

#69-F-232 M

SITE 19-44

LOT 25, CONCESSION 8

EIGHTH BRIDGE

RECONSTRUCTION.

69-F-232 M

BA. 3136
Site 19-44

Golder Associates

SOIL AND FOUNDATION ENGINEERS

October 1, 1969.

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A. M. Spriet and Associates Limited,
555 York Street,
LONDON 14, Ontario.

CON 8 LOT 25

ATTENTION: Mr. W. E. Kelley, P. Eng.

RE: Subsurface Investigation,
Proposed Eighth Bridge
Reconstruction, McGillivray
Township, Middlesex County, Ontario

Dear Sirs:

This letter reports the results of a subsurface investigation carried out at the site of the proposed Eighth Bridge reconstruction at Concession VIII crossing of the Ausable River, McGillivray Township in the County of Middlesex, Ontario. The purpose of the investigation was to determine the soil and groundwater conditions at the site and to make recommendations for the design and construction of the proposed structure and approach embankments.

PROCEDURE

Four boreholes were put down at the site on September 10 and 11, 1969, at the locations shown on the plan, Figure 1, using a trailer mounted power auger supplied and operated by P.V.K and Sons Drilling Limited. Standard penetration tests were carried out in all the boreholes and the samples obtained brought to our London laboratory for detailed examination and representative testing. The soil stratigraphy encountered in the boreholes is shown in detail on the Record of Borehole

sheets attached to this letter and an inferred stratigraphic section along the centreline of the proposed bridge is shown together with the plan on Figure 1. The results of the laboratory testing are given on the Records of Boreholes and on Figures 2 to 5 inclusive. Groundwater levels were observed in the open boreholes during drilling and in perforated standpipes installed in the completed boreholes. The groundwater levels as measured one week after the completion of drilling are shown on the Records of Boreholes and on the stratigraphic section. The field work was continuously supervised by a member of our engineering staff.

The ground surface elevations at borehole locations given in this report are referred to a bench mark, namely, a nail in a tree 15 feet south of station 12+06. The elevation of this point was given by A. M. Spriet and Associates Limited as 200.00 referred to a local datum.

SITE AND GEOLOGY

The site is located on Lot 25 of Concession VIII of McGillivray Township in the County of Middlesex, Ontario. The Ausable River at this point is some 50 feet wide at normal stage and is presently spanned by an 87 foot long steel truss bridge with a timber deck.

The site is located in the physiographic region known as the Horseshoe Moraines. Available geological information indicates that the general soil conditions at the site consist of clay overlying glacial till strata which in turn overlie limestone bedrock of the Delaware Formation.

SOIL CONDITIONS

The soil conditions at the site consist of fill from the existing roadway embankment overlying strata of sand and

gravel and stiff to very stiff silty clay which in turn overlies a layer of hard silty clay till. The existing roadway clayey silt fill was about 10 feet thick at the borehole locations and was generally firm to stiff with an average N value as determined in the standard penetration test of about 8 blows per foot. The fill had a natural water content of about 10 to 30 per cent and a typical grain size distribution curve is shown on Figure 2. Beneath the fill in boreholes 3 and 4, a 2 foot stratum of topsoil was encountered probably representing the original ground surface before the existing embankment was constructed.

Below the fill and topsoil, a stratum of loose to dense and generally compact sand and gravel was encountered in all boreholes. The sand and gravel was from 2 to 3 feet thick at the borehole locations; a typical grain size distribution curve for this layer is shown on Figure 3.

Underlying the sand and gravel, about 6 feet of very stiff silty clay was found. This stratum had an average natural water content of about 22 per cent with liquid and plastic limits of 27 and 15 respectively. Typical grain size distribution curves for the silty clay are shown on Figure 4.

Beneath the silty clay, a stratum of hard silty clay till with some sand and occasional pieces of gravel was penetrated for about 10 feet in each boring. The till had an average natural water content of about 15 per cent and liquid and plastic limits of 33 and 17 respectively. Typical grain size distribution curves for the till are shown on Figure 5. Borehole 4 was terminated in very dense silt which probably forms a pocket within the till stratum.

GROUNDWATER CONDITIONS

The groundwater level readings taken one week after the completion of drilling in the perforated standpipes installed in the completed boreholes showed the groundwater level to vary from elevation 180 to 192. The corresponding water level in the Ausable River was at elevation 191. The low groundwater levels in boreholes 1 and 4 are believed due to the smearing of the more pervious strata with the underlying clay during drilling and are not considered representative of the actual groundwater conditions.

DISCUSSION

General

It is understood that the existing single span steel truss structure is to be replaced by a 3 span reinforced concrete bridge following the existing roadway alignment. The new centreline grade will be some 4 feet above existing grade.

Foundation

The proposed bridge may be founded on spread footings bearing on the hard silty clay till. An allowable bearing pressure of 4.0 tons per square foot may be used at elevation 181. It is recommended that a thin layer of lean concrete be placed over the foundation soil as soon as the footings are excavated to grade to prevent softening of the soil due to unfavourable weather conditions or construction procedures.

