

MEMORANDUM

To: Mr. C. K. Hunter,
Regional Road Design Engr.,
Central Region,
Central Bldg., Downsview.

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

ATTENTION: A. G. Kelly,
Sr. Project Design Engr.

DATE: April 6, 1970

OUR FILE REF.

IN REPLY TO

APR - 9 1970

SUBJECT:

FOUNDATION INVESTIGATION REPORT

For

Retaining Wall on Hwy. 2
Adjacent to Hamilton Entrance
District No. 4 (Hamilton)

W.J. 70-F-12 -- W.P. 113-66-01

CONT. 72-119

Attached, we are forwarding to you our detailed foundation investigation report on the subsoil conditions existing at the above retaining structure site.

We believe that the factual data and recommendations contained therein, will prove adequate for your design requirements. Should additional information be required, please feel free to contact our Office.

AGS/EdF
Attach.

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

cc: Messrs. G. K. Hunter (2)
B. R. Davis
H. A. Tregaskes
D. W. Farren
C. B. Robertson
W. S. Melinyshyn (2)
T. J. Kovich
B. A. Singh

Foundations Files
Gen. Files

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FOUNDATION INVESTIGATION REPORT
For
Retaining Wall on Hwy. 2
Adjacent to Hamilton Entrance
District No. 4 (Hamilton)
W.J. 70-F-12 -- W.P. 113-66-01

1. INTRODUCTION:

A foundation investigation was requested by Mr. G. K. Hunter, Regional Road Design Engineer, Central Region, for the proposed retaining wall alongside Highway #2 adjacent to Hamilton Entrance Bridge #1. The request was submitted in a memo dated January 23, 1970. The new structure will retain fill required in the proposed relocation and widening of Highway #2.

Upon receipt of the memo, a field investigation and subsequently a laboratory testing programme was carried out by this Section.

Presented in this report are the results of the investigation, together with recommendations concerning foundations.

2. DESCRIPTION OF THE SITE:

The proposed retaining wall is located on the north side of Highway #2 approximately 1/2 mile east of the junction of Hwys. #2 and #6 in the City of Burlington.

Generally the topography is undulating and the portion of Highway #2 under consideration lies some 80 feet above depressions, which exist north and south of the highway, with approximate slopes of 1:1½.

Geologically the area belongs to the physiographic region known as the Iroquois Plain. Lake Iroquois was the forerunner of Lake Ontario in the late Pleistocene times. Its

2. DESCRIPTION OF THE SITE: (cont'd.) ...

old shorelines, including cliffs, bars, beaches and boulder pavements, are easily identifiable features. In our particular area, the great gravel bar, which separates Coot's Paradise from Hamilton Harbour, marks the shoreline of the glacial lake.

3. FIELD AND LABORATORY INVESTIGATIONS:

The field investigation consisted of 5 sampled boreholes and adjacent to certain boreholes, 4 dynamic cone penetration tests.

All the boreholes were located on the centre-line of the proposed retaining wall.

Boreholes #1, #4 and #5 were sampled down to practical refusal and #1 and #5 were cored using BXL core barrels.

Boreholes #2 and #3 were terminated at depths of 55 ft. and 40 ft., respectively.

Equipment used consisted of two diamond drills adapted for soil sampling purposes.

Disturbed samples were obtained using a 2" O.D. split-spoon sampler; the energy used for driving the latter conformed to the requirements of the Standard Penetration Test. Undisturbed samples were obtained by means of 2" I.D. Shelby tubes pushed manually into the subsoil.

All samples were visually identified in the field and then returned to the laboratory where further tests were carried out to determine Atterberg Limits and moisture contents, density, particle size distribution and unconfined shear strength.

4. SUBSOIL CONDITIONS:

4.1) General:

The subsoil at the site consists of the following:

The uppermost deposit is somewhat mixed and is classified

4. SUBSOIL CONDITIONS: (cont'd.) ...

4.1) General: (cont'd.) ...

as silt to clays; silt with sand. Beneath the foregoing is a stratum of silty sand with occasional traces of gravel and clay. Underlying the sand layer, a deposit of clayey silt with traces of sand rests over shale bedrock.

The individual layers mentioned above, are described in greater detail as below:

4.2) Silt to Clayey Silt with Sand:

This material is of a red colour and has a thickness varying from 8 - 20 feet. The plasticity varies throughout the deposit and no definite boundaries could be drawn.

Laboratory tests gave the following results:

| | | | | |
|--------------------------|--------|----------|------|----------|
| Grain Size Distribution: | Gravel | 2 - 7% | Sand | 3 - 37% |
| | Silt | 46 - 74% | Clay | 11 - 15% |

Moisture Content: 7 - 26%

The plasticity of the deposit ranged from 'non-plastic' to the following values of liquid and plastic limits:

Plastic Limit: 14 - 21%

Liquid Limit: 18 - 32%

Typical grain size distribution curves are shown in Fig. #1; a plot of Plasticity Index vs. Liquid Limit in Fig. #2.

4.3) Silty Sand with Occasional Traces of Gravel and Clay - Light Brown:

This deposit underlies the silt to clayey silt layer and has a thickness ranging from 27 to 43 ft. It also exists as the uppermost layer in Borehole #1 only to a depth of 9 feet. Basically the material is silty fine sand, though in occasional samples, coarser material was found.

4. SUBSOIL CONDITIONS: (cont'd.) ...

4.3) Silty Sand with Occasional Traces of Gravel and Clay -
Light Brown: (cont'd.) ...

Thin horizontal seams of clay were found throughout the deposit and also in the lower regions, traces of red till material.

Laboratory tests gave the following results:

Grain Size Distribution: Gravel 0 - 9% Sand 69 - 79%
Silt and Clay 15 - 31%

Moisture Contents: 5 - 18%

Typical grain size distribution curves are shown in Fig. #3.

4.4) Grey Clayey Silt with Traces of Sand:

This material was found underlying the sand stratum and extends for a thickness of from 40 - 45 feet.

'N' values, as determined from the Standard Penetration Test, varied from 13 to 57 blows/ft., indicating a consistency of 'stiff' to 'hard'.

Laboratory tests gave the following results:

Mean Grain Size Distribution: Gravel 1% Sand 5% Silt 53% Clay 41%

Moisture Content: 17 - 23%

Liquid Limit: 18 - 32%

Plastic Limit: 16 - 20%

A typical grain size distribution curve is shown in Fig. #4, and a plot of Plasticity Index vs. Liquid Limit in Fig. #5.

