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GEOCRES No. 31G-105

DIST. 8 REGION

W.P. No. 6-66

CONT. No.

W. O. No. 70-11078

STR. SITE No.

HWY. No. 416

LOCATION RELOCATED County Rd 19

No. of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

(RM. 110 LAB. 3406.)

DEPARTMENT OF HIGHWAYS ONTARIO

MEMORANDUM

316-105

To: Mr. B. R. Davis,
Bridge Engineer,
Bridge Office,
Admin. Bldg.

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

ATTENTION: Mr. S. McCombie

DATE: September 28, 1970

OUR FILE REF.

IN REPLY TO OCT 1 1970

SUBJECT:

PRELIMINARY
FOUNDATION INVESTIGATION REPORT
For

Proposed Underpass at the Crossing of
Hwy. #416 and Relocated County Rd. #19
Co. of Grenville - Twp. of South Gower
District No. 8 (Kingston)
W.O. 70-11078 -- W.P. 6-66

1. INTRODUCTION:

A request to carry out a preliminary foundation investigation at the above mentioned site, was contained in a memo dated August 7, 1970, from the Kingston Bridge Section (Mr. T. C. Kingsland, Regional Bridge Planning Engineer).

An investigation consisting of two sampled boreholes each accompanied by a dynamic cone penetration test, was subsequently carried out by this Section to determine the subsoil conditions at the proposed site.

This memo contains the results of the preliminary investigation with recommendations pertaining to the foundations of the structure and the stability of the approach embankments.

2. DESCRIPTION OF SITE:

The site is located about 6 miles north of Kemptville and some 400 ft. east of the existing County Road #19. At this location the Rideau River is located about 1,000 ft. west of the site. The area surrounding the site is generally flat and used mainly for agricultural purposes.

3. SUBSOIL:

The subsoil over the site consists of a surficial layer of loose to compact ('N' values - 6 - 14 blows/ft.), brown sand from 3 to 3.5 ft. thick, followed by a deposit of sensitive marine silty clay from 27 to 29 ft. thick. The undrained shear strength of this deposit ranges from 540 p.s.f. in the upper portion, generally increasing to 1,640 p.s.f. in the lower portion, indicating a firm to stiff consistency. The upper 3 ft. of the cohesive deposit is less plastic and somewhat desiccated and contains layers up to 1 inch thick of silty sand.

Underlying the silty clay stratum is a glacial till deposit consisting of a heterogeneous mixture of clayey silt, sand and gravel some 42 to 43 ft. thick. 'N' values within this deposit range from 11 to in excess of 100 blows per foot, indicating a consistency ranging from stiff, increasing to hard with depth. In B.H. #1 boulders up to 6 inches in size were encountered between elevations 213 and 219.

The glacial till deposit is followed by a very dense stratum of silt approximately 7 ft. thick, which contains seams of clay up to 1/4" thick. The silt deposit overlies sound dolomite bedrock at elevation 202, or some 83 ft. below ground level.

The groundwater level was observed in the open boreholes to be approximately at elev. 279.6, or some 6 ft. below ground level. This agrees closely with the Rideau River water level at the time of the field investigation.

A stratigraphical profile across the site is shown on Drawing 70-11078A, which is included in this memo along with the Record of Borehole sheets.

4. RECOMMENDATIONS:

It is proposed to construct an underpass structure to carry relocated County Rd. #19 over proposed Hwy. #416. The investigation revealed that the subsoil consists mainly of a 3-ft. surficial layer of sand followed by 27 to 29 ft. of firm to stiff silty clay underlain by an extensive glacial till deposit having a maximum thickness of 43 ft. The glacial till deposit is underlain by a 7-ft. thick stratum of very dense silt which, in turn, is followed by dolomite bedrock about 83 ft. below ground surface.

At the present time the geometrics of the new structure is not available; however, it is assumed that a three-span structure having a maximum height of 25 ft. for the approach fills, may be adopted at this location. Our recommendations pertaining to the proposed underpass, are as follows:

The presence of a firm sensitive clay at a shallow depth precludes the possibility of a conventional spread footing type foundation. Therefore, the new structure piers and abutments perched within the approach fills, should be supported on end-bearing piles driven to practical refusal within the glacial till stratum to approximate elevation 215 - 210.