*11' below
NWL 0*

If retaining type abutments are used, it is recommended that free draining, non-frost susceptible backfill be used behind the abutments. The backfill should be compacted in loose lifts not exceeding 12 inches loose thickness and should extend at least 6 feet back from the abutment walls. Provided that there is effective drainage behind the walls, an active

coefficient of earth pressure of 0.3 and a total unit weight of 135 pounds per cubic foot may be used for the design of the walls.

The presence of the pervious waterbearing sand and gravel stratum above the recommended founding elevation may present some difficulties during construction. However, it should be possible to handle the anticipated inflow of water by pumping from sumps. Timber sheeting may be required to support the sides of the footing excavations if construction is carried out during a wet period when high river levels would preclude the use of sloped sides for the excavations.

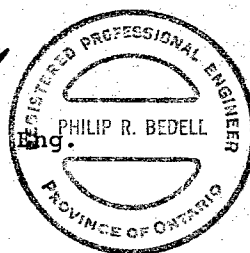
We trust this letter provides sufficient information for the design of the proposed bridge foundations and approach embankments. If any point requires further clarification, do not hesitate to contact our office.

Yours truly,

H. Q. GOLDER & ASSOCIATES LTD.,

Philip R. Bedell

Philip R. Bedell, P. Eng.



Brian E. W. Dowse

Brian E. W. Dowse, P. Eng. /PRB

PRB:BEWD:cmn
69426

LIST OF ABBREVIATIONS

The abbreviations commonly employed on each "Record of Borehole," on the figures and in the text of the report, are as follows:

I. SAMPLE TYPES

AS auger sample
CS chunk sample
DO drive open
DS Denison type sample
FS foil sample
RC rock core
ST slotted tube
TO thin-walled, open
TP thin-walled, piston
WS wash sample

II. PENETRATION RESISTANCES

Dynamic Penetration Resistance: The number of blows by a 140-pound hammer dropped 30 inches required to drive a 2-inch diameter, 60 degree cone one foot, where the cone is attached to 'A' size drill rods and casing is not used.

Standard Penetration Resistance, *N*: The number of blows by a 140-pound hammer dropped 30 inches required to drive a 2-inch drive open sampler one foot.

WH sampler advanced by static weight—weight, hammer
PH sampler advanced by pressure—pressure, hydraulic
PM sampler advanced by pressure—pressure, manual

III. SOIL DESCRIPTION

(a) Cohesionless Soils

| <i>Relative Density</i> | <i>N, blows/ft.</i> |
|-------------------------|---------------------|
| Very loose | 0 to 4 |
| Loose | 4 to 10 |
| Compact | 10 to 30 |
| Dense | 30 to 50 |
| Very dense | over 50 |

(b) Cohesive Soils

| <i>Consistency</i> | <i>c_u, lb./sq. ft.</i> |
|--------------------|-----------------------------------|
| Very soft | Less than 250 |
| Soft | 250 to 500 |
| Firm | 500 to 1,000 |
| Stiff | 1,000 to 2,000 |
| Very stiff | 2,000 to 4,000 |
| Hard | over 4,000 |

IV. SOIL TESTS

C consolidation test
H hydrometer analysis
M sieve analysis
MH combined analysis, sieve and hydrometer¹
Q undrained triaxial²
R consolidated undrained triaxial²
S drained triaxial
U unconfined compression
V field vane test

NOTES:

¹Combined analyses when 5 to 95 per cent of the material passes the No. 200 sieve.

²Undrained triaxial tests in which pore pressures are measured are shown as \bar{Q} or \bar{E} .

LIST OF SYMBOLS

I. 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 |

II. STRESS AND STRAIN

| | |
|-----------------|--|
| u | pore pressure |
| σ | normal stress |
| σ' | normal effective stress ($\bar{\sigma}$ is also used) |
| τ | shear stress |
| ϵ | linear strain |
| ϵ_{xy} | 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 |

III. SOIL PROPERTIES

(a) Unit weight

| | |
|------------|---|
| 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_s | specific gravity of solid particles $G_s = \gamma_s / \gamma_w$ |
| e | void ratio |
| n | porosity |
| w | water content |
| S_r | degree of saturation |

(b) Consistency

| | |
|-----------|--|
| w_L | liquid limit |
| w_P | plastic limit |
| I_P | plasticity index |
| w_S | shrinkage limit |
| I_L | liquidity index = $(w - w_P) / I_P$ |
| I_C | consistency index = $(w_L - w) / I_P$ |
| e_{max} | void ratio in loosest state |
| e_{min} | void ratio in densest state |
| D_r | relative density = $(e_{max} - e) / (e_{max} - e_{min})$ |

(c) Permeability

| | |
|-----|-------------------------------|
| 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 |

(d) Consolidation (one-dimensional)

| | |
|-------|--|
| m_v | coefficient of volume change = $-\Delta e / (1+e) \Delta \sigma'$ |
| C_c | compression index = $-\Delta e / \Delta \log_{10} \sigma'$ |
| c_s | coefficient of consolidation |
| T_v | time factor = c_s / d^2 (d , drainage path) |
| U | degree of consolidation |

(e) Shear strength

| | |
|----------|---|
| τ_f | shear strength |
| c' | effective cohesion |
| 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 | sensitivity |

*For the case of a saturated cohesive soil, $\phi_u = 0$ and the undrained shear strength $\tau_f = c_u$ is taken as half the undrained compressive strength.

