

ONTARIO DEPARTMENT OF HIGHWAYS  
Toronto, Ontario

REPORT

on

FOUNDATION INVESTIGATION

PROPOSED REVISIONS TO CROSSING OF  
NIAGARA - ST. CATHARINES - TORONTO  
ELECTRIC RAILWAY OVER  
THE QUEEN ELIZABETH WAY  
CITY OF ST. CATHARINES, DISTRICT NO. 4  
W.P. 224-61

---

H.G. ACRES & COMPANY LIMITED  
Consulting Engineers  
Niagara Falls, Canada

November 1961

ONTARIO DEPARTMENT OF HIGHWAYS  
Toronto, Ontario

REPORT

on

FOUNDATION INVESTIGATION

PROPOSED REVISIONS TO CROSSING OF  
NIAGARA - ST. CATHARINES - TORONTO  
ELECTRIC RAILWAY OVER  
THE QUEEN ELIZABETH WAY  
CITY OF ST. CATHARINES, DISTRICT NO. 4  
W.P. 224-61

Table of Contents

Introduction

Geology of the Site

Exploratory Work

Site Conditions and Soil Properties

- (a) - Embankment Fill
- (b) - Silty Clay Crust
- (c) - Silty Clay

Performance of Existing Structures

Design Considerations

- (a) - Bearing Capacity
- (b) - Settlement

Conclusions and Recommendations

Appendix A - Program of Work

- B - Summary of Laboratory Test Results
- C - Results of In-Situ Vane Tests
- D - List of Plates

ONTARIO DEPARTMENT OF HIGHWAYS  
Toronto, Ontario

REPORT

on

FOUNDATION INVESTIGATION

PROPOSED REVISIONS TO CROSSING OF  
NIAGARA - ST. CATHARINES - TORONTO  
ELECTRIC RAILWAY OVER  
THE QUEEN ELIZABETH WAY  
CITY OF ST. CATHARINES, DISTRICT NO. 4  
W.P. 224-61

---

Introduction

At the request of the Ontario Department of Highways, soil explorations were carried out by H.G. Acres & Company Limited at the above-mentioned site to determine the foundation conditions for the two new bridges required by the construction of service roads parallel to the Queen Elizabeth Way and beneath the Niagara - St. Catharines - Toronto Railway. The centrelines of the proposed service roads are at approximately 100 feet north and 90 feet south of the centreline of the Queen Elizabeth Way. A plan of the site is shown on Plate 1.

The F.E. Johnston Drilling Company Limited performed the drilling and soil sampling operations under the supervision of Mr. H.W. Ryder of H.G. Acres & Company Limited. The field work started on October 19, 1961 and

- 2 -

was completed on November 8, 1961. Soil testing in the laboratory of H.G. Acres & Company Limited was completed in November 1961.

The results of the field and laboratory work are presented in this report, together with our interpretation of the data obtained, and our recommendations concerning foundation conditions and designs.

#### Geology of the Site

The site of the proposed structures is located in the narrow strip of low land extending from Hamilton to the Niagara River and lying between the Niagara Escarpment and Lake Ontario. The area is characterized by a broad flat till plain covered in places by sand and gravel beach deposits and overlying red Queenston shales of Upper Ordovician age.

During the Pleistocene epoch this area was covered by glaciers several times, resulting in the deposition of a compact till complex composed primarily of clay and silt with some sand and gravel. Lenses and beds of stratified waterlain clay, silt, sand, and gravel are commonly encountered. In addition, the stiffness of the present surface zones of the till complex has generally been increased by weathering and desiccation.

### Exploratory Work

The modified wash boring method of drilling was employed and NX or BX casing was used to advance the holes. Two-inch diameter thin-walled Shelby tube samples were taken at five-foot intervals in holes 954-1 and 954-2. Vane tests were performed 18 inches below the lower elevations of tube samples to determine both the natural and remoulded undrained shear strength of the soil at five-foot intervals wherever possible in all four holes. In holes 954-3 and 954-4, piston samples were also taken. Where the stratum was too stiff for vane tests, standard penetration tests were carried out and the split-spoon samples were retained for inspection and identification.

The locations of the four holes are shown on Plate 1, and the program of work is outlined in Appendix A.

### Site Conditions and Soil Properties

The original ground elevation at the site is approximately 318 feet. The existing embankment is about 20 feet wide at the crest and stands about 16 feet above the original ground elevation. Its side slopes are 2 to 1.

The proposed alterations in the highway facilities involve the construction of two service roads approximately 100 feet north and 90 feet south of the centreline of the Queen Elizabeth Way. These would have to be excavated

- 4 -

through the existing embankment, and new supports for the Niagara - St. Catharines - Toronto Railway would have to be provided.

The soils which were encountered in the exploratory holes are described in the attached drilling reports, Plates 2 to 5 inclusive. Simplified sections of the bore holes are shown on Plate 1.

(a) - Embankment Fill - The embankment fill consists of loosely compacted silt, sand, and some gravel. The borings indicate that the fill material extends to approximately elevation 313 feet, that is, to a depth of about five feet below the existing ground level adjacent to the embankment.

(b) - Silty Clay Crust - Directly below the embankment fill lies a stiff brown silty clay containing varying proportions of gravel and sand. The natural undrained shear strength of this layer, from the field vane tests shown on Plates 5 to 9, generally exceeds 2 ksf and can be as high as 4 ksf. In hole 954-3, however, the material is slightly softer, with shear strengths as low as 1.5 ksf.

Three Atterberg limit tests carried out on samples of the layer showed the following average properties:

|                  |                 |
|------------------|-----------------|
| Liquid limit     | = 27.8 per cent |
| Plastic limit    | = 15.4 per cent |
| Plasticity index | = 12.4 per cent |

- 5 -

The soil is therefore an inorganic clay of medium plasticity and the position on Casagrande's plasticity chart is given on Plate 10. The liquidity index of the material ranges from 0.18 to 0.33 and the sensitivity is of the order of 2.

(c) - Silty Clay - Below approximately elevation 290 feet, the silty clay becomes softer, the undrained shear strength of this layer ranging from 1 to 2 ksf. The silty clay is brown in colour and fairly homogeneous with occasional laminations. The results of three Atterberg limit tests show that the liquid limit ranges from 37 per cent to 46 per cent and the plastic limit varies from 19 per cent to 24 per cent. These results are given in Appendix B and plotted on the plasticity chart on Plate 10. The liquidity index of the material averages 0.6 and the sensitivity determined by the in-situ vane tests varies from 2 to 4. In hole 954-3, the softest silty clay is encountered, and the laboratory unconfined compression tests showed a sensitivity of this soil as high as 8. The silty clay again becomes stiffer below elevation 265 feet approximately, and contains some gravel.

It should be noted that in hole 954-3 the results of the laboratory unconfined compression tests give a higher value for the natural undrained shear strength than the

field vane tests. Experience indicates that this would not normally be expected and in view of this apparent anomaly, the analysis of safe foundation bearing pressures should be based on the lower values of shear strength derived from the field vane tests.

All the laboratory test results are summarized in Appendix B and the field vane tests are tabulated in Appendix C.

#### Performance of Existing Structures

The existing reinforced concrete bridge at this site was built in 1939, with an overall span of 100 feet resting on two abutments and a central pier to provide a single track for the Niagara - St. Catharines - Toronto Railway. At both of the abutment wing walls, cracks, oriented at approximately right angles to the sloping top of the wing wall, are evident. These wing walls were constructed as a single unit with the abutment wall.

#### Design Considerations

The construction of the two proposed service roads parallel to the Queen Elizabeth Way will necessitate the provision of permanent overhead support for the Niagara - St. Catharines - Toronto Railway. The soil problems involved will therefore be the bearing capacity and the settlements of the bridge abutments.



- 7 -

(a) - Bearing Capacity - A method of supporting the new bridges would be with spread footings. The ultimate bearing capacity of a shallow spread footing is given by the formula:

$$q_{ult} = 5 \left(1 + 0.2 \frac{D}{B}\right) \left(1 + 0.2 \frac{B}{L}\right) S_u \dots (1)$$

Where:  $q_{ult}$  denotes the ultimate bearing capacity of the foundation soil.

D denotes the depth of the base of the footing below the surface of the overburden.

B denotes the width of the footing.

L denotes the length of the footing.

$S_u$  denotes the natural undrained shear strength of the soil beneath the foundation.

In view of some horizontal variation in shear strength, the minimum undrained shear strengths as indicated in hole 954-3 should be used. On the basis of these results, the average shear strength within the first 15 feet of the stratum is in the order of 2,000 psf. Assuming a four-foot wide footing and using a factor of safety of 3, the allowable bearing pressure would be approximately 4,000 psf. A footing of this width may be located at any convenient depth between four feet and ten feet below the ground surface. In the case of eccentric loading, the

- 8 -

width of the footing should be increased to limit the maximum contact stress at the base of the footing to the allowable bearing pressure as given above.

(b) - Settlement - No consolidation tests were carried out on the soil samples obtained. However, a comparison of properties between soil samples recovered at this site and those from another site nearby (see Report by H.G. Acres & Company Limited on Foundation Investigation at Crossing of Niagara Street over the Queen Elizabeth Way, City of St. Catharines, District No. 4, W.P. 41-61, November 1961) has shown that the overburden at both sites is essentially composed of the same materials. The difference is found in the shear strength of the upper crust which exhibits higher natural undrained shear strength at this site than at the nearby Niagara Street site. This would suggest that the compressibility of the clay crust would probably be considerably lower at this site. It was found that the compressibility ( $M_v$ ) of the soil at a depth of 15 feet at the Niagara Street site was  $6.7 \times 10^{-3} \text{ ft}^2/\text{kip}$ .

The computed settlement of a footing about four feet wide, using the above value of compressibility, is approximately 1.5 inches. In view of the lower compressibility at this site, it is considered unlikely that the actual total and differential settlements will exceed one inch and three-quarters of an inch, respectively. While these values are

- 9 -

normally considered to be within permissible limits, it should be recognized that the tolerable values of differential settlement depend almost entirely on the nature of the structure. With the exception of minor cracking in the wing walls, the existing structure is free from damage due to differential settlement.

#### Conclusions and Recommendations

(a) - The borings show that the depth of overburden at the site extends to at least 60 feet below the ground surface. The overburden is composed predominantly of a silty clay with varying contents of sands and gravels. The thickness of the stiff weathered crust of the silty clay layer varies from 15 to 25 feet. Below this crust the silty clay is fairly homogeneous with little sand and gravel but with occasional laminations. The gravel content of the soil increases below a depth of 55 feet and the soil becomes very compact and stiff.

(b) - The properties of the foundation soil are summarized on Plates 5 to 9.

(c) - The new bridges may be supported on spread footings founded at least four feet below the ground surface.

