

GEOCRES No. 31G-17DIST. 9 REGION W.P. No. CONT. No. W. O. No. 72-11063STR. SITE No. HWY. No. LOCATION PROPOSED DOME,NAVAN ' PATROL YARD SITENo of PAGES - 1=====OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. REMARKS:

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS

MEMORANDUM

31 G-17

TO: Mr. E. V. Saint, (2)
Reg. Materials Engineer,
Eastern Region,
KINGSTON, Ontario.

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

ATTENTION:

DATE: August 10, 1972

OUR FILE REF.

IN REPLY TO

AUG 14 1972

SUBJECT:

FOUNDATION INVESTIGATION REPORT
For
Proposed Dome, Navan Patrol Yard Site
Township of Cumberland
Reg. Mun. of Ottawa-Carleton
District No. 9 (Ottawa)
W.O. 72-11063 -- W.P. --

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.

AGS/ht
Attch.

A. G. Stermac
A. G. Stermac,
PRINCIPAL FOUNDATIONS ENGINEER.

c.c. D. W. Farren
B. R. Davis
A. Rutka
S. J. Markiewicz
J. C. Callaghan
B. J. Giroux
T. C. Kingsland
G. A. Wrong
B. A. Singh

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FOUNDATION INVESTIGATION REPORT
For
Proposed Dome, Navan Patrol Yard Site
Township of Cumberland
Reg. Mun. of Ottawa-Carleton
District No. 9 (Ottawa)
W.O. 72-11063 -- W.P. --

1. INTRODUCTION:

In a memo from the Eastern Region, Materials and Testing Office (Mr. A. M. Batten, Senior Soils Supervisor) dated May 11, 1972, the Foundations Office was requested to undertake a subsurface investigation at the site of the aforementioned dome. An investigation was subsequently carried out by this Office to determine the subsoil and groundwater conditions at the site.

This report presents the factual information obtained from the investigation as well as comments with regard to the stability and settlement considerations associated with the stock piles to be placed within this M.T.C. standard dome.

2. DESCRIPTION OF THE SITE AND GEOLOGY:

The Patrol Yard in question is located on Hwy. #17, approximately 1.5 miles east of the Village of Orleans.

The site is predominantly flat to gently undulating in relief, ranging in elevation from 264 to 276 ft. A number of lightly loaded single storey structures are located on the property.

Physiographically, the site is located in the "Ottawa Valley Clay Plain". In this area * an oxidized non-calcareous

*Report and Map 16 - 1962
Gadd, N.R., Surficial Geology of Ottawa Map - Area Ontario and
Quebec, 1963, Geo. Survey of Canada

and non-fossiliferous, rust-mottled clay lies upon a soft, un-oxidized, calcareous, fossiliferous marine clay. The physical differences in these two clays are best explained by assigning the older of the two to a marine or brackish water environment of deposition, namely, the Champlain Sea, and the younger to a fresh water lacustrine or fluvial environment of deposition - (The Ancestral Ottawa River). The thickness of the clay beds in the area varies randomly from 30 to over 200 feet. The clay stratum is underlain by till, which in turn is underlain by limestone of the Leray beds of the Trenton and Black River formation, Palaeozoic Period.

3. FIELD AND LABORATORY INVESTIGATION PROCEDURES:

Two sampled boreholes, one accompanied by a dynamic cone penetration test were carried out during the course of the field investigation. The holes were advanced by wash boring procedures using a conventional diamond drill rig. Disturbed samples were obtained with the use of a standard 2" O.D. split spoon sampler which was driven in conformance to the specifications of the Standard Penetration Test. Relatively undisturbed samples were obtained by using 2" I.D. Shelby tubes.

The location and elevation of the boreholes are shown on Drawing No. 72-11063A which accompanies this report. An inferred stratigraphical section across the site is also shown on this drawing.

All samples were visually identified and classified in the field and laboratory and subsequently laboratory tests were undertaken to determine the following physical properties of the overburden.

- Atterberg Limits
- Moisture Content
- Grain-Size Distribution
- Bulk Density
- Consolidation Characteristics

The test results are summarized on the Record of Borehole sheets contained in the Appendix of this report.

4. SUBSURFACE CONDITIONS:

A brief description of the deposits encountered at the site is presented in the following subsections. The boundaries of the various deposits, as determined in the boreholes are shown on the accompanying Record of Borehole sheets. The stratigraphical profile shown on Drawing No. 72-11063A has been inferred from this data.

4.1) Pavement and Granular Fill:

The borings took place through 6 inches of asphalt pavement and then 3 feet of granular fill. The fill is composed of sand and gravel.

