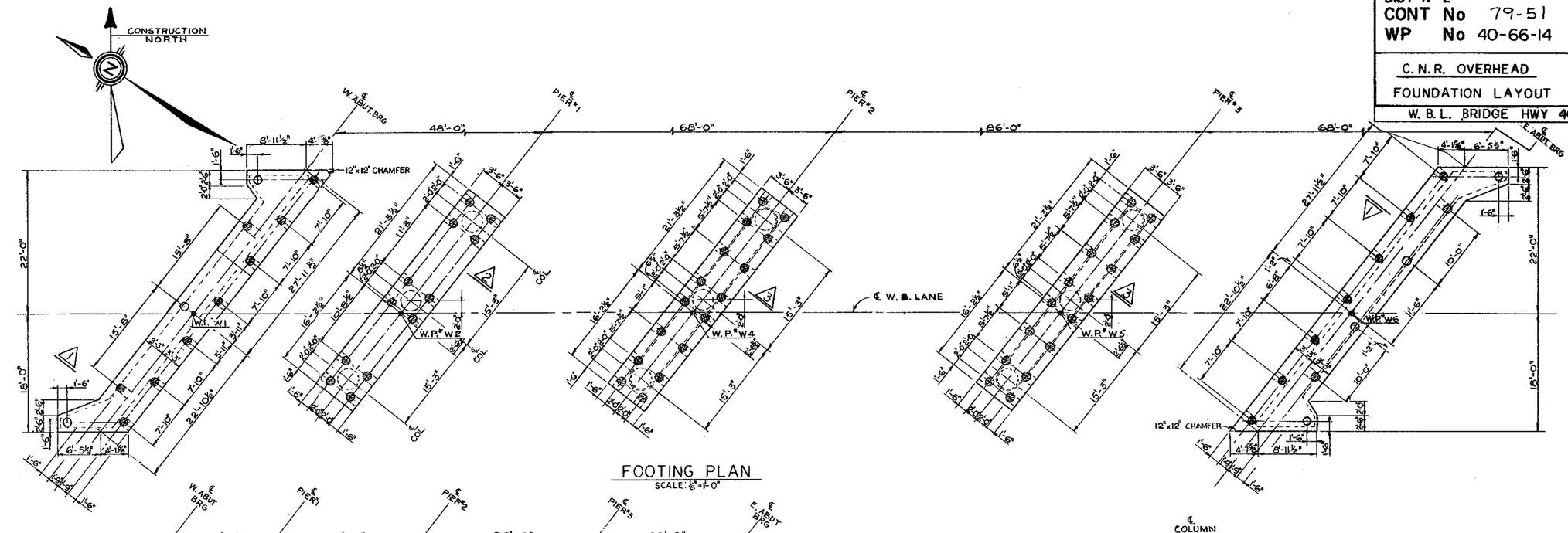
REVISIONS			
DATE	BY	DESCRIPTION	
DESIGN A.L.	CHECK J.K.	LOADING HS-20-44	DATE Mar. 78
DRAWING O.C.	CHECK A.K.	SITE No. 19-527B	DWG 1

DIST Nº 2
CONT No 79-51
WP No 40-66-14

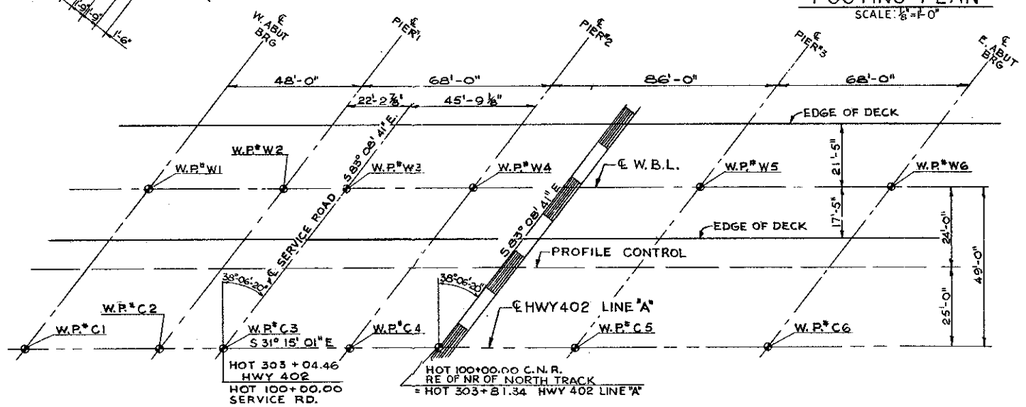
C.N.R. OVERHEAD
FOUNDATION LAYOUT

SHEET 235

W. B. L. BRIDGE HWY 402



FOOTING PLAN
SCALE: ⅛"=1'-0"