(d) - An allowable bearing pressure of 4,000 psf may be used for footings with a width of four feet between elevations 312 and 306 feet. For other footing dimensions

- 10 -

the allowable bearing pressure may be computed from the equation on page 7 of this report, using a value for the natural undrained shear strength,  $S_u$ , of 2,000 psf, and a factor of safety of 3.

APPENDIX AProgram of Work

October 19, 1961 Diamond drill arrived at the site.  
Hole No. 954-1 was commenced.

October 21, 1961 Hole 954-1 was completed.

October 23, 1961 Hole 954-2 was commenced.

October 25, 1961 Hole 954-2 was completed.

November 3, 1961 Hole 954-3 was commenced.

November 6, 1961 Hole 954-3 was completed.

November 7, 1961 Hole 954-4 was commenced.

November 8, 1961 Hole 954-4 was completed.

Summary of Time

| <u>Work Type</u>        | <u>Number<br/>of Holes</u> | <u>Total Length<br/>(Feet)</u> | <u>Total Time<br/>(Hours)</u> |
|-------------------------|----------------------------|--------------------------------|-------------------------------|
| Modified<br>wash boring | 4                          | 206.5                          | 77                            |

## APPENDIX B

### Summary of Laboratory Test Results

| Hole No. | Sample No. | Elevation (Feet) | Water Content (%) | Liquid Limit (%) | Plastic Limit (%) | Liquidity Index | Sun (Psf) | ef (%) | Sur (Psf) | Sensitivity |
|----------|------------|------------------|-------------------|------------------|-------------------|-----------------|-----------|--------|-----------|-------------|
| 954-1    | 3          | 305.2            | 17.1              | 27.3             | 14.9              | 0.18            | 3270      | 9      | -         | -           |
|          | 6          | 290.2            | 27.7              | 36.8             | 18.6              | 0.50            | 2200      | 3      | -         | -           |
| 954-3    | 21         | 304.0            | 18.6              | 27.8             | 16.3              | 0.20            | 2260      | 12     | 870       | 2.6         |
|          | 23         | 294.5            | 19.4              | 28.2             | 15.0              | 0.33            | 1960      | 8      | 680       | 2.9         |
|          | 25         | 284.5            | 37.3              | 45.5             | 23.6              | 0.63            | 1340      | 5      | 190       | 7.0         |
|          | 27         | 274.5            | 37.0              | 43.0             | 22.4              | 0.71            | 1150      | 7      | 140       | 8.1         |

Note: ef - Failure strain

Sun - Undrained shear strength from unconfined compression tests on undisturbed samples.

Sur - Undrained shear strength from unconfined compression tests on remoulded samples.

APPENDIX CResults of In-Situ Vane Tests

| Hole No. | Elevation<br>(Feet) | Undrained Shear Strength<br>(Psf) |           | Sensitivity |
|----------|---------------------|-----------------------------------|-----------|-------------|
|          |                     | Undisturbed                       | Remoulded |             |
| 954-1    | 307.7               | 3100                              | 1930      | 1.6         |
|          | 301.7               | 4240                              | 2900      | 1.5         |
|          | 296.7               | 3100                              | 1930      | 1.6         |
|          | 292.2               | 4260                              | 1930      | 2.2         |
|          | 287.2               | 1730                              | 480       | 3.6         |
|          | 282.2               | 1370                              | 400       | 3.4         |
|          | 277.2               | 1480                              | 400       | 3.6         |
|          | 272.2               | 1200                              | 320       | 3.8         |
|          | 267.2               | 2920                              | 2300      | 1.3         |
| 954-2    | 305.8               | 3780                              | 1730      | 2.2         |
|          | 290.8               | 3460                              | 1880      | 1.8         |
|          | 285.8               | 1880                              | 690       | 2.7         |
|          | 280.8               | 1580                              | 440       | 3.6         |
|          | 275.8               | 1130                              | 440       | 2.6         |
|          | 269.8               | 2040                              | 1570      | 1.3         |
|          | 265.8               | 2840                              | 2360      | 1.2         |
| 954-3    | 307.0               | 2200                              | 1390      | 1.6         |
|          | 301.5               | 1640                              | 950       | 1.7         |
|          | 296.5               | 1640                              | 950       | 1.7         |
|          | 291.5               | 1010                              | 320       | 3.1         |
|          | 286.5               | 1010                              | 250       | 4.0         |
|          | 281.5               | 950                               | 280       | 3.4         |
|          | 276.5               | 980                               | 310       | 3.1         |
|          | 271.5               | 910                               | 310       | 3.0         |
| 954-4    | 311.1               | 3300                              | 1730      | 1.9         |
|          | 306.1               | 2520                              | 1570      | 1.6         |
|          | 302.1               | 1730                              | 1000      | 1.7         |
|          | 296.1               | 2080                              | 1100      | 1.9         |
|          | 292.1               | 3460                              | 1730      | 2.0         |
|          | 286.1               | 1570                              | 440       | 3.6         |
|          | 281.1               | 1200                              | 440       | 2.7         |

APPENDIX D

List of Plates

- 1 - Exploratory holes, plan and section
- 2 - Drilling report, Hole 954-1
- 3 - Drilling report, Hole 954-2
- 4 - Drilling report, Hole 954-3
- 5 - Drilling report, Hole 954-4
- 6 - Summary of drilling and test results, Hole 954-1
- 7 - Summary of drilling and test results, Hole 954-2
- 8 - Summary of drilling and test results, Hole 954-3
- 9 - Summary of drilling and test results, Hole 954-4
- 10 - Summary of drilling and test results, Plasticity Chart.



# DRILLING REPORT

CLIENT: ONTARIO DEPARTMENT OF HIGHWAYS JOB No. 954  
 PROJECT: W.P. 224-61 HOLE No. 954-1  
 SITE: QEW & NS&T Railway Subway SHEET No. 1 OF 2  
 CONTRACTOR: F.E. Johnston Drilling Company Limited STARTED 8:00 A.M. October 19 1961  
 FINISHED 1:00 P.M. October 21 1961  
 METHOD OF DRILLING: SOIL Modified wash boring CASING DIAM. NX  
 ROCK CORE DIAM.  
 LOCATION: LATITUDE Sta 85+89 ELEVATIONS: DATUM G.S.C.  
 DEPARTURE 121.5' Left of Centreline DRILL PLATFORM -  
 BEARING 90 degrees GROUND SURFACE 320.2  
 INITIAL DIP 90 degrees ROCK SURFACE -  
 OTHER DIPS BOTTOM OF HOLE 261.2  
 WATER TABLE -

| DEPTH<br>Feet | SOIL TYPE               | DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.                          | SAMPLE |      |           |                            |      | PENETRATION<br>TEST OR<br>Blows |
|---------------|-------------------------|--|--------|------|-----------|----------------------------|------|---------------------------------|
|               |                         |  | NO.    | TYPE | SIZE      | DEPTH                      | RETD |                                 |
|               |                         |  |        |      | In.       | Ft.                        | In.  |                                 |
| 0.0           | Silty Clay              | Railway Embankment reddish brown   |        |      |           |                            |      |                                 |
| 3.0           | Medium Sand             | Reddish brown medium dense   | 1      | BO   | 2         | 5.0<br>5.5<br>6.0<br>6.5   |      |                                 |
| 7.0           | Gravel Sand Silt & Clay | Brownish grey mottled with numerous gravel size particles throughout, homogeneous and very stiff, with stiffness decreasing with depth | 2      | BO   | 2         | 9.0<br>9.5<br>10.0<br>10.5 |      |                                 |
|               |                         |  |        |      | Vane Test | 12.5                       |      |                                 |
|               |                         |  | 3      | BO   |           | 15.0<br>16.1<br>16.5       |      | Pushed<br>1300 lb<br>6          |
|               |                         |  |        |      | Vane Test | 18.5                       |      |                                 |
|               |                         |  | 4      | AQ   |           | 17.0<br>19.0               |      |                                 |

## SAMPLING METHOD

A - SPLIT TUBE  
 B - THIN WALL TUBE  
 C - PISTON SAMPLER  
 D - CORE BARREL

E - AUGER  
 F - WASH

## SHIPPING CONTAINER

N - INSERT  
 O - TUBE  
 P - WATER CONTENT TIN  
 Q - GLASS JAR

R - CLOTH BAG  
 S - PNEUM. BAG  
 Z - DISCARDED

INSPECTOR: H.W. Ryder  
 LOGGED BY: H.W. Ryder

APPROVED

DATE

November 1961

DRILLING REPORT

CLIENT ONTARIO DEPARTMENT OF HIGHWAYS  
 PROJECT W.P. 224-61  
 SITE QEW & NS&T Railway Subway

JOB No. 954  
 HOLE No. 954-1  
 SHEET No. 2 OF 2

| DEPTH<br>feet | SOIL TYPE | DESCRIPTION COLOUR CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.  | SAMPLE    |      |             |                              |              | PENETRATION<br>TEST # |
|---------------|-----------|--|-----------|------|-------------|------------------------------|--------------|-----------------------|
|               |           |  | NO        | TYPE | SIZE<br>In. | DEPTH<br>Ft.                 | RET'D<br>In. |                       |
|               |           |  | 5         | BO   | 2           | 20.0<br>21.5                 | 18           | Pushed<br>1300 lbs    |
|               |           |  | Vane Test |      |             | 23.5                         |              |                       |
|               |           |  | 6         | AQ   |             | 23.0<br>25.0                 |              |                       |
|               |           |  | 7         | BO   | 2           | 25.0<br>26.5                 | 16           | Pushed<br>1300 lbs    |
|               |           |  | Vane Test |      |             | 28.0                         |              |                       |
|               |           | Below 30 feet Shelby<br>Tube pushed easier and<br>material is less stiff   | 8         | BO   | 2           | 30.0<br>31.5                 | 18           | Pushed<br>1300 lbs    |
|               |           |  | Vane Test |      |             | 33.0                         |              |                       |
|               |           | * Penetration Test<br>This is the number<br>of blows of a 140-pound<br>weight falling 30 inches<br>required to advance the<br>tube sampler or split-<br>spoon to depth indicated | 9         | BO   | 2           | 35.0<br>36.5                 | 18           | Pushed<br>1000 lbs    |
|               |           |  | Vane Test |      |             | 38.0                         |              |                       |
|               |           |  | 10        | BO   | 2           | 40.0<br>41.5                 | 18           | Pushed<br>900 lbs     |
|               |           |  | Vane Test |      |             | 43.0                         |              |                       |
|               |           |  | 11        | BO   | 2           | 45.0<br>46.5                 | 18           | Pushed<br>900 lbs     |
|               |           |  | Vane Test |      |             | 48.0                         |              |                       |
|               |           |  | 12        | BO   | 2           | 50.0<br>51.5                 | 18           | Pushed<br>900 lbs     |
| 2.5           |           | Felt as if there was a<br>higher percentage of<br>gravel size particles<br>for some 6 inches.<br>Could not push 2"<br>Shelby with 1300 lbs.                                      | Vane Test |      |             | 53.0                         |              |                       |
|               |           |  | 13        | BO   | 2           | 55.0<br>55.5<br>56.0<br>56.5 | 16           | 6<br>16<br>27         |
|               |           |  | Vane Test |      |             | 58.0                         |              |                       |
| 3.0           |           | Very dense & stiff with<br>large percentage of<br>gravel size particles  | 14        | AQ   | 2           | 58.0<br>58.5<br>59.0         | 12           | 14<br>22              |
| 3.0           |           | End of Hole  |           |      |             |                              |              |                       |

