

MEMORANDUM

W.P. 30-65-5

33-62-23

To: Mr. B. R. Davis,
Bridge Engineer,
Bridge Division.

From: Foundation Section,
Materials & Testing Div.,
Room 107, Lab. Bldg.

Attention: Mr. S. McCombie

DATE: November 29, 1966

OUR FILE REF.

IN REPLY TO: **NOV 30 1966**

SUBJECT:

FOUNDATION INVESTIGATION REPORT
For
Proposed Structure at the Crossing
at Ramps 'H' & 'Fa' and Ramp 'P',
Hwy. #406 and Hwy. #58 Interchange,
District #4 (Hamilton)
W.J. 66-F-79 -- W.P. 30-65-5

Attached, we are forwarding to you, our detailed foundation investigation report on the subsoil conditions existing at the above structure site.

We believe that you will find the factual data and recommendations contained therein, adequate for your design requirements. Should you require additional information, please feel free to contact our Office.

AGS/MdeF
Attach.

cc: Messrs. B. R. Davis (2)
H. A. Tregaskes
D. W. Farren
G. K. Hunter (2)
H. Greenland
W. S. Melinyshyn
T. J. Kovich
A. Watt

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

Foundations Office
Gen. Files ✓

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FOUNDATION INVESTIGATION REPORT
For
Proposed Structure at the Crossing
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Hwy. #406 and Hwy. #58 Interchange,
District #4 (Hamilton)
W.J. 66-F-79 -- W.P. 30-65-5

1. INTRODUCTION:

The Foundation Section was requested to carry out an investigation at the crossing of Ramps 'H' & 'Fa' over Ramp 'P' of the future Hwy. #406 and Hwy. #58 interchange in the township of Thorold. The request was contained in a memo from the Bridge Location Section (Mr. W. S. Melinyshyn, Regional Bridge Location Engineer), dated August 16, 1966. The site is located at the south limits of the City of St. Catharines in Welland and Lincoln Counties. The general area is flat to undulating.

An investigation was carried out by this Section to determine the subsoil conditions at the site of the proposed structure.

Presented in this report are the results of the investigation, together with our recommendations pertaining to the foundations for the structure and the stability of the proposed approach embankments.

2. SUBSOIL CONDITIONS:

2.1) General:

A total of 8 sampled boreholes and 8 dynamic cone penetration tests were carried out. The boundaries between the different deposits are shown on the borelog sheets attached to this report.

cont'd. /2 ...

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

The estimated stratigraphical profile shown on Drawing 66-F-79A is based upon this information.

From ground level downward, the different soil types encountered are as follows:

2.2) Clayey Silt to Silty Clay with traces of Sand and Gravel:

This deposit was encountered in all boreholes overlying the existing bedrock. The depth of this deposit ranges from 6.5 feet to 10.2 feet below the existing ground surface.

Physical properties of the material, as determined from field and laboratory tests, are summarized as follows:

Liquid Limit	(WL%)	--	24% - 47%
Plastic Limit	(Wp%)	--	16% - 25%
Moisture Content	(W%)	--	9% - 19%
'N' Values		--	47 - 100 blows/ft.

The consistency of the deposit is estimated to be hard.

2.3) Dolomite Bedrock:

Bedrock was proven in all boreholes and was found to be dolomite. The depth at which bedrock was encountered ranged from elevation 572.7 to 574.8 or 6.5 feet to 10.2 feet below the existing ground surface. Bedrock was sound and recovery was 100%.

3. GROUNDWATER:

No groundwater was observed in any of the boreholes during the progress of the field investigation.

4. DISCUSSION AND RECOMMENDATIONS:

It is proposed to construct at the future interchange of Hwy. #406 and 58 with St. David's Road, a structure at the crossing of Ramps 'E' and 'Fa' over Ramp 'P'.

cont'd. /3 ...

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

Present proposals call for a three-span (30'-38'-30') structure with approach fills having a maximum height of about 19 ft. above the proposed grade of Ramp 'P'.