4.2) Clay to Silty Clay:

The granular fill is underlain by a sensitive marine clay to silty clay. The total thickness of this stratum in Borehole #1 was found to be 106.5 feet - i.e., the clay extended down to elevation 62.5. The top 10.5 feet of this stratum is brown in colour indicating that this zone has been desiccated. The soil below this is grey in colour with inclusions of organic material below 90'.

The properties of the upper desiccated portion, as well as the lower portion of the stratum, have been determined by field and laboratory testing and are summarized on the Record of Borehole sheets in the Appendix. A brief resume, presented in tabular form follows:

<u>Identity Tests</u>	<u>Upper Desiccated Zone Range (Average)</u>	<u>Lower Zone Range (Average)</u>
Bulk Density () (p.c.f.)	111	98.5 - 108 (99.8)
Liquid Limit (W_L) (%)	52-68 (59.5)	58
Plastic Limit (W_P) (%)	29-31 (30)	34
Natural Moisture Content (W) (%)	38-70 (60)	45

Consolidation Characteristics

Initial Void Ratio (e_o)	1.82 - 1.99 (1.92)
Compression Index (C_c)	1.27 - 2.23 (1.88)
Recompression Index (C_{CR})	0.03 - 0.06 (0.04)
Degree of Preconsolidation ($P_c - P_o'$) (t.s.f.)	1.68 - 1.86 (1.73)

Undrained Shear Strength (C_u)

1) Field Tests	1,500 - 1,950 p.s.f.	1,400 - 2,000 p.s.f.
2) Lab. Tests	1,200 p.s.f.	950 - 1,950 p.s.f.

Standard Penetration Resistance Testing

4 - 13 blows/ft. 6 - 85 blows/ft.

The Atterberg limit tests are also plotted on the Plasticity Chart, Figure #1. These results indicate that the cohesive subsoil is essentially inorganic with a plasticity that varies from medium to high. The natural water content is generally above the liquid limit throughout the stratum. This is indicative of a sensitive material.

The results of the undrained shear strength testing indicate that the consistency of this stratum varies from stiff to very stiff.

The consolidation characteristics of the stratum were determined by carrying out three laboratory tests; the results of which are shown as Void Ratio vs. Pressure Plots on Figure #2. The results of these tests indicate that the clay stratum is preconsolidated by about 3,300 - 3,800 p.s.f. in excess of

existing overburden pressure. The relatively high values of initial void ratio (e_0) and the compression index (C_c) compare favourably with those of other deposits in this area, and are a further indication of the sensitive nature of the stratum.

4.3) Glacial Till:

Beneath the cohesive stratum there exists a deposit of very dense ('N' values of 69 and 70 blows/ft.) granular glacial till. The till was not fully penetrated in either of the borings put down, however, it was proven for a 2 ft. depth at B.H. #1. The glacial till is composed of a heterogeneous mixture of sand, silt, gravel and a trace of clay. A grain-size distribution of this till is found on Figure #3.

5. GROUNDWATER CONDITIONS:

Observations of water levels in open boreholes were made during the course of the field investigation. These are shown on the Record of Borelog sheets as well as on Drawing #72-11063A. The groundwater level at the site of the proposed storage dome was at elevation 109 ft. A depth of 3.5 feet below the ground surface.

6. DISCUSSION AND RECOMMENDATIONS:

6.1) General:

It is proposed to construct a storage dome for the M.T.C. patrol yard on Hwy. #17 in the vicinity of Orleans.

6.2) Dome and Stock Piles:

The domes which are of light frame construction are 100 feet in diameter at the base and 51 feet high. The structures will be carried on a ring footing, 23 inches wide and 16 inches deep. The footing will be placed on top of an asphalt mat which is supported by 3 feet of granular fill. The domes will house sand and salt for winter maintenance of Hwy. #17.

An allowable bearing capacity of 1.4 t.s.f. can be used for the footing design.

The stock piles placed within the domes will be underlain by a cohesive stratum of clay to silty clay approximately 106.5 feet thick. Stability analyses in terms of total stresses were carried out to determine the safe height to which the stock pile may be built. The following assumptions were made for computational purposes:

1) Soil Properties

<u>Depth</u>	<u>Soil</u>	<u>Density (p.c.f.)</u>	<u>Strength Parameters</u>	
			<u>C_u (p.s.f.)</u>	<u>Ø (°)</u>
Above O.G.S.	Dome Material	120	0	30
O.G.S. - 4'	Granular Fill	130	0	30
4' - 14'	Clay to Silty Clay	110	1700	0
14' - 34'	Clay to Silty Clay	100	1400	0
34' - 41'	Clay to Silty Clay	100	1550	0
41' - 47'	Clay to Silty Clay	100	1850	0
57' -	Clay to Silty Clay	110	2000	0

2) Side Slopes

The side slopes of the stock piles will be 1-1/2:1.

