GEN. FILES

W.P. 242-66

DEPARTMENT OF HIGHWAYS ONTARIO

MEMORANDUM

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

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

Attention: Mr. F. I. Hewson,
Sr. Bridge Liaison
Engr.

Date: September 12, 1967

Our File Ref.

In reply to

SEP 26 1967

Subject:

PRELIMINARY
FOUNDATION INVESTIGATION REPORT
For
Forkes Rd. Crossing of the Proposed
Welland Canal
District No. 4 (Hamilton)
W.J. 66-F-111 -- W.P. 242-66

In order to provide the necessary information for the study of the tunnel and high-level bridge at the above location, we are forwarding to you, two (2) copies of our Preliminary Foundation Investigation Report on subsoil conditions, test results, and recommendations.

We believe that the data contained therein, although preliminary in nature only, will prove adequate for your present requirements. Should there be any queries regarding this report, please do not hesitate to contact our Office.

A. G. Stermac
PRINCIPAL FOUNDATION ENGINEER

AGS/MdeF
Attach.
cc: Messrs. B. R. Davis (2)
T. G. Tustin - St. Lawrence Seaway Authority. (2)
R. Conlon - H. G. Acres Co. Ltd.
B. A. Singh - Ontario Water Resources Commission.
H. Greenland - District Engineer - Hamilton.

Foundations Files (6)
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PRELIMINARY
FOUNDATION INVESTIGATION REPORT
For
Forkes Rd. Crossing of the Proposed Welland Canal
District No. 4 (Hamilton)
W.J. 66-F-111 -- W.P. 242-66

1. INTRODUCTION:

A request, dated November 22, 1966, was received from the Bridge Division (Mr. F. I. Hewson, Senior Bridge Liaison Engineer) to carry out a preliminary foundation investigation at the site of the proposed Forkes Road crossing of the realigned Welland Canal.

The Welland Canal is to be reconstructed on an alignment east of the present location between Port Colborne and Port Robinson. A tunnel, or a high-level bridge, is proposed for the crossing of the realigned canal by Forkes Road.

Subsequently, a foundation investigation was conducted at the proposed site and at an alternative site 2000 feet north along the centre-line of the canal, to determine the subsoil and groundwater conditions. Field and laboratory test results, together with discussion and recommendations, are reported herein.

2. DESCRIPTION OF SITE:

The proposed site lies in the Township of Humberstone, County of Welland, and extends about 3500 feet east along Forkes Road from the edge of the settlement of Welland Junction. This line of investigation will be called Line 'A'. The alternative site (Line 'B') is some 2000 feet north of Forkes Road along the centre-line of the proposed canal with the line of investigation perpendicular to the new canal alignment and extending 1500 feet east and west of the centre-line of the canal.

cont'd. /2 ...

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

The area is predominantly pasture land or mixed bushland except the western portion of Line 'A' which is lightly residentially developed. Overall, the area is flat to gentl, undulating and is poorly drained.

3. GEOLOGY:

Physiographically, both lines are within the region termed the Haldimand Clay Plain which lies between the Niagara escarpment and Lake Erie.

Geologically, the subsoil is composed of glacial and glacial lacustrine deposits of Wisconsin age, which overlie bedrock of the Pleistocene epoch.

The Wisconsin deposits are divided into a number of distinct zones. The upper zone is composed predominantly of clay-sized particles with a trace of sand, and with well-defined but discontinuous layers or pockets of stratified material which is composed also, of predominantly clay-sized particles. This zone might have been deposited beneath a readvancing glacier that over-rode and reworked an underlying deposit of layered or varved clay. Hence, much of the 'till' is essentially composed of layered or varved clay sediments.

The next zone is more clearly defined as a glacial till best described as a silty clay with some sand and a trace of gravel. Gravel sizes up to 1 inch in diameter are not uncommon, but larger sizes are rare.

Beneath this zone is a zone of layered or 'varved' clay. This material was deposited in a short-term lake which was formed in front of the glacier that occupied the Lake Ontario Basin. At least once the ice readvanced over this clay deposit creating a zone composed predominantly of the same material as the layered (varved) zones lying above and below, but of a mottled appearance.

cont'd. /3 ...

3. GEOLOGY: (cont'd.) ...

The basal zone is another till partially derived from the underlying bedrock. Particles in such a till can be expected to be subangular and to vary from boulder to clay size.

The bedrock is part of the Salina formation of the Silurian period, Paleozoic epoch. The Salina formation is mainly dolomite with shale interbeds and numerous gypsum inclusions.

4. FIELD AND LABORATORY WORK:

Seventeen sampled and three unsampled boreholes, together with one Norwegian Vane borehole, were carried out during the investigation of Lines 'A' and 'B'. In general, the first 50 to 60 feet of each hole was sampled using a Pennsylvania-type continuous flight auger, and the remainder of the hole was sampled using conventional diamond drill equipment converted for soil sampling purposes.

In general, in cohesive materials, 2-inch I.D. Shelby tube samples were obtained by pushing the tubes into the soil, if possible. Otherwise, samples of cohesive and non-cohesive materials were obtained using a 2-inch O.D. split-spoon sampler driven according to the specifications of the standard penetration test. Borehole 20 was sampled using 3-inch I.D. Shelby tubes and will be reported at a later date.

The in-situ value of shear strength was determined, where possible, with a field vane test which employed the standard D.H.O. vane. Adjacent to borehole 8, a Norwegian vane borehole was conducted.

Bedrock was proven in some of the boreholes generally by obtaining BX or BXL size core. Some AX size core was also obtained.

Samples were visually examined and identified in the field and subsequently in the laboratory. A comprehensive

cont'd. /4 ...

4. FIELD AND LABORATORY WORK: (cont'd.) ...

laboratory test program was carried out, in the course of which Atterberg limits, natural moisture content, bulk density, grain-size distribution, consolidation characteristics, and shear strength were obtained, where applicable.

Results of the laboratory tests will be discussed in detail, and are presented graphically together with the field test results and the location and elevation of the boreholes in the appendix of this report. The results for borehole 20 will be reported at a later date.

In order to establish the groundwater conditions, a total of 29 piezometers was installed along the investigated lines in the vicinity of the proposed tunnels and the deepest portion of the proposed cuts. The specific location and elevations of these piezometers, together with the information obtained, will be discussed in the section on groundwater conditions.

The locations and elevations of all boreholes were surveyed in the field by D.H.O. personnel from the Hamilton District. All elevations are referred to a Geodetic datum.

5. SUBSOIL CONDITIONS:

5.1) General:

The subsoil conditions at both sites (i.e., Lines 'A' and 'B') are essentially similar except for the thickness of the deposits. In general, both sites are underlain by a deep deposit of clay to clayey silt which can be subdivided into 5 zones by physical appearance and soil property variations.

This deposit is underlain by a till-like deposit of variable thickness and then bedrock.

cont'd. /5 ...

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

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

The assumed stratigraphical profile for Lines 'A' and 'B' are shown in the appendix (Drawings 66-F-111-A and 66-F-111-B respectively) and are based upon the records of the boreholes as presented in the Borehole Log sheets, also in the appendix.

A description of the subsoil follows. The shear strength varied considerably, and will be discussed in detail in a subsequent section, together with the consolidation characteristics of the subsoil.

5.2) Silty Clay to Clay: (Zone 1)

This zone extends from the ground surface to a depth of 16 to 28 feet on both lines and is characterized as a mottled material with well-defined but discontinuous layers or pockets of layered material. Oxidation and desiccation were apparent throughout the zone and occasional thin vertical gypsum deposits were noted.

The consistency of the deposit varied, in general, from hard to stiff with occasional firm pockets. 'N' values varied from 62 to 4 blows per foot, and shear strength varied from 4900 psf to 600 psf.

The layered and mottled material had liquid limits in the range of 30% to 60%, but predominantly 45% to 60%. In general, the layered zones were slightly more plastic than the mottled material. Refer to figures 1 to 4 for detailed plasticity charts. Typical grain-size distribution curves are shown in Fig. 13.

The natural moisture content generally varied from 22% to 40%. Reference should be made to the individual borehole logs as well as a plot of moisture content versus depth (Fig. 23) for detailed variations.

cont'd. /6 ...

5. <u>SUBSOIL CONDITIONS</u>: (cont'd.) ...

5.3) <u>Clayey Silt to Silty Clay</u>: (Zone 2)

This zone might be categorized as a glacial till. It is predominantly a silty clay (with a few Atterberg limits indicating a clayey silt) along Line 'A', and a silty clay to clayey silt along Line 'B' with a trace of sand and gravel. Gravel sizes up to 1 inch in diameter are not uncommon, but larger sizes are rare.

Shear strengths varied from about 2400 psf to about 600 psf, which indicates a very stiff to firm consistency.

Liquid limits varied, in general, from 32% to 48% (Fig's 5 and 6). The moisture content was generally fairly uniform in the order of 23% to 25%. Some typical grain-size curves are shown in Fig. 14.

5.4) <u>Silty Clay to Clay</u>: (Zones 3, 4 and 5)

These three zones, although different in physical appearance, are composed of basically the same materials. Taken together, the three zones varied in thickness from 40 to 52 feet along Line 'A' and 26 to 45 feet along Line 'B'.

The consistency of all three zones is essentially the same, firm to stiff, as indicated by shear strengths between 500 psf and 1700 psf. A few soft pockets of about 400 psf shear strength are indicated in Zone 5.

Zones 3 and 5 are generally layered material, red, brown and grey in colour, with individual layers in any one sample similar in plasticity, although over the two zones the soil varied irregularly from silty clay to clay with occasional thin layers of clayey silt and very occasional thin layers (less than 3/4 inch) of silt.

Zone 4 was a mottled material which appeared to be glacially reworked material similar to Zones 3 and 5. In general, this zone was silty clay.

cont'd. /7 ...

5. <u>SUBSOIL CONDITIONS</u>: (cont'd.) ...

5.4) <u>Silty Clay to Clay</u>: (Zones 3, 4 and 5) - (cont'd.) ...

Plasticity charts for each zone are shown in Fig's 7 to 12 in the appendix. Figures 15 to 18 show typical grain-size distribution curves.

Natural moisture content of the three zones varied from 20% to 50% with a tendency of the layered zones to have the higher moisture contents, and the mottled zone to have the lower moisture contents.

5.5) <u>Heterogeneous Mixture of Clayey Silt, Sand and Gravel</u> - (<u>Glacial Till - Basal Till</u>):

This deposit (which will be referred to as the basal till) was encountered immediately above the bedrock and varied considerably in thickness as well as physical properties, particularly along Line 'A' where the thickness varied from 7 to 20 feet. Along Line 'B' the thickness varied from 3 to 14 feet.

'N' values varied from 24 to much in excess of 100 blows per foot, indicating a very stiff to hard consistency.

Along Line 'A' the material contained about 10% to 30% gravel sizes, 20% to 40% sand sizes, and the remainder silt and clay-sized particles. Typical grain-size distribution curves are shown in Fig's 19 and 20. Layers or pockets of predominantly clayey silt were encountered as well as occasional boulders.

Along Line 'B' the material contained 18% to 32% gravel sizes, 32% to 34% sand sizes, and the remainder silt and clay-sized particles. Occasional pockets of loose predominantly granular material were encountered as well as occasional boulders. One sample was predominantly gravel.

cont'd. /8 ...

5. <u>SUBSOIL CONDITIONS</u>: (cont'd.) ...

5.6) <u>Bedrock</u>:

Bedrock was encountered along Line 'A' between elevations 458.5 and 482.4. Along Line 'B' the same formation was proven to commence between elevations 497.0 and 500.8, and was established as probable bedrock in two other holes at elevations 489.7 and 507.7. Bedrock elevations are indicated on Drawing 66-F-111-A and 66-F-111-B.

The bedrock was predominantly dolomite with some shale interbeds and numerous gypsum inclusions. This is typical of the Salina formation of the Paleozoic epoch.

Core recovery was poor in the upper portions of the bedrock - probably because the rock is weathered and fractured and, in some instances, rather vuggy where some of the gypsum has been removed by solution in the groundwater.

6. <u>GROUNDWATER CONDITIONS</u>:

To establish the groundwater table and to observe variations in that level, a total of 29 piezometers was installed. Fourteen were installed along Line 'A', and fifteen along Line 'B'. The location, relative depth and observed groundwater levels are shown in Fig's 21 and 22.

Along both lines, the piezometer readings indicate a nearly normal hydrostatic pore water pressure distribution. The water table is at about elevation 575, which is 4 to 5 feet below the ground surface on Line 'B', and is equal to the ground surface along Line 'A'.

During the field operation, it was noted that when the borehole penetrated the basal till, water rapidly filled the borehole and, in some instances where the ground surface was somewhat depressed, the water flowed out of the borehole. The free water supply continued as the hole penetrated the upper portions of the bedrock, and was noted to be quite sulphury throughout.

cont'd. /9 ...

6. GROUNDWATER CONDITIONS: (cont'd.) ...

Subsequent laboratory tests have indicated a Sulphate (SO_4) content of 1930 to 2000 ppm; a concentration which is considered to cause considerable to severe sulphate attack on concrete. In addition, tests for calcium and magnesium content indicated about 960 to 970 ppm of Calcium (C_aO) and about 317 ppm of Magnesium (M_gO).

7. DISCUSSION OF SHEAR STRENGTH AND CONSOLIDATION CHARACTERISTICS:

7.1) Unconsolidated Undrained Tests:

Primary consideration has been given to boreholes 7, 8 and 10 along Line 'A', and boreholes 15, 16 and 17 along Line 'B', and summaries of the shear strengths obtained for these boreholes are presented in Fig's 26 and 28 respectively. The shear strength has been evaluated by means of field vane, laboratory vane, unconfined compression and quick triaxial tests as well as, in one instance (B.H. 8), Norwegian vane test results. Additional shear strength versus depth profiles are shown in Fig's 24, 25, 28 and 29 for the outer boreholes.

In general, in the lower 30 to 40 feet of each borehole (approximately coincident with Zones 3, 4 and 5), there is a noticeable difference between laboratory and field test results. It is well known that with increasing depth of sampling, it is increasingly difficult to obtain 'undisturbed' samples; however, samples obtained in borehole 8 using an Osterberg sampler, were not significantly better than those obtained by routine sampling procedures. This would suggest that the lack of agreement between laboratory and field tests may be, in part, a characteristic of the particular soil deposit although, unquestionably, sample disturbance does contribute significantly to the lack of agreement.

In general, the shear strength obtained using a standard D.H.O. vane, compared quite well with the results from the more sophisticated Norwegian Vane Apparatus.

cont'd. /10 ...

7. DISCUSSION OF SHEAR STRENGTH AND CONSOLIDATION CHARACTERISTICS: (cont'd.) ...

7.1) Unconsolidated Undrained Tests: (cont'd.) ...

The shear strength and the bulk density chosen for design purposes, are as shown below:

-- LINE 'A' --			-- LINE 'B' --		
Elevation	Shear Strength	Bulk Density	Elevation	Shear Strength	Bulk Density
Surface - 555	2000 psf	124 pcf	Surface - 565	2000 psf	122 pcf
555 - 545	1600 psf	124 pcf	565 - 545	1200 psf	124 pcf
545 - 535	1100 psf	122 pcf	545 - 530	875 psf	117 pcf
535 - 515	800 psf	118 pcf	530 - Basal Till	1000 psf	117 pcf
515 - Basal Till	1000 psf	117 pcf			

7.2) Consolidated Undrained Triaxial Tests with Pore Pressure Measurement:

The detailed test results for the consolidated undrained tests (both multiple sample and stage tests) with pore pressure measurements, are presented in Fig's 30 to 49 inclusive.

The test results for Zone 1 and Zone 2 are consistent within each zone. Results from Zones 3, 4 and 5, when summarized, are quite consistent, in general, (Fig. 52).

cont'd. /11 ...

7. DISCUSSION OF SHEAR STRENGTH AND CONSOLIDATION CHARACTERISTICS: (cont'd.) ...

7.2) Consolidated Undrained Triaxial Tests with Pore Pressure Measurement: (cont'd.) ...

Accordingly, three layers have been defined for the choice of effective stress parameters, as indicated below:

ELEVATION		Descriptive Zone Number	C' (psf)	Ø' Degrees	Bulk Density (pcf)
LINE 'A'	LINE 'B'				
Ground Surface - 555	Ground Surface - 560	1	144	24	122
555 - 530	560 - 540	2	0	25	124
530 - Basal Till	540 - Basal Till	3, 4 & 5	200	17	117

7.3) K_o Consolidated, Drained Tests:

A subsequent evaluation of the effective stresses acting along the critical circle and other circles through typical slope configurations obtained using the above parameters, indicated that the average effective normal stress acting on a failure plane was in the order of 5 to 15 psi. Since undrained tests with pore pressure measurements do not provide consistently reliable results in a low stress range, two conventional K_o consolidated, drained test series were conducted with σ_3 constant and σ_1 increasing. The results are shown in Fig's 50 and 51.

cont'd. /12 ...

7. DISCUSSION OF SHEAR STRENGTH AND CONSOLIDATION CHARACTERISTICS:

(cont'd.) ...

7.3) K_o Consolidated, Drained Tests: (cont'd.) ...

Although the drained tests and the undrained tests were consolidated under different conditions and may not be directly comparable, the tests did indicate that in the lower stress range the value of C' tends to be reduced and the value of $\emptyset'$ tends to be increased. On the basis of the two reported tests, the following parameters could be chosen:

Zone	C'	Ø'	Bulk Density
2	70 psf	27°	124 pcf
3, 4 & 5	100 psf	25°	117 pcf

These parameters are more favourable than those chosen on the basis of the undrained tests with pore pressure measurement but have not been used in the computations reported; hence, the design excavation slopes might be improved somewhat at a later date if the tunnel scheme is adopted. These values should be verified by further testing. In addition, it is recommended that a series of drained tests be conducted with σ_3 decreasing and σ_1 constant.

cont'd. /13 ...

7. DISCUSSION OF SHEAR STRENGTH AND CONSOLIDATION CHARACTERISTICS: (cont'd.) ...

7.4) Consolidation Characteristics:

The results of the consolidation tests conducted are presented in graphical form in Fig's 53 to 62. Interpretation of these results to obtain preconsolidation pressures was made using the Casagrande and Schmertmann constructions if possible. A summary of the preconsolidation values thus obtained is shown in Fig. 63. Although the results are scattered, in general the deposit appears to be lightly overconsolidated.

It will be noted that a number of the test curves are quite flat; a characteristic normally attributed to disturbed samples. Although it is possible that some samples could have been disturbed to this extent, it is unlikely that so many samples were disturbed. These flat curves may be a characteristic of the soil rather than of the degree of disturbance.

A number of curves, for example B.H. 8, Sample 27, exhibit a change in direction of the virgin curve after an unload cycle. Subsequent testing has indicated that if the natural groundwater (high in sulphate, calcium and magnesium content) is used to surround the consolidation specimen in place of the usual distilled water, this change in curvature does not occur. A series of tests is currently underway to verify this soil behaviour and will be reported at a later date. Presumably this behaviour is an effect of the change in pore fluid caused when the distilled water is drawn into the sample during an unload cycle.

cont'd. /14 ...

8. DISCUSSION AND RECOMMENDATIONS:

8.1) General:

Two alternatives are proposed for the Forkes Road crossing of the realigned Welland Canal. One proposal is to construct a tunnel beneath the canal; the alternative is to construct a high-level bridge over the canal.

Subsoil at the site consists generally of a deep deposit of clay to clayey silt, underlain by a heterogeneous mixture of clayey silt, sand and gravel (glacial till) and then bedrock.

8.2) Tunnel Scheme:

8.2.1) General:

The proposed tunnel scheme requires a cut and cover type of construction with about 400 feet of tunnel resulting. The approach grades are proposed as 5%. Cuts about 80 feet deep will be required for this proposal.

Subsoil conditions along Line 'A' and Line 'B' are essentially similar although the basal till and bedrock are encountered higher along Line 'B' in the tunnel area.

8.2.2) Design Slopes:

The slopes proposed below were calculated for Line 'B'; however, they may be applied to Line 'A' as well.

Slopes have been checked for stability in terms of total and effective stresses.

For the effective stress analysis, the phreatic surface has been assumed as 5 feet below the original ground surface to the slope of the cut, and then as if following the cut slope surface. Design parameters are listed in Sections 7.1 and 7.2.

cont'd. /15 ...

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

8.2) Tunnel Scheme: (cont'd.) ...

8.2.2) Design Slopes: (cont'd.) ...

The design slopes suggested below, are overall slopes and have been achieved by means of various berms. These slopes have been applied to Line 'A' as shown on Drawing 66-F-111-C, and the berms shown are horizontal. In a final design, the berms would be graded, possibly at a 20:1 slope. This configuration is stable with 20:1 slopes on the berms; probably, the lower berm could be reduced somewhat for Line 'A'.

-- Design Slopes --

Depth of Cut	Overall Slope	Berms Required
0 - 20 feet	2:1	-
20 - 40 feet	4:1	75' at 20' depth
40 - 80 feet	5:1	130' at 40' depth 50' at 60' depth

8.2.3) De-watering (Construction & Permanent Control):

The field investigation has indicated a confined aquifer in the till and upper bedrock. Subsequent pumping tests conducted for the St. Lawrence Seaway Authority have confirmed the presence of this aquifer and have suggested that it is extensive.

The following comments originate, in part, from a preliminary report by J. P. Nunan, Hydrologist (Hydrology Consultants Ltd.), and are based on Pumping Test No. 4 (St. Lawrence Seaway Authority), which was about 3800 feet north of Line 'A'.

cont'd. /16 ...

8. <u>DISCUSSION AND RECOMMENDATIONS</u>: (cont'd.) ...

8.2) <u>Tunnel Scheme</u>: (cont'd.) ...

8.2.3) <u>De-watering (Construction & Permanent Control)</u>: - (cont'd.) ...

These proposals should be used for estimating purposes only. A pumping test will be necessary if a tunnel scheme is adopted.

<u>During the construction stage</u>, it is recommended that de-watering commence when the excavation has been taken to Elev. 535.0 for Line 'A' (for Line 'B', substitute Elev. 540.0 for Elev. 535.0). Two schemes are possible, both employing deep wells taken at least 15 to 20 feet into the bedrock. If the construction of the canal has required the lowering of the hydrostatic level below Elev. 535.0 and, if this level is being maintained at the time of construction of the tunnel, a system of deep wells could be installed along either side of the proposed tunnel at Elev. 535.0, or (536.0 in the canal bed). A typical scheme of six 12-inch diameter wells is shown on Dwg. 66-F-111-C, Scheme 1.

Alternatively, if the hydrostatic head is above Elev. 535.0 at the time of construction, a system of deep wells should be established from the original ground surface to lower the water level to Elev. 535.0 as construction proceeds. At Elev. 535.0, additional wells should be installed. A typical scheme would require eight 12-inch diameter wells as shown on Dwg. 66-F-111-C, Scheme 2.

Both Scheme 1 and Scheme 2 should include two additional wells at Elev. 535.0 as standby wells. For both schemes, pumping rates would be in the order of 300 gpm per well; hence, Scheme 2 would lower the hydrostatic level somewhat more than Scheme 1. This is considered desirable.

It should be noted that because of the high transmissibility of the aquifer, these schemes or any other scheme (including de-watering for the canal construction) will affect

cont'd. /17 ...

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

8.2) Tunnel Scheme: (cont'd.) ...

8.2.3) De-watering (Construction & Permanent Control): - (cont'd.) ...

the wells of local home-owners. Since th s construction will require several years to complete, some alternative means of water supply will be required for the affected homes. Consequently, few additional problems should arise if the water table is lowered permanently.

For the completed tunnel, there are two alternative proposals to accommodate the potential water pressure from the aquifer. Permanent de-watering is one proposal whereby a series of permanent pressure relief wells should be installed into the aquifer at either end of the tunnel. A typical scheme which utilizes 10 wells (headed at Elev. 505.0) each yielding 200 gpm, is shown on Dwg. 66-F-111-C. This would require a sump and pumping system capable of handling 1000 gpm at either end of the tunnel for the dewatering alone; surface runoff would be extra. It is expected that this flow would reduce with time and could be substantially reduced by other permanent de-watering schemes in the vicinity (e.g., a separate railroad tunnel). A permanent pressure relief scheme would reduce the uplift water pressure on the tunnel essentially to zero.

Alternatively, the tunnel could be designed to resist the uplift pressure. This will require a monolithic type of construction which should be extended to at least Elev. 520.0. The backfill around the tunnel should be compacted clayey silt. The tunnel should be designed for full hydrostatic pressure assuming that the water level in the aquifer would return to Elev. 575.0.

cont'd. /18 ...

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

8.2) Tunnel Scheme: (cont'd.) ...

8.2.4) Estimated Cost of De-watering:

Temporary Pressure Relief Wells - approx. $3,000. each.

Permanent Pressure Relief Wells - approx. $5,000. each.

Sump pumps, together with monthly pumping and maintenance costs, will be in addition to the above cost.

8.3) High-Level Bridge Scheme:

8.3.1) General:

An alternative proposal to the tunnel scheme is a high-level bridge scheme. Approach grades are proposed as 6% with 120 feet vertical clearance required above the water level of the canal. Therefore, the proposed grade over the centre-line of the canal is about Elev. 711.0 and reduces to the original ground elevation (Elev. 575.0 to 580.0) within about 2900 feet (i.e., a total length of about 5800 feet).

The subsoil conditions for Line 'A' and Line 'B' are essentially similar; therefore, the following comments, although based on calculations for Line 'A' conditions, may be applied to Line 'B' as well. The preliminary field investigation, although adequate for initial design purposes, may require a supplementary field investigation if the bridge scheme is adopted.

8.3.2) Embankments:

Large quantities of fill will be available from the canal excavation at a reasonably low unit cost. Hence, high embankments are desirable, if feasible.

cont'd. /19 ...

8. <u>DISCUSSION AND RECOMMENDATIONS</u>: (cont'd.) ...

8.3) <u>High-Level Bridge Scheme</u>: (cont'd.) ...

8.3.2) <u>Embankments</u>: (cont'd.) ...

The subsoil at the site is adequate to support a 30-foot embankment with 2:1 side-slopes. To attain a 70-foot embankment, side-slopes of 10:1 are necessary for a factor of safety of 1.3 (total stress analysis). Alternatively, berms may be used as shown in Fig. 64 where a berm of 360 foot length provides a safe embankment with an overall slope of about 6.6 to 1. Other embankment heights are possible up to about 85 ft. at which point the toe of the embankment is influenced by the canal cut and instability results.

8.3.3) <u>Settlements</u>:

The subsoil at the site is a compressible type of soil which is only lightly overconsolidated. The proposed embankment material is also compressible; hence, substantial settlements might be expected beneath and within high embankments.

For a 70-foot embankment, it is estimated that about 6 feet of settlement will occur due to the imposed embankment load alone. In addition, the fill itself will compress. The magnitude of this settlement is dependent upon the state of compaction of the fill as well as the nature of the fill material. Accordingly, settlements are difficult to estimate, but could be in the order of one foot.

Settlements of the magnitude discussed above, may not be acceptable for a high-level bridge structure. In order to reduce the settlements to about 2 feet, the embankment height should be limited to about 30 feet.

cont'd. /20 ...

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

8.3) High-Level Bridge Scheme: (cont'd.) ...

8.3.4) Foundations:

For the piers in the canal vicinity, pile-type foundations are recommended. To avoid disturbance to the canal banks, small displacement piles (i.e., H-piles) are recommended. Allowable loads will depend upon the pile section chosen (e.g., 12 BP 74 steel H-piles may be designed for 90 tons per pile).

Piles 80 to 95 feet in length will be required along Line 'B', and 90 to 115 feet in length along Line 'A'. Pre-augering to a depth of about 50 ft. might be advantageous both to reduce the disturbance due to driving and to permit more accurate plumb control of such long piles.

For the intermediate piers, spread footing-type foundations are recommended. For design purposes, a safe load of 1 tsf may be used for the footings. It should be noted that if a cellular-type of footing is employed, the weight of the soil excavated could be equal to or greater than the load imposed by the pier. In this case, settlement would be reduced essentially to zero.

The abutments may be founded on end-bearing piles driven to bedrock. The length of pile required will depend upon the location of the abutments, but could exceed 130 feet on Line 'A'. For such long piles, pre-augering might be advantageous. The piles may be designed for the maximum allowable load permitted for the section chosen. Alternatively, a spread footing-type of foundation may be employed if the embankments are limited to 30 feet in height. Specific recommendations will be made by this Section if such a scheme is adopted, but for design purposes, an allowable load of 2 tsf may be employed.

cont'd. /21 ...

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

8.3) High-Level Bridge Scheme: (cont'd.) ...

No de-watering problems are anticipated for footing excavations. In order to prevent softening of the footing base, a working slab should be cast immediately when the excavated grade is reached.

Since the subsoil stratigraphy has been assumed similar between boreholes spaced as much as 500 feet apart, recommendations contained herein should be regarded as preliminary in nature and are subject to reviewal when final structural details are available. Additional field investigation may be required.

9. SUMMARY:

A preliminary foundation investigation for the proposed Forkes Road crossing of the realigned Welland Canal is reported. Two lines of investigation were carried out; Line 'A' was along Forkes Road, and Line 'B' was some 2000 feet north of Forkes Road. Two proposals are discussed, as a tunnel scheme and a high-level bridge scheme.

Subsoil at both sites consists of a deep deposit of clayey silt to clay underlain by a heterogeneous mixture of clayey silt, sand and gravel (glacial till) and then by bedrock. The till and bedrock are water-bearing and may be categorized as a confined aquifer.

For the tunnel scheme, detailed cut slopes are presented. If this scheme is adopted, it is indicated that further testing could result in improved slope configurations. Because of the confined aquifer, a de-watering scheme will be required for construction purposes, and two alternative schemes are proposed on the basis of a test well some 3800 feet north of Line 'A'.

cont'd. /22 ...

9. SUMMARY: (cont'd.) ...

A pumping test will be necessary at the tunnel location if the tunnel scheme is adopted. For the permanent structure, either a permanent de-watering scheme may be employed or, alternatively, the tunnel may be designed for full hydrostatic pressure with a monolithic slab extended to an elevation above which basal heave will not occur.

For the high-level bridge scheme, it is recommended that embankments be limited to 30 feet in height. Central piers in the canal vicinity should be founded on a pile-type foundation employing end-bearing piles driven to bedrock; intermediate piers may be founded on a spread footing-type foundation; the abutments may be founded either on a spread footing-type of foundation or on a pile-type foundation employing end-bearing piles driven to bedrock.

The groundwater has a high sulphate content; hence, concrete should be adequately protected or designed to resist sulphate attack.

All recommendations should be regarded as preliminary in nature until the proposed structure details are available at which time, some additional field investigation may be required.

10. MISCELLANEOUS:

The field investigation was carried out in the period from December 14, 1966 to February 3, 1967, employing drilling equipment owned and operated by Master Soil Investigations Ltd., under the direction of Mr. D. Katauskas, Mr. J. McDougall, and Mr. L. Palmer, Project Foundation Engineers. Mr. Palmer subsequently prepared this report. The entire project was under the general supervision of Mr. M. Devata, Supervising Foundation Engineer, who also reviewed this report.

September 1967

APPENDIX I

ABBREVIATIONS USED IN THIS REPORT

PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE 'N' :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

CONSISTENCY	'N' BLOWS / FT.	c LB. / SQ. FT.	DENSENESS	'N' BLOWS / FT.
VERY SOFT	0 - 2	0 - 250	VERY LOOSE	0 - 4
SOFT	2 - 4	250 - 500	LOOSE	4 - 10
FIRM	4 - 8	500 - 1000	COMPACT	10 - 30
STIFF	8 - 15	1000 - 2000	DENSE	30 - 50
VERY STIFF	15 - 30	2000 - 4000	VERY DENSE	> 50
HARD	> 30	> 4000		

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.B.	SCRAPER BUCKET SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE
S.T.	SLOTTED TUBE SAMPLE		

P.H. SAMPLE ADVANCED HYDRAULICALLY

P.M. SAMPLE ADVANCED MANUALLY

SOIL TESTS

Qu	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V.	FIELD VANE
Qcu	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Qd	DRAINED TRIAXIAL	S	SENSITIVITY

ABBREVIATIONS USED IN THIS REPORT

SOIL PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
S_r	DEGREE OF SATURATION
w_L	LIQUID LIMIT
w_P	PLASTIC LIMIT
I_P	PLASTICITY INDEX
s	SHRINKAGE LIMIT
I_L	LIQUIDITY INDEX $= \frac{w - w_P}{I_P}$
I_C	CONSISTENCY INDEX $= \frac{w_L - w}{I_P}$
e_{max}	VOID RATIO IN LOOSEST STATE
e_{min}	VOID RATIO IN DENSEST STATE
I_D	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY D_r IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
m_v	COEFFICIENT OF VOLUME CHANGE $= \frac{-\Delta e}{(1+e)\Delta\sigma'}$
c_v	COEFFICIENT OF CONSOLIDATION
C_c	COMPRESSION INDEX $\frac{\Delta e}{\Delta \log_{10} \sigma}$
T_v	TIME FACTOR $= \frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION INTERCEPT
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
	(c' and ϕ':) IN TERMS OF EFFECTIVE STRESS $\tau_f = c' + \sigma' \tan \phi'$
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
	(c_u and ϕ_u:) IN TERMS OF TOTAL STRESS $\tau_f = c_u + \sigma \tan \phi$
μ	COEFFICIENT OF FRICTION
S_t	SENSITIVITY

GENERAL

π	$= 3{\cdot}1416$
e	BASE OF NATURAL LOGARITHMS 2·7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

STRESS AND STRAIN

u	PORE PRESSURE
σ	NORMAL STRESS
σ'	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ε	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNGS MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

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

FOUNDATIONS

B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
k_s	MODULUS OF SUBGRADE REACTION

SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL

FORM DB-MT-126
66-4546

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 1

FOUNDATION SECTION

JOB 66-F-111 LOCATION Sta. 11 + 89 ; 59' Lt. ORIGINATED BY DK

W.P. 242-66 BORING DATE December 14, 1966 COMPILED BY HS, LP

DATUM Geodetic BOREHOLE TYPE Penndrill CHECKED BY LP

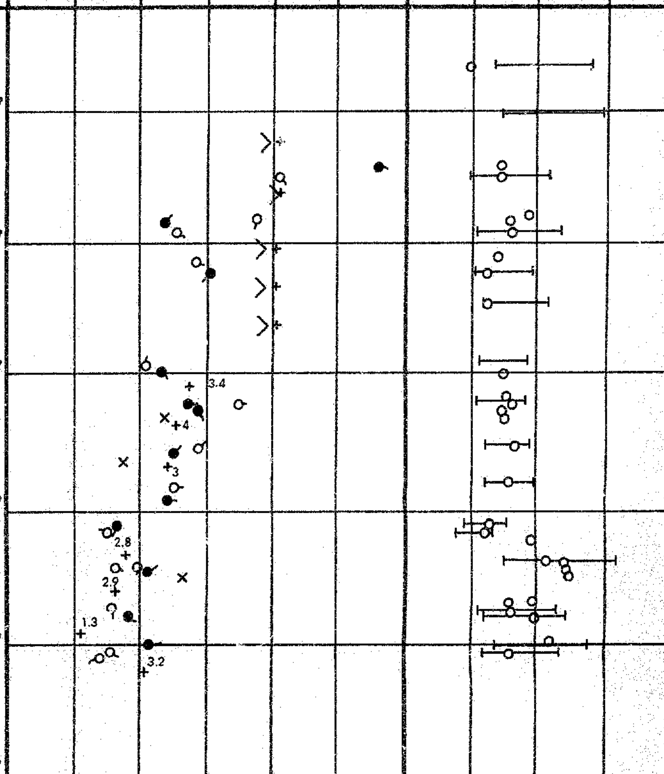
ELEV. DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	BULK DENSITY γ P.C.F.	REMARKS Gr.	Sa.	Si.	Cl
575.0	Ground Level									
0.0	Clay to silty clay. Very stiff to stiff Brown, grey-brown.	1	SS	20						
		2	SS	36						
		3	SS	26	567					
		4	SS	12						
	(Zone 1)	5	TW	PH		121 122	0	2	38	60
	Layered red, brown & grey.	6	TW	PM	557	119				
						124				
		7	TW	PM						
	Mottled	8	TW							
		9	SS	-						
		10	TW							
548.5		11	SS	-		121.5				
26.5	Silty clay, occasional gravel. Stiff to firm Grey Brown to brown. Occ. pockets silt.	12	TW	PM	547	122				
		13	TW	PM		119.5				
		14	TW	PM		120				
		15	TW	PM	537					
535.0	(Zone 2)	16	TW	PM		127				
40.0	Clayey silt to clay, Stiff to firm. Layered (Zone 3)	17	TW	PM		111	0	0	80	20
531.0 44.0	Silty clay to clay. Stiff to firm. Mottled (Zone 4)	18	TW	PM		121				
526.8		19	TW	PM	527	112 121 116				
51.0	End of Borehole				517					

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT

SHEAR STRENGTH P.S.F.
● Triaxial + Field Vane
○ Unconfined × Lab. Vane
500 1000 1500 2000 2500

LIQUID LIMIT —— w_L
PLASTIC LIMIT —— w_P
WATER CONTENT —— w

WATER CONTENT %
20 40 60



0
15 — 5 % Strain
10

FORM 06-MT-126
66-4546

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 2

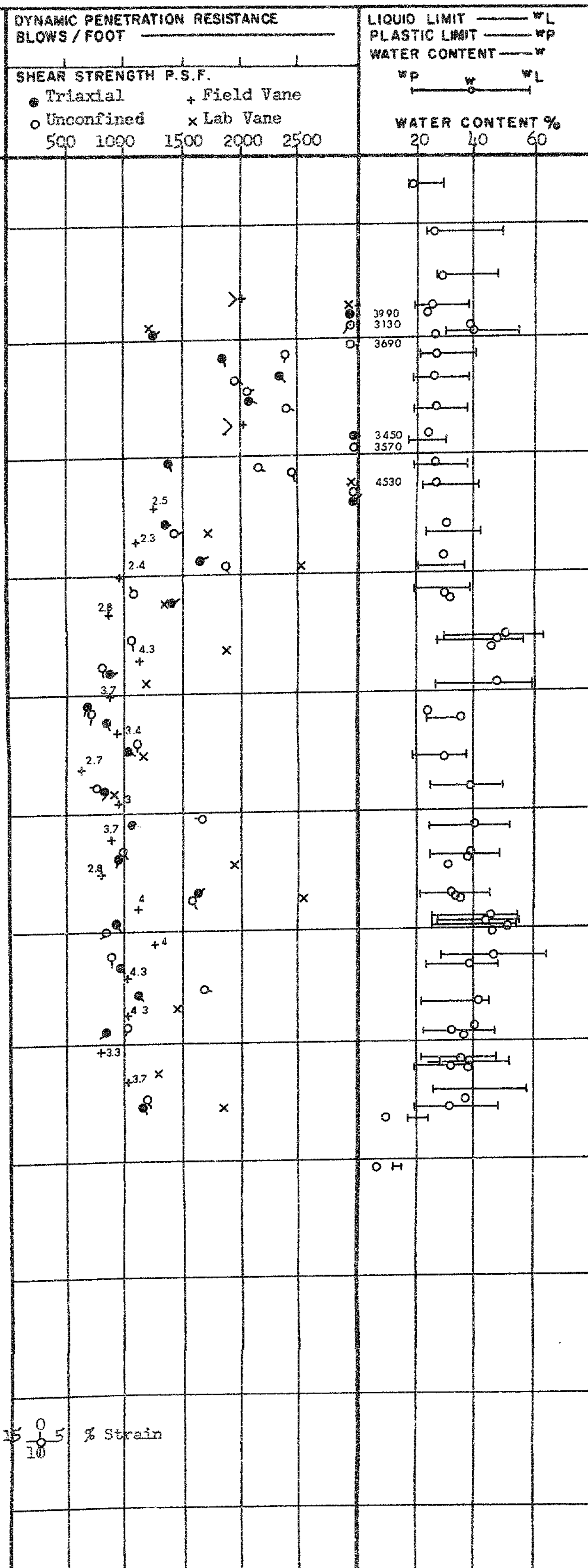
FOUNDATION SECTION

JOB 66-F-111 LOCATION Sta. 16 + 68 (63' Lt.) ORIGINATED BY PP

W.P. 242-66 BORING DATE December 14, 1967 COMPILED BY HS, LP

DATUM Geodetic BOREHOLE TYPE Washboring CHECKED BY LP

ELEV. / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE
572.9	Ground Level				
0.0	Clayey silt to clay. Very stiff to stiff. Brown to grey-brown. (Zone 1)	1	SS	4	
		2	SS		
		3	SS	62	567
		4	SS	32	
		5	SS	23	
		6	SS	12	
		7	TW	PM	
		8	TW	PM	557
		9	TW	PM	
		10	TW	PM	
548.9		11	TW	PM	
24.0	Clayey silt to silty clay. Very stiff to stiff. Occasional Gravel. Brown (Zone 2)	12	TW	PM	547
		13	TW	PM	
		14	TW	PM	
		15	TW	PM	
536.9		16	TW	PM	537
36.0	Layered silty clay to clay. Stiff to Firm. Red-brown, brown & grey (Zone 3)	17	TW	PM	
529.4		18	TW	PM	
43.5	Silty clay to clay, mottled with silt & some clay, occasional silt pockets. Stiff to firm. Red-brown to grey. (Zone 4)	19	TW	PM	527
		20	TW	PM	
		21	TW	PM	
		22	TW	PM	
		23	TW	PM	517
		24	TW	PM	
508.4		25	TW	PM	
64.5	Silty clay to clay, indefinite layers & mottling. Stiff to firm. Red-brown, grey-brown & grey. (Zone 5)	26	TW	PM	507
		27	TW	PM	
		28	TW	PM	
		29	TW	PM	497
		30	TW	PM	
490.9		31	TW	PM	
82.0	Hetrogeneous mixture of clayey silt, sand & gravel. Occ. boulders. Hard. (Glacial Till)	32	SS	65	
		33	SS	45/6"	487
		34	SS	53	
		35	SS	50/1"	
477.9		36	RC AXT	26% Rec	
95.0	Bedrock - extensively weathered and fractured in upper 8 feet.	37	RC AXT	22% Rec	477
		38	RC AXT	40% Rec	
464.5		39	RC AXT	79% Rec	467
108.4	End of Borehole				457



BULK DENSITY γ P.C.F.	Gr.Sa.Si.Cl REMARKS
	∇579.6
	0.1% Org.
	0.4% Org.
127	
117	
127	
123	
125	
126.5	
126.5	
126	
123	
122.5	
121	
121.5	
111.5	
112	
116	
119	
121	
114.5	
121	
113.5	
114.5	
118	
111	
112.5	
115.5	
117	
117.5	
	31 34 25 10
	∇ 488.2 Art. Water
	481.1 ∇ Art. Water

FORM DB-MT-126
66-4546

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 3

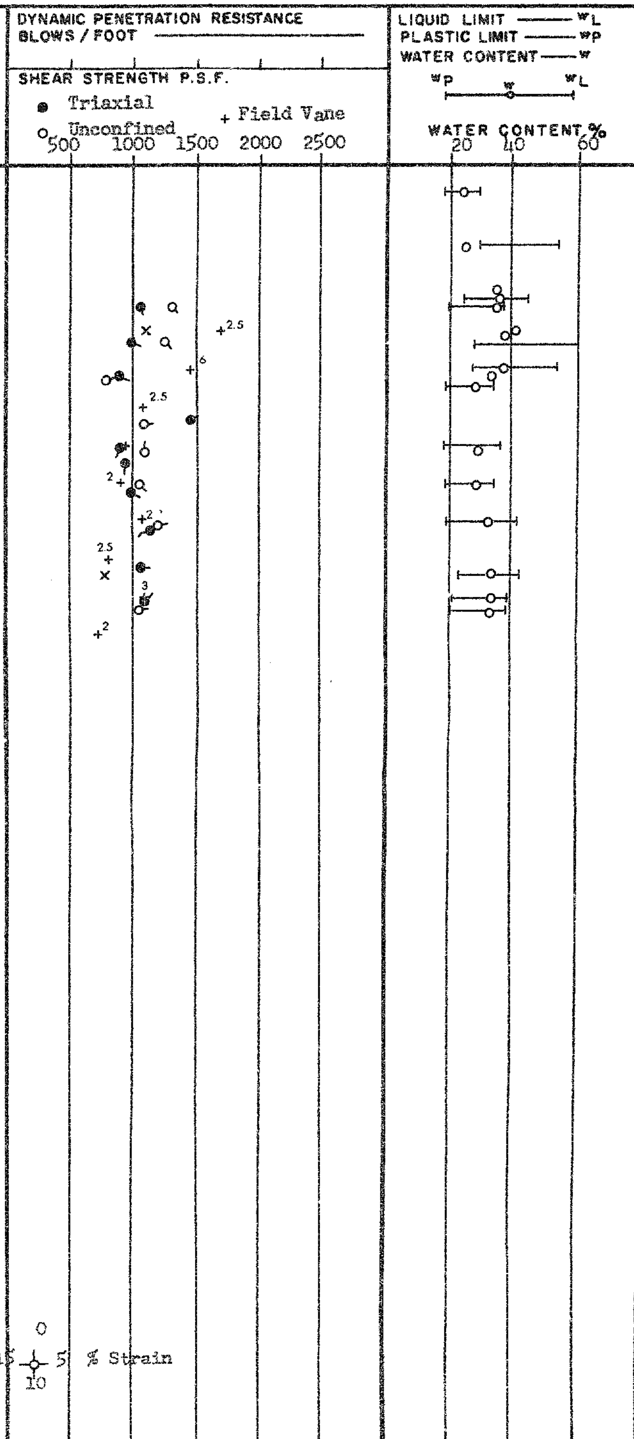
FOUNDATION SECTION

JOB 66-F-111 LOCATION Fork's Rd., Welland Jct. ORIGINATED BY BK, JM

W.P. 242-66 BORING DATE December 15, 1966 COMPILED BY VK, LP

DATUM Geodetic BOREHOLE TYPE Penn Drill Auger CHECKED BY L.P.

ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	BULK DENSITY γ P.C.F.	REMARKS
578.1	Ground Level						
0.0	Clayey silt to clay. Hard to firm		1	SS	28		
			2	SS	39		
			3	SS	35		
			4	SS	13		
	Layered Material Red-brown, brown & grey. (Zone 1)		5	TW	P	120 116	
562.1			6	TW	P	113 121	
16.0	Clayey silt to silty clay, occasional gravel, occasional pockets grey silt, Brown		7	TW	P	117 116 123 122	
			8	TW	P	123 124 124.5	
			9	TW	P	123 123	
	Firm to stiff		10	TW	P	121 121	
			11	TW	P	120	
	(Zone 2)		12	TW	P	120	
543.1 35.0			13	TW	P	119 120	
541.1	(Zone 3)						
37.0	End of Borehole						



FORM CB-MT-126
66-4546

OFFICE REPORT ON SOIL EXPLORATION

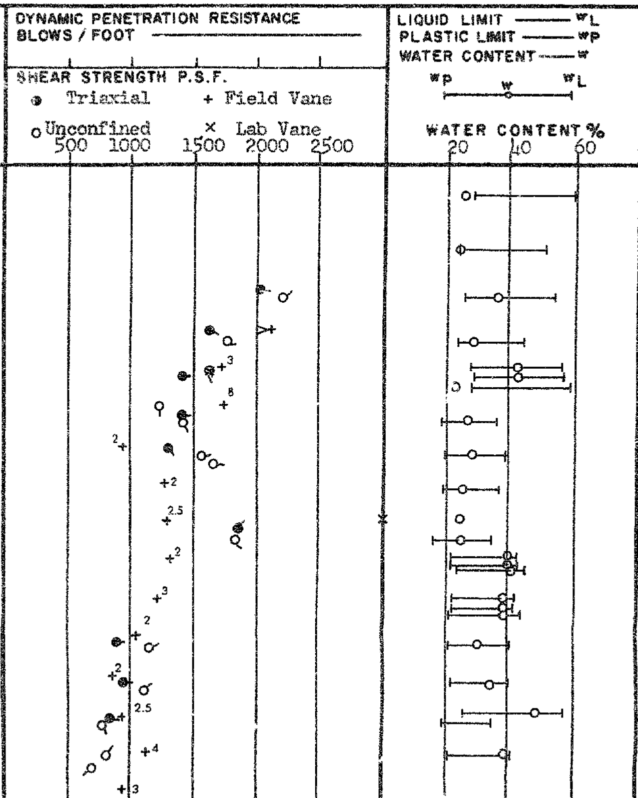
DEPARTMENT OF HIGHWAYS – ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 4

FOUNDATION SECTION

JOB 66-F-111 LOCATION Fork's Rd., Welland Jct. ORIGINATED BY DK, J.M.
W.P. 242-66 BORING DATE December 14, 1966 COMPILED BY VK, LP
DATUM Geodetic BOREHOLE TYPE Pen Drill Auger CHECKED BY L.P.