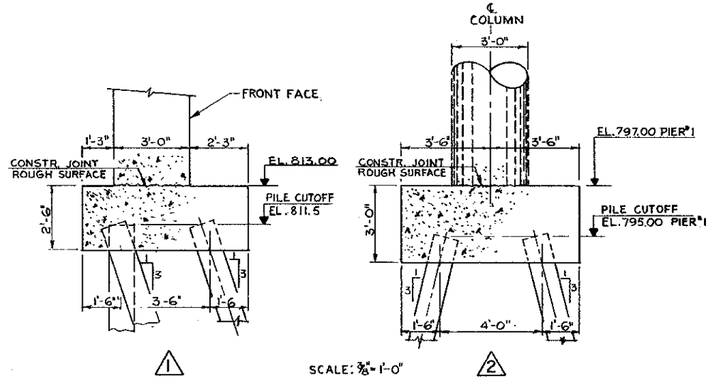


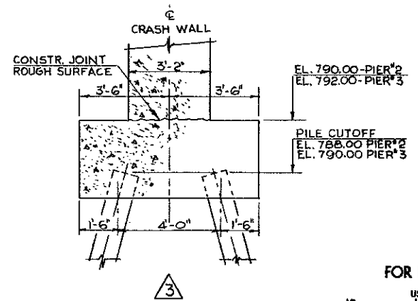
SITE LAYOUT PLAN
N. T. S.

W. P.	STATION	CO-ORDINATES NORTH	CO-ORDINATES EAST	W. P.	STATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
W.P.ºC1	302+34.22	15606858.16	1260874.28	W.P.ºW1	302+72.65	15606850.73	1260936.10
W.P.ºC2	302+82.22	15606817.13	1260899.18	W.P.ºW2	303+20.65	15606809.70	1260961.01
W.P.ºC3	303+04.46	15606798.11	1260910.72	W.P.ºW3	303+42.89	15606790.68	1260972.54
W.P.ºC4	303+50.22	15606758.99	1260934.46	W.P.ºW4	303+88.65	15606751.56	1260996.28
W.P.ºC5	304+36.22	15606685.47	1260979.07	W.P.ºW5	304+74.65	15606678.04	1261040.90
W.P.ºC6	305+04.22	15606627.34	1261014.35	W.P.ºW6	305+42.65	15606619.91	1261076.17

PILE DATA

LOCATION	FACE	Nº REQD	BATTER	LENGTH
W. ABUTMENT	FRONT	7	1:3	62'-0"
	REAR	3	VERTIC	59'-0"
	REAR	2	1:3	62'-0"
PIER Nº 1	WEST	6	1:3	44'-0"
	EAST	6	1:3	44'-0"
PIER Nº 2	NORTH	2	1:3	37'-0"
	SOUTH	2	1:3	37'-0"
	WEST	6	1:5	35'-0"
	EAST	6	1:5	35'-0"
PIER Nº 3	W & E FACE	16	1:3	41'-0"
E. ABUTMENT	FRONT	7	1:3	62'-0"
	REAR	2	1:3	62'-0"
	REAR	4	VERTIC	59'-0"





LEGEND

- PILES BATTERED 1:3
- PILES DRIVEN VERTICALLY
- PILES BATTERED 1:5

NOTES

ALL PILE SPACING TO BE MEASURED AT UNDER SIDE OF FOOTING.

ALL PILES ARE 12¾" O.D. x 0.25" WALL THICKNESS STEEL TUBE PILES.

TUBE PILES TO BE FILLED WITH 3000 P. S. I. CONCRETE AFTER INSTALLATION AND INSPECTION.

PILES TO BE DRIVEN IN ACCORDANCE WITH SS3-11 USING DESIGN LOAD 60 TONS/PILE.

CONCRETE QUANTITI IN TUBE PILES 100- C. Y.

REGISTERED PROFESSIONAL ENGINEER PROVINCE OF ONTARIO CIVIL A. KOTZEFF

FOR REDUCED PLAN
USE SCALE BELOW
0 1 2 3
3 INCHES ON ORIGINAL PLAN

REVISIONS			
DATE	BY	DESCRIPTION	
DESIGN A.K.	CHECK PKR	LOADING HS20-44	DATE MAR 78
DRAWING Z K	CHECK	SITE No 19-5216	DWG 3

APPENDIX B

Site Photographs

Photograph 1: Looking at the west abutment of the CNR EBL structure from the service road. Surficial cracks were observed on the abutment wall. The front slope was covered with crushed rock (July 27, 2016).