RECORD OF BOREHOLES 1a2

LOCATION See Figure 1

BORING DATE SEPT. 10 & 11, 1963

DATUM LOCAL

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.

PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

| BORING METHOD | SOIL PROFILE | | | SAMPLES | | | ELEVATION SCALE | DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. | | | | COEFFICIENT OF PERMEABILITY, K, CM./SEC. | | | | ADDITIONAL LAB. TESTING | PIEZOMETER OR STANDPIPE INSTALLATION |
|-----------------------------------|--------------|---|-------------|---------|------|-----------|-----------------|---|----|----|----|--|------|------|--|--|--------------------------------------|
| | ELEV'N DEPTH | DESCRIPTION | STRAT. PLOT | NUMBER | TYPE | BLOWS/FT. | | SHEAR STRENGTH Cu., LB./SQ. FT. | | | | WATER CONTENT, PERCENT | | | | | |
| | | | | | | | | 20 | 40 | 60 | 80 | 1x10 | 1x10 | 1x10 | 1x10 | | |
| POWER AUGER 4.5" DIA (UNCASED) | 200.0 | ROAD LEVEL | | | | | | | | | | | | | | PROTECTIVE PIPE AND CAP GROUND SURFACE SURFACE SEAL BACKFILL PLASTIC TUBING STANDPIPE WATER LEVEL IN STANDPIPE AT ELEV. 175.0 SEPT. 17, 1963 | |
| | 199.0 | ROAD BASE | | 1 | 2" | 3 | | | | | | | | | | | |
| | 198.0 | SOFT TO FIRM BROWN CLAYEY SILT (FILL) | | 2 | " | 6 | | | | | | | | | | | |
| | 197.0 | DOUBTLESSLY SAND AND GRAVEL TRACED SILT | | 3 | " | 8 | | | | | | | | | | | |
| | 196.0 | DOUBTLESSLY SAND AND GRAVEL TRACED SILT | | 4 | " | 8 | | | | | | | | | | | |
| | 195.0 | DOUBTLESSLY SAND AND GRAVEL TRACED SILT | | 5 | " | 33 | | | | | | | | | | | |
| | 194.0 | DOUBTLESSLY SAND AND GRAVEL TRACED SILT | | 6 | " | 10 | | | | | | | | | | | |
| | 193.0 | DOUBTLESSLY SAND AND GRAVEL TRACED SILT | | 7 | " | 1 | | | | | | | | | | | |
| | 192.4 | DOUBTLESSLY SAND AND GRAVEL TRACED SILT | | 8 | " | 1 | | | | | | | | | | | |
| | 191.0 | DOUBTLESSLY SAND AND GRAVEL TRACED SILT | | 9 | " | 99 | | | | | | | | | | | |
| | 190.0 | DOUBTLESSLY SAND AND GRAVEL TRACED SILT | | 10 | " | 75 | | | | | | | | | | | |
| 188.0 | END OF HOLE | | 11 | " | 60 | | | | | | | | | | | | |
| POWER AUGER 4.5" DIA (UNCASED) | 201.6 | ROAD LEVEL | | | | | | | | | | | | | PROTECTIVE PIPE AND CAP GROUND SURFACE SURFACE SEAL PLASTIC TUBING STANDPIPE BACKFILL WATER LEVEL IN STANDPIPE AT ELEV. 180.0 SEPT. 17, 1963 | | |
| | 200.0 | ROAD BASE | | 1 | 2" | 8 | | | | | | | | | | | |
| | 199.0 | FIRM BROWN CLAYEY SILT SOME SAND (FILL) | | 2 | " | 8 | | | | | | | | | | | |
| | 198.0 | DOUBTLESSLY SAND AND GRAVEL TRACED SILT | | 3 | " | 7 | | | | | | | | | | | |
| | 197.0 | DOUBTLESSLY SAND AND GRAVEL TRACED SILT | | 4 | " | 22 | | | | | | | | | | | |
| | 196.0 | DOUBTLESSLY SAND AND GRAVEL TRACED SILT | | 5 | " | 6 | | | | | | | | | | | |
| | 195.0 | DOUBTLESSLY SAND AND GRAVEL TRACED SILT | | 6 | " | 21 | | | | | | | | | | | |
| | 194.0 | DOUBTLESSLY SAND AND GRAVEL TRACED SILT | | 7 | " | 21 | | | | | | | | | | | |
| | 193.0 | DOUBTLESSLY SAND AND GRAVEL TRACED SILT | | 8 | " | 40 | | | | | | | | | | | |
| | 192.0 | DOUBTLESSLY SAND AND GRAVEL TRACED SILT | | 9 | " | 100 | | | | | | | | | | | |
| | 191.0 | DOUBTLESSLY SAND AND GRAVEL TRACED SILT | | 10 | " | 100 | | | | | | | | | | | |
| | 190.0 | END OF HOLE | | 11 | " | 60 | | | | | | | | | | | |

0
15 5 Percent axial strain at failure
10

VERTICAL SCALE
1 IN. TO 10 FT.