ELEV. DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FOOT	BULK DENSITY γ P.C.F.	REMARKS
575.0	Ground Level					
0.0	Silty clay to clay. Hard to stiff Brown to grey-brown	1	SS	24		
		2	SS	57		
		3	SS	47		0.7 % Org.
		4	SS	19		
	Layered red, brown & grey.	5	TW	P	119 117	
	(Zone 1)	6	TW	P	121 119	
556.5	Layered, red, brown & grey.	7	TW	P	112	
18.5	Silty clay, occasional gravel, Grey-brown to brown. Stiff to firm.	8	TW	P	124 123 124	
		9	TW	P	122 122 123	
		10	TW	P	123	
		12	TW	P		
	(Zone 2)	13	TW	P		
		14	TW	P		
		15	TW	P	121 121	
532.0		16	TW	P	119 117	
43.0	Clayey silt to silty clay. Layered red, brown & grey. Firm. (Zone 3)	17	TW	P	112 109	
526.0		18	TW	P	118 110	
49.0	End of Borehole					



15 5 % Strain
0
10

FORM DB-MT-126
66-4546

OFFICE REPORT ON SOIL EXPLORATION

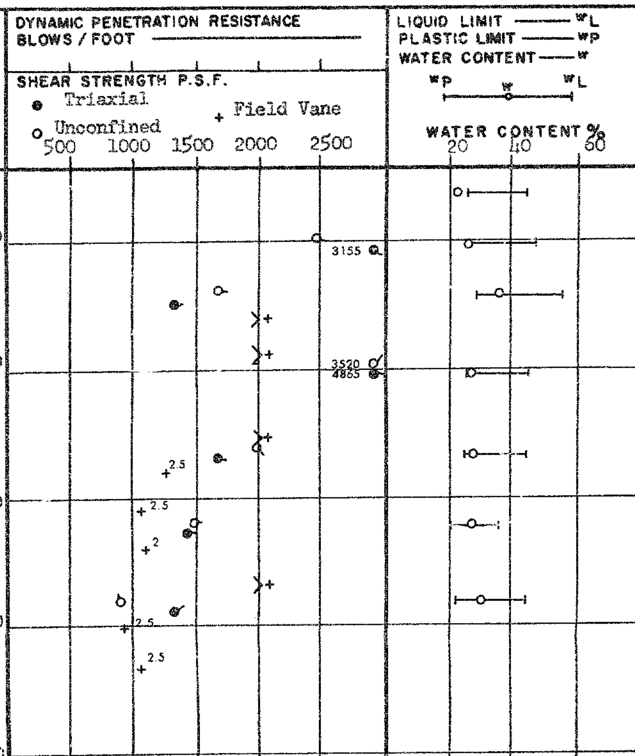
DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 5

FOUNDATION SECTION

JOB 66-F-102
W.P. 242-66
DATUM Geodetic
LOCATION Fork's Rd., Welland Jct.
BORING DATE December 19, 1966
BOREHOLE TYPE Pen Drill Auger
ORIGINATED BY DK, JM
COMPILED BY VK LP
CHECKED BY L.P.

ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	BULK DENSITY γ P.C.F.	REMARKS
576.0	Ground Level							
0.0	Silty clay to clay. Very stiff to stiff. Brown, some mottled red-brown & grey zones (Zone 1)		1	TW	P			
			2	TW	P	570	124.5	
			3	TW	P			
			4	TW	P		116	
			5	TW	P			
			6	TW	P			
			7	TW	P	560	125	
557.0 / 19.0	Silty clay, occasional gravel. Brown. Very stiff to firm. (Zone 2) Occ. pockets of silt and seams of grey silty clay.		8	TW	P			
			9	TW	P		125.5	
			10	TW	P	550	124.5	
			11	TW	P			
			12	TW	P		121.5	
			13	TW	P	540		
			14	TW	P			
536.0 / 40.0	End of Borehole					530		



15 0 5 10 % Strain

FORM OB-MT-126
66-4546

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 6

FOUNDATION SECTION

JOB 66-F-111
W.P. 242-66
DATUM Geodetic
LOCATION Fork's Rd. Welland Jct.
BORING DATE December 19, 1966
BOREHOLE TYPE Pendrill, Diamond Drill, NX & BX Cased, BXL Core
ORIGINATED BY DK, JM.
COMPILED BY JM, V.K., LP
CHECKED BY L.P.

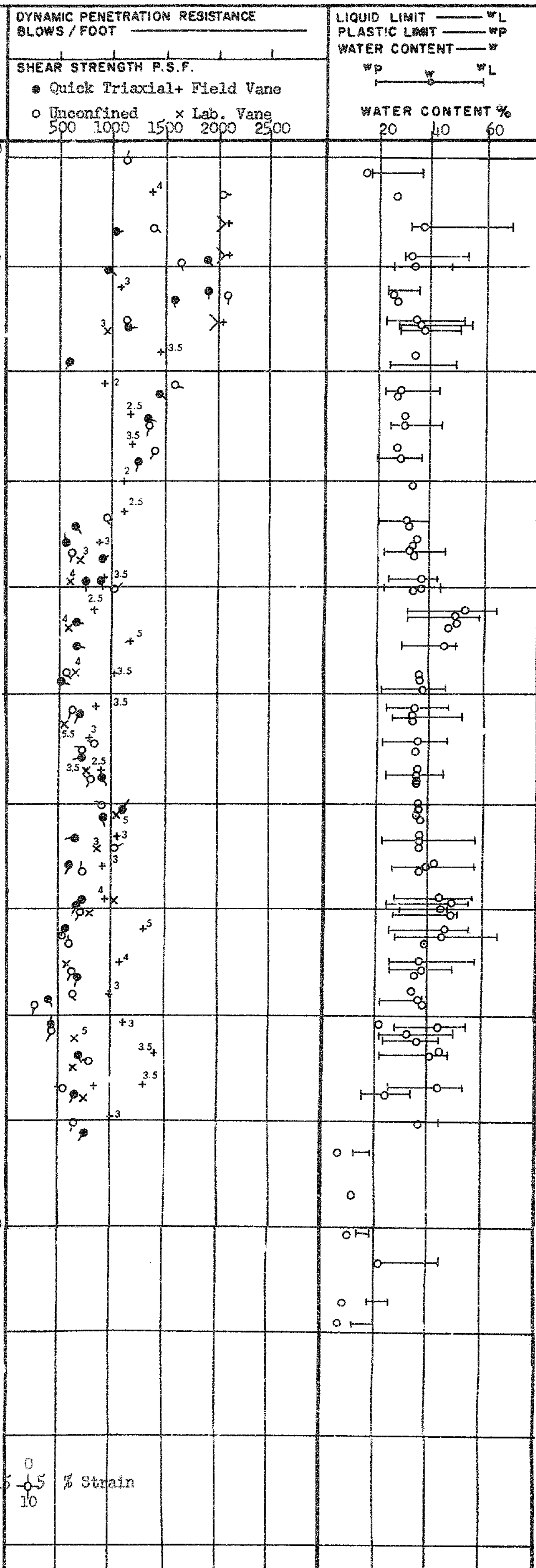
Soil Profile

ELEV. DEPTH	DESCRIPTION
571.8	Ground Level
0.0	Clayey silt to clay. Very stiff to firm. Mottled grey & brown. Layered - red, brown & gray (Zone 1) Layered red, brown & grey.
547.8 / 24.0	Silty clay, occasional gravel. Stiff to Firm. Red - Brown (Zone 2) Occasional pockets of silt.
529.8 / 42.0	Clay to silty clay. Stiff to firm. Layered red-brown, grey-brown & grey (Zone 3)
520.3 / 51.5	Silty clay to clay. Stiff to firm. Red-brown, some mottling. (Zone 4)
501.8 / 70.0	Silty clay to clay. Stiff to Firm. Layered red-brown, grey-brown & grey. Occasional thin silt seam. (Zone 5)
478.3 / 93.5	Heterogeneous mixture of clayey silt, sand and gravel. Hard. (Glacial Till) Layers of silty clay
458.3 / 113.5	Bedrock - extensively fractured in upper 8 feet.
444.3 / 127.5	End of Borehole

Samples

NUMBER	TYPE	BLOWS / FOOT
1	TW	P
2	TW	P
3	TW	P
4	TW	P
5	TW	P
6	TW	P
7	TW	P
8	TW	P
9	TW	P
10	TW	P
11	TW	P
12	TW	P
13	TW	P
14	TW	P
15	TW	P
16	TW	P
17	TW	P
18	TW	P
19	TW	P
20	TW	P
21	TW	P
22	TW	P
23	TW	P
24	TW	P
25	TW	P
26	TW	P
27	TW	P
28	TW	P
29	TW	P
30	TW	P
31	TW	P
32	SS	154
33	SS	100
34	SS	100/6"
35	SS	48
36	SS	156/11"
37	SS	114/9"
38	SS	69
39	SS	38
40	SS	115
41	SS	47
42	SS	50/4"
43	RC BXL	27% Rec
44	RC BXL	5% Rec
45	RC BXL	50%

ELEV. SCALE: 570, 560, 550, 540, 530, 520, 510, 500, 490, 480, 470, 460, 450, 440



Bulk Density γ (P.C.F.)

126, 123, 117, 116, 121, 120, 119, 124, 126, 128, 116, 118, 123, 122, 123, 124, 121, 120, 119, 121, 117, 116, 105, 111, 115, 117, 117.5, 119, 117, 119, 119, 117, 116, 111, 116, 110, 110, 116, 121, 115, 114, 115, 119, 114, 120

Remarks (Gr. Sa. Si. Cl)

▽ 573.5, ▽ 573.8, ▼ 571.3

Org. 1.2%

Gr.	Sa.	Si.	Cl
19	33	38	10
1	33	51	15
1	4	38	57
16	34	(50)	

Art. Water ▽ 459.3

Art. Water 453.3 ▽

FORM DB-MT-126
66-4546

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 7

FOUNDATION SECTION

JOB 66-F-111	LOCATION Fork's Rd. Welland Jct.	ORIGINATED BY DK, JM,
W.P. 242-66	BORING DATE December 21, 1966	COMPILED BY VK, JM, LP.
DATUM Geodetic	BOREHOLE TYPE Pen Drill Auger	CHECKED BY L.P.

SOIL PROFILE

ELEV. / DEPTH	DESCRIPTION
574.3	Ground Level
0.0	Silty clay to clay. Very stiff to stiff. Grey-brown, some mottled grey & red-brown. layered red, brown & grey. (Zone 1)
550.8 / 23.5	Silty clay, occasional gravel. Very stiff to firm. Brown (Zone 2)
534.8 / 39.5	Silty clay to clay. Stiff to firm. Layered brown, red-brown & grey. (Zone 3)
525.8 / 48.5	Silty clay to clay, occasional pockets of silt. Stiff to firm. Brown - some mottling (Zone 4)
502.8 / 71.5	Silty clay to clay. Stiff to firm. Layered to mottled. Brown, red-brown & grey. (ZONE 5) Occ. pockets of silt & sandy silt.
485.8 / 88.5	Heterogeneous mixture of clayey silt, sand and gravel. Hard. (Glacial Till)
471.3 / 103.0	Bedrock - extensively weathered & fractured in upper 4 feet.
464.0 / 113.1	End of Borehole

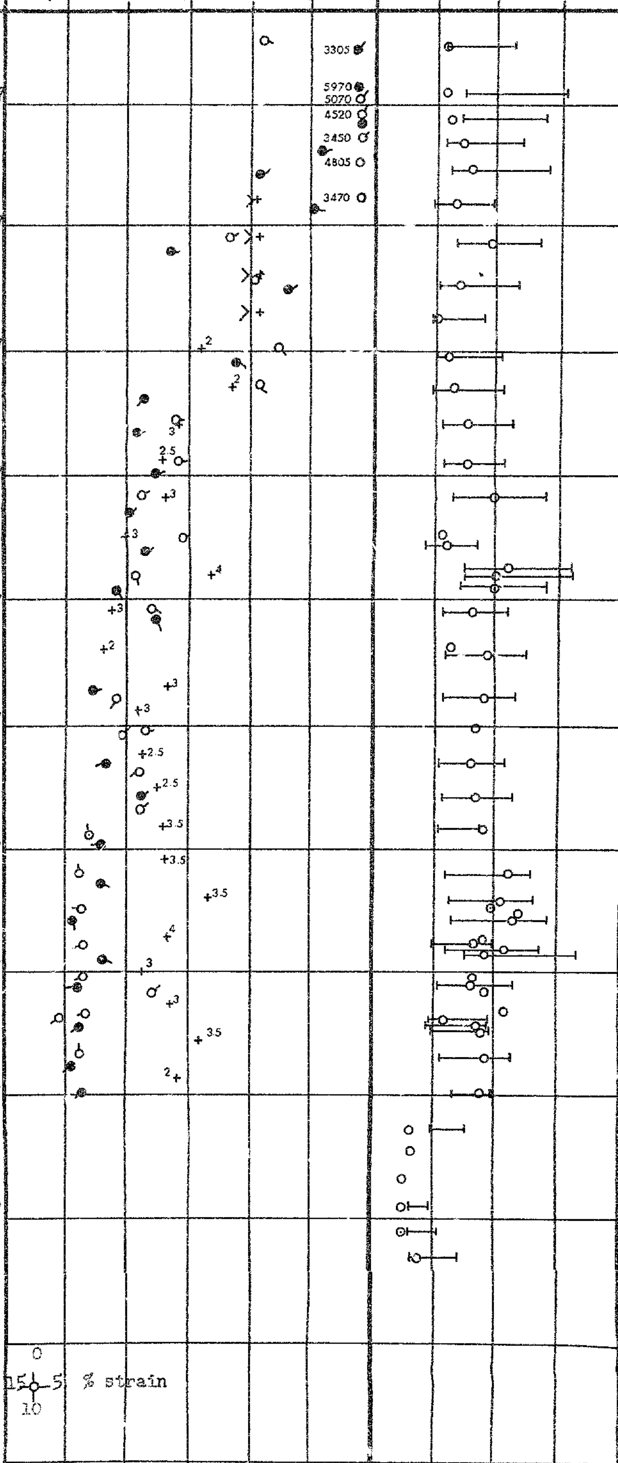
SAMPLES

NUMBER	TYPE	BLOWS / FOOT
1	TW	P
2	TW	P
3	TW	P
4	TW	P
5	TW	P
6	TW	P
7	TW	P
8	TW	P
9	TW	P
10	TW	P
12	TW	P
13	TW	P
14	TW	P
15	TW	P
16	TW	P
17	TW	P
18	TW	P
19	TW	P
19A	TW	P
20	TW	P
21	TW	P
22	TW	P
23	TW	P
24	TW	P
25	TW	P
26	TW	P
27	TW	P
28	TW	P
29	TW	P
30	TW	P
31	TW	P
32	SS	55
33	SS	68
34	SS	150
35	SS	66
36	SS	98
37	SS	103
38	SS	136
39	SS	110/6"
40	RC BXL	61%
41	RC BXL	85% Rec
42	RC BXL	81%

ELEV. SCALE: 567, 557, 547, 537, 527, 517, 507, 497, 487, 477, 467, 457

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT
SHEAR STRENGTH P.S.F.: ● Triaxial, ○ Unconfined, + Field Vane, × Lab. Vane — 500, 1000, 1500, 2000, 2500

LIQUID LIMIT — w_L; PLASTIC LIMIT — w_P; WATER CONTENT — w
WATER CONTENT % — 20, 40, 60



BULK DENSITY γ P.C.F.: 130, 125, 120, 123, 115, 122, 125, 127, 121, 122, 115, 127, 111, 121, 117, 118, 121, 120, 116, 112, 110, 116, 115, 117, 117, 118

REMARKS

▽ 578.2

Gr. Sa. Si. Cl

0 1 69 30

8 23 69 0

8 35 46 11

8 25 48 19

Art. Water ▽ 474.6

FORM OB-MT-126
66-4546

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 8

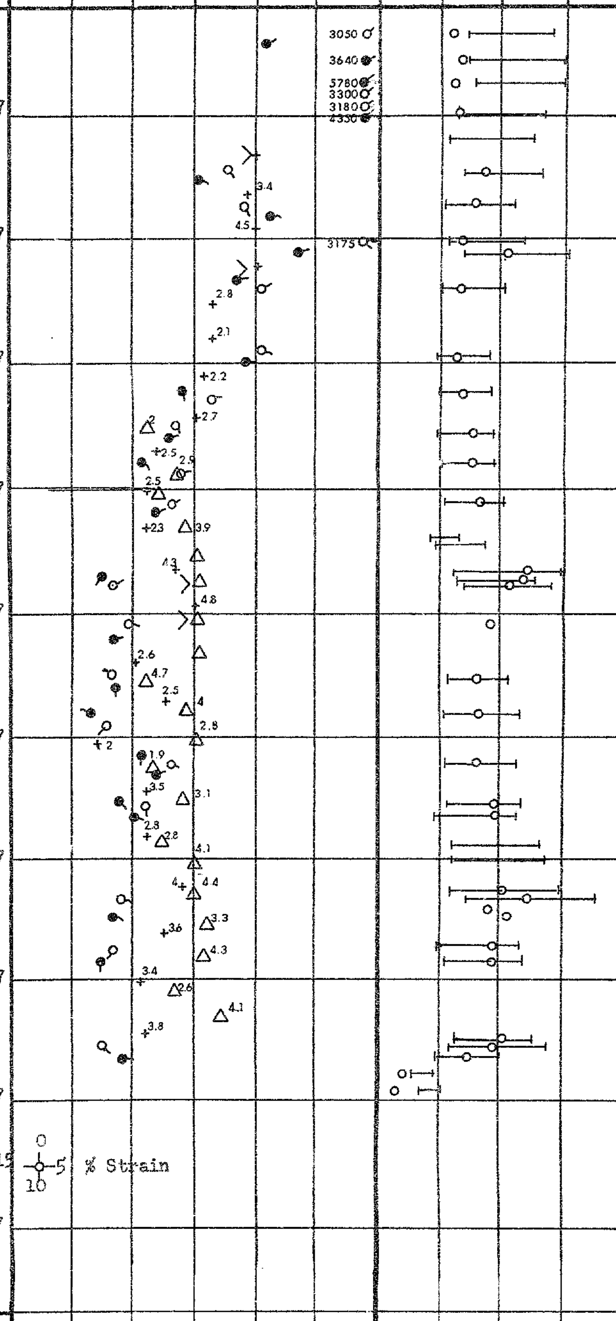
FOUNDATION SECTION

JOB 66-F-111
W.P. 242-66
DATUM Geodetic
LOCATION Sta. 23 + 65 (69' Lt.)
BORING DATE December 22, 1966
BOREHOLE TYPE Penn Drill & Washboring
ORIGINATED BY D.K., J.M.
COMPILED BY H.S., L.P.
CHECKED BY L.P.

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT

SHEAR STRENGTH P.S.F. ● Triaxial ○ Unconfined + Field Vane × Lab. Vane △ Norwegian Vane — 500 1000 1500 2000 2500

LIQUID LIMIT — w_L; PLASTIC LIMIT — w_P; WATER CONTENT — w — WATER CONTENT % 20 40 60



ELEV. / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	BULK DENSITY P.C.F.	REMARKS Gr.	Sa.	Si.	Cl
575.8	Ground Level									
0.0	Clay to silty clay. Very stiff to stiff. Brown & grey-brown mottled.	1	TW	PH		127				
		2	TW	PH		124				
		3	TW	PH						
		4	TW	PH	567	125				
	Layered red, brown & grey	5	TW	PM						
		6	TW	PM		120				
	(Zone 1)	7	TW	PM						
554.8	Layered brown & grey.	8	TW	PM	557	125				
21.0	Silty clay occasional gravel. Stiff.	9	TW	PM						
		10	TW	PM						
		11	SS	-						
	Brown	12	TW	PM	547	126				
	(Zone 2)	13	TW	PM						
		14	TW	PM						
		15	TW	PM	537	122				
		16	TW	PM						
531.3		17	TW	PM						
44.5	Clay, layered brown, red & grey. Stiff to Firm.	18	TW	PM	527	110				
523.3	(Zone 3)	19	TW			115				
52.5	Silty clay, pockets of silt. Stiff to Firm.	20	TW	PM		119				
	Brown or mottled.	21	TW	PM	517	120				
	(Zone 4)	22	OS	PH						
507.8		23	OS	PH		118				
68.0	Silty clay to clay. Stiff to Firm. Layered brown & red-brown.	24	OS	PH	507	112				
		25	OS	PH		118				
	(Zone 5)	26	OS	PH	497					
	Pockets & occ. seams of silt & silty sand.	27	OS	PH		122	21	30	27	22
489.8		28	OS	PH			21	39	28	12
86.0	Clayey silt, sand and gravel. Occasional boulders. (Glacial Till)	29	SS	38	487					
		30	SS	100/5"						
		31	RC BX	lost						
482.3		32	SS	120/3"						
93.5	Bedrock - Extensively weathered & fractured in upper 6 feet.	33	RC BX	50% Rec						
		34	RC BX	77%	477					
		35	RC BX	95% Rec.						
472.8		36	RC BX	89% Rec						
105.8	End of Borehole									

FORM OB-MT-126
66-4546

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 9

FOUNDATION SECTION

JOB 66-F-111
W.P. 242-66
DATUM Geodetic

LOCATION Line "B" Stn. 14 + 99 o/s 4.5" Lt.
BORING DATE December 28, 1966; January 3, 1967
BOREHOLE TYPE Penndrill, Diamond Drill BX Cased, BX Core

ORIGINATED BY DK, JM
COMPILED BY JM, LP
CHECKED BY L.P.

SOIL PROFILE: ELEV. DEPTH	SOIL PROFILE: DESCRIPTION	STRAT. PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS / FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F.	LIQUID LIMIT w_L, PLASTIC LIMIT w_P, WATER CONTENT w — WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS
580.8	Ground Level									
0.0	Probable Clayey silt to clay. (Zone 1)									
	Probable Layered Material									
561.0	Probable layered material									
20.0	Probable silty clay Occasional gravel (Zone 2)									
542.0				AUGERED TO BEDROCK						
39.0	Probable silty clay Layered (Zone 3)									
532.0			NOT SAMPLED							
49.0	Probable silty clay Mottled (Zone 4)									
519.0										
62.0	Probable silty clay to clay. Layered (Zone 5)									
503.0 / 78.0	Probable Till									
500.2 / 80.6	Bedrock - extensively weathered & fractured		1	RC BX	57% Rec					
490.6			2	RC BX	46% Rec					
90.2	End of Borehole									

FORM DB-MT-126
66-4546

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS – ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 10

FOUNDATION SECTION

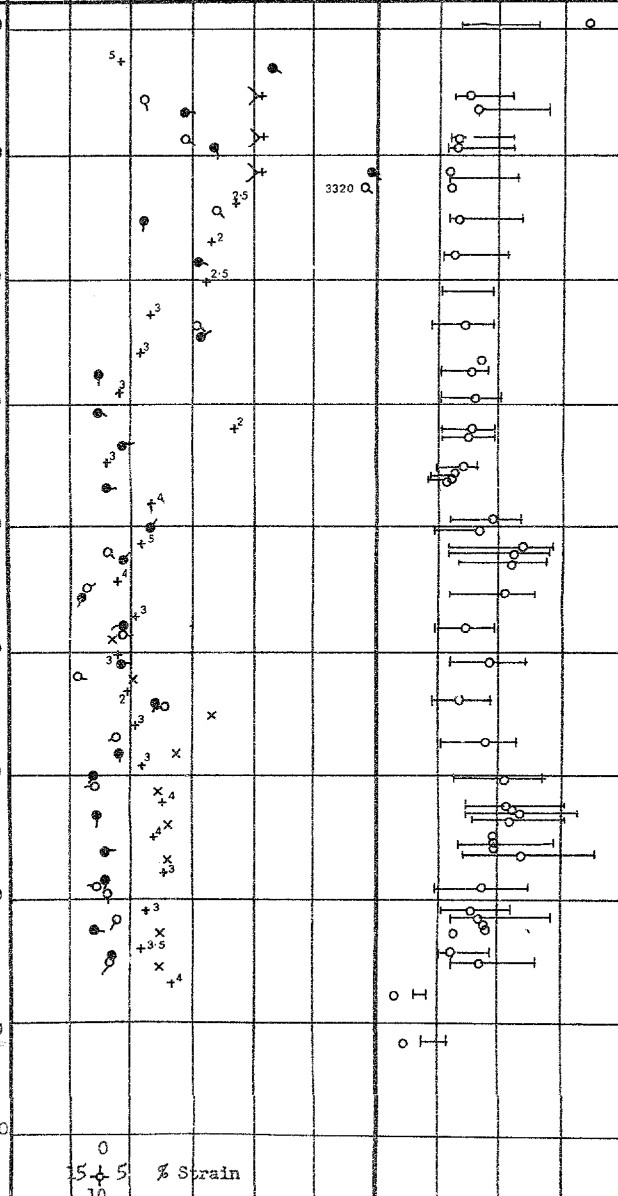
JOB 66-F-111 LOCATION Fork's Rd., Welland Jct. ORIGINATED BY DK, JM
W.P. 242-66 BORING DATE December 28, 1966 COMPILED BY VK, LP
DATUM Geodetic BOREHOLE TYPE Penn Drill Auger CHECKED BY L.P.

ELEV. / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLES – NUMBER	TYPE	BLOWS / FOOT	BULK DENSITY γ P.C.F.	REMARKS Gr.Sa.Si.Cl
572.3	Ground Level					
0.0	Silty clay to clay. Very stiff to stiff Brown to grey Mottled Zone (Zone 1)	1	TW	P		16.7% by wt. 6.7% Org.
		2	TW	P	125	
		3	TW	P	120	
		4	TW	P	125	2 52 46
555.3		5	TW	P		
17.0	Silty clay, occas. gravel. Stiff to firm. Red-brown. (Zone 2) Occasional pockets of silt.	6	TW	P	123	
		7	TW	P	125	
		8	TW	P		
		9	TW	P		
		10	TW	P	121, 119	
536.3		11	TW	P	121	
36.0	Clayey silt to clay. Stiff to firm Layered or mottled Brown, red & grey (Zone 3)	12	TW	P	127	
		13	TW	P		
		14	TW	P	121	
		15	TW	P	119	
523.8		16	TW	P	113	
48.5	Silty clay to clay Stiff to firm Pockets of silt Brown or mottled. (Zone 4)	17	TW	P	122	
		18	TW	P	118	
		19	TW	P	123	
508.8		20	TW	P	116	
63.5	Silty clay to clay. Stiff to firm Layered or mottled Red-brown, brown, grey. (Zone 5)	21	TW	P	112	
		22	TW	P	109	
		23	TW	P	111	
		24	TW	P	116	
		25	TW	P	118	
492.3		26	TW	P	123	
80.0	Heterogeneous mixture of clayey silt, sand and gravel. Hard. Occasional boulders.	26A	SS	55		13 41 37 9
		27&28	SS BXL	100/1.5" RC		27 32 (41)
484.3		29	SS	105		
88.0	Bedrock – weathered and fractured. Some gypsum.	30	RC	80% Loss		
		32	BXL	60%		
		33		80%		
		34	RC BXL	90%		
		35	RC BXL	95% Rec		
477.6		36	RC B XL	70%		
97.5	End of Borehole					

ELEV. SCALE: 570, 560, 550, 540, 530, 520, 510, 500, 490, 480

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT
SHEAR STRENGTH P.S.F. ● Triaxial + Field Vane ○ Unconfined × Lab. Vane
500 1000 1500 2000 2500

LIQUID LIMIT —— w_L
PLASTIC LIMIT —— w_P
WATER CONTENT —— w
WATER CONTENT % 20 40 60



DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 11

FOUNDATION SECTION

JOB 66-F-111
W.P. 242-66
DATUM Geodetic
LOCATION Line "B" Stn. 18 + 08 o/s 29.5' Lt.
BORING DATE January 9, 1967
BOREHOLE TYPE Penndrill
ORIGINATED BY LP
COMPILED BY JM, LP
CHECKED BY L.P.

ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS / FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F.	LIQUID LIMIT w_L, PLASTIC LIMIT w_P, WATER CONTENT w; WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS
580.4	Ground Level									
0.0	Probable silty clay to clay. (Zone 1) Prob. layered material									
	Probable clayey silt Occasional Gravel (Zone 2)		AUGERED TO PROBABLE BEDROCK NOT SAMPLED							
	Probable silty clay to clay. Layered (Zone 3)									
	Probable silty clay to clay. Mottled. (Zone 4)									
507.0	Probable silty clay to clay. Layered. (Zone 5)									
73.0 498.4	Probable Till	T T T								
82.0	End of Borehole Probable Bedrock									

FORM OB-MT-126
66-4546

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 12

FOUNDATION SECTION

JOB 66-F-111
W.P. 242-66
DATUM Geodetic
LOCATION Line "B" Stn. 12 + 05 o/s 18' Rt.
BORING DATE January 11, 1967
BOREHOLE TYPE Penn Drill
ORIGINATED BY LP
COMPILED BY JM LP
CHECKED BY L.P.

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS / FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F.	LIQUID LIMIT w_L; PLASTIC LIMIT w_P; WATER CONTENT w; WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS
581.0	Ground Level									
0.0 / 559.0	Probable silty clay to clay. Occasional layered zone. (Zone 1)									
22.0 / 539.0	Probable Silty Clay to clayey silt. Occasional gravel. (zone 2)									
42.0 / 533.0	Probable silty clay Layered (Zone 3)									
48.0 / 522.0	Probable silty clay Mottled (Zone 4)		AUGERED TO PROBABLE BEDROCK NOT SAMPLED							
59.0 / 505.0	Probable silty clay to clay. Layered. (Zone 5)									
76.0 / 499.5	Probable Till	T T T								
81.5	End of Borehole Probable Bedrock									

FORM DB-MT-126
66-4546

OFFICE REPORT ON SOIL EXPLORATION

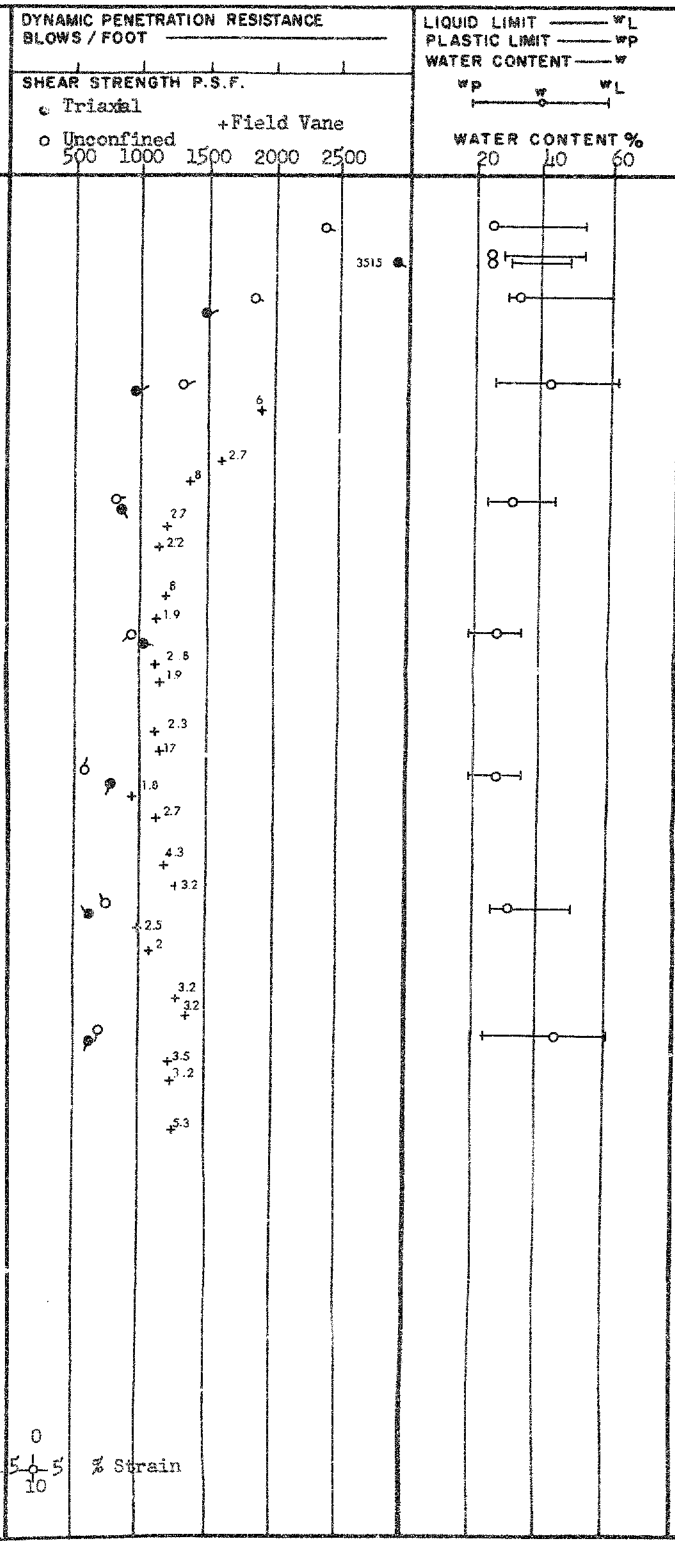
DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 13

FOUNDATION SECTION

JOB 66-F-111
LOCATION Line "B" 00 + 99.5' o/s 49.5 Rt.
ORIGINATED BY DK
W.P. 242-66
BORING DATE January 20 & 23, 1967
COMPILED BY DK, JM, LP
DATUM Geodetic
BOREHOLE TYPE Penn Drill
CHECKED BY L.P.

ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	BULK DENSITY γ P.C.F.	REMARKS Gr.	Sa.	Si.	Cl
582.2	Ground Level										
0.0	Silty clay to clay Occasional pockets of gypsum. Very stiff to firm. Brown mottled with grey.		1	TW	PH		124.5				
			2	TW	PH		127				
			3	TW	PH		118 119				
			4	TW	PH						
	Layered grey, red & brown		5	TW	PH		113				
	(Zone 1)		6	TW	PM						
			7	TW	PM		120				
555.7 26.5	Silty clay, occ. gravel. Stiff to firm. Brown		8	TW	PM						
			9	TW	PM		124				
	(Zone 2)		10	TW	PM						
			11	TW	PM		125				
534.7 47.5	Silty clay to clay. Stiff to firm. Red-brown, grey, brown mottled & layered zones not defined.		12	TW	PM						
			13	TW	PM		117 123				
	(Zones 3, 4 & 5)		14	TW	PM						
			15	TW	PM		110.5				
510.2			16	TW	PM						
72.0 506.7	Gravel, some sand, trace silt & clay.		17	SS	24			68	27	(5)	
75.5	End of Borehole										



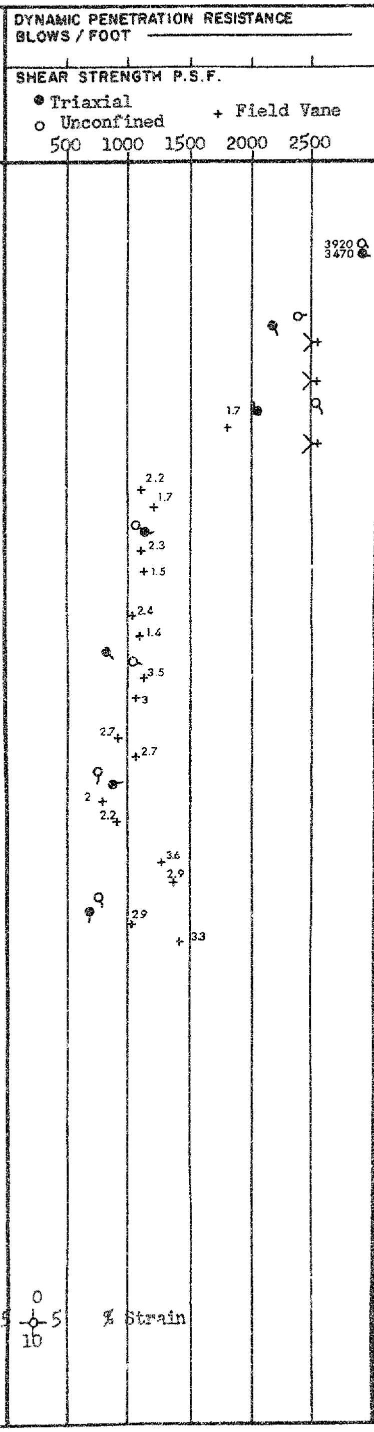
DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

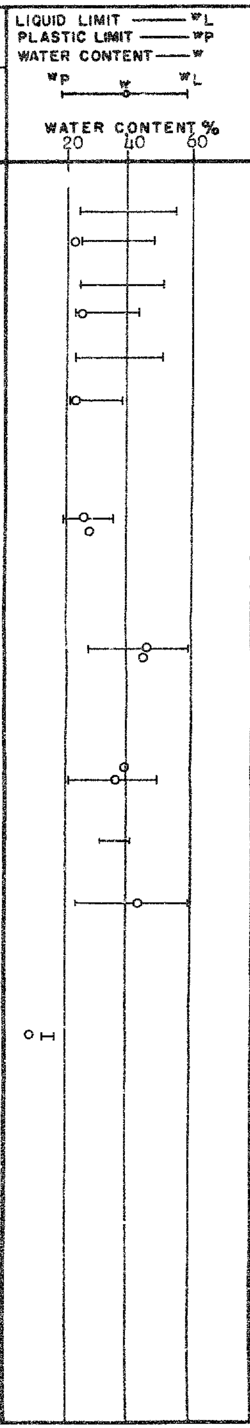
RECORD OF BOREHOLE NO. 14

FOUNDATION SECTION

JOB 66-F-111 LOCATION Line "B" 05 + 98.5' o/s 49.0 Left ORIGINATED BY DK
W.P. 242-66 BORING DATE January 19, 1967 COMPILED BY DK, JM, LP
DATUM Geodetic BOREHOLE TYPE Penndrill CHECKED BY L.P.

ELEV. DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS / FOOT	BULK DENSITY γ P.C.F.	Gr.	Sa.	Si.	Cl
581.6	Ground Level								
0.0	Silty clay, very stiff. Mottled grey & brown. (Zone 1)	1	TW	PH					
		2	TW	PH	126				
		3	TW	PH					
		4	TW	PH	128				
		5	TW	PH					
563.6 / 18.0	Silty clay, occasional gravel. Very stiff to stiff. Brown. (Zone 2)	6	TW	PM	128				
		7	TW	PM					
		8	TW	PM	126				
		9	TW	PM					
545.1 / 36.5	Silty clay to clay. Stiff to firm. Layered and mottled Zones not defined. Red-brown, brown & grey. (Zones 3, 4 & 5)	10	TW	PM	111				
		11	TW	PM					
		12	TW	PM	115				
		13	TW	PM					
		14	TW	PM	111				
		15	TW	PM					
516.1 / 65.5	Heterogeneous mixture of clayey silt, sand and gravel. Hard. (Glacial Till)	16	SS	126		21	37	32	10
507.1 / 74.5	End of Borehole Probable Bedrock								





66-4546

DEPARTMENT OF HIGHWAYS – ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 15

FOUNDATION SECTION

JOB 66-F-111 LOCATION Line "B" Stn. 10 + 99.5 o/s 51.0' Rt. ORIGINATED BY DK, JM

W.P. 242-66 BORING DATE January 17, 18, 25-27, 30, 1967 COMPILED BY JM, LP

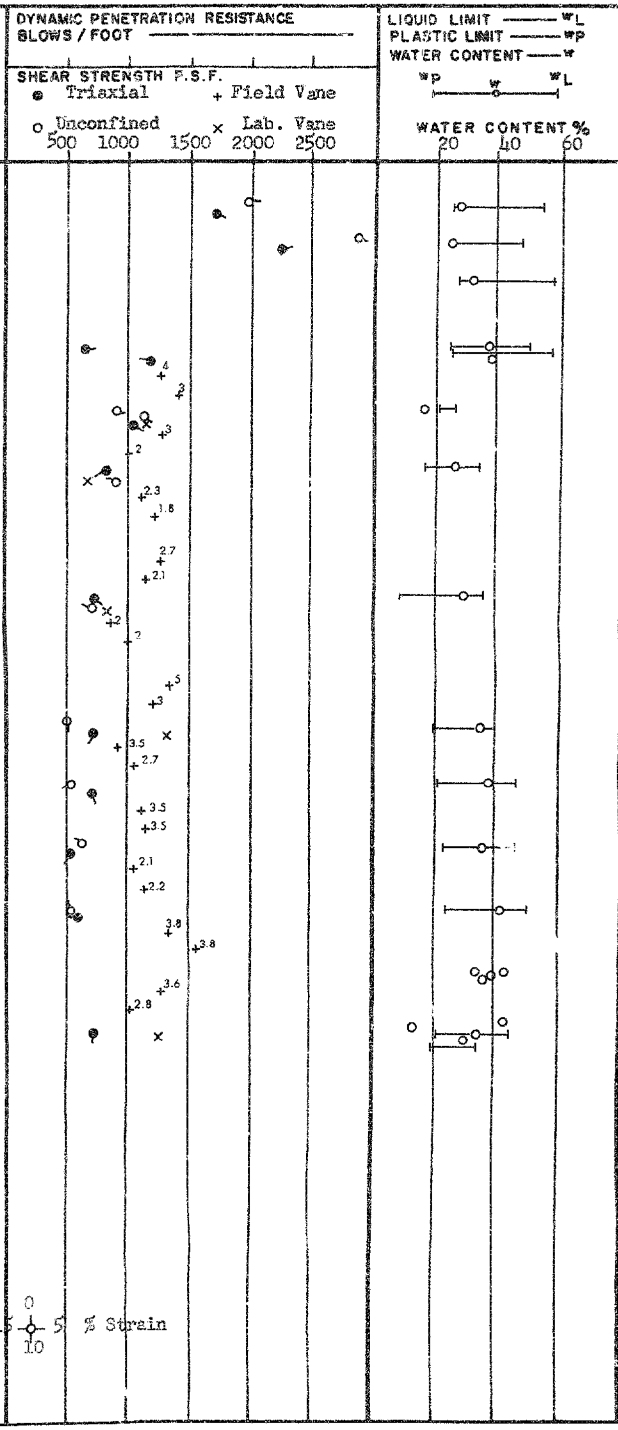
DATUM Geodetic BOREHOLE TYPE Pen. Drill, Washboring, NX & BX, Diamond Drill BX CHECKED BY L.P.

Soil Profile

Elev. / Depth	Description
580.9	Ground Level
0.0	Clayey silt to clay. Very stiff to firm. Brown, grey-brown Mottled. Layered brown & grey. (Zone 1) Layered brown & grey. Distorted silt layers and pockets.
557.4 / 23.5	Silty clay, occasional gravel. Stiff to Firm. Brown (Zone 2)
535.9 / 45.0	Silty clay, stiff to firm. Layered red, grey & brown. (Zone 3)
530.4 / 50.5	Silty clay, stiff to firm, Mottled. (Zone 4)
524.9 / 56.0	Silty clay. Stiff to firm. Layered red, grey & brown. (Zone 5)
509.9 / 71.0	Heterogeneous mixture of clayey silt, sand and gravel. Hard. (Glacial Till)
500.4 / 80.5	Bedrock – weathered and fractured.
490.5 / 90.4	End of Borehole

Samples

Number	Type	Blows / Foot	Bulk Density γ P.C.F.	Remarks Gr. Sa. Si. Cl.
1	TW	PH	125	
2	TW	PH		
3	TW	PH		
4	TW	PH		
5	TW	PM	114	
6	TW	PM	128	71 29
7	TW	PM	124	
8	TW	PM		
9	TW	PM	120	
10	TW	PM		
11	TW	PM	118	
12	TW	PM	118	
13	TW	PM	117	
14	TW	PM	111	
15	TW	PM		
16	TW	PM	122	
17	SS	80/6"		
18	SS	54/1"		
19	RC BX	77% Rec		
20	RC BX	92% Rec		



FORM DB-MT-12C
66-4546

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS – ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 16

FOUNDATION SECTION

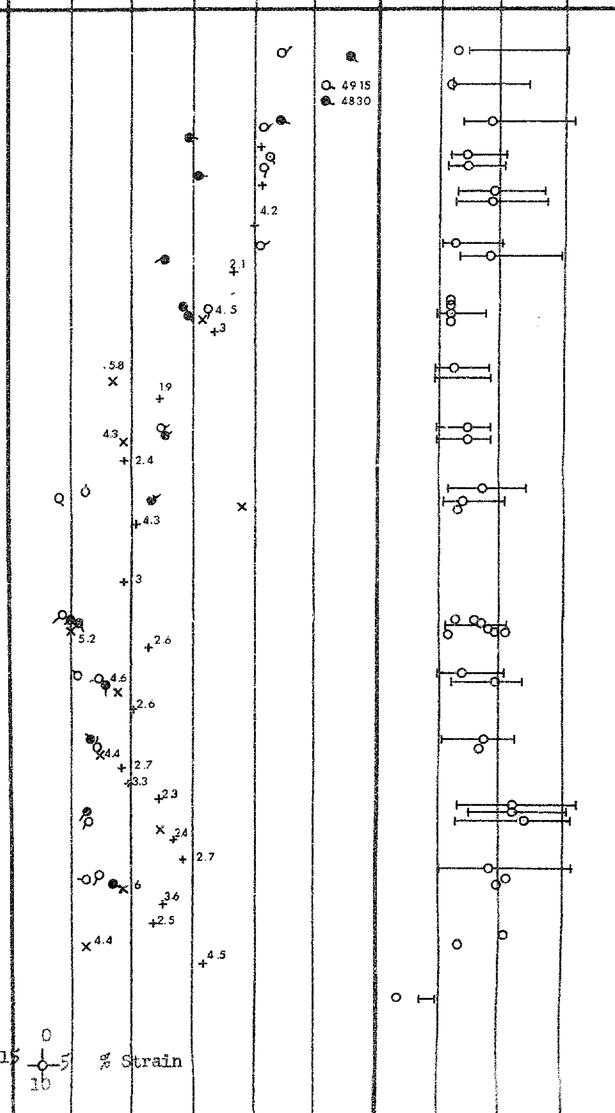
JOB 66-F-111
W.P. 242-66
DATUM Geodetic

LOCATION Line "B" 15 + 00.5' o/s 05.0' Rt.
BORING DATE January 11, 12, & 19, 1967
BOREHOLE TYPE Penndrill & Washboring

ORIGINATED BY DK
COMPILED BY DK, JM
CHECKED BY L.P.

