

G.I.-30 SEPT. 1976

GEOCRES No. 400-5DIST. 1 REGION W.P. No. 43-66-20CONT. No. 75-27W. O. No. STR. SITE No. 14-374HWY. No. CRLOCATION Michigan Ave and
Telfer ChannelNo of PAGES - =====OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. REMARKS:

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

MEMORANDUM

40-0-5

TO: Mr. A. P. Watt, (2) FROM: Foundations Office,
Regional Structural Planning Eng., Design Services Branch,
Southwestern Region, West Bldg., Downsview.
London, Ontario.

ATTENTION: Mr. S. Jants, DATE: February 14, 1973.

OUR FILE REF. Structural Planning Technician REPLY TO FEB 16 1973

SUBJECT:

FOUNDATION INVESTIGATION REPORT
For
The Proposed Bridge Site 14-374
Michigan Ave. Bridge Over Telfer
Channel Diversion Approx. 0.4 Miles
East of Telfer Road
District #1, Chatham
W.O. 72-11127 -- W.P. 43-66-20
CONT. 75-27

40-0-5

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 design requirements. Should additional information be required, please do not hesitate to contact our Office.

A. G. Stermac

A. G. Stermac,
PRINCIPAL FOUNDATIONS ENGINEER.

AGS/ao
Attch.

cc: E. J. Orr
B. R. Davis
A. Rutka
A. Wittenberg
F. C. Brown
B. J. Giroux
J. R. Roy
G. A. Wrong
B. A. Singh

Foundations Files ✓
Documents

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FOUNDATION INVESTIGATION REPORT
For
The Proposed Bridge Site 14-374
Michigan Ave. Bridge Over Telfer
Channel Diversion Approx. 0.4 Miles
East of Telfer Road
District #1, Chatham
W.O. 72-11127 -- W.P. 43-66-20

1. INTRODUCTION:

A foundation investigation was undertaken for the proposed Michigan Ave. Bridge over Telfer Diversion Channel. The proposal consists of a two-lane, three-span structure. On receiving a request from Mr. S. Jants, Structural Planning Technician for the South-western Region, dated October 31, 1972, a field and laboratory investigation was undertaken by this Office so as to determine the existing subsoil and groundwater conditions at the proposed crossing. Presented in this report are the results of the investigation together with recommendations concerning the structure foundations.

2. DESCRIPTION OF SITE:

At the proposed crossing the area is very flat. The area is generally used as farmland with corn the main crop. There is an 8 to 10 foot deep ditch along the south side of Michigan Ave. The field to the south is drained by tiles and as a result the ditch contained about 2 feet of water at all times.

Geologically, the site is part of the physiographic region known as the St. Clair Clay Plain. The region is one of little relief with a deep deposit of clay. At the site the clay is some 130 ft. deep. Most of Lambton County is essentially till plains smoothed by shallow deposits of lacustrine clay which settled

in the depressions while the knolls were being lowered by wave action.

3. FIELD WORK AND LABORATORY INVESTIGATION:

The field work consisted of three sampled boreholes and seven dynamic cone tests, two of the cones being adjacent to two boreholes. The drilling was done by a Bombardier mounted C.M.E. equipped with hollow stem augers. The bedrock in B.H. #1 was cored by a second C.M.E. using NX casing and BX core barrel. Split spoon samples were taken at regular intervals and standard penetration tests were conducted in driving the split spoon. The resulting penetration "N" values are recorded in the Appendix. Thin walled 2 inch I.D. Shelby tube soil samples were obtained either by advancing the Shelby hydraulically or manually. In situ shear strength was measured using an M.T.C. vane. All field and laboratory test results are recorded on the accompanying borelog sheets.

Soil samples were identified in the field and again upon arrival in the laboratory. Laboratory tests to determine moisture content, grain size and Atterberg Limits were carried out on representative samples. The soil samples obtained from the Shelby tubes were subjected to unconfined compression, quick triaxial and consolidation tests.

The groundwater levels across the site were determined by recording the water levels in the open boreholes over the period of the investigation.

The locations and elevations of the boreholes as well as a stratigraphical profile are plotted on Drawing 72-11127A attached at the end of this report. The surveying of the site was carried out by personnel from the Southwestern Region Engineering Surveys Section.

4. SUBSOIL CONDITIONS:

4.1) General:

Uniform subsoil conditions were found to prevail over the site. The first layer encountered was the roadbed material which is granular in nature and from 1 to 3.5 ft. deep. This layer

is followed by a deep deposit of clayey silt which to a depth of 4 to 7 feet is dark grey in colour then turns to a brown colour. Following the clayey silt is a stratum of silty clay and finally the bedrock. A summary of the main deposit is given below.