Unconfined Shear Strength - PSF 1310 - 2730

Density PCF 128 - 130

4. SUBSOIL CONDITIONS: (cont'd.) ...

4.5) Shale Bedrock:

Bedrock, as mentioned earlier, was proved at two locations. The rock was classified to be calcareous shale of the Queenston Formation. The colour is generally red, having interbedded grey seams and layers. These shales tend to weather mechanically when uncovered and break down to clays and clayey silts.

The surface of the bedrock varied from elev. 237.9 in Borehole #4 to elev. 216.7 in Borehole #1.

5. GROUNDWATER CONDITIONS:

The groundwater in all boreholes, apart from Borehole #3, which was blocked around 19 feet depth, was found to lie just above or below the upper level of the grey clayey silt layer; the exact elevations are given below:

| | | | |
|---------|-------|---------|-------|
| B.H. #1 | 268.0 | B.H. #4 | 275.9 |
| B.H. #2 | 272.0 | B.H. #5 | 272.1 |
| B.H. #3 | - | | |

6. DISCUSSION AND RECOMMENDATIONS:

6.1) General:

The future plans for the Hamilton Entrance bridges necessitate widening of the highway approach from Burlington. The existing Highway #2 runs east-west at this location, and for a length of some 300 ft. lies some 30 ft. above the surrounding ground with approximately 1:1½ side slopes on the north side. The widening in this location is on the north side, and it is proposed to construct a retaining wall for the 300-foot length. The elevation of the top of the wall will be at elev. 328.0, some 10 to 13 feet above existing ground level, elev. 328.0 being the approximate elevation of the existing highway. The line of the wall lies between 35 - 45 feet from the edge of the existing Highway #2. (A typical section showing the location of the wall is shown in Fig. #6.)

6. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

6.1) General: (cont'd.) ...

The slope upon which the wall is to be founded is fairly consistent apart from a stretch of some 40 feet at the eastern end of the proposed wall where an 18" ϕ C.I.P. has been placed to drain the existing highway and the area has been backfilled with what can be classed as 'bouldery fill' (this is shown on attached Dwg. 70-F-12A). The flow from the culvert has washed away the slope beneath it, resulting in a considerable gully.

The wall extends to a distance of 300 feet at 37.5 feet right of the centre-line of new Highway #2 from Station 176+90 to Station 179+90.

Subsoil at the site consists of silt to clayey silt with sand, silty sand with occasional traces of gravel and clay, grey clayey silt with traces of sand and finally, shale bedrock.

Silty sand was found overlying the silt to clayey silt with sand layer in Borehole #1 only to a depth of 3 feet.

The 'bouldery fill' mentioned earlier, extends from approximately Station 177+26 to Station 177+64.

Recommendations concerning the foundation for the retaining structure, are given below:

6.2) Spread Footings:

The proposed retaining structure can be founded on spread footings at elev. 305.0 with a safe bearing capacity of 2 tons/sq.ft. or, alternatively, at or below elev. 302.0 with a safe bearing capacity of 3-1/2 tons/sq.ft.

The horizontal resistance of the retaining structure can be computed using a value of 0.35 as the coefficient of friction (μ) between the base of the footing and the underlying subsoil.

The following points are made with regard to the area of 'bouldery fill' mentioned earlier in the report:

6. DISCUSSION AND RECOMMENDATIONS: (cont'd.)...

6.2) Spread Footings: (cont'd.) ...

i) If soft material be encountered during construction, then this should be excavated and mass concrete used as backfill. An alternative method would be to 'step' the footing down until a hard stratum is reached.

ii) The existing ground level drops several feet in this area, and a 'stepping down' of the footing may be necessary to give the required 4 feet minimum cover.

6.3) Short Tube Piles:

Due to the deep excavation involved for spread footings, it may be more economically feasible to adopt a piled foundation as follows:

Tube piles of 12-3/4" O.D. and 1/4" wall thickness can be driven into the silty sand stratum. It is estimated that the above piles will have a capacity of 55 tons if driven to elev. 230.0. This working load should be checked during pile driving by means of the Hiley Formula (D.H.O. Standards DD 1218 & 1219).

6.4) H-Piles Driven to Bedrock:

Another alternative would be steel H-piles driven down to the shale bedrock. In this case, the capacity of the pile would be the maximum design load for the particular section chosen.

6.5) General Recommendations:

(a) For all footings, a minimum cover of 4 feet should be provided to give adequate frost protection.

(b) The elevation of the water table is at such a depth as to cause no dewatering problems.

6. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

6.5) General Recommendations: (cont'd.) ...

(c) The granular backfill to the wall should conform to D.H.O. Standards SD-4-58. In this case, the coefficient of active earth pressure (K_a) can be taken as 0.33.

(d) To relieve the build-up of excess hydrostatic pressure behind the retaining wall, suitable weepholes should be provided at a maximum spacing of 10 feet.

7. MISCELLANEOUS:

The field work, carried out during the period February 9 to 24, 1970, was supervised by Mr. G. Allen, Project Foundation Engineer.

Equipment used was owned and operated by Master Soil Investigations, and P.V.K. & Sons.

This report was written by Mr. G. Allen, Project Foundation Engineer, and reviewed by Mr. K. G. Selby, Supervising Foundation Engineer.

