

61-F-242M

EDEN BRIDGE

61-F-242 M

S7198

REPORT

TO

R. C. DUNN AND ASSOCIATES, LTD.

ON

SOIL INVESTIGATION

PROPOSED EDEN BRIDGE

COUNTY OF ELGIN

ONTARIO

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Rexdale, Ontario,
March 22nd, 1961.

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R. C. Dunn and Associates Ltd.,
Consulting Engineers,
410 Third Street,
London, Ontario.

Attention: Mr. N. M. Warner, P. Eng.

Re: Soil Investigation,
Proposed Eden Bridge,
County of Elgin, Ontario.

Dear Sirs:

This letter reports the results of the above investigation carried out in accordance with our proposal dated March 2nd, 1961 and your letter of acceptance dated March 3rd, 1961. The object of the investigation was to determine and interpret the subsoil conditions at the above site as they affect the design and construction of a proposed new creek crossing. It is understood that the proposed crossing revision will consist of either a box culvert scheme or a three span concrete bridge scheme.

PROCEDURE

The field work was carried out between March 2nd, and March 7th, 1961. Two boreholes with adjacent dynamic penetration tests were put down using mobile power auger equipment. An additional wash probing was put down manually. The boreholes were located on opposite banks of Otter Creek and the wash probing was located centrally in the existing creek channel.

R. C. Dunn and Associates Ltd.,
March 22nd, 1961,
Page 2.

PROCEDURE (continued)

The locations of the boreholes together with the inferred soil stratigraphy are shown on Drawing S7198-1 at the rear of this report. A detailed log of each boring is given on the Office Reports on Soil Exploration in Appendix I.

The laboratory testing of soil samples was carried out in the Soil Mechanics Laboratory of Geocon Ltd in Toronto and the results are given on the Office Reports and shown on the Figures in Appendix II. The samples remaining after testing will be stored until September 30th, 1961 at which time you will be notified regarding their disposal.

All elevations given in this report are referred to Local Datum. The centreline of bridge deck above the east pier, with given elevation 278.6 feet, was used as a bench mark.

SITE AND GEOLOGY

The existing Eden Bridge is located on County Road 6, about 8 miles south of Tillsonburg, between Concession VIII and IX of Bayham Township. The proposed structure is to improve the Otter Creek crossing and will be located approximately along the existing highway alignment.

Otter Creek flows in a southern direction along the bottom of a wide valley which is about 120 feet below the general elevation of the surrounding countryside. The creek has a meandering course along the valley floor which forms a flood plain. From available information the creek is known to rise about 14 feet above normal water level during maximum runoff periods.

SITE AND GEOLOGY (continued)

From available geological information it is known that Otter Creek flows approximately along the surface boundary between till moraine deposits to the west and a sand plain to the east.

SOIL CONDITIONS

The principal soil conditions encountered are as follows:

Topsoil

The valley floor is generally overlain by a thin mantle of topsoil. The topsoil was encountered in boreholes 1 and 2 and has a thickness of less than 1 foot.

Very Loose Brown Silty Sand

A stratum of very loose brown silty sand underlies the topsoil and surfaces on the creek bed. The stratum varies in thickness from 2 feet where it underlies the creek to 5 to 11 feet on the west and east banks respectively.

The results of 2 mechanical analyses performed on typical samples of the stratum are plotted on Figure 1 of Appendix II and show that the stratum is a silty fine sand with up to 50 percent silt sizes. Some organic matter in the form of roots and wood chips was encountered throughout the stratum.

Standard penetration tests carried out in the stratum gave "N" values ranging from 2 to 11 blows per foot which, together with the results of the dynamic penetration tests, indicate that the relative

SOIL CONDITIONS (continued)

Very Loose Brown Silty Sand (continued)

density of the stratum varies from very loose to compact and is generally very loose.

For design purposes the stratum may be assumed to have wet and submerged unit weights of 110 and 50 pounds per cubic foot respectively. The stratum is cohesionless and should be assumed to have an angle of internal friction of 28 degrees. The coefficient of active earth pressure K_A may be taken as 0.35.

Compact to Dense Grey Silty Sand

A stratum 11 feet thick of compact to dense grey silty sand was encountered underlying the very loose brown silty sand in borehole 1 only. This stratum was not encountered in boreholes 2 and 3.

The results of a mechanical analysis carried out on a typical sample (number 8) are given on Figure 1 of Appendix II and show the stratum to be composed of fine sand and silt. From visual inspection the stratum contains occasional roots throughout.

Standard penetration tests carried out in the stratum gave " N " values ranging from 19 to 45 blows per foot with an average value of about 30 blows per foot. These values, together with the results obtained from the dynamic penetration tests, indicate that the stratum is compact to dense and is generally dense.

SOIL CONDITIONS (continued)

Compact to Dense Grey Silty Sand (continued)

For design purposes the stratum may be considered to have a wet unit weight of 120 pounds per cubic foot and a corresponding submerged unit weight of 60 pounds per cubic foot. The angle of internal friction may be taken as 35 degrees.

Hard Grey Clayey Silt

The very loose brown silty sand in borehole 2 and the compact to dense grey silty sand in borehole 1 are underlain by a stratum of hard grey clayey silt. The upper surface of the stratum was encountered in boreholes 1 and 2 at approximately elevation 246 and 265 respectively and in the wash probing in mid creek at an elevation of 258 feet. The stratum was penetrated for a depth of 18 and 34 feet respectively in boreholes 1 and 2, at which depths the boreholes were terminated. The clayey silt is homogeneous, but contains some small subrounded pebbles up to $\frac{1}{2}$ inch in size.