4.2) Clayey Silt, Some Sand and Traces of Gravel:

All the boreholes for this site were put through the existing road. As a result the first layer encountered was about 1 to 3.5 feet of roadbed material. Following this there is a deep deposit of clayey silt with some sand and traces of gravel. This deposit was found to extend some 35 to 49 feet below ground level corresponding to elevations 556 to 542. Standard penetration "N" values within this layer varied between 10 and 62 blows per foot. Laboratory grain size analyses yielded the following distributions.

Gravel	1	-	5%
Sand	3	-	21%
Silt	45	-	52%
Clay	27	-	41%

The following average physical properties were obtained from field and laboratory tests.

Natural Moisture Content (%)	12	-	35.5
Liquid Limit (%)	30	-	35
Plastic Limit (%)	16	-	20
Bulk Density (p.c.f.)	122	-	132
<u>Undrained Shear Strength</u>			
Field Vane (p.s.f.)	960	->	2,000
Unconfined Compression Test (p.s.f.)	860	-	1915
Triaxial Compression Test (p.s.f.)	750	-	1830

Based on the foregoing the consistency of the deposit is estimated to be firm to hard. A typical grain size envelope is included in the Appendix as Fig. 1.

4.3) Silty Clay, Some Sand, Traces of Gravel:

Following the clayey silt is a 97 to 83 ft. deposit of

silty clay, some sand and traces of gravel. This deposit was encountered in B.H. #1 between elevation 556 and 459. Standard penetration "N" values range between 13 and 40 blows per foot. Laboratory grain size analyses yielded the following distribution.

Gravel	1 - 6%
Sand	7 - 20%
Silt	47 - 52%
Clay	25 - 45%

The following physical properties of the subsoil were obtained from laboratory tests.

Natural Moisture Content (%)	16 - 29.5
Liquid Limit (%)	35 - 40
Plastic Limit (%)	17 - 24
Bulk Density (p.c.f.)	121.5 - 131

Undrained Shear Strength

Field Vane (p.s.f.)	560 - 1820
Unconfined Compression Test (p.s.f.)	825 - 1350
Triaxial Compression Test (p.s.f.)	1180 - 1330

Based on the foregoing the consistency of the deposit is estimated to be firm to hard. A typical grain size envelope is included in the Appendix as Fig. 2.

4.4) Bedrock:

A brief description has been given, below by Mr. K. W. Ingham, Geologist, for the borehole drilled to bedrock at this site, together with the appropriate bedrock elevations.

Hole No. 1	Bedrock at 459.0
459.0 - 460.0	Dark brown shale: slightly calcareous, fragmented due to vertical fissure.
460.0 - 464.0	Dark brown shale; slightly calcareous.

5. GROUNDWATER CONDITIONS:

The following groundwater levels were observed during the field investigation.

B.H. #1	575.0
B.H. #8	558.2

These levels may not be representative of the actual groundwater levels due to the relatively impermeable nature of the subsoil and the short duration of the field work.

6. DISCUSSION AND RECOMMENDATIONS:

6.1) General:

The proposal at this site is to build a three-span (35' - 60' - 35') structure at Michigan Ave. and Telfer Channel Diversion. The profile grade of Michigan Ave. is to remain the same at elevation 592. The base of the channel will be at elevation 573₊.

The subsoil at this site consists of a deep deposit of clayey silt and silty clay. The upper 9 to 12 ft. is a very stiff to hard desiccated surface crust. Below the crust the undrained shear strength of the material decreases until a minimum value of about 800 p.s.f. is reached, then increases again with depth, with some random variation.

6.2) Foundations:

a) Spread Footings:

This structure may be supported on spread footings with a safe net pressure of 1.5 t.s.f. for both abutment and pier locations. The abutment footings may be placed at or below elevation 582 and the pier footings may be located at or below elevation 567. As the subsoil is susceptible to softening on contact with water, it is recommended that the footing excavations be protected by a concrete working slab, immediately on exposure.

Settlement calculations indicate that the abutments and piers will settle in the order of 1.5 to 2.0 inches. It is recommended that the structure be built to accommodate a 1.0 inch differential settlement between the abutment and pier footings.