Stability analyses, in terms of total stress ($\phi = 0$) have been carried out for various fill heights by the use of the electronic computer. The various properties of the subsoil and the fill material used in the stability analyses are shown on Fig. 1. As a result of these analyses, our conclusions are as follows:

1) Fills up to 17 ft. in height will be stable with standard 2:1 slopes.

2) Fills in excess of 17 ft. in height will require counterbalancing berms in all directions. The required length of berms for various fill heights is shown on Fig. 1.

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

The underlying firm to stiff silty clay layer will undergo settlement due to consolidation over a long-term period due to the weight of the approach embankments. A graph showing the estimated time-rate of settlement and total settlement anticipated is shown on Figure #1. In order to minimize future pavement maintenance on County Rd. #19, it is recommended that the embankments within at least 100 ft. of the bridge be completed for as long a period as possible in advance of the structure construction.

The various recommendations outlined in this memo are for preliminary design purposes, based on limited number of boreholes. It will be necessary to carry out additional boreholes in the field when the final design details are available. Recommendations given in this memo are, therefore, to be regarded as conditional only, and as such, are subject to revision at a later date when and if new information becomes available.

If you have any further queries, or if any of the foregoing requires clarification, please do not hesitate to call us.

MD/MdeF
Attach.

cc: Messrs. B. R. Davis
H. A. Tregaskes
D. W. Farren
S. J. Markiewicz
V. A. Snell
T. C. Kingsland (2)
M. R. Ernesaks (2)
J. E. Gruspier
B. A. Singh

M. Devata

M. Devata
SUPERVISING FOUNDATION ENGR.
For:
A. G. Stermac
PRINCIPAL FOUNDATION ENGR.

Foundations Files ✓
Gen. Files

APPENDIX I

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 1

FOUNDATION SECTION

JOB 70-11078

LOCATION Hwy. 416-Co. Rd. #19 Sta. 49+65 20' Rt.

ORIGINATED BY WH

W.P. 6-66

BORING DATE Sept. 8-10, 1970

COMPILED BY WH

DATUM Geodetic

BOREHOLE TYPE Diamond Drill-Washboring

CHECKED BY

| SOIL PROFILE | | | SAMPLES | | | ELEV. SCALE | DYNAMIC PENETRATION RESISTANCE | | | | | 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 | | BLOWS / FOOT | | | | | SHEAR STRENGTH P.S.F. | | | | | WATER CONTENT % | | | | | |
| | | | | | | | 20 | 40 | 60 | 80 | 100 | UNCONFINED | | | | | FIELD VANE | | | LAB. VANE | | |
| | | | | | | | 400 | 800 | 1200 | 1600 | 2000 | ○ | ● | × | | | + | × | + | × | + | |
| 285.6 | Ground Level | | | | | | | | | | | | | | | | | | | | | |
| 0.0 | Sand | | 1 | SS | 10 | | | | | | | | | | | | | | | | | |
| 282.6 | Compact Brown | | | | | | | | | | | | | | | | | | | | | |
| 3.0 | Clayey silt with layers of silty sand. (Desiccated) | | 2 | SS | 16 | | | | | | | | | | | | | | | | | |
| 279.6 | | | 3 | TW | PM | | | | | | | | | | | | | | | | | |
| 6.0 | Silty Clay (Marine Clay) | | 4A | SS | PM | | | | | | | | | | | | | | | | | |
| | Firm to Stiff | | 5 | TW | PM | | | | | | | | | | | | | | | | | |
| | | | 6 | TW | PM | | | | | | | | | | | | | | | | | |
| | | | 7 | TW | PM | | | | | | | | | | | | | | | | | |
| | | | 8 | TW | PM | | | | | | | | | | | | | | | | | |
| | Dark Grey | | 9 | TW | PM | | | | | | | | | | | | | | | | | |
| 252.6 | | | 10 | TW | PM | | | | | | | | | | | | | | | | | |
| 33.0 | Het. mix. of clayey silt, sand & gravel (Glacial Till) | | 11 | SS | 17 | | | | | | | | | | | | | | | | | |
| | | | 12 | SS | 29 | | | | | | | | | | | | | | | | | |
| | | | 13 | SS | 41 | | | | | | | | | | | | | | | | | |
| | | | 14 | SS | 55 | | | | | | | | | | | | | | | | | |
| | | | 15 | SS | 27 | | | | | | | | | | | | | | | | | |
| | | | 16 | SS | 23 | | | | | | | | | | | | | | | | | |
| | Very Stiff to Hard | | 17 | SS | 68 | | | | | | | | | | | | | | | | | |
| | | | 18 | SS | 100/8" | | | | | | | | | | | | | | | | | |
| | | | 19 | SS | 87 | | | | | | | | | | | | | | | | | |
| | Grey | | 20 | SS | 130 | | | | | | | | | | | | | | | | | |
| 209.6 | | | 21 | SS | 155 | | | | | | | | | | | | | | | | | |
| 76.0 | Silt with occ. clay seams up to 1/4" thick | | 22 | SS | 67 | | | | | | | | | | | | | | | | | |
| 202.6 | Very Dense Grey | | | | | | | | | | | | | | | | | | | | | |
| 83.0 | Bedrock - Dolomite | | 23 | AXT | 78% | | | | | | | | | | | | | | | | | |
| 197.9 | Sound | | | | | | | | | | | | | | | | | | | | | |
| 87.7 | End of Borehole | | | | | | | | | | | | | | | | | | | | | |

