

G.I.-30 SEPT. 1976

GEOCRES No. 40I13-34DIST. 1 REGION W.P. No. CONT. No. 72-175W. O. No. 73-11077STR. SITE No. HWY. No. 402LOCATION Culvert Sites Sta. 69+95 &Sta. 90+50No. of PAGES -=====OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. REMARKS:

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

MEMORANDUM

TO: Mr. J. G. Forester,
Senior Soils Engineer,
Southwestern Region,
London, Ontario.

FROM: Foundations Office,
Design Services Branch,
West Bldg., Downsview.

ATTENTION:

DATE: October 26, 1973.

OUR FILE REF.

IN REPLY TO

OCT 31 1973

SUBJECT:

FOUNDATION INVESTIGATION
For
Culvert Sites, Stations 69+95 & 90+50
Hwy. No. 402
District #1 (Chatham)
W.O. 73-11077 -- Contract 72-175

~~401-106~~
40113-34
GEOCRES No.

Attached we are forwarding to you our detailed foundation investigation report on the subsoil conditions existing at the above-mentioned sites, the type of culverts to be provided, and the construction procedures to be followed.

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

AGS/ao
Attch.

c.c. A. Rutka
G. A. Metcalfe
W. Katarynczuk
J. R. Roy
A. Wittenberg
C.S. Grebski

Foundations Files
Documents

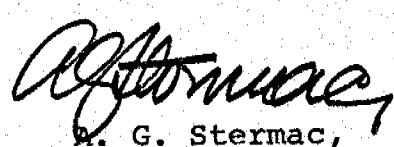

W. G. Stermac,
PRINCIPAL FOUNDATIONS ENGINEER.

TABLE OF CONTENTS

1. INTRODUCTION.
 2. STATION 69+95 (CULVERTS #53 AND 54).
 3. STATION 90+50 (CULVERTS #55 AND 56).
 4. MISCELLANEOUS.
-

FOUNDATION INVESTIGATION
For
Culvert Sites, Stations 69+95 & 90+50
Hwy. No. 402
District #1 (Chatham)
W.O. 73-11077 -- Contract 72-175

1. INTRODUCTION:

A request to carry out a foundation investigation at the above-mentioned sites was received verbally from Mr. J. G. Forester, Senior Soils Engineer, Southwestern Region. The problem to be resolved was as follows:

Footings for two culverts #55 and #56 at Station 90+50 were poured in the month of August 1973. Later it was discovered that the north portions of footings for culvert #55 had cracked. Footings for culvert #56 were apparently intact. Excavation for culverts #53 and #54 at Station 69+95 was being carried out, when it was discovered that the subsoil conditions at this location were similar to those at Station 90+50. It was, therefore, feared that the subsoil may not be suitable for spread footing type foundations for culverts #53 and #54.

An investigation was subsequently carried out by this Office to determine the subsoil conditions at these sites.

This report contains the results of our field and laboratory investigation together with our recommendations regarding the type of culverts to be provided and the construction procedures to be followed.

2. STATION 69+95 (CULVERTS #53 AND 54):

It was originally proposed to construct two 10' x 6'

concrete rigid frame culverts with inverts at elevations 704.0 - 704.6 and founded on spread footings. At the time of field investigation an excavation was made down to elevation 704. One sampled borehole and nine dynamic cone penetration tests were carried out within the excavation at this location. The borehole indicated the following subsoil conditions:

0 - 1.5	Clayey silt, firm
1.5 - 4.0	Sand, compact
4.0 - 6.0	Clayey Silt, firm
6.0 - 8.7	Silt, loose to compact
8.7 - 9.7	Clayey silt, very stiff
9.7 - 11.0	Sand, compact
11.0 - 30.0	Clayey silt/silty clay, stiff to very stiff

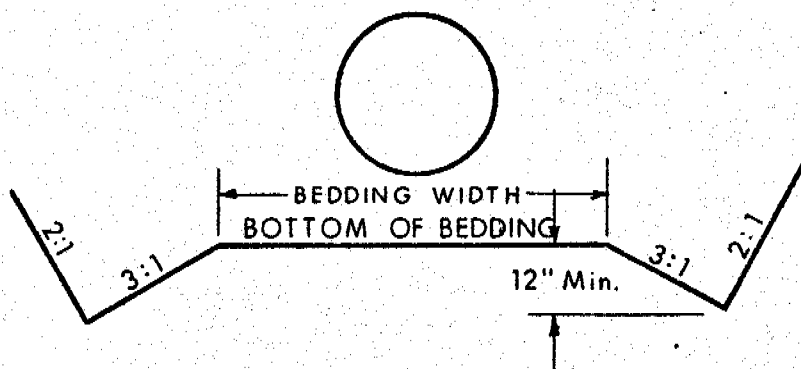
The dynamic cone penetration tests indicated that relatively uniform subsoil conditions prevailed over the entire area.