Golder Associates

DRAWN Y.H.
CHECKED Y.H.

RECORD OF BOREHOLES 3 & 4

LOCATION See Figure 1

BORING DATE SEPT. 11, 1965

DATUM LOCAL

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.

PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

| BORING METHOD | SOIL PROFILE | | | SAMPLES | | | ELEVATION SCALE | DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. | | | | COEFFICIENT OF PERMEABILITY, K, CM./SEC. | | | | ADDITIONAL LAB. TESTING | PIEZOMETER OR STANDPIPE INSTALLATION |
|-----------------------------------|--------------|---|-------------|---------|------|-----------|-----------------|---|--------------------------------|---------------------------------------|--|--|--|--|--|-------------------------|--------------------------------------|
| | ELEV'N DEPTH | DESCRIPTION | STRAT. PLOT | NUMBER | TYPE | BLOWS/FT. | | 20 40 60 80 | | | | 1x10 1x10 1x10 1x10 | | | | | |
| | | | | | | | | SHEAR STRENGTH Cu, LB./SQ.FT. | NAT. V. - + REM. V. - ⊕ U. - ○ | WATER CONTENT, PERCENT Wp — W — Wl | | | | | | | |
| POWER AUGER 4.5" DIA (UNCASED) | 202.5 | ROAD LEVEL | | | | | | | | | | | | | | | |
| | 202.5 | LOAD BASE | | 1 | 02" | 16 | | | | | | | | | | | |
| | 199.5 | STIFF TO VERY STIFF BROWN CLAYEY SILT SAND (FILL) | | 2 | " | 3 | | | | | | | | | | | |
| | 198.5 | | | 3 | " | 10 | | | | | | | | | | | |
| | 198.5 | SOFT BLACK SILTY TOPSOIL | | 4 | " | 7 | | | | | | | | | | | |
| | 197.5 | COMPACT BROWN SAND AND GRAVEL | | 5 | " | 2 | | | | | | | | | | | |
| | 197.5 | | | 6 | " | 17 | | | | | | | | | | | |
| | 197.5 | STIFF TO VERY STIFF GREY SILTY CLAY | | 7 | " | 10 | | | | | | | | | | | |
| | 181.5 | HARD GREY SILTY CLAY SOME SAND OCCASIONAL GRAVEL (TILL) | | 8 | " | 16 | | | | | | | | | | | |
| | 175.5 | | | 9 | " | 80 | | | | | | | | | | | |
| | 28.5 | END OF HOLE | | 10 | " | 160 | | | | | | | | | | | |
| POWER AUGER 4.5" DIA (UNCASED) | 202.5 | ROAD LEVEL | | | | | | | | | | | | | | | |
| | 202.5 | LOAD BASE | | 1 | 02" | 3 | | | | | | | | | | | |
| | 199.5 | FIRM TO STIFF BROWN CLAYEY SILT SAND (FILL) | | 2 | " | 5 | | | | | | | | | | | |
| | 198.5 | | | 3 | " | 8 | | | | | | | | | | | |
| | 198.5 | SOFT BLACK SILTY TOPSOIL | | 4 | " | 5 | | | | | | | | | | | |
| | 197.5 | COMPACT BROWN SAND AND GRAVEL | | 5 | " | 4 | | | | | | | | | | | |
| | 197.5 | | | 6 | " | 12 | | | | | | | | | | | |
| | 197.5 | STIFF TO VERY STIFF GREY SILTY CLAY | | 7 | " | 14 | | | | | | | | | | | |
| | 181.5 | HARD GREY SILTY CLAY SOME SAND OCCASIONAL GRAVEL (TILL) | | 8 | " | 16 | | | | | | | | | | | |
| | 175.5 | | | 9 | " | 75 | | | | | | | | | | | |
| | 172.5 | VERY FINE GREY SILT FINE CLAY | | 10 | " | 66 | | | | | | | | | | | |
| 31.0 | END OF HOLE | | 11 | " | 00 | | | | | | | | | | | | |