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT
SHEAR STRENGTH P.S.F. ● Triaxial + Field Vane ○ Unconfined × Lab. Vane 500 1000 1500 2000 2500

LIQUID LIMIT — w_L PLASTIC LIMIT — w_P WATER CONTENT — w
WATER CONTENT % 20 40 60



ELEV. DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FOOT	BULK DENSITY γ P.C.F.	REMARKS Gr.	Sa.	Si.	Cl
580.7	Ground Level								
0.0	Silty clay to clay occas. gypsum deposits Very stiff to stiff. Grey-brown (Zone 1)	1	TW	PH	125				
		2	TW	PH	128				
	Layered red-brown & grey-brown.	3	TW	PH	117				
		4	TW	PH	122				
	Layered red-brown, brown & grey.	5	TW	PH					
560.7		6	TW	PM	125				
20.0	Silty clay, occas. gravel. Stiff to firm. Brown. (Zone 2)	7	TW	PM	124 127.5				
		8	TW	PM					
		9	TW	PM	123	0	2	88	10
541.7		10	TW	PM	124 125 126				
39.0	Silty clay, stiff to firm. Layered brown, red & grey. (Zone 3)	11	TW	PM					
530.2		12	TW	PM	119	0 [illegible] 0	2 [illegible] 0	48 [illegible] 80	50 [illegible] 20
50.5	Silty clay, occasional pockets of silt. Stiff to firm. Mottled red, brown & grey. (Zone 4)	13	TW	PM	114 121 124				
518.7		14 / 15	TW / TW	OW / PM	119.5				
62.0	Silty clay to clay. Stiff to firm. Layered brown, red & grey. (Zone 5)	16	TW	PM	110.5				
		17	TW	PM	117.5	0 / 0	1 / 1	36 / 83	63 / 16
502.7		18	TW	PM					
78.0 / 499.7	Clayey silt, sand & gravel. (Glacial Till)	19	SS	80/2"		25	37	(38)	
81.0	Bedrock, weathered and fractured.	20	RC BX	80% Rec					
491.3		21	RC BX	75% Rec					
89.4	End of Borehole								

FORM DB-MT-126
66-4546

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS – ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 17

FOUNDATION SECTION

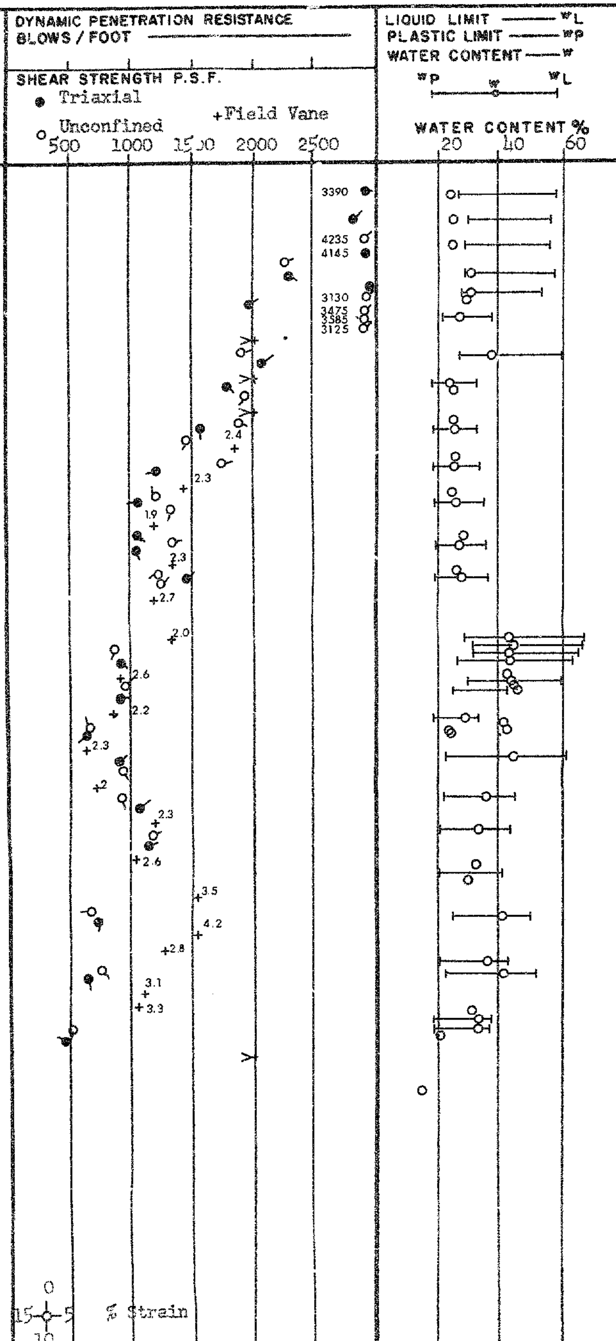
JOB 66-F-111
W.P. 242-66
DATUM Geodetic
LOCATION Line "B" 19 + 00.5' o/s 41.5' Rt.
BORING DATE January 13, 16 & 24, 1967
BOREHOLE TYPE Penndrill
ORIGINATED BY DK
COMPILED BY DK, LP
CHECKED BY L.P.

Soil Profile

ELEV. / DEPTH	DESCRIPTION
580.1 / 0.0	Clay to silty clay. Very stiff. Mottled grey to brown (Zone 1)
563.4	Lay. red, brown & grey.
16.7	Clayey silt, occas. gravel & pockets of silt. Very stiff to stiff. Brown. (Zone 2)
541.1 / 39.0	Silty clay to clay, stiff to firm. Layered red, grey & brown. (Zone 3)
535.1 / 45.0	Silty clay to clay. Firm to stiff. Grey-brown, brown & grey mottled. (Zone 4)
520.1 / 60.0	Silty clay to clay. Stiff to firm. Layered grey-brown, brown & red. (Zone 5)
507.1 / 73.0	Heterogeneous mixture of clayey silt, sand and gravel. Occ. boulders. Hard. (Glacial Till)
497.1 / 83.0	Bedrock, weathered & fractured.
488.7 / 91.4	End of Borehole

Samples

NUMBER	TYPE	BLOWS / FOOT
1	TW	PH
2	TW	PH
3	TW	PH
4	TW	PH
5	TW	PH
6	TW	PM
7	TW	PM
8	TW	PM
9	TW	PM
10	TW	PM
11	TW	PM
12	TW	PM
13	TW	PM
14	TW	PM
15	TW	PM
16	TW	PM
17	TW	PM
18	TW	PM
19	TW	PM
20	TW	PM
21	TW	PM
22	TW	PM
23	TW	PM
24	TW	PM
25	SS	48
26	RC BX	10% REC
27	RC BXL	45% Rec
28	RC BXL	100% Rec



BULK DENSITY γ P.C.F.: 128, 127, 121, 122, 117, 128, 125, 127, 124, 110, 121, 111, 119, 113, 116, 120

REMARKS (Gr. Sa. Si. Cl.):

Gr.	Sa.	Si.	Cl.
		30	70
	1	89	10
	1	83	16

FORM OB-MT-126
66-4546

OFFICE REPORT ON SOIL EXPLORATION

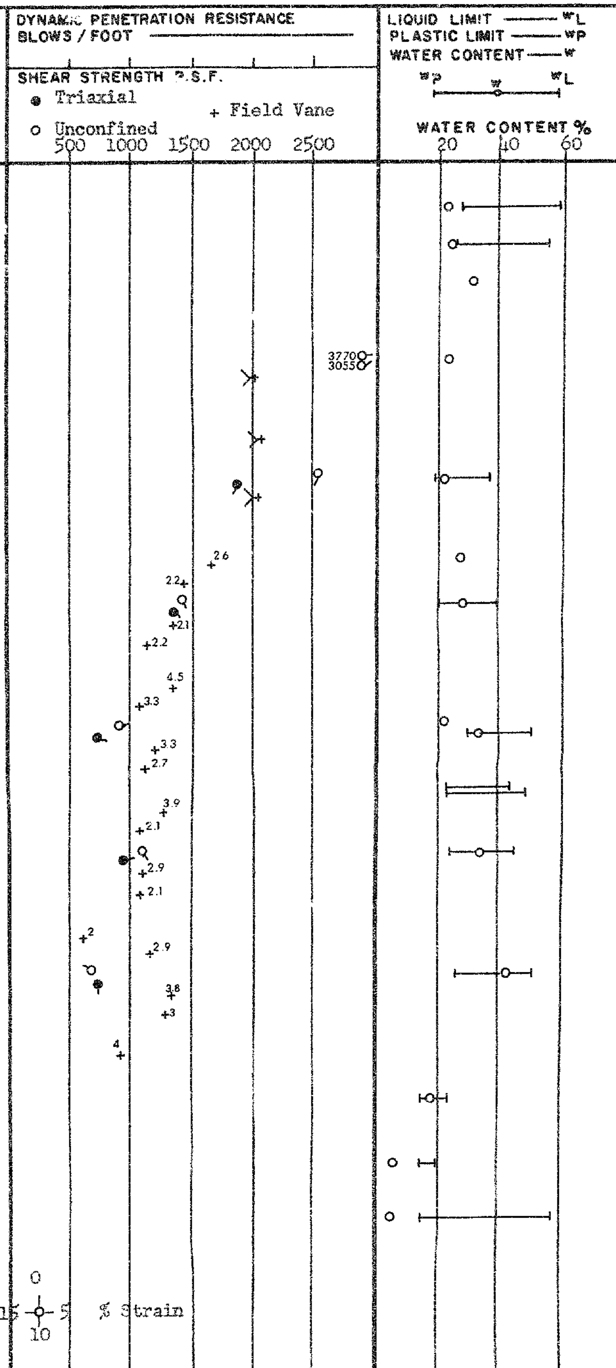
DEPARTMENT OF HIGHWAYS – ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 18

FOUNDATION SECTION

JOB 66-F-111 LOCATION Line "B", Stn. 23 + 75 o/s 89' Lt. ORIGINATED BY JM
W.P. 242-66 BORING DATE Jan. 31, Feb. 1-3, 1967 COMPILED BY JM, LP
DATUM Geodetic BOREHOLE TYPE Washboring NX & BX Cased CHECKED BY L.P.

ELEV. DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS / FOOT	BULK DENSITY γ P.C.F.	REMARKS Gr. Sa. Si. Cl
578.7	Ground Level					
0.0	Clay to silty clay. Very stiff. Brown to red-brown (ZONE 1)	1	SS	26		
		2	SS	36		
		3	SS	14		
		4	TW	PM		
		5	TW	PM	127.5	
559.2 / 19.5	Silty clay, occasional gravel & silt pockets. Very stiff to stiff. Brown. (Zone 2)	6	TW	PM		
		7	TW	PM	129	
		8	TW	PM		
		9	TW	PM	124	
539.7 / 39.0	Silty clay. Stiff to firm. Layered red, grey & brown. (Zone 3)	10	TW	PM		
532.7 / 46.0	Silty clay. Stiff to firm. Brown, some mottled grey. (Zone 4)	11	TW	PM	117	0 0 92
		12	TW	PM		
	Occasional gravel.	13	TW	PM	119	
518.7 / 60.0	Silty clay to clay. Stiff to firm. Layered brown, grey & red-brown. (Zone 5)	14	TW	PM		
		15	TW	PM	114	
		16	TW	PM		
504.7 / 74.0	Heterogeneous mixture of clayey silt, sand and gravel. (Glacial Till)	17	TW SS	-		
		18	SS	106		31 31 37
	Layer of silty clay.	19	SS	97/6"		
489.5		20	SS	103/3"		
89.2	End of Borehole Probable Bedrock					



FORM DB-MT-126
66-4546

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS – ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 19

FOUNDATION SECTION

JOB 66-F-111
W.P. 242-66
DATUM Geodetic

LOCATION Line "B" 29 + 01 o/s 49.5' Rt.
BORING DATE January 24 & 25, 1967
BOREHOLE TYPE Penn Drill

ORIGINATED BY DK
COMPILED BY DK, JM.
CHECKED BY L.P.

SOIL PROFILE

ELEV. / DEPTH	DESCRIPTION
577.5	Ground Level
0.0	Clay to silty clay. Very stiff to stiff. Vertical seam of gypsum. Mottled red-brown, brown & grey. (Zone 1)
554.5 / 23.0	Silty clay, occasional gravel. Very stiff to firm. Brown. (Zone 2)
538.0 / 39.5	Silty clay to clay. Stiff to firm. Occasional pockets silt. Brown, grey-brown, grey. Mottled and layered zones not defined. (Zones 3, 4 & 5)
492.5 / 85.0	Probable silt with sand and gravel.
485.5 / 92.0	End of Borehole

SAMPLES

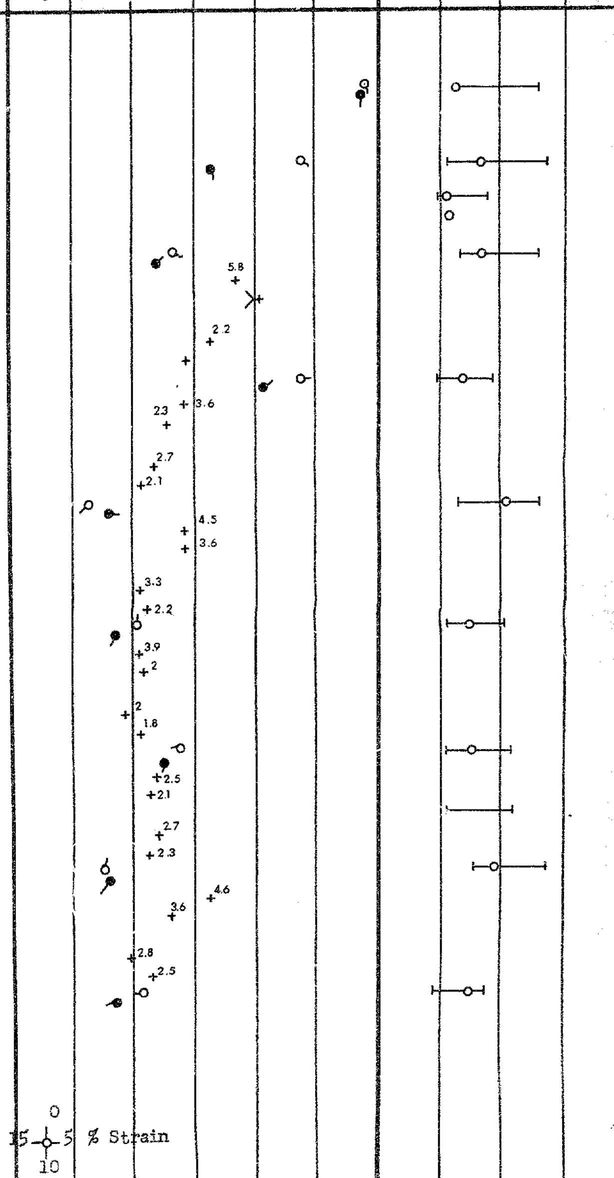
NUMBER	TYPE	BLOWS / FOOT	BULK DENSITY γ P.C.F.
1	TW	PH	126.5
2	TW	PH	
3	TW	PH	
4	TW	PH	119
5	TW	PH	
6	TW	PM	119 / 115
7	TW	PM	
8	TW	PM	121 / 124
9	TW	PM	
10	TW	PM	111 / 124
11	TW	PM	
12	TW	PM	122
13	TW	PM	
14	TW	PM	121
15	TW	PM	
16	TW	PM	113
17	TW	PM	
18	TW	PM	124
19	TW	OW	

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT

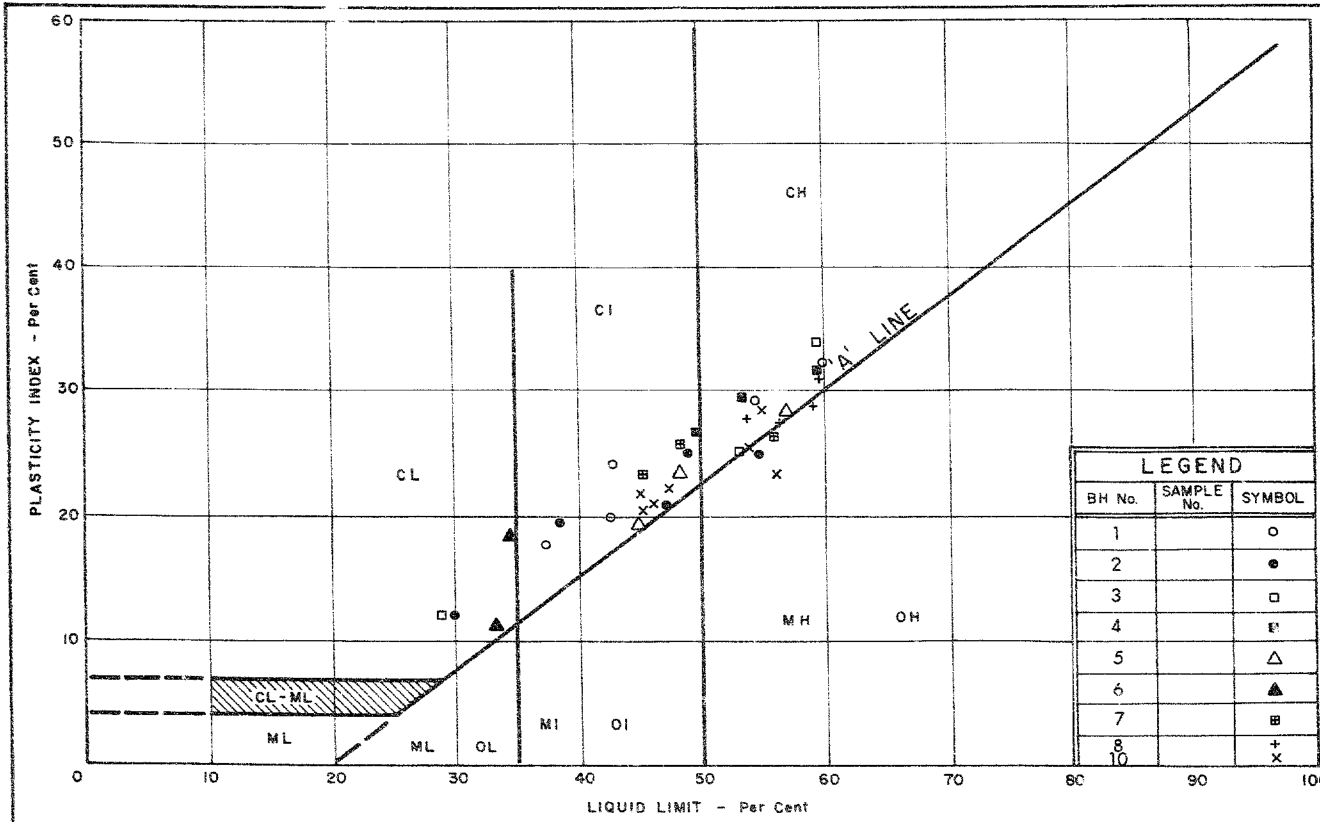
SHEAR STRENGTH P.S.F. ● Triaxial ○ Unconfined + Field Vane
500 1000 1500 2000 2500

LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w
WATER CONTENT % 20 40 60

REMARKS



FORM OD-MT-252
(REV. JUNE 1965)
65-1624



DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

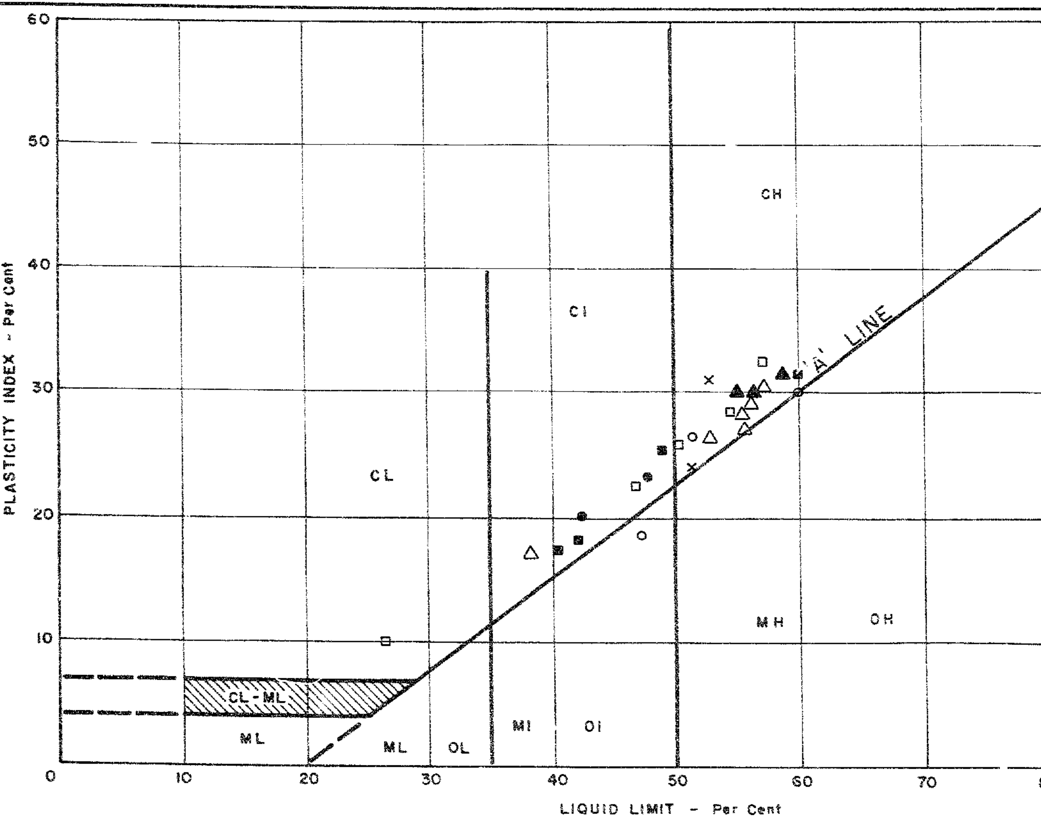
PLASTICITY CHART
LINE 'A' ZONE 1
(MOTTLED MATERIAL)

W.P. No. 242-66

JOB No. 66-F-111

FIG. No. 1

FORM OB-MT-252
(REV. JUNE 1965)
65-1624



BH No.	SAMPLE No.	SYMBOL
13		○
14		●
15		□
16		■
17		△
18		▲
19		×

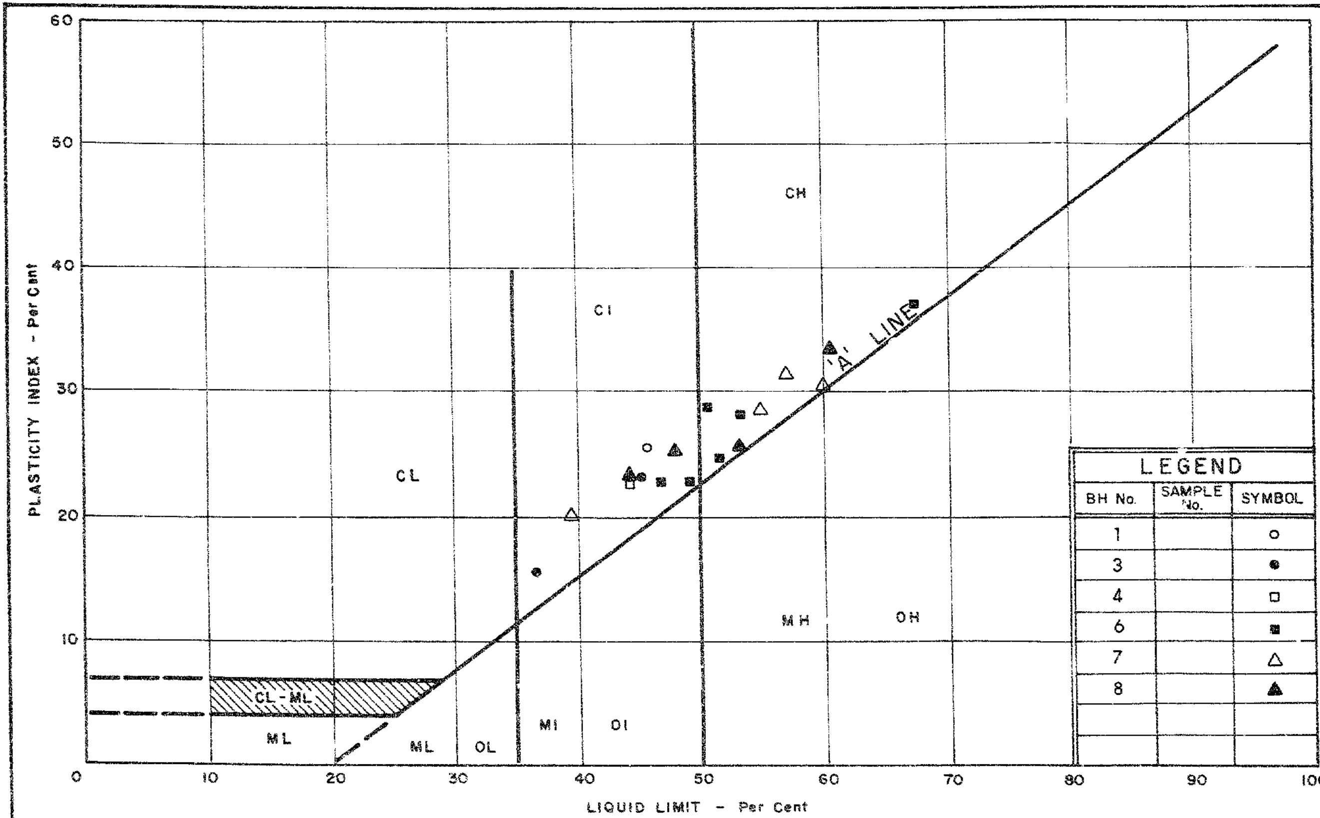
LEGEND

DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

PLASTICITY CHART
LINE 'B' ZONE 1
(MOTTLED MATERIAL)

W.P. No. 242-66
JOB No. 66-F-111
FIG. No. 2

FORM OD-MT-252
(REV. JUNE 1965)
65-1624

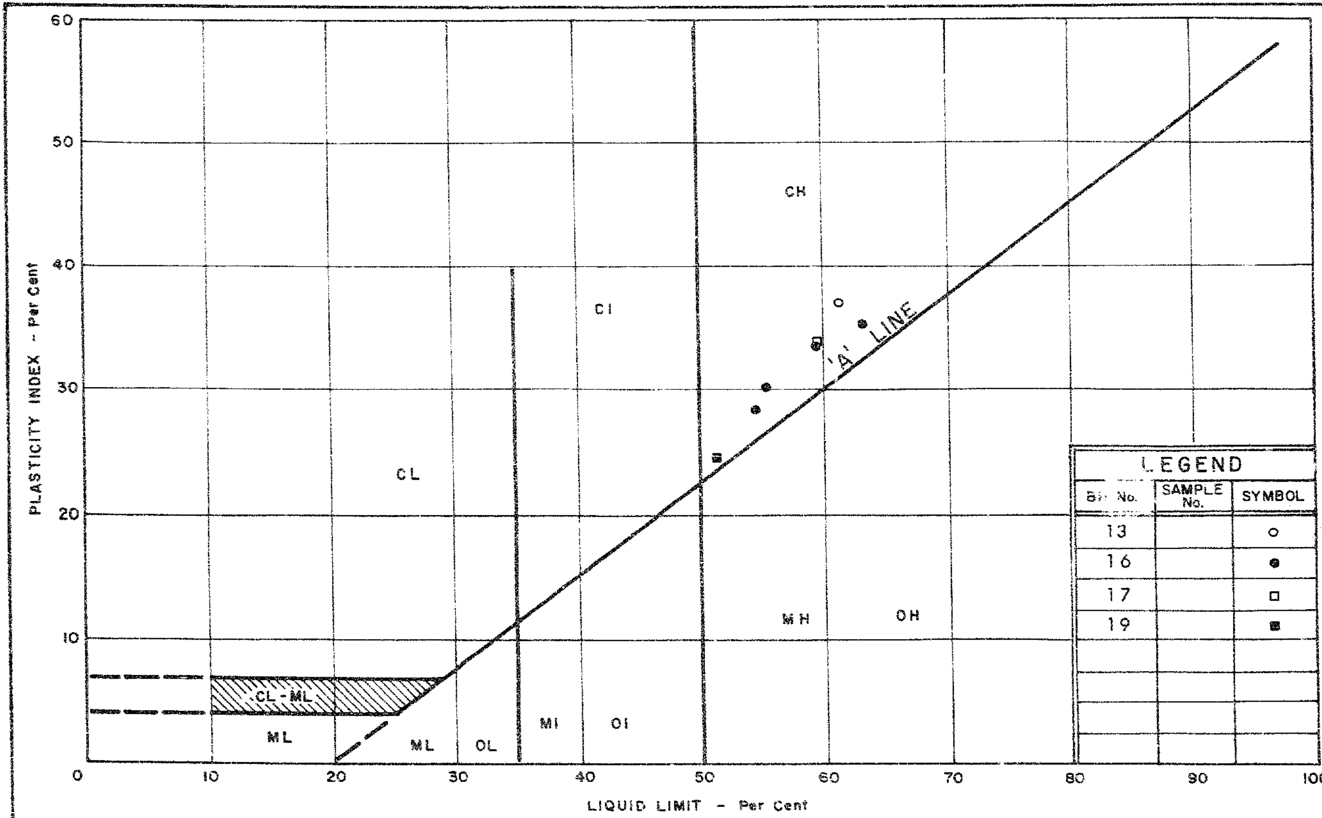


DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

PLASTICITY CHART
LINE A ZONE 1
(LAYERED MATERIAL)

W.P. No.	242-66
JOB No.	66-F-111
FIG. No. 3	

FORM 08-MT-252
(REV. JUNE 1965)
65-1624

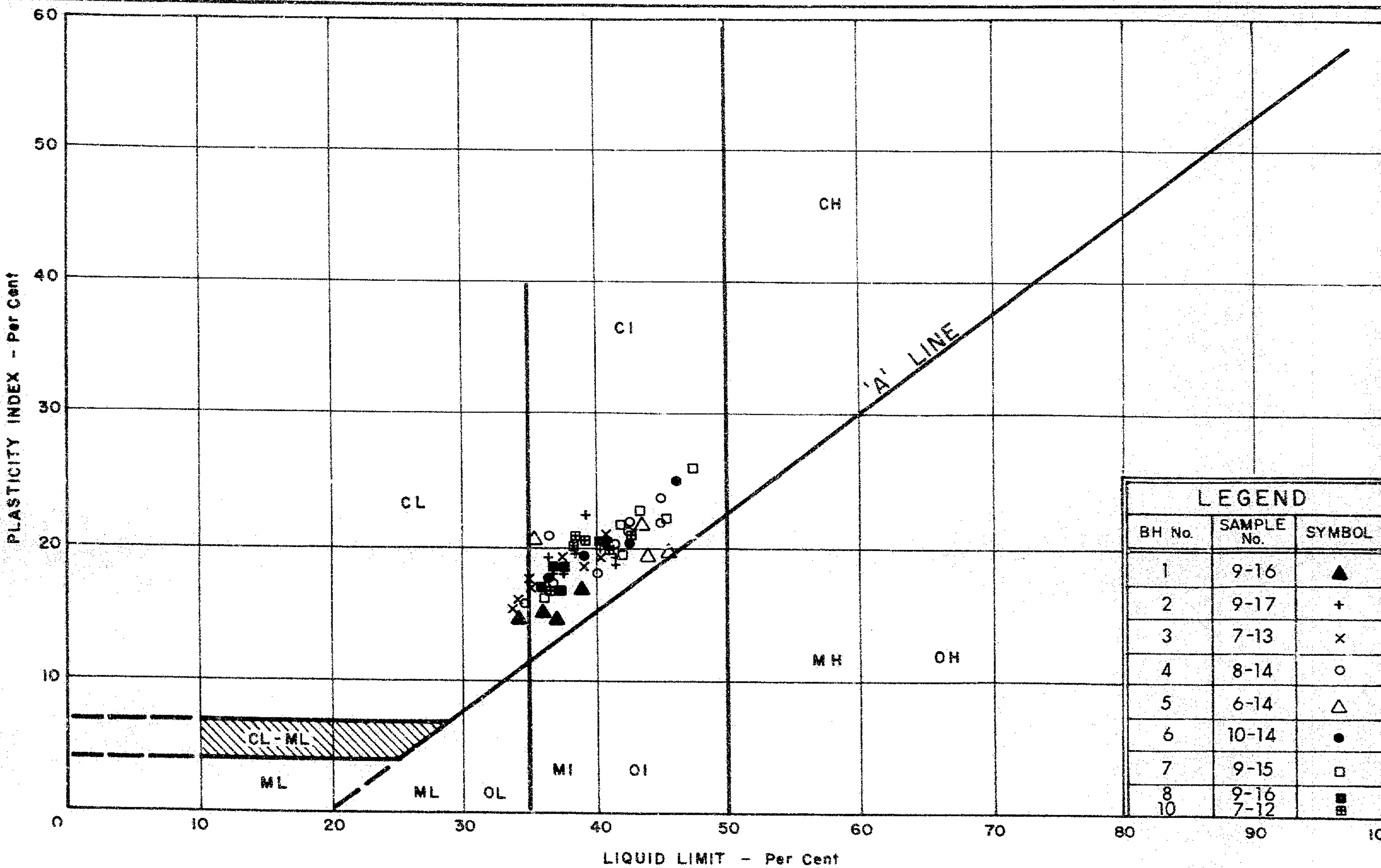


DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

PLASTICITY CHART
LINE 'B' ZONE 1
(LAYERED MATERIAL)

W.P. No. 242-66
JOB No. 66-F-111
FIG. No. 4

FORM OD-MT-252
(REV. JUNE 1965)
65-1624



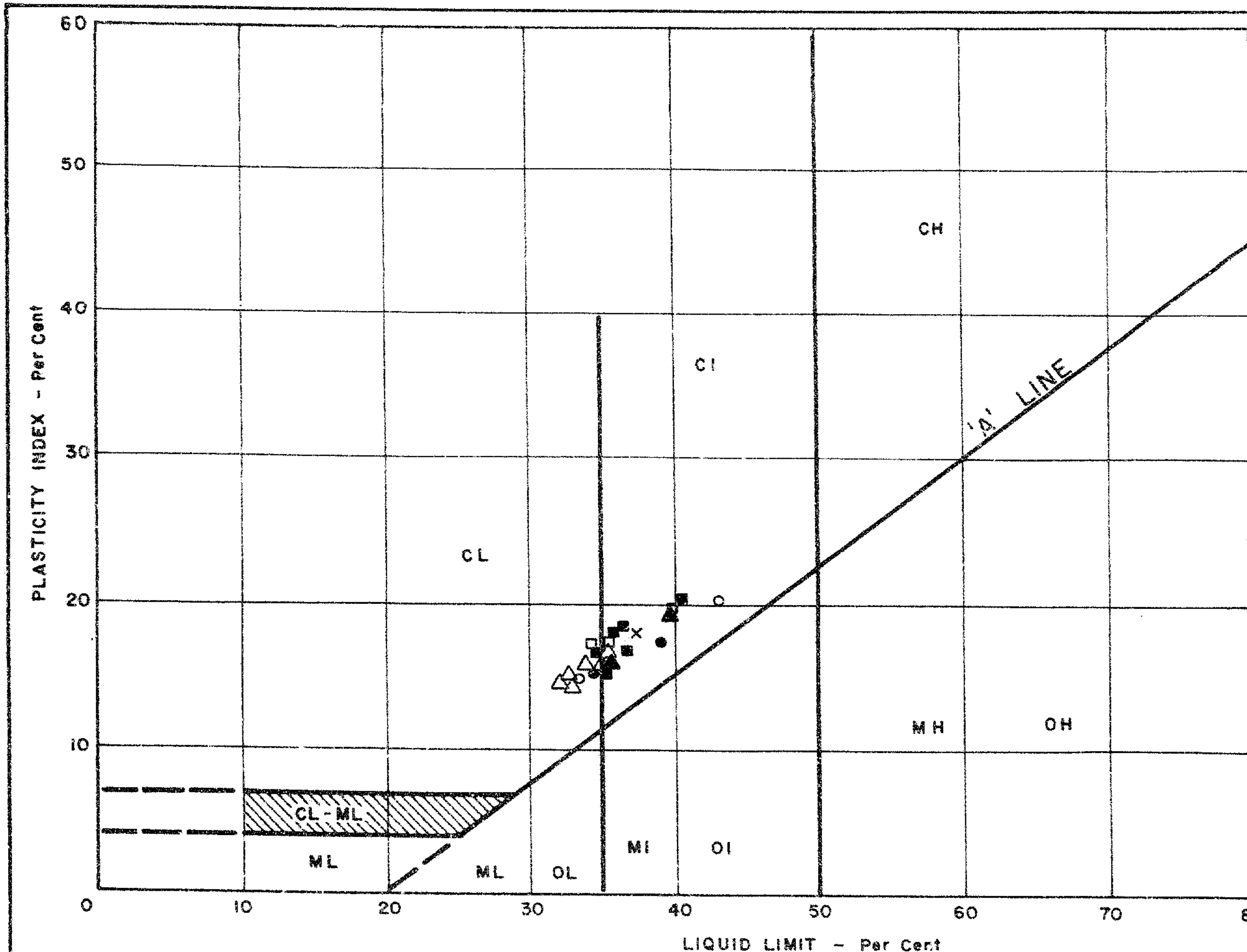
LEGEND		
BH No.	SAMPLE No.	SYMBOL
1	9-16	▲
2	9-17	+
3	7-13	×
4	8-14	○
5	6-14	△
6	10-14	●
7	9-15	□
8	9-16	■
10	7-12	⊞

DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

PLASTICITY CHART
LINE 'A' ZONE 2

W.P. No. 242-66
JOB No. 66-F-111
FIG. No. 5

FORM DB-MT-252
(REV. JUNE 1965)
65-1624



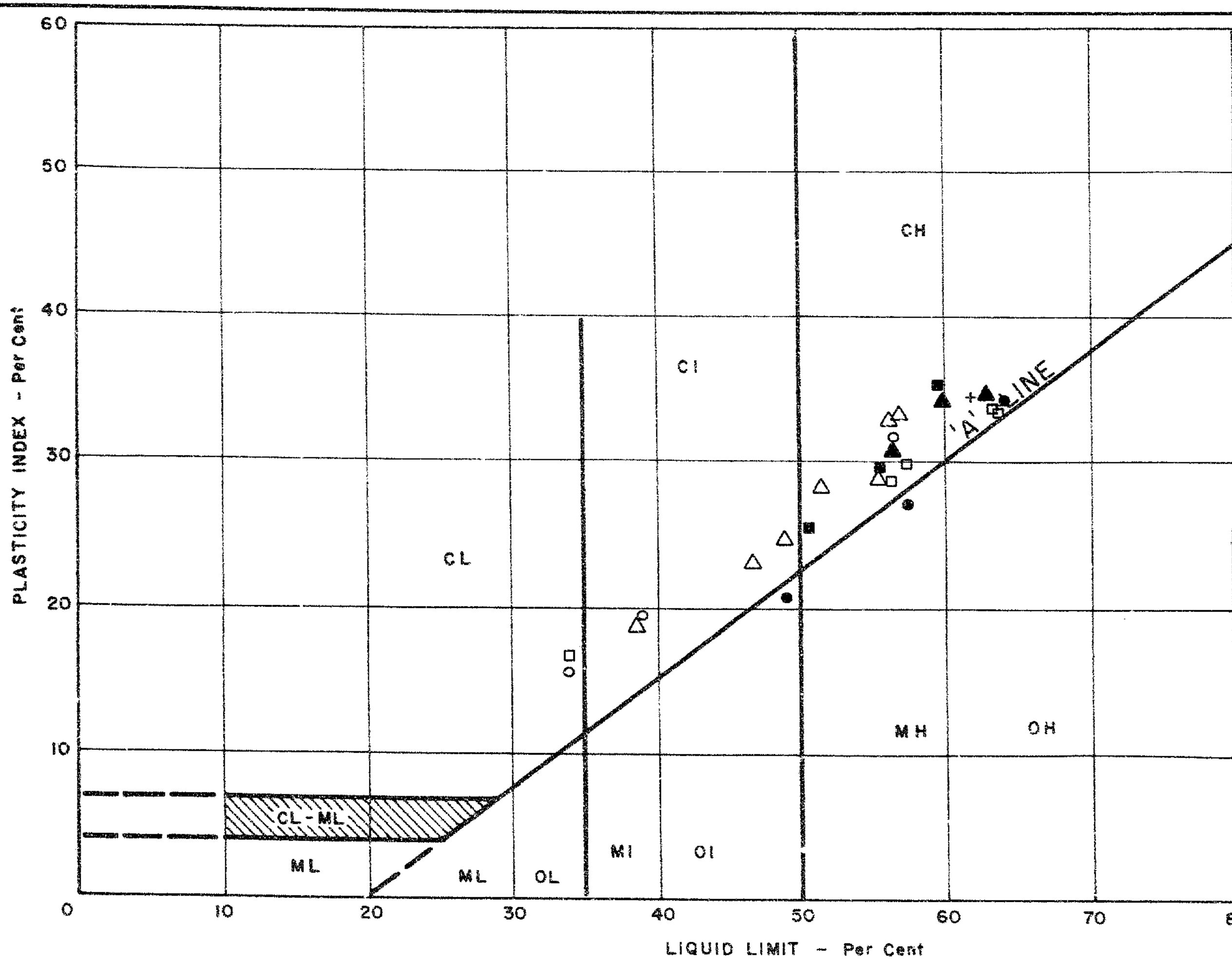
LEGEND		
BH No.	SAMPLE No.	SYMBOL
13		○
14		●
15		□
16		■
17		△
18		▲
19		×

DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

PLASTICITY CHART
LINE 'B' ZONE 2

W.P. No.	242 - 66
JOB No.	66 - F - 111
FIG. No. 6	

FORM 08-M1-252
(REV. JUNE 1965)
65-1624



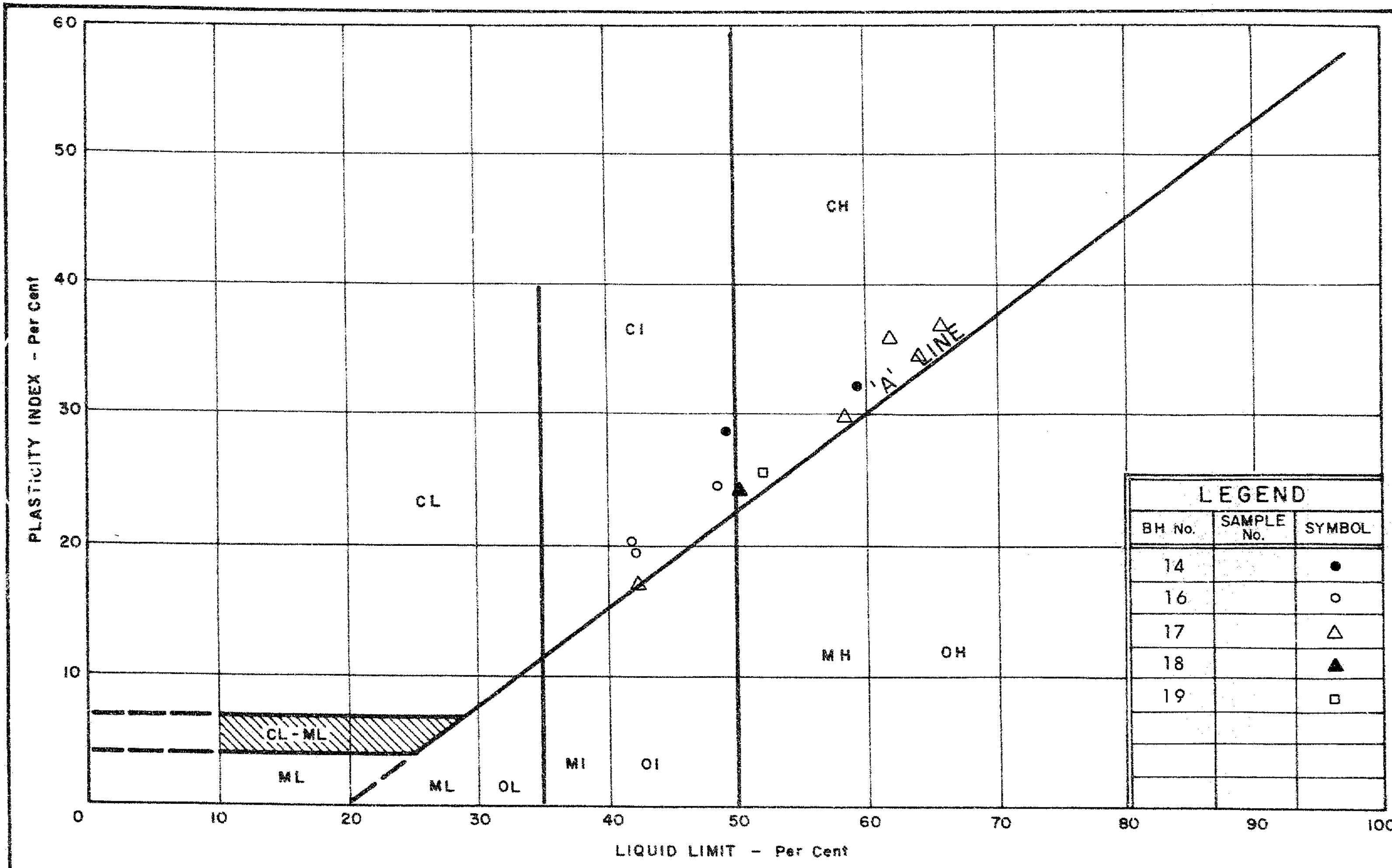
LEGEND		
BH. No.	SAMPLE No.	SYMBOL
1	17	+
2	18-19	▲
4	15-18	○
6	15-16	●
7	16-18	□
8	18	■
10	14-18	△

DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

PLASTICITY CHART
LINE 'A' ZONE 3

W.P. No. 242-66
JOB No. 66-F-111
FIG. No. 7

FORM OB-MT-252
(REV. JUNE 1965)
65-1624

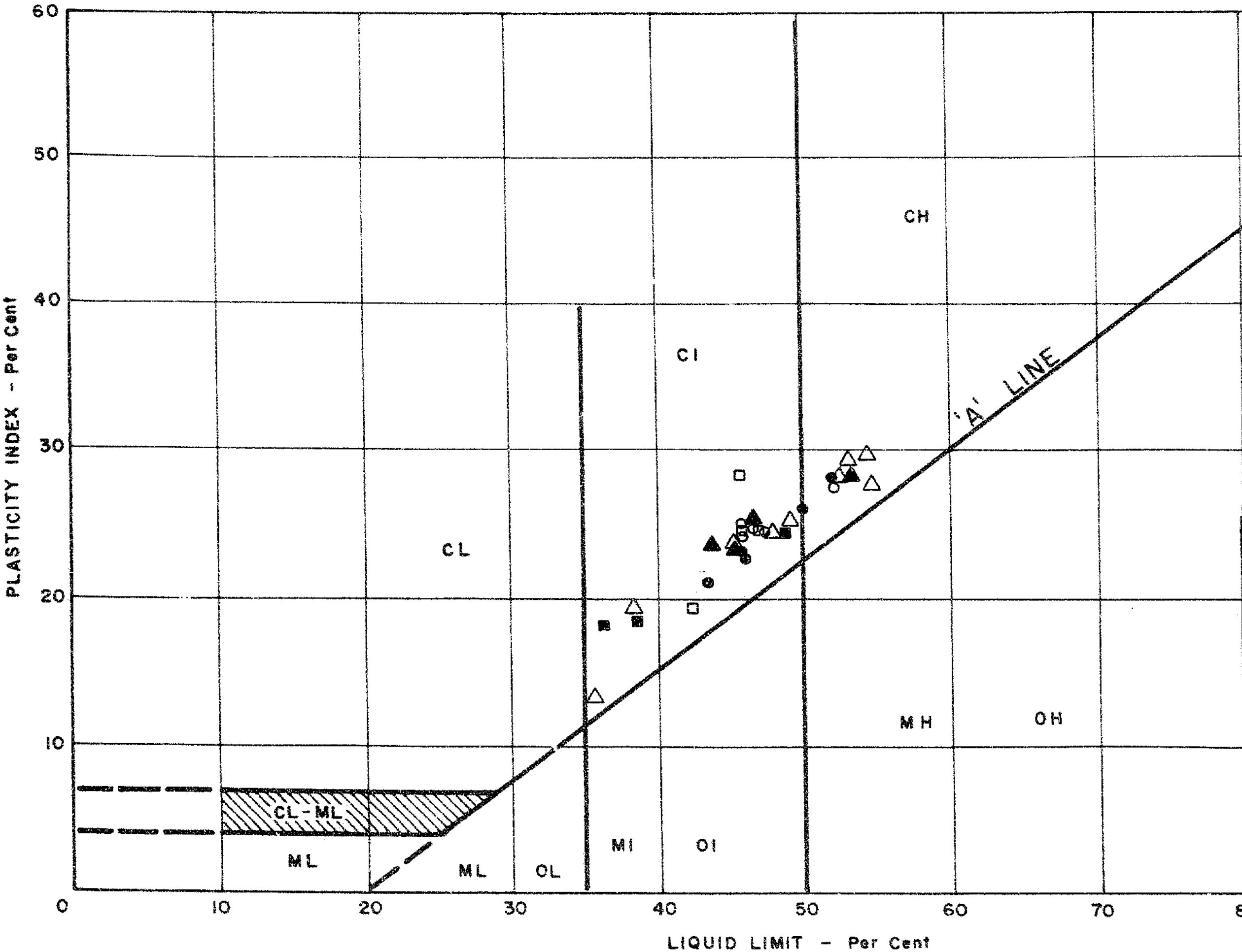


DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

PLASTICITY CHART
LINE 'B' ZONE 3

W.P. No. 242 - 66
JOB No. 66 - F - 111
FIG. No. 8

FORM DB-MT-252
(REV. JUNE 1965)
65-1624



LEGEND

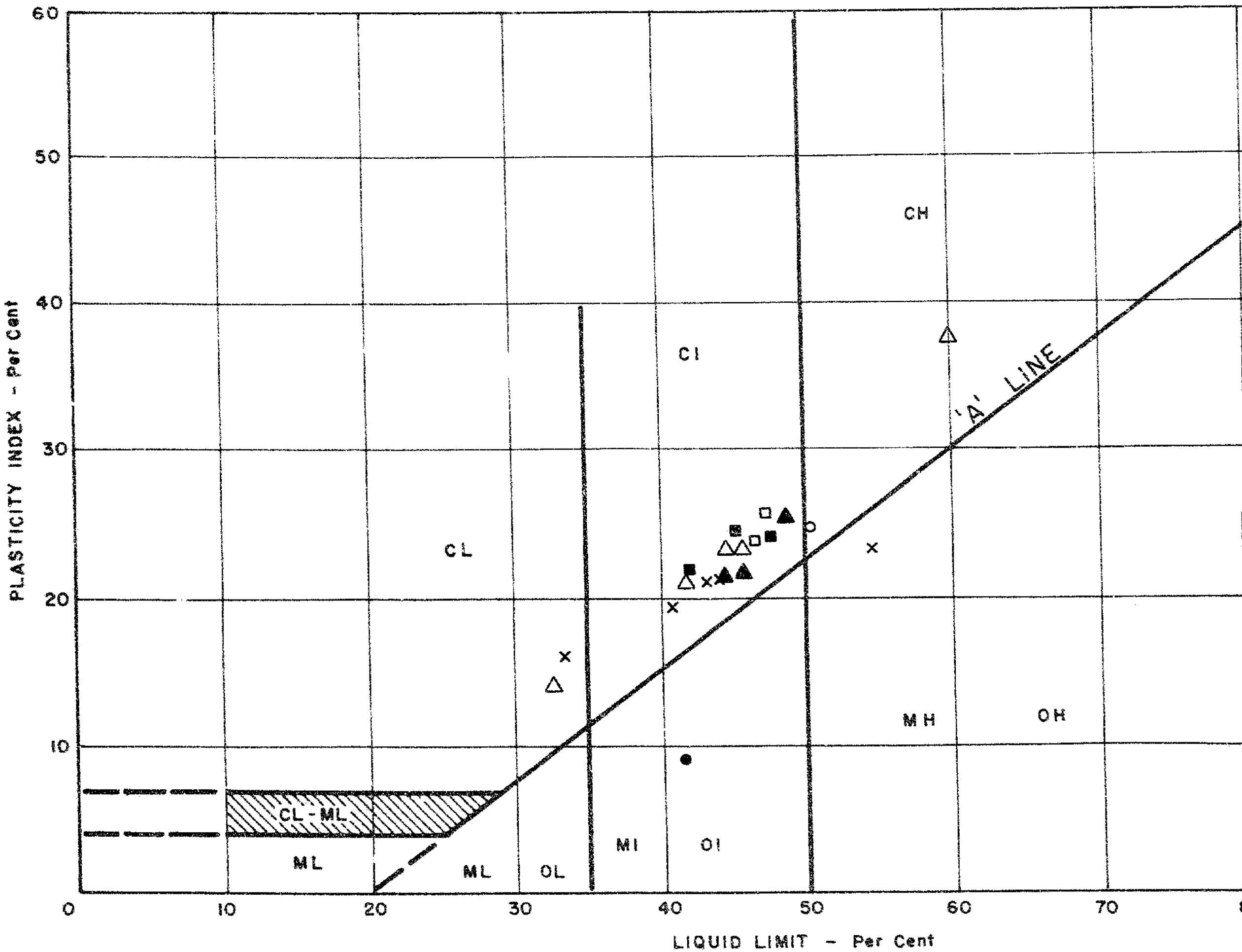
BH No.	SAMPLE No.	SYMBOL
1		▲
2		△
6		○
7		●
8		□
10		■

DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

PLASTICITY CHART
LINE 'A' ZONE 4

W.P. No. 242-66
JOB No. 66-F-111
FIG. No. 9

FORM OB-MT-252
(REV. JUNE 1965)
55-1624



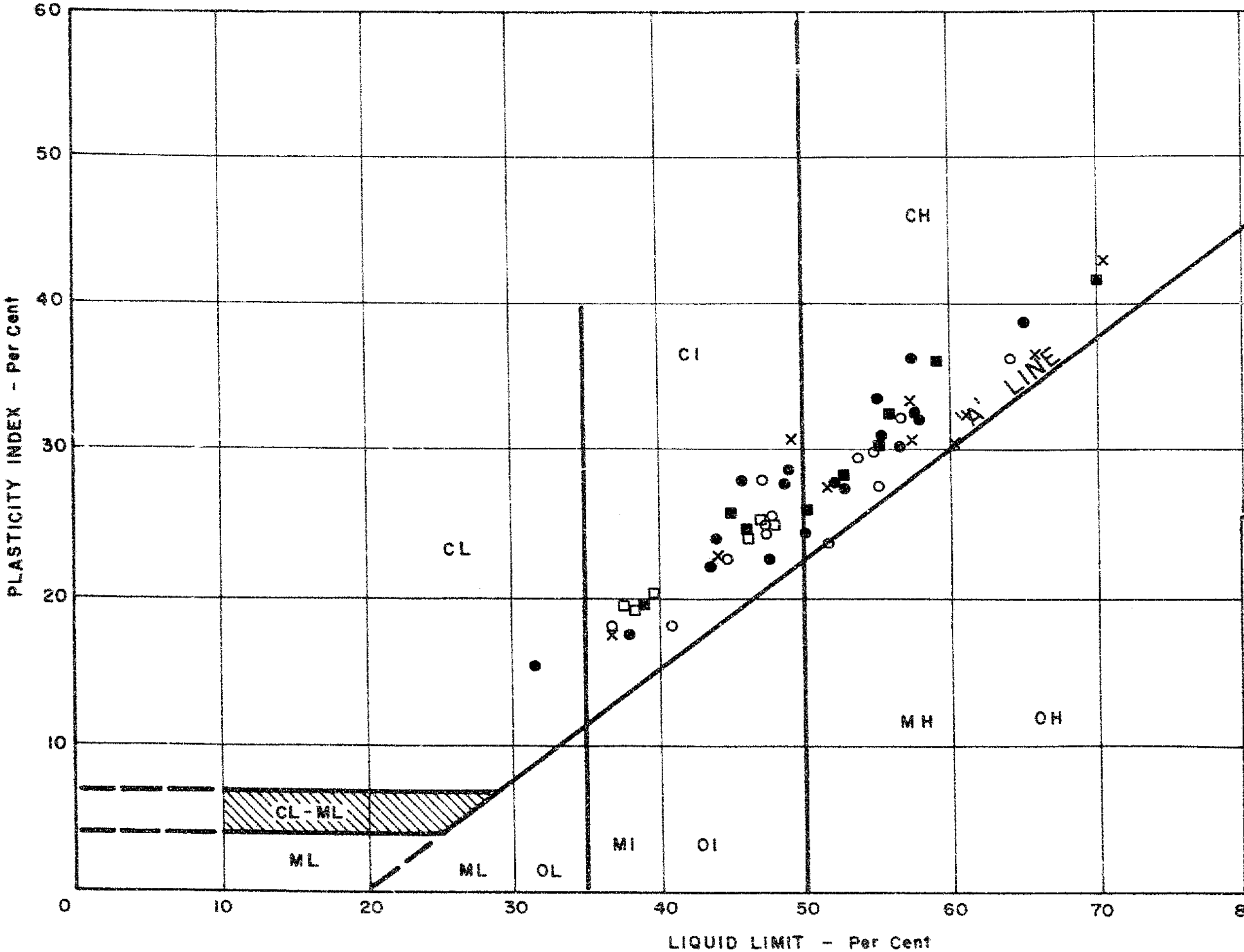
LEGEND		
BH No.	SAMPLE No.	SYMBOL
13		○
14		●
15		□
16		■
17		△
18		▲
19		×

DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

PLASTICITY CHART
LINE 'B' ZONE 4

W.P. No. 242-66
JOB No. 66-F-111
FIG. No. 10

FORM DB-MT-252
(REV. JUNE 1965)
65-1624



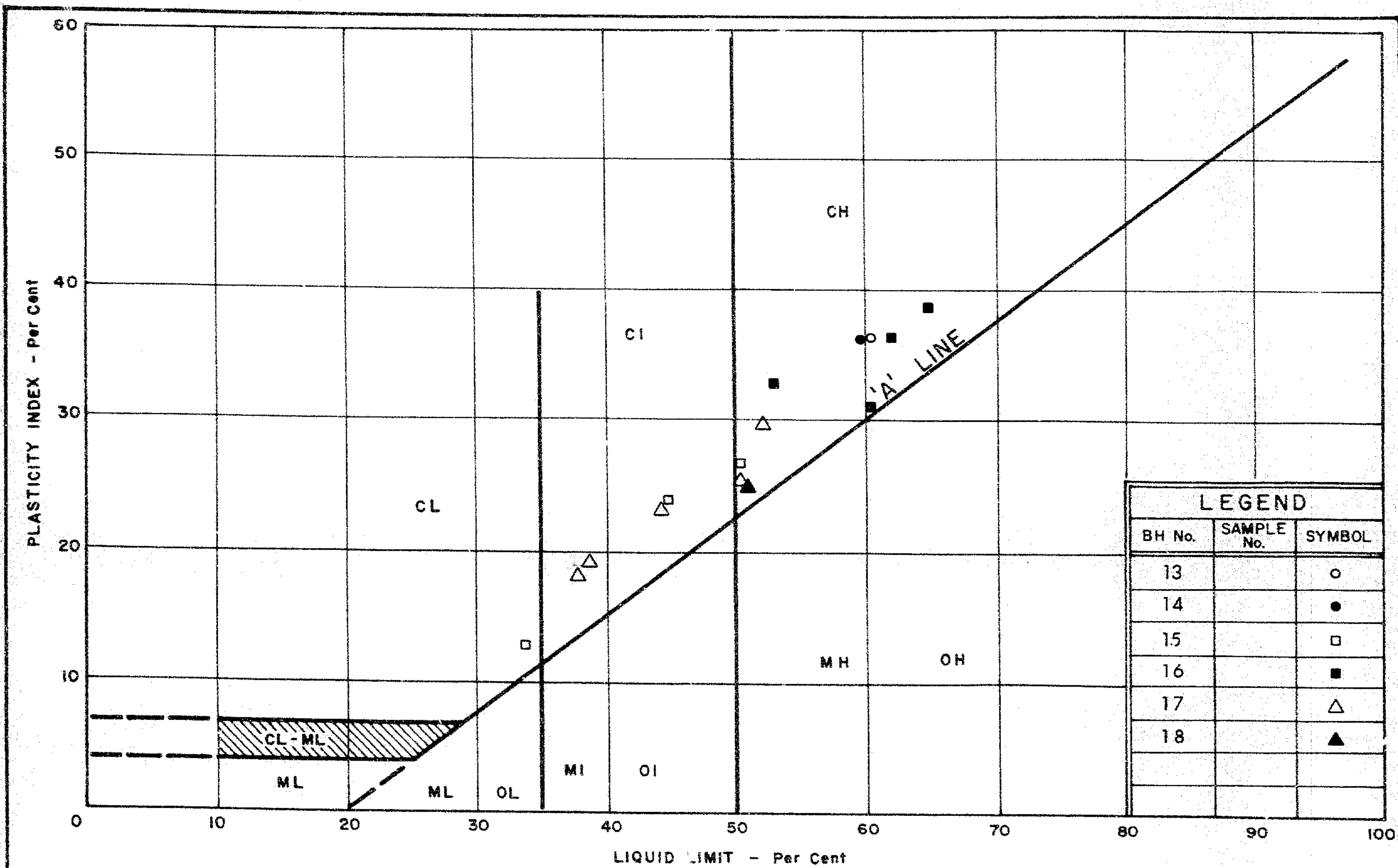
LEGEND		
BH No.	SAMPLE No.	SYMBOL
2		○
6		●
7		□
8		■
10		×

DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

PLASTICITY CHART
LINE 'A' ZONE 5

W.P. No. 242-66
JOB No. 66-F-111
FIG. No. 11

FORM OB-MT-232
(REV. JUNE 1965)
65-1624

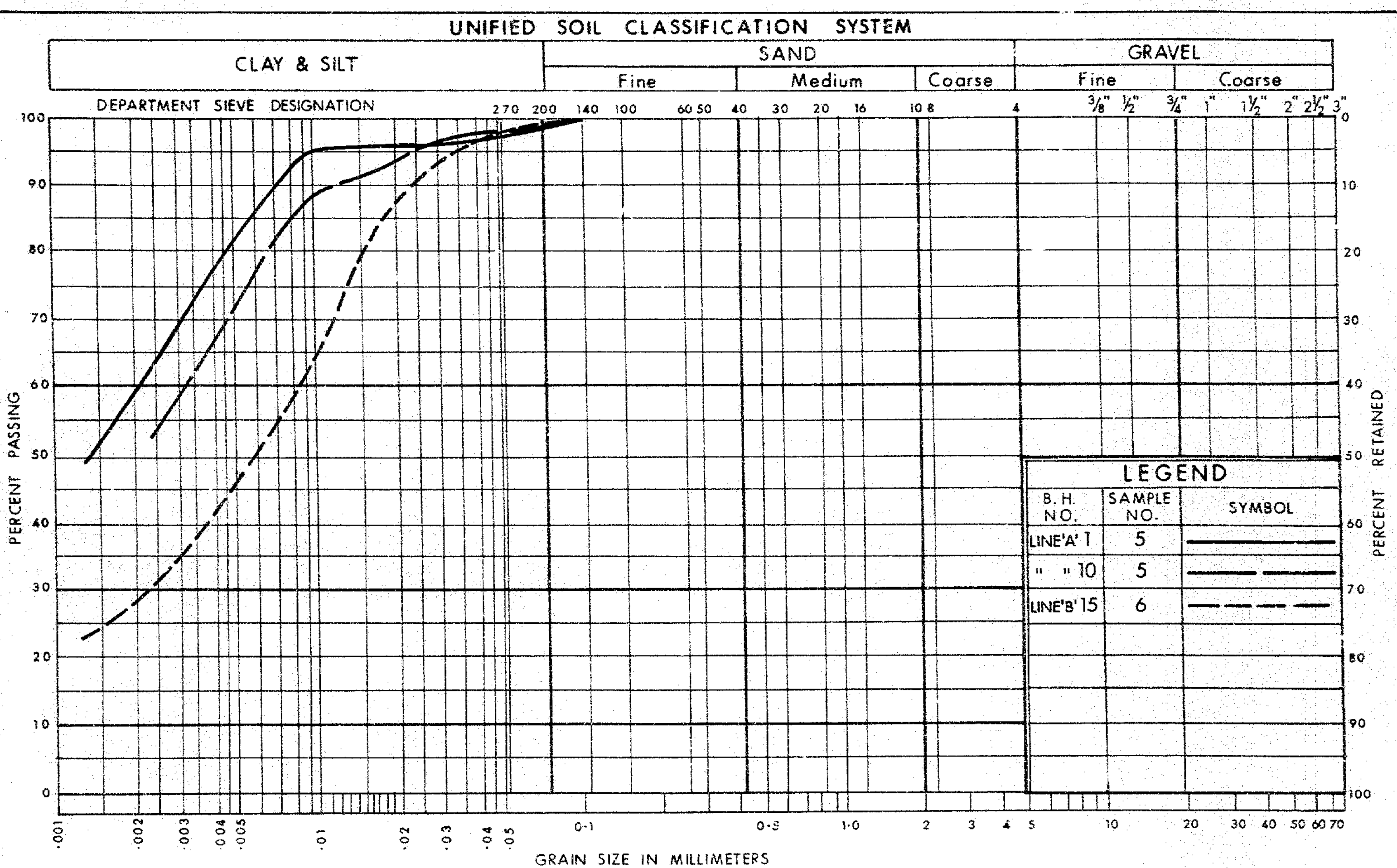


DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

PLASTICITY CHART
LINE 'B' ZONE 5

W.P. No.	242-66
JOB No.	66-F-111
FIG. No.	12

FORM OB MT-17
REV. APR. 1965
65-414

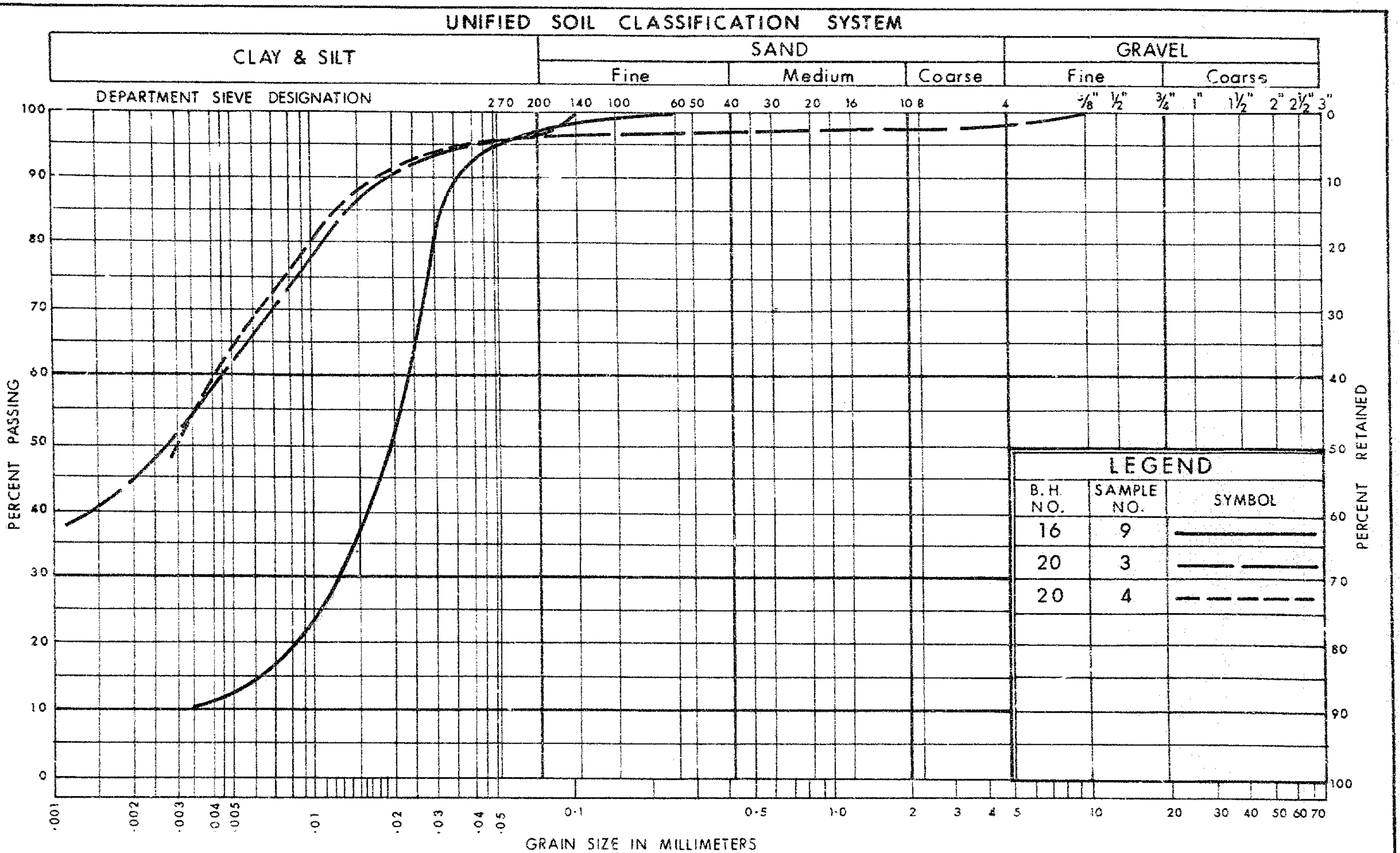


DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

GRAIN SIZE DISTRIBUTION
LINE 'A' & 'B' ZONE 1

W.P. No.	242-66
JOB No.	66-F-111
FIG. No.	13

FORM OB MT-17
REV. APR. 1965
65-414



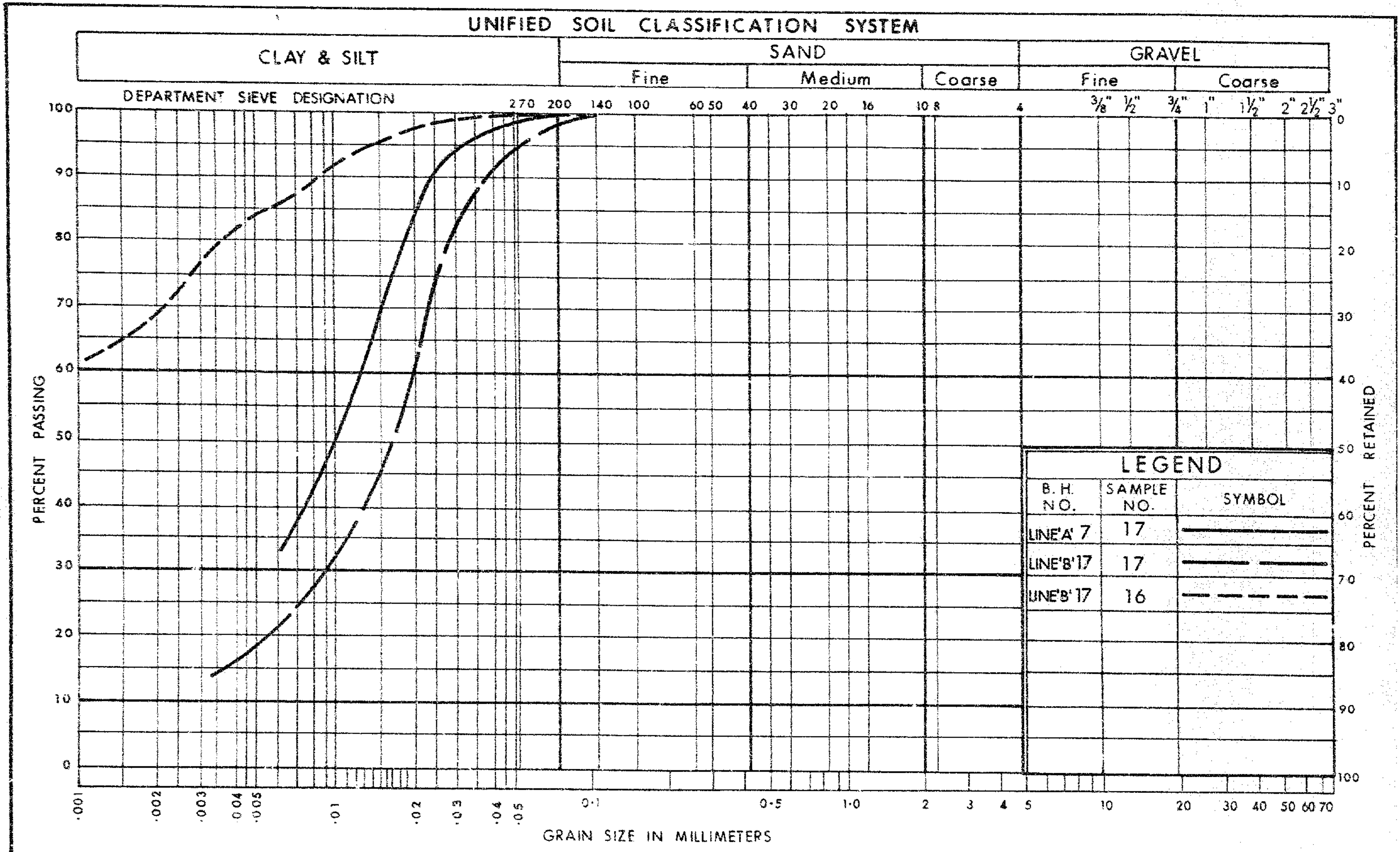
B.H. NO.	SAMPLE NO.	SYMBOL
16	9	solid line
20	3	long dash line
20	4	short dash line

DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

GRAIN SIZE DISTRIBUTION
LINE 'B' ZONE 2

W.P No.	242-66
JOB No.	66-F-111
FIG. No.	14

FORM OB MT-17
REV. APR. 1965
65-414

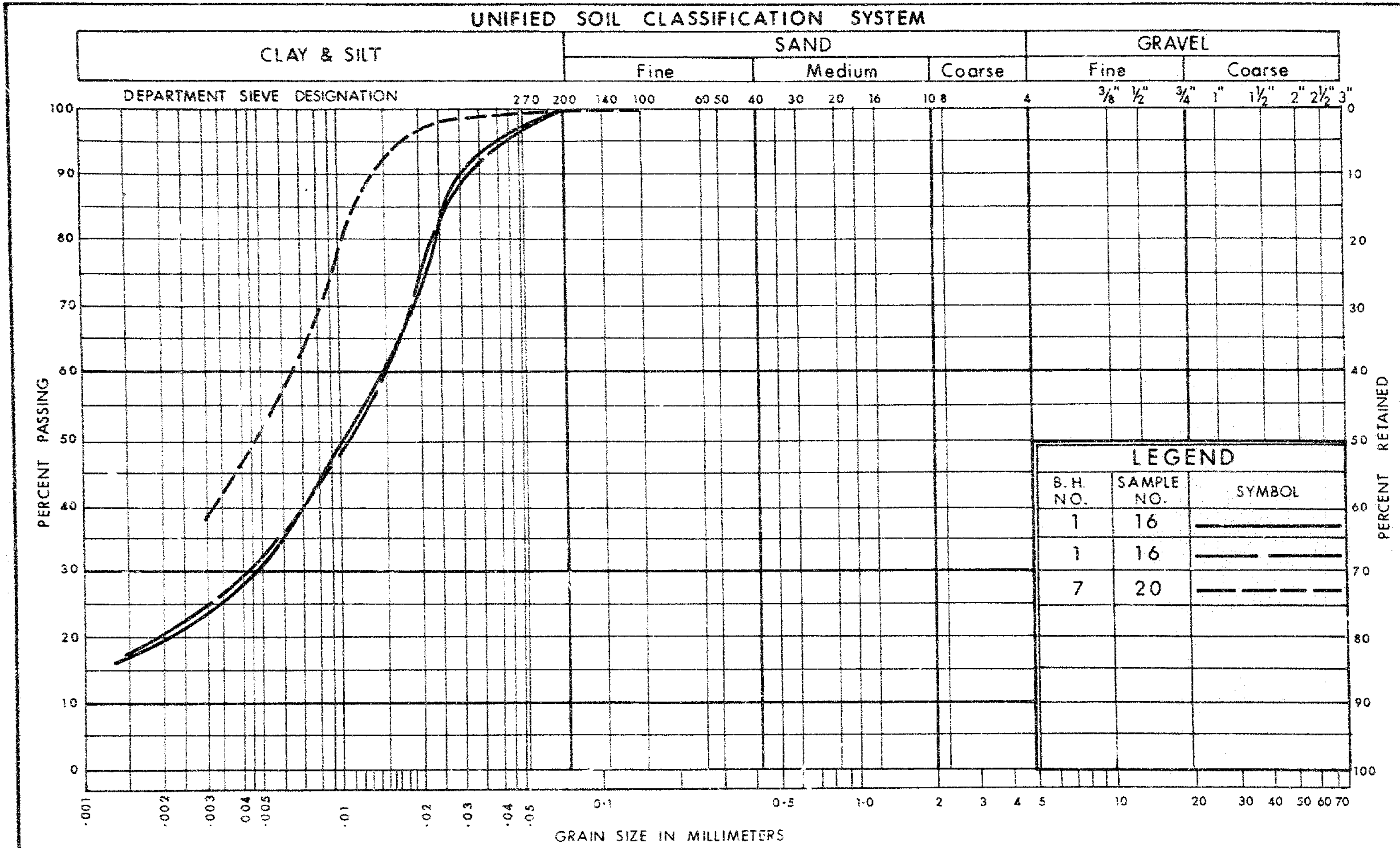


DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

GRAIN SIZE DISTRIBUTION
LINE 'A' & 'B' ZONE 3

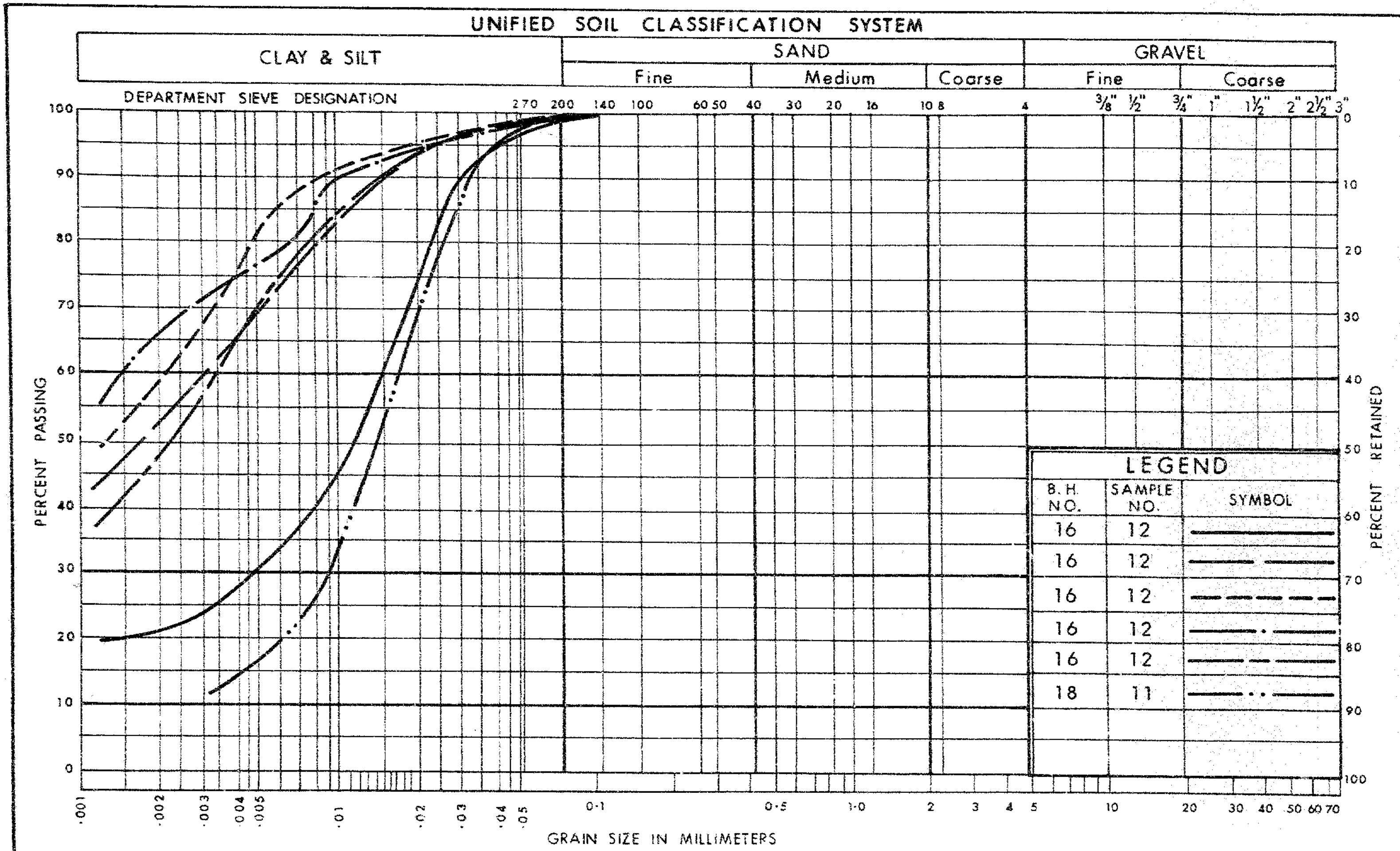
W.P. No. 242-66
JOB No. 66-F-111
FIG. No. 15

FORM OB MT-17
REV. APR. 1965
65-414



DEPARTMENT OF HIGHWAYS MATERIALS and TESTING DIVISION ONTARIO	GRAIN SIZE DISTRIBUTION LINE 'A' ZONE 4	W.P. No. 242-66
		JOB No. 66-F-111
		FIG. No. 16

FORM OB MT-17
REV. APR. 1965
65-414

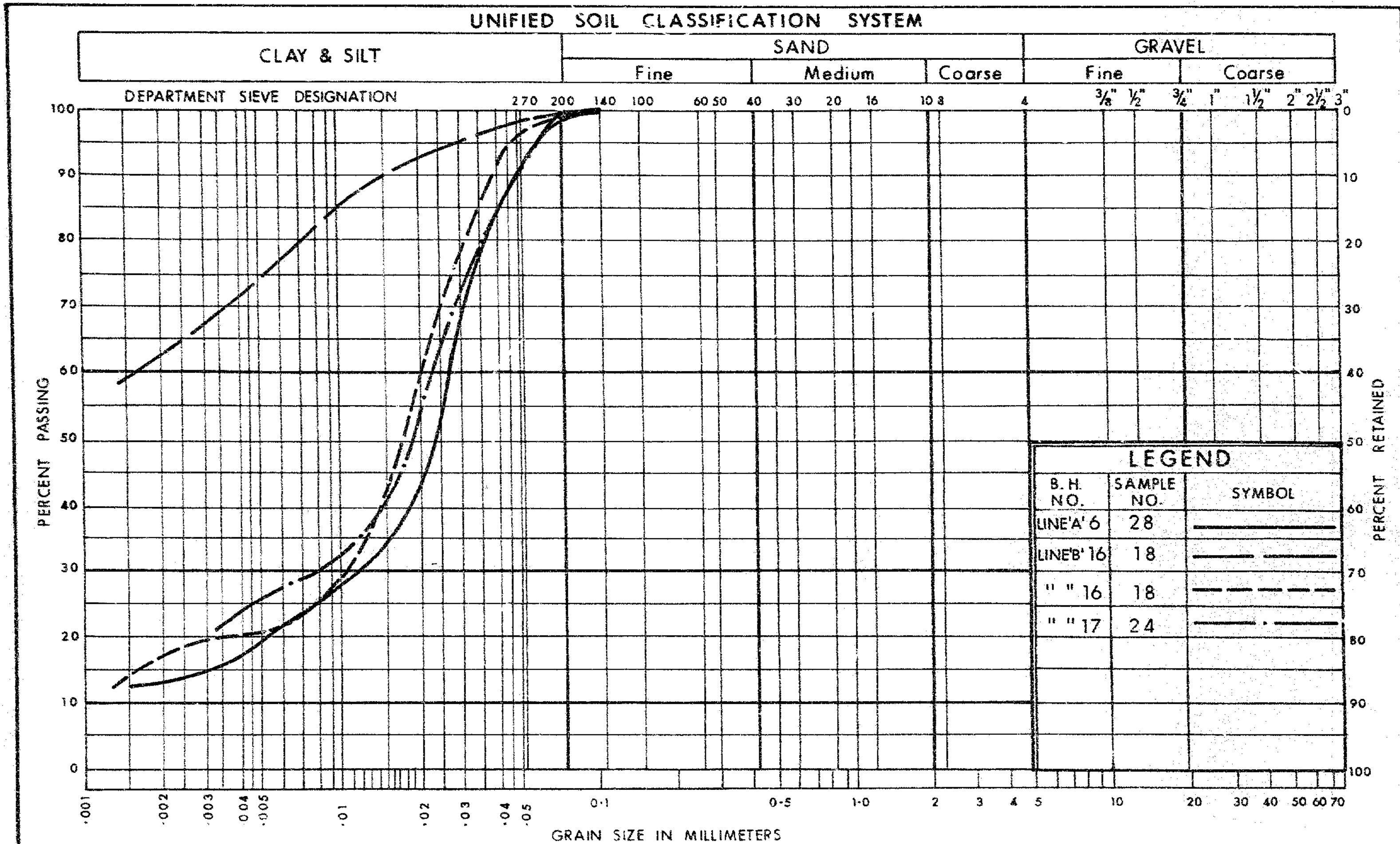


DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

GRAIN SIZE DISTRIBUTION
LINE 'B' ZONE 4

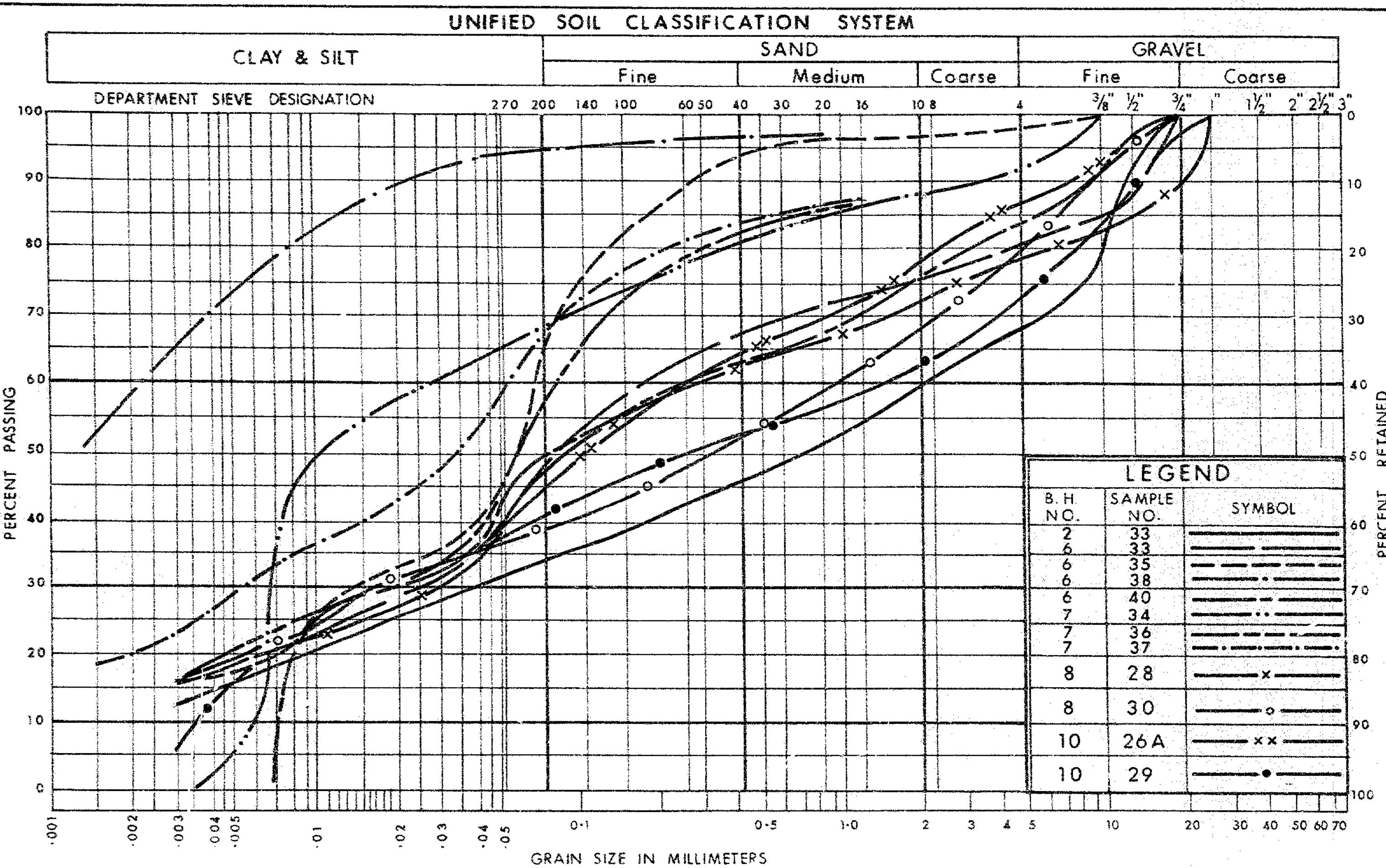
W.P. No. 242-66
JOB No. 66-F-111
FIG. No. 17

FORM OB MT-17
REV. APR. 1965
65-414



DEPARTMENT OF HIGHWAYS **MATERIALS and TESTING DIVISION** ONTARIO	**GRAIN SIZE DISTRIBUTION** **LINE 'A' & 'B' ZONE 5**	W.P. No. 242-66 JOB No. 66-F-111 FIG. No. 18

FORM OB MT-17
REV. APR. 1965
65-414



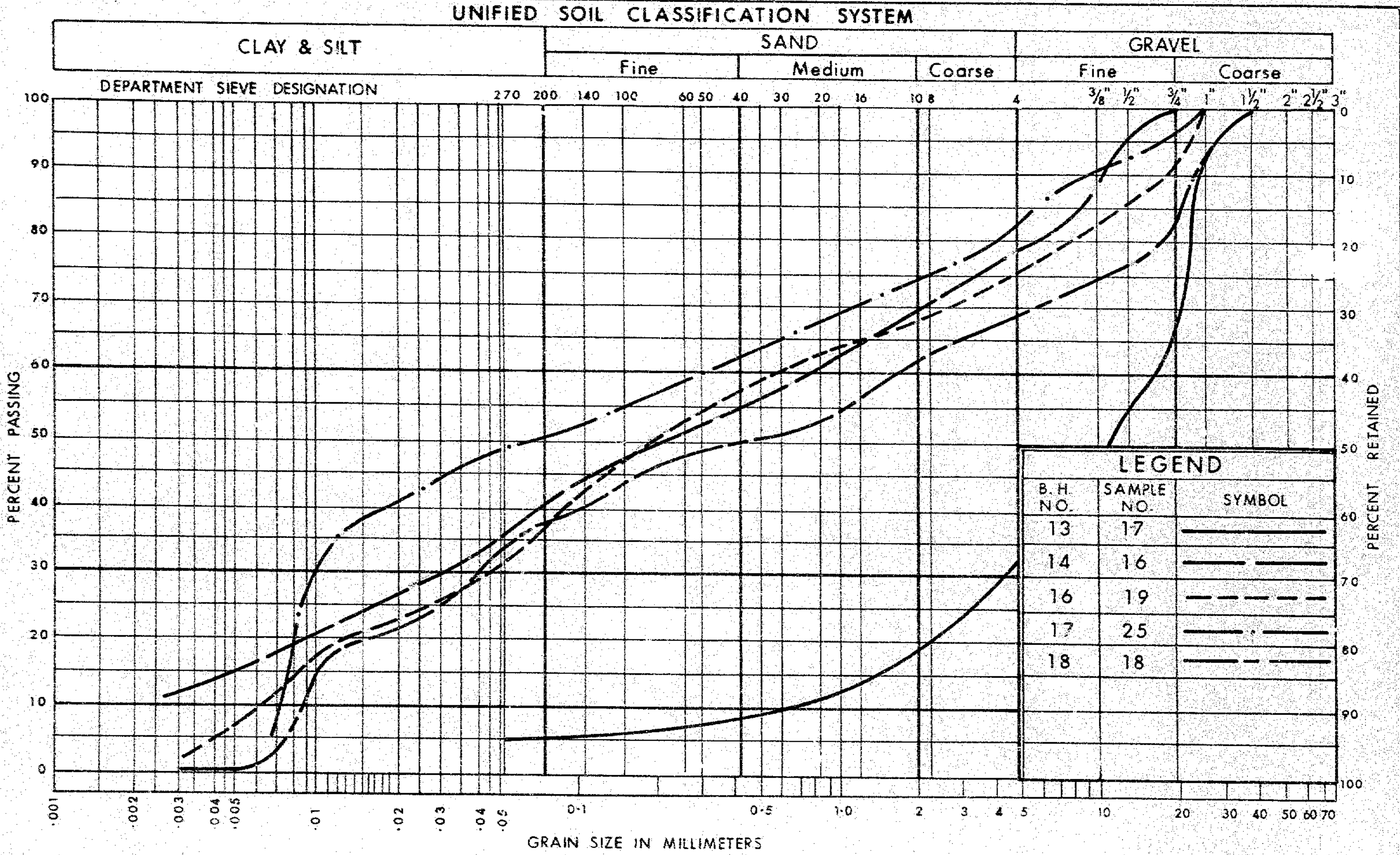
B.H. NO.	SAMPLE NO.	SYMBOL
2	33	
6	33	
6	35	
6	38	
6	40	
7	34	
7	36	
7	37	
8	28	
8	30	
10	26A	
10	29	

DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

GRAIN SIZE DISTRIBUTION
LINE 'A' BASAL TILL

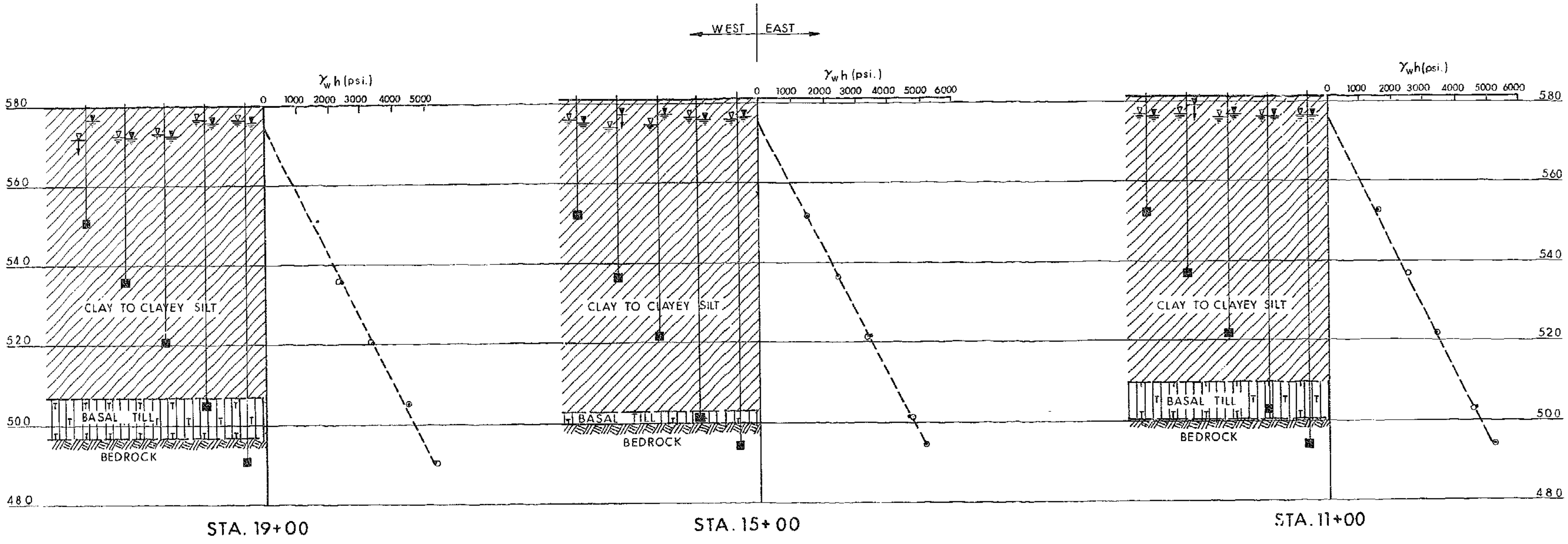
W.P. No. 242-66
JOB No. 66-F-111
FIG. No. 19