Subsoil at the site consists generally of a deposit of hard clayey silt to silty clay with traces of sand and gravel which ranges in thickness from 6.5 to 10.2 feet and overlies dolomite bedrock.

The proposed north and south piers should be supported on spread footings founded directly on bedrock, at or below the proposed grade of Ramp 'P'. A safe bearing pressure of 10 tons p.s.f. may be used for design purposes for footings founded on sound bedrock.

The abutments may be supported either on end-bearing piles driven to bedrock or on spread footings located within the fill. In the former case, the design load for the piles may be the maximum for the section used. The length of pile required may be determined by reference to Drawing No. 66-F-79A. If piles are adopted, care should be taken to ensure that no bouldery fill is placed in the area where piles have to be driven. In the case of spread footings, a safe bearing pressure of 2 t.s.f. may be used for design purposes. The fill material below the top of the footings should consist of well compacted G.B.C. Class 'A' material and should extend for a horizontal distance of at least 10 feet from the footing edges in the plane of the footing tops. This portion of the fill should be placed with side slopes of 2:1. The remainder of the fill should be completed to about profile grade for a distance of 50 feet behind the abutments before re-excavating for the abutment footings.

No major dewatering problems are anticipated for the excavation of the piers.

cont'd. /4

5. MISCELLANEOUS:

The field work, performed during the period October 19 to October 20, 1966, was undertaken by Mr. V. Korlu, Project Foundation Engineer. The investigation was carried out under the general supervision of Mr. M. Devata, Supervising Foundation Engineer.

This report was prepared by Mr. A. Calder, Project Foundation Engineer, and was reviewed by Mr. M. Devata.

Equipment used was owned and operated by Johnston Drilling Company Limited.

Survey work was performed by Central Region Engineering Survey Section.

November 1966

APPENDIX I.

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 1

FOUNDATION SECTION

JOB 66-F-79 LOCATION Sta. 25 + 41 (22' Rt. E) Ramp "Fa" ORIGINATED BY V.K.
 W.P. 30-65-5 BORING DATE October 19, 1966 COMPILED BY H.S.
 DATUM Geodetic BOREHOLE TYPE Washboring CHECKED BY [Signature]

SOIL PROFILE		SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE	LIQUID LIMIT — WL	BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE		BLOWS / FOOT	BLOWS / FOOT		
581.7 0.0	GROUND LEVEL								
	Silty Clay Traces of Sand Occ. Seams and Pockets of Silt Hard		1	SS	61				
			2	SS	65				
573.0 8.7	Bedrock (Dolomite)		3	AXT. Rec. R.C. 100%					
568.0 13.7	End of Borehole								

WATER CONTENT %
 20 40 60
 wp — w — WL
 For 8"

FOUNDATION SECTION

CHECKED BY AK

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT	Liquid Limit ——— WL	BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.	PLASTIC LIMIT ——— WP		
							20 40 60 80 100			
								WP W WL		
									WATER CONTENT % 20 40 60	
									P.C.F.	
581.5	GROUND LEVEL									
0.0	Silty Clay Traces of Sand Occ. Seams and Pockets of Silt		1	SS	63	580				
	Hard		2	SS	75					
573.0										
8.5	Probably Bedrock					570				

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

108 66-F-79

LOCATION Sta. 25 + 78 (22' Rt. C) Ramp "Fa"

FOUNDATION SECTION

ORIGINATED BY V.K.

W. P. 30-65-5

BORING DATE October 20, 1966

COMPILED BY _____ H.S.