Photograph 2: Looking at the south wing wall and the adjacent slope of west abutment of the CNR EBL structure from the service road. Surficial cracks were observed on the abutment wall and the wing wall. The adjacent slope is vegetated and effect of erosion on the slope face was not observed (July 27, 2016).

Photograph 3: Looking at the north wing wall and the adjacent slope of west abutment and the Pier No. 1 of the CNR EBL Structure from the service road. Surficial cracks were observed on the abutment wall, wing wall and pier. The adjacent slope is vegetated and effect of erosion on the slope face was not observed (July 27, 2016).

Photograph 4: Looking at the west abutment and the Pier No. 1 of the CNR EBL structure from the service road. Crushed rock protection of the front slope of the abutment was observed. Surficial cracks were observed on the piers (July 27, 2016).

Photograph 5: Looking at the northerly column of Pier No. 1 of the CNR EBL Structure. Slight erosion at the foot of the pier was observed (July 27, 2016).

Photograph 6: Looking at the Pier No. 2 with crash wall of the CNR EBL structure from the service road. Surficial cracks were observed on the columns and crash wall. The ground was vegetated and effect of erosion was not observed (July 27, 2016).

Photograph 7: Looking at the Pier No. 3 with the crash wall and east abutment of the CNR EBL structure and the single CNR track from the service road. Surficial cracks were observed on the pier and the crash wall (July 27, 2016).

Photograph 8: Looking at the east abutment with the front slope of the CNR EBL structure from the service road. Surficial cracks were observed on the abutment wall. The front slope of the east abutment is covered with crushed rock. Effect of erosion on the slope face was not observed (July 27, 2016).

Photograph 9: Looking at the east abutment, the Pier No. 3, the south slope adjacent to east abutment of the CNR EBL structure and single CNR track from the service road. The adjacent slope is vegetated and effect of erosion on the slope face was not observed (July 27, 2016).

Photograph 10: Looking at the north wing wall of the east abutment of the CNR EBL structure, the slope adjacent to the east abutment and the single CNR track. Surficial cracks were observed on the wingwall. Also, a local concrete spalling area was observed at the corner of the wing wall. The adjacent slope is vegetated and effect of erosion on the slope face was not observed (July 27, 2016).

Photograph 11: Looking at the west abutment of the CNR WBL structure and the front slope. Surficial cracks were observed on the abutment wall from the service road. The slope is covered with crushed rock and effect of erosion on the slope face was not observed (July 27, 2016).

Photograph 12: Looking at the south wing wall and the adjacent slope of west abutment of the CNR WBL structure from the service road. Surficial cracks were observed on the wing wall. The adjacent slope is heavily vegetated and effect of erosion on the slope face was not observed (July 27, 2016).

Photograph 13: Looking at the north wing wall and the adjacent slope of west abutment of the CNR Overhead WBL structure from the service road. Surficial cracks were observed on the wing wall. A C.S.P. was observed on the side slope. The slope is vegetated and effect of erosion on the slope face was not observed (July 27, 2016).

Photograph 14: Looking at the west abutment and the Pier No. 1 of the CNR WBL structure from the service road. Crushed rock protection was covering the front slope of the abutment. Surficial cracks were observed on the pier (July 27, 2016).

Photograph 15: Looking at the Pier No. 2 with the crash wall of the CNR WBL structure from the service road. Surficial cracks were observed on the pier and the crash wall. The ground around the crash wall was vegetated and effect of erosion was not observed (July 27, 2016).

Photograph 16: Looking at the Pier No. 3 with the crash wall of the CNR WBL structure from the service road. Surficial cracks were observed on the pier and the crash wall. The ground around the crash wall was vegetated and effect of erosion was not observed (July 27, 2016).

Photograph 17: Looking at the east abutment of the CNR WBL structure from the service road. Surficial cracks were observed on the abutment wall. The front slope is covered with crushed rock and effect of erosion was not observed (July 27, 2016).

Photograph 18: Looking at the south adjacent slope of east abutment of the CNR WBL structure and single CNR track from the service road. The adjacent slope is vegetated and effect of erosion on the slope face was not observed (July 27, 2016).

Photograph 19: Looking at the north wing wall and the adjacent slope of east abutment of the CNR WBL structure and single CNR track from the service road. Surficial cracks were observed on the wing wall. The slope is vegetated and effect of erosion on the slope face was not observed (July 27, 2016).