Computations indicate that in order to ensure stability, the stock piles can be built to a height of 27 feet. Further computations reveal that if the 27 feet of fill are placed, the cohesive subsoil can be expected to settle 3 to 4 inches, 50% of this settlement can be expected in approximately 18 months of continuous loading while the total should be realized within a period of six years of continuous loading. However, in view of the fact that the loads will be placed and removed on an annual basis, the times given above for settlement to occur may be doubled.

7. MISCELLANEOUS:

The field work for this project was carried out during the period of June 6 to June 13, 1972, under the supervision of Mr. A. Tieman, Student Technician (Field).

The equipment was owned and operated by F.E. Johnston Drilling Ltd, Ottawa.

This report was written by Mr. A. Tieman, Student Technician (Field), with the assistance of Mr. B.T. Darch, Senior Foundations Engineer. This report was reviewed by Mr. M. Devata, Supervising Foundations Engineer.

Andie Tieman

A. Tieman

M. Devata

M. Devata, P. Eng.

AT/ht

August 8, 1972

APPENDIX I

OVERSIZE DRAWING

CHECKED BY

[illegible]

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_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

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 :-

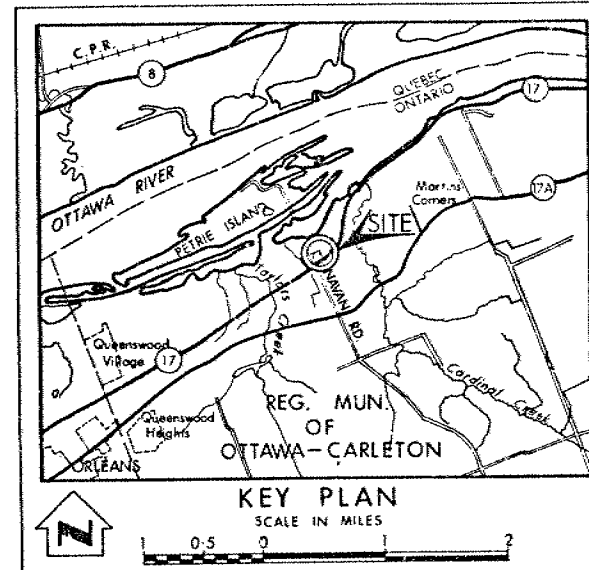
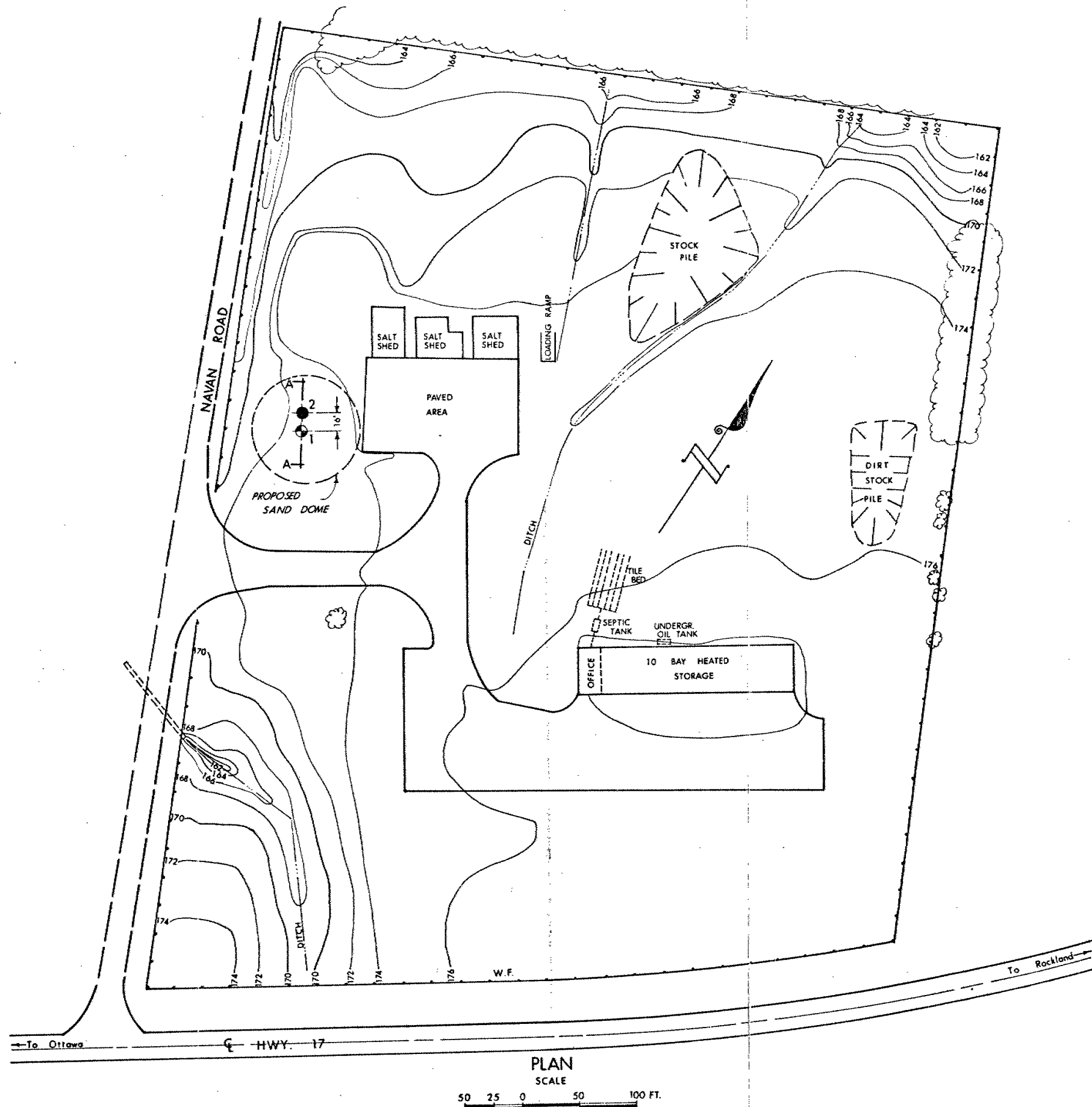
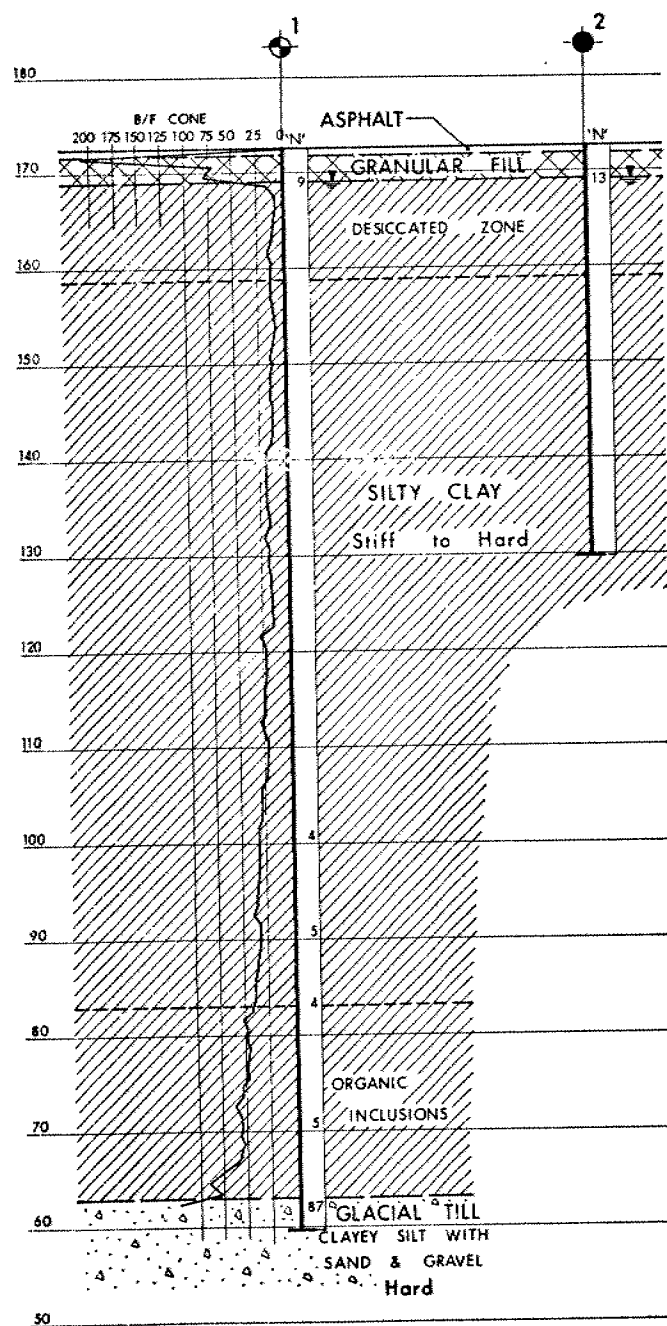
<u>CONSISTENCY</u>	<u>'N' BLOWS / FT.</u>	<u>c LB. / SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
VERY SOFT	0 - 2	0 - 250	VERY LOOSE	0 - 4
SOFT	2 - 4	250 - 500	LOOSE	4 - 10
FIRM	4 - 8	500 - 1000	COMPACT	10 - 30
STIFF	8 - 15	1000 - 2000	DENSE	30 - 50
VERY STIFF	15 - 30	2000 - 4000	VERY DENSE	>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



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

NO.	ELEVATION	STATION	OFFSET
1	172.6	AS SHOWN ON PLAN	ON PLAN
2	172.6	AS SHOWN ON PLAN	ON PLAN

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
DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

PATROL YARD — 'NAVAN ROAD'

HIGHWAY NO. 17 DIST. NO. 9
REG. MUN. OF OTTAWA — CARLETON
TWP. LOT 30 CON. 1 OF

BORE HOLE LOCATIONS & SOIL STRATA

SUBMD. A.T. CHECKED	W.P. NO.	DRAWING NO.
DRAWN O.E. CHECKED	JOB NO. 72-11063	72-11063A
DATE JULY 21, 1972	SITE NO.	BRIDGE DRAWING NO.
APPROVED	CONT. NO.	