# DRILLING REPORT

CLIENT: ONTARIO DEPARTMENT OF HIGHWAYS  
 PROJECT: W.P. 224-61  
 SITE: QEW & NS&T Railway Subway  
 CONTRACTOR: F.E. Johnston Drilling Company Limited  
 METHOD OF DRILLING: SOIL Modified wash boring  
 LOCATION: LATITUDE Sta 87+30  
 DEPARTURE 110 ft Right Centreline  
 BEARING QEW  
 INITIAL DIP 90 degrees  
 OTHER DIPS  
 STARTED 8:00 A.M. October 23 1961  
 FINISHED 11:00 A.M. October 25 1961  
 CASING DIAM. NX  
 CORE DIAM.  
 DATUM G.S.C.  
 DRILL PLATFORM -  
 GROUND SURFACE 315.8  
 ROCK SURFACE -  
 BOTTOM OF HOLE 257.3  
 WATER TABLE

| DEPTH<br>Feet | SOIL TYPE          | DESCRIPTION COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC. | SAMPLE |        |           |       |       | PENETRATION<br>TEST #<br>Blows |
|---------------|--------------------|--|--------|--------|-----------|-------|-------|--------------------------------|
|               |                    |  | NO.    | TYPE * | SIZE      | DEPTH | RET'D |                                |
| 0.0           | Gravel             | Brownish loose fill  |        |        | In.       | Ft.   | In.   |                                |
|               | Sand Silt and Clay | material   |        |        |           |       |       |                                |
| 2.0           | Gravel             | Brownish mottled grey  |        |        |           |       |       |                                |
|               | Sand Silt and Clay | and yellow highly weathered stiff and dry  | 1      | AQ     | 2         | 5.0   | 15    |                                |
|               |                    |  |        |        |           | 5.5   |       | 8                              |
|               |                    |  |        |        |           | 6.0   |       | 23                             |
|               |                    |  |        |        |           | 6.5   |       | 35                             |
|               |                    |  | 2      | BO     | 2         | 10.0  | 10    | Pushed                         |
|               |                    |  |        |        |           | 10.7  |       | 1300 lb                        |
|               |                    |  |        |        |           | 11.0  |       | 10                             |
|               |                    |  |        |        |           | 11.5  |       | 17                             |
| 2.0           | Gravel             | Grey, stiff and no signs   |        |        |           |       |       |                                |
|               | Sand Silt and Clay | of weathering observed   |        |        | Vane Test | 13.0  |       |                                |
|               |                    |  | 3      | BO     | 2         | 15.0  | 12    |                                |
|               |                    |  |        |        |           | 15.5  |       |                                |
| 6.0           | Gravel             | Brownish grey, some  |        |        |           |       |       |                                |
|               | Sand Silt and Clay | varving or layering visible  |        |        |           | 16.0  |       |                                |
|               |                    |  |        |        |           | 16.5  |       |                                |
|               |                    |  |        |        | Vane Test | 17.0  |       |                                |
|               |                    |  | 4      | AQ     | 2         | 17.0  | 12    |                                |
|               |                    |  |        |        |           | 17.5  |       | 5                              |
|               |                    |  |        |        |           | 18.0  |       | 8                              |
|               |                    |  |        |        |           | 18.5  |       | 26                             |

SAMPLING METHOD:

\* A - SPLIT TUBE  
 B - THIN WALL TUBE  
 C - PISTON SAMPLER  
 D - CORE BARREL

E - AUGER  
 F - WASH

SHIPPING CONTAINER

N - INSERT  
 O - TUBE  
 P - WATER CONTENT TIN  
 Q - GLASS JAR

R - CLOTH BAG  
 S - PLYFILM BAG  
 Z - DISCARDED

INSPECTOR: H.W. Hyder  
 LOGGED BY: H.W. Hyder

APPROVED

DATE

November 1961

# DRILLING REPORT

SHEET No. 2 OF 3

**●**

# DRILLING REPORT

CLIENT ONTARIO DEPARTMENT OF HIGHWAYS  
 PROJECT W.P. 224-61  
 SITE QEW & NS&T Railway Subway

JOB No. 954  
 HOLE No. 954-2  
 SHEET No. 3 OF 3

| DEPTH<br>Feet | SOIL TYPE                 | DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC.                              | SAMPLE    |      |             |                              |              | PENETRATION<br>TEST * |
|---------------|---------------------------|--|-----------|------|-------------|------------------------------|--------------|-----------------------|
|               |                           |  | NO.       | TYPE | SIZE<br>In. | DEPTH<br>Ft.                 | RET'D<br>In. |                       |
|               |                           |  | 12        | AQ   |             | 42.0                         |              |                       |
| 45.0          | Silty Clay                | Greyish medium stiff<br>some 1" diameter stones  | 13        | BO   | 2           | 44.0<br>45.0<br>46.2         | 15           | Pushed                |
| 46.2          | Silty Clay                | Greyish brown silty clay<br>with patches and laminations of silt, some gravel present  | Vane Test |      |             | 46.2                         |              |                       |
|               |                           |  | 14        | AQ   | 2           | 46.2<br>46.7<br>47.2<br>47.7 | 16           |                       |
|               |                           |  | Vane Test |      |             | 49.0                         |              |                       |
| 50.0          | Gravel Sand Silt and Clay | Reddish brown, very stiff  | 15        | AQ   | 2           | 50.0<br>50.5<br>51.0<br>51.5 | 18           | 12<br>9<br>13         |
|               |                           |  | Vane Test |      |             | 53.0                         |              |                       |
|               |                           |  |           | BZ   | 2           | 55.0<br>55.4                 | 0            | 40                    |
|               |                           |  | 17        | AQ   | 2           | 55.4<br>55.9<br>56.4<br>56.9 | 18           | 14<br>19<br>23        |
|               |                           |  | Vane Test |      |             | 57.2                         |              |                       |
|               |                           |  |           | AQ   | 2           | 60.0<br>60.5<br>61.0<br>61.5 | 0            | 23<br>17<br>26        |
| 1.5           |                           | End of Hole  |           |      |             |                              |              |                       |
|               |                           | * Penetration Test   |           |      |             |                              |              |                       |
|               |                           | This is the number of blows of a 140-pound weight falling 30 inches required to advance the tube sampler or split-spoon to depth indicated |           |      |             |                              |              |                       |



# DRILLING REPORT

|                     |  |              |                      |                        |
|---------------------|--|--------------|----------------------|------------------------|
| CLIENT              | ONTARIO DEPARTMENT OF HIGHWAYS         |              | JOB No.              | 954                    |
| PROJECT             | W.P. 224-61                            |              | HOLE No.             | 954-3                  |
| SITE                | QEW & NS&T Railway Subway              |              | SHEET No.            | 1 OF 2                 |
| CONTRACTOR:         | F.E. Johnston Drilling Company Limited | STARTED      | 4:00 P.M. November 3 | 19 61                  |
|                     |  | FINISHED     | 5:00 P.M. November 6 | 19 61                  |
| METHOD OF DRILLING: | SOIL Modified wash boring              | CASING DIAM. | 4"                   |                        |
|                     | ROCK                                   | CORE DIAM.   |                      |                        |
| LOCATION:           | LATITUDE Sta 86+91                     | ELEVATIONS:  | DATUM                | G.S.C.                 |
|                     | DEPARTURE 52 ft Left Centreline        |              | DRILL PLATFORM       | -                      |
|                     | BEARING QEW                            |              | GROUND SURFACE       | 319.5                  |
|                     | INITIAL DIP 90 degrees                 |              | ROCK SURFACE         | 43.0                   |
|                     | OTHER DIPS                             |              | BOTTOM OF HOLE       | <del>261.2</del> 271.5 |
|                     |  |              | WATER TABLE          | -                      |

| DEPTH<br>feet | SOIL TYPE       | DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC. | SAMPLE |        |           |       |       | PENETRATION TEST #<br>Blows |
|---------------|-----------------|---|--------|--------|-----------|-------|-------|-----------------------------|
|               |                 |   | NO     | TYPE * | SIZE      | DEPTH | RET'D |                             |
|               |                 |   |        |        | In.       | Ft.   | In.   |                             |
| 0.0           | Gravel and Sand | reddish brown dense and dry   |        |        |           |       |       |                             |
| 0.0           | Silty Clay      | Yellowish brown and dry and dense   | 1      | BO     | 2         | 5.0   | 18    | Pushed                      |
|               |                 |   |        |        |           | 5.5   |       | 1200 lb                     |
|               |                 |   |        |        |           | 6.0   | 16    | 16                          |
|               |                 |   |        |        |           | 6.5   |       | 24                          |
|               |                 |   |        |        | Vane Test | 7.2   |       |                             |
| 0.0           | Silty Clay      | Brownish grey with some weathering to 15 feet. The silty clay is stiff and some gravel is present             | 2      | CO     | 3         | 10.0  | 12    | Pushed                      |
|               |                 |   |        |        |           | 11.0  |       | 1500 lb                     |
|               |                 |   |        |        |           |       |       | (refusal)                   |
|               |                 |   |        |        | Vane Test | 12.5  |       |                             |
|               |                 |   | 3      | CO     | 3         | 15.0  | 20    | Pushed                      |
|               |                 |   |        |        |           | 16.8  |       |                             |
|               |                 |   |        |        | Vane Test | 18.0  |       |                             |
|               |                 |   | 4      | CO     | 3         | 20.0  | 20    |                             |
|               |                 |   |        |        |           | 21.8  |       |                             |
|               |                 |   |        |        | Vane Test | 23.0  |       |                             |
|               |                 |   | 5      | CO     | 3         | 25.0  | 15    |                             |
|               |                 |   |        |        |           | 26.8  |       |                             |