FORM OB MT-17
REV. APR. 1965
65-413



DEPARTMENT OF HIGHWAYS **MATERIALS and TESTING DIVISION** ONTARIO	W.P. No. 242-66
	JOB No. 66-F-111
	FIG. No. 20

GRAIN SIZE DISTRIBUTION
LINE 'B' BASAL TILL



LEGEND

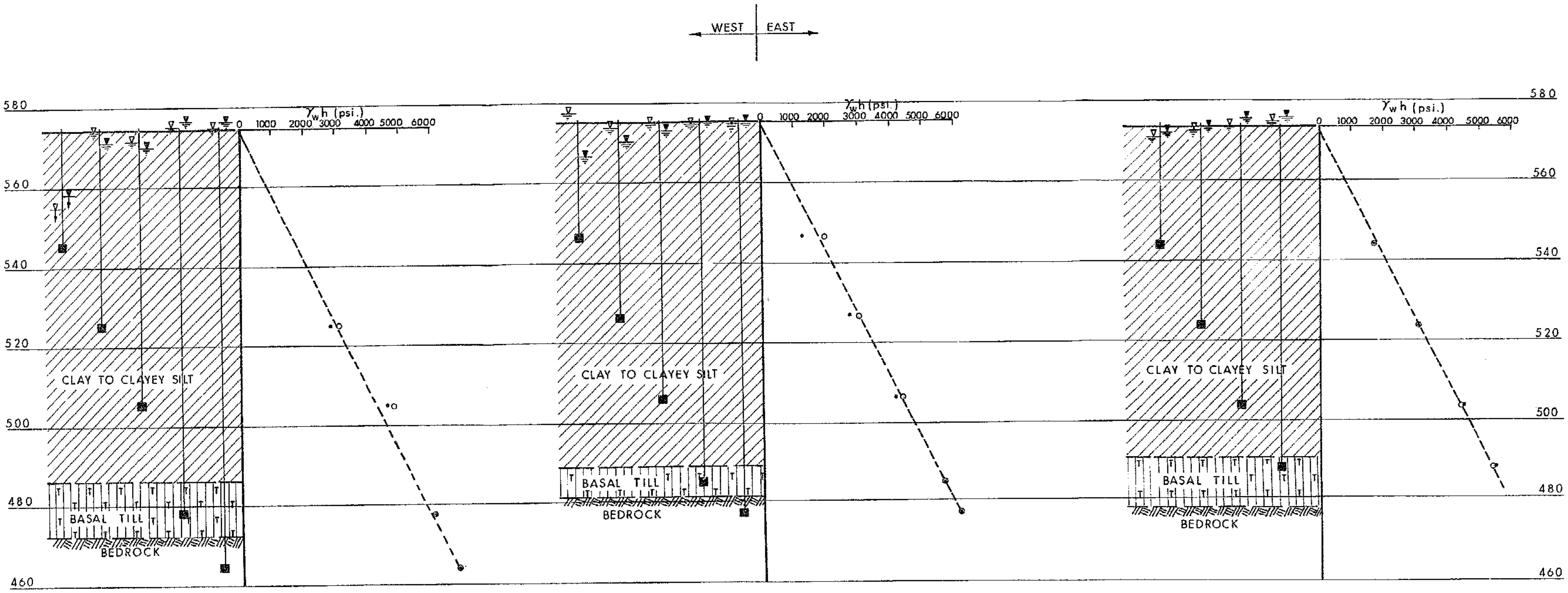
NORMAL HYDROSTATIC DISTRIBUTION ----

READINGS — FEB. 20, 1967 —— ▼ •
APR. 27, 1967 —— ▽ o

PIEZOMETER —— ■

66-F-111

DEPARTMENT OF HIGHWAYS MATERIALS and TESTING DIVISION ONTARIO	LINE 'B' PIEZOMETER DATA	
DATE 28 AUG. 1967	APPROVED [signature]	FIGURE NO. 21



STA. 26+90

STA. 26+65

STA. 16+70

LEGEND

NORMAL HYDROSTATIC DISTRIBUTION - - - -

READINGS – FEB. 20, 1967 ——— ▼ •
APR. 27, 1967 ——— ▽ o

PIEZOMETER ——— ■

66-F-111

DEPARTMENT OF HIGHWAYS MATERIALS and TESTING DIVISION ONTARIO	LINE 'A' PIEZOMETER DATA	
DATE 28 AUG. 1967	APPROVED A.G. Stermac	FIGURE NO. 22

WATER CONTENT VS DEPTH

66-F-111

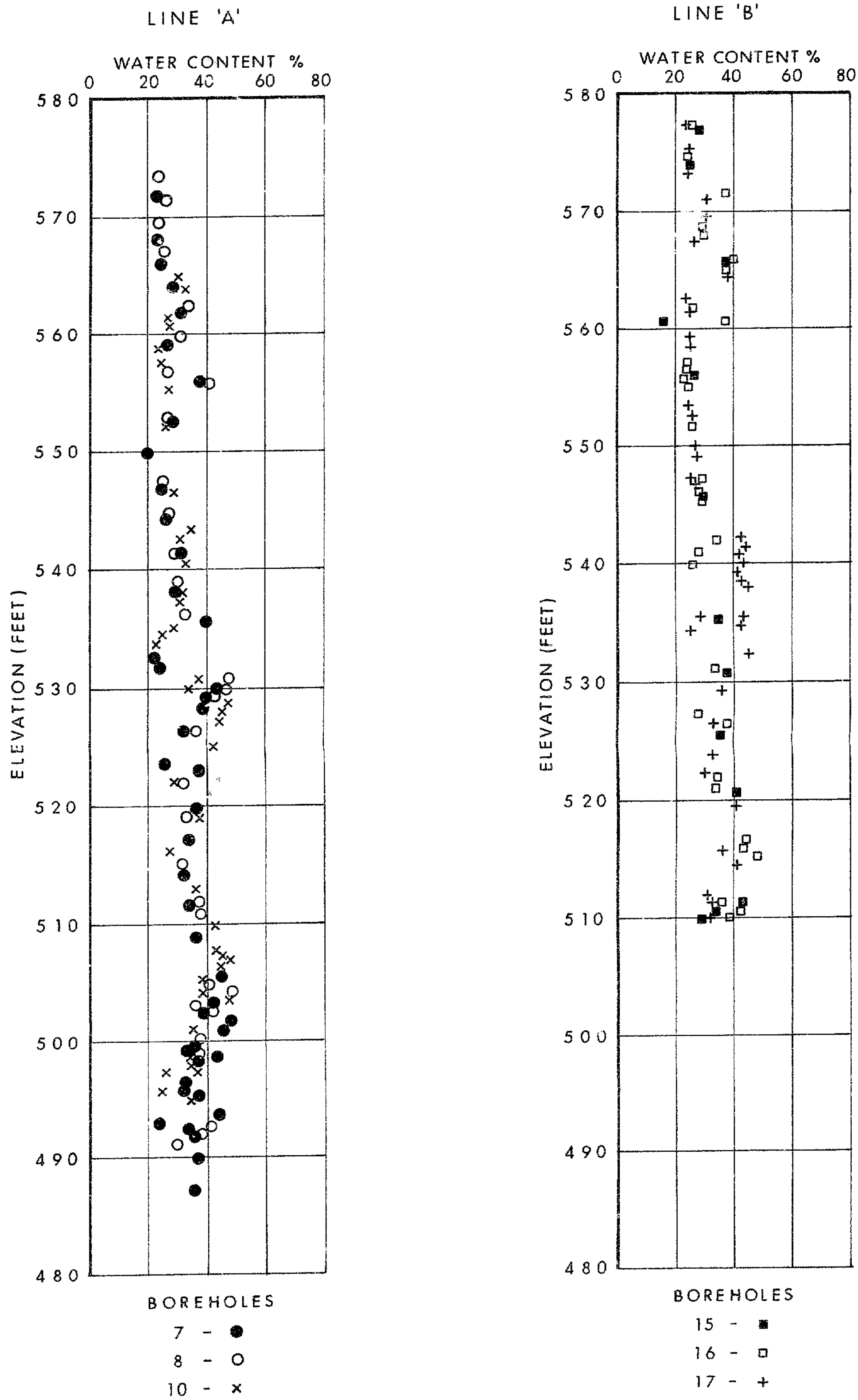


FIG. 23

BORE HOLES 1,2 & 3

66 - F - 111 LINE 'A'

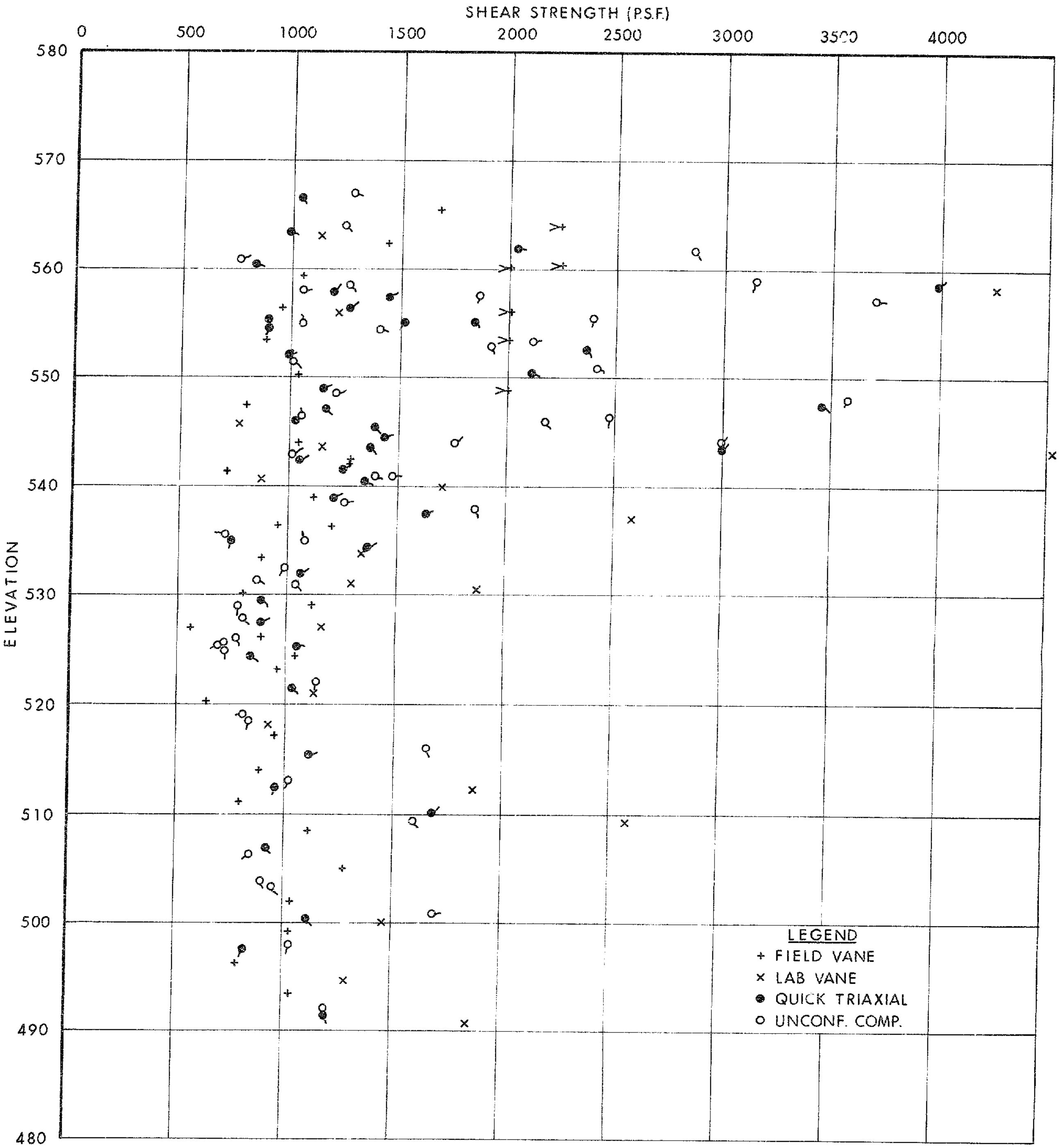


FIG. 24

BORE HOLES 4,5 & 6

66 - F - 111 LINE 'A'

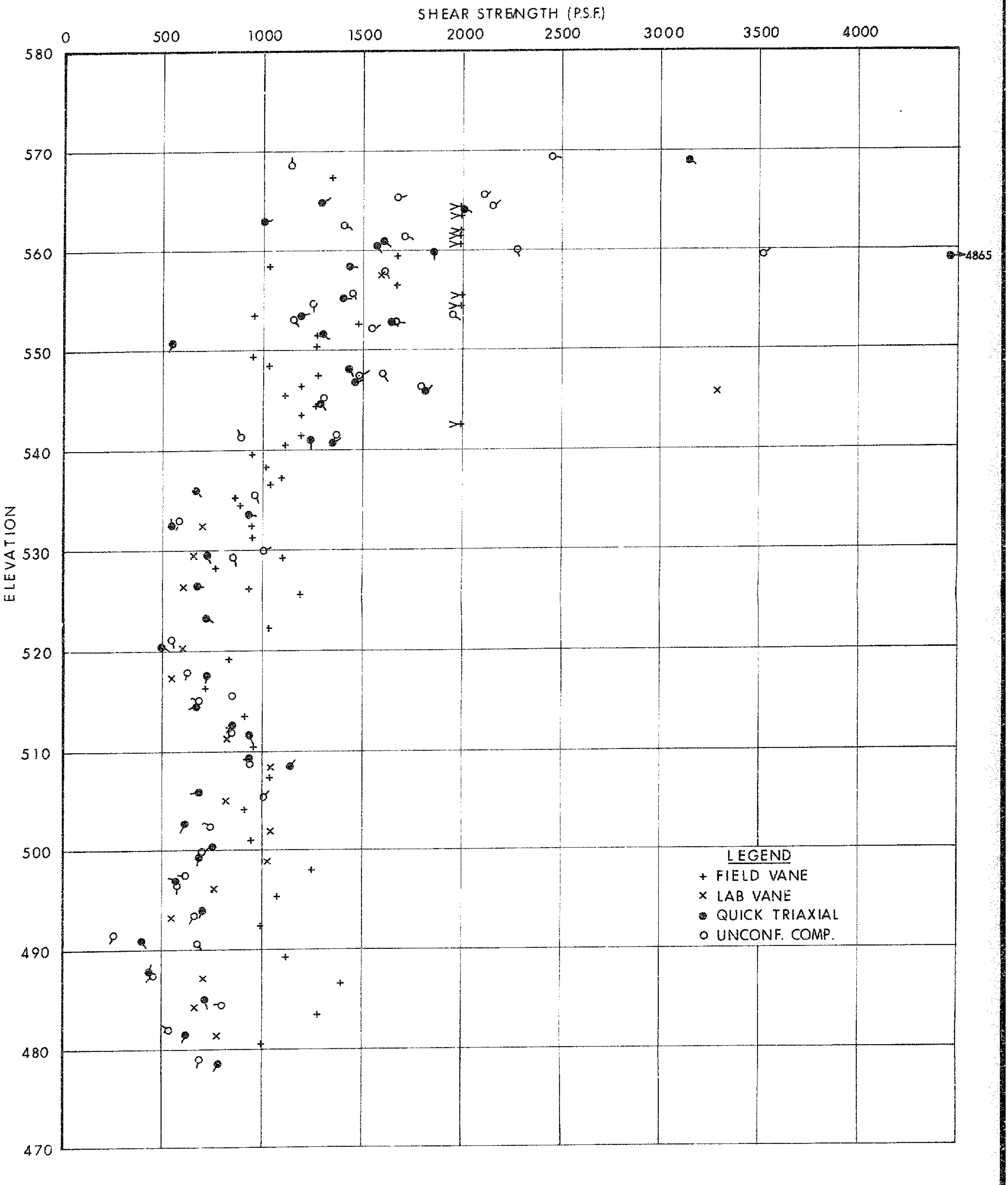


FIG. 25

BORE HOLES 7, 8 & 10

66 - F - 111 LINE 'A'

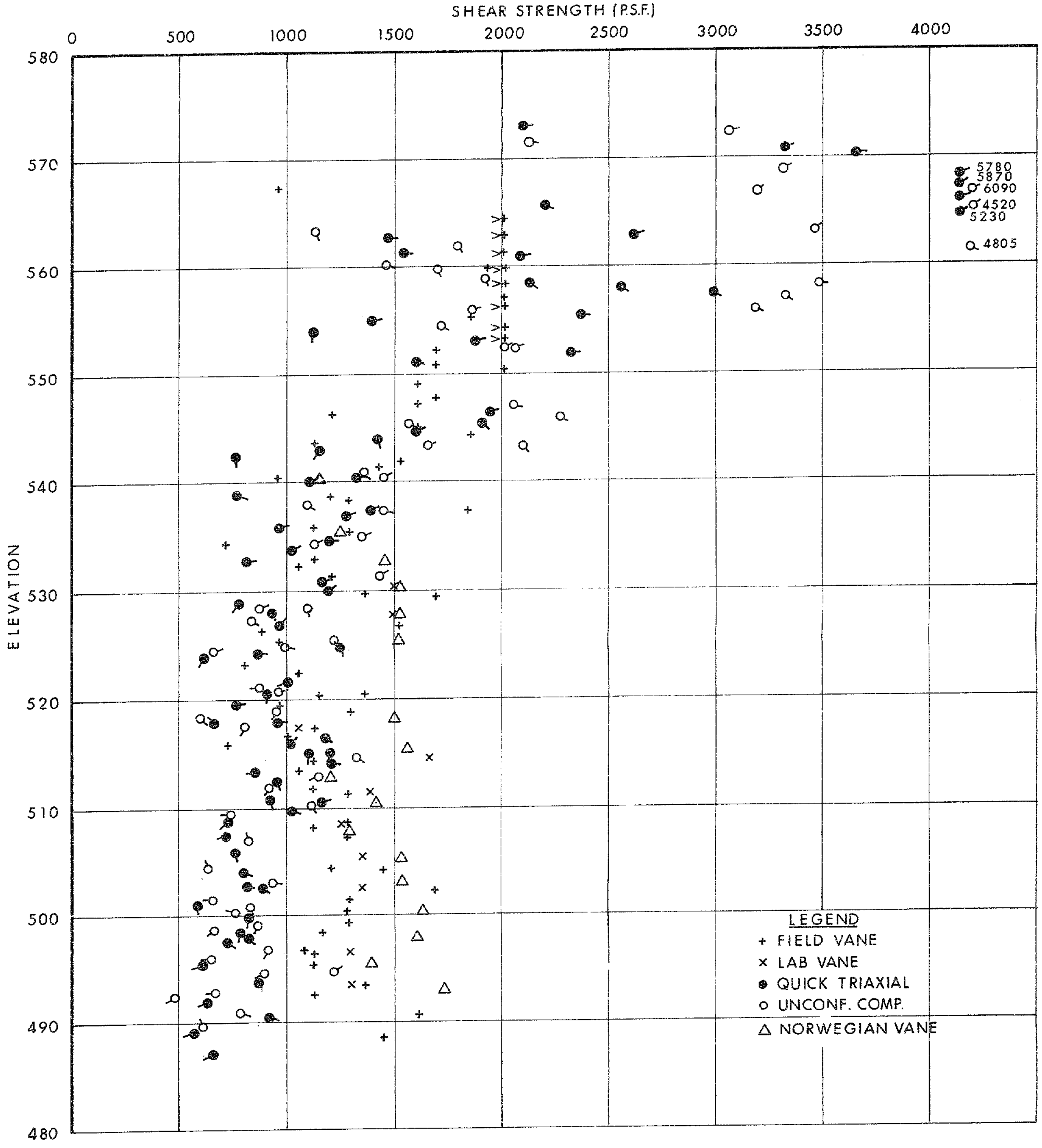


FIG. 26

BORE HOLES 13 & 14

66 - F - 111 LINE 'A'

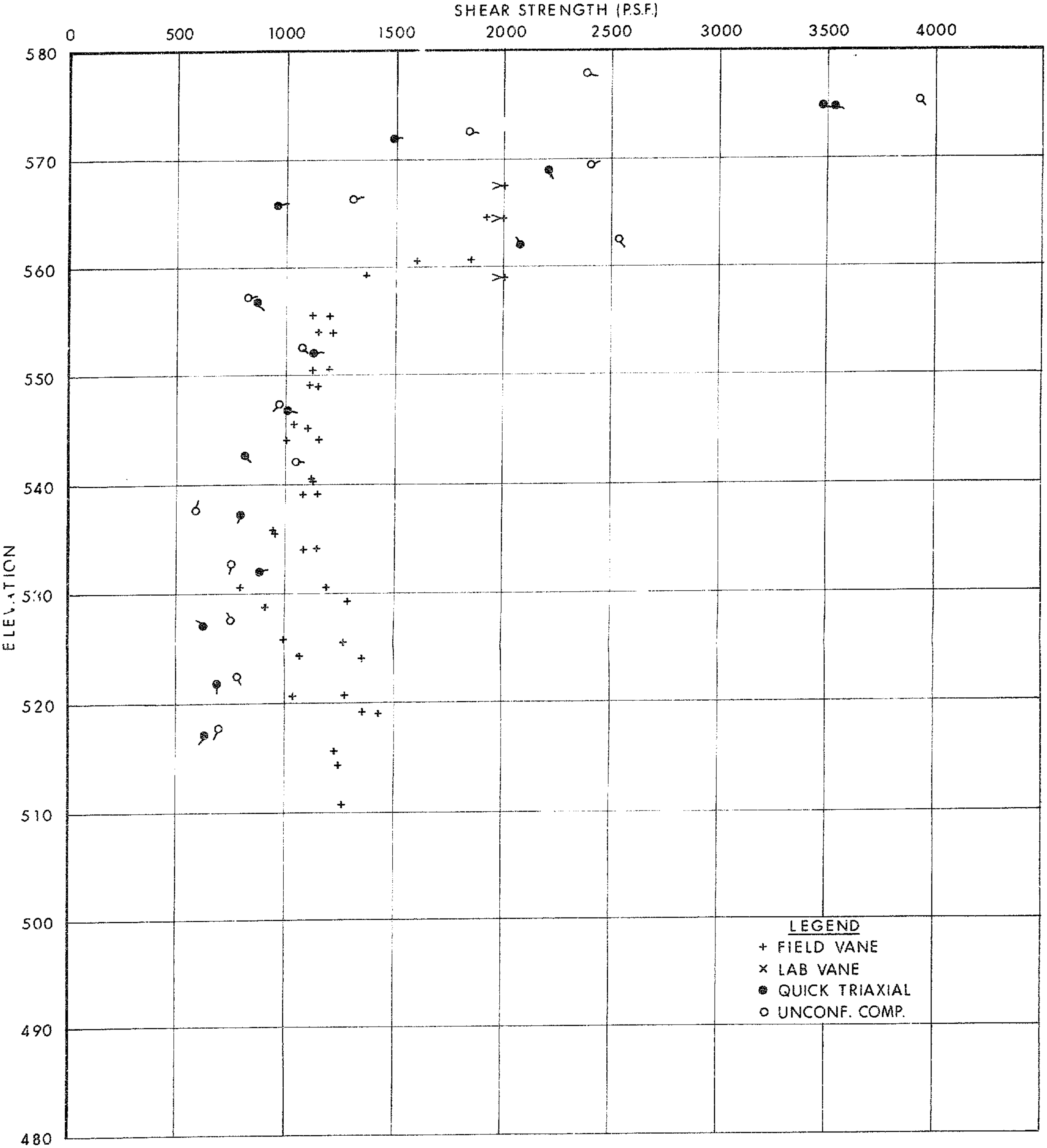


FIG. 27

BORE HOLES 15,16 & 17

66 - F - 111 LINE 'A'

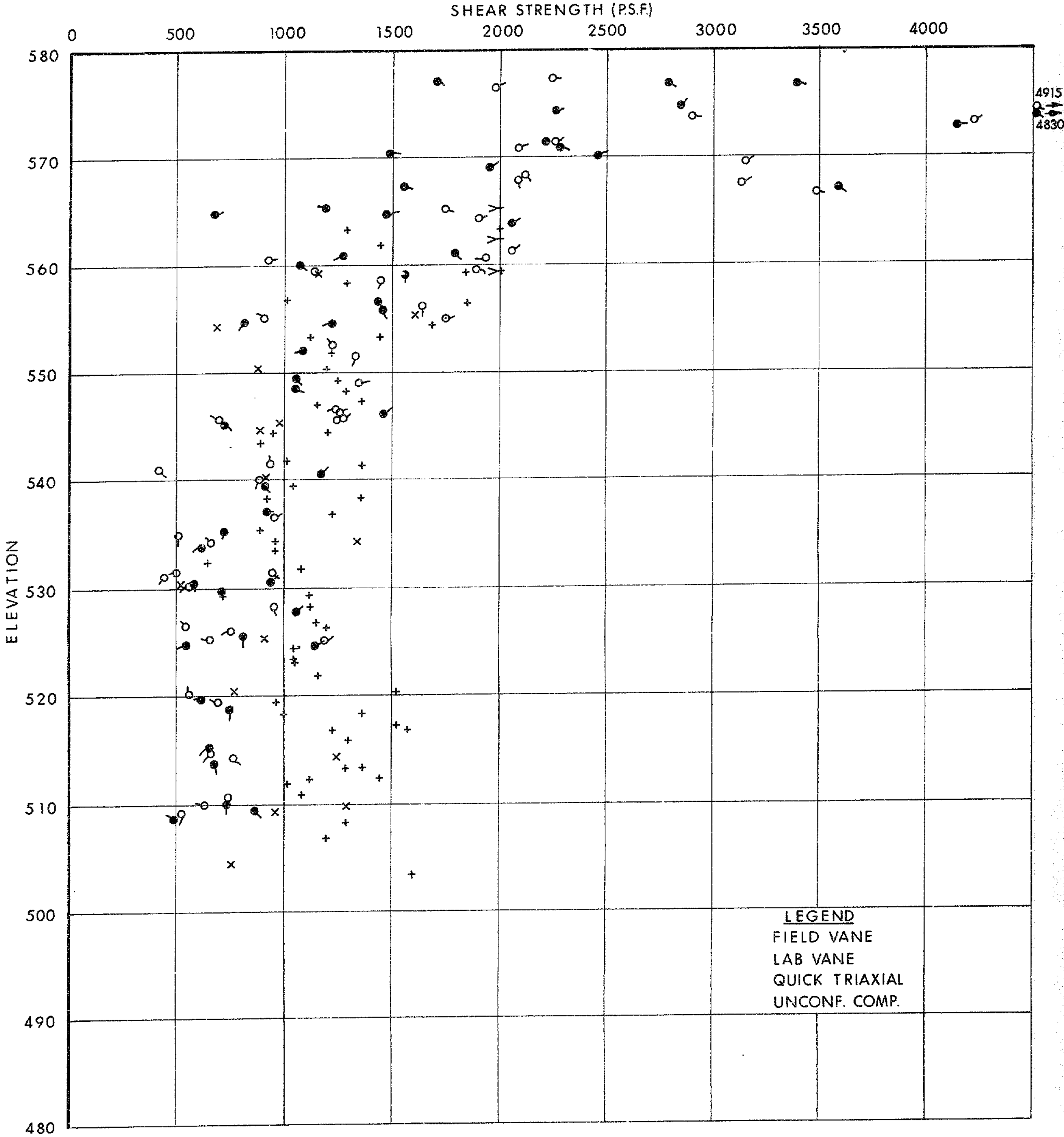


FIG. 28

BORE HOLES 18 & 19

66 - F - 111 LINE 'A'

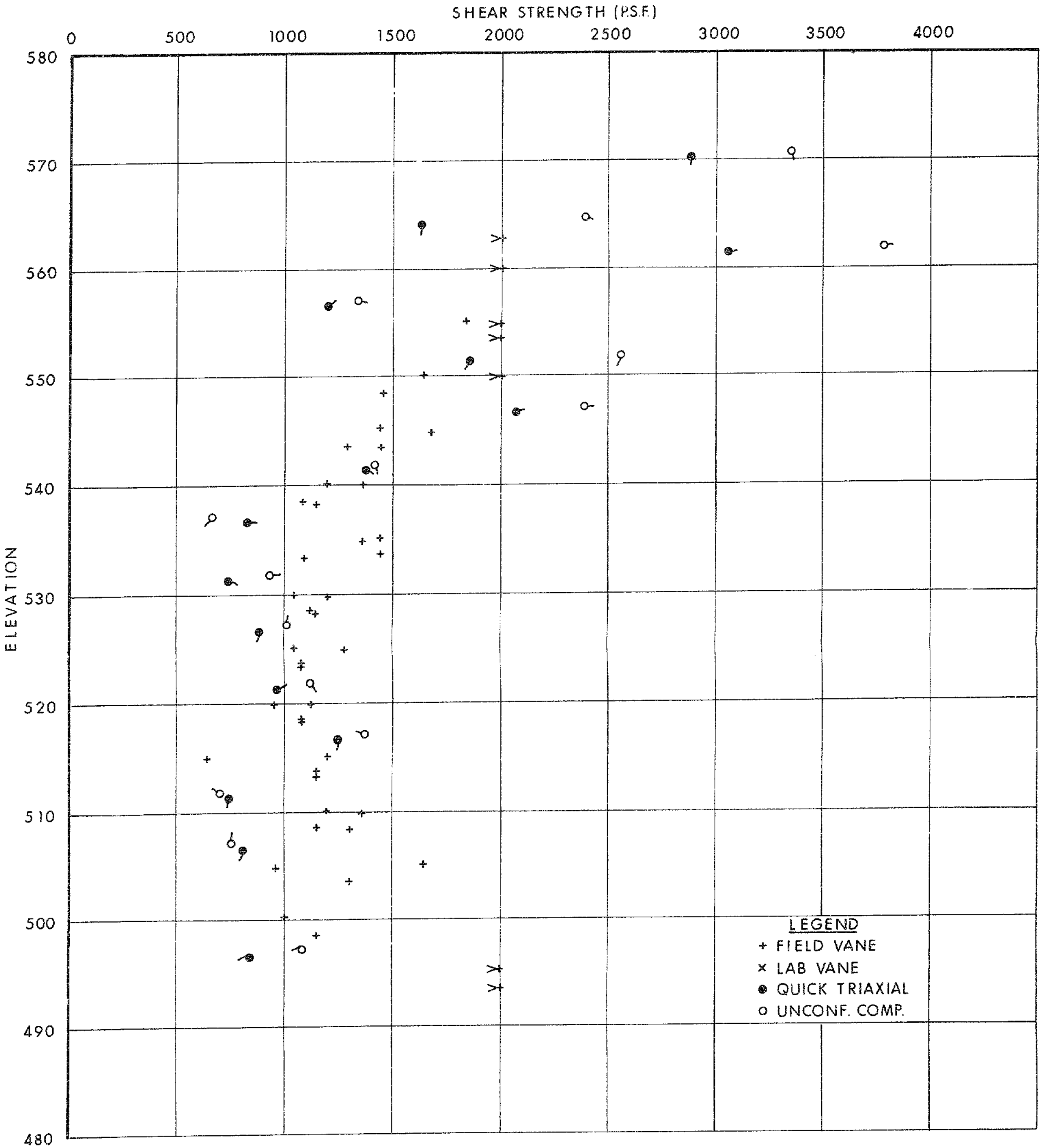
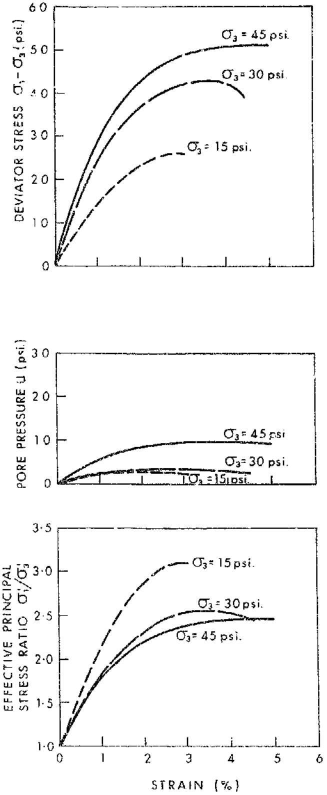
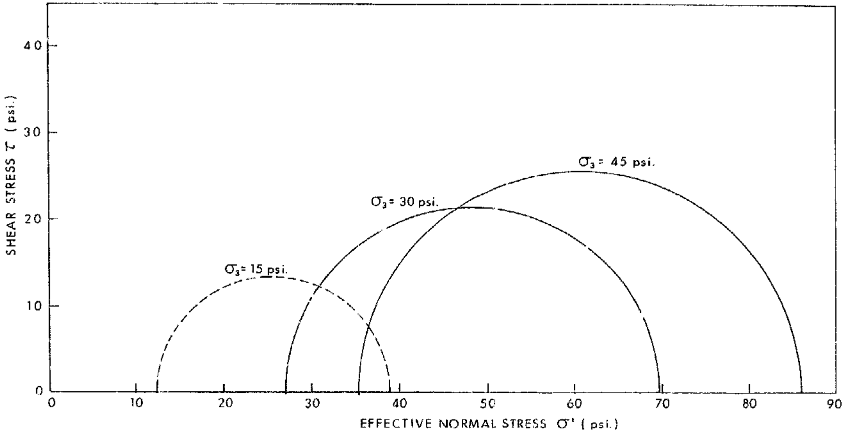
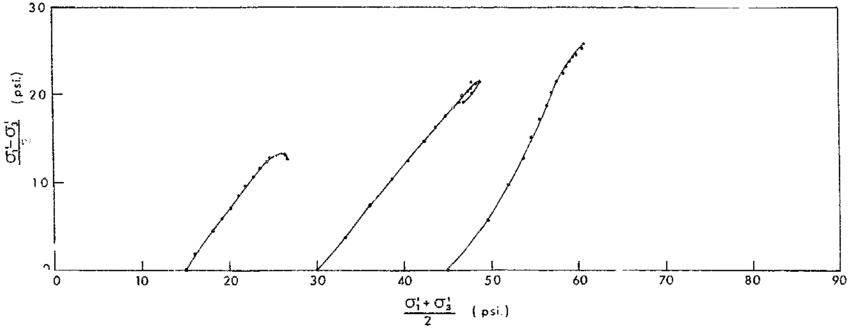


FIG. 29







ZONE 1 (Layered Material)
BORE HOLE 15
SAMPLE 3

σ_3 CONSTANT
σ_1 INCREASING
RATE OF STRAIN .00048 in./min.
SAMPLE SIZE 1½" × 3"

σ_3 CONFINING PRESSURE (psi)		15	30	45	60*
MID-SAMPLE DEPTH		9'-4"	9'-8"	9'-11"	—
MOISTURE CONTENT %	Initial	34·1	32·8	34·4	—
	Final	32·5	29·8	31·2	—
BULK DENSITY (pcf)	Initial	122	125	123	—
	Final	126	129	127	—
LIQUID LIMIT		57·6 %			
PLASTIC LIMIT		27·5 %			

* Insufficient material

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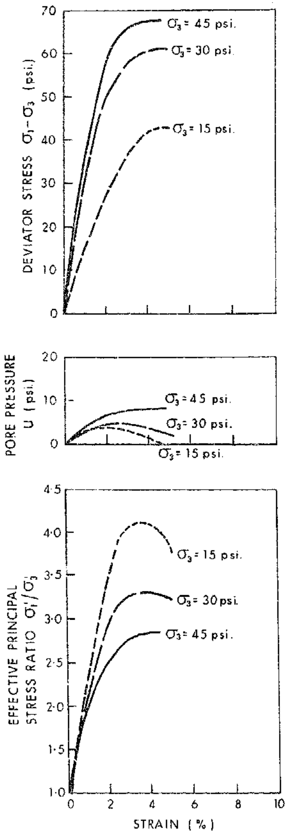
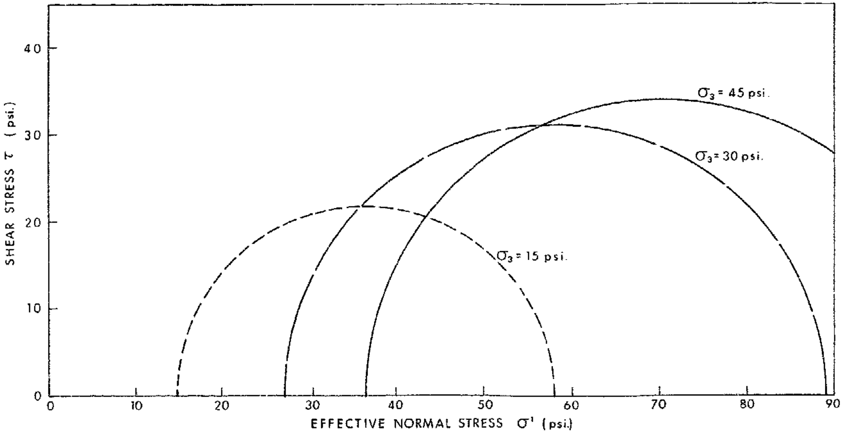
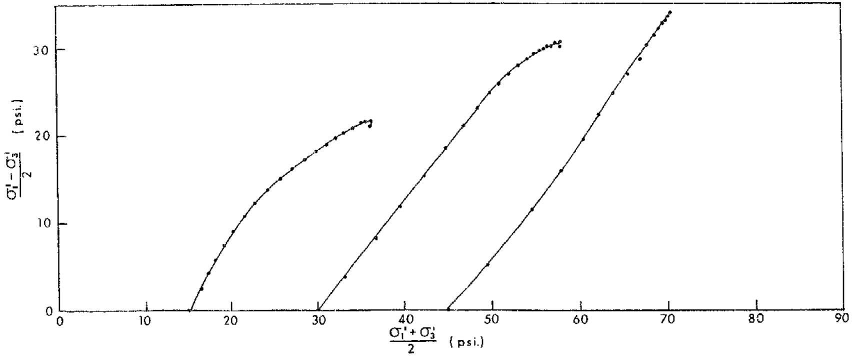
DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TESTS WITH PORE PRESSURE MEASUREMENTS

DATE 12 JUNE, 1967 | APPROVED [signature] | FIGURE NO. 30







ZONE 1 (Mottled Material)

BORE HOLE 8

SAMPLE 5

σ_3 CONSTANT

σ_1 INCREASING

RATE OF STRAIN 00048 in/min.

SAMPLE SIZE 1½" × 3"

σ_3 CONFINING PRESSURE (psi)		15	30	45	60*
MID-SAMPLE DEPTH		10'-5½"	10'-9"	11'-0"	—
MOISTURE CONTENT %	Initial	32·8	31·8	30·1	—
	Final	33·6	31·8	29·3	—
BULK DENSITY (pcf)	Initial	122	122	124	—
	Final	121	122	125	—
LIQUID LIMIT		49·2%			
PLASTIC LIMIT		22·7%			

* Insufficient material

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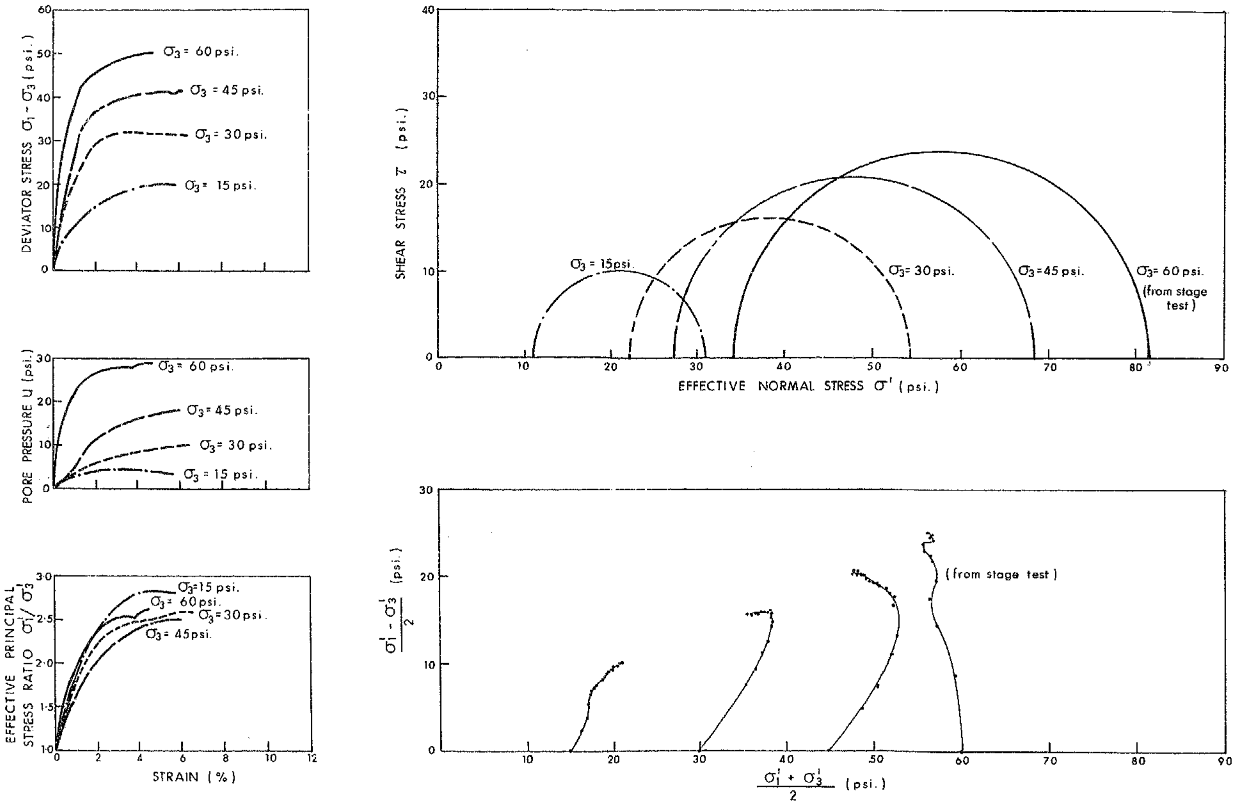
DEPARTMENT OF HIGHWAYS MATERIALS and TESTING DIVISION

ONTARIO

CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TESTS WITH PORE PRESSURE MEASUREMENTS

DATE 12 JUNE, 1967 | APPROVED [signature] | FIGURE NO. 31



ZONE 2

BORE HOLE 10

SAMPLE 8

σ_3 CONSTANT

σ_1 INCREASING

RATE OF STRAIN .00048 in./min.

SAMPLE SIZE 1½" × 3"

σ_3 CONFINING PRESSURE (psi)		15	30	45	60*
MID-SAMPLE DEPTH		23'-4"	23'-8"	24'-0"	24'-4"
MOISTURE CONTENT %	Initial	25·7	27·9	27·9	23·1
	Final	24·3	26·5	25·0	23·0
BULK DENSITY (pcf)	Initial	126	125	125	124
	Final	128	126	128	129
LIQUID LIMIT		38·0 %			
PLASTIC LIMIT		20·7 %			

* Data from the Stage Test.

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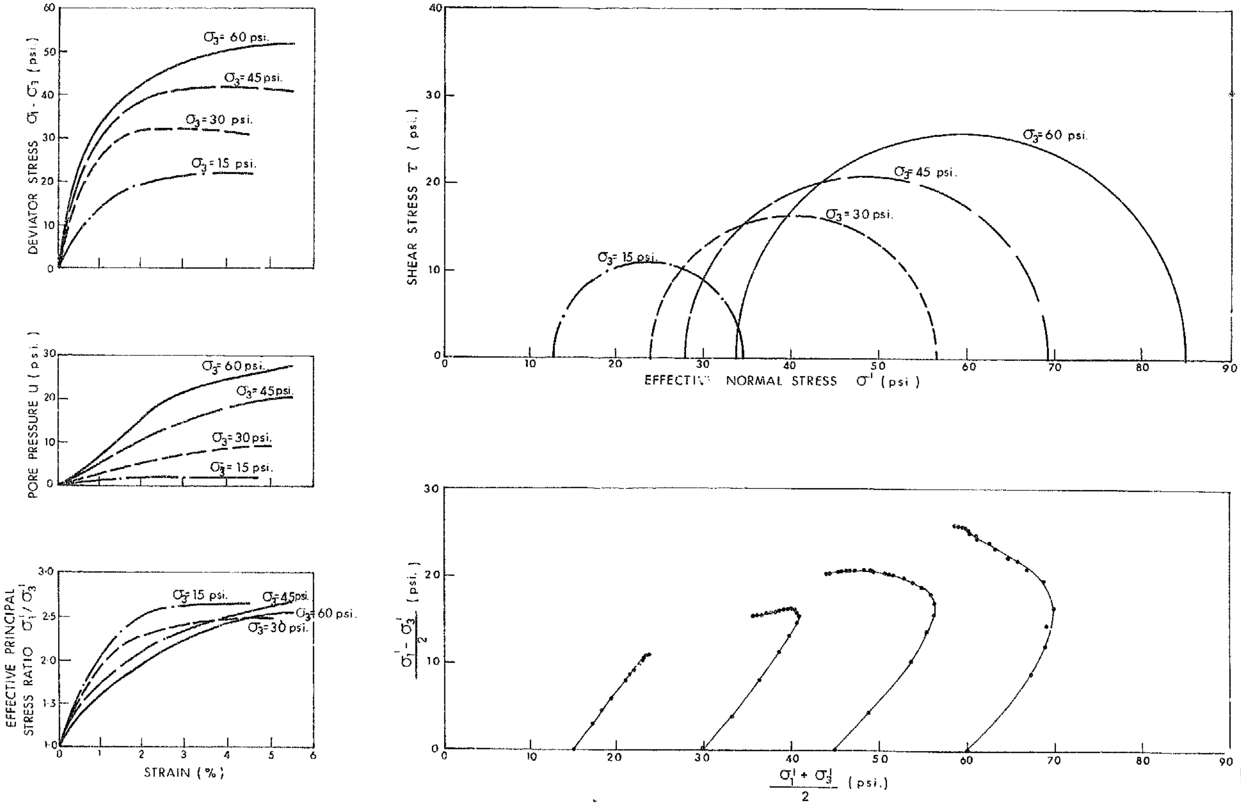
DEPARTMENT OF HIGHWAYS MATERIALS and TESTING DIVISION ONTARIO	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TESTS WITH PORE PRESSURE MEASUREMENTS	
DATE 12 JUNE, 1967	APPROVED [signature]	FIGURE NO. 32



ZONE 2

BORE HOLE 16

SAMPLE 8

σ CONSTANT

σ INCREASING

RATE OF STRAIN .0004 8 in./min

SAMPLE SIZE $1\frac{1}{2}$" × 3"

σ CONFINING PRESSURE (psi.)		15	30	45	60
MID-SAMPLE DEPTH		30'-1"	29'-9"	29' 5"	29'-1"
MOISTURE CONTENT %	Initial	27·2	27·2	25·9	25·9
	Final	26·5	26·5	23·8	23·0
BULK DENSITY (pcf)	Initial	124	124	126	126
	Final	125	125	128	129
LIQUID LIMIT		35·3 %			
PLASTIC LIMIT		18·1 %			

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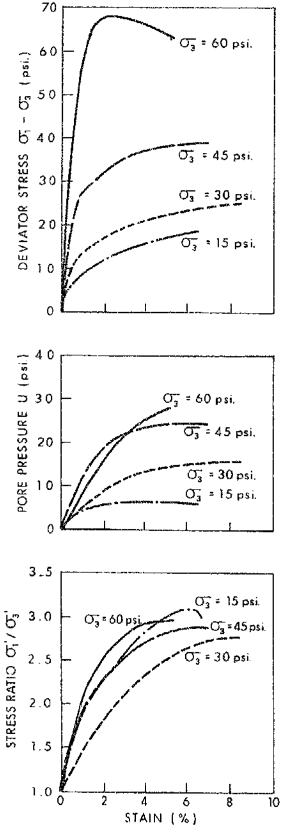
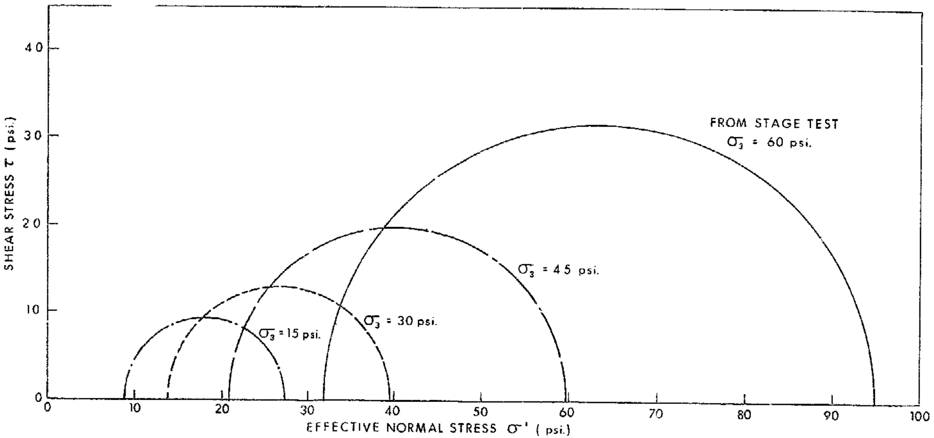
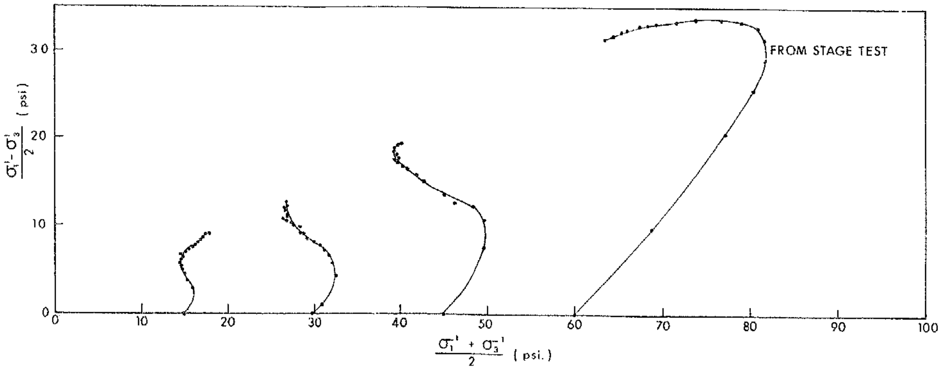
DEPARTMENT OF HIGHWAYS MATERIALS and TESTING DIVISION ONTARIO

CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TESTS WITH PORE PRESSURE MEASUREMENTS

DATE 12 JUNE 1967. | APPROVED [signature] | FIGURE NO. 33







ZONE 2

BORE HOLE 8

SAMPLE 17

σ_3 CONSTANT

σ_1 INCREASING

RATE OF STRAIN .00048 in./min.