April, 1970

APPENDIX I

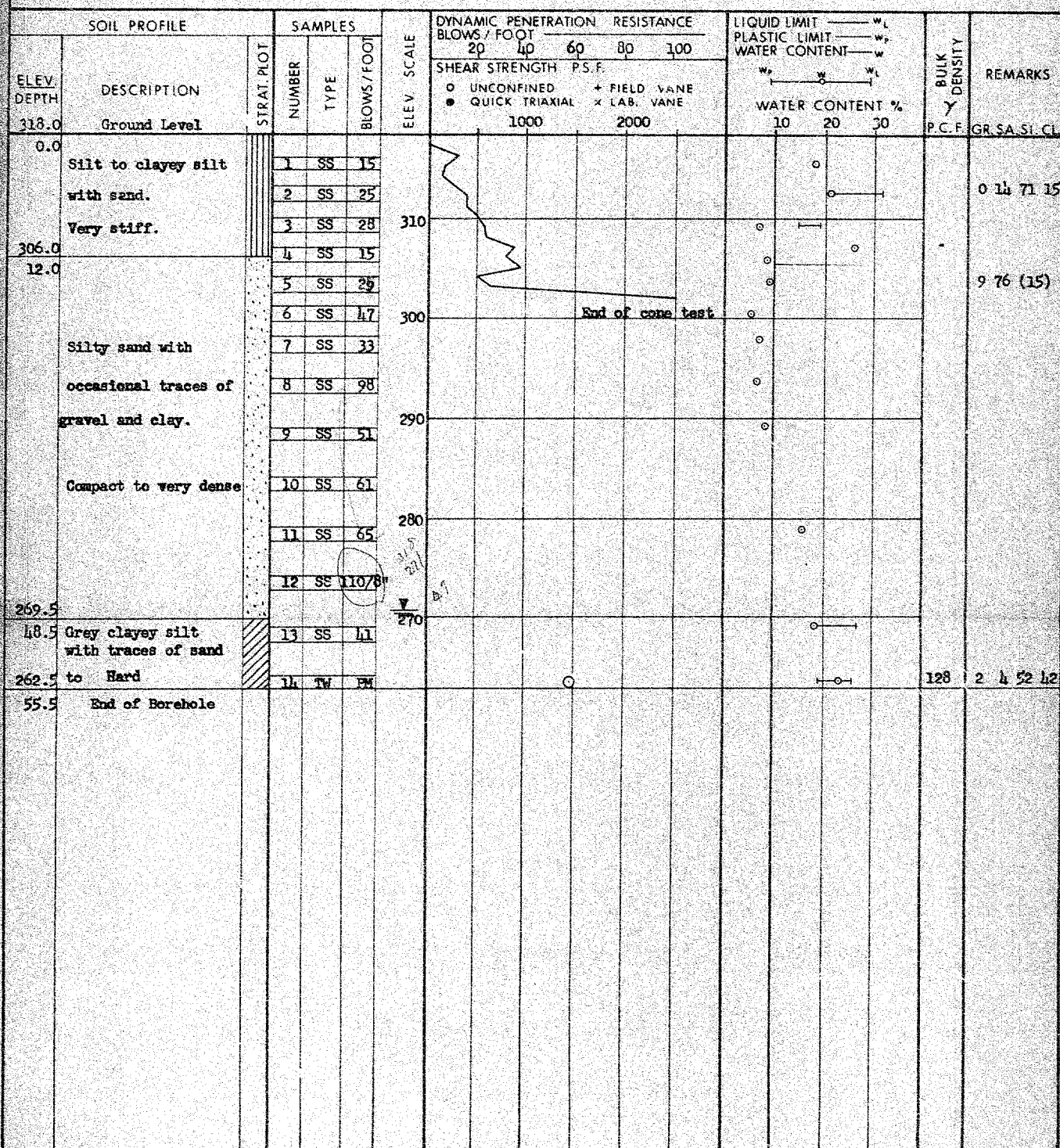
| DEPARTMENT OF HIGHWAYS - ONTARIO MATERIALS & TESTING OFFICE | | | | RECORD OF BOREHOLE No. 1 | | | | FOUNDATION SECTION | | | |
|--|--|---|--------|--------------------------|------------|------------|-----|--------------------|-----|----------------|----------------|
| JOB <u>70-F-12</u> | | LOCATION <u>Co-ords. 730,002 N; 898,567 E</u> | | ORIGINATED BY <u>GA</u> | | | | | | | |
| W.P. <u>113-66-01</u> | | BORING DATE <u>February 12, 13, 16 & 17, 1970</u> | | COMPILED BY <u>GA</u> | | | | | | | |
| DATUM <u>Geodetic</u> | | BOREHOLE TYPE <u>Washboring, MX & BX Casing</u> | | CHECKED BY <u>GA</u> | | | | | | | |
| SOIL PROFILE | | SAMPLES | | DYNAMIC PENETRATION | | RESISTANCE | | LIQUID LIMIT | | PLASTIC LIMIT | |
| ELEV. DEPTH | DESCRIPTION | STRAT. PLT. | NUMBER | TYPE | BLOWS/FOOT | 60 | 100 | 60 | 100 | W _L | W _P |
| 324.2 | Ground Level | | | | | | | | | | |
| 0.0 | Silty sand | | 1 | SS | 12 | | | | | | |
| | Compact | | 2 | SS | 28 | | | | | | |
| 314.2 | | | 3 | SS | 25 | | | | | | |
| 10.0 | Silt to clayey silt with sand. | | 4 | SS | 22 | | | | | | |
| 307.7 | Very stiff | | 5 | SS | 20 | | | | | | |
| 16.5 | | | 6 | SS | 44 | | | | | | |
| | | | 7 | SS | 46 | | | | | | |
| | Silty sand with occasional traces of gravel & clay | | 8 | SS | 42 | | | | | | |
| | | | 9 | SS | 110 | | | | | | |
| | Dense to very dense | | 10 | SS | 84 | | | | | | |
| | | | 11 | SS | 64 | | | | | | |
| | | | 12 | SS | 88 | | | | | | |
| | | | 13 | SS | 102.5" | | | | | | |
| | | | 14 | SS | 103.5" | | | | | | |
| 262.7 | | | 15 | SS | 11 | | | | | | |
| 62.5 | | | 16 | TW | 58 | | | | | | |
| | Grey clayey silt with traces of sand | | | | | | | | | | |
| | | | 17 | SS | 22 | | | | | | |
| | Stiff to very stiff | | | | | | | | | | |
| | | | 18 | TW | Hammered | | | | | | |
| 216.7 | | | | | | | | | | | |
| 107.5 | Probably Bedrock | | 19 | RC | - | | | | | | |
| 212.2 | | | | | | | | | | | |
| 212.0 | Red Shale Bedrock | | 20 | RC | 95% | | | | | | |
| 207.0 | | | | | | | | | | | |
| 117.2 | End of Borehole | | | | | | | | | | |

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 2

FOUNDATION SECTION

JOB 70-F-12 LOCATION Co-ords. 730,039 N; 898,474 E. ORIGINATED BY GA
 W.P. 113-66-01 BORING DATE February 19 & 20, 1970 COMPILED BY GA
 DATUM Geodetic BOREHOLE TYPE Washboring, NX & BX Casing CHECKED BY UK