Atterberg limits carried out on typical samples of the stratum show the liquid limit to range from 25 to 34 and the plasticity index to range from 10 to 17. The natural moisture content varies from 15 to 20 percent and is generally at or below the plastic limit. Based on these results the stratum is therefore an inorganic clayey silt which has been heavily preconsolidated and is of low to medium plasticity. The average wet unit weight of the stratum is 138 pounds per cubic foot at a corresponding natural moisture content of 16 percent.

SOIL CONDITIONS (continued)

Hard Grey Clayey Silt (continued)

The results of a consolidation test carried out on a sample from this stratum are given on Figure 3 of Appendix II together with a plot of the computed coefficients of consolidation. The results of the test show the stratum to be preconsolidated and to have a compression index of approximately 0.1.

Two unconfined compression tests and two undrained quick tri-axial tests were carried out on typical undisturbed samples. The results of the tests show a range of shear strength from 2.5 to 5.0 tons per square foot with an average value of 3.75 tons per square foot. The results of the tests are shown as stress-strain curves on Figure 2, Appendix II and are plotted on the borehole logs.

WATER CONDITIONS

During the period of the investigation the water level of Otter Creek was approximately at elevation 263 feet. The maximum water level which has been recorded at the site during heavy runoff periods was at elevation 277.

The water level at the location of the boreholes was several feet above the creek level and within the very loose silty sand stratum. A spring was observed uphill and west of borehole 2 at about elevation 278 feet and it is understood from local information that similar springs occur in the fields to the west of Otter Creek. It is further understood that the normal summer water level in this area is 3 to 4 feet below ground level.

DISCUSSION

It is understood that the existing Eden Bridge over Otter Creek is to be replaced in order to improve the crossing. The proposed improvement would consist of either a 3 span reinforced concrete bridge having a total length of 150 feet or a reinforced concrete box culvert, having 4-25 foot bays. The proposed box culvert would be designed so as to enable a future easing of the road grade by increasing the height of embankment over the culvert. The proposed locations and layouts are shown on R. C. Dunn and Associates Ltd. sketch 1, Job No. 61-103 and are reproduced on our drawing S7198-2 located at the rear of this report.

The alternative proposals are discussed separately below:

Proposed Culvert Scheme

The proposed culvert would be located off-centre by approximately 40 feet east of the existing creek channel and centrally on the existing alignment centrelines. Future raising of the road embankment would be accomplished by increasing the width of the culvert to the south.

The strata of compact to dense grey silty sand and hard grey clayey silt are suitable bearing strata for the founding of the box culvert, with provisions as discussed below. It is therefore recommended that the lower slab of the culvert as proposed be founded at or below elevation 256. On the basis of the field and laboratory test results and considering the limited thickness of the sand strata the net allowable bearing value for the proposed slab would be 2 tons per square foot. Considering even the maximum loading imposed by the

DISCUSSION (continued)

Proposed Culvert Scheme (continued)

future grade revision the actual loading will be less than the allowable value. The total and differential settlements will be within the tolerable limits for this type of structure.

The outer culvert walls should be designed so as to resist lateral pressures due to the retained soil. Due to the rigidity of the structure the at-rest conditions for the soil should be assumed and a lateral earth pressure coefficient of 0.5 for both the granular fill and the natural sand strata is recommended for use in design.

The culvert foundations at elevations 256 would be located about 4 feet below the level of the present creek bed. The upstream and downstream wing walls should be founded on spread footings at or below elevation 256 and the footings may be designed for a net allowable bearing value of 3 tons per square foot.

In view of the previously recorded maximum height of flood rise it is recommended that a suitable concrete or rip-rap apron should be provided both upstream and downstream of the culvert. This apron should be extended at the sides to provide scour protection for the wing wall foundations.

It is recommended that the approach embankments should consist of well-graded granular material compacted to at least 95 percent of optimum density as given by modified AASHO compaction. Natural embankment slopes of 1 vertical to 2 horizontal may be used. Some 3 to 4 inches of settlement of the embankments due to consolidation of the loose sand will occur but this will, for practical purposes, take place as construction progresses.

DISCUSSION (continued)

Proposed Bridge Scheme

The proposed bridge will span between shore abutments and two central piers. It is understood that the existing creek channel will be widened and the final creek banks re-sloped. The total span of the new bridge will be approximately 150 feet.

The bridge abutments and piers could be carried on spread footings founded in the compact to dense silty sand stratum or the hard clayey silt stratum, at sufficient depths to resist scour. Since the end slopes of the approach embankments must be protected by rip-rap, the east and west abutments would be safe from scour and may be founded at about elevations 256 and 265 respectively. The elevation at which the central piers should be founded is dependent on the type of scour protection used, as discussed later. Considering the measured standard penetration resistances and shear strengths of the strata involved, and the proposed superstructure design, it is recommended that an allowable bearing value of 2 tons per square foot be used in the design of the east abutment footings and a value of 3 tons per square foot in the design of the west abutment at the elevations given above. An alternative abutment design would be to provide the spill-through type supported on piles, with the piles extending above ground in the superstructure. The piles could be driven to end-bearing in the compact to dense sand and the hard silt strata at the east and west abutments at about elevations 250 and 255 respectively. The central pier foundations may also be carried on spread footings and designed for a net increase in pressure of 3 tons per square foot if positive scour protection is provided. It is recommended that the footings be founded at elevation 254 and that the creek bed be provided with rip-rap protection to prevent scour or other positive means

DISCUSSION (continued)

Proposed Bridge Scheme (continued)

used to effect this. If surface scour protection cannot be provided the pier foundations should be taken lower, probably to a depth of 10 feet. However, this is not a positive means of protection.