SAMPLE SIZE 1½" × 3"

σ_3 CONFINING PRESSURE (psi)		15	30	45	60*
MID-SAMPLE DEPTH		43'-5"	43'-9"	44'-0"	44'-4"
MOISTURE CONTENT %	Initial	28·2	31·5	24·7	24·8
	Final	26·7	27·6	21·1	20·6
BULK DENSITY (pcf)	Initial	124	120	127	126
	Final	125	123	131	131
LIQUID LIMIT		33·6	-	-	25·6
PLASTIC LIMIT		18·8	-	-	16·3

* Data from the Stage Test.

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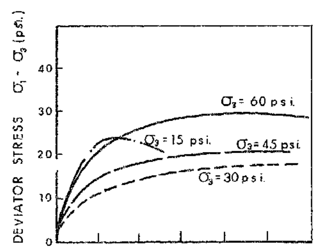
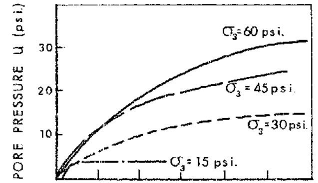
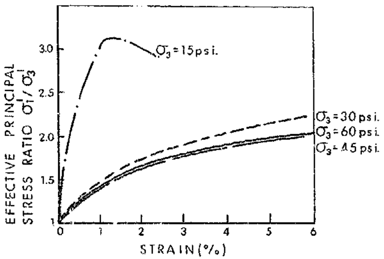
MATERIALS and TESTING DIVISION
ONTARIO

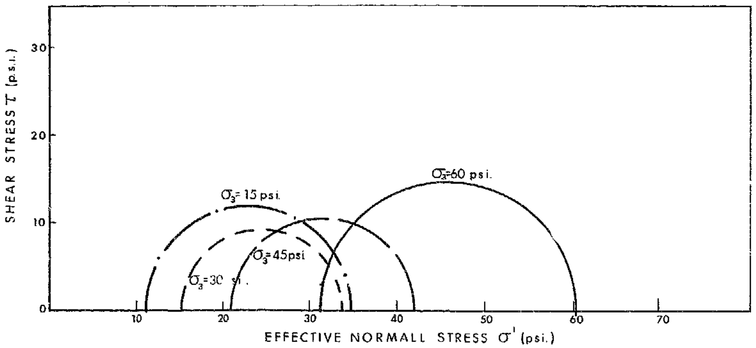
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TESTS WITH PORE PRESSURE MEASUREMENTS

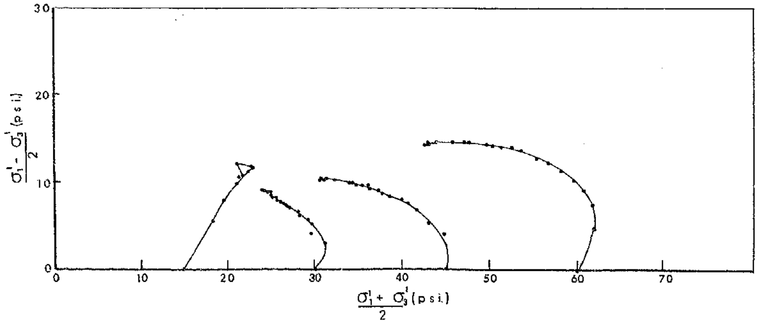
DATE 12 JUNE, 1967 | APPROVED [signature] | FIGURE NO. 34











ZONE 3

BORE HOLE 16

SAMPLE 11

σ_3 CONSTANT

σ_1 INCREASING

RATE OF STRAIN .00048 in/min

SAMPLE SIZE $1\frac{1}{2}$" × 3"

σ_3 CONFINING PRESSURE (psi)		15	30	45	60
MID-SAMPLE DEPTH		45'-4"	44'-8"	44'-4"	44'-0"
MOISTURE CONTENT %	Initial	33·6	49·0	50·5	50·5
	Final	33·6	47·1	45·5	43·5
BULK DENSITY (pcf)	Initial	120	109	109	109
	Final	120	110	112	113
LIQUID LIMIT		44·1% *			
PLASTIC LIMIT		22·3% *			

* Average for adjacent samples

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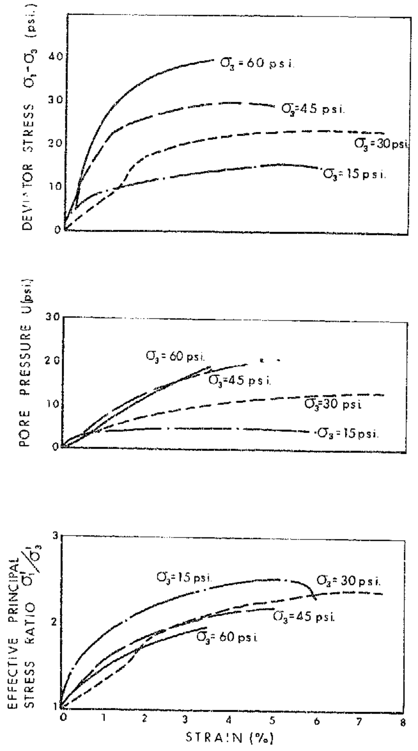
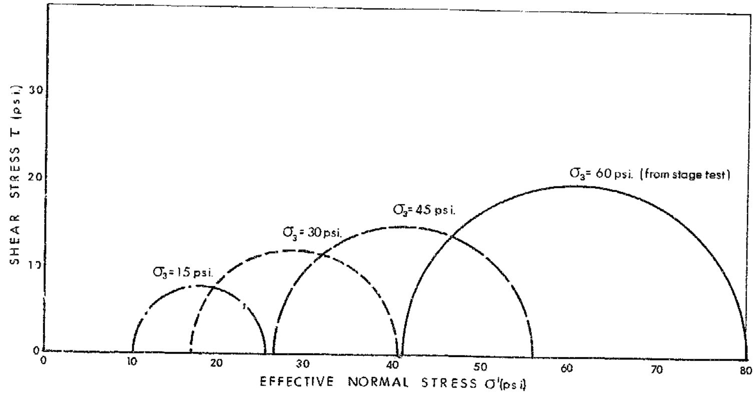
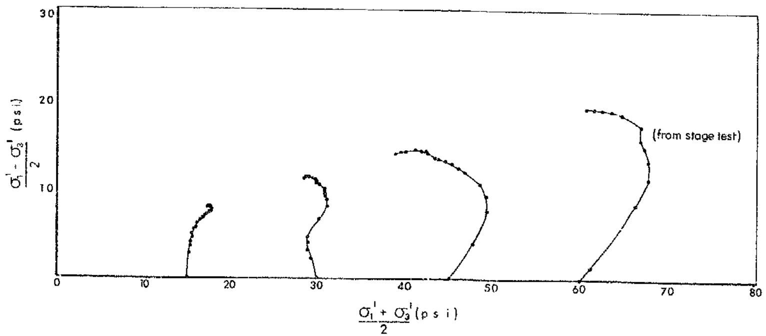
ONTARIO

CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TESTS WITH PORE PRESSURE MEASUREMENTS

DATE 12 JUNE 1967 | APPROVED [signature] | FIGURE NO. 35







ZONE 4

BORE HOLE 18

SAMPLE 12

σ_3 CONSTANT

σ_1 INCREASING

RATE OF STRAIN .00048 in./min.

SAMPLE SIZE $1\frac{1}{2}$" × 3"

σ_3 CONFINING PRESSURE (psi)		15	30	45	60 *
MID-SAMPLE DEPTH		50'-4"	50'-8"	51'-0"	51'-4"
MOISTURE CONTENT %	Initial	34·4	32·8	36·4	33·6
	Final	32·0	29·6	33·8	28·3
BULK DENSITY (pcf)	Initial	118	119	118	120
	Final	119	122	120	124
LIQUID LIMIT		48·3 %		46·6 %	
PLASTIC LIMIT		22·7 %		22·2 %	

* From stage test

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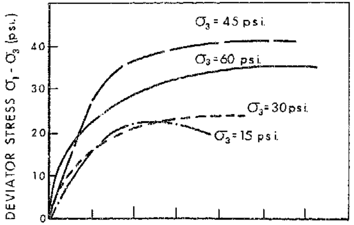
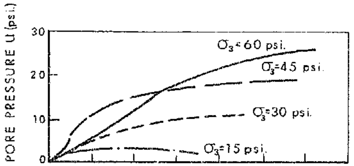
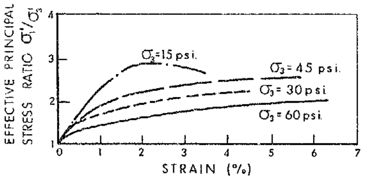
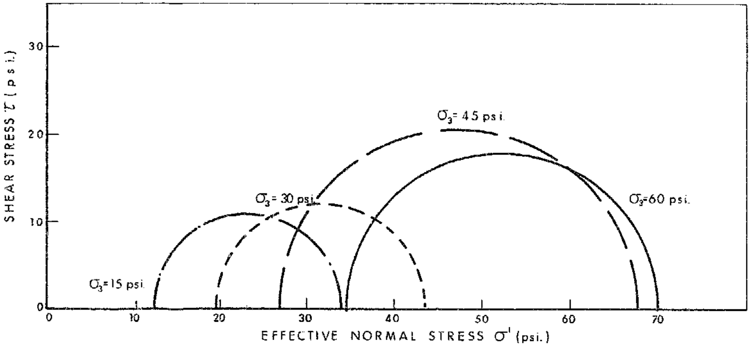
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TESTS WITH PORE PRESSURE MEASUREMENTS

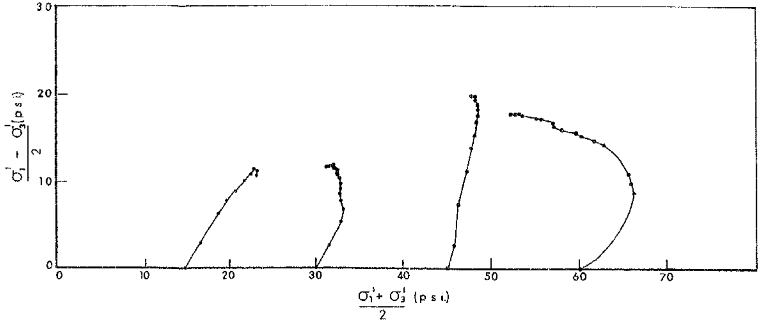
DATE 12 JUNE 1967 | APPROVED [signature] | FIGURE NO. 36











ZONE 4

BORE HOLE 17

SAMPLE 21

σ_3 CONSTANT

σ_1 INCREASING

RATE OF STRAIN .00048 in./min.

SAMPLE SIZE 1½" × 3"

σ_3 CONFINING PRESSURE (psi)		15	30	45	60
MID-SAMPLE DEPTH		58'-4"	58'-0"	57'-8"	57'-4"
MOISTURE CONTENT %	Initial	32·5	35·0	33·8	33·8
	Final	29·8	32·5	29·0	29·0
BULK DENSITY (pcf)	Initial	120	119	119	119
	Final	125	122	125	128
LIQUID LIMIT		41·5 %			
PLASTIC LIMIT		20·6 %			

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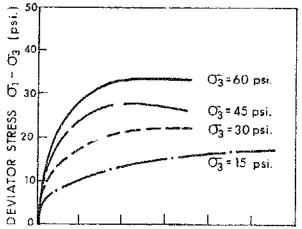
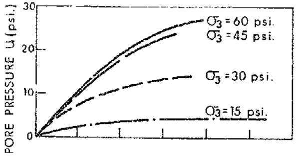
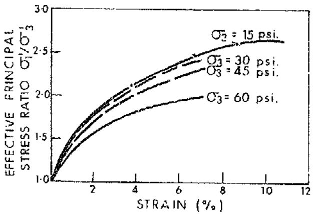
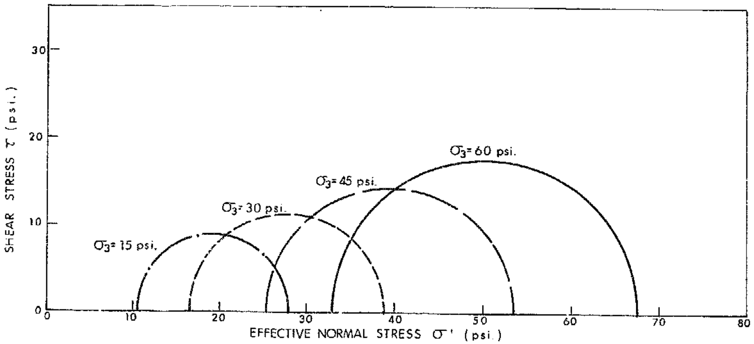
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TESTS WITH PORE PRESSURE MEASUREMENTS

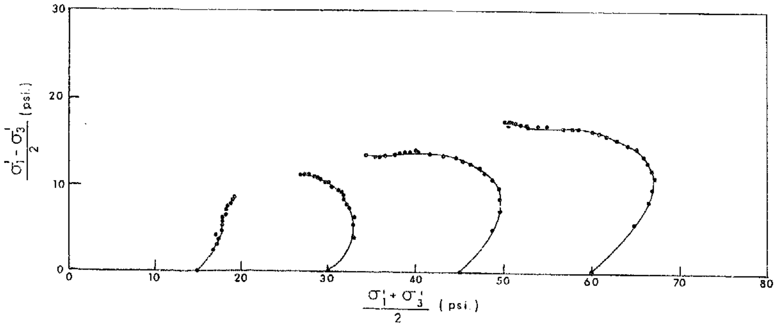
DATE 12 JUNE 1967 | APPROVED [signature] | FIGURE NO. 37











ZONE 5

BORE HOLE 8

SAMPLE 24

σ_3 CONSTANT

σ_1 INCREASING

RATE OF STRAIN .00048 in/min.

SAMPLE SIZE $1\frac{1}{2}$" × 3"

σ_3 CONFINING PRESSURE (psi)		15	30	45	60
MID-SAMPLE DEPTH		69'-7"	69'-3"	68'-11"	68'-7"
MOISTURE CONTENT %	Initial	42·0	46·2	43·5	44·8
	Final	42·0	43·4	40·6	40·2
BULK DENSITY (pcf)	Initial	114	111	111	111
	Final	114	113	113	114
LIQUID LIMIT		53·7 %			
PLASTIC LIMIT		24·5 %			

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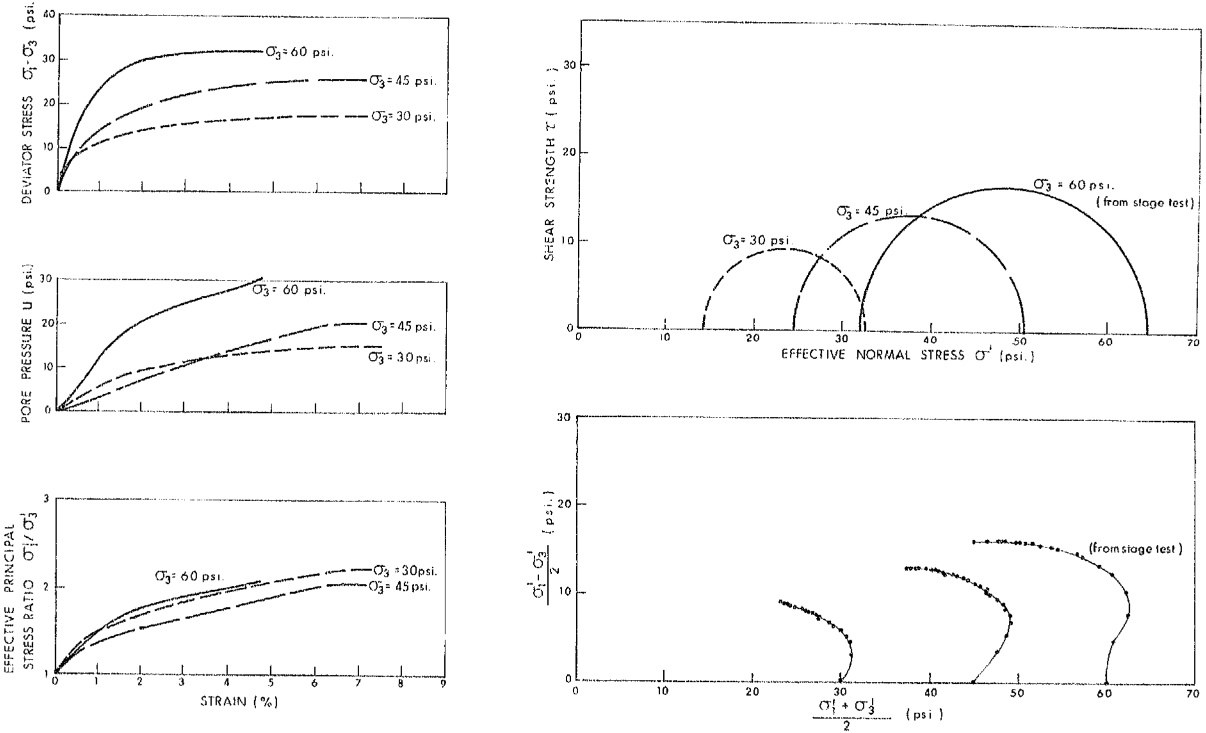
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TESTS WITH PORE PRESSURE MEASUREMENTS

DATE 12 JUNE 1967 | APPROVED [signature] | FIGURE NO. 38



ZONE 5

BORE HOLE 14

SAMPLE 13

σ_2 CONSTANT

σ_1 INCREASING

RATE OF STRAIN 00048 in./min.

SAMPLE SIZE 1½" × 3"

σ_3 CONFINING PRESSURE (psi)		15*	30	45	60**
MID-SAMPLE DEPTH		——	55'-0"	54'-7"	55'-4"
MOISTURE CONTENT %	Initial	——	47·6	44·4	46·2
	Final	——	44·8	38·9	37·7
BULK DENSITY (pcf)	Initial	——	111	112	111
	Final	——	113	116	117
LIQUID LIMIT		41·1 %			
PLASTIC LIMIT		31·9 %			

* Insufficient material

** From stage test

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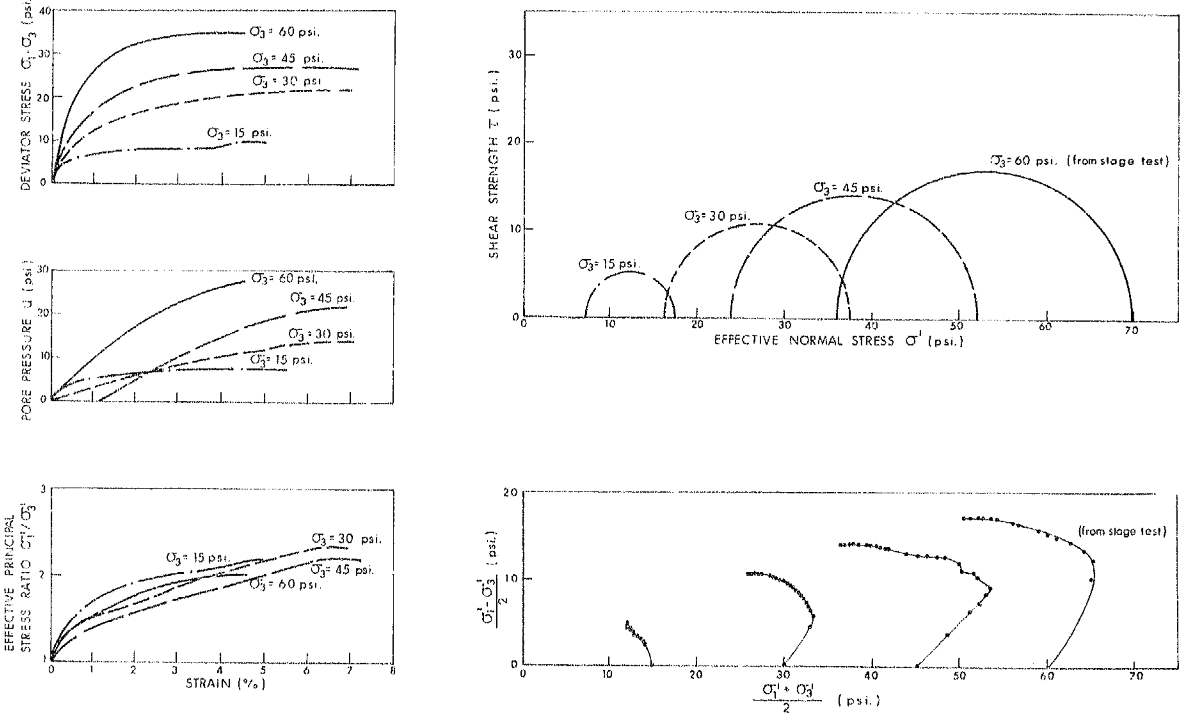
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TESTS WITH PORE PRESSURE MEASUREMENTS

DATE 12 JUNE 1967 | APPROVED [signature] | FIGURE NO. 39



ZONE 5
BORE HOLE 15
SAMPLE 15

σ_3 CONSTANT
σ_1 INCREASING
RATE OF STRAIN .00048 in/min
SAMPLE SIZE 1½" × 3"

σ_3 CONFINING PRESSURE (psi)		15	30	45	60*
MID-SAMPLE DEPTH		66'-0"	65'-8"	65'-4"	66'-4"
MOISTURE CONTENT %	Initial	43·6	44·9	43·6	46·2
	Final	40·0	39·5	35·4	37·7
BULK DENSITY (pcf)	Initial	113	113	113	111
	Final	116	120	119	117
LIQUID LIMIT		47·0 % **			
PLASTIC LIMIT		22·0 % **			

* From stage test
** Average for adjacent samples

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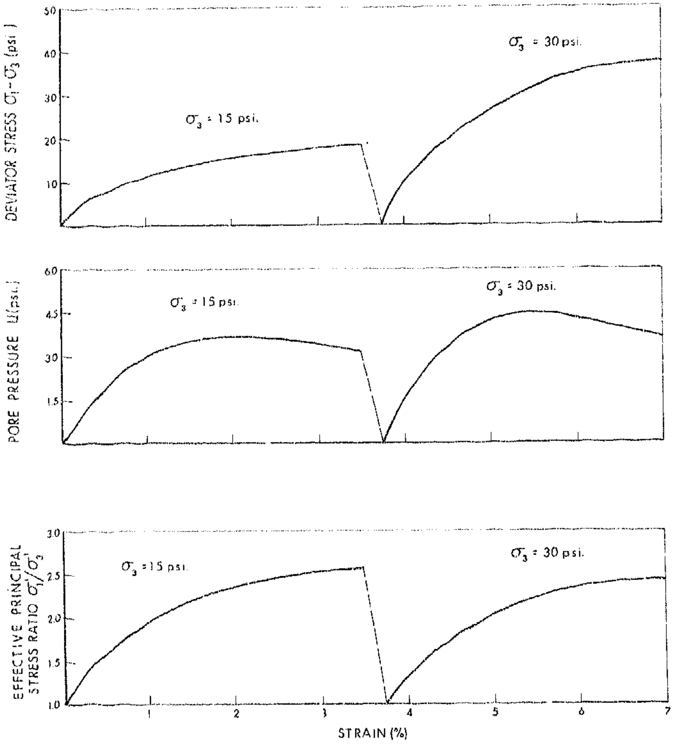
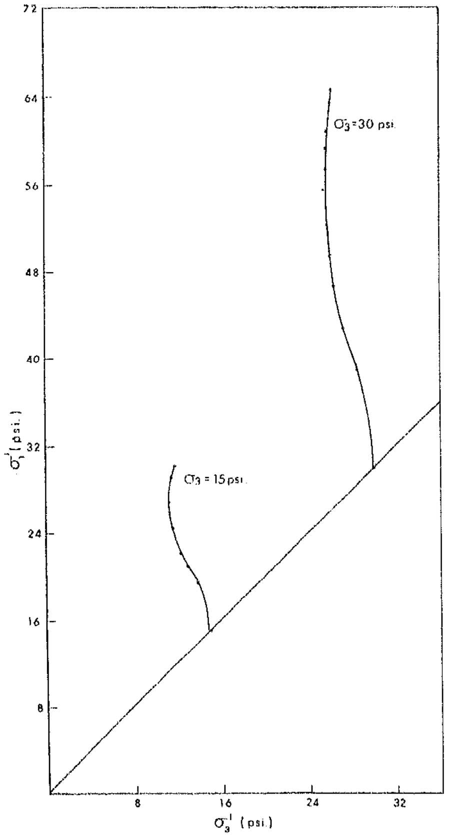
DEPARTMENT OF HIGHWAYS MATERIALS and TESTING DIVISION ONTARIO

CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TESTS WITH PORE PRESSURE MEASUREMENTS

DATE 12 JUNE 1967 APPROVED [signature] FIGURE NO 40





ZONE 1

BOREHOLE 13

SAMPLE 2

σ_3 CONSTANT

σ_1 INCREASING

MID - SAMPLE DEPTH	7' 3½"
SAMPLE SIZE	1½" × 3"
LIQUID LIMIT	47·5 %
PLASTIC LIMIT	29·1 %
INITIAL MOISTURE CONTENT	26·0 %
FINAL MOISTURE CONTENT	26·0 %
INITIAL BULK DENSITY	125 pcf
FINAL BULK DENSITY	125 pcf

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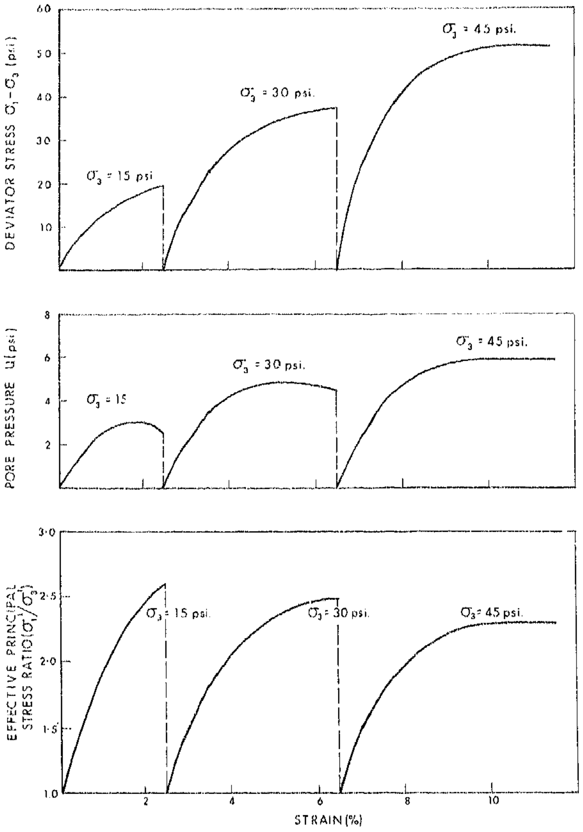
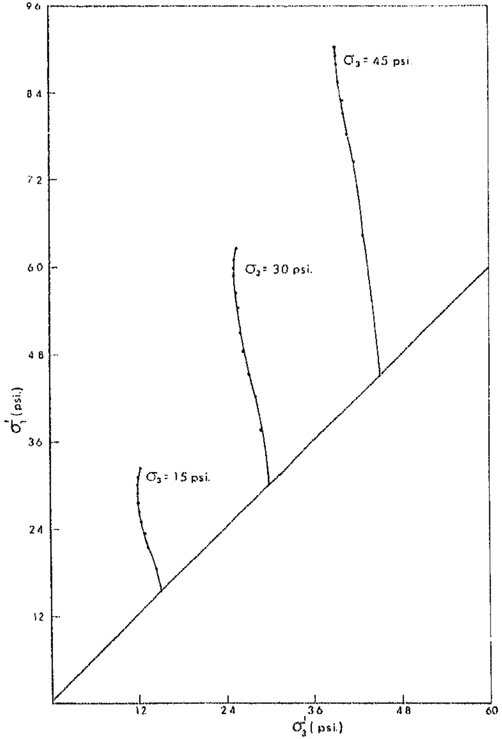
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION STAGE TESTS WITH PORE PRESSURE MEASUREMENTS

DATE 24 AUG. 1967 | APPROVED [signature] | FIGURE NO. 41





ZONE 1

BOREHOLE 15

SAMPLE 3

σ_3 CONSTANT

σ_1 INCREASING

MID - SAMPLE DEPTH ———— 10' 6"

SAMPLE SIZE ———— 1½" x 3"

LIQUID LIMIT ———— 57.6 %

PLASTIC LIMIT ———— 27.5 %

INITIAL MOISTURE CONTENT ———— 31.5 %

FINAL MOISTURE CONTENT ———— 31.5 %

INITIAL BULK DENSITY ———— 123 pcf

FINAL BULK DENSITY ———— 123 pcf

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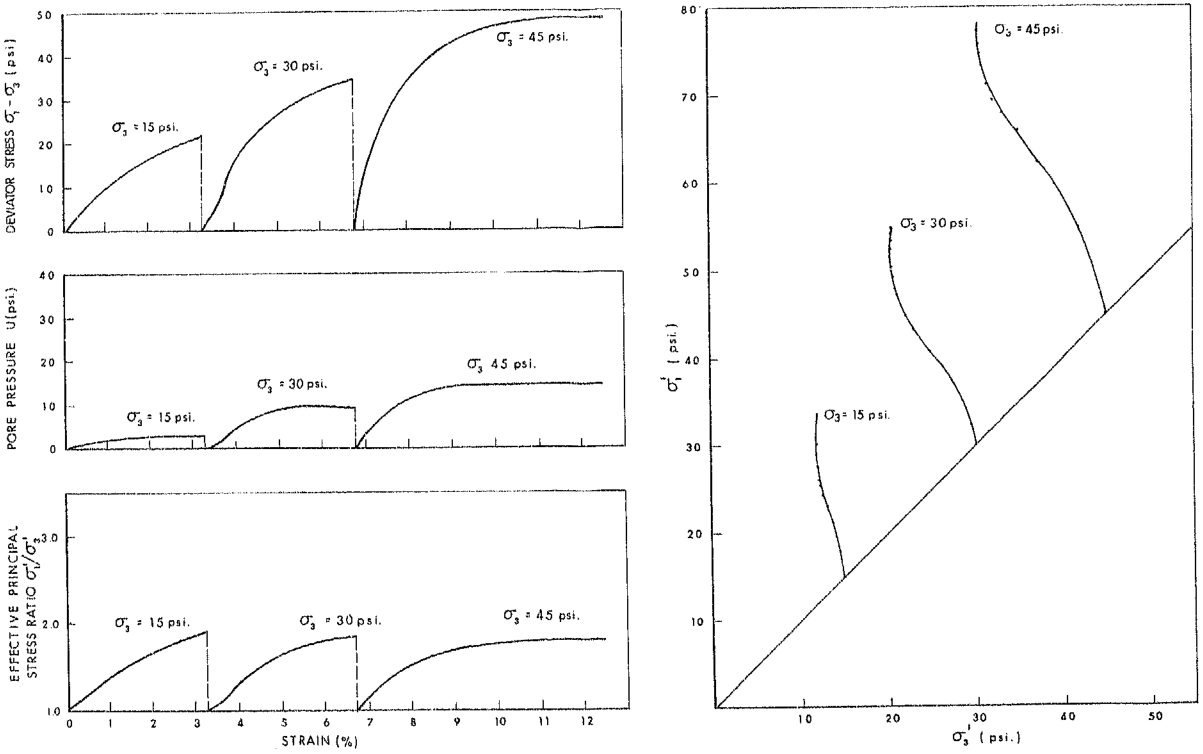
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION STAGE TESTS WITH PORE PRESSURE MEASUREMENTS

DATE 25 AUG. 1967 | APPROVED | FIGURE NO 42



ZONE 1

BOREHOLE 8

SAMPLE 5

σ_3 CONSTANT

σ_1 INCREASING

MID - SAMPLE DEPTH	11'4"
SAMPLE SIZE	$1\frac{1}{2}$" x 3"
LIQUID LIMIT	49·2 %
PLASTIC LIMIT	22·7 %
INITIAL MOISTURE CONTENT	38·4 %
FINAL MOISTURE CONTENT	36·7 %
INITIAL BULK DENSITY	116 pcf
FINAL BULK DENSITY	117 pcf

66-f-111

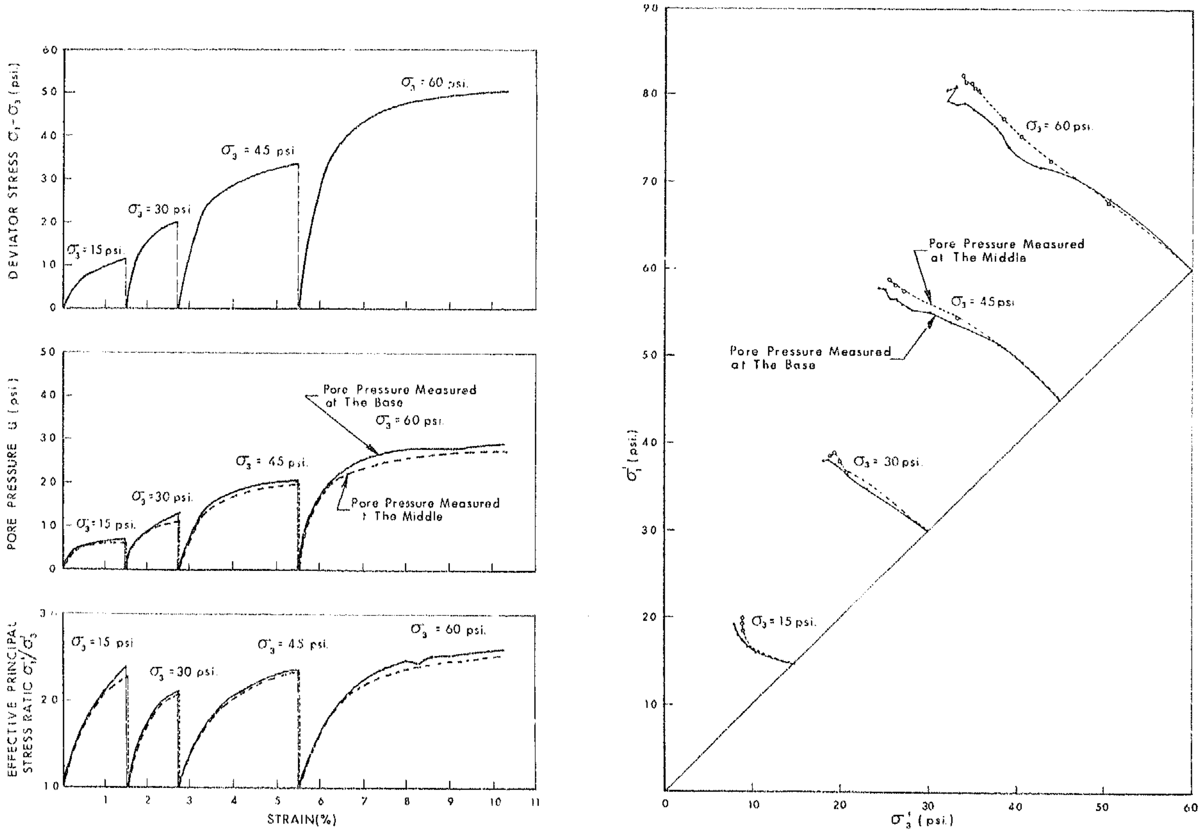
DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION STAGE TESTS WITH PORE PRESSURE MEASUREMENTS

DATE 24 AUG. 1967

APPROVED [signature]

FIGURE NO. 43



ZONE 2

BOREHOLE 10

SAMPLE 8

σ_3 CONSTANT

σ_1 INCREASING

MID - SAMPLE DEPTH	24' 2"
SAMPLE SIZE	1½" x 3"
LIQUID LIMIT	38.0%
PLASTIC LIMIT	20.7%
INITIAL MOISTURE CONTENT	28.1%
FINAL MOISTURE CONTENT	23.0%
INITIAL BULK DENSITY	124 pcf
FINAL BULK DENSITY	129 pcf

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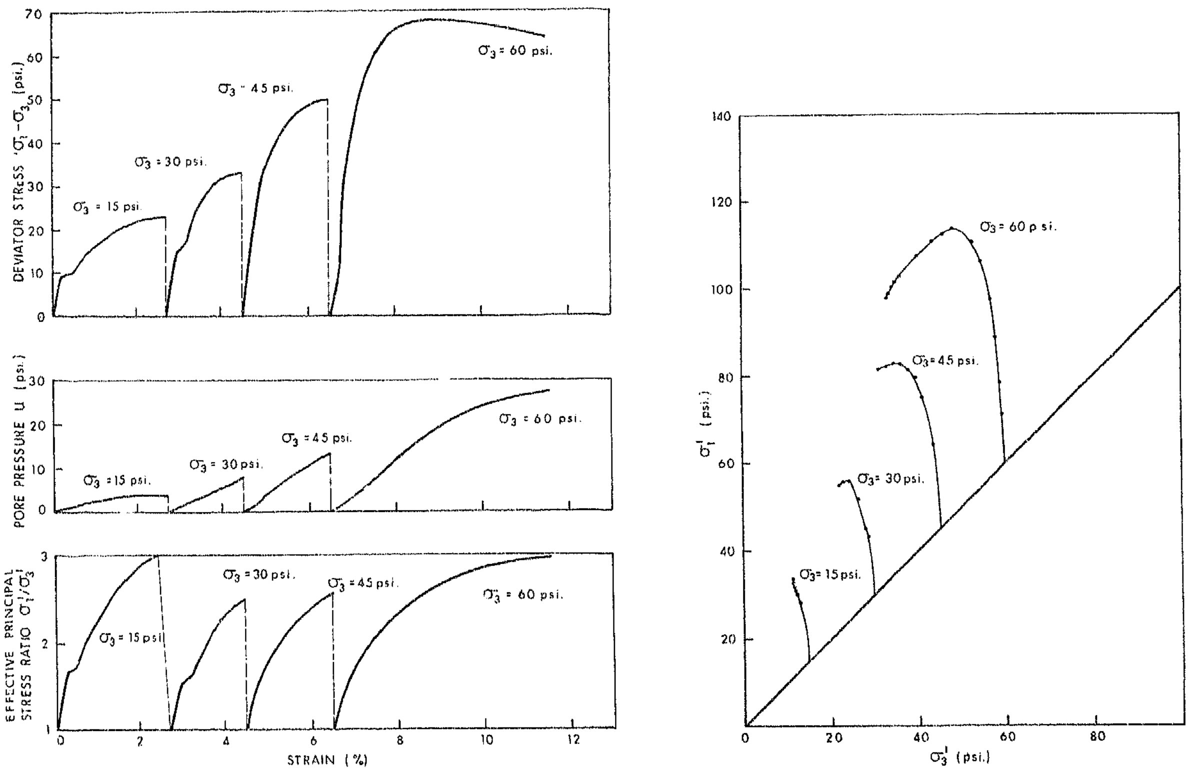
DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION STAGE TESTS WITH PORE PRESSURE MEASUREMENTS

DATE 24 AUG. 1967 | APPROVED [signature] | FIGURE NO. 44



ZONE 2

BOREHOLE 8

SAMPLE 17

σ_3 CONSTANT

σ_1 INCREASING

MID - SAMPLE DEPTH	44' 2"
SAMPLE SIZE	1½" × 3"
LIQUID LIMIT	25·6 %
PLASTIC LIMIT	16·3 %
INITIAL MOISTURE CONTENT	24·8 %
FINAL MOISTURE CONTENT	20·6 %
INITIAL BULK DENSITY	126 pcf
FINAL BULK DENSITY	131 pcf

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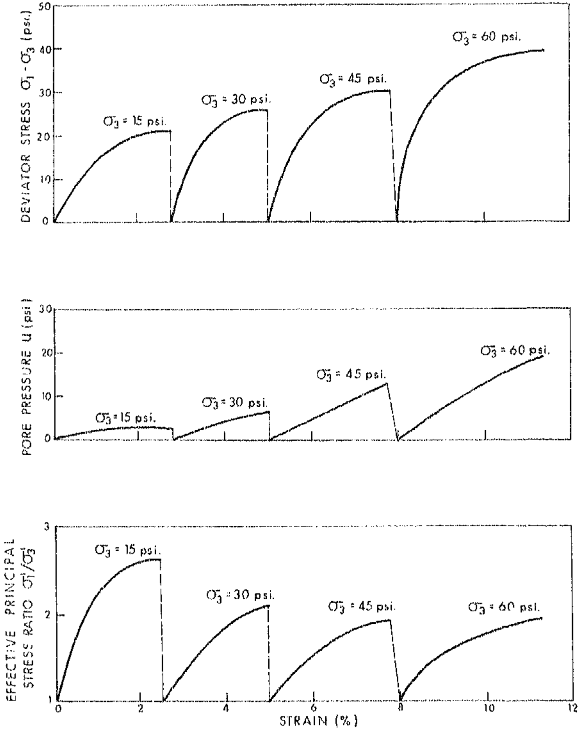
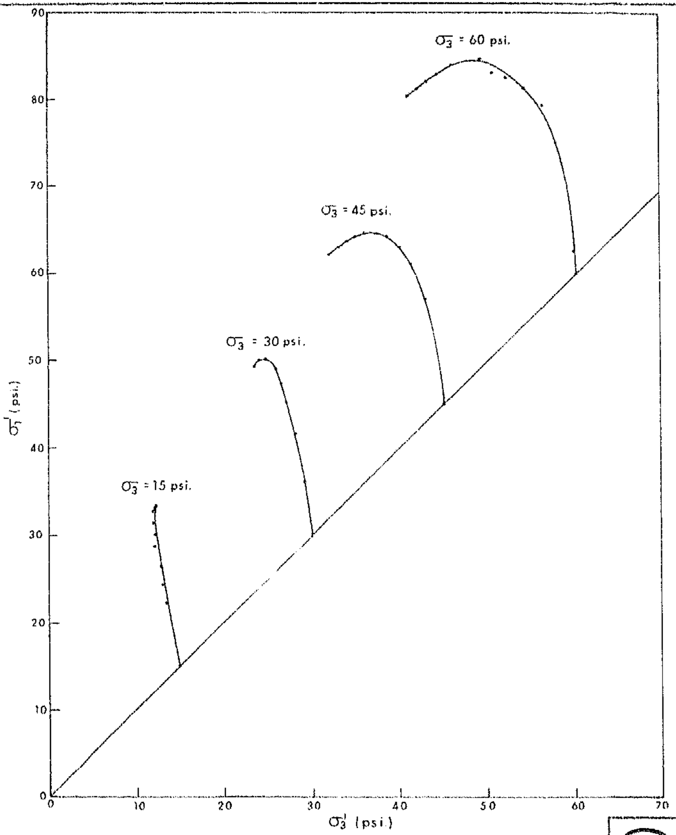
DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION STAGE TESTS WITH PORE PRESSURE MEASUREMENTS

DATE 24 AUG. 1967 | APPROVED [signature] | FIGURE NO. 45





ZONE 4

BOREHOLE 18

SAMPLE 12

σ_3 CONSTANT

σ_1 INCREASING

MID - SAMPLE DEPTH	51'4"
SAMPLE SIZE	1½" x 3"
LIQUID LIMIT	43.6 %
PLASTIC LIMIT	22.2 %
INITIAL MOISTURE CONTENT	33.6 %
FINAL MOISTURE CONTENT	28.8 %
INITIAL BULK DENSITY	120 pcf
FINAL BULK DENSITY	124 pcf

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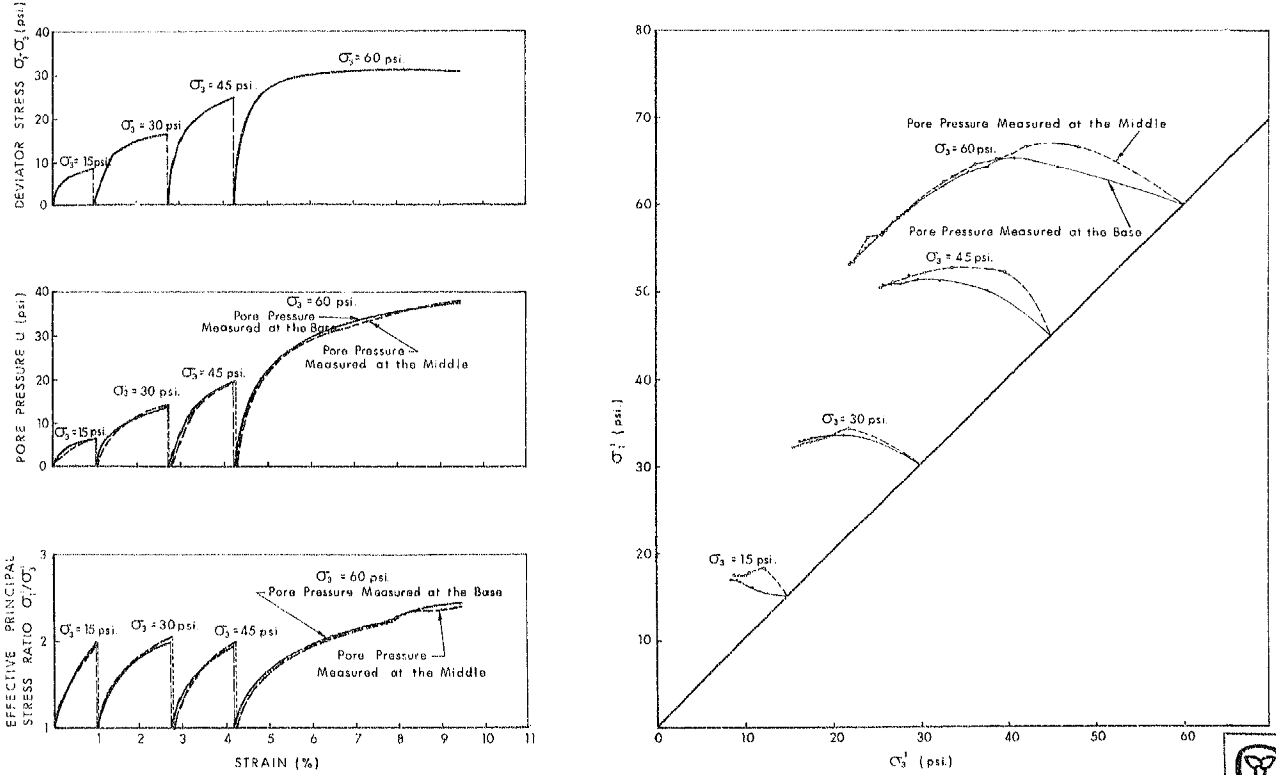
DEPARTMENT OF HIGHWAYS MATERIALS and TESTING DIVISION
ONTARIO

CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION STAGE TESTS WITH PORE PRESSURE MEASUREMENTS

DATE 24 AUG. 1967 | APPROVED [signature] | FIGURE NO. 46



ZONE 5

BOREHOLE 8

SAMPLE 24

σ_3 CONSTANT

σ_1 INCREASING

MID-SAMPLE DEPTH	69' 11"
SAMPLE SIZE	$1\frac{1}{2}$" × 3"
LIQUID LIMIT	52·4 %
PLASTIC LIMIT	24·1 %
INITIAL MOISTURE CONTENT	42·9 %
FINAL MOISTURE CONTENT	36·6 %
INITIAL BULK DENSITY	115 pcf
FINAL BULK DENSITY	120 pcf