## SAMPLING METHOD

\* A — SPLIT TUBE  
 B — THIN WALL TUBE  
 C — PISTON SAMPLER  
 D — CORE BARREL  
 E — AUGER  
 F — WASH

## SHIPPING CONTAINER

N — INSERT  
 O — TUBE  
 P — WATER CONTENT T.N.  
 Q — GLASS JAR  
 R — CLOTH BAG  
 S — PLIOFILM BAG  
 Z — DISCARDED

INSPECTOR H.W. Ryder  
 LOGGED BY H.W. Ryder

APPROVED

DATE

November 1961

DRILLING REPORT

CLIENT ONTARIO DEPARTMENT OF HIGHWAYS  
 PROJECT W.P. 224-61  
 SITE QEW & NS&T Railway Subway

JOB No. 954  
 HOLE No. 954-3  
 SHEET No. 2 OF 2

| DEPTH<br>Feet | SOIL TYPE | DESCRIPTION COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTION, WATER LOSS OR GAIN, ETC.  | S A M P L E |      |             |              |             | PENETRATION<br>TEST * |
|---------------|-----------|--|-------------|------|-------------|--------------|-------------|-----------------------|
|               |           |  | NO          | TYPE | SIZE<br>In. | DEPTH<br>Ft. | RETD<br>In. |                       |
|               |           |  |             |      | Vane Test   | 28.0         |             |                       |
|               |           | Below 25 feet material became less stiff   | 6           | CO   | 3           | 30.0<br>31.8 | 20          | Pushed<br>800 lbs     |
|               |           |  |             |      | Vane Test   | 33.0         |             |                       |
|               |           |  | 7           | CO   | 3           | 35.0         | 20          | Pushed<br>800 lbs     |
|               |           |  |             |      | Vane Test   | 38.0         |             |                       |
|               |           |  | 8           | CO   | 3           | 40.0<br>40.8 | 15          | Pushed<br>200 lbs     |
|               |           |  |             |      | Vane Test   | 43.0         |             |                       |
|               |           |  | 9           | CO   | 3           | 45.0<br>46.8 | 20          | Pushed<br>200 lbs     |
| 48.0          |           | End of Hole  |             |      | Vane Test   | 48.0         |             |                       |
|               |           | * Penetration Test<br>This is the number of blows of a 140-pound weight falling 30 inches required to advance the tube sampler or split-spoon to depth indicated |             |      |             |              |             |                       |

# DRILLING REPORT

CLIENT: ONTARIO DEPARTMENT OF HIGHWAYS  
 PROJECT: W.P. 224-61  
 SITE: QEW and NS&T Railway Subway

JOB No. 954  
 HOLE No. 954-4  
 SHEET No. 1 OF 2

CONTRACTOR: F.E. Johnston Drilling Company Limited  
 SOIL: Modified wash boring  
 METHOD OF DRILLING: ROCK  
 STARTED 8:00 A.M. November 7 1961  
 FINISHED 5:00 P.M. November 8 1961  
 CASING DIAM. 4"  
 CORE DIAM.

LOCATION: LATITUDE Sta 86+35 ELEVATIONS: DATUM G.S.C.  
 DEPARTURE 49 ft Right Centreline  
 BEARING QEW  
 INITIAL DIP 90 degrees  
 OTHER DIPS  
 DRILL PLATFORM -  
 GROUND SURFACE 319.1  
 ROCK SURFACE -  
 BOTTOM OF HOLE 281.1  
 WATER TABLE

| DEPTH<br>Feet | SOIL TYPE  | DESCRIPTION: COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTNESS, WATER LOSS OR GAIN, ETC      | SAMPLE |           |             |              |             | PENETRATION TEST *  |
|---------------|------------|---|--------|-----------|-------------|--------------|-------------|---------------------|
|               |            |   | NO     | TYPE      | SIZE<br>In. | DEPTH<br>Ft. | RETD<br>In. |                     |
| 0.0           | Silty Sand | Reddish brown backfill  |        |           |             |              |             |                     |
| 3.5           | Silty Clay | Brownish grey, stiff with some layering and gravel size particles. Between 25.0 and 30.0 gravel content increases | 1      | BO        | 3           | 5.0<br>6.5   | 18          | Pushed<br>1500 lbs  |
|               |            |   |        | Vane Test |             | 8.0          |             |                     |
|               |            |   | 2      | CO        | 3           | 10.0<br>11.7 | 20          | Pushed<br>1200 lbs  |
|               |            |   |        | Vane Test |             | 13.0         |             |                     |
|               |            |   | 3      | CO        | 3           | 15.0<br>16.7 | 20          | Pushed<br>1200 lbs  |
|               |            |   |        | Vane Test |             | 17.0         |             |                     |
|               |            |   | 4      | CO        | 3           | 20.0<br>21.7 | 20          | Pushed<br>1200 lbs  |
|               |            |   |        | Vane Test |             | 23.0         |             |                     |
|               |            |   |        |           | CO          | 3            | 25.0        | 0<br>Unable to push |

SAMPLING METHOD

A - SPLIT TUBE  
 B - THIN WALL TUBE  
 C - PISTON SAMPLER  
 D - CORE BARREL

E - AUGER  
 F - WASH

SHIPPING CONTAINER

N - INSERT  
 O - TUBE  
 P - WATER CONTENT TIN  
 Q - GLASS JAR

R - CLOTH BAG  
 S - FLOFILM BAG  
 Z - DISCARDED

INSPECTOR: H.W. Ryder

LOGGED BY: H.W. Ryder

APPROVED

DATE

November 1961

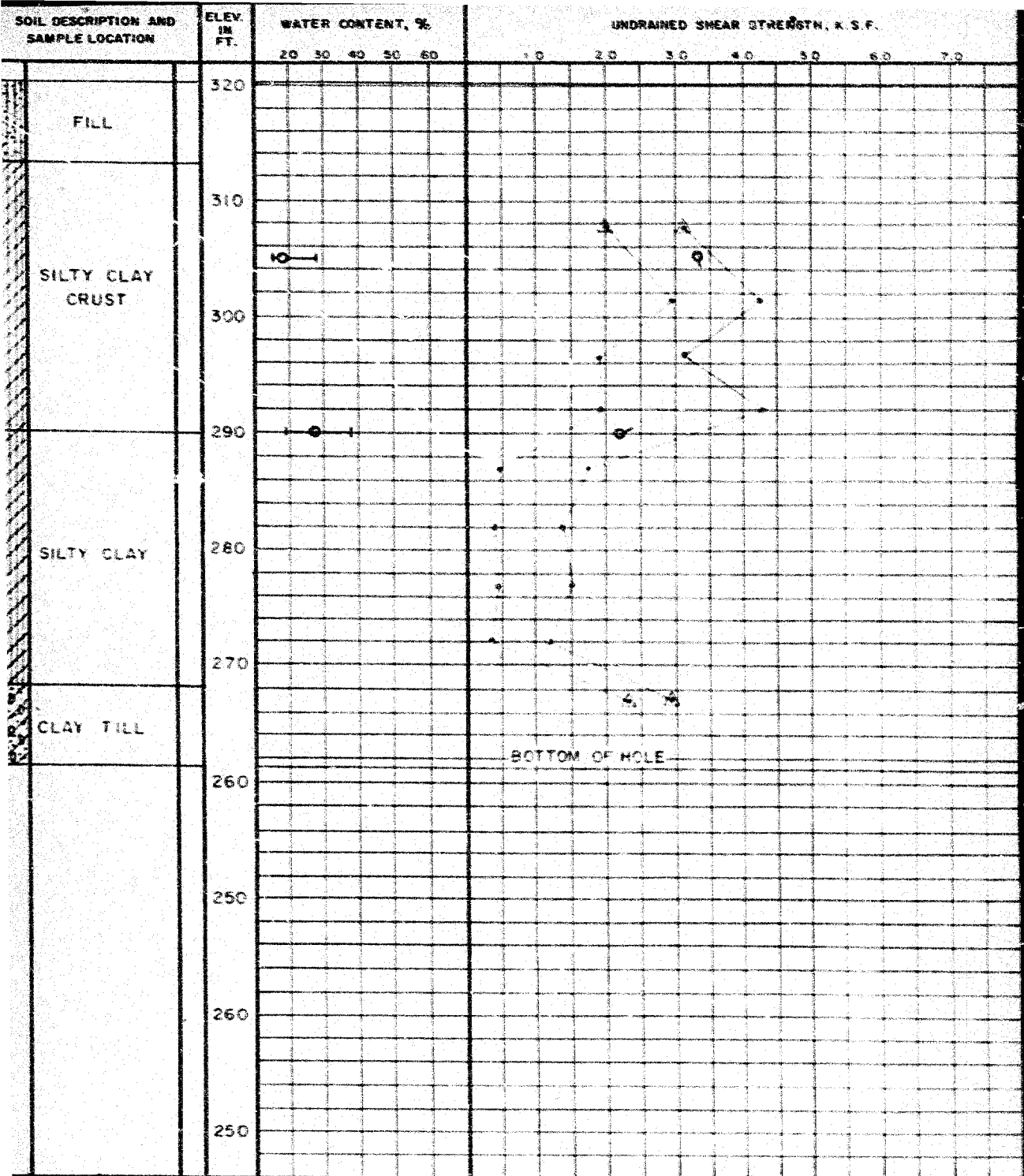


DRILLING REPORT

CLIENT ONTARIO DEPARTMENT OF HIGHWAYS  
 PROJECT W.P. 224-61  
 SITE QEW & NS&T Railway Subway

JOB No. 954  
 HOLE No. 954-4  
 SHEET No. 2 OF 2

| DEPTH<br>Feet | SOIL TYPE | DESCRIPTION, COLOUR, CONSISTENCY, STRUCTURE, WATER CONTENT, PLASTICITY, COMPACTION, WATER LOSS OF GAIN, ETC.  | S A M P L E |      |             |              |              | PENETRATION TEST |
|---------------|-----------|---|-------------|------|-------------|--------------|--------------|------------------|
|               |           |   | NO.         | TYPE | SIZE<br>In. | DEPTH<br>Ft. | DEPTH<br>In. | BLOWS            |
|               |           |   | 5           | BO   | 3           | 25.0         | 18           |                  |
|               |           |   |             |      |             | 25.5         |              | 8                |
|               |           |   |             |      |             | 26.0         |              | 7                |
|               |           |   |             |      |             | 26.5         |              | 7                |
|               |           |   | Vane Test   |      |             | 27.0         |              |                  |
|               |           |   | 6           | CO   | 3           | 30.0         | 12           | Unable           |
|               |           |   |             |      |             | 31.7         |              | to push          |
|               |           |   | Vane Test   |      |             | 33.0         |              | 30 blows         |
|               |           |   | 7           | CO   | 3           | 35.0         | 20           | Pushed           |
|               |           |   |             |      |             | 36.7         |              | 1300 lbs         |
| 8.0           |           | End of Hole   | Vane Test   |      |             | 38.0         |              |                  |
|               |           | <u>* Penetration Test</u><br>This is the number of blows of a 140-pound weight falling 30 inches required to advance the tube sampler or split-spoon to depth indicated |             |      |             |              |              |                  |