The foundations should be protected against the scour action of the water. The depth of scour may be obtained from the Hydrology Office.

b) Pile Foundations:

As an alternative the structure may be supported on No. 14 timber piles driven to the elevation necessary to achieve the required pile capacity. It is recommended that the piles be treated, if they are not completely below the groundwater level. In determining the safe capacity of a timber pile, the following equation may be used.

$$Q = 0.5 L \text{ (Tons)}$$

$$Q = \text{Safe capacity of one pile}$$

$$L = \text{Embedded length in original ground (ft.)}$$

Settlements for the pile groups were calculated to be in the order of 1.5 inches for both the abutment and pier locations. It is recommended, however, that the structure be built to tolerate a differential settlement of 1.0 inch between the abutment and pier footings.

As a second alternative for the pile foundation the structure may be supported on steel H-piles driven to bedrock, utilizing the maximum allowable design load for the particular steel section used.

All footings and/or pile caps should be protected against frost action by at least 4 feet of earth cover.

No major dewatering problems are anticipated because of the relatively impervious nature of the subsoil.

6.3) Channel Slopes:

It is recommended that the proposed channel be constructed with 2:1 slopes and be protected against scour action in the vicinity of the new structure.

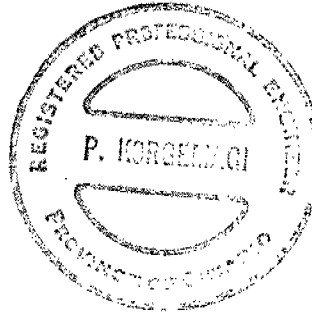
7. MISCELLANEOUS:

The field work was carried out from November 30 to December 11, 1972, and was supervised by Mr. P. Korgemagi, Project Foundations Engineer.

The equipment used was owned and operated by P.V.K. and Sons Drilling Ltd., Burford, Ontario.

The report was written by Mr. P. Korgemagi and reviewed by Mr. K. G. Selby, Supervising Foundations Engineer.

P. Korgemagi
P. Korgemagi, P. Eng.



K. G. Selby

PK/ao
Feb. 13, 1973.

K. G. Selby, P. Eng.

APPENDIX I

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 1

JOB 72-11127

LOCATION Sta. 99 + 35 12' Lt.

ORIGINATED BY PK

W.P. 43-66-20

BORING DATE Nov. 30 to Dec. 6, 1972

COMPILED BY PK

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger & Washboring

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — w_L			BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		BLOWS / FOOT		PLASTIC LIMIT — w_p	WATER CONTENT — w			
591.3	Ground Level												
587.8	Sand and gravel roadbed.												
3.5	Very Stiff to Hard Brown		1	SS	21	590							4 23 45 28
			2	SS	35								
			3	SS	39								
			4	SS	28	580							
			5	SS	29								
573.1	Clayey silt, some sand, traces of gravel.		6	SS	10	570							131 1 14 50 35
18.2			7	TW	PM								
			8	SS	16								
			9	TW	PM	560							
			10	SS	15								
	Grey		11	SS	22	550							131 128.5
			12	SS	10								
542.3	Stiff to Very Stiff												121.5 123 1 7 47 45
49.0	Silty clay, some sand, traces of gravel		13	TW	PM	540							
			14	SS	31	530							
	Grey												
	Very Stiff to Hard		15	SS	33	520							
						510							
						500							
						490							

Continued

20
15 5 % STRAIN AT FAILURE
10

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE No 1 Cont.

JOB 72-11127

LOCATION Sta. 99 + 35 12' Lt.

ORIGINATED BY PK

W.P. 43-66-20

BORING DATE Nov. 30 to Dec. 6, 1972

COMPILED BY PK

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger & Washboring

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. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 1000 2000			w_p w w_L WATER CONTENT % 10 20 30				
159.0	Silty clay, some sand, traces of gravel. Grey Very Stiff to Hard		17	SS	27	480								6 12 52 30
132.3	Shale Bedrock		18	SS	19	470								
151.0			19	SS	35	460								
137.3	End of Borehole		20	BX	100%									
			21	BX	84%									
						450								

OFFICE REPORT OF SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 2

JOB 72-11127

LOCATION Sta. 99 + 70 17' Lt.

ORIGINATED BY PK

W.P. 43-66-20

BORING DATE Nov. 30, 1972

COMPILED BY PK

DATUM Geodetic

BOREHOLE TYPE Cone Test

 CHECKED BY *CK*

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — w_L			BULK DENSITY	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	BLOWS / FOOT 25 50 75 100 125					PLASTIC LIMIT — w_p WATER CONTENT — w w_p — w — w_L					
591.4	Ground Level					SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB. VANE					WATER CONTENT %			γ	P.C.F. GR. SA. SI. CL.	
0.0						590										
						580										
						570										
						560										
549.4						550										
42.0	End of Cone Test					540										

OFFICE REPORT SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 3

JOB 72-11127

LOCATION Sta. 100 + 30 17' Lt.