The groundwater level at the time of field investigation was approximately 15 inches below the bottom of the excavation. Occasional gas pockets were encountered during the drilling.

The subsoil conditions at this site are not suitable for spread footing type foundations. Therefore, it is recommended that a corrugated steel pipe culvert be placed here. The culvert should be designed and placed according to the appropriate Ministry standards. A minimum 2 foot thick Granular 'B' bedding should be provided beneath the culvert. An impervious clay seal should be placed at the upstream end. A filter blanket should be placed at the downstream end of the culvert. It is recommended that the creek bed at both the upstream and downstream ends be protected by rip-rap. The size of the area to be covered by rip-rap should be determined by the Hydrology Office. .

In order to properly compact the culvert bed, it is necessary to carry out this work in the dry. To accomplish this, a dewatering scheme will be required. It is believed that an undisturbed and dry excavation base can be exposed with an oversize

excavation as illustrated on the sketch below. This method would involve an initial gradual pumping, with final pumping confined to the shallow ditches around the bottom of the excavation. Perimeter ditches must be pumped out at all times until the culvert is installed.



3. STATION 90+50 (CULVERTS #55 AND 56):

It was originally proposed to construct two 6' x 4' concrete culverts with inverts at elevations 705.6 - 706.8 and founded on spread footings. It is reported that excavations for the footings were made and dewatered using ordinary pumping method. Later, it was discovered that footings for culvert #55 had settled and cracked at its north end. No apparent damage to culvert #56 could be noticed.

The field work at this location consisted of one sampled borehole near the failed portion of the culvert and sixteen dynamic cone penetration tests. One cone test was carried out adjacent to the borehole. Fifteen other cone tests were carried out just outside the footings. The borehole indicated the following subsoil conditions, as measured from the top of footing.

0 - 7.3	Silt to sandy silt, very loose to loose
7.3 - 9.9	Fine sand, loose
9.9 - 15.0	Clayey silt to silty clay, stiff

The dynamic cone penetration tests indicated that relatively uniform subsoil conditions prevailed over the entire area.

The groundwater level was 4.5 ft. below the top of the footings.

The greatest damage to culvert #55 had occurred at the north-east corner. We believed that it was caused by rapid pumping of water from this end, which created an unbalanced hydrostatic head. This resulted in loosening of the underlying silt and fine sand which is very susceptible to 'boiling.' Later, it was confirmed that indeed pumping was carried out from this end.

From the dynamic cone penetration tests it is clear that the subsoil underneath the footings is very loose. At places this loose and incompetent material extends to depths of 9 ft. below the footings. In view of the above facts, it is felt that the present settlement of the footings is not ultimate. The footings will settle further under additional loads, thus aggravating the damage. Culvert #56, which is apparently undamaged, at present, is also most likely to settle and suffer damage under additional loads. Therefore, it is recommended that no further load be placed on these footings, and the culverts, as originally proposed, not be constructed.

We agree with the suggestion that a 4-ft. diameter corrugated steel pipe be placed between the footings. The pipe should be placed in accordance with the appropriate Ministry standards.

A minimum 18-inch thick Granular 'B' bedding should be placed beneath the pipe. Material beneath the bedding may consist of compacted sand already in place.

4. MISCELLANEOUS:

The field work for this project was carried out during the period of September 20 to 27, 1973, under the supervision of Mr. P. Korgemagi, Project Foundations Engineer.

The equipment used was owned and operated by Dominion
Soil Investigation Ltd.

This report was prepared by Mr. A. Prakash, Senior
Foundations Engineer, and reviewed by Mr. K. G. Selby, Supervising
Foundations Engineer.

A. Prakash

A. Prakash, P. Eng.



K. G. Selby

K. G. Selby, P. Eng.

AP/ao
Oct. 26, 1973.