The approach embankments should consist of a well compacted granular fill as discussed above for the culvert scheme. The re-sloped creek banks should be formed at 1 vertical to 2 horizontal, which will allow an adequate factor of safety against failure. Adequate rip-rap protective slope cover should be provided for the end slope with a minimum depth of 1 foot.

Construction Procedures

Where it is not possible for reasons of space to slope the sides of excavation these should be supported by adequate sheeting and bracing designed to withstand lateral active earth pressures using the appropriate coefficients given under "SOIL CONDITIONS". To minimize quickening of the bottom all temporary sheeting should penetrate into undisturbed granular soil a distance at least equal to the height of the water table above the bottom of the excavations, or to a toe hold in the silt. Because of the relatively low permeability of the soils the flow of water into excavations should be such that it can be handled by normal pumping from sumps.

R. C. Dunn and Associates Ltd.,
March 22nd, 1961,
Page 11.

We believe that this report, written by Mr. R. M. Wilson, checked by Mr. K. H. King and reviewed by Mr. J. C. Osler, P. Eng., contains all the information necessary for the design of the foundations for the proposed structures. If we can be of any further assistance, we would be pleased if you would call us.

Yours very truly,

GEOCON LTD



R. M. Wilson,
Senior Soils Engineer.

RMW/dw
S7198

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APPENDIX I

OFFICE REPORTS ON SOIL EXPLORATION

GEOCON

EXPLANATION OF THE FORM "OFFICE REPORT ON SOIL EXPLORATION"

The object of this form is to enable a comprehensive study of the soil to be made by combining on one sheet all of the information obtained from the boring. An explanation of the various columns of the report follows.

ELEVATION AND DEPTH

This column gives the elevation and depth of boundaries between the various soil strata. The elevation is referred to the datum shown in the general heading.

WATER CONDITIONS

In this column the water level in the casing at the time of boring or the water table in the ground, determined by a series of observations in a piezometer or standpipe, is indicated to scale by a horizontal line with the symbol W.L. or W.T. above the line. A notation of any complicated groundwater conditions will be made in this column.

DESCRIPTION

A description of the soil, using standard terminology, is contained in this column. The consistency of cohesive soils and the relative density of non-cohesive soils are described by the following terms:

Consistency	U-Strength Tons/sq. ft.	Relative Density	Standard Penetration Resistance, Blows/ft.
Very soft	0.03 to 0.25	Very loose	0 to 4
Soft	0.25 to 0.5	Loose	4 to 10
Firm	0.5 to 1.0	Compact	10 to 30
Stiff	1.0 to 2.0	Dense	30 to 50
Very stiff	2.0 to 4.0	Very dense	over 50
Hard	over 4.0		

STRATIGRAPHIC PLOT

The stratigraphic plot follows the standard symbols of the National Research Council, Canada.

ELEVATION SCALE

The information in all columns is plotted to a true elevation scale which is shown in this column.

GRAPHS

The main body of the report forms a graph which is used to plot to correct elevation the important soil properties which are obtained through field and laboratory tests. The scales and symbols for the plotting are shown at the head of the column.

OTHER TESTS

In this column are shown, by symbol, the other field or laboratory tests which have been performed on the soil and for which the results have not been plotted on the above graph.

SAMPLES

The first three columns describe the condition, type and number of each sample obtained from the boring. The location and extent of each sample is plotted to scale.

In the last column is shown the penetration resistance in blows of 4200 inch-pounds required to drive one foot of the sampler into the ground. When a 2 inch Drive Sampler is used the result obtained is termed the "Standard Penetration Resistance".

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OFFICE REPORT ON SOIL EXPLORATION

APPEX. I

CONTRACT 57133 BORING # 1 DATUM LOCAL CASING
 BORING DATE MAR. 23, 1961 REPORT DATE MAR 31, 1961 COMPILED BY CES CHECKED BY
 SAMPLER HAMMER WT. 140 LBS. DROP 30 INCHES (PENETRATION RESISTANCES CONVERTED TO BLOWS OF 4200 IN. LBS. ENERGY)