3 SOIL SAMPLE  
O NATURAL WATER CONTENT  
T LIQUID LIMIT  
T PLASTIC LIMIT

O UNDRAINED COMPRESSION TEST  
△ FIELD VANE TEST  
— NATURAL STRENGTH  
--- REMOULDED STRENGTH

0  
15 — 5  
10  
FAILURE STRAIN

H. G. ACRES & COMPANY LIMITED  
CONSULTING ENGINEERS  
NIAGARA FALLS CANADA

SUMMARY OF DRILLING AND TEST  
RESULTS

MOLE 954-1

ONTARIO DEPARTMENT OF HIGHWAYS

APPROVED

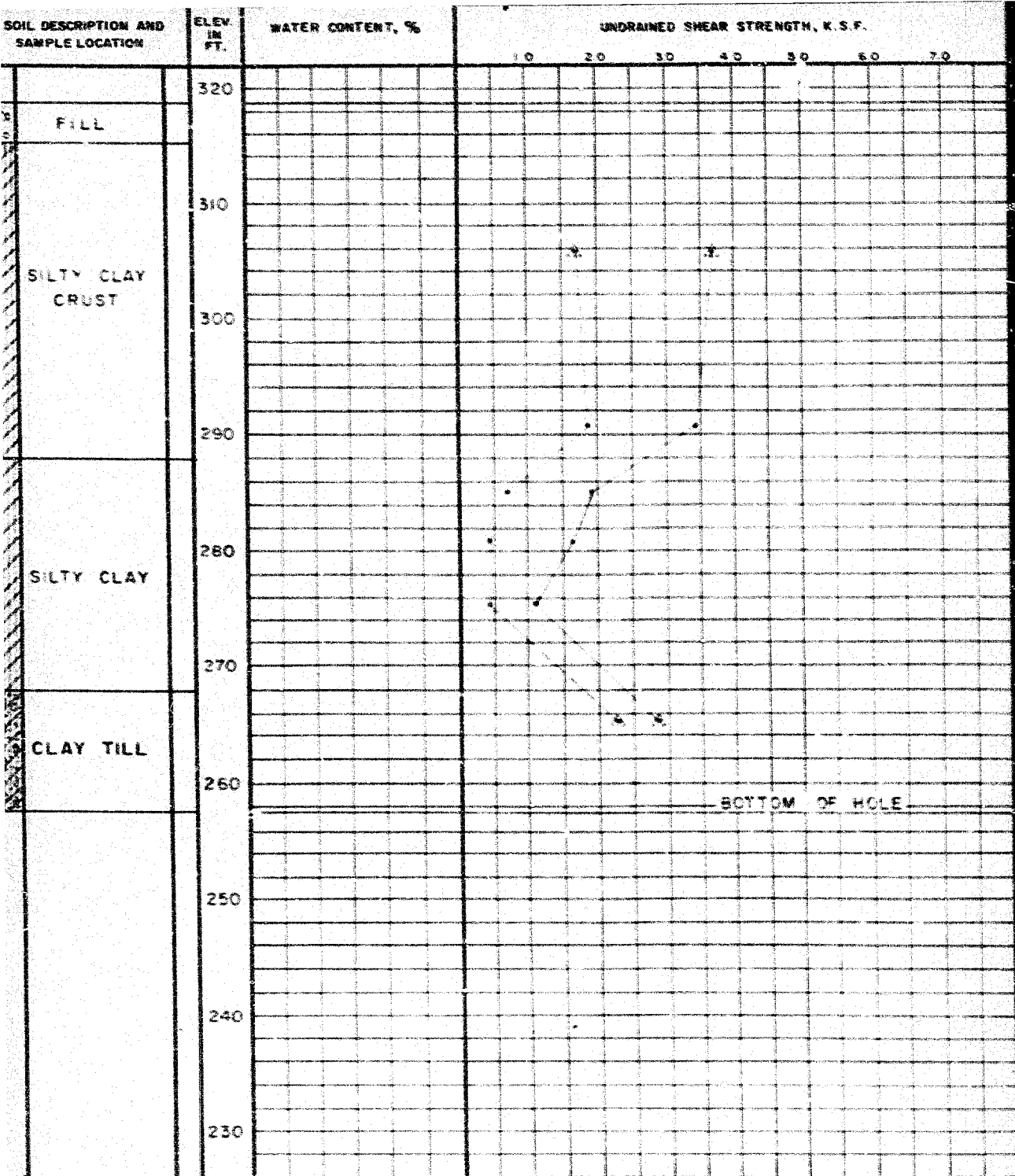
DATE NOVEMBER 1961

W.P. 224-61

H.G. ACRES & COMPANY LTD.