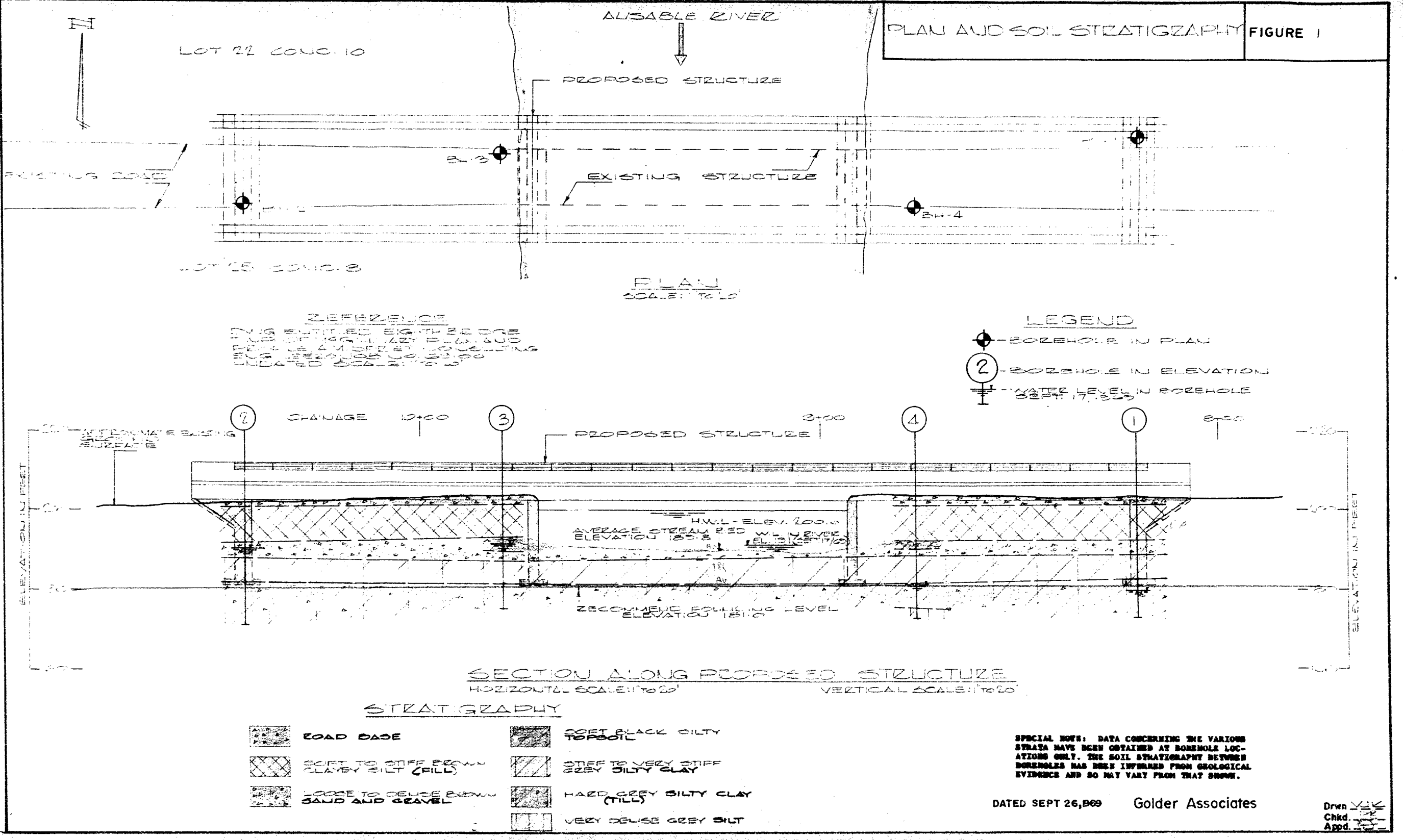
0
15 5 Percent axial strain at failure

0
15 ± 5 Percent axial strain at failure
10

VERTICAL SCALE
1 IN. TO 10 FT.