APPENDIX I

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 2A

JOB 73-11077

LOCATION Culvert 54 Sta. 69 + 95 109' Lt.

ORIGINATED BY AP

W.P.

BORING DATE Sept. 20 and 21, 1973

COMPILED BY PK

DATUM Geodetic

BOREHOLE TYPE Auger

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT				LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			BULK DENSITY γ P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		SHEAR STRENGTH P.S.F.				WATER CONTENT %					
							○ UNCONFINED ● QUICK TRIAXIAL		+ FIELD VANE x LAB VANE		w_p	w	w_L			
704.0	Ground Level														GR.SA.SI.CL.	
0.0	Clayey silt, traces of sand. Firm		1	SS	8	700									0 9 51 40 702.7	
702.5																0 83 (17)
1.5	Sand, traces of silt & clay. Compact		2	SS	25											
700.0			3	SS	11											
4.0	Clayey silt. Firm		4	SS	6											
698.0			5	SS	14											0 28 66 6
6.0	Silt with sand. Loose to Compact		6	SS	8											
695.3	Clayey silt. Very Stiff		7	SS	19	690									22 68 (10)	
694.3	Sand, some gravel, trace silt. Compact		8	SS	19											
693.0			9	SS	20											
11.0	Clayey silt to silty clay, some sand. Stiff to Very Stiff		10	SS	18											0 4 52 44
			11	SS	17											
			12	SS	20	680										
			13	SS	33											7 22 45 26
673.7	sand with gravel		14	SS	76/11										32 52 (16)	
30.3	End of Borehole															

OFFICE REPORT SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 8

JOB 73-11077

LOCATION Culvert 55 Sta. 90 + 55.5 42' Rt. of Hwy. 402

W.P.

BORING DATE Sept. 25 and 26, 1973

ORIGINATED BY PK

DATUM Geodetic

BOREHOLE TYPE Auger and Cone Test

COMPILED BY PK

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 20 40 60 80 100				LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE				WATER CONTENT % 10 20 30				
706.7	Ground Level														
0.0	Silt to sandy silt, some clay, traces of gravel.		1	SS	6										2 3 4 19 702.2
699.4	Very Loose to Loose Brown		2	SS	3										
7.3	Fine sand, some clay & silt.		3	SS	7										
696.8	Loose		4	SS	10										
9.9	Clayey silt to silty clay.		5	SS	15										0 79 (21)
691.7	Grey Stiff		6	SS	16										
15.0	End of Borehole														
685.7															
21.0	End of Cone Test														

ABBREVIATIONS & SYMBOLS USED IN THIS REPORTPENETRATION 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 :-

<u>CONSISTENCY</u>	<u>c LB./SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
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 "		

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
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
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 (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