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 2

FOUNDATION SECTION

JOB 70-11078

LOCATION Hwy. 416-Co.Rd.#19 Sta. 51+65 20' Lt.

ORIGINATED BY WH

W.P. 6-66

BORING DATE Sept. 8 - 11, 1970

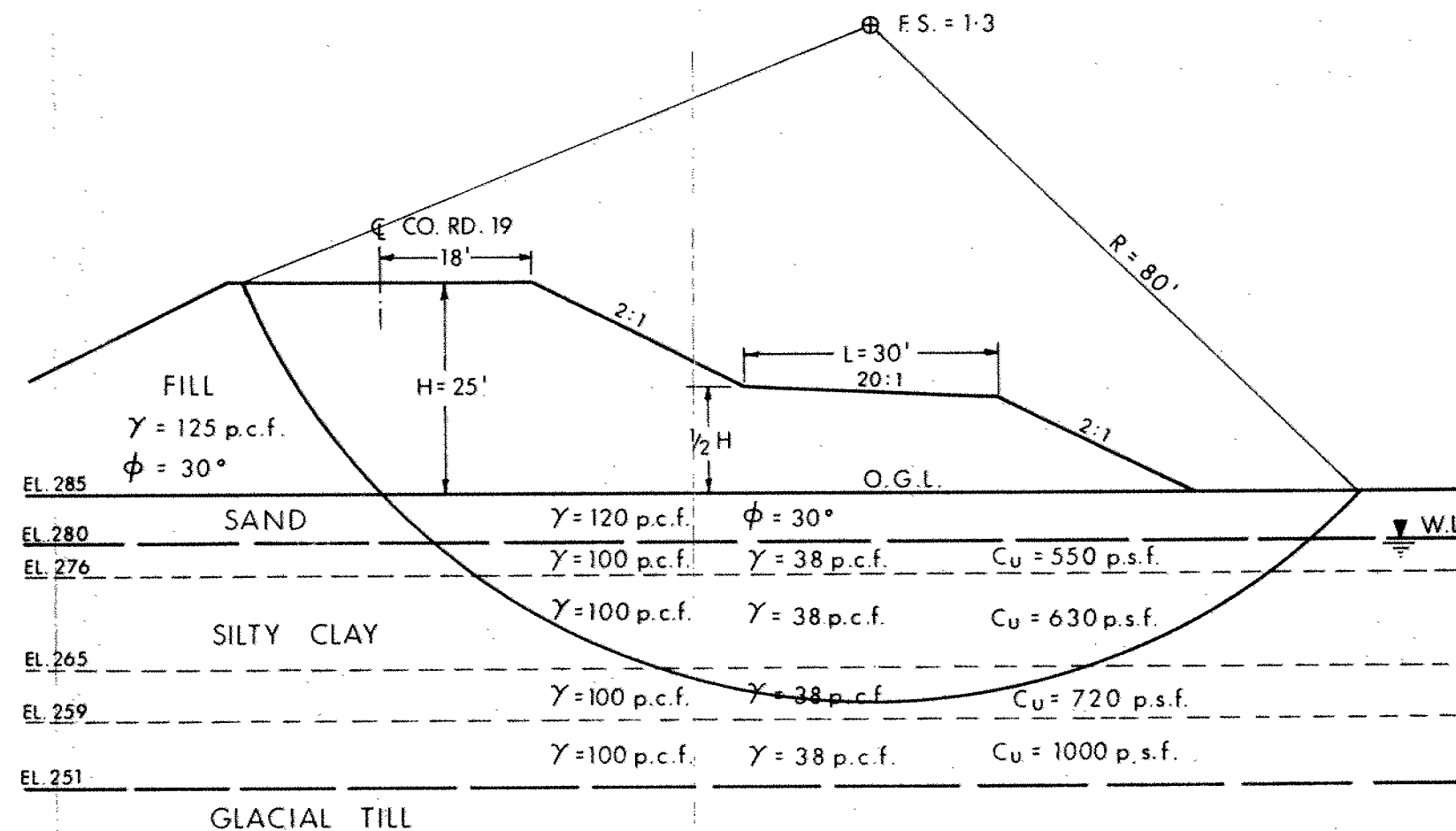
COMPILED BY WH

DATUM Geodetic

BOREHOLE TYPE Diamond Drill - Washboring

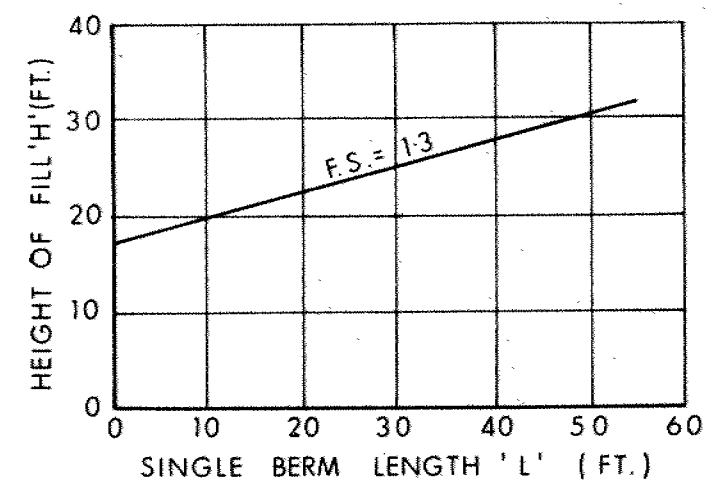
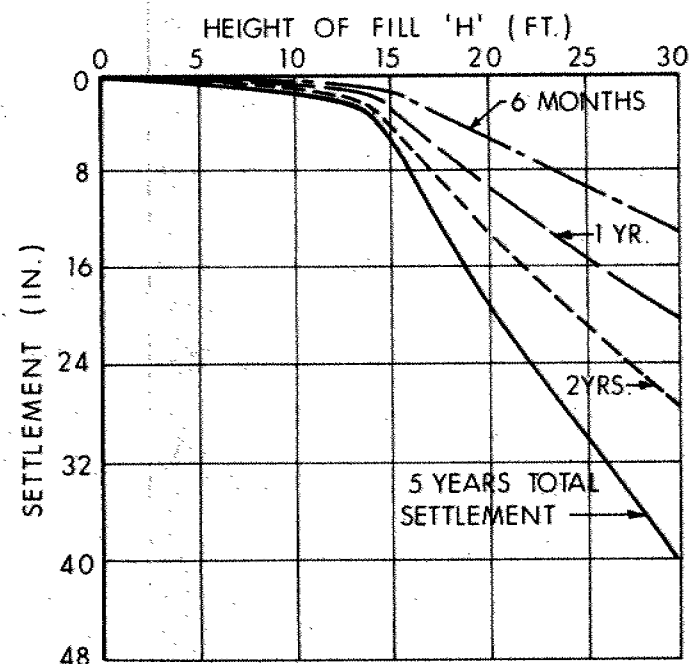
CHECKED BY