Golder Associates

DRAWN VJK
CHECKED



GRAIN SIZE DISTRIBUTION

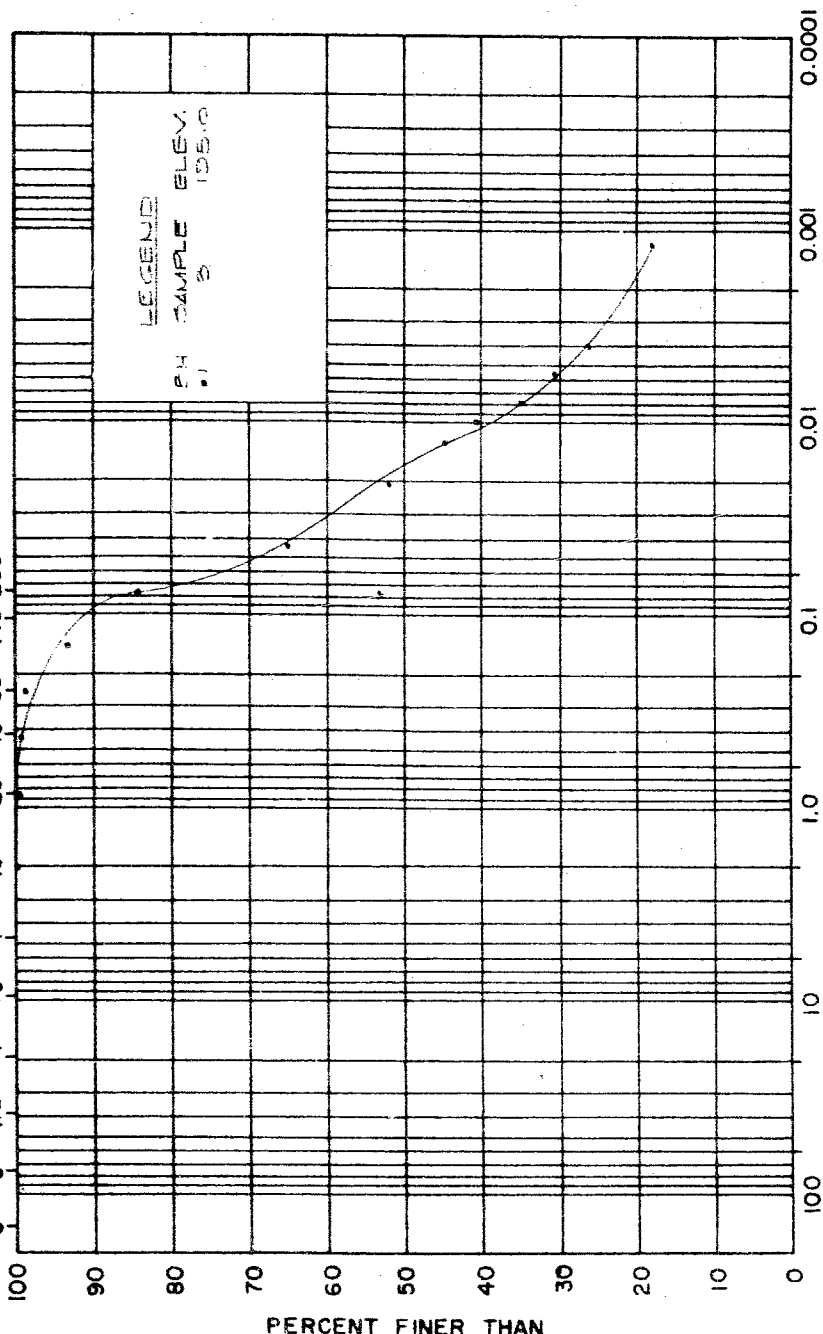
CLAYEY SILT FILL

FIGURE 2

M.I.T. GRAIN SIZE SCALE

SIZE OF OPENING - INS. U.S.S. SIEVE SIZE - MESHES/IN.

6" 3" 1 1/2" 3/4" 3/8" 4 10 20 40 60 140 200



GRAIN SIZE - MM

| COBBLE SIZE | GRAVEL SIZE | | | SAND SIZE | | | FINE GRAINED | |
|----------------|-------------|--------|------|-----------|--------|------|--------------|-----------|
| | COARSE | MEDIUM | FINE | COARSE | MEDIUM | FINE | SILT SIZE | CLAY SIZE |