JOB No. 954

PLATE 6



3

SOIL SAMPLE  
NATURAL WATER CONTENT  
LIQUID LIMIT  
PLASTIC LIMIT

○

△

---

UNDRAINED COMPRESSION TEST  
FIELD VANE TEST  
NATURAL STRENGTH  
REMOLDED STRENGTH

0  
15 - 5  
10

FAILURE STRAIN

H. G. ACRES & COMPANY LIMITED  
CONSULTING ENGINEERS  
NIAGARA FALLS CANADA

ONTARIO DEPARTMENT OF HIGHWAYS

W.P. 224-61

SUMMARY OF DRILLING AND TEST RESULTS

HOLE 954-2

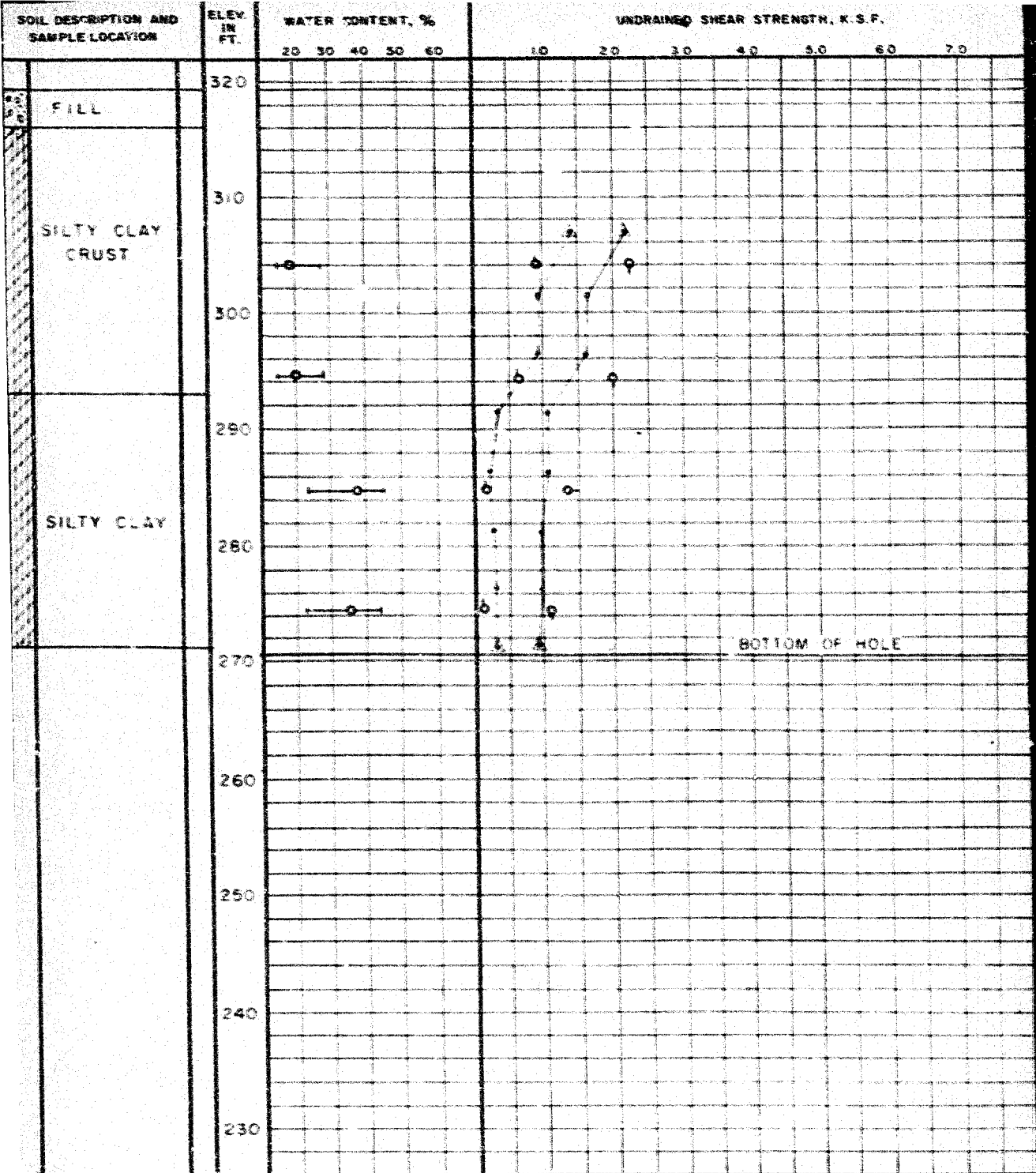
APPROVED

DATE: NOVEMBER 1961

JOE No. 954

H. G. ACRES & COMPANY LTD.

PI ATF 7



3

SOIL SAMPLE  
NATURAL WATER CONTENT  
LIQUID LIMIT  
PLASTIC LIMIT

○

△

—  
---

UNDRAINED COMPRESSION TEST  
FIELD VANE TEST  
NATURAL STRENGTH  
REMOLDED STRENGTH

0  
15—5  
10

FAILURE STRAIN

H. G. ACRES & COMPANY LIMITED  
CONSULTING ENGINEERS  
NIAGARA FALLS CANADA

ONTARIO DEPARTMENT OF HIGHWAYS

W. P. 224 - 61

SUMMARY OF DRILLING AND TEST  
RESULTS

HOLE 954-3

APPROVED

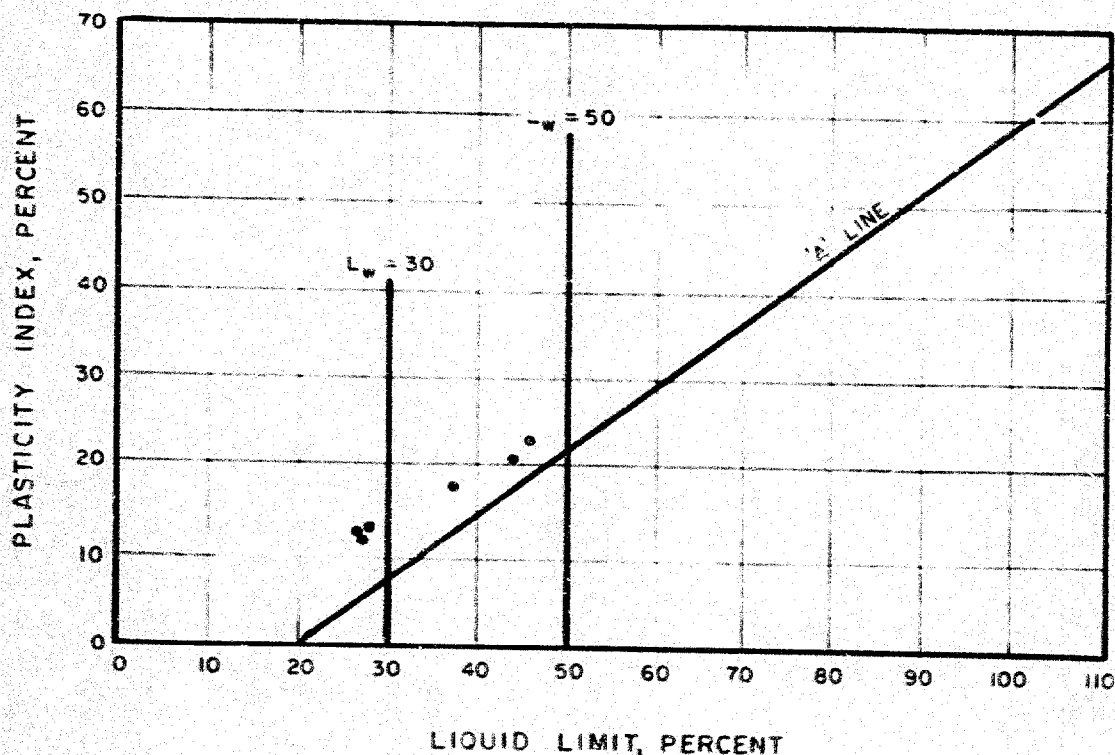
*H. G. Acres*  
H. G. ACRES & COMPANY LTD.

DATE NOVEMBER 1961

JOB No. 954

PLATE 8





|   |  |                         |
|---|--|-------------------------|
| H. G. ACRES & COMPANY LIMITED<br>CONSULTING ENGINEERS<br>NIAGARA FALLS CANADA | SUMMARY OF DRILLING AND TEST RESULTS<br>PLASTICITY CHART |                         |
| ONTARIO DEPARTMENT OF HIGHWAYS  | APPROVED<br><i>[Signature]</i>                           | DATE NOVEMBER 1961      |
| W.P. 224-61   | H.G. ACRES & COMPANY LTD.                                | JOB No. 954<br>PLATE 10 |

Mr. A. M. Toye,

Bridge Engineer.

Materials & Research Division,

(Foundation Section).

Attention: Mr. E. McCombie.

January 5, 1962.

FOUNDATION INVESTIGATION REPORT

By: H. G. Acres & Co., Ltd.

Re: Proposed Revisions to Crossing of  
Niagara-St. Catharines-Toronto  
Electric Railway over the Queen  
Elizabeth Way, City of St. Catharines,  
W.P. 224-61 -- District No. 4.

Attached, we are sending you the report on the foundation investigation for the above-mentioned structure, submitted by the Consultant, H. G. Acres & Company, Ltd.

We have reviewed the report and have found the factual information well presented. We also agree with the conclusions and recommendations given in the report.

We believe that the data contained in the report should prove to be adequate for your future design work. However, should there be any questions you would like to discuss, please feel free to contact our Office.

AGS/HdaP

Attach.

cc: Messrs. A. M. Toye (2)

H. A. Fregaskes

H. D. McMillan

I. C. Campbell

J. C. Thatcher

T. J. Kovich

J. Roy

J. E. Graspier

M. E. Saint

F. Borman

A. Watt

Foundations Office

Gen. Files.

*AGS/HdaP*  
A. G. Sternac,  
PRINCIPAL FOUNDATION ENGINEER



January 15, 1962

Ontario Department of Highways,  
Materials and Research Section,  
Parliament Buildings,  
Toronto 2, Ontario.

Attention: Mr. A. Rutka,  
A/ Materials and Research Engineer.

Gentlemen:      Proposed Revisions to Crossing of  
Niagara - St. Catharines - Toronto  
Electric Railway Over the Queen  
Elizabeth Way, City of St. Catharines,  
District No. 4, W.P. 224-61

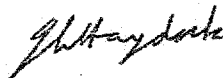
You will recall that in our report on the foundation investigation at the above site we pointed out an apparent anomaly between the laboratory unconfined compression tests and the field vane tests. In hole 954-3 the results of the laboratory tests gave higher values for the natural undrained shear strengths than the field vane tests.

A further investigation of this apparent anomaly has revealed that an error existed in the calibration of the torque wrench with which some of the vane tests had been performed. The results of the vane tests have been re-evaluated and an addendum with the corrected data is attached. These changes do not altogether reverse the original condition with respect to the test results. However, it is considered that any discrepancies can now be explained simply by scatter in the results.

The magnitude of the changes do not have any practical effect on the design considerations. Therefore, our report remains essentially unchanged.

Yours very truly,

H.G. ACRES & COMPANY LIMITED



RJC:dr  
Encl.

J.L. Haydock  
Head, Applied Mechanics Department



ADDENDUM NO. 1

ONTARIO DEPARTMENT OF HIGHWAYS  
Toronto, Ontario

REPORT

on

FOUNDATION INVESTIGATION

PROPOSED REVISIONS TO CROSSING OF  
NIAGARA - ST. CATHARINES - TORONTO  
ELECTRIC RAILWAY OVER  
THE QUEEN ELIZABETH WAY  
CITY OF ST. CATHARINES, DISTRICT NO. 4  
W.P. 224-61

---

H.G. ACRES & COMPANY LIMITED  
Consulting Engineers  
Niagara Falls, Canada

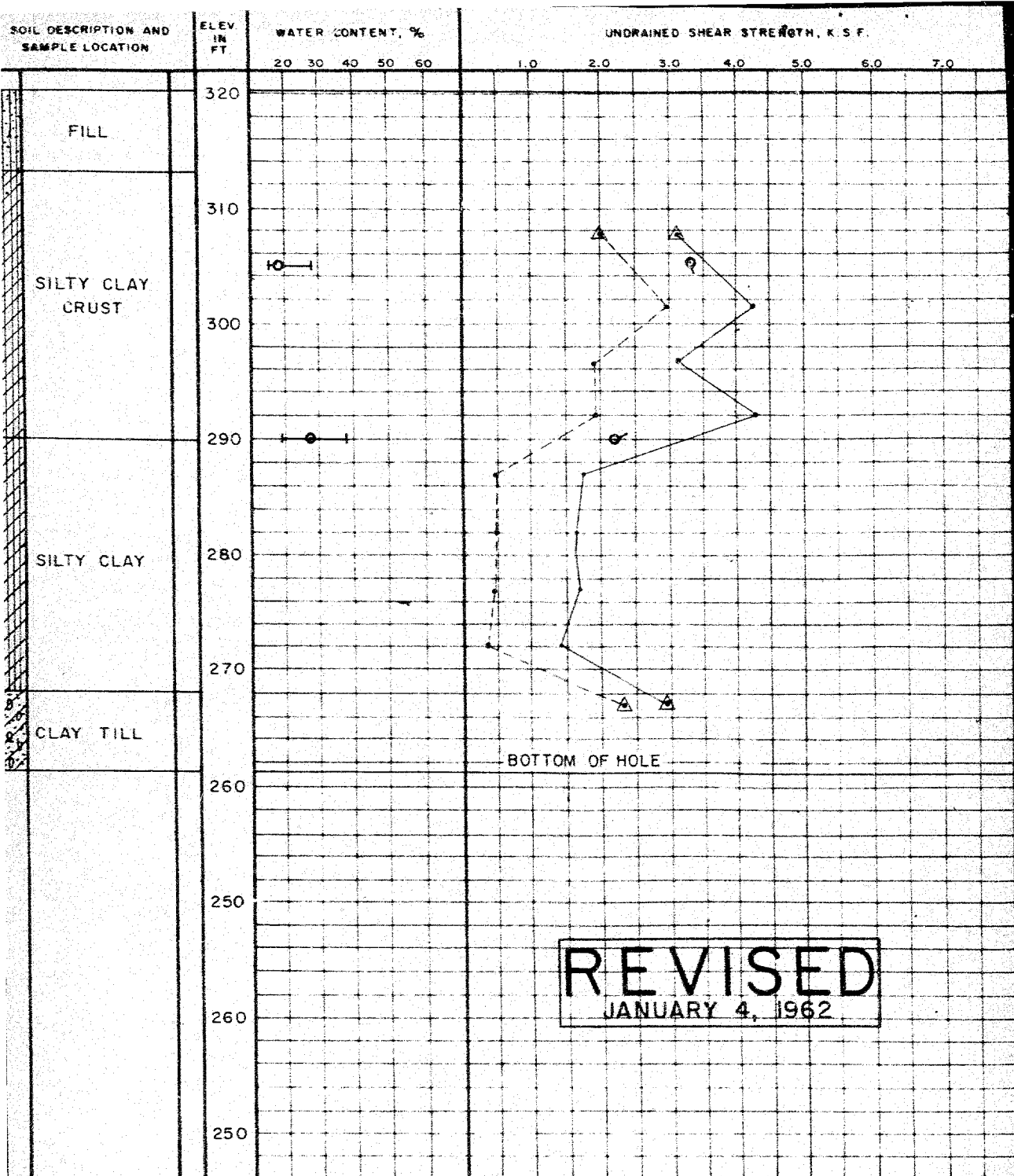
January 4, 1962

APPENDIX C

Results of In-Situ Vane Tests

| Hole No. | Elevation<br>(Feet) | Undrained Shear Strength<br>(Psf) |           | Sensitivity |
|----------|---------------------|-----------------------------------|-----------|-------------|
|          |                     | Undisturbed                       | Remoulded |             |
| 954-1    | 307.7               | 3100                              | 1930      | 1.6         |
|          | 301.7               | 4240                              | 2900      | 1.5         |
|          | 296.7               | 3100                              | 1930      | 1.6         |
|          | 292.2               | 4260                              | 1930      | 2.2         |
|          | 287.2               | 1730                              | 480       | 3.6         |
|          | 282.2               | 1600*                             | 450*      | 3.6*        |
|          | 277.2               | 1680*                             | 450*      | 3.7*        |
|          | 272.2               | 1390*                             | 350*      | 4.0*        |
|          | 267.2               | 2920                              | 2300      | 1.3         |
| 954-2    | 305.8               | 3780                              | 1730      | 2.2         |
|          | 290.8               | 3780*                             | 2170*     | 1.7*        |
|          | 285.8               | 2170*                             | 750*      | 2.9*        |
|          | 280.8               | 1800*                             | 440       | 4.1*        |
|          | 275.8               | 1260*                             | 440       | 2.9*        |
|          | 269.8               | 2330*                             | 1800*     | 1.3*        |
|          | 265.8               | 3310*                             | 2740*     | 1.2*        |
| 954-3    | 307.0               | 2520*                             | 1600*     | 1.6         |
|          | 301.5               | 1860*                             | 1040*     | 1.8*        |
|          | 296.5               | 1860*                             | 1040*     | 1.8*        |
|          | 291.5               | 1130*                             | 320       | 3.5*        |
|          | 286.5               | 1130*                             | 250       | 4.5*        |
|          | 281.5               | 1040*                             | 280       | 3.7*        |
|          | 276.5               | 1100*                             | 310       | 3.5*        |
|          | 271.5               | 1010*                             | 310       | 3.3*        |
| 954-4    | 311.1               | 3780*                             | 1990*     | 1.9         |
|          | 306.1               | 2930*                             | 1800*     | 1.6         |
|          | 302.1               | 1990*                             | 1130*     | 1.8*        |
|          | 296.1               | 2360*                             | 1260*     | 1.9         |
|          | 292.1               | 3780*                             | 1950*     | 1.9*        |
|          | 286.1               | 1800*                             | 440       | 4.1*        |
|          | 281.1               | 1350*                             | 440       | 3.1*        |

\* These values are changed from original report.