| 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 | | 20 | 40 | 60 | 80 | 100 | w_p | w | w_L | | |
| 285.6 | Ground Level | | | | | | | | | | | | | | | |
| 0.0 | Sand | | 1 | SS | 6 | | | | | | | | | | | |
| 282.1 | Loose Brown | | | | | | | | | | | | | | | |
| 3.5 | Clayey silt with layers of silty sand (Desiccated) | | 2 | SS | 14 | | | | | | | | | | | |
| 6.0 | Silty Clay (Marine Clay) | | 3 | TW | FM | | | | | | | | | | | |
| | | | 4 | TW | FM | | | | | | | | | | | |
| | | | 5 | TW | FM | | | | | | | | | | | |
| | Firm to Stiff | | 6 | TW | FM | | | | | | | | | | | |
| | | | 7 | TW | FM | | | | | | | | | | | |
| | | | 8 | TW | FM | | | | | | | | | | | |
| | Dark Grey | | 9 | TW | FM | | | | | | | | | | | |
| | | | 10 | TW | FM | | | | | | | | | | | |
| 150.6 | | | | | | | | | | | | | | | | |
| 35.0 | Het. mix. of clayey silt, sand & gravel | | 11 | SS | 13 | | | | | | | | | | | |
| | (Glacial Till) | | 12 | SS | 28 | | | | | | | | | | | |
| | | | 13 | SS | 11 | | | | | | | | | | | |
| | Occ. boulders up to 6" in size | | 14 | SS | 11 | | | | | | | | | | | |
| | | | 15 | SS | 17 | | | | | | | | | | | |
| | | | 16 | SS | 49 | | | | | | | | | | | |
| | | | 17 | SS | 68 | | | | | | | | | | | |
| | Stiff to Hard | | 18 | SS | 144 | | | | | | | | | | | |
| | Grey | | 19 | AXT | 13% | | | | | | | | | | | |
| 208.6 | | | | | | | | | | | | | | | | |
| 77.0 | Silt with occ. clay seams up to 1/4" thick. | | 20 | SS | 113/8" | | | | | | | | | | | |
| 202.1 | Very Dense Grey | | 21 | SS | 150 | | | | | | | | | | | |
| 83.5 | Bedrock - Dolomite | | | | | | | | | | | | | | | |
| 196.8 | Sound | | 22 | AXT | 100% | | | | | | | | | | | |
| 88.8 | End of Borehole | | | | | | | | | | | | | | | |



LEGEND

H - HEIGHT OF FILL (FT.)
 L - LENGTH OF BERM (FT.)
 F.S. - FACTOR OF SAFETY
 ⊕ - CENTRE OF CRITICAL CIRCLE
 R - RADIUS OF CIRCLE



DEPARTMENT OF HIGHWAYS
**MATERIALS and
 TESTING
 DIVISION**

ONTARIO

**SUMMARIZED RESULTS OF
 STABILITY & SETTLEMENT ANALYSES**
 (APPROACH EMBANKMENTS)

W.P. 6-66

DIST. 8

JOB 70-11078

DATE 24 SEPT. 1970

APPROVED

FIGURE NO. 1

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_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