DATUM Geodetic

BOREHOLE TYPE Washboring

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT	Liquid Limit ——— WL	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT			PLASTIC LIMIT ——— WP	
							SHEAR STRENGTH P.S.F.	WATER CONTENT ——— W	
								$\frac{WP}{\quad} \text{ --- } \frac{W}{\quad} \text{ --- } \frac{WL}{\quad}$	
								WATER CONTENT %	
								$\frac{\quad}{20} \quad \frac{\quad}{40} \quad \frac{\quad}{60}$	
									BULK DENSITY γ
									P.C.F.
582.2	GROUND LEVEL								
0.0	Silty Clay Traces of Sand and Gravel occ. seams and pockets of Silt	/	1	SS	59	580			
	Hard	/	2	SS	55				
572.7		/							
9.5	Probably Bedrock	X				570	for 4"		

FOUNDATION SECTION

JOB 66-F-79

LOCATION Sta. 26 + 28 (26' Lt. E) Ramp "pa"

ORIGINATED BY V.K.

W. P. 30-65-5

BORING DATE October 21, 1966

COMPILED BY _____ H.S.

DATUM Geodetic

BOREHOLE TYPE Washboring

CHECKED BY AK

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT ——— WL PLASTIC LIMIT ——— WP WATER CONTENT ——— W <div><div>wp</div><div>w</div><div>wL</div></div>	BULK DENSITY <div><div>γ</div><div>P.C.F.</div></div>	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	SHEAR STRENGTH P.S.F.				
							20	40				60
581.4	GROUND LEVEL											
0.0	Silty Clay Traces of sand and gravel, occ. seams and pockets of Silt	<div></div>					580					
			1	SS	59							
	Hard		2	SS	147	200						
572.9												
8.5	Bedrock (Dolomite)	<div></div>	3	Axt. Rec. R.C. 100%		570						
567.9												
13.5	End of Borehole											
							560					

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 5

FOUNDATION SECTION

JOB 66-F-79 LOCATION Sta. 26 + 37 (22' Rt. E) Ramp "fa" ORIGINATED BY V.K.
 W.P. 30-65-5 BORING DATE October 20, 1966 COMPILED BY H.S.
 DATUM Geodetic BOREHOLE TYPE Washboring CHECKED BY HL

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — WL		BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	SHEAR STRENGTH P.S.F.	PLASTIC LIMIT — WP	WATER CONTENT — W		
582.9	GROUND LEVEL											
0.0	Clayey Silt to Silty Clay Traces of Sand		1	SS	47	580						
	Hard		2	SS	59							
572.7												
10.2	Bedrock Dolomite		3	Axt. Rec R.C.	100%	570						
567.7												
15.2	End of Borehole											
						560						

MATERIALS & TESTING DIVISION

FOUNDATION SECTION

LOCATION Sta. 26 + 82 (26' Lt. . C) Ramp "Fa"

ORIGINATED BY V.K.

BORING DATE October 21, 1966

COMPILED BY _____ H.S.

BOREHOLE TYPE Washboring

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — WL		BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	SHEAR STRENGTH P.S.F.	PLASTIC LIMIT — WP	WATER CONTENT — W		
581.6	GROUND LEVEL											
0.0	Silty Clay Traces of Sand Occ. seams and pockets of Silt Hard		1	SS	64	580						
574.8												
6.8	Probably Bedrock					570						

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 7

FOUNDATION SECTION

JOB 66-F-79

LOCATION Sta. 26 + 73 (22' Rt. C) Ramp "FA"

ORIGINATED BY V.K.

W. P. 30-65-5

BORING DATE October 21, 1966

COMPILED BY H.S.

DATUM Geodetic

BOREHOLE TYPE Washboring

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT	LIQUID LIMIT ——— WL PLASTIC LIMIT ——— WP WATER CONTENT ——— W WP W WL WATER CONTENT % 20 40 60	BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.			
582.8	GROUND LEVEL									
0.0	Silty Clay to Clayey Silt, Traces of Sand Occ. seams and pockets of Silt					580				
	Hard		1	SS	55					
574.7			2	SS	48					
8.1	Probably Bedrock					570	for 1 1/2"			

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

JOB 66-F-79

LOCATION Sta. 27 + 21 (26' Lt. ϕ) Ramp "Fa"

ORIGINATED BY V.K.

W. P. 30-65-5

BORING DATE October 21, 1966

COMPILED BY H.S.