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS

MEMORANDUM

TO: Mr. E. R. Saint, (2)
Reg. Materials Engineer,
Eastern Region,
Kingston, Ontario.

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

ATTENTION:

DATE:

August 24, 1972.

OUR FILE REF.

IN REPLY TO

AUG 29 1972

SUBJECT:

FOUNDATION INVESTIGATION REPORT
For
Proposed Dome, Navan Patrol Yard Site
Township of Cumberland
Reg. Mun. of Ottawa-Carleton
District No. 9 (ottawa)
W.O. 72-11063 -- W.P. --

With reference to the above-mentioned report dated August 10, 1972, please attach the enclosed figures to the Appendix of that report.

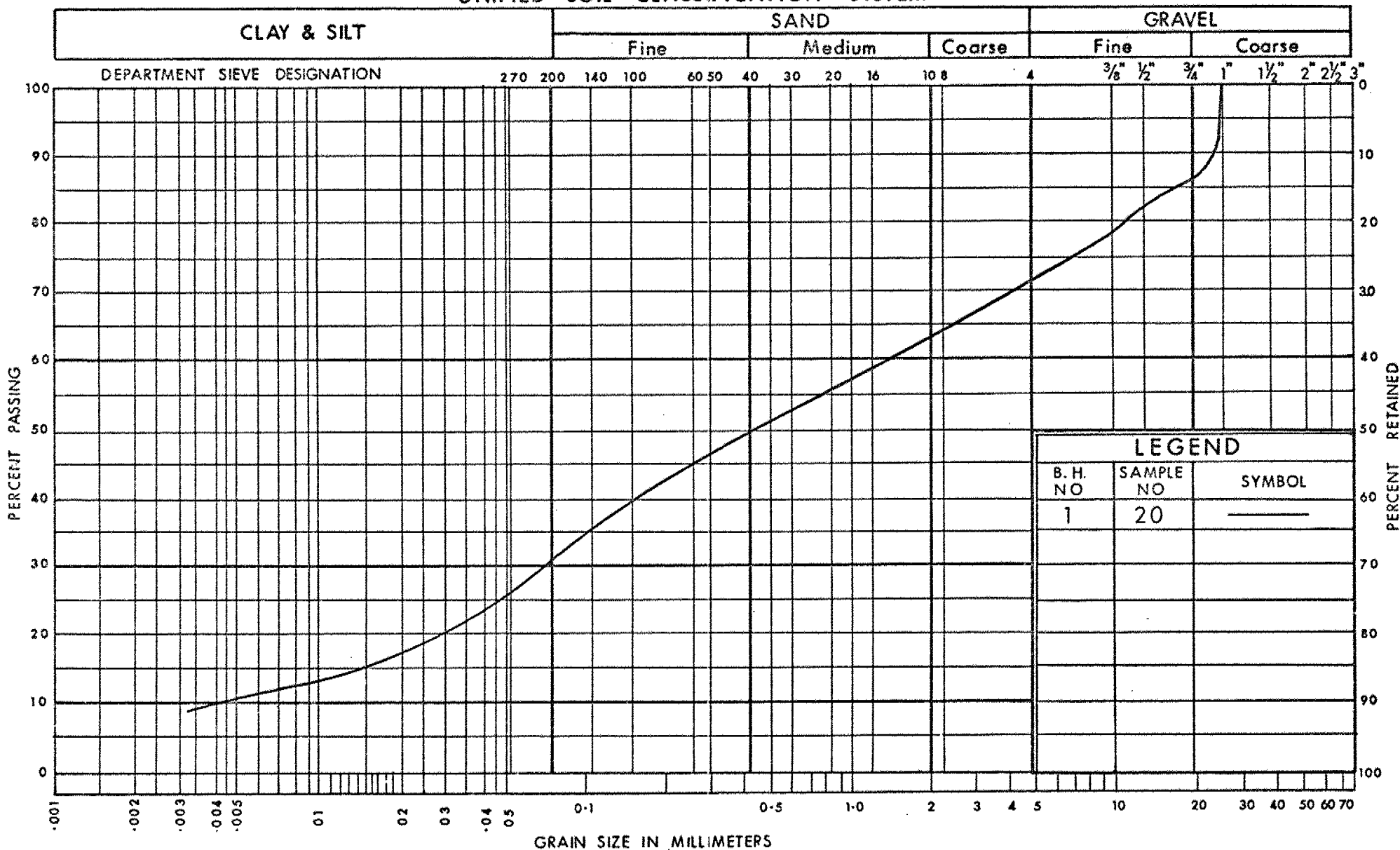
AGS/ao
Attch.