SAMPLE CONDITION

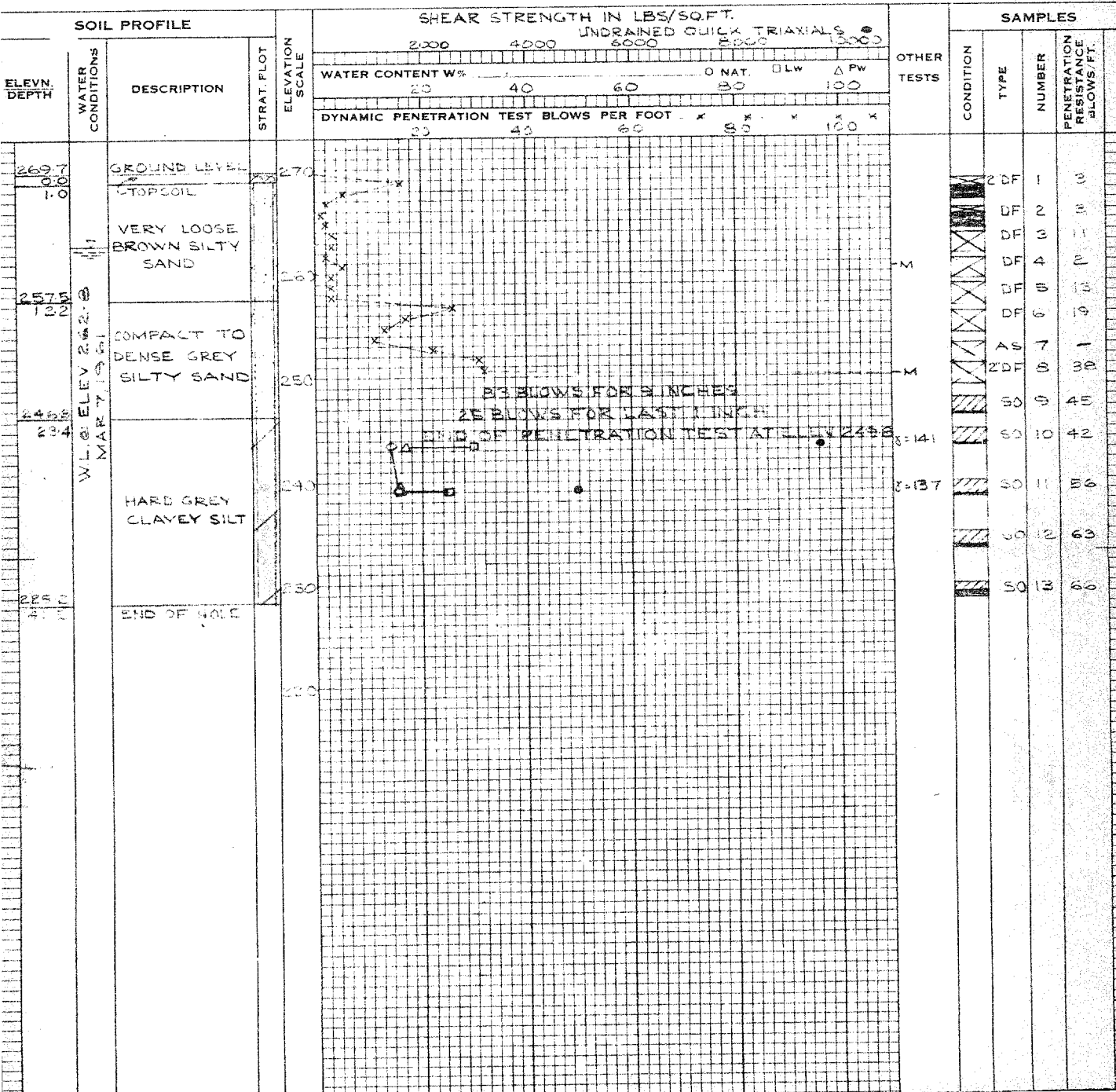
☐ DISTURBED
☐ FAIR
☐ GOOD
☐ LOST

SAMPLE TYPES

A.S. - AUGER SAMPLE
 S.T. - SLOTTED TUBE
 W.S. - WASHED SAMPLE
 D.O. - DRIVE-OPEN
 D.F. - DRIVE-FOOT VALVE
 C.S. - CHUNK SAMPLE
 F.S. - FOIL SAMPLE
 S.O. - SLEEVE-OPEN
 S.F. - SLEEVE-FOOT VALVE
 T.O. - THIN WALLED OPEN
 R.C. - ROCK CORE

ABBREVIATIONS

V - IN-SITU VANE TEST
 M - MECHANICAL ANALYSIS
 U - UNCONFINED COMPRESSION
 QC - TRIAXIAL CONSOLIDATED QUICK
 Q - TRIAXIAL QUICK
 S - TRIAXIAL SLOW
 γ - WET UNIT WEIGHT
 K - PERMEABILITY
 C - CONSOLIDATION
 WL - WATER LEVEL IN CASING
 WT - WATER TABLE IN SOIL



OFFICE REPORT ON SOIL EXPLORATION

APPENDIX I

CONTRACT S-7198 BORING # 2 DATUM LOCAL CASING ---
 BORING DATE MAR 23, 1961 REPORT DATE MAR 7, 1961 COMPILED BY DES CHECKED BY ---
 SAMPLER HAMMER WT. 140 LBS. DROP 30 INCHES (PENETRATION RESISTANCES CONVERTED TO BLOWS OF 4200 IN - LBS. ENERGY)

SAMPLE CONDITION



A.S. - AUGER SAMPLE
 S.T. - SLOTTED TUBE
 W.S. - WASHED SAMPLE
 D.O. - DRIVE-OPEN
 D.F. - DRIVE-FOOT VALVE
 C.S. - CHUNK SAMPLE