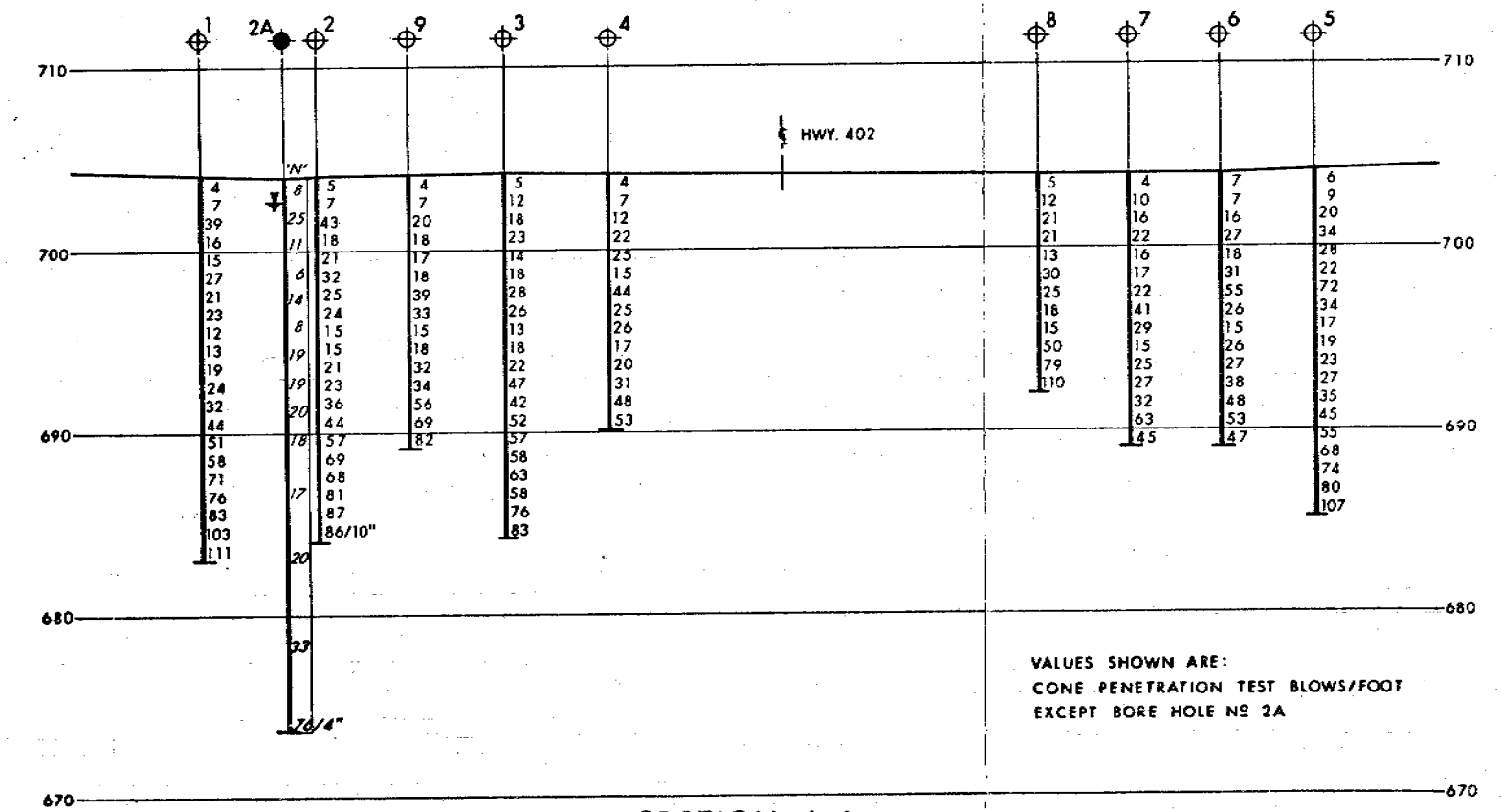
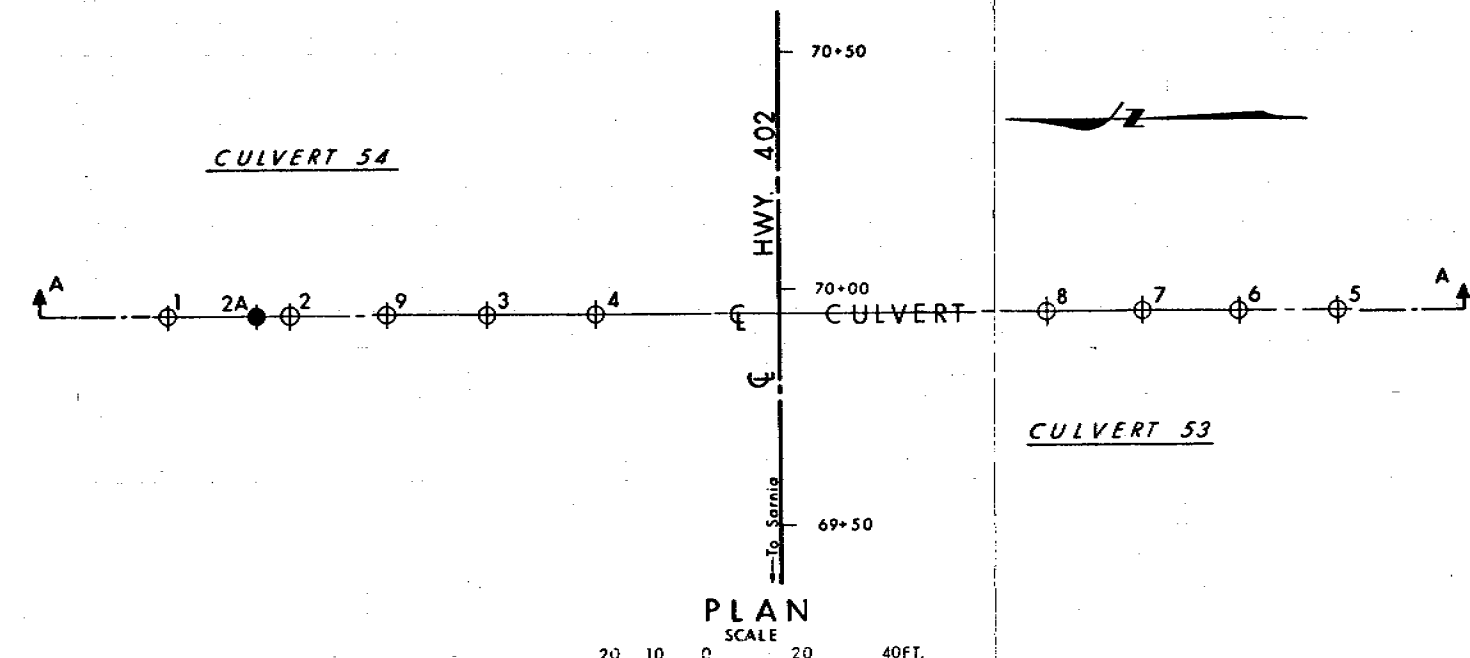
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_0	COEFFICIENT OF EARTH PRESSURE AT REST