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

cc: Messrs. D. W. Farren
B. R. Davis
A. Rutka
S. J. Markiewicz
J. E. Callaghan
B. J. Giroux
T. C. Kingsland
G. A. Wrong
B. A. Singh

Foundations Office ✓
Documents

UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT
OF
TRANSPORTATION AND COMMUNICATIONS



DESIGN SERVICES
BRANCH

GRAIN SIZE DISTRIBUTION GLACIAL TILL

HET. MIX OF CLAY, SILT, SAND & GRAVEL

W.P. No.

JOB No. 72-11063

FIG. 3

VOID RATIO-PRESSURE CURVES

JOB NO. 72-11063

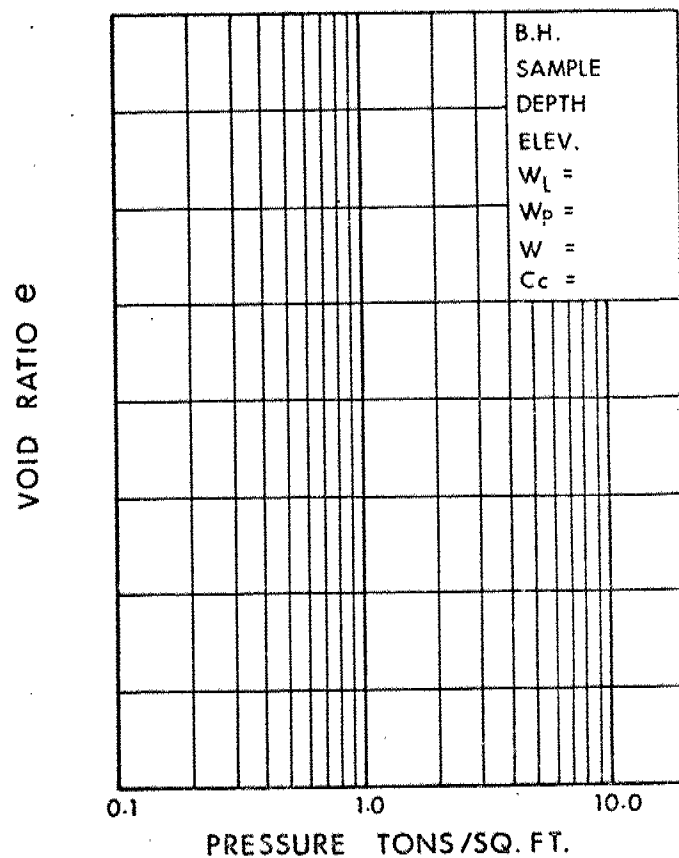
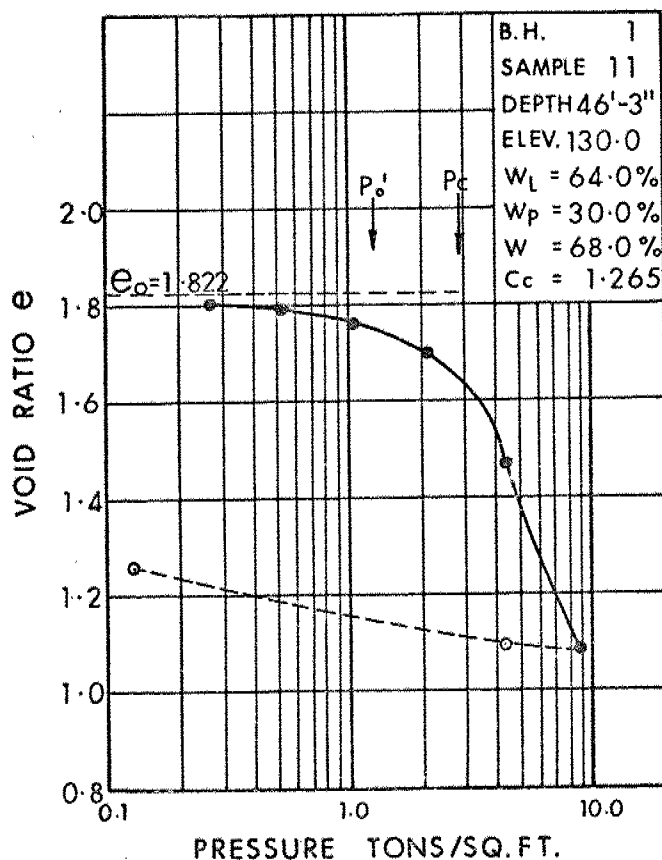
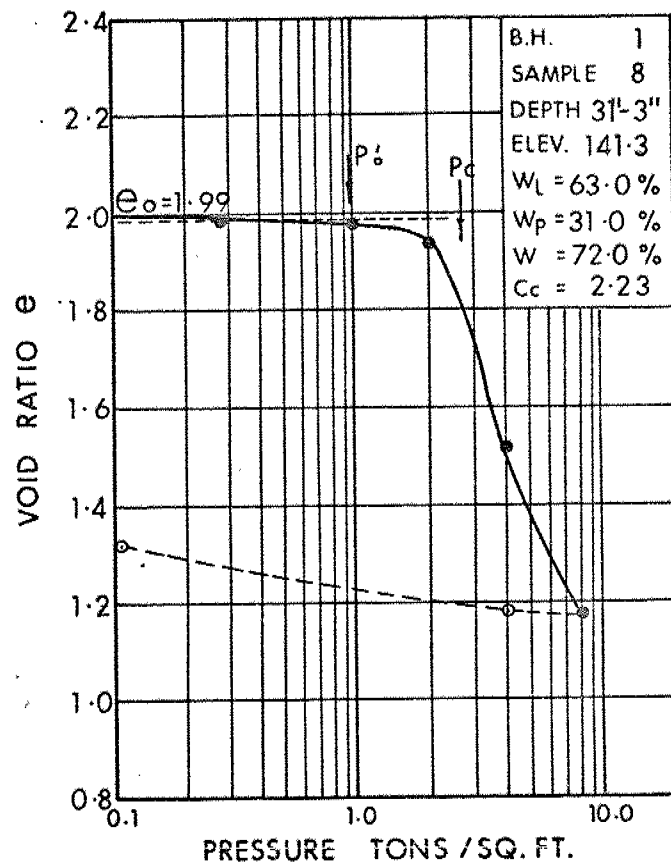
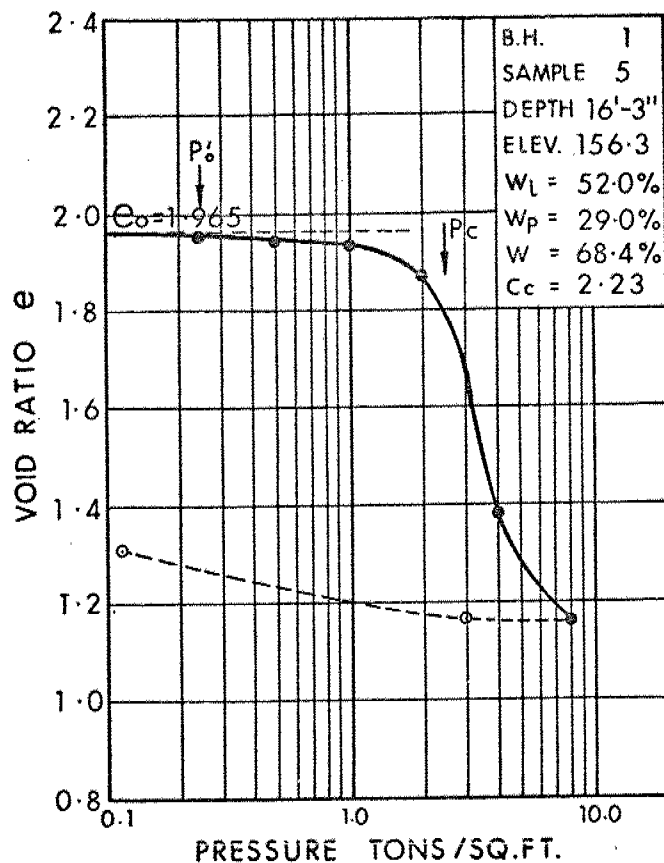
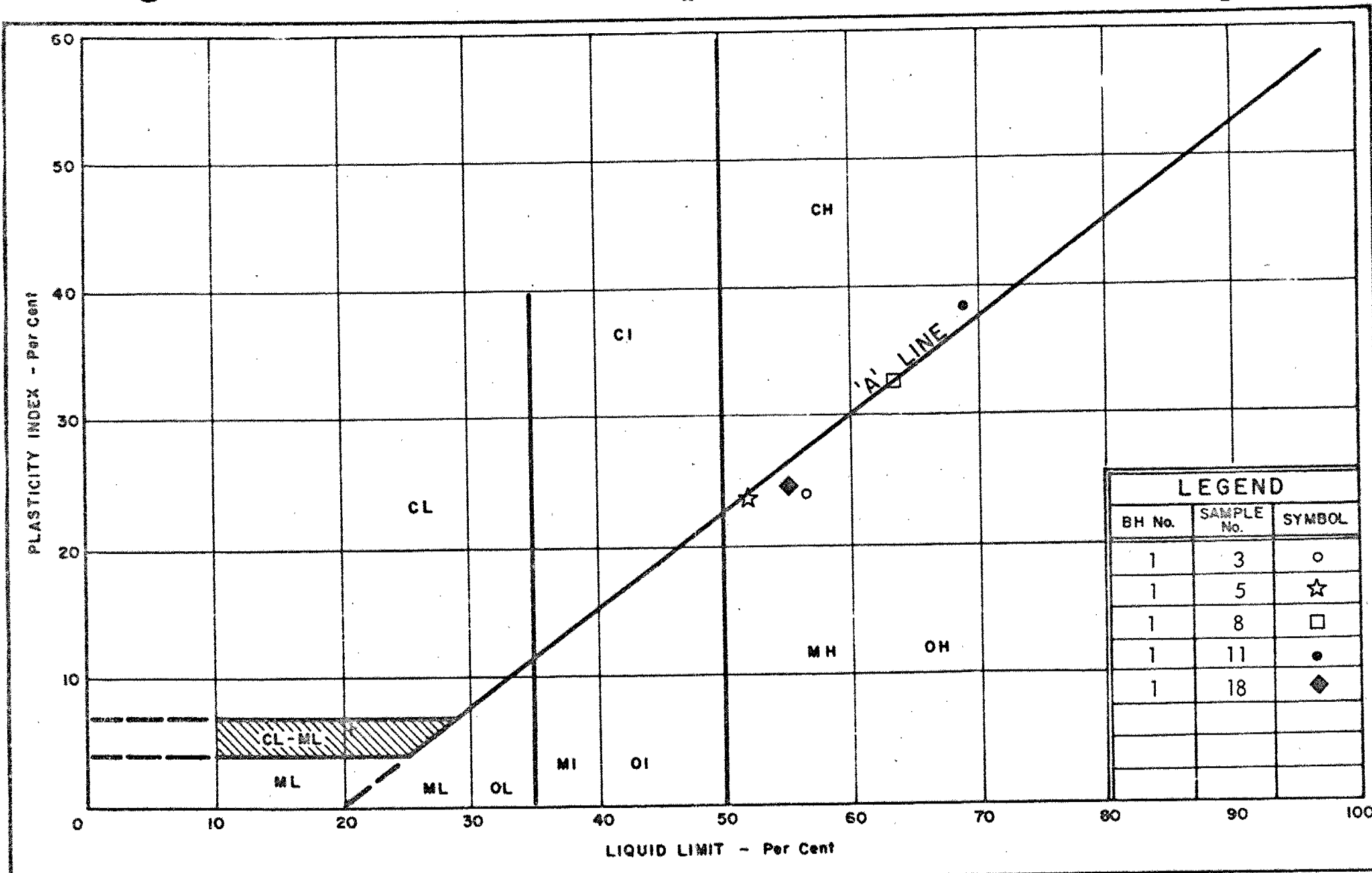