H. G. ACRES & COMPANY LIMITED  
CONSULTING ENGINEERS  
NIAGARA FALLS CANADA

ONTARIO DEPARTMENT OF HIGHWAYS

W.P. 224-61

# SUMMARY OF DRILLING AND TEST RESULTS

HOLE 954-1

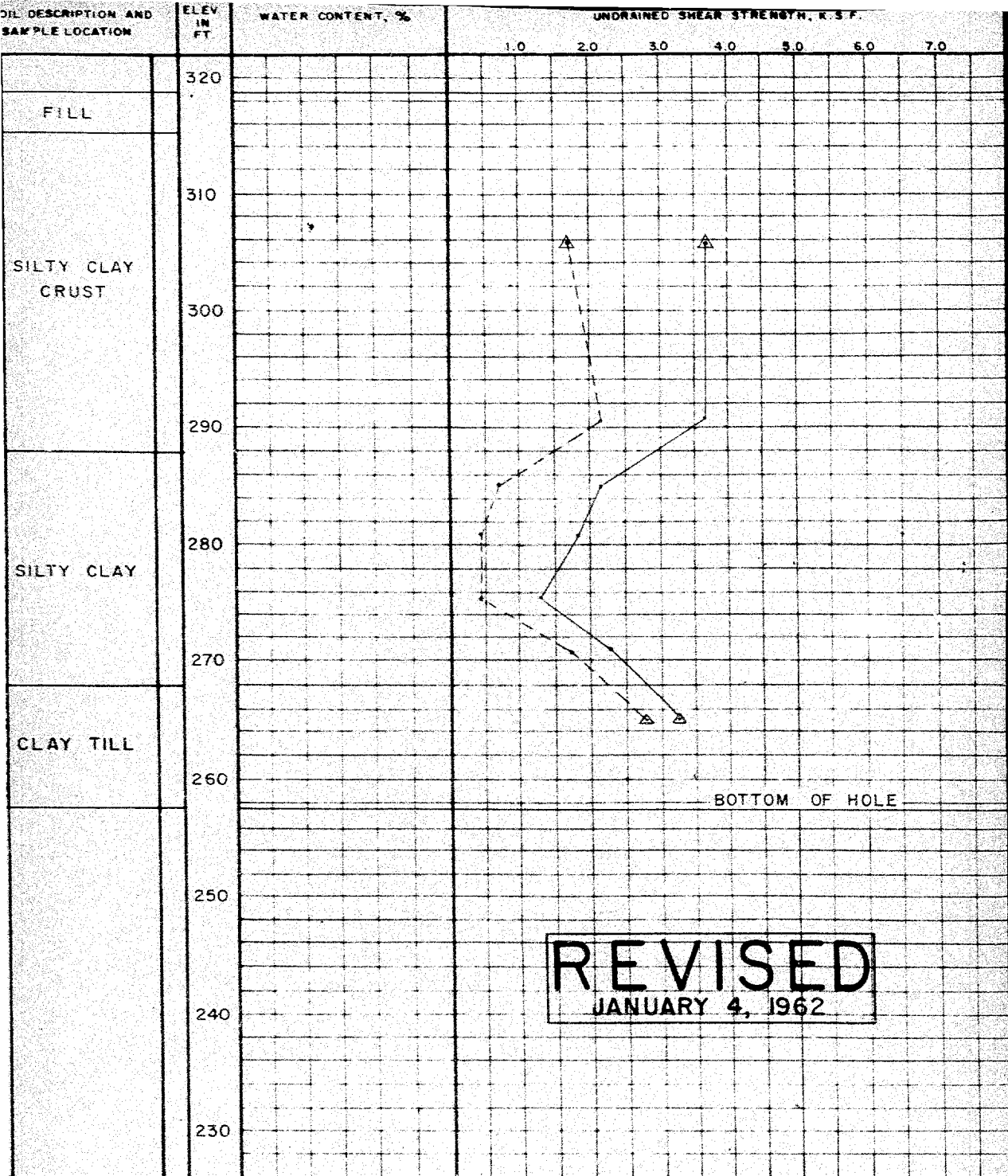
APPROVED

DATE NOVEMBER 1961

JOB No. 954

H.G. ACRES & COMPANY LTD

PLATE 6



3

○

—

—

SOIL SAMPLE

NATURAL WATER CONTENT

LIQUID LIMIT

PLASTIC LIMIT

○

△

—

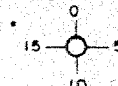
---

UNDRAINED COMPRESSION TEST

FIELD VANE TEST

NATURAL STRENGTH

REMOULDED STRENGTH



FAILURE STRAIN

H. G. ACRES & COMPANY LIMITED  
CONSULTING ENGINEERS  
NIAGARA FALLS CANADA

## SUMMARY OF DRILLING AND TEST RESULTS

HOLE 954-2

APPROVED

DATE NOVEMBER 1961

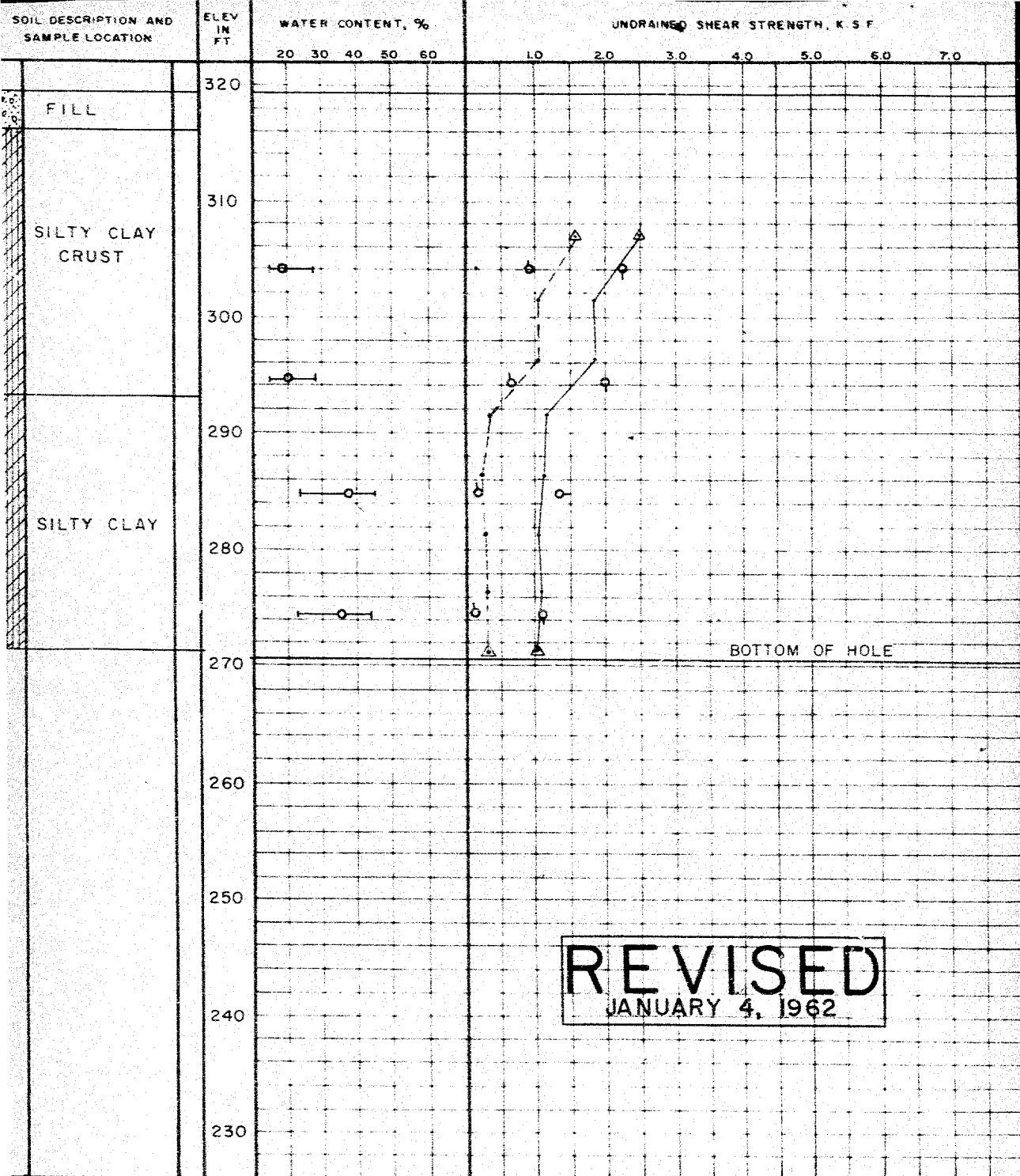
JOB No. 954

*H. G. Acres*  
H. G. ACRES & COMPANY LTD.