PERCENT FINER THAN

GOLDER & ASSOCIATES

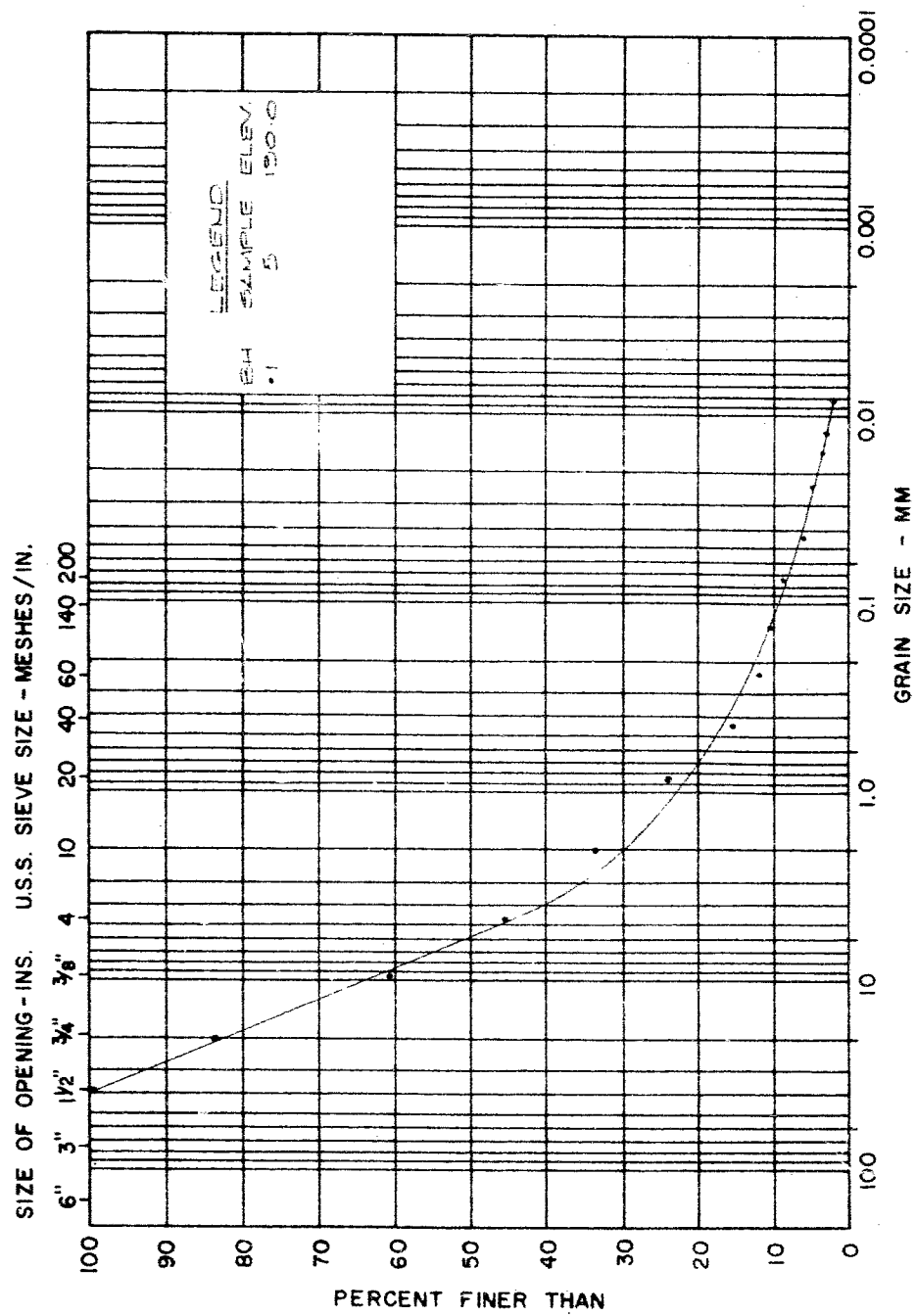
PROJECT NO. 100-100-100

GRAIN SIZE DISTRIBUTION

SAND AND GRAVEL

FIGURE 3

M.I.T. GRAIN SIZE SCALE



GOLDER & ASSOCIATES

GRAIN SIZE DISTRIBUTION

SILTY CLAY

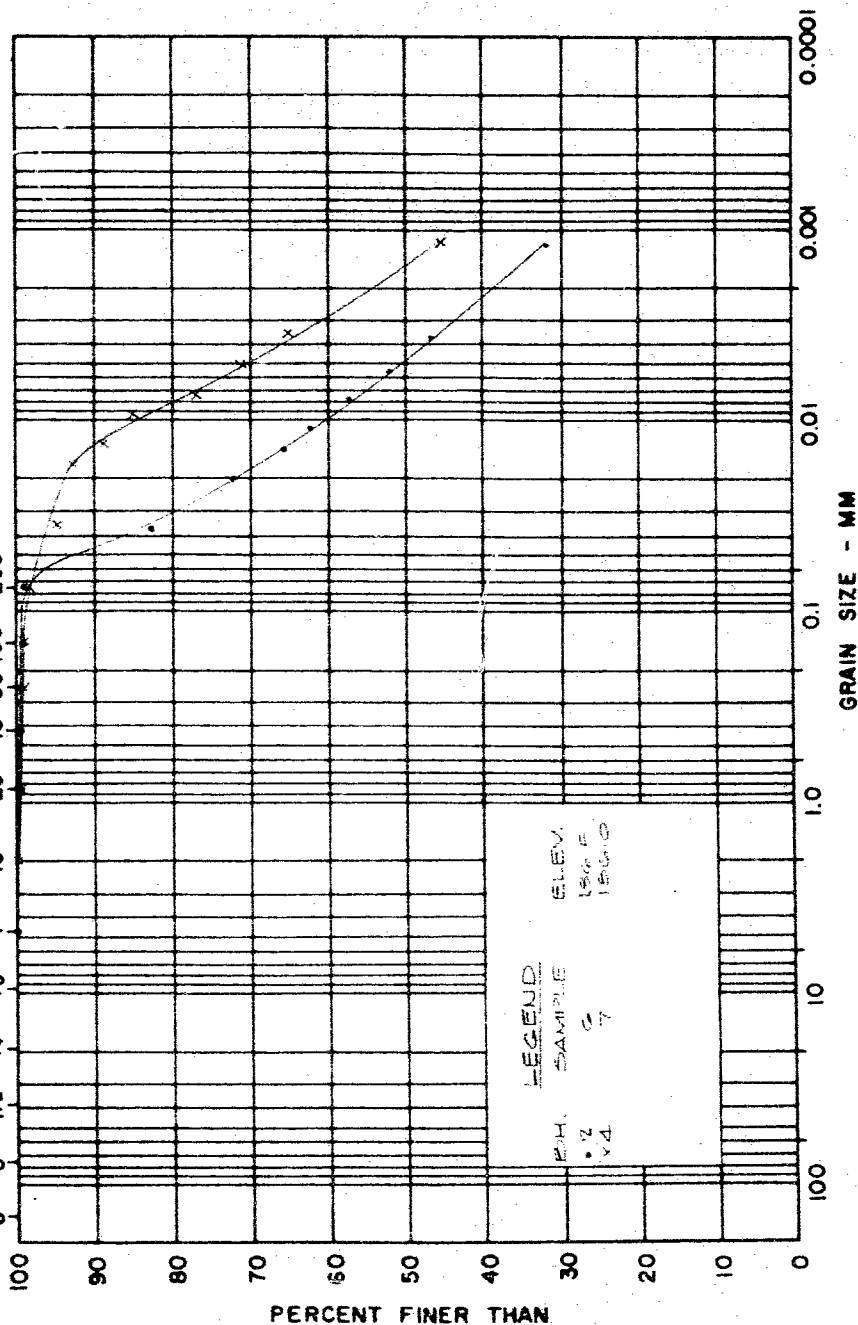
FIGURE

4

M.I.T. GRAIN SIZE SCALE

SIZE OF OPENING - INS. U.S. SIEVE SIZE - MESHES / IN.