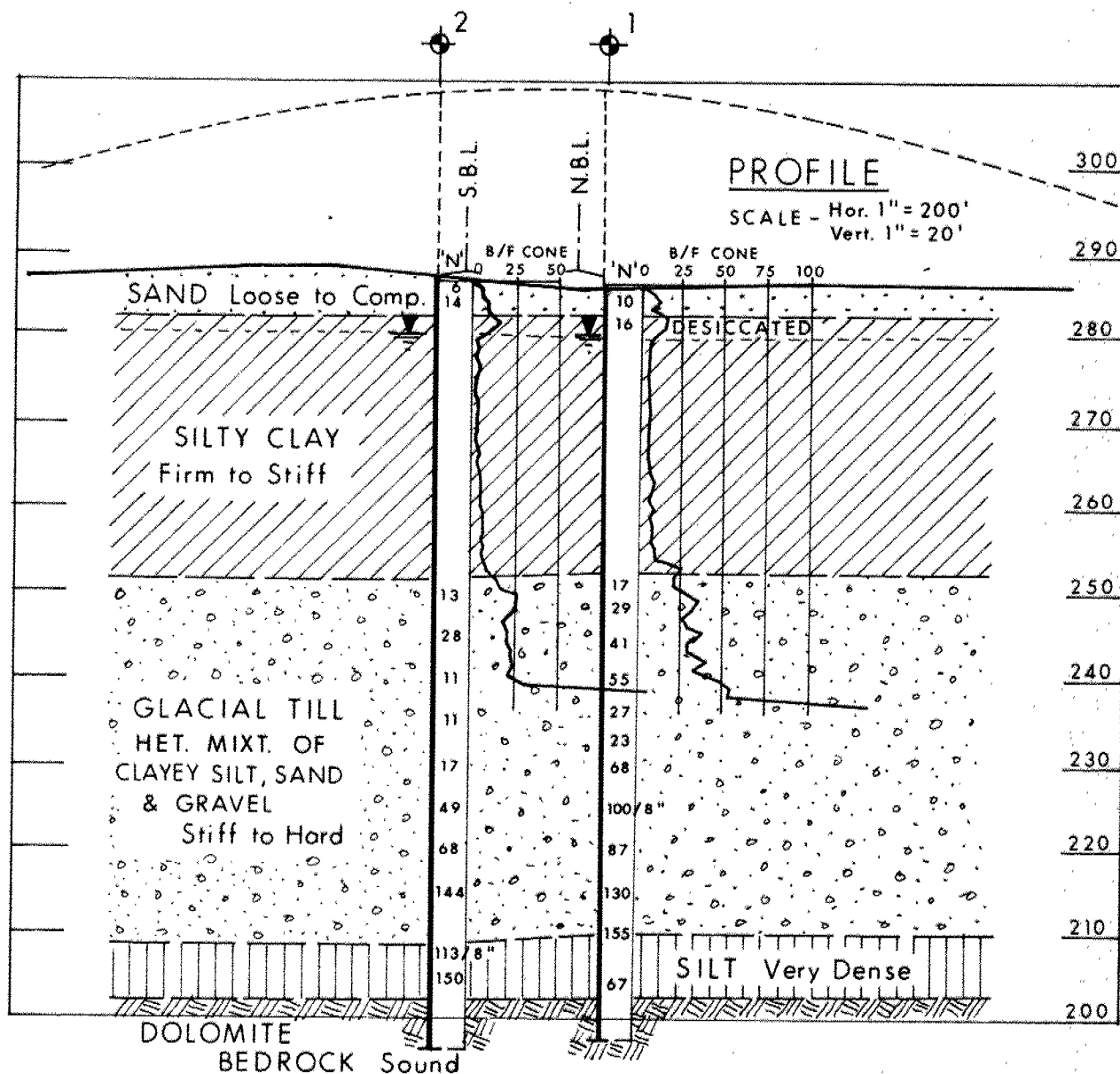
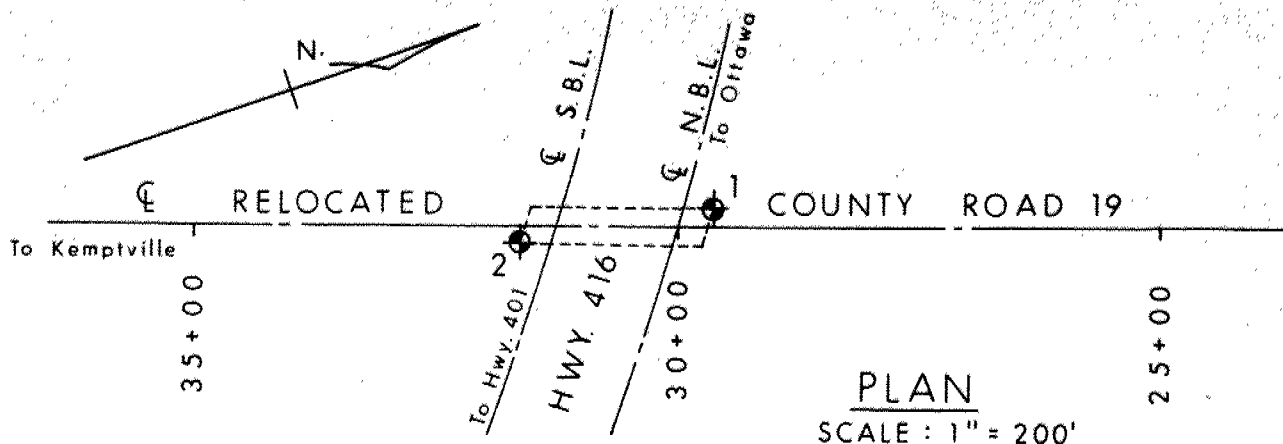
| | |
|----------|---|
| d | DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE |
| δ | ANGLE OF WALL FRICTION |
| K | DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS |
| K_0 | COEFFICIENT OF EARTH PRESSURE AT REST |

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 |



ONTARIO

DEPARTMENT OF HIGHWAYS
**MATERIALS and
TESTING
DIVISION**

WP 6-66

HIGHWAY No. 416

RELOCATED COUNTY ROAD 19

DIST. 8

JOB 70-11078

DATE 24 SEPT. 1970

APPROVED

DRAWING NO. 70-11078 A