FOUNDATION SECTION

CHECKED BY

| SOIL PROFILE | | | SAMPLES | | | ELEV. SCALE | DYNAMIC PENETRATION RESISTANCE | | LIQUID LIMIT — w_L | | BULK DENSITY | REMARKS | | | | |
|--------------|---|-------------|---------|------|--------------|---|--------------------------------|----|----------------------|----|--------------|---------|-----------------------|---------------------|-----------------|--|
| ELEV. DEPTH | DESCRIPTION | STRAT. PLOT | NUMBER | TYPE | BLOWS / FOOT | | BLOWS / FOOT | | | | | | PLASTIC LIMIT — w_p | | WATER CONTENT % | |
| | | | | | | | 20 | 40 | 60 | 80 | | | 100 | WATER CONTENT — w | | |
| | | | | | | | SHEAR STRENGTH P.S.F. | | | | | | w_p — w — w_L | | | |
| | | | | | | ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB. VANE | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| 314.3 | Ground Level | | | | | | | | | | | | | | | |
| 0.0 | Silt to clayey silt with sand. | | 1 | SS | 9 | 310 | | | | | | | 2 37 46 15 | | | |
| | Stiff to very stiff | | 2 | SS | 22 | | | | | | | | | | | |
| 303.3 | | | 3 | SS | 22 | | | | | | | | | | | |
| 11.0 | | | 4 | SS | 44 | 300 | | | | | | | | | | |
| | Silty sand with occasional traces of gravel & clay. | | 5 | SS | 66 | | | | | | | | | | | |
| | | | 6 | SS | 48 | | | | | | | | | | | |
| | | | 7 | SS | 35 | | | | | | | | | | | |
| | | | 8 | SS | 60/6" | 290 | | | | | | | | | | |
| | Dense to very dense | | 9 | SS | 76 | | | | | | | | | | | |
| | | | 10 | SS | 63 | 280 | | | | | | | | | | |
| 274.3 | | | | | | | | | | | | | | | | |
| 272.8 | Grey clayey silt with traces of sand. Hard | | 11 | SS | 54 | | | | | | | | | | | |
| 41.5 | End of Borehole | | | | | 270 | | | | | | | | | | |

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 4

FOUNDATION SECTION

JOB 70-F-12 LOCATION Co-ords. 730,115 N; 898,288 E.

ORIGINATED BY GA

W.P. 113-66-01 BORING DATE Feb. 9, 10, 11, 12 & 13, 1970

COMPILED BY GA

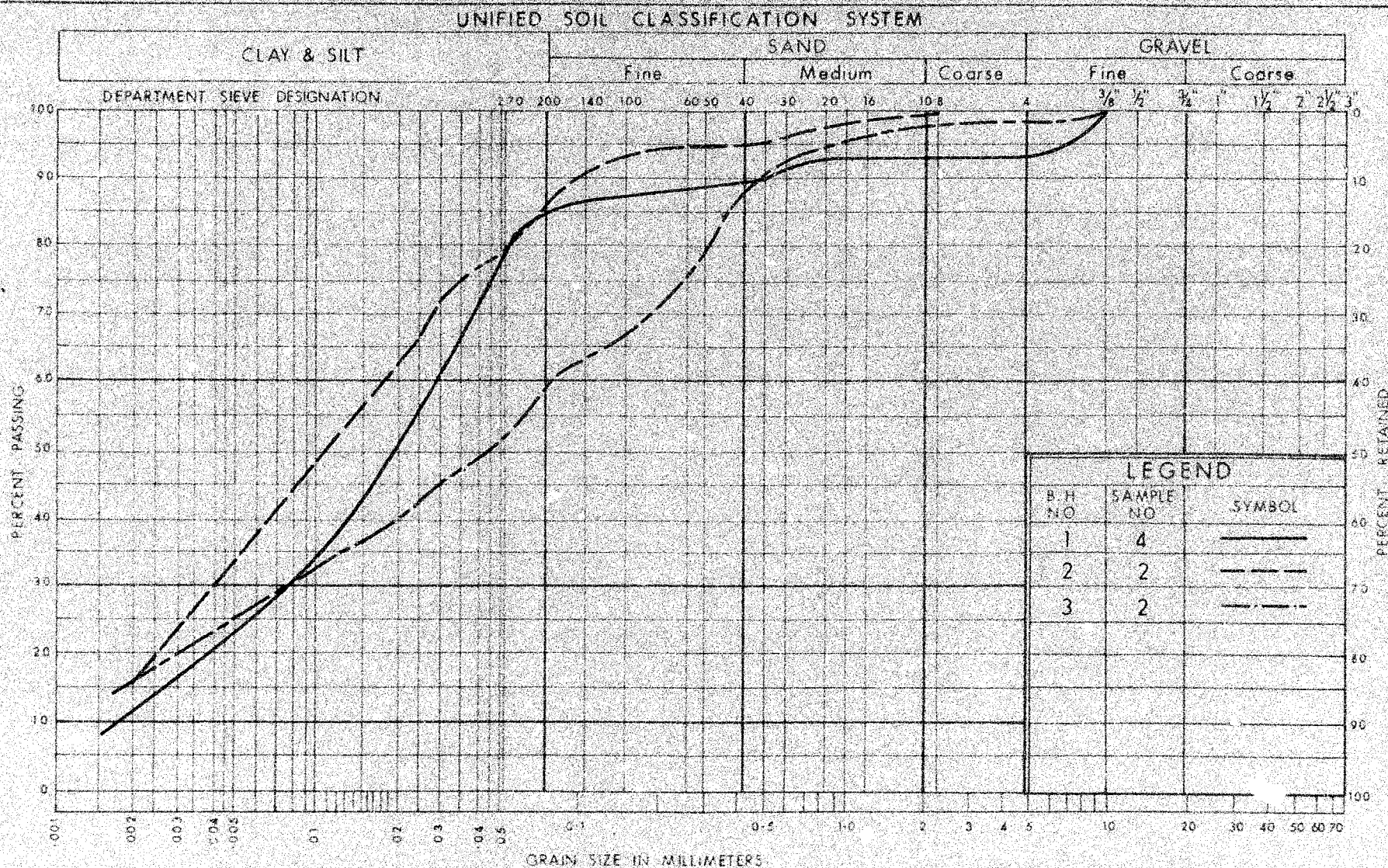
DATUM Geodetic BOREHOLE TYPE Washboring, NX & BX Casing