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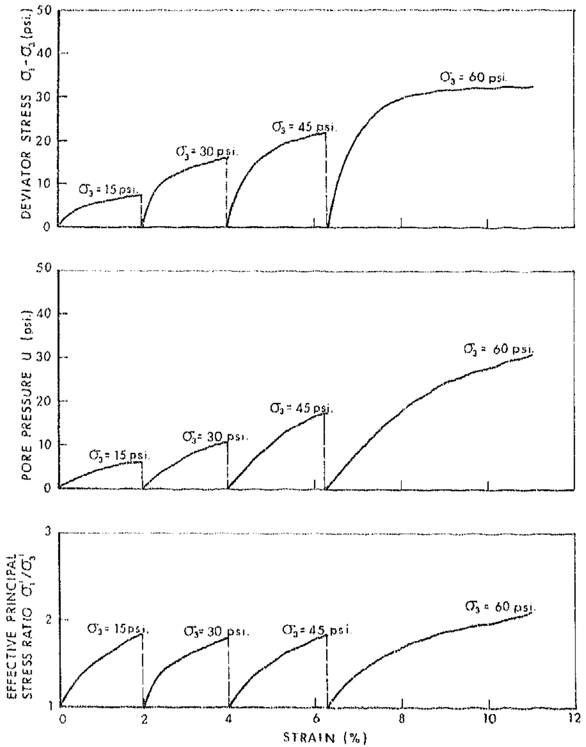
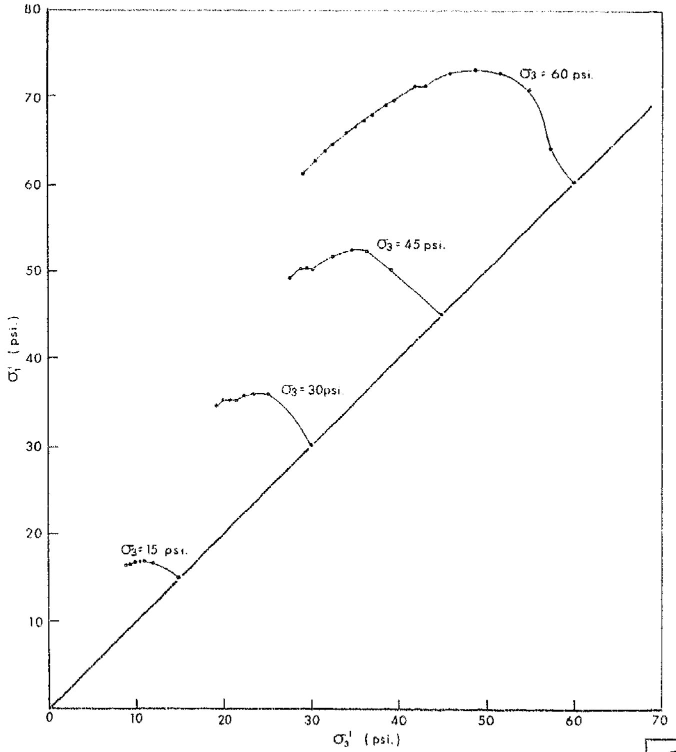
DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION STAGE TESTS WITH PORE PRESSURE MEASUREMENTS

DATE 24 AUG. 1967 | APPROVED [signature] | FIGURE NO. 47





ZONE 5

BOREHOLE 14

SAMPLE 13

σ_3 CONSTANT

σ_1 INCREASING

MID - SAMPLE DEPTH	55' 2"
SAMPLE SIZE	1½" × 3"
LIQUID LIMIT	41 1 %
PLASTIC LIMIT	31 9 %
INITIAL MOISTURE CONTENT	46 2 %
FINAL MOISTURE CONTENT	37 7 %
INITIAL BULK DENSITY	111 pcf
FINAL BULK DENSITY	117 pcf

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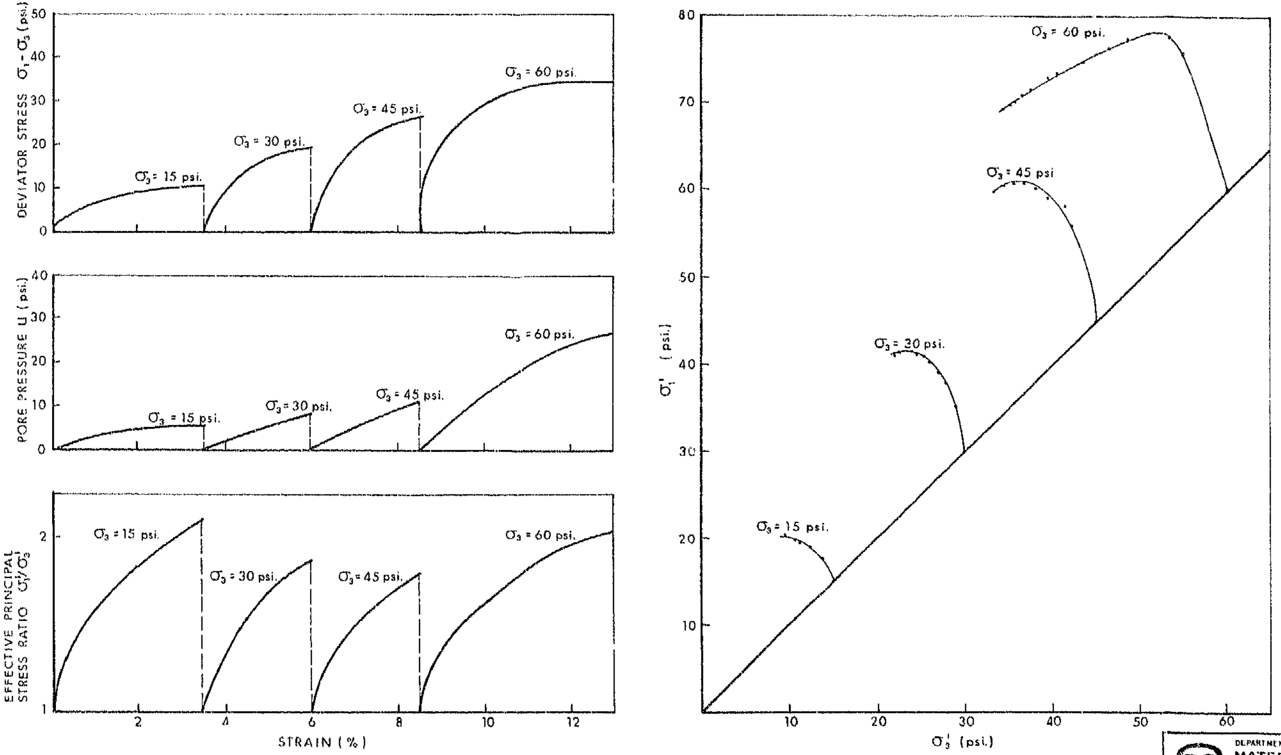
DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION STAGE TESTS WITH PORE PRESSURE MEASUREMENTS

DATE 24 AUG. 1967 | APPROVED | FIGURE NO. 48



ZONE 5

BOREHOLE 15

SAMPLE 15

σ_3 CONSTANT

σ_1 INCREASING

MID - SAMPLE DEPTH	66' 4"
SAMPLE SIZE	$1\frac{1}{2}$" x 3"
LIQUID LIMIT	47·0 % *
PLASTIC LIMIT	22·0 % *
INITIAL MOISTURE CONTENT	46·2 %
FINAL MOISTURE CONTENT	37·7 %
INITIAL BULK DENSITY	111 pcf
FINAL BULK DENSITY	117 pcf

* AVERAGE FROM ADJACENT SAMPLES

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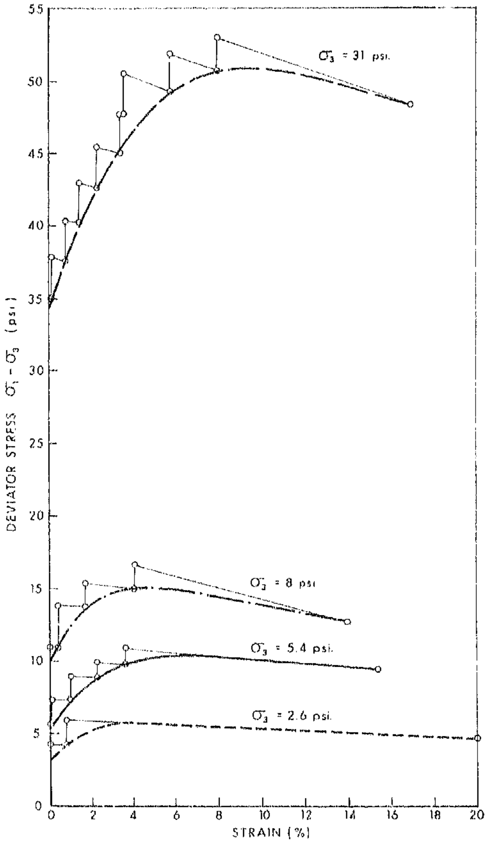
ONTARIO
DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION

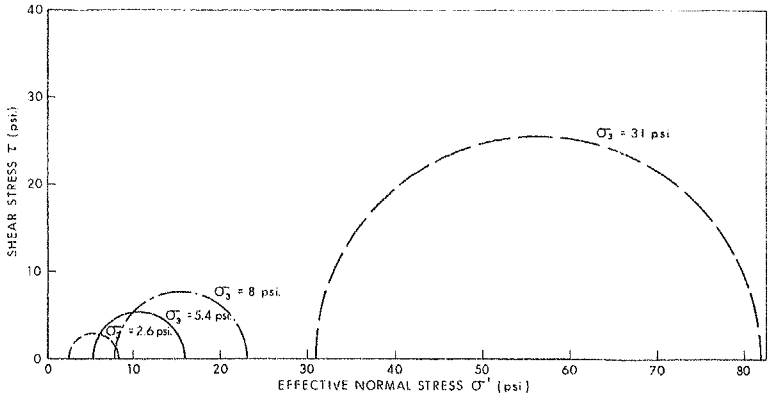
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION STAGE TESTS WITH PORE PRESSURE MEASUREMENTS

DATE 24 AUG. 1967 | APPROVED [signature] | FIGURE NO. 49

ZONE 2
BOREHOLE 18
SAMPLE 8

K_o CONSOLIDATION
σ_1 INCREASING (DEAD LOAD)
σ_3 CONSTANT
SAMPLE SIZE $1\frac{1}{2}$" × 3"





		2.6	5.4	8	31
σ_3 CONFINING PRESSURE (psi)		2.6	5.4	8	31
MID - SAMPLE DEPTH		31'-6"	31'-4"	31'-0"	31'-4"
MOISTURE CONTENT (%)	INITIAL	25.4	25.7	26.8	29.4
	FINAL	27.4	25.7	26.8	23.5
BULK DENSITY (pcf)		126.4	126.0	125.5	126.2
LIQUID LIMIT (%)		36.1			
PLASTIC LIMIT (%)		18.3			

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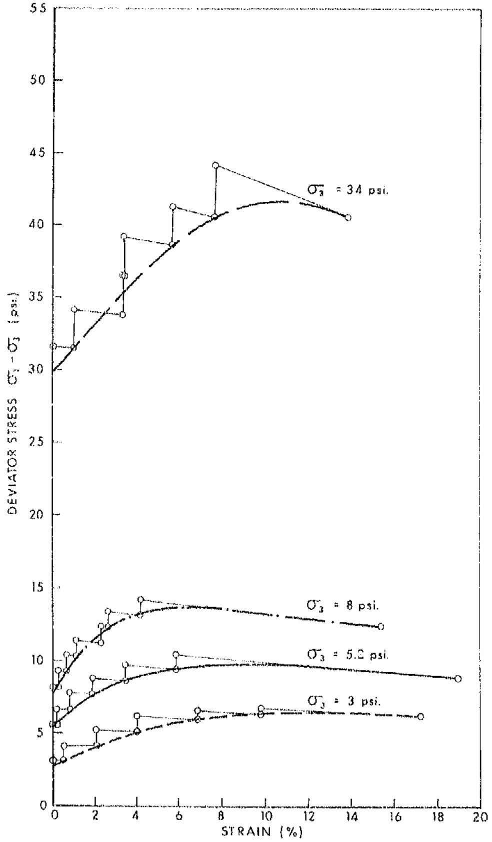
DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

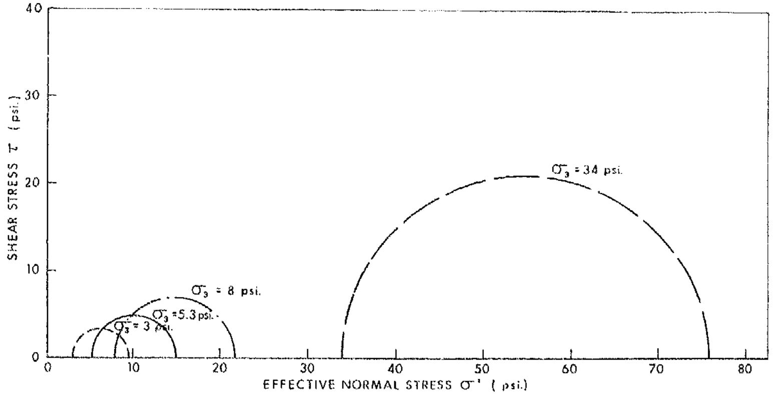
K_o CONSOLIDATION - DRAINED TESTS

DATE 23 AUG. 67 | APPROVED [signature] | FIGURE NO. 50

ZONE 4
BOREHOLE 19
SAMPLE 15

K_o CONSOLIDATION
σ_1 INCREASING (DEAD LOAD)
σ_3 CONSTANT
SAMPLE SIZE $1\frac{1}{2}'' \times 3''$





σ_3 CONFINING PRESSURE (psi)		3	5.3	8	34
MID - SAMPLE DEPTH		65'-6"	65'-2"	64'-10"	65'-10"
MOISTURE CONTENT (%)	INITIAL	32.5	31.2	32.1	35.0
	FINAL	35.2	32.3	32.7	29.3
BULK DENSITY (pcf.)		119.6	122.2	121.2	119
LIQUID LIMIT (%)		—	40.6	42.3	43.1
PLASTIC LIMIT (%)		—	19.9	19.8	21.4

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DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

K_o CONSOLIDATION - DRAINED TESTS

DATE 23 AUG. 67 | APPROVED [signature] | FIGURE NO. 51

SUMMARY OF CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TESTS WITH PORE PRESSURE MEASUREMENTS (ZONES 3, 4, & 5)

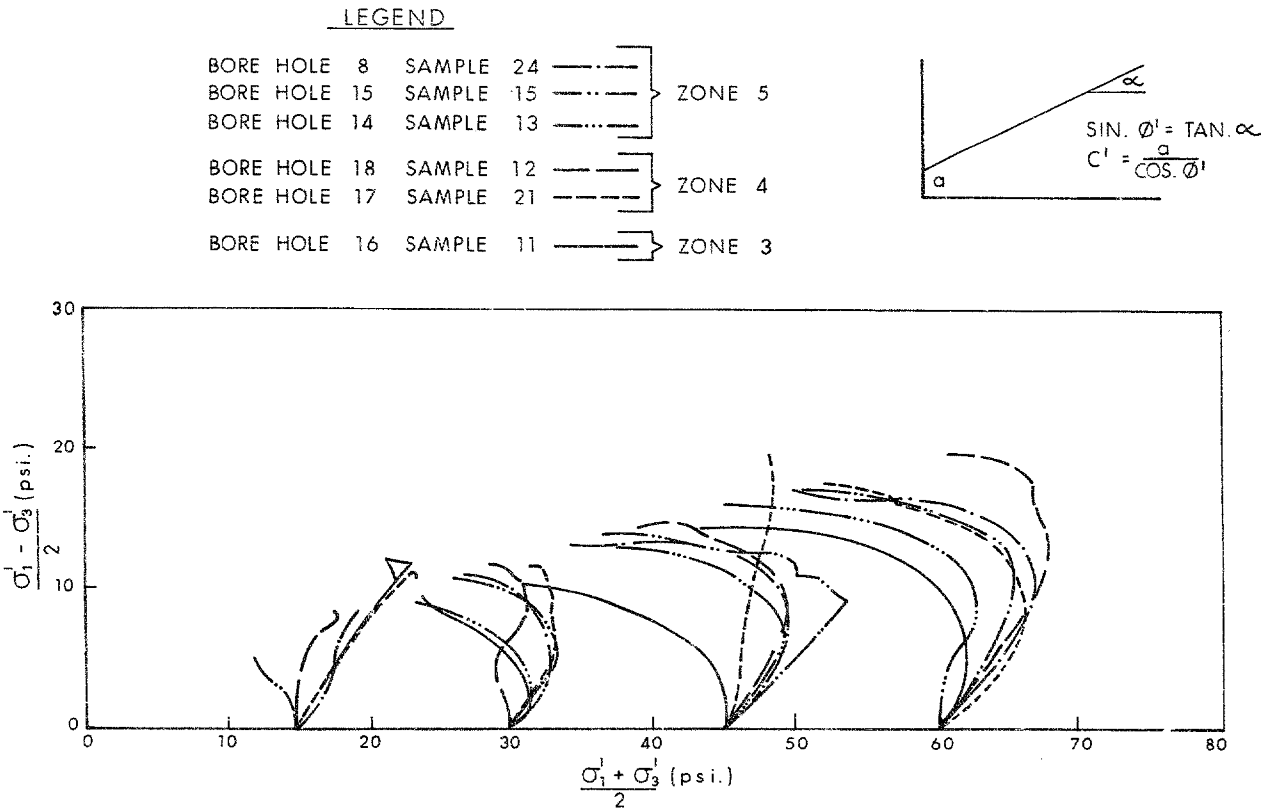


FIG. 52

VOID RATIO
VS
PRESSURE

ZONE - 1
BORE HOLE - 8
SAMPLE - 5
DEPTH - 11'-1" (EL.563.9)

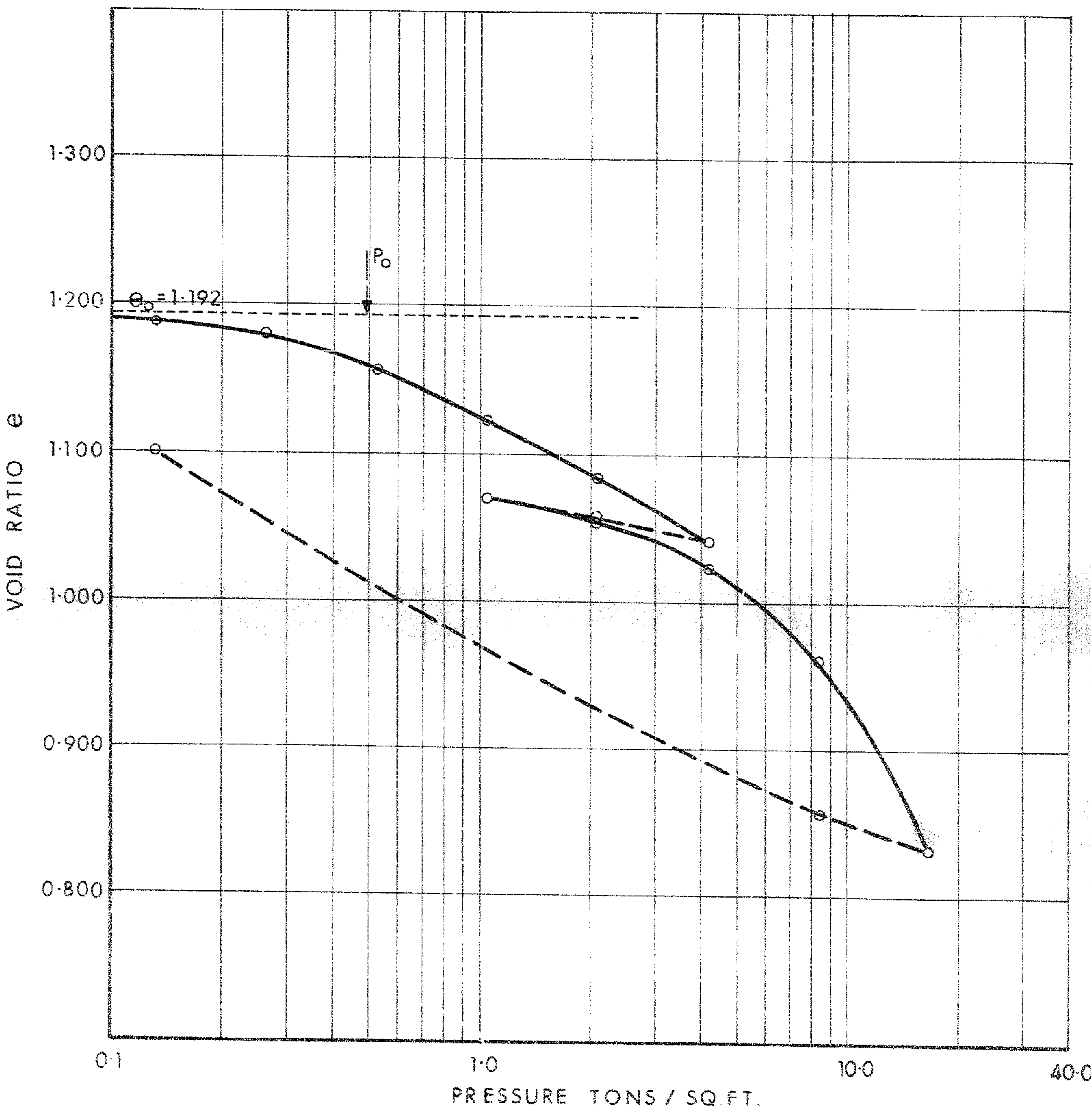


FIG 53

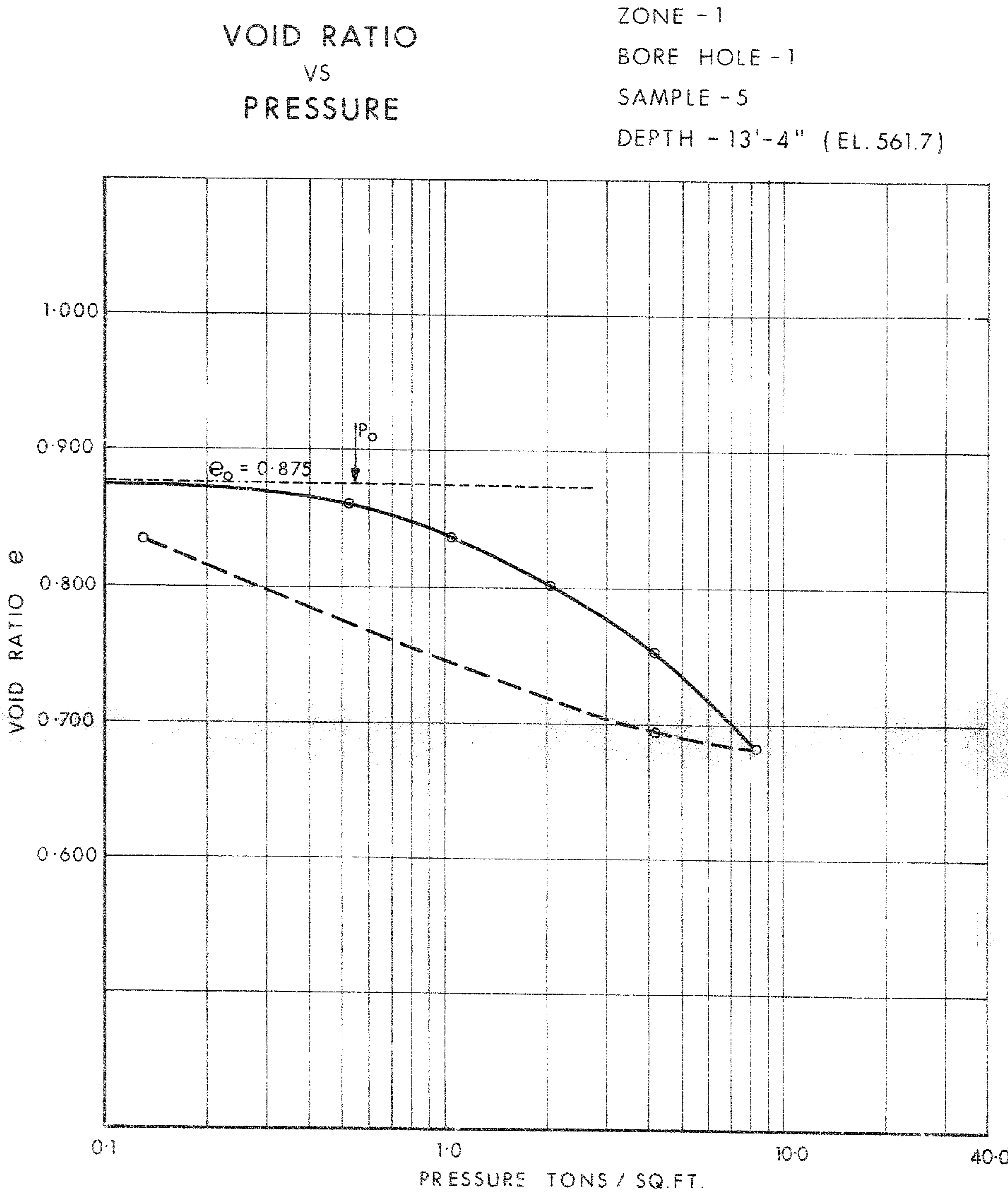

VOID RATIO
VS
PRESSURE
ZONE - 1
BORE HOLE - 1
SAMPLE - 5
DEPTH - 13'-4" (EL. 561.7)
VOID RATIO e
1·000
0·900
0·800
0·700
0·600
e_o = 0·875
P_o
0·1
1·0
10·0
40·0
PRESSURE TONS / SQ.FT.

FIG. 54

VOID RATIO
VS
PRESSURE

ZONE - 1
BORE HOLE - 16
SAMPLE - 5
DEPTH - 15'-2" (EL. 565.5)

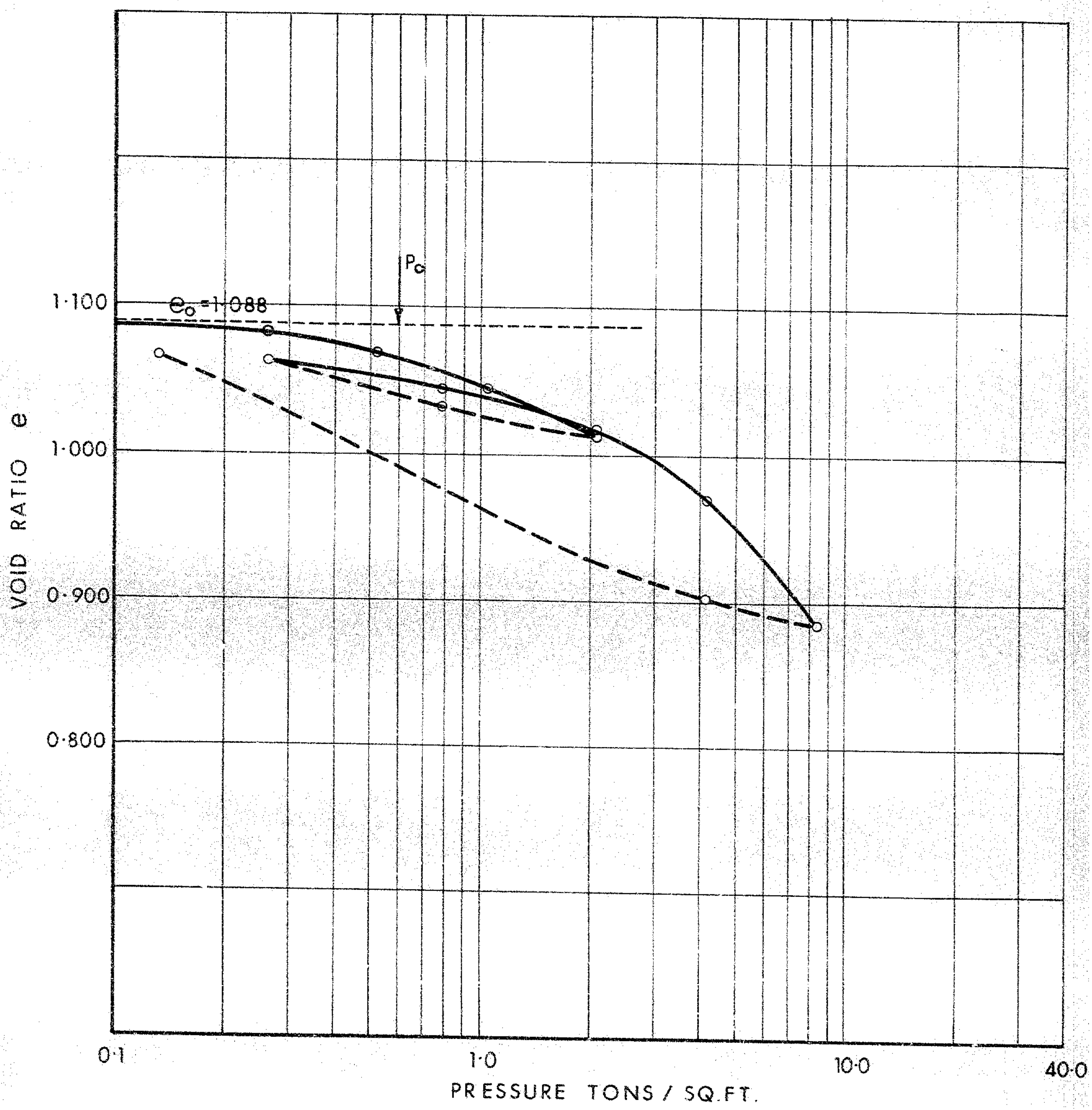


FIG. 55

ZONE - 1
BORE HOLE - 15
SAMPLE - 5
DEPTH - 15'-11" (EL. 565.0)

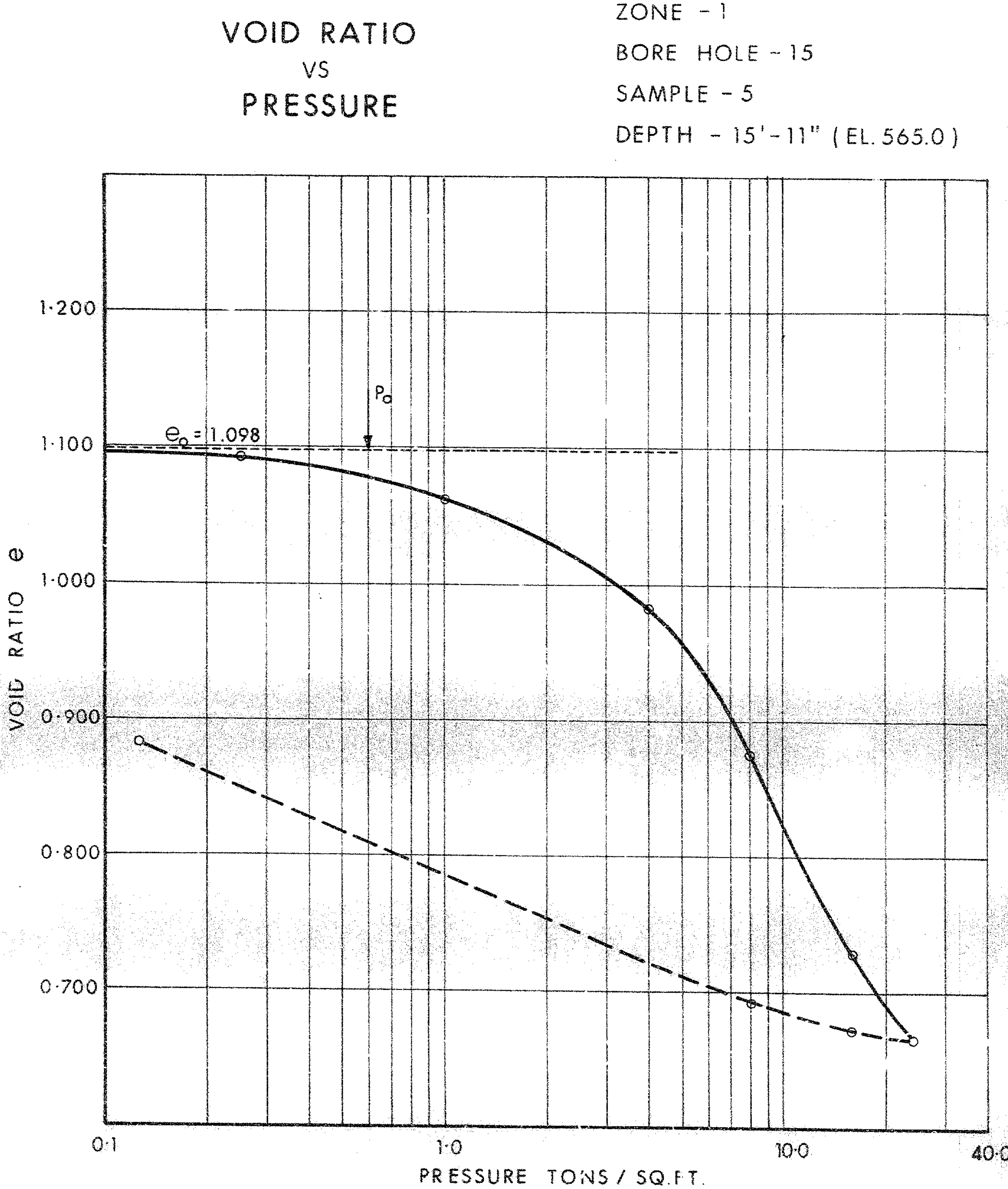


FIG. 56

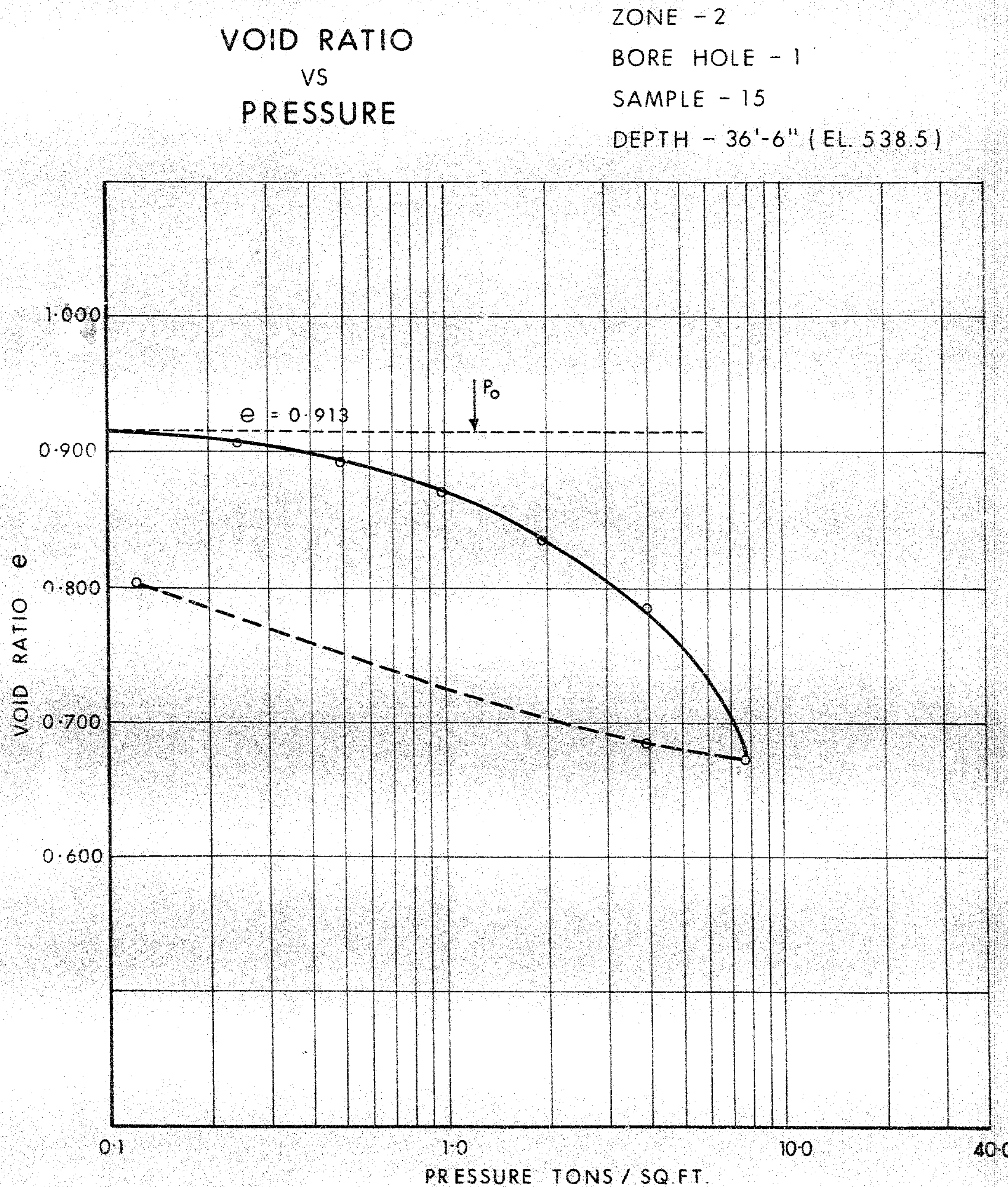

VOID RATIO
VS
PRESSURE
ZONE - 2
BORE HOLE - 1
SAMPLE - 15
DEPTH - 36'-6" (EL. 538.5)
1·000
0·900
0·800
0·700
0·600
VOID RATIO e
e = 0·913
Po
0·1
1·0
10·0
40·0
PRESSURE TONS / SQ.FT.

FIG. 57

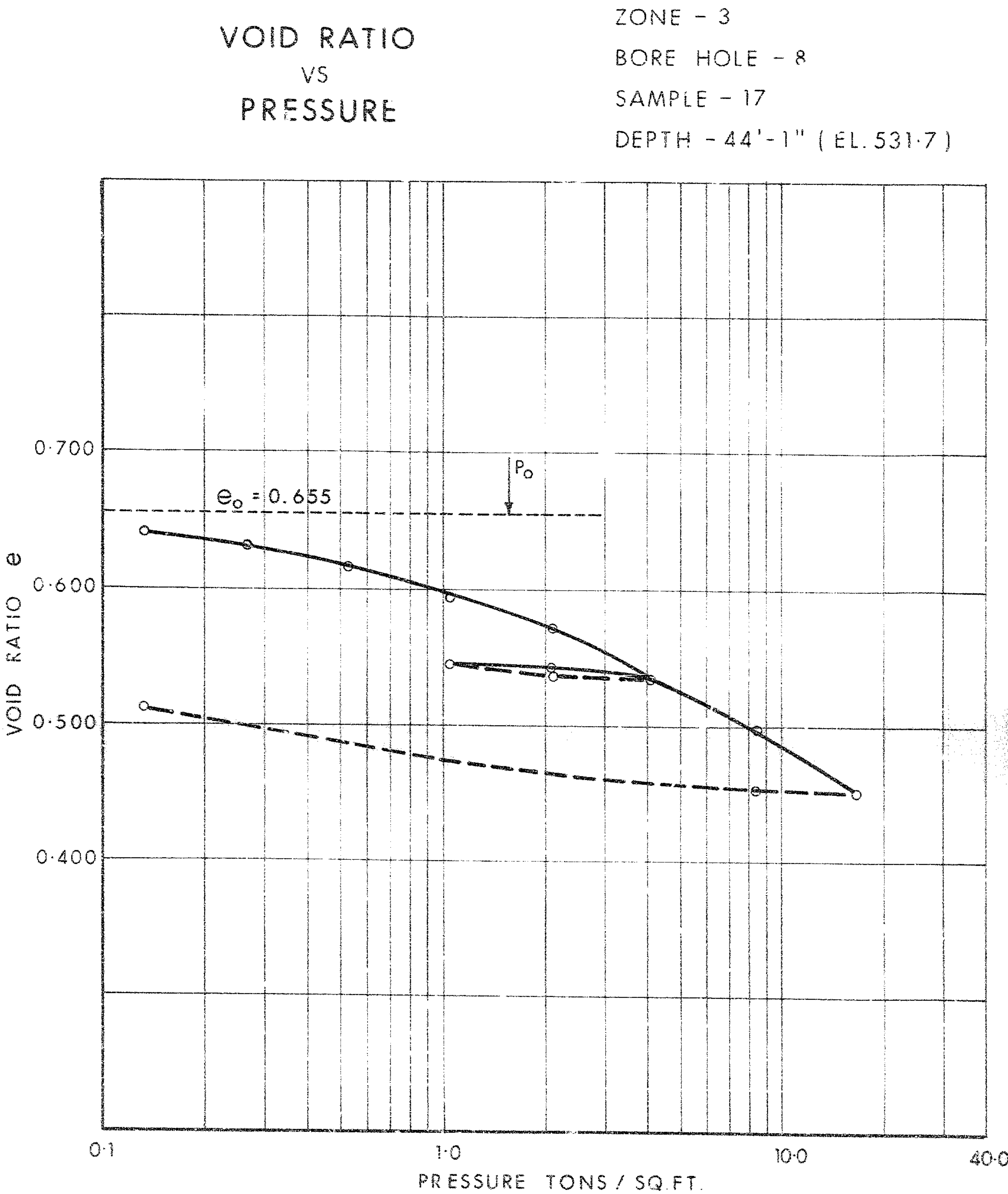

VOID RATIO
VS
PRESSURE
ZONE - 3
BORE HOLE - 8
SAMPLE - 17
DEPTH - 44'-1" (EL. 531·7)
0·700
0·600
0·500
0·400
e_o = 0.655
P_o
VOID RATIO e
0·1
1·0
10·0
40·0
PRESSURE TONS / SQ.FT.

FIG. 58

VOID RATIO VS PRESSURE

ZONE - 4
BORE HOLE - 16
SAMPLE - 12
DEPTH - 49'-10" (EL. 530·9)

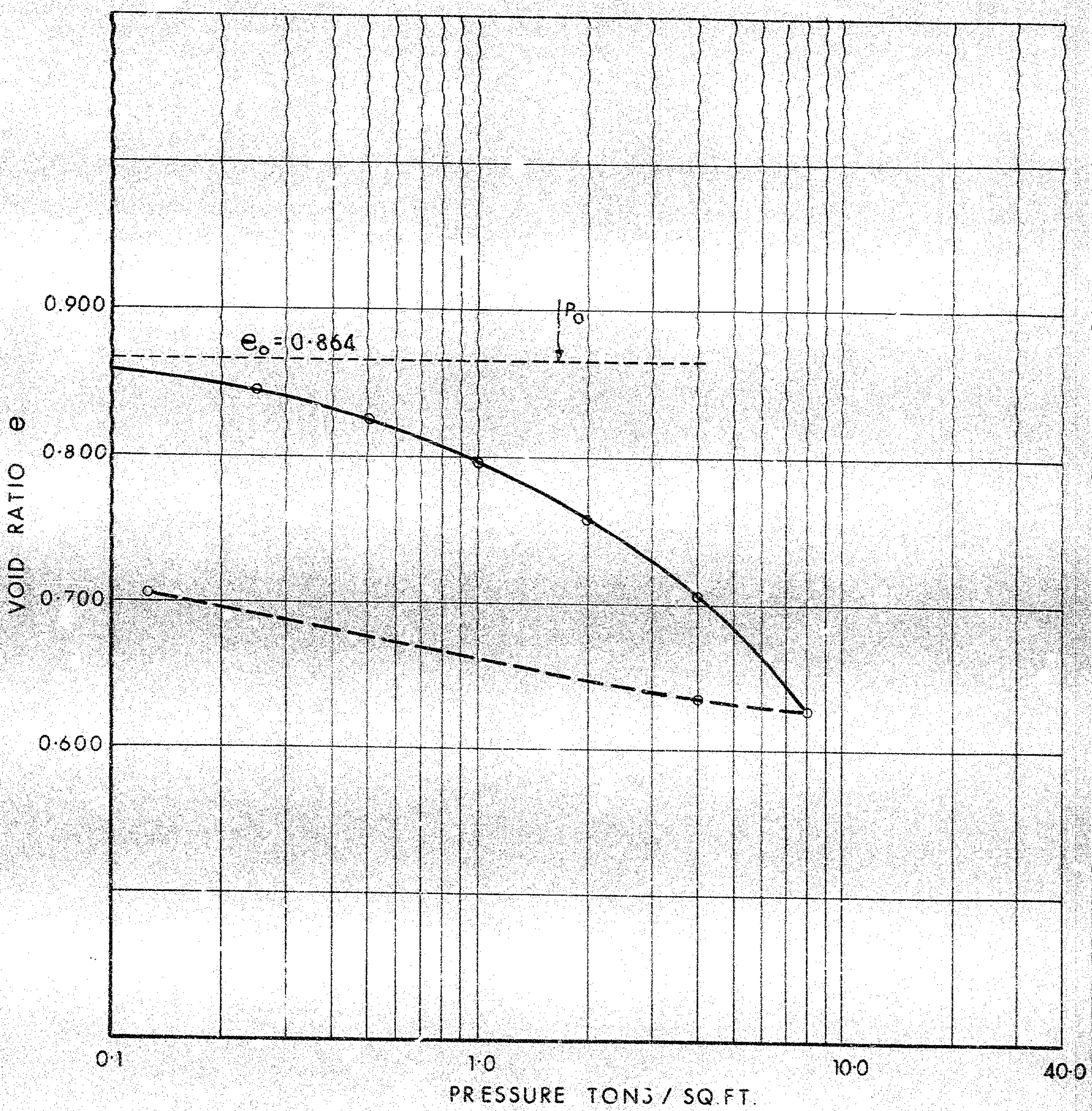


FIG. 59

VOID RATIO VS PRESSURE

ZONE - 4
BORE HOLE - 6
SAMPLE - 22
DEPTH - 65'-4" (EL. 506.6)

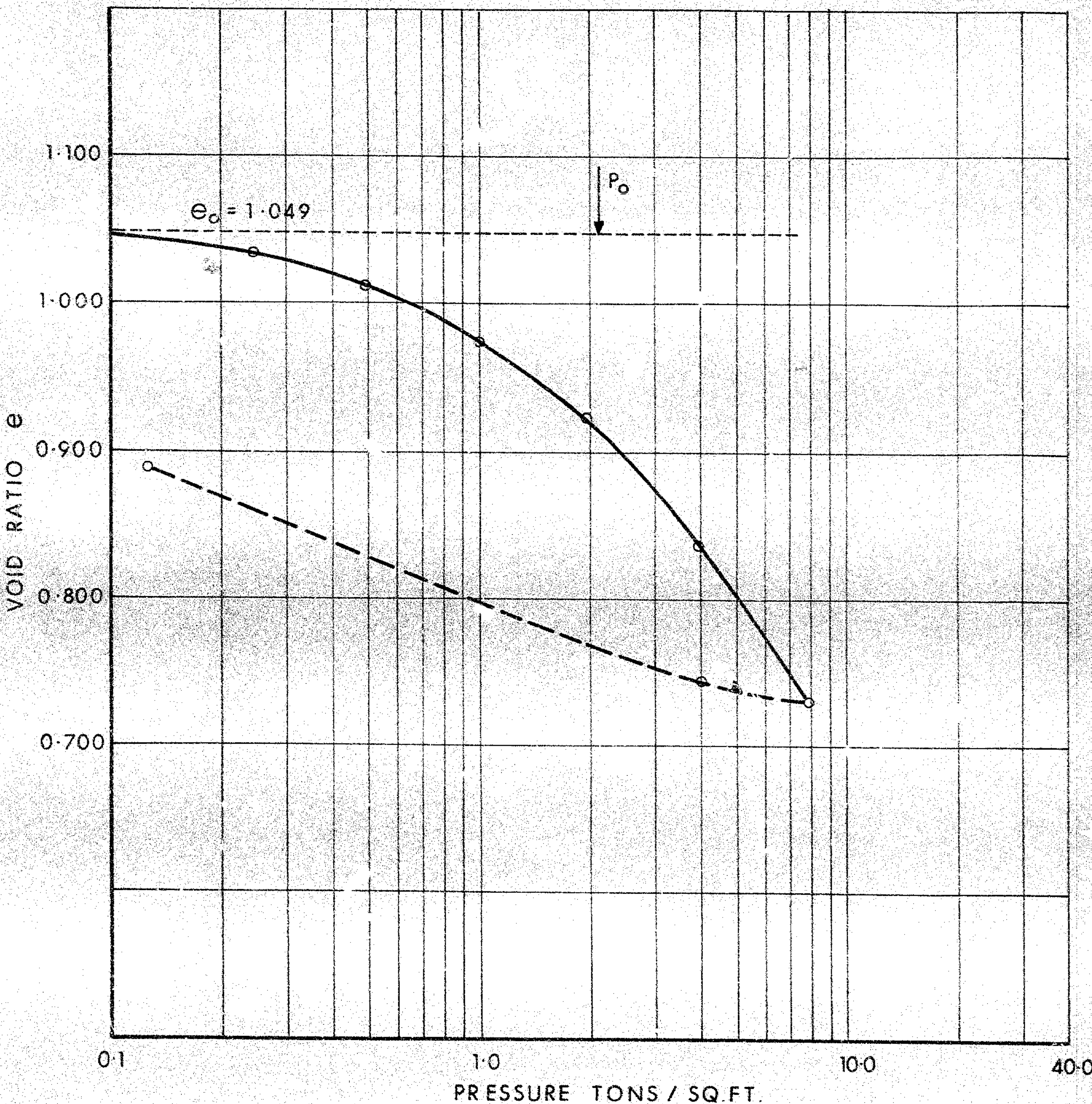


FIG. 60

VOID RATIO
VS
PRESSURE

ZONE - 5
BORE HOLE - 8
SAMPLE - 24
DEPTH - 70'-3" (EL. 505.6)