ORIGINATED BY PK

W.P. 43-66-20

BORING DATE Nov. 30, 1972

COMPILED BY JK

DATUM Geodetic

BOREHOLE TYPE Cone Test

CHECKED BY JLC

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — w_L			BULK DENSITY	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	BLOWS / FOOT					PLASTIC LIMIT — w_p				
591.0	Ground Level						25 50 75 100 125					WATER CONTENT — w				
0.0						590										
						580										
						570										
						560										
552.0																
39.0	End of Cone Test					550										

OFFICE REPORT SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 4

JOB 72-11127

LOCATION Sta. 100 + 55 17' Lt.

ORIGINATED BY PK

W.P. 43-66-20

BORING DATE Nov. 30, 1972

COMPILED BY PK

DATUM Geodetic

BOREHOLE TYPE Cone Test

CHECKED BY *SR*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 25 50 75 100 125	LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w SHEAR STRENGTH P.S.F. w_p — w — w_L ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	WATER CONTENT %	BULK DENSITY γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT						
591.0	Ground Level					590					
0.0											
580.0						580					
11.0	End of Cone Test										

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 5

JOB 72-11127

LOCATION Sta. 99 + 35 17' Rt.

ORIGINATED BY PK

W.P. 43-66-20

BORING DATE Nov. 30, 1973

COMPILED BY PK

DATUM Geodetic

BOREHOLE TYPE Cone Test

CHECKED BY *MR*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 25 50 75 100 125	LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT W W_P — W — W_L WATER CONTENT %	BULK DENSITY γ P.C.F. GR.SA.SI.CL	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT					
591.3	Ground Level					590				
0.0										
580.3										
11.0	End of Cone Test					580				

OFFICE REPORT SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 6

JOB 72-11127

LOCATION Sta. 99 + 70 17' Rt.

ORIGINATED BY PK

W.P. 43-66-20

BORING DATE Dec. 1, 1973

COMPILED BY PK

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger

CHECKED BY *[Signature]*

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		25	50	75	100	125	w_p	w	w_L		
591.3	Ground Level															
0.0						590										Hole Dry
587.3	Brown		1	SS	14											
1.0																
584.3	Dark Grey		3	AS	-											
7.0	Brown		2	SS	15											
578.3	Very Stiff to Hard					580										5 21 47 27
13.0			4	SS	25											
			5	SS	14											
	Clayey silt, some		6	TW	PM	570									132	
	sand, traces of		7	SS	21											
	gravel.		8	SS	23											1 13 46 40
553.3	Grey					560										
38.0	Very Stiff		9	SS	28											
			10	TW	PH	550									131	
	Silty clay, some		11	SS	17										128	
	sand, traces of		12	SS	17	540										6 20 49 25
	gravel.															
	Grey					530									123	
	Very Stiff		13	TW	PH										121	
517.3			14	SS	25	520										
64.0	End of Borehole					510										

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 7

JOB 72-11127

LOCATION Sta. 100 + 30 17' Rt.

ORIGINATED BY PK

W.P. 113-66-20

BORING DATE Nov. 30, 1972

COMPILED BY PK

DATUM Geodetic

BOREHOLE TYPE Cone Test

CHECKED BY *PK*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 25 50 75 100 125	LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT W W_P — W — W_L WATER CONTENT %	BULK DENSITY γ P.C.F. GR. SA. SI. CL.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT					
591.3	Ground Level					590				
0.0										
580.5										
10.8	End of Cone Test					580				

FOUNDATIONS OFFICE

JOB 72-11127

LOCATION Sta. 100 + 55 17' Rt.