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 Y P.C.F. | REMARKS | | |
|--------------|---|------------|--------|------|-------------|--|----|--|----|-----------------------------|---------|-----|-----------------|
| ELEV. DEPTH | DESCRIPTION | STRAT. PLT | NUMBER | TYPE | | 20 | 40 | 60 | 80 | | | 100 | 10 |
| 325.4 | Ground Level | | | | | | | | | | | | |
| 0.0 | | | | | | | | | | | | | |
| | Silt to clayey silt with sand. | | 1 | SS | 18 | | | | | | | | |
| | | | 2 | SS | 21 | | | | | | | | |
| | Very stiff to hard. | | 3 | SS | 41 | | | | | | | | |
| | | | 4 | SS | 29 | | | | | | | | |
| 304.4 | | | 5 | SS | 33 | | | | | | | | |
| 21.0 | | | 6 | SS | 61 | | | | | | | | |
| | Silty sand with occasional traces gravel and clay | | 7 | SS | 71 | | | | | | | | |
| | | | 8 | SS | 57/6" | | | | | | | | |
| | | | 9 | SS | 130 | | | | | | | | |
| | | | 10 | SS | 110 | | | | | | | | |
| 277.9 | | | 11 | SS | 40 | | | | | | | | |
| 48.5 | | | 12 | SS | 17 | | | | | | | | |
| | Grey clayey silt traces sand. | | 13 | TW | PM | | | | | | | | 128.5 |
| | Very stiff to hard. | | 14 | TW | PM | | | | | | | | 129.0 |
| | | | 15 | SS | 22 | | | | | | | | |
| | | | 16 | TW | PM | | | | | | | | 129.0 2 5 51 42 |
| | | | 17 | SS | 23 | | | | | | | | |
| 237.9 | | | | | | | | | | | | | |
| 87.5 | Red Shale Bedrock | | 18 | RC | 70% | | | | | | | | |
| 235.1 | | | | | | | | | | | | | |
| 90.3 | End of Borehole | | | | | | | | | | | | |

JOB 70-F-12 LOCATION Co-ords. 730,062 N; 898,418 E. ORIGINATED BY GA
W.P. 113-66-01 BORING DATE February 16, 17, 18 & 19, 1970 COMPILED BY GA
DATUM Geodetic BOREHOLE TYPE Washboring, NX & BX Casing CHECKED BY LR

| SOIL PROFILE | | | SAMPLES | | | DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT | | | | | LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w | | | BULK DENSITY γ | REMARKS |
|----------------|---|-------------|---------|------|--------------|--|----|----|----|-----|--|----|----|-----------------------------|---------|
| ELEV. DEPTH | DESCRIPTION | STRAT. PLOT | NUMBER | TYPE | BLOWS / FOOT | 20 | 40 | 60 | 80 | 100 | 10 | 20 | 30 | | |
| 315.8 | Ground Level | | | | | | | | | | | | | | |
| 0.0 | Silt to clayey silt with sand. | | 1 | SS | 9 | | | | | | | | | | |
| 308.1 | Stiff to very stiff. | | 2 | SS | 24 | | | | | | | | | | |
| 7.3 | Silty sand with occasional traces of gravel and clay. Compact to very dense. | | 3 | SS | 40 | | | | | | | | | | |
| | | | 4 | SS | 21 | | | | | | | | | | |
| | | | 5 | SS | 90 | | | | | | | | | | |
| | | | 6 | SS | 41 | | | | | | | | | | |
| | | | 7 | SS | 39 | | | | | | | | | | |
| | | | 8 | SS | 65 | | | | | | | | | | |
| | | | 9 | SS | 80 | | | | | | | | | | |
| | | | 10 | SS | 100 | | | | | | | | | | |
| | | | 11 | SS | 108 | | | | | | | | | | |
| | | | 12 | SS | 100 | | | | | | | | | | |
| 270.1 | | | | | | | | | | | | | | | |
| 45.3 | Grey clayey silt. Stiff to hard | | 13 | TW | PM | | | | | | | | | 130 | |
| | | | 14 | SS | 14 | | | | | | | | | | |
| | | | 15 | TW | PM | | | | | | | | | 129 | |
| 230.1 | Bit bouncing probably bedrock | | 16 | SS | 57 | | | | | | | | | | |
| 85.3 | End of Borehole | | | | | | | | | | | | | | |