SAMPLE TYPES

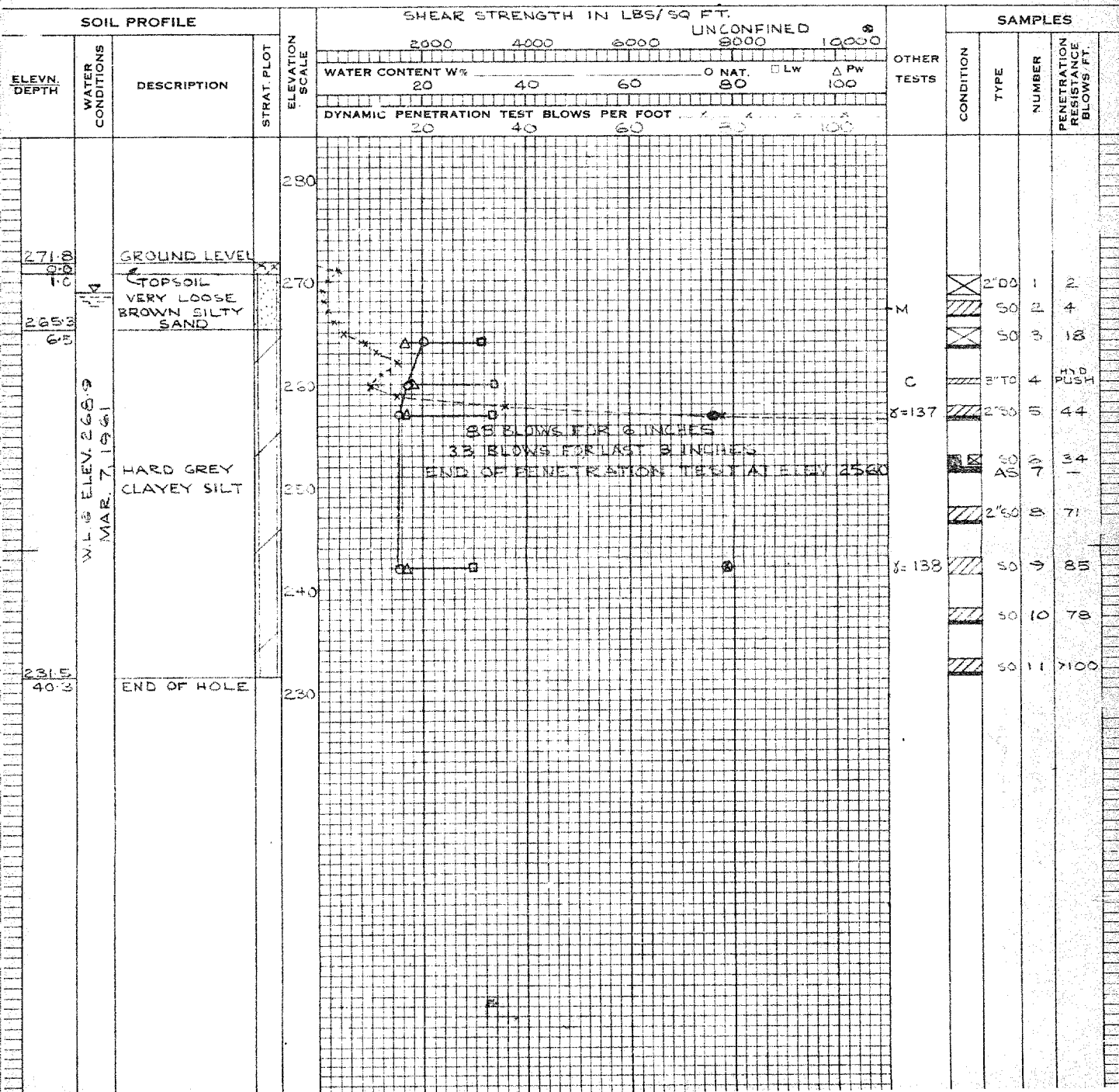
F.S. - FOIL SAMPLE
 S.O. - SLEEVE-OPEN
 S.F. - SLEEVE-FOOT VALVE
 T.O. - THIN WALLED OPEN
 R.C. - ROCK CORE

ABBREVIATIONS

V - IN-SITU VANE TEST
 M - MECHANICAL ANALYSIS
 U - UNCONFINED COMPRESSION
 QC - TRIAXIAL CONSOLIDATED QUICK
 Q - TRIAXIAL QUICK
 S - TRIAXIAL SLOW

γ - WET UNIT WEIGHT
 K - PERMEABILITY
 C - CONSOLIDATION

WL - WATER LEVEL IN CASING
 WT - WATER TABLE IN SOIL



GEOCON

OFFICE REPORT ON SOIL EXPLORATION

APPENDIX I

CONTRACT 67192 BORING # WASH PROBE #2 DATUM LOCAL CASING ---
 BORING DATE MAR 7 1961 REPORT DATE MAR 8 1961 COMPILED BY DES CHECKED BY ---
 SAMPLER HAMMER WT. --- LBS. DROP --- INCHES (PENETRATION RESISTANCES CONVERTED TO BLOWS OF 4200 IN - LBS. ENERGY)

SAMPLE CONDITION

☐ DISTURBED
☐ FAIR
☐ GOOD
☐ LOST

SAMPLE TYPES

A.S. - AUGER SAMPLE
 S.T. - SLOTTED TUBE
 W.S. - WASHED SAMPLE
 D.O. - DRIVE-OPEN
 D.F. - DRIVE-FOOT VALVE
 C.S. - CHUNK SAMPLE
 F.S. - FOIL SAMPLE
 S.O. - SLEEVE-OPEN
 S.F. - SLEEVE-FOOT VALVE
 T.O. - THIN WALLED OPEN
 R.C. - ROCK CORE