FIG. 2



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

PLASTICITY CHART

CLAY STRATUM (SENSITIVE)

W.P. No.
JOB No. 72 - 11063
FIG. 1

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS DESIGN SERVICES BRANCH				RECORD OF BOREHOLE No. 1				FOUNDATION SECTION			
JOB 72-11063		LOCATION Hwy. 17-Nevan Rd. Patrol Yard		ORIGINATED BY A.T.		COMPILED BY A.T.		CHECKED BY			
W.P.		BORING DATE June 6, 7, 8, 9, 1972									
DATUM		BOREHOLE TYPE BX-NX Coaling - Washboro									
SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE				LIQUID LIMIT		REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	SCALE	BLANKS / FOOT	PLASTIC LIMIT	WATER CONTENT	BULK DENSITY	
172.6	Asphalt.		1	CS							
169.0	Granular fill.		2	SS							
-3.6	Silty clay (Desiccated zone) Brown. Stiff.		3	2" TW 10' layer							
			4	2" TW 10' layer							
			5	2" TW PM							
	Silty clay.		6	2" TW PM							
	Grey.		7	2" TW 5' layer							
			8	2" TW PM							
	Stiff to hard.		9	2" TW PM							
			10	2" TW PM							
			11	2" TW PM							
			12	2" TW PM							
			13	2" TW PM							
			14	2" TW PM							
			15	SS 4							
			16	SS 5							
			17	SS 4							
	Organic inclusions.		18	2" TW PM							
			19	SS 5							
62.6			20	SS 87							
110.6	Clayey silt with ss. & grn. (Glacial Till) Hard.		21	SS							
59.7											
112.9	End of borehole.										