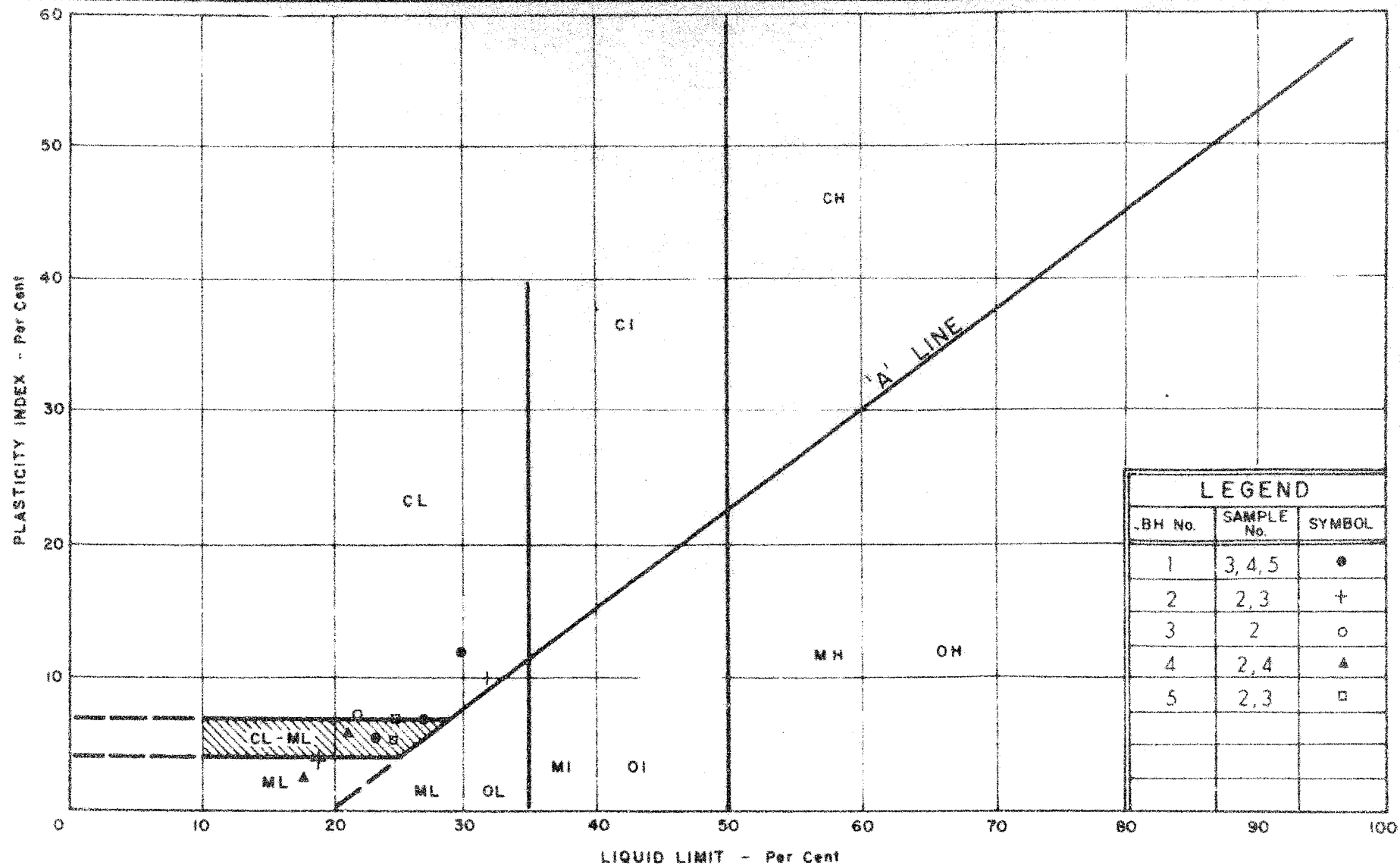
DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

GRAIN SIZE DISTRIBUTION SILT TO CLAYEY SILT WITH SAND

W.P. No. 113-66-01

JOB No. 70-F-12

FIG. No. 1

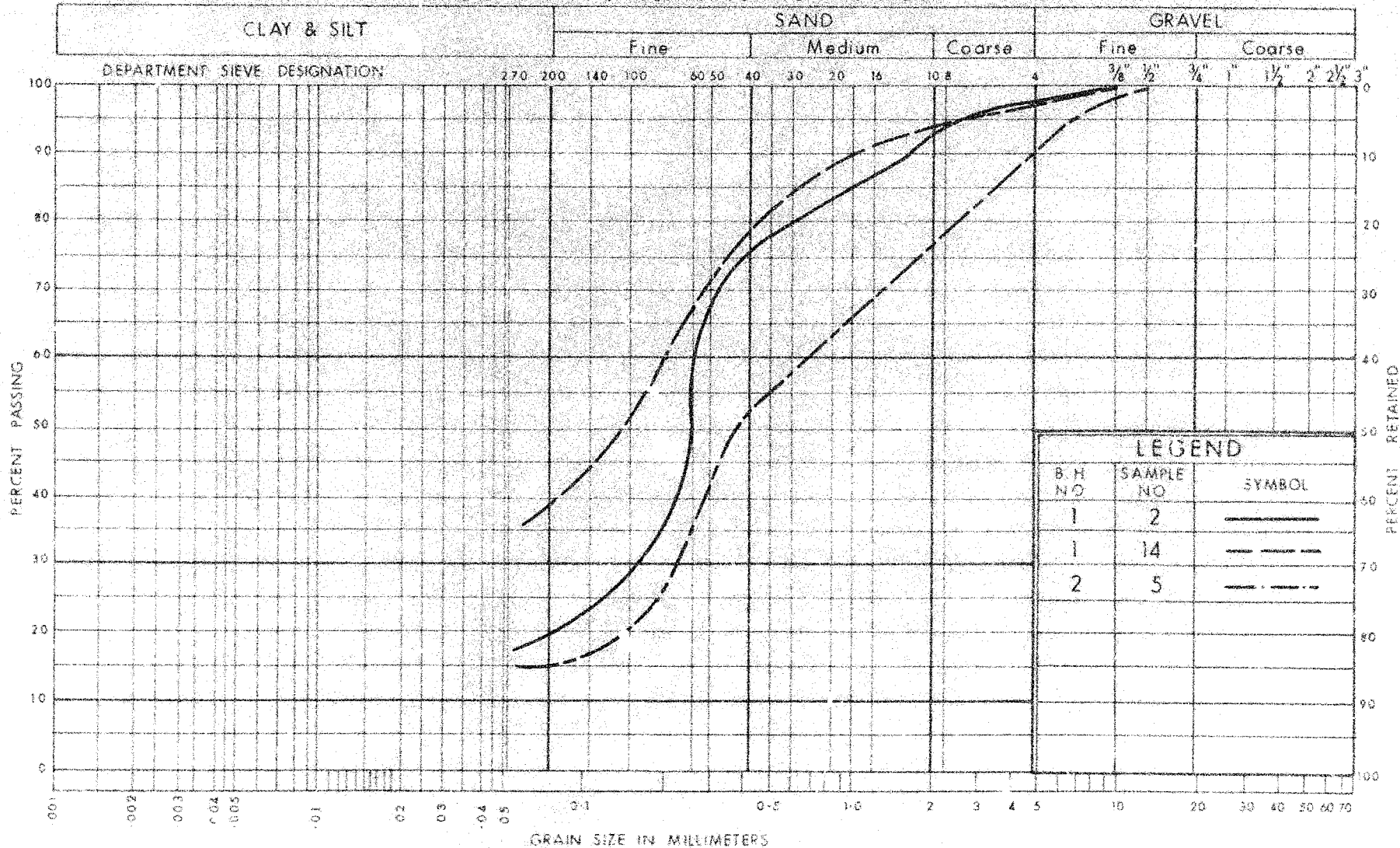


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TESTING
DIVISION

PLASTICITY CHART SILT TO CLAYEY SILT

WP No. 113-66-01
JOB No. 70-F-12
FIG No. 2

UNIFIED SOIL CLASSIFICATION SYSTEM



| LEGEND | | |
|----------|------------|-----------|
| B.H. NO. | SAMPLE NO. | SYMBOL |
| 1 | 2 | ————— |
| 1 | 14 | - - - - - |
| 2 | 5 | ————— |