ORIGINATED BY PK

W.P. 43-66-20

BORING DATE Dec. 8 to 11, 1972

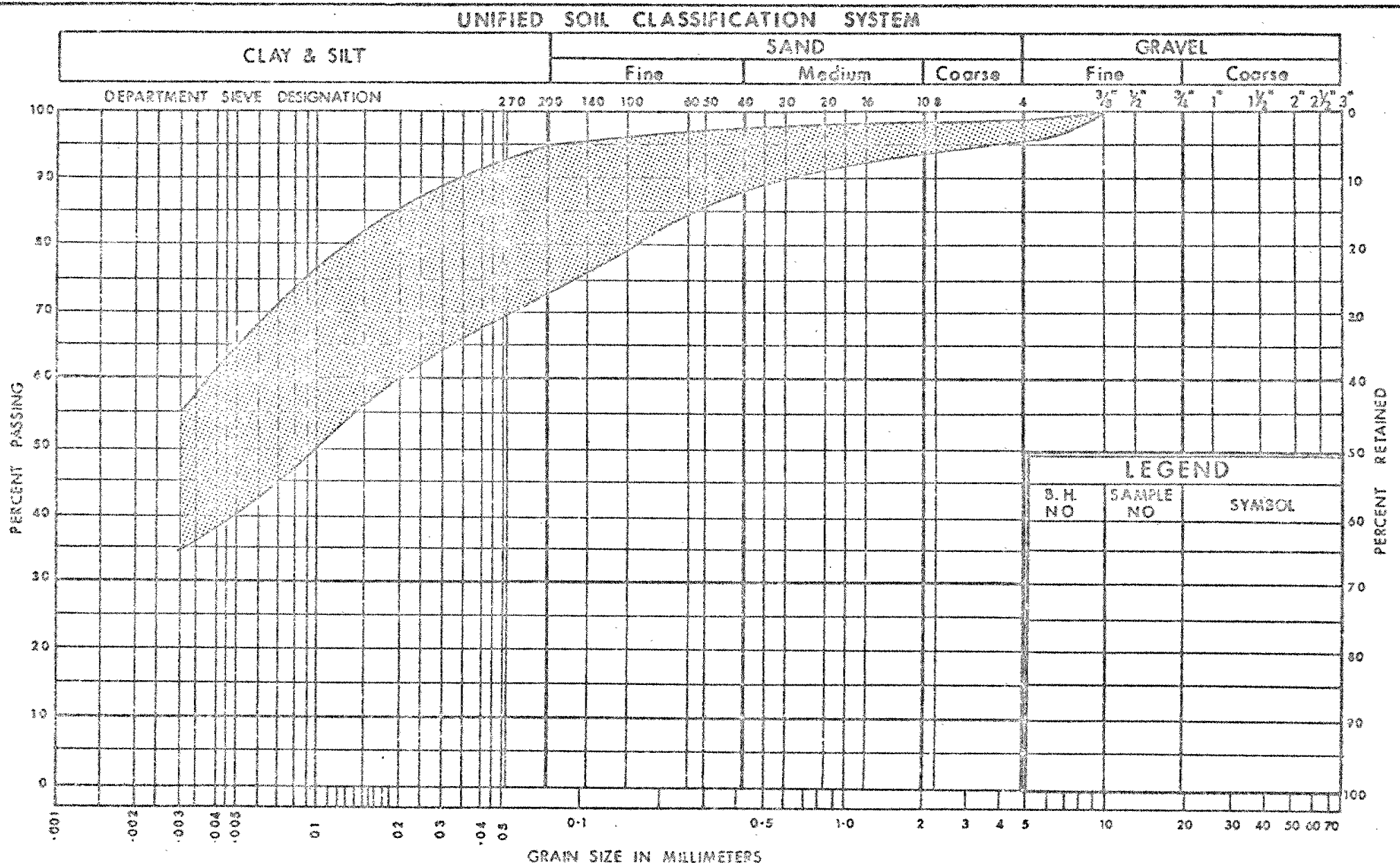
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DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger

CHECKED BY SA

20
15 ϕ 5 % STRAIN AT FAILURE
10

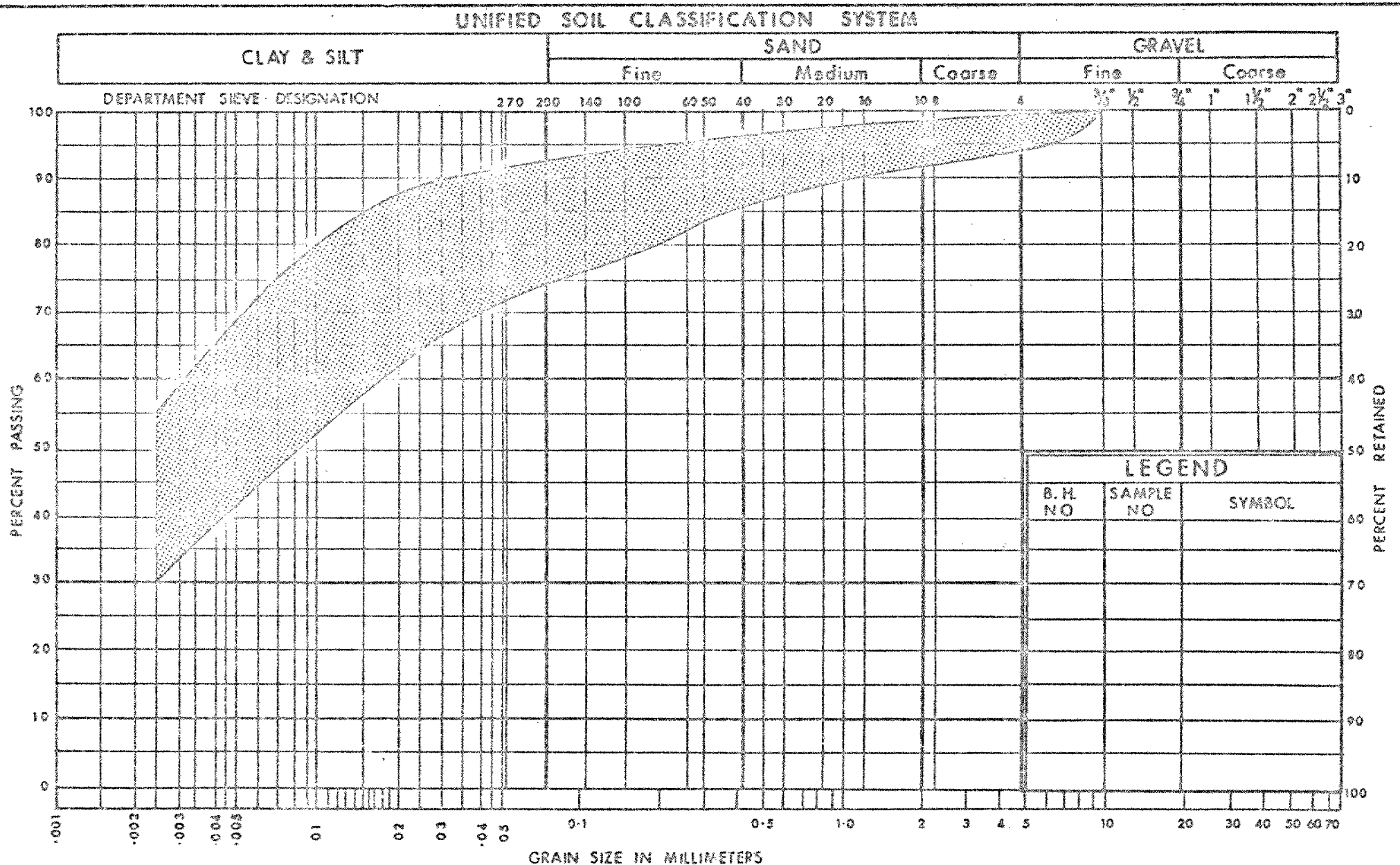


DEPARTMENT
OF
TRANSPORTATION AND COMMUNICATIONS

DESIGN SERVICES
BRANCH

GRAIN SIZE DISTRIBUTION
CLAYEY SILT
SOME SAND, TRACES OF GRAVEL

W.P. No.	43-66-20
JCB No.	72-11127
FIG. 1	



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

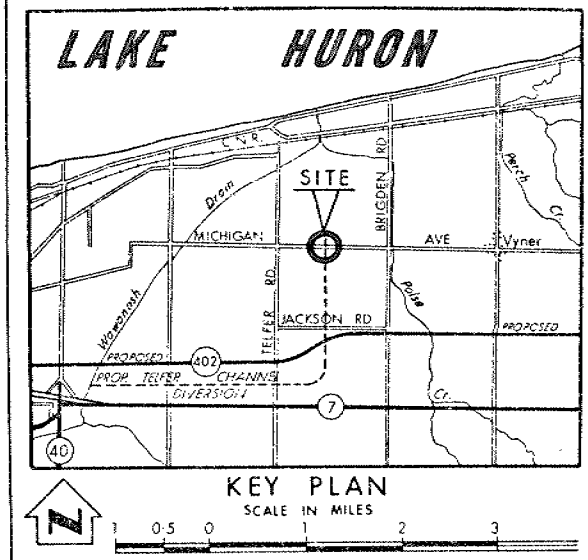
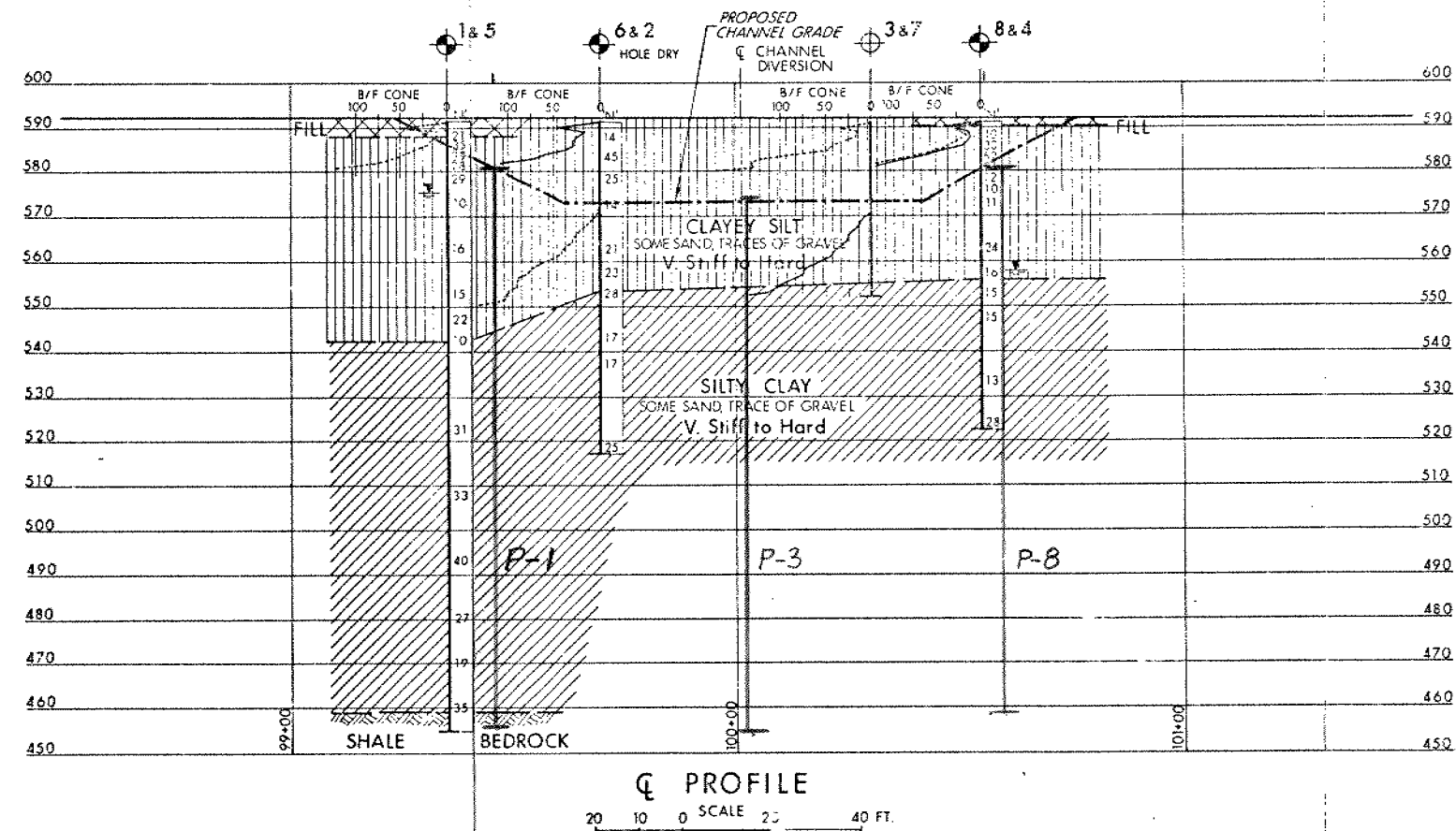
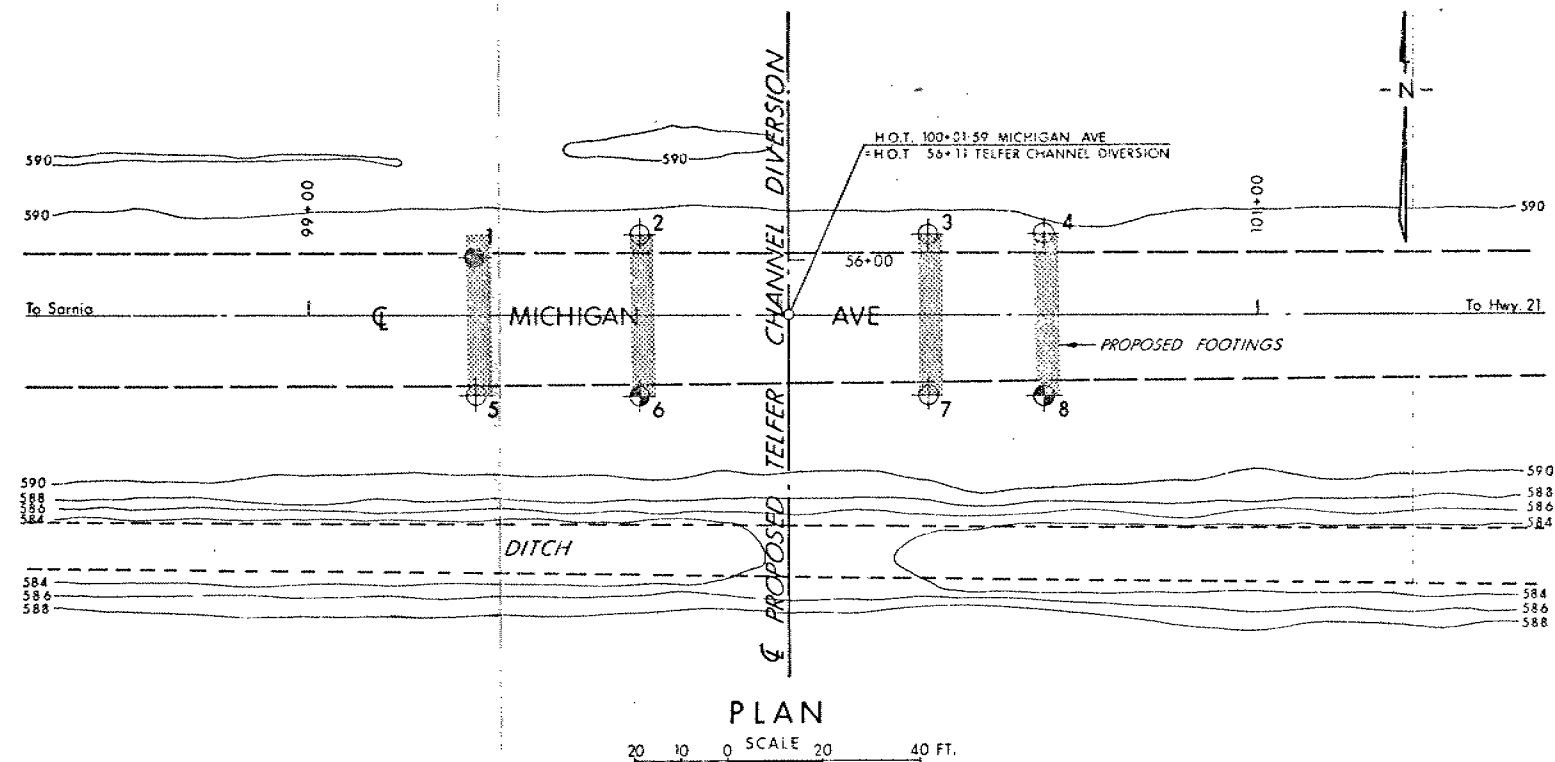