ABBREVIATIONS

V - IN-SITU VANE TEST
 M - MECHANICAL ANALYSIS
 U - UNCONFINED COMPRESSION
 QC - TRIAXIAL CONSOLIDATED QUICK
 Q - TRIAXIAL QUICK
 S - TRIAXIAL SLOW
 γ - WET UNIT WEIGHT
 K - PERMEABILITY
 C - CONSOLIDATION
 WL - WATER LEVEL IN CASING
 WT - WATER TABLE IN SOIL

SOIL PROFILE

ELEV. DEPTH	WATER CONDITIONS	DESCRIPTION	STRAT. PLOT	ELEVATION SCALE	OTHER TESTS				SAMPLES			
					WATER CONTENT W% O NAT. □ LW ▲ PW				CONDITION	TYPE	NUMBER	PENETRATION RESISTANCE BLOWS/FT.
					DYNAMIC PENETRATION TEST BLOWS PER FOOT							
262.3	17	CREEK LEVEL		265								
259.3		WATER										
257.9		VERY LOOSE TO LOOSE GREY SILTY SAND		260					<input checked="" type="checkbox"/>	WS	1	1
255.2		HARD GREY CLAYEY SILT							<input checked="" type="checkbox"/>	DO	2	1
250		END OF PROBE		255								

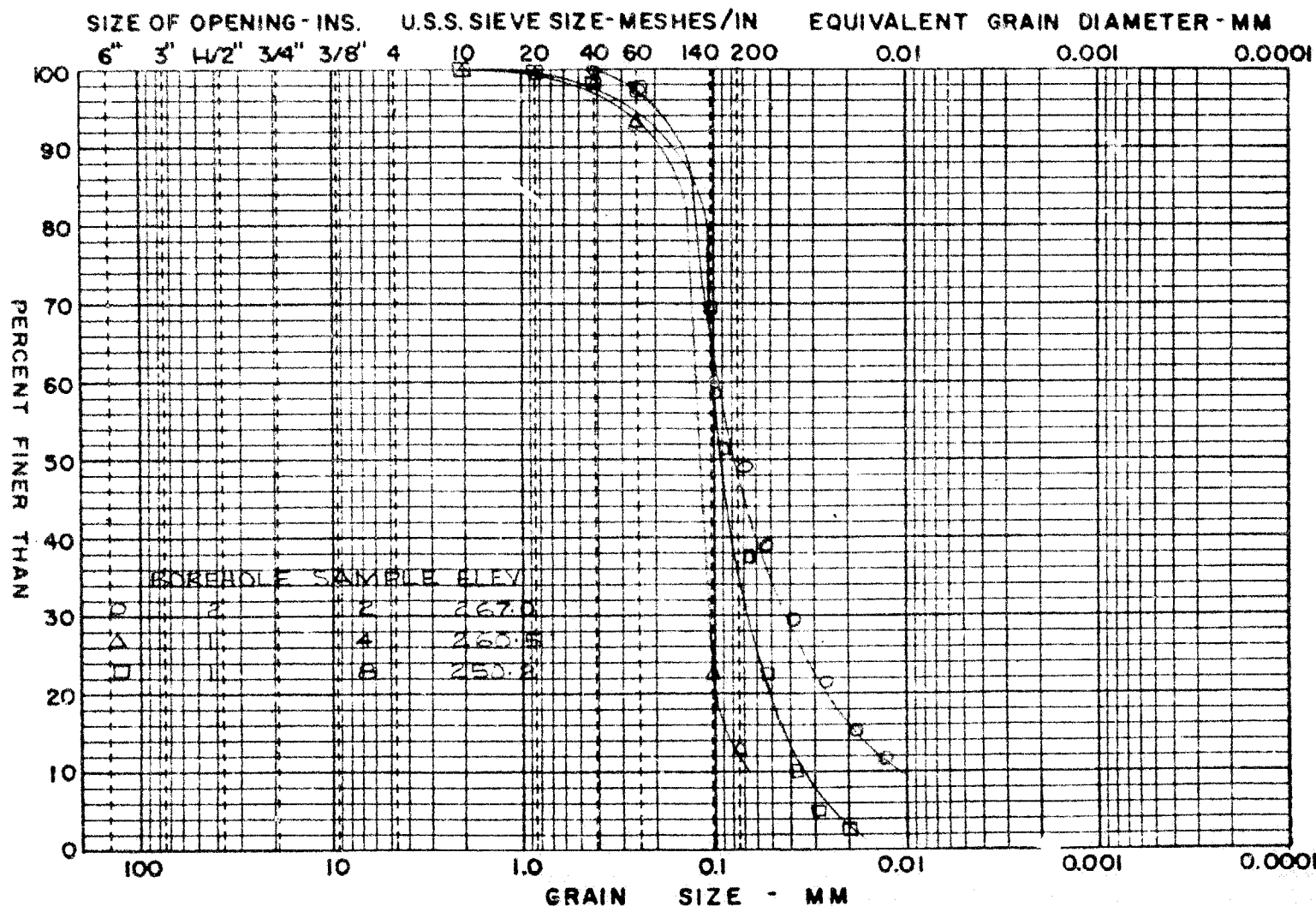
APPENDIX II

FIGURES - LABORATORY TESTING

GRAIN SIZE DISTRIBUTION

APPENDIX II
FIGURE 1
PROJECT S 7198

COBBLE ← SIZE	GRAVEL SIZE			SAND SIZE			FINE GRAINED		CLAY SIZE →
	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE		