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

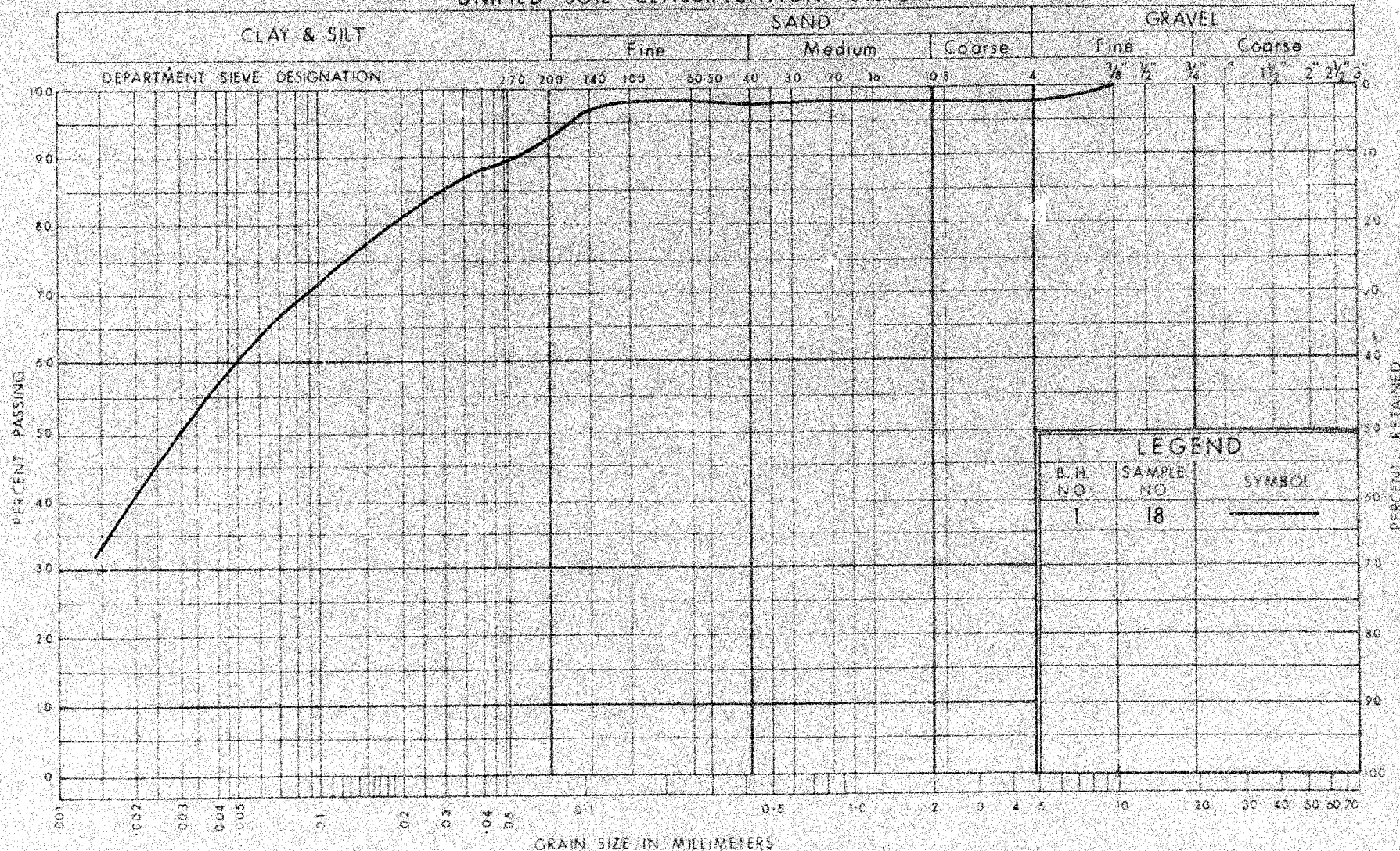
GRAIN SIZE DISTRIBUTION
SILTY SAND WITH OCCASIONAL TRACES
OF GRAVEL & CLAY

W.P. No. 113 - 66 - 01

JOB No. 70 - F - 12

FIG. No. 3

UNIFIED SOIL CLASSIFICATION SYSTEM



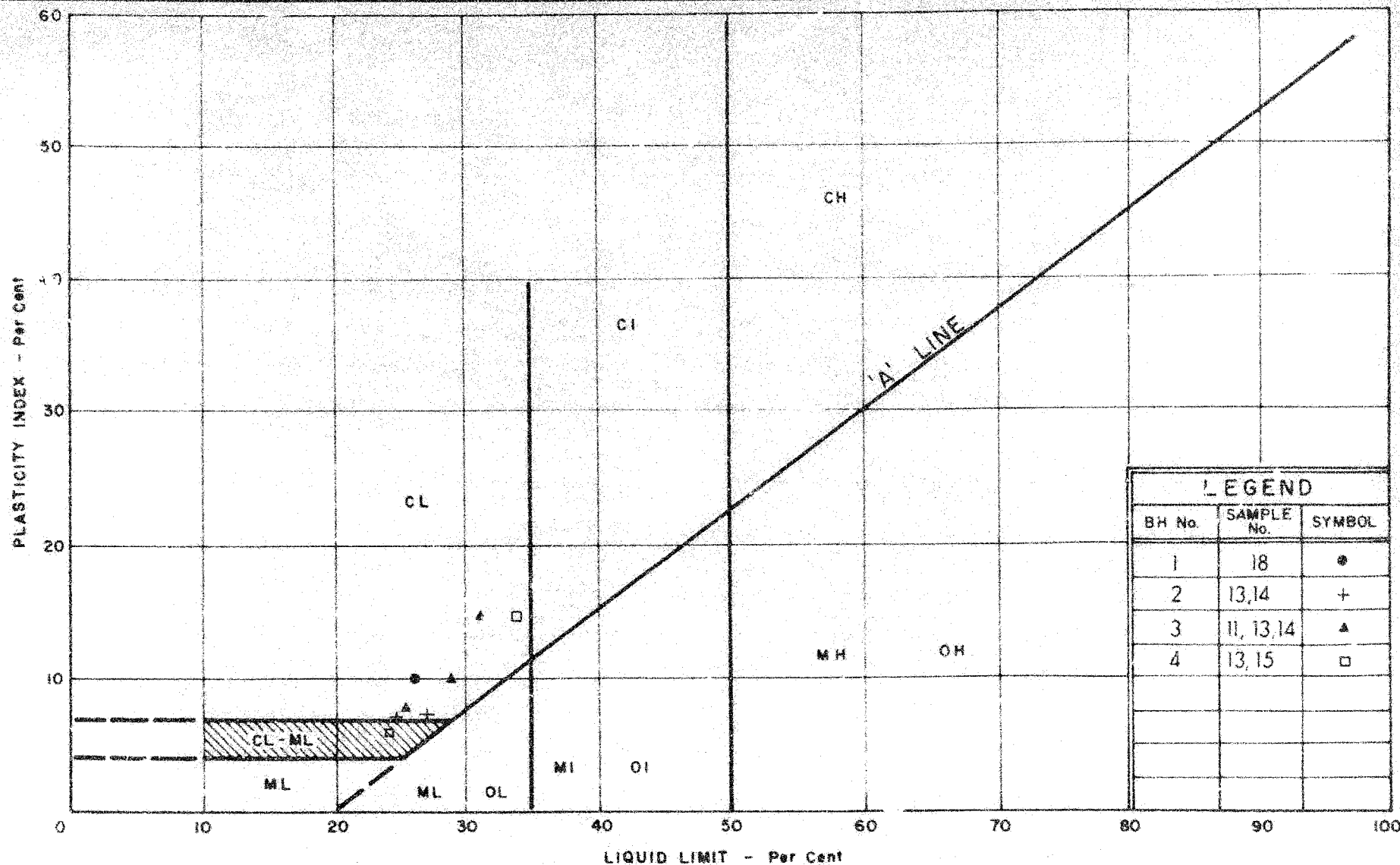
DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