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

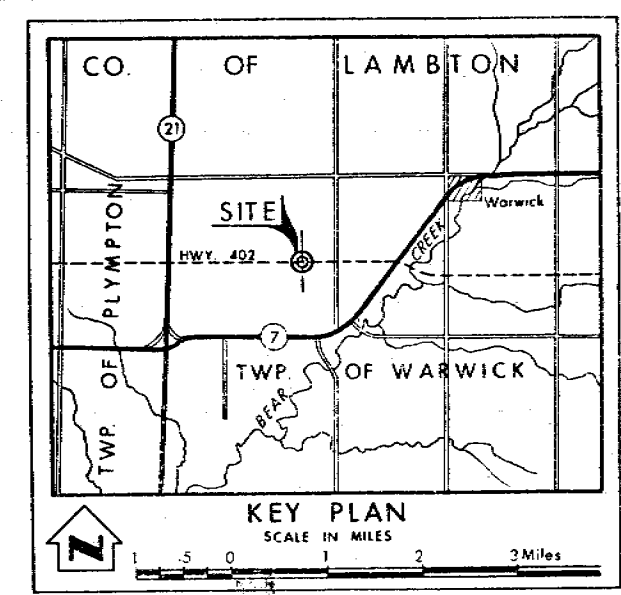
H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL



SECTION A-A
SCALE
HORIZ. 20 10 0 20 40 FT.
VERT. 5 0 5 10 FT.

VALUES SHOWN ARE:
CONE PENETRATION TEST BLOWS/FOOT
EXCEPT BORE HOLE NO. 2A

NOTE: FOR CONTRACT DOCUMENT
The complete foundation investigation report for this structure may be examined at the Structural Office and Foundations Office, Downsview, and at the CHATHAM District Office.



LEGEND			
	Bore Hole		
	Cone Penetration Test		
	Bore Hole & Cone Test		
	Water Levels established at time of field investigation, Sept. 1973		

NO.	ELEVATION	STATION	OFFSET
1	704.1	69+95	128' LT.
2	704.2	69+95	102' LT.
2A	704.0	69+95	109' LT.
3	704.3	69+95	61' LT.
4	704.2	69+95	38' LT.
5	704.3	69+95	116' RT.
6	704.1	69+95	96' RT.
7	704.1	69+95	76' RT.
8	704.1	69+95	56' RT.
9	704.2	69+95	82' LT.



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
DESIGN SERVICES BRANCH—FOUNDATIONS OFFICE

CULVERTS NO. 53 & 54
(STA. 69+95)

HIGHWAY NO. 402 DIST. NO. 1
CO. LAMBTON
TWP. WARWICK LOT 6 CON. II SER.

BORE HOLE LOCATIONS & CONE VALUES

SUBWD. A.P. CHECKED	WP. NO.	DRAWING NO.
DRAWN BY CHECKED	WO NO. 73-11077	73-11077A
DATE Oct. 16, 1973	SITE NO.	BRIDGE DRAWING NO.
APPROVED: <i>[Signature]</i>	CONT. NO.	