PLATE 7

W.P. 224-61

ONTARIO DEPARTMENT OF HIGHWAYS



[3] SOIL SAMPLE  
 ○ NATURAL WATER CONTENT  
 — LIQUID LIMIT  
 — PLASTIC LIMIT

○ UNDRAINED COMPRESSION TEST  
 △ FIELD VANE TEST  
 — NATURAL STRENGTH  
 - - - REMOULDED STRENGTH

0  
 15 — ○ — 5  
 10  
 FAILURE STRAIN

**H. G. ACRES & COMPANY LIMITED**  
 CONSULTING ENGINEERS  
 NIAGARA FALLS CANADA

### SUMMARY OF DRILLING AND TEST RESULTS

HOLE 954-3

ONTARIO DEPARTMENT OF HIGHWAYS

APPROVED

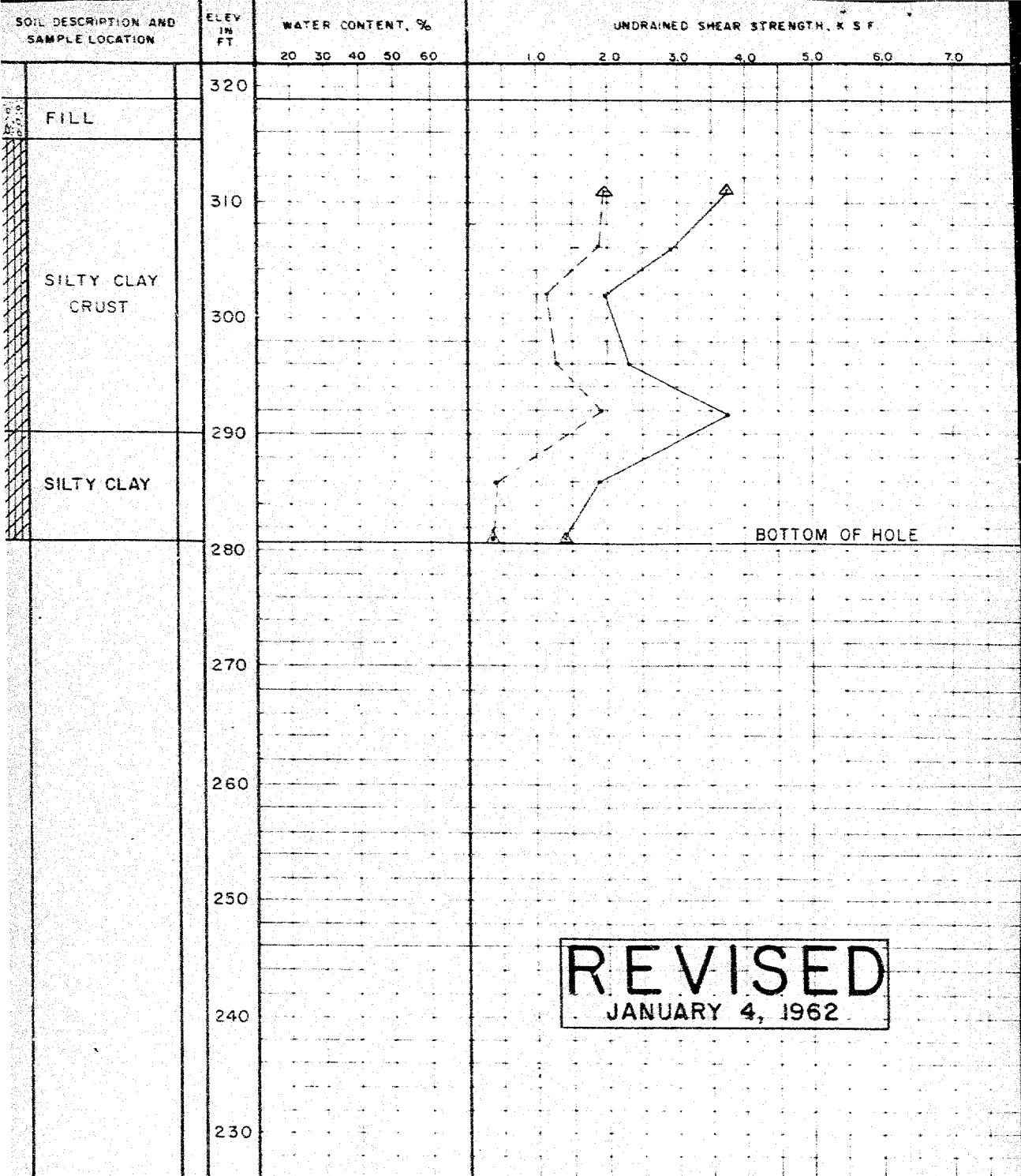
DATE NOVEMBER 1961

W. P. 224-61

JOB No. 954

H. G. ACRES & COMPANY LTD

PLATE 8



**REVISED**  
JANUARY 4, 1962

|  |   |   |
|--|---|---|
| <input checked="" type="checkbox"/> 3 SOIL SAMPLE<br><input type="checkbox"/> NATURAL WATER CONTENT<br><input type="checkbox"/> LIQUID LIMIT<br><input type="checkbox"/> PLASTIC LIMIT | <input type="checkbox"/> UNDRAINED COMPRESSION TEST<br><input type="checkbox"/> FIELD VANE TEST<br><input type="checkbox"/> NATURAL STRENGTH<br><input type="checkbox"/> REMOULDED STRENGTH | 0<br>15 — ○ — 5<br>10<br>FAILURE STRAIN |
|--|---|---|

H. G. ACRES & COMPANY LIMITED  
CONSULTING ENGINEERS  
NIAGARA FALLS CANADA

SUMMARY OF DRILLING AND TEST  
RESULTS

HOLE 954-4

ONTARIO DEPARTMENT OF HIGHWAYS

APPROVED

DATE NOVEMBER 1961

W. P. 224-61

*H. G. Acres*  
H. G. ACRES & COMPANY LTD.

JOB No. 954

PLATE 9

Mr. A. H. Foye,

January 18, 1962.

Bridge Engineer.

Materials & Research Division,

(Foundation Section,

Attention: Mr. S. McCombie.

APPENDIX TO FOUNDATION  
INVESTIGATION REPORT

BY H. G. ACRES & CO., LTD.

(Sent out January 5, 1962)

Re: Proposed Revisions to Crossing of  
Niagara - St. Catharines - Toronto  
Electric Railway Over the Queen  
Elizabeth Way, City of St. Catharines,  
District No. 4, S.P. 224-61.

attached, please find self-explanatory addendum  
concerning corrected wave test data, which is to be inserted  
in your copy(s) of H. G. Acres' report on the above-mentioned  
project.

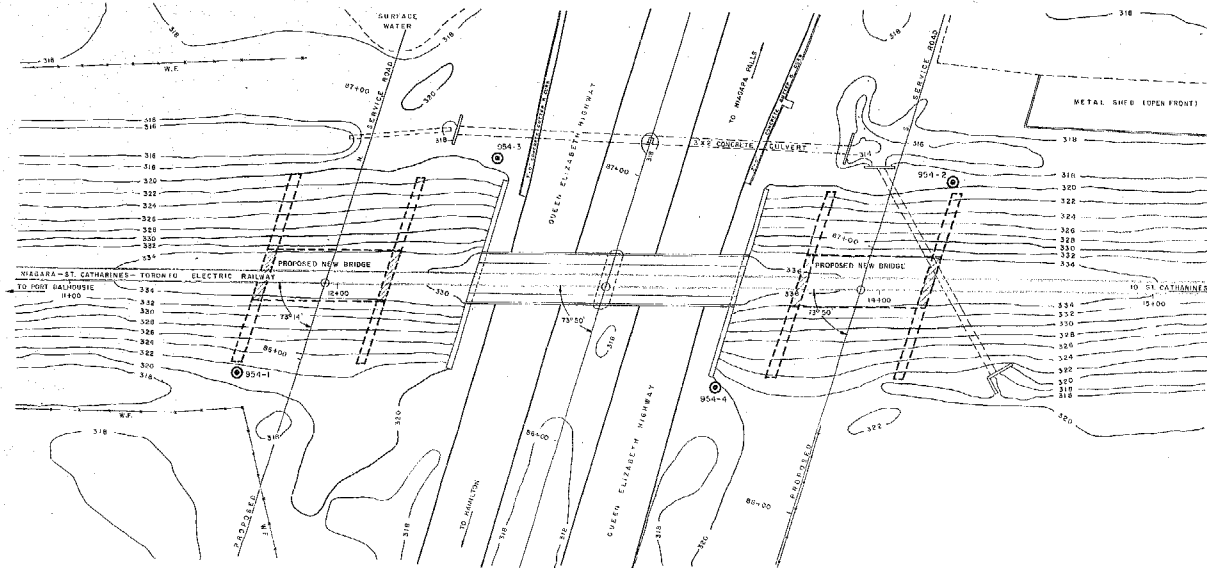
cc/ndcf  
attach.

*W. G. Sternac*  
W. G. Sternac,  
PRINCIPAL FOUNDATION ENGINEER

cc: Messrs. A. H. Foye (2)  
E. A. Yzaguires  
E. B. Maxwell  
I. C. Campbell  
J. C. Thatcher  
F. J. Novick  
J. Foy  
J. E. Grusnier  
S. H. Saint  
F. Korman  
A. Watt  
Foundations Office ✓  
Gen. Files.

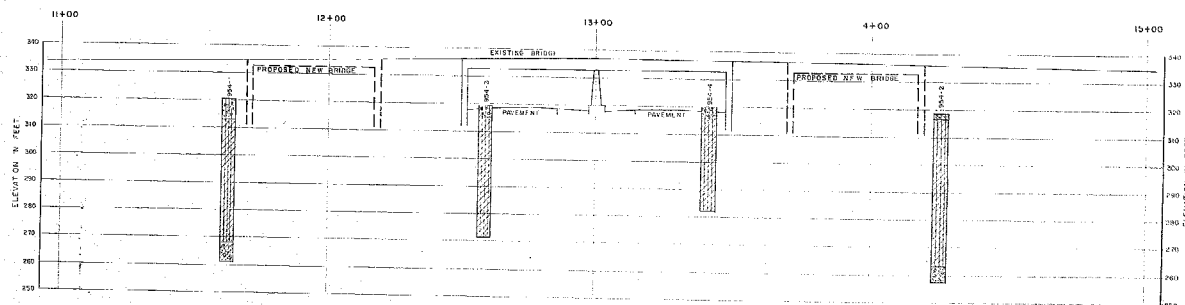
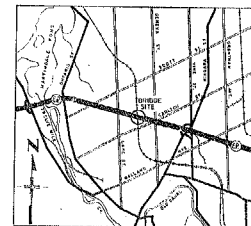
#61-F-202-C  
W.P. #224-61  
Q.E.W. AND  
ELECTRIC R.W.Y.  
CROSSING





# LEGEND

- NEW BRIDGE
- DRILL HOLE
- GRAVEL
- SAND
- SILT
- CLAY



SCALE 20 0 20 40 60 FEET

|   |                     |
|---|---------------------|
| H. G. AGNES & COMPANY LIMITED SURVEYING ENGINEERS |                     |
| ONTARIO DEPARTMENT OF HIGHWAYS                    |                     |
| WP 224-61   |                     |
| EXPLORATORY HOLES<br>PLAN AND SECTIONS            |                     |
| <i>H. G. Agnes</i>                                | DATE: NOVEMBER 1951 |
| H. G. AGNES & COMPANY LIMITED                     | PLATE I             |