GRAIN SIZE DISTRIBUTION
CLAYEY SILT WITH TRACES OF
SAND & GRAVEL

WP No. 113-66-01

JOB No. 70-F-12

FIG. No. 4



DEPARTMENT OF HIGHWAYS
**MATERIALS and
 TESTING
 DIVISION**

PLASTICITY CHART CLAYEY SILT WITH TRACES OF SAND & GRAVEL

WP No. 113-66-01

JOB No. 70-F-12

FIG No. 5

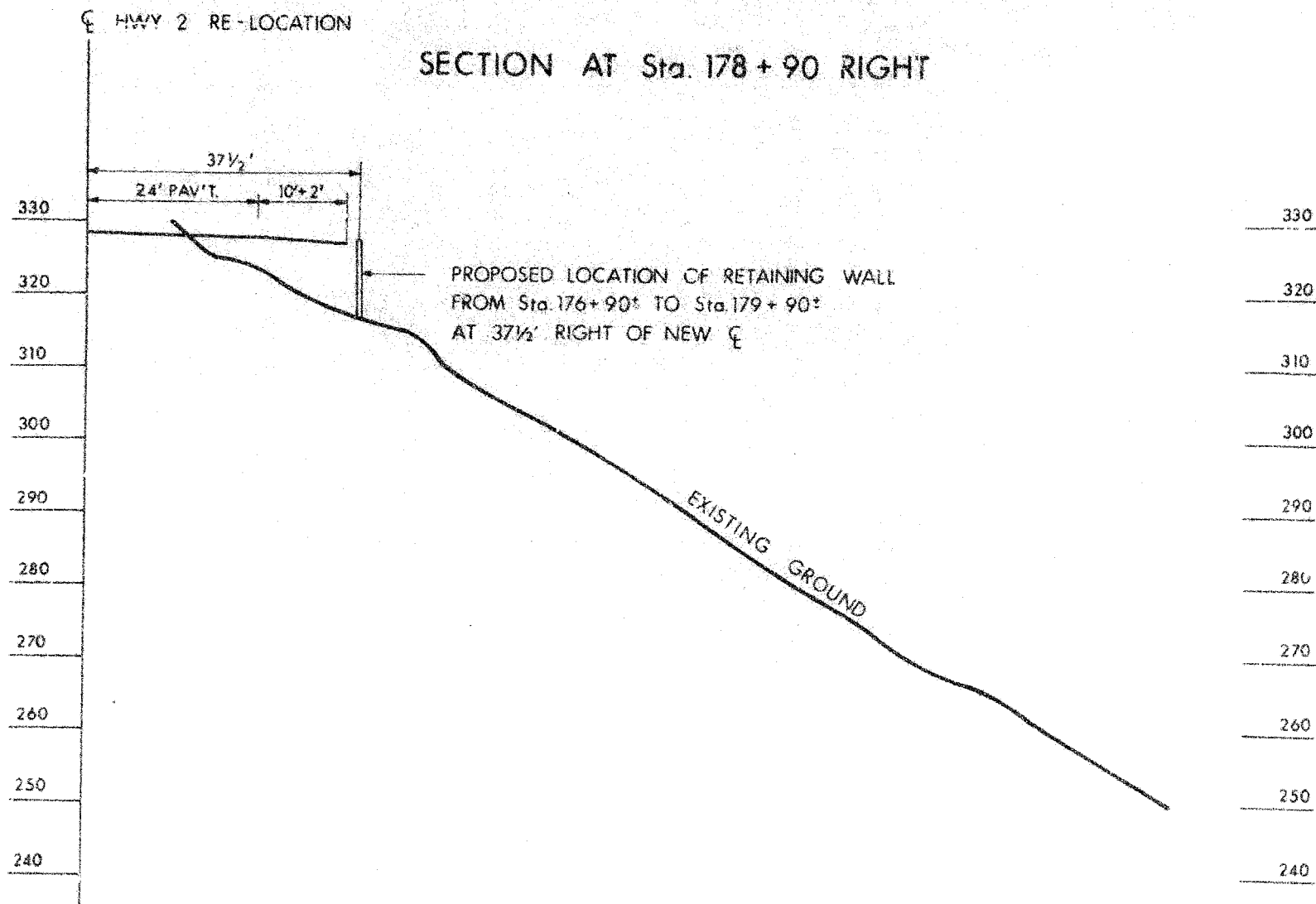


FIG. No. 6

CONT. 72-119

HWY. 2 ADJ. TO

HAMILTON

ENTRANCE

30MS-73