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_0	COEFFICIENT OF EARTH PRESSURE AT REST

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



LEGEND			
	Bore Hole		
	Cone Penetration Test		
	Bore Hole & Cone Test		
	Water Levels established at time of field investigation NOV. & DEC 1972		

NO.	ELEVATION	STATION	OFFSET
1	591.3	99+35	12' LT.
2	591.4	99+70	17' LT.
3	591.0	100+30	17' LT.
4	591.0	100+55	17' LT.
5	591.3	99+35	17' RT.
6	591.3	99+70	17' RT.
7	591.3	100+30	17' RT.
8	591.3	100+55	17' RT.

— 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

MICHIGAN AVENUE AND TELFER CHANNEL DIVERSION

HIGHWAY NO. _____ DIST. NO. 1
CO. LAMBTON
TWP. SARNIA LOT 8 CON. 8

BORE HOLE LOCATIONS & SOIL STRATA

SUBMD P.K.	CHECKED	WP NO. 43-66-20	DRAWING NO.
DRAWN S.O.	CHECKED	WC NO. 72-11127	72-11127 A
DATE 30 JAN 1973		SITE NO. 14-374	BRIDGE DRAWING NO.
APPROVED		CONT. NO.	

PRINCIPAL FOUNDATION ENGINEER

REF. NO. E-5336-1