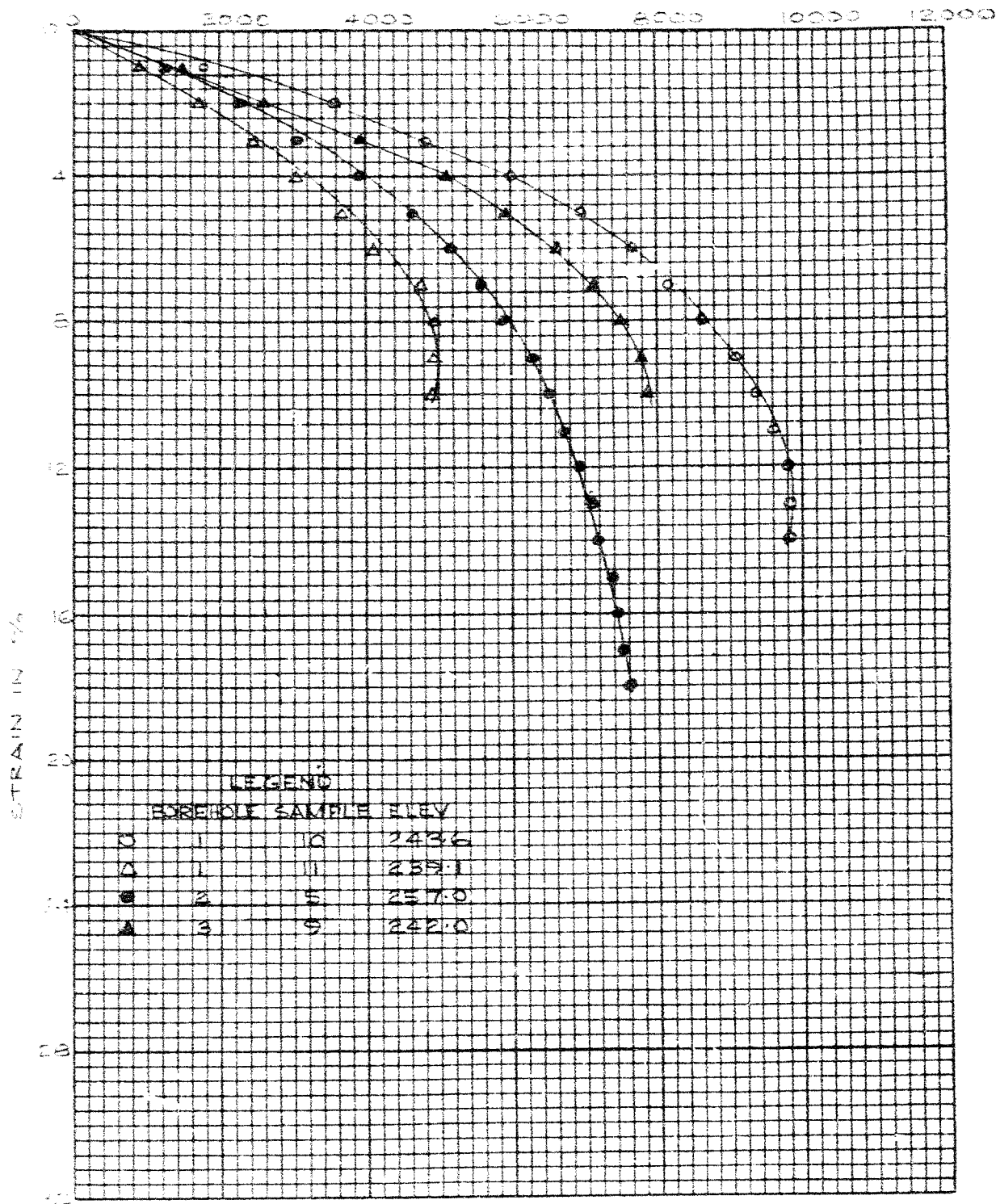


M.I.T. GRAIN SIZE SCALE

UNCONFINED COMPRESSION & QUICK TRIAXIAL TESTS STRESS STRAIN CURVES

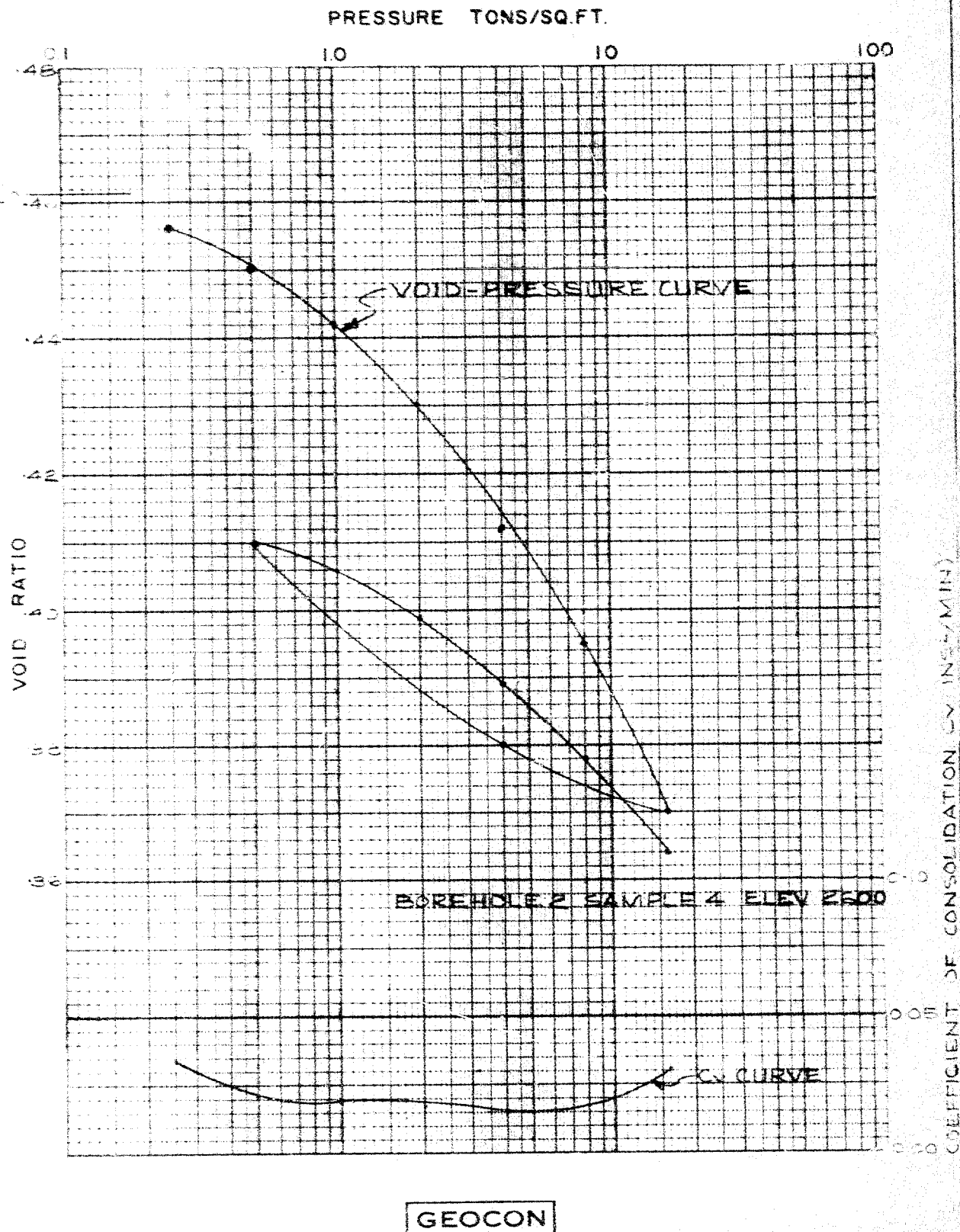
APPENDIX II
FIGURE 2
PROJECT S 7198

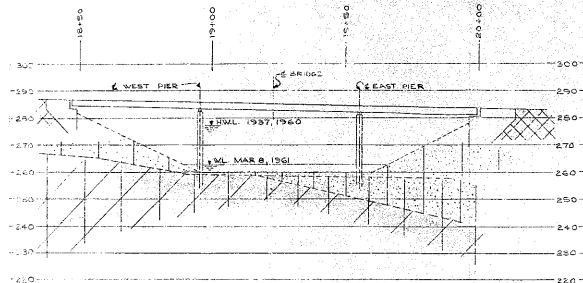
SHEAR STRESS IN LBS/SQ.FT



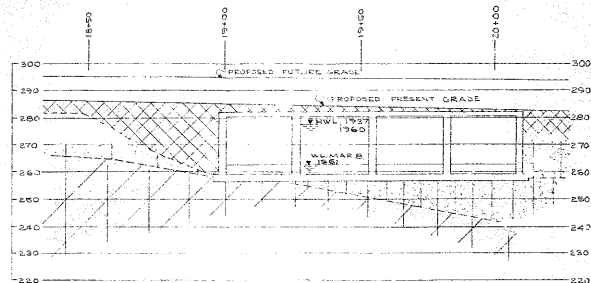
VOID RATIO-PRESSURE CURVES CONSOLIDATION TEST

APPENDIX II
FIGURE 3
PROJECT S 7198









PROPOSED BRIDGE SCHEME
SCALE: 1"=20'-0"



ALTERNATE CULVERT SCHEME
SCALE: 1"=20'-0"

STRATIGRAPHY

-  PROPOSED FILL
-  VERY LOOSE BROWN SILTY SAND
-  COMPACT TO DENSE GREY SILTY SAND
-  HARD GREY CLAYEY SILT

SPECIAL NOTE: DATA CONCERNING THE VARIOUS STRATA HAVE BEEN OBTAINED AT BOREHOLE LOGS. ONLY THE SOIL STRATIGRAPHY BETWEEN BOREHOLES HAS BEEN INFERRED FROM GEOLOGICAL EVIDENCE AND SO MAY VARY FROM THAT SHOWN.

SPECIAL NOTE: ALL ELEVATIONS SHOWN REFER TO LOCAL DATUM

REFERENCE	
DWG. NO.	DESCRIPTION
SKETCH #1	R.C. DUNN & ASSOC., LTD., EDEN BRIDGE PROJECT LONDON
S-7193-1	LOS G103, BRIDGE VS. CULVERT
	GEOCON LTD., BORING PLAN & SOIL STRATIGRAPHY.

R.C. DUNN & ASSOCIATES, LTD.
ONTARIO
PROPOSED EDEN BRIDGE
COUNTY OF ELGIN
CENTRELINE SECTIONS BRIDGE & CULVERT

GEOCON LTD.

DATE: MAR 10, 1961 SCALE: 1"=20'-0"

MADE BY: [Signature] CHECKED BY: [Signature] APPROVED BY: [Signature] No. S-7193-2