DATUM Geodetic

BOREHOLE TYPE Washboring

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT	Liquid Limit ——— W _L	BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.	PLASTIC LIMIT ——— w _p		
581.0	GROUND LEVEL									
0.0	Clayey Silt Traces of Sand					580				
	Hard		1	SS	100					
574.5	Bedrock									
6.5	Dolomite		2	Axt. Rec R.C. 100%						
569.5						570				
11.5	End of Borehole									
						560				

ABBREVIATIONS USED IN THIS REPORT

PENETRATION RESISTANCE

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

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

DESCRIPTION OF SOIL

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

<u>CONSISTENCY</u>	<u>'N' BLOWS / FT.</u>	<u>c LB. / SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
VERY SOFT	0 - 2	0 - 250	VERY LOOSE	0 - 4
SOFT	2 - 4	250 - 500	LOOSE	4 - 10
FIRM	4 - 8	500 - 1000	COMPACT	10 - 30
STIFF	8 - 15	1000 - 2000	DENSE	30 - 50
VERY STIFF	15 - 30	2000 - 4000	VERY DENSE	> 50
HARD	> 30	> 4000		

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.B.	SCRAPER BUCKET SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE
S.T.	SLOTTED TUBE SAMPLE		
	P.H. SAMPLE ADVANCED HYDRAULICALLY		
	P.M. SAMPLE ADVANCED MANUALLY		

SOIL TESTS

Qu	UNCONFINED COMPRESSION	L.V	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V.	FIELD VANE
Qcu	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Qd	DRAINED TRIAXIAL	S	SENSITIVITY

ABBREVIATIONS USED IN THIS REPORT

SOIL PROPERTIES

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
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
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
μ	COEFFICIENT OF FRICTION
S_f	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 (YOUNG'S 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_0	COEFFICIENT OF EARTH PRESSURE AT REST

FOUNDATIONS

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

SLOPES

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

Copy for the information of

Mr. A. Stermac, Principal Foundation Engineer,
Room 107, Lab. Building

Mr. W. Melinyshyn,
Regional Bridge Location Engineer,
Central Region,
Administration Building

Bridge Division,
Downsview, Ontario

March 3, 1967

St. David's Rd. Interchange
Bridge #5 - Ramp 'H' & 'Fa' over Ramp 'P'
W.P. 30-65-5, Site 34-201
Highway 406, District No. 4

Attached herewith are prints of the Preliminary Bridge
Plan Drawing D-6123-P1 for the above-mentioned structure.

The estimated cost of the proposed structure is \$120,000.
This cost includes tender, materials, engineering and sundry
construction.

Any comments or revisions you may have should be submitted
within three weeks.

CSG:rd

C.S. Grebski,
Bridge Design Engineer

Attach.

c.c. S. McCombie
A. Stermac
R. Forrest
E. Cross

alp

Mr. C. S. Grebski,
Bridge Design Engineer,
Bridge Division,
Admin. Bldg.

Foundation Section,
Materials & Testing Div.,
Room 107, Lab. Bldg.

March 17, 1967

St. David's Road Interchange,
Bridge #5 - Ramp 'E' & 'Fa' over Ramp 'P',
W.P. 30-65-5, Site 34-201, W.J. 66-F-79,
Hwy. #406, District #4 (Hamilton).

We have reviewed the Preliminary Bridge Plan D-6123-P1
for the above mentioned structure, and submit the following
comments:

The southeast and northwest column footings are shown
below the bedrock surface. This is not essential from a
foundation point of view, since they may be placed on the rock
surface. We assume that you have some other reason.

RD/WdsF

R. Devata
R. Devata,
SUPERVISING FOUNDATION ENGR.
For:
A. G. Sternac,
PRINCIPAL FOUNDATION ENGR.

cc: Messrs. S. McCombie
W. S. Melinyshyn

Foundations Files ✓
Gen. Files

#66-F-79
W.P.#30-65-5
Hwy. #58 E
Hwy. #406
ST. DAVID'S RD.
RAMPS H, FA & P
BRIDGE #5