6" 3" 1 1/2" 3/4" 3/8" 200



GOLDER & ASSOCIATES

GRAIN SIZE DISTRIBUTION

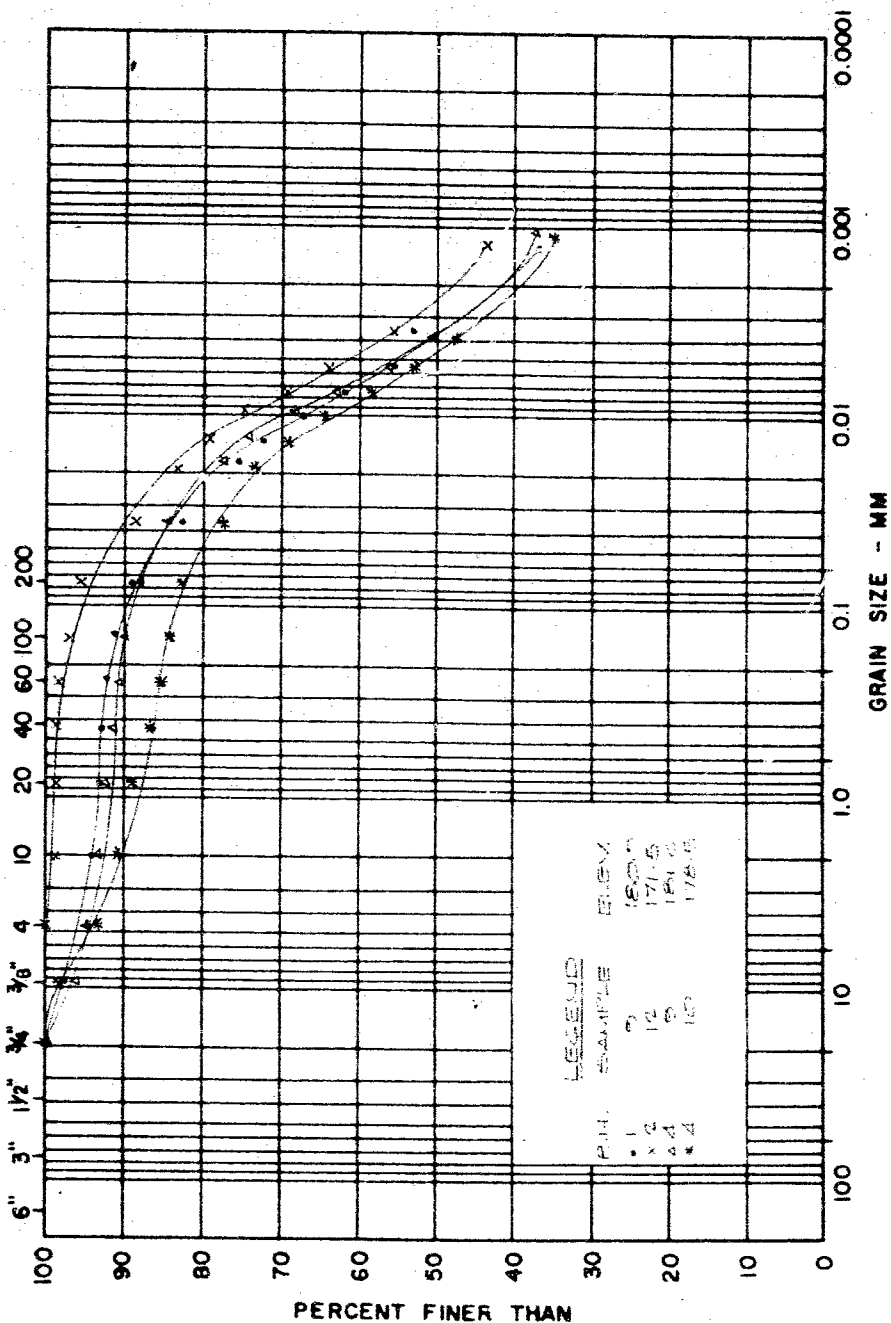
SILTY CLAY TILL

FIGURE

15

M.I.T. GRAIN SIZE SCALE

SIZE OF OPENING - INS. U.S.S. SIEVE SIZE - MESHES/IN.



| COBBLE SIZE | COARSE | MEDIUM | FINE | SAND SIZE | | SILT SIZE | | CLAY SIZE | |
|----------------|-------------|--------|------|-----------|--------|-----------|--------------|--------------|--------------|
| | GRAVEL SIZE | | | COARSE | MEDIUM | FINE | FINE GRAINED | FINE GRAINED | FINE GRAINED |

GOLDER & ASSOCIATES