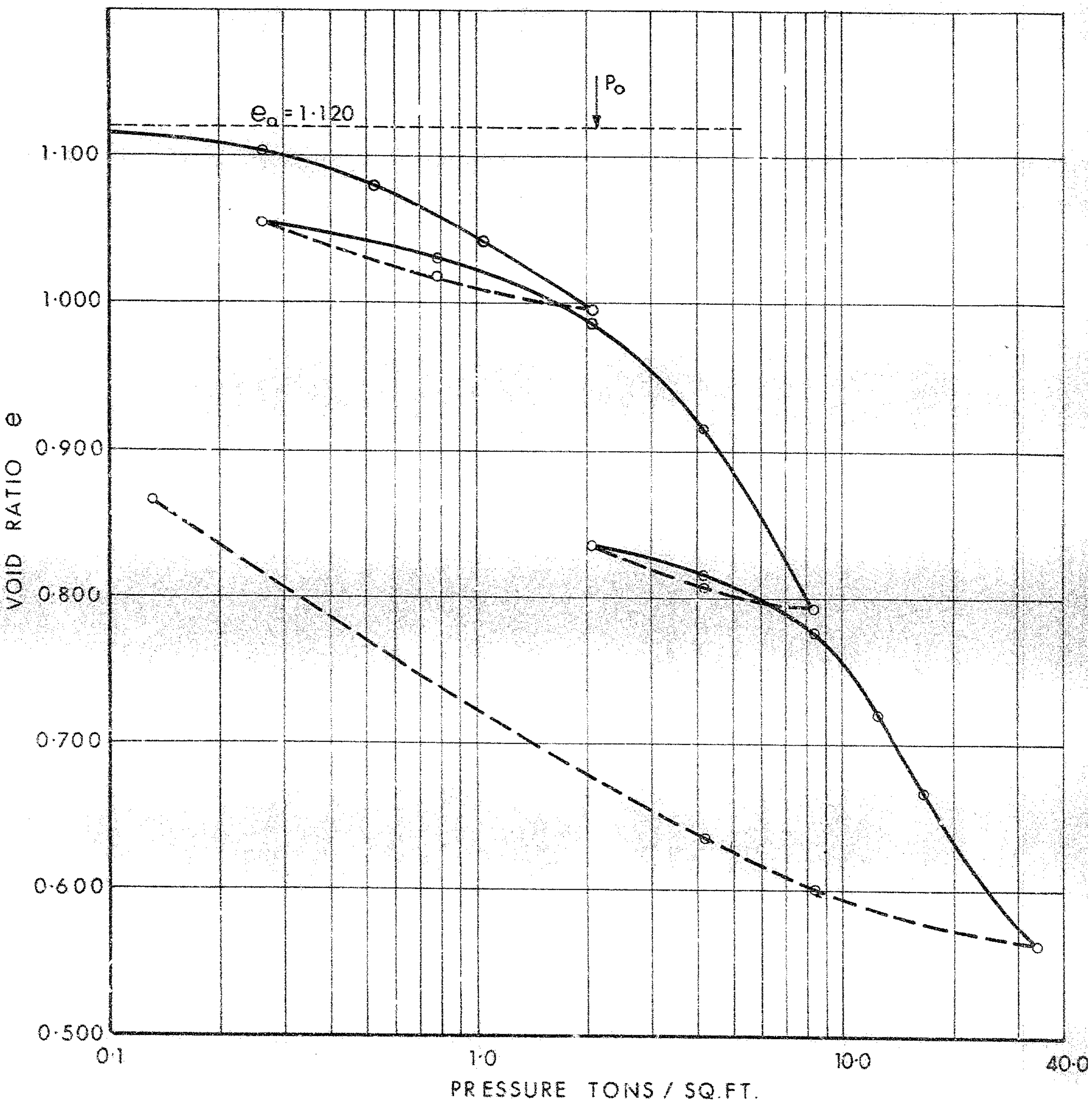


FIG. 61

VOID RATIO
VS
PRESSURE

ZONE - 5
BORE HOLE - 8
SAMPLE - 27
DEPTH - 81'-10" (EL. 494·0)

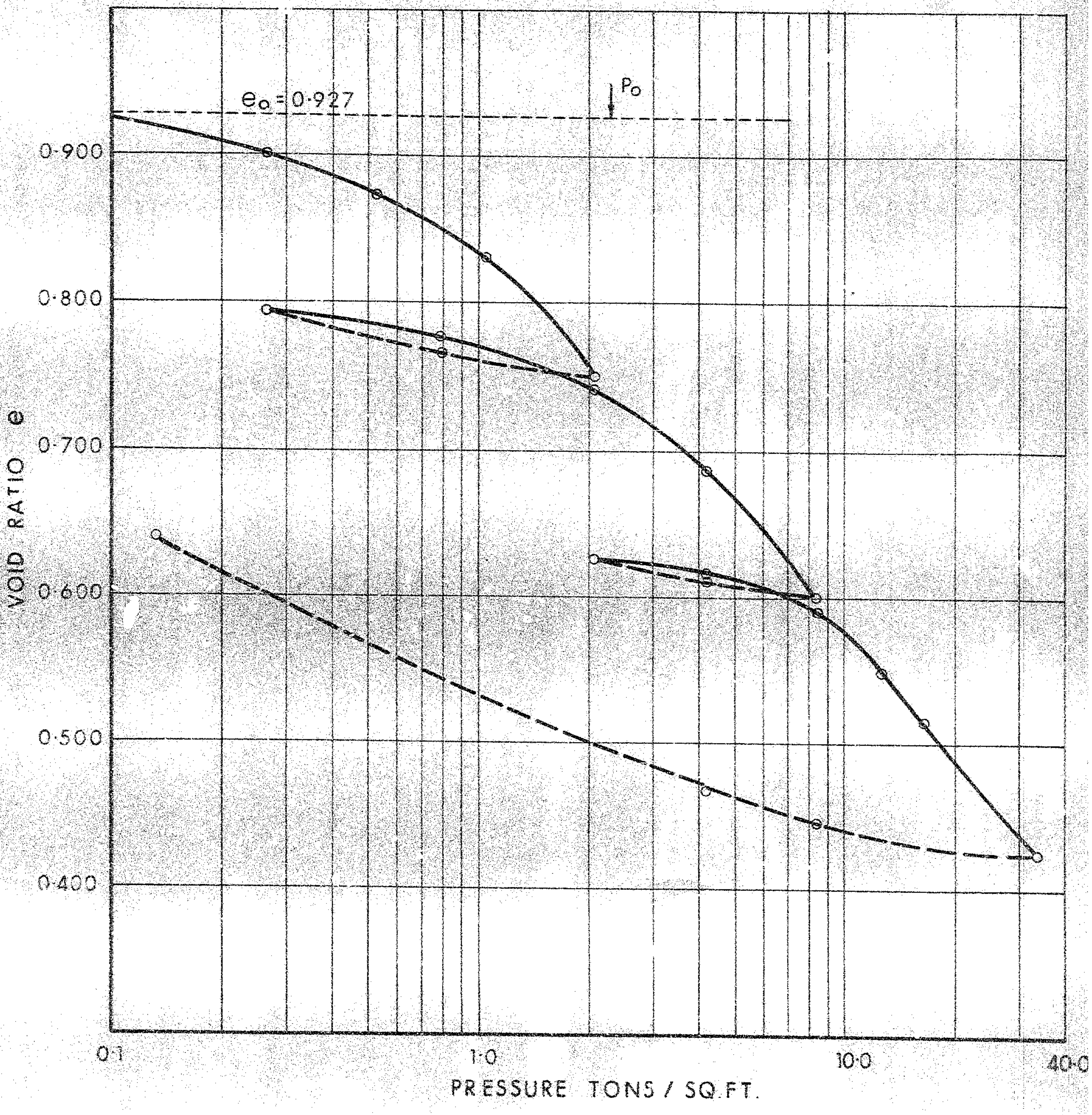


FIG. 62

70 FT. EMBANKMENT

SCALE 1" = 80'

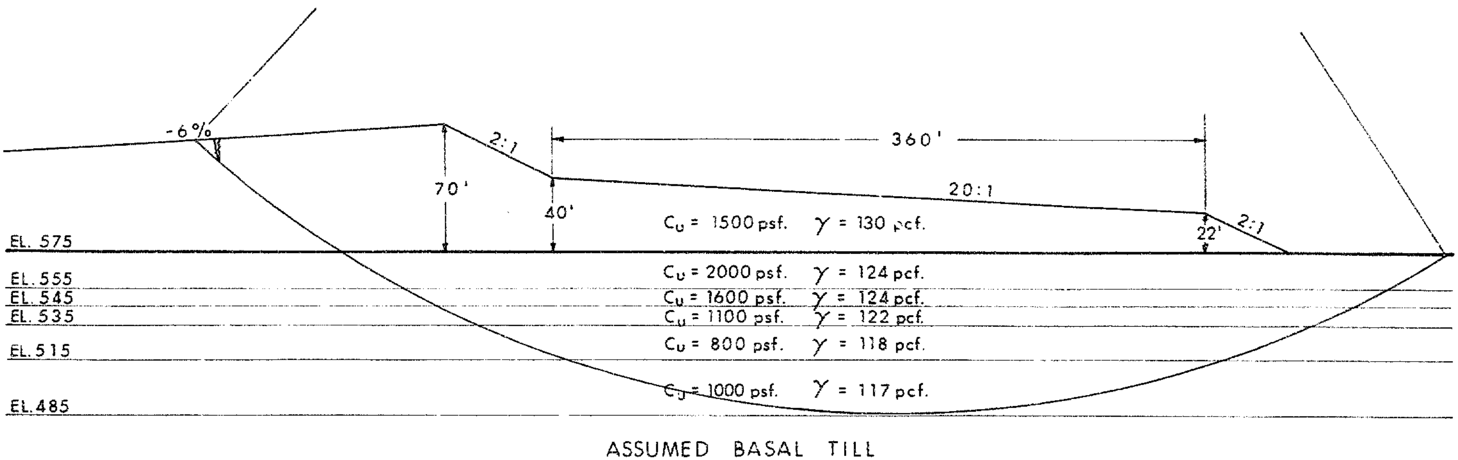


FIG. 64

P_C vs DEPTH

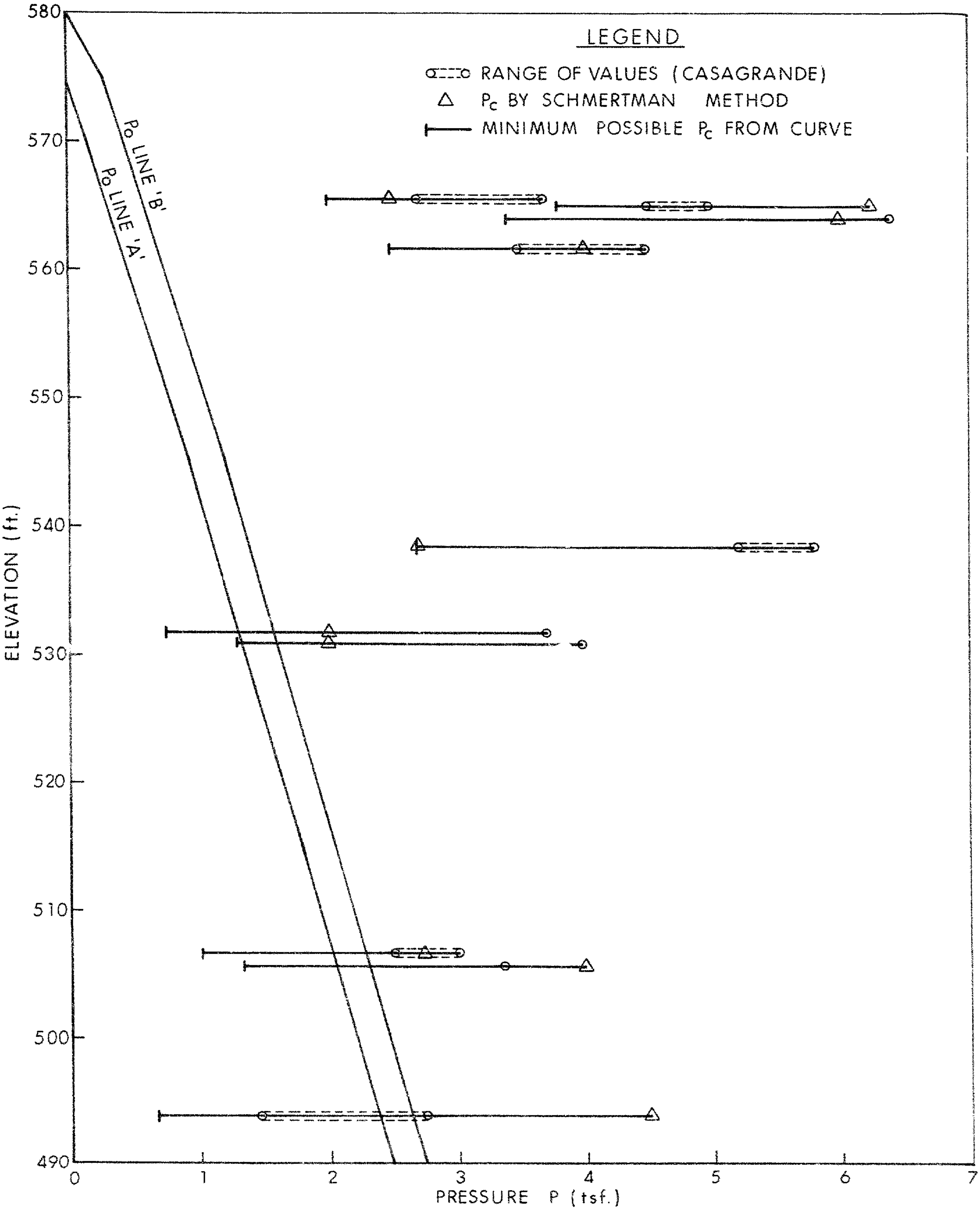


FIG. 63

FOUNDATIONS - (7 265)

DEPARTMENT OF HIGHWAYS ONTARIO

MEMORANDUM

To: Mr. B. R. Davis,
Bridge Engineer,
Bridge Division,
Admin. Bldg.
Attention: Mr. F. I. Hewson,
Sr. Bridge Liaison
Engr.

Our File Ref.

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

Date: January 5, 1968

In reply to

Subject:

PRELIMINARY
FOUNDATION INVESTIGATION REPORT
For
Forkes Rd. Crossing of the Proposed
Welland Canal
District No. 4 (Hamilton)
W.J. 66-F-111 -- W.P. 242-66

(Report dated September 12, 1967)

Attached, are the following:

1. REVISED DRAWING 66-F-111-A,
2. REVISED DRAWING 66-F-111-B,
3. Sheet containing piezometer installation data.

Please include these items in your copy(s) of the above report.

Note: Existing Drawings 66-F-111-A & B are to be deleted before replacing with revised drawings.

M. Devata

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

MD/MdeF
Attach. (3)
cc: Messrs. B. R. Davis (2)
T. G. Tustin -
(St. Lawrence Seaway Authority) (2)
R. Conlon -
(H. G. Acres Co. Ltd.)
B. A. Singh - (Ontario Water Resources Comm.)
H. Greenland - (District Engineer - Hamilton)
Foundations Files (6)
Gen. Files

INSTALLATION DATA - PIEZOMETERS 66-F-111(E)

Piezometer	Type	Date Installed	Location	Original Ground Elevation	Tip: Below Ground	Tip: Elevation	Top of Pipe: Above Ground	Top of Pipe: Elevation	Remarks
1	Norwegian	Jan.9/67	Line 'A', 16+69 o/s 67.5' Lt.	573.6	30	543.6	2'-3"		
2	Norwegian	Jan.9/67	Line 'A', 16+63 o/s 62.5' Lt.	573.4	50	523.4	2'-0"		
3	Norwegian	Jan.9/67	Line 'A', 16+73 o/s 62.5' Lt.	573.3	70	503.3	1'-6"		
4	Peaker	Jan.9/67	Line 'A', 16+68 o/s 63' Lt.	572.9	85	487.9	-		
5	Not installed successfully								
6	Norwegian	Jan.17/67	Line 'A', 23+59 69' Lt.	576.1	30	546.1	1'-6"		
7	Norwegian	Jan.18/67	Line 'A', 23+69.5 65.2' Lt.	575.9	50	525.9			
8	Norwegian	Jan.18/67	Line 'A', 23+68 71.5' Lt.	575.8	70	505.8			
9	Peaker	Jan.17/67	Line 'A', 23+65, o/s 69' Lt.	575.8	91	484.8			
10	Peaker	Jan.16/67	Line 'A', 23+65 o/s 69' Lt.	575.8	99	476.8			
11	Norwegian	Jan.19/67	Line 'A', 26+86 71' Lt.	574.1	30	544.1			
12	Norwegian	Jan.24/67	Line 'A', 26+95 69' Lt.	574.1	50	524.1			
13	Norwegian	Jan.23 23/67	Line 'A', 26+91 75.3' Lt.	574.2	70	494.2			
14	Peaker	Jan.20/67	Line 'A', 26+91 o/s 77' Lt.	574.3	97	477.3			
15	Peaker	Jan.19/67	Line 'A', 26+91 o/s 77' Lt.	574.3	110.5	463.8			
16	Norwegian	Jan.30/67	Line 'B', 11+04.5 o/s 51' Rt.	581.0	30	551.0	0'9"		
17	Norwegian	Jan.30/67	Line 'B', 10+95 o/s 51' Rt.	581.1	45	536.0	0'6"	581.6	
18	Norwegian	Jan.30/67	Line 'B', 10+99.5 o/s 55' Rt.	581.0	60	521.0	0'6"	581.5	
19	Norwegian	Jan.11/67	Line 'B', 12+15 o/s 18' Rt.	581.0	79	502.	0'6"	581.5	
20	Peaker	Jan.27/67	Line 'B', 10+99.5 o/s 51' Rt.	580.9	88	492.9	0'2'	581.1	
21	Norwegian	Jan.20/67	Line 'B', 14+96 o/s 5' Rt.	580.7	30	550.7	0'6"	581.2	
22	Norwegian	Jan.23/67	Line 'B', 15+06 o/s 5' Rt.	580.6	45	535.6	0'6½"	581.1	
23	Norwegian	Jan.23/67	Line 'B', 15+00.5 o/s 10.5' Rt.	580.6	60	520.6	0'6"	581.1	
24	Norwegian	Feb. 3/67	Line 'B', 14+99 o/s 4.5' Lt.	580.8	80.25	500.6	1'1½"	581.9	Lost Tube
25	Peaker	Jan.20/67	Line 'B', 15+08.5 o/s 5' Rt.	580.7	87.5	493.2	0'6"	581.2	
26	Norwegian	Jan.26/67	Line 'B', 19+04.5 o/s 41.5Rt.	580.2	30	550.2	0'8"	580.9	
27	Norwegian	Jan.27/67	Line 'B', 18+95.5 o/s 41.5Rt.	579.7	45	534.7	0'6"	580.2	
28	Norwegian	Jan.27/67	Line 'B', 19+01 o/s 46' Rt.	580.2	60	520.2	0'8"	580.9	
29	Norwegian	Jan. 9/67	Line 'B', 18+08 o/s 29.5' Lt.	580.4	76	504.4	0'7"	581.0	
30	Peaker	Jan.25/67	Line 'B', 19+00.5 o/s 41.5Rt.	580.1	90	490.1	1'2"	581.3	

INSTALLATION DATA - PIEZOMETERS 66-F-111(R)

Piezometer	Type	Date Installed	Location	Original Ground Elevation	Tip		Top of Pipe		Remarks
					Below Ground	Elevation	Above Ground	Elevation	
1	Norwegian	Jan.9/67	Line 'A', 16+69 o/s 67.5' Lt.	573.6	30	543.6	2'-3"		
2	Norwegian	Jan.9/67	Line 'A', 16+63 o/s 62.5' Lt.	573.4	50	523.4	2'-0"		
3	Norwegian	Jan.9/67	Line 'A', 16+73 o/s 62.5' Lt.	573.3	70	503.3	1'-6"		
4	Peaker	Jan.9/67	Line 'A', 16+68 o/s 63' Lt.	572.9	85	487.9	-		
5	Not installed successfully								
6	Norwegian	Jan.17/67	Line 'A', 23+59 69' Lt.	576.1	30	546.1	1'-0"		
7	Norwegian	Jan.18/67	Line 'A', 23+69.5 65.2' Lt.	575.9	50	525.9			
8	Norwegian	Jan.18/67	Line 'A', 23+68 71.5' Lt.	575.8	70	505.8			
9	Peaker	Jan.17/67	Line 'A', 23+65,o/s 69' Lt.	575.8	91	484.8			
10	Peaker	Jan.16/67	Line 'A', 23+65 o/s 69' Lt.	575.8	99	476.8			
11	Norwegian	Jan.19/67	Line 'A', 26+86 71' Lt.	574.1	30	544.1			
12	Norwegian	Jan.24/67	Line 'A', 26+95 69' Lt.	574.1	50	524.1			
13	Norwegian	Jan.20,23/67	Line 'A', 26+91 75.3' Lt.	574.2	70	494.2			
14	Peaker	Jan.20/67	Line 'A', 26+91 o/s 77' Lt.	574.3	97	477.3			
15	Peaker	Jan.19/67	Line 'A', 26+91 o/s 77' Lt.	574.3	110.5	463.8			
16	Norwegian	Jan.30/67	Line 'B', 11+04.5 o/s 51' Rt.	581.0	30	551.0	0'5"		
17	Norwegian	Jan.30/67	Line 'B', 10+95 o/s 51' Rt.	581.1	45	536.0	0'6"	581.6	
18	Norwegian	Jan.30/67	Line 'B', 10+99.5 o/s 55' Rt.	581.0	60	521.0	0'6"	581.5	
19	Norwegian	Jan.11/67	Line 'B', 12+15 o/s 18' Rt.	581.0	79	502.	0'6"	581.5	
20	Peaker	Jan.27/67	Line 'B', 10+99.5 o/s 51' Rt.	580.9	88	492.9	0.2'	581.1	
21	Norwegian	Jan.20/67	Line 'B', 14+96 o/s 5' Rt.	580.7	30	550.7	0'6"	581.2	
22	Norwegian	Jan.23/67	Line 'B', 15+06 o/s 5' Rt.	580.6	45	535.6	0'6½"	581.1	
23	Norwegian	Jan.23/67	Line 'B', 15+00.5 o/s 10.5' Rt.	580.6	60	520.6	0'6"	581.1	
24	Norwegian	Feb. 3/67	Line 'B', 14+99 o/s 4.5' Lt.	580.8	80.25	500.6	1'1½"	581.9	Lost Tube
25	Peaker	Jan.20/67	Line 'B', 15+00.5 o/s 5' Rt.	580.7	87.5	493.2	0'6"	581.2	
26	Norwegian	Jan.26/67	Line 'B', 19+04.5 o/s 41.5Rt.	580.2	30	550.2	0'8"	580.9	
27	Norwegian	Jan.27/67	Line 'B', 18+95.5 o/s 41.5Rt.	579.7	45	534.7	0'6"	580.2	
28	Norwegian	Jan.27/67	Line 'B', 19+01 o/s 46' Rt.	580.2	60	520.2	0'8"	580.9	
29	Norwegian	Jan. 9/67	Line 'B', 18+08 o/s 29.5' Lt.	580.4	76	504.4	0'7"	581.0	
30	Peaker	Jan.25/67	Line 'B', 19+00.5 o/s 41.5Rt.	580.1	90	490.1	1'2"	581.3	

cc: Foundations Files (Rm. 110)

Hwy. 401 & Keele St.,
Downsview, Ontario.

Tel. 248-3282
(Area Code 416)

Materials and Testing Division

December 14, 1967

H. G. Acres & Co. Ltd.,
Consulting Engineers,
Niagara Falls, Ontario.

Attention: Mr. Robert Gould

Re: Piezometer Data for Forkes Rd. & Welland Canal
Line A & B -- District No. 4 (Hamilton)
W.P. 242-66 -- W.J. 66-F-111

Dear Mr. Gould:

Further to our recent telephone conversation as per your request, we are enclosing Piezometer Data sheets for all 30 piezometers we have installed at the above mentioned location. For your information, we are including two drawings: 66-F-111A and 66-F-111B which will give the location of the piezometers.

If you need any further information regarding the above mentioned project, please feel free to call us.

Yours truly,

M. Devata

M. Devata
SUPERVISING FOUNDATION ENGINEER

MD/MdeF

Encls. 30 Piezometer Data sheets

2 Drawings

cc: Foundations Files

MEMORANDUM

To: Mr. A.G. Stermac,
Principal Foundation Engineer.

From: Chemical Section,
Materials & Testing Division.

Date: January 11, 1967.

Our File Ref. 11-7-5

In reply to

Subject: Sulphate Water Samples

At the request of Mr. M. Devata, Supervising Foundation Engineer, five samples of water were tested for their sulphate content. The tests were made with respect to attack of concrete by sulphate containing waters.

The test results are listed in the Appendix together with a table showing the relative degree of sulphate attack on concrete by waters containing various concentrations of sulphate. The table was taken from the "Concrete Manual" (Sixth Edition, 1956, Page 12, Table 2).

The test results indicated that, according to the "Concrete Manual", all above water samples should be rated as showing a considerable degree of sulphate attack.

A.C. Suter,
Principal Chemical Engineer.

Per.

R. Sterk,
Chemical Engineer.

RS/c

cc. Mr. M. Devata,
Files.

APPENDIX

ATTACK On CONCRETE BY SOILS AND WATER CONTAINING VARIOUS SULPHATE CONCENTRATIONS

Relative Degree of SO_4 Attack	% Water Soluble SO_4 in Soil Samples	PPM SO_4 in Water Sampl...
Negligible	0.00 - 0.10	0 - 150
Positive	0.10 - 0.20	150 - 1000
Considerable	0.20 - 0.50	1000 - 2000
Severe	Over 0.50	Over 2000

TEST RESULTS OF SO_4 - DETERMINATION

Chemical Lab. No.	67-S-9653	9654	9655	9656	9657
Sample Designation	A	B	C	filtered	un-filtered
Job. No.	66-F-111	66-F-111	66-F-111	66-F-111	66-F-111
B.H.No.	2	2	2	9	9
Depth (ft.)	93-108	93-108	93-108	-	-
Location of Bore Hole	S. side of Forkes Rd. (Artesian Water)	Forkes Rd. (Artesian Water)	Forkes Rd. (Artesian Water)	-	-
ppm SO_4	1938	1930	1925	1950	1960

File: 12-508-3-1.

THE ST. LAWRENCE SEAWAY AUTHORITY

ADMINISTRATION DE LA VOIE MARITIME DU SAINT-LAURENT

Construction Branch,
Box 592,
St. Catharines, Ontario,
February 7, 1967.

Mr. A. G. Stermac,
Principal Foundation Engineer,
Ontario Department of Highways,
Downsview, Ontario.

Dear Sir:

We are presently carrying a rock probing program along the new Welland Canal alignment near Dain City.

I would appreciate receiving the bedrock depth information which has been obtained from the recent geotechnical program carried out by your division in the Dain City area.

Thanking you in advance for your co-operation in this matter, I remain,

Yours very truly,

for W. A. O'Neil, P. Eng.,
Director of Construction.

JYL/dp

cc: FoundatYour File: C22-508-31D)

Hwy. 401 & Keele St.,
Downsview, Ontario.
Tel. No. 248-3282

Materials and Testing Division

February 15, 1967

66-F-111

Mr. W. A. O'Neil, P. Eng.,
Director of Construction,
The St. Lawrence Seaway Authority,
Construction Branch,
Box 592,
St. Catharines, Ontario.

Dear Sir:

With reference to your letter of February 7, 1967, attached, please find the plan showing the location of our boreholes in the vicinity of Forkes Rd. At each borehole where bedrock was encountered, the elevation of bedrock is given.

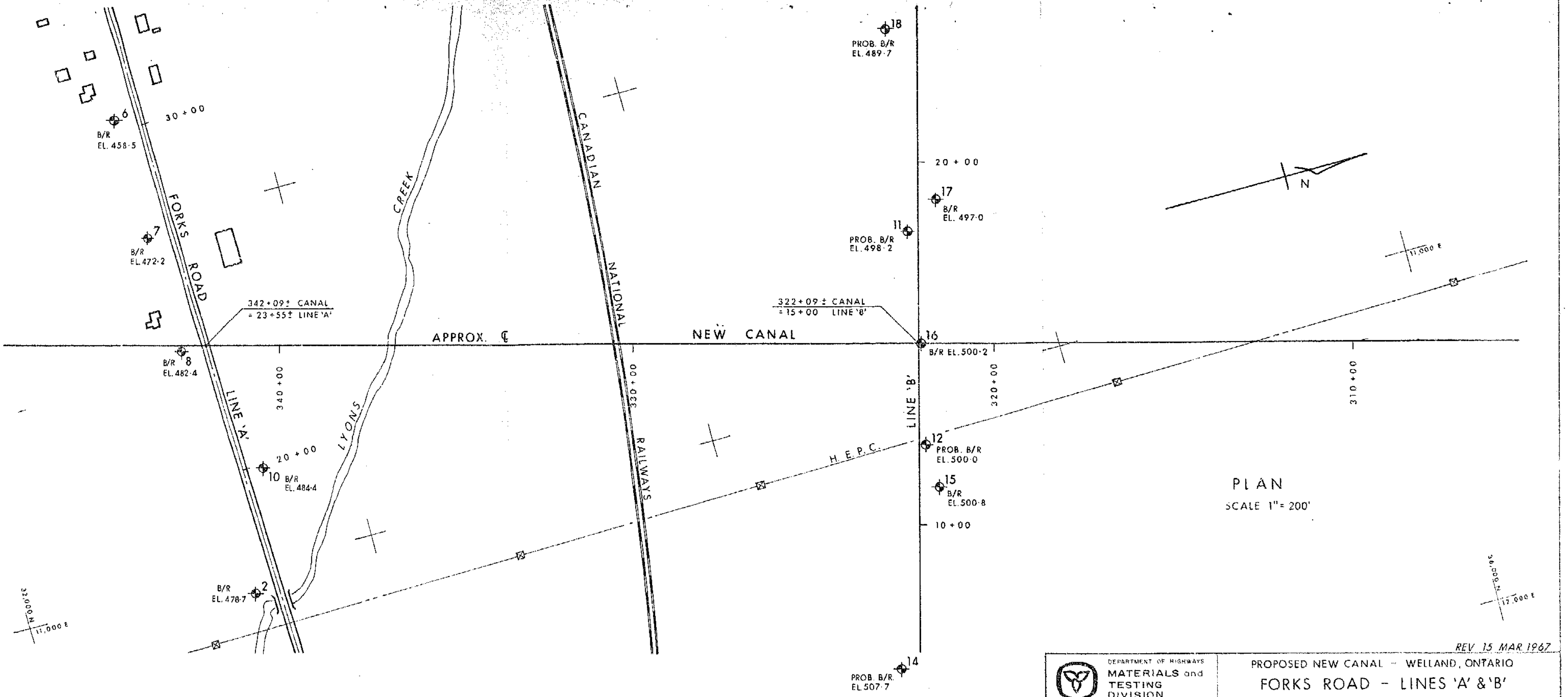
Trusting that this is the information you requested, I remain,

Sincerely yours,

A. G. Stermac,
Principal Foundation Engr.

AGS/MdeF
Attach.

cc: Foundations Files
Gen. Files



REV 15 MAR 1967

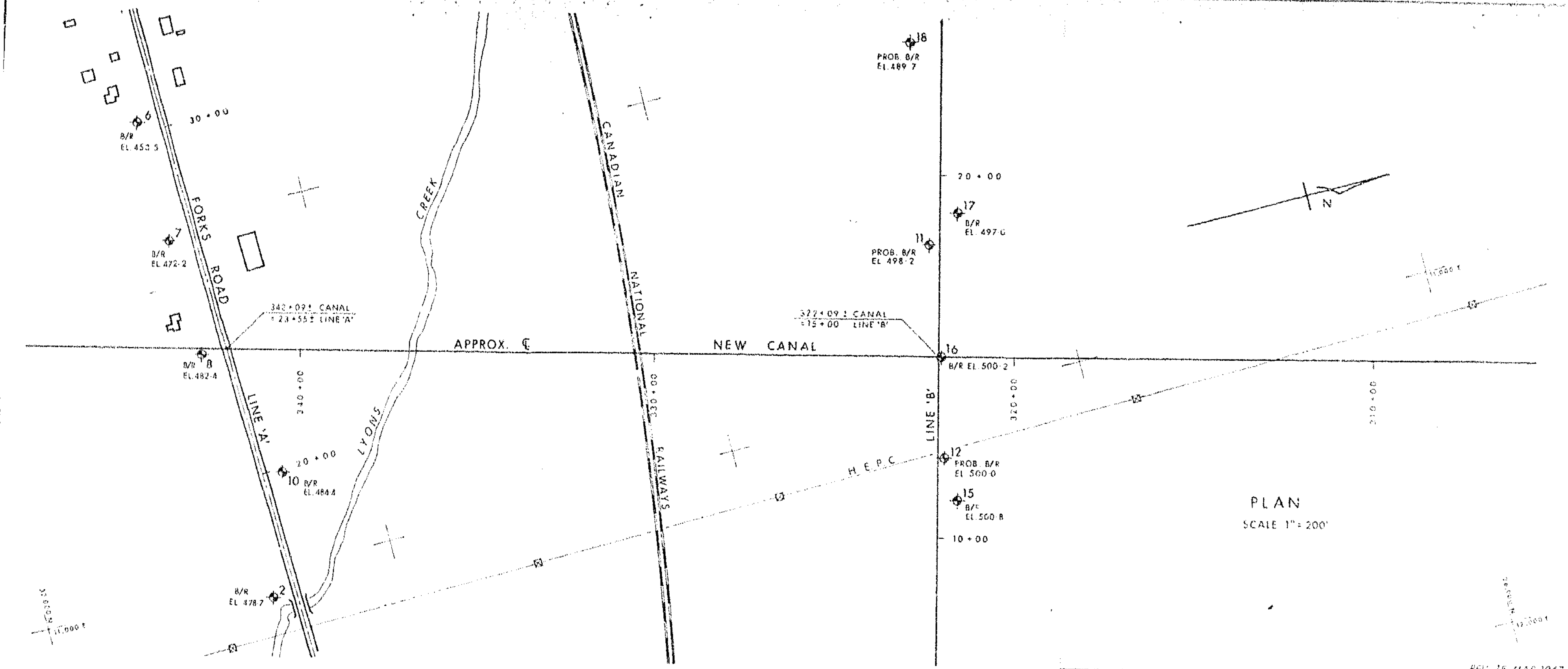
DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO

PROPOSED NEW CANAL – WELLAND, ONTARIO

FORKS ROAD – LINES 'A' & 'B'

BOREHOLE LOCATIONS & BEDROCK ELEVATIONS

DATE 14 FEB. 1967 | APPROVED [signature] | DRAWING NO. 66-F-111



REV. 15 MAR 1967

MATERIALS and TESTING DIVISION

ONTARIO

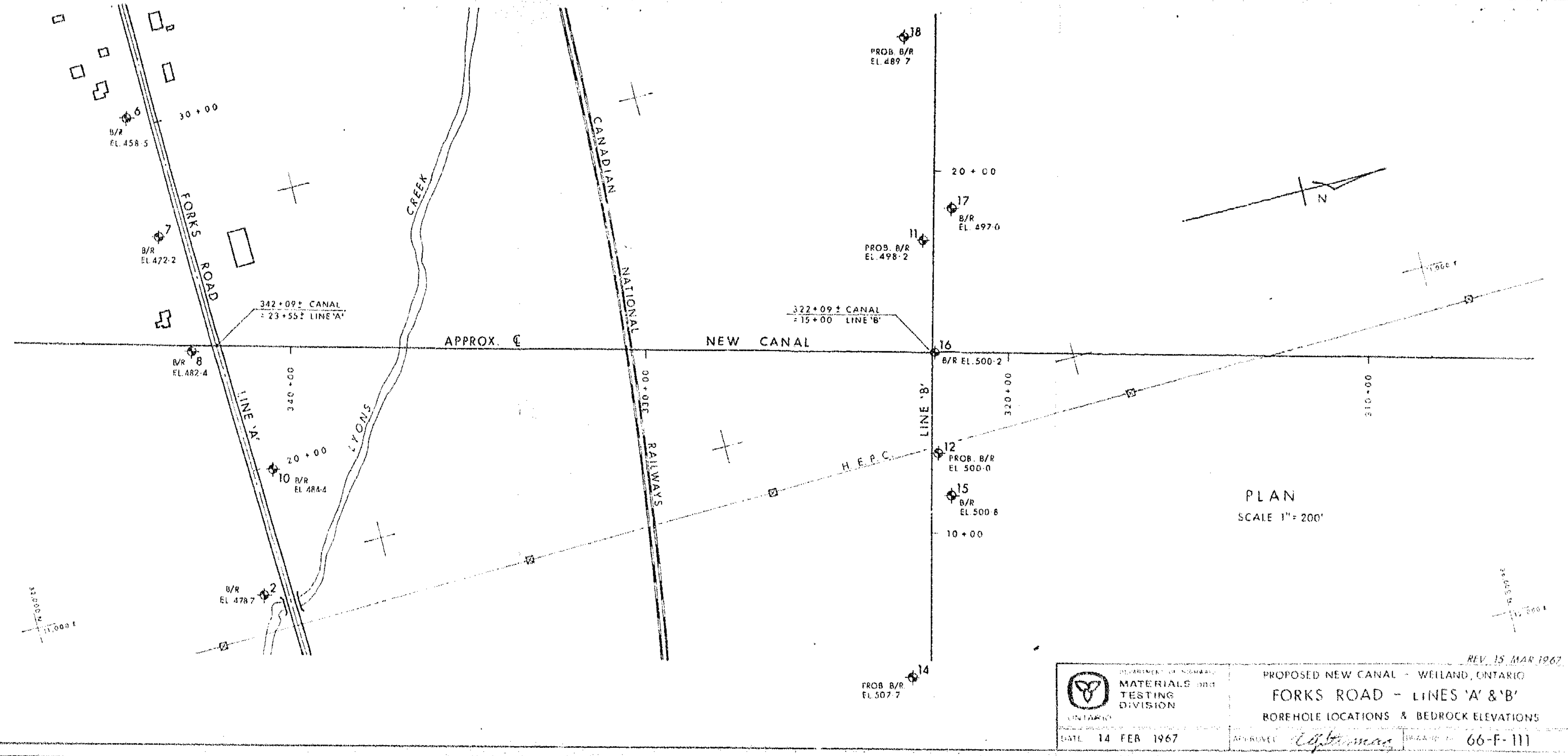
PROPOSED NEW CANAL - WELLAND, ONTARIO

FOPKS ROAD - LINES 'A' & 'B'

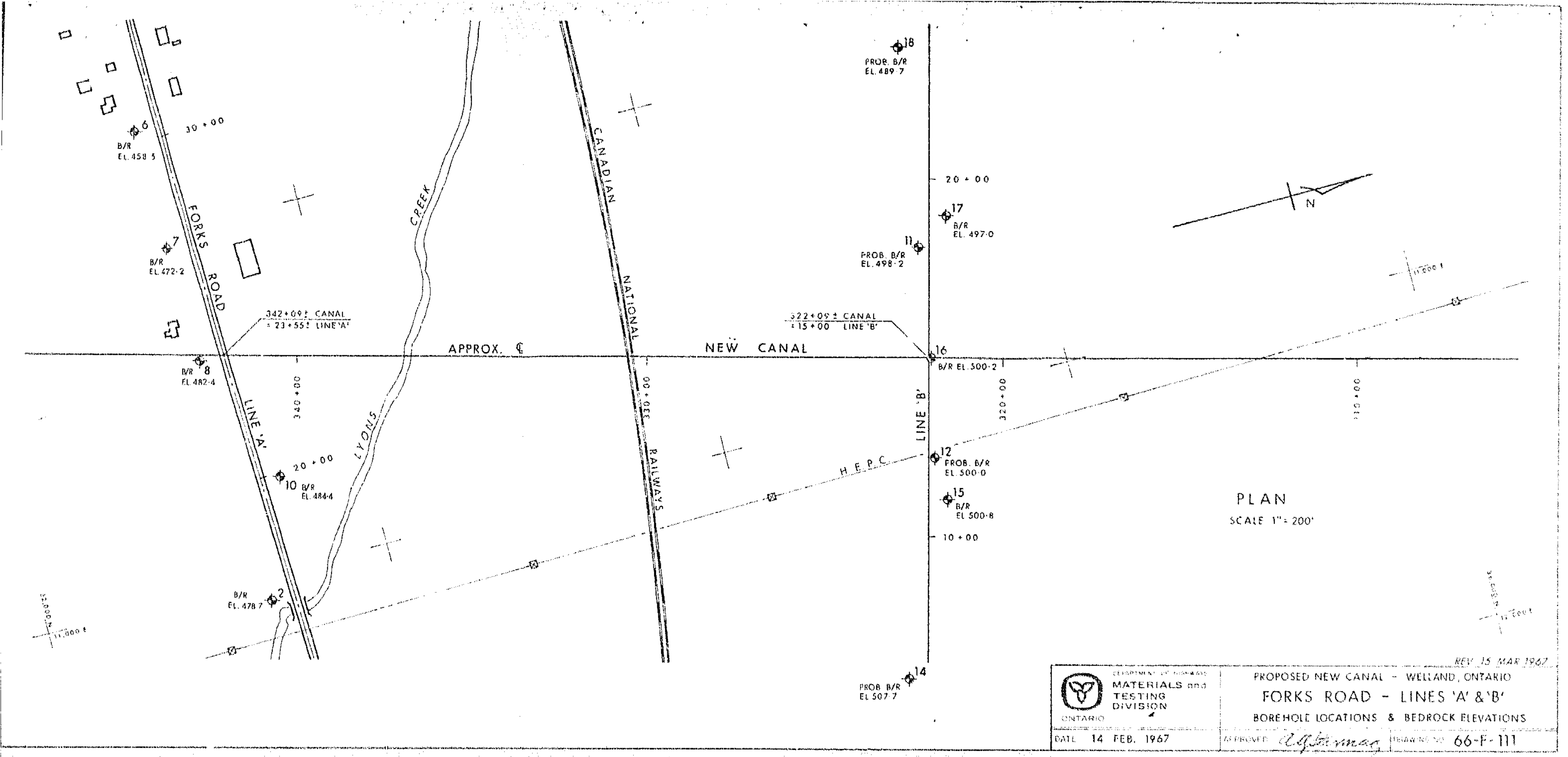
BOREHOLE LOCATIONS & BEDROCK ELEVATIONS

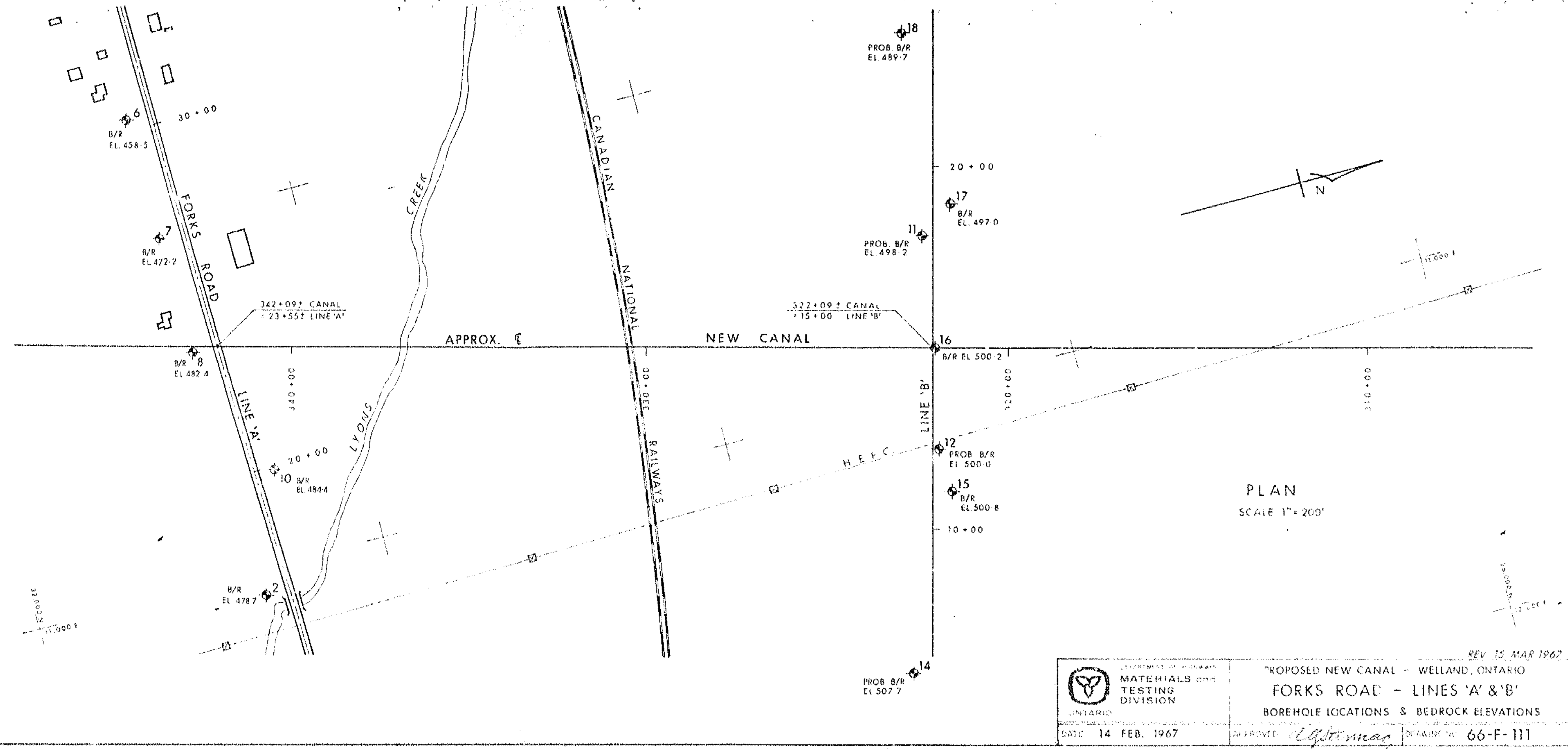
DATE 14 FEB. 1967

DWG. NO. 66-F-111



FORKS ROAD
LINE 'A'
LYONS CREEK
CANADIAN NATIONAL RAILWAYS
APPROX. ℄ NEW CANAL
LINE 'B'
H.E.P.C.
30 + 00
20 + 00
10 + 00
340 + 00
330 + 00
320 + 00
310 + 00
342 + 09± CANAL
= 23 + 55± LINE 'A'
322 + 09± CANAL
= 15 + 00 LINE 'B'
6 B/R EL. 458·5
7 B/R EL. 472·2
8 B/R EL. 482·4
10 B/R EL. 484·4
2 B/R EL. 478·7
18 PROB. B/R EL. 489·7
17 B/R EL. 497·0
11 PROB. B/R EL. 498·2
16 B/R EL. 500·2
12 PROB. B/R EL. 500·0
15 B/R EL. 500·8
14 PROB. B/R EL. 507·7
N
PLAN
SCALE 1" = 200'
REV. 15 MAR 1967
DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO
PROPOSED NEW CANAL - WELLAND, ONTARIO
FORKS ROAD - LINES 'A' & 'B'
BOREHOLE LOCATIONS & BEDROCK ELEVATIONS
DATE 14 FEB 1967
APPROVED
DRAWING No. 66-F-111


FORKS ROAD
LINE 'A'
LYONS CREEK
CANADIAN NATIONAL RAILWAYS
APPROX. ℄ NEW CANAL
LINE 'B'
H.E.P.C.
342+09± CANAL
= 23+55± LINE 'A'
322+09± CANAL
= 15+00 LINE 'B'
30+00
20+00
10+00
340+00
330+00
320+00
6 B/R EL. 458.5
7 B/R EL. 472.2
8 B/R EL. 482.4
10 B/R EL. 484.4
2 B/R EL. 478.7
18 PROB. B/R EL. 489.7
17 B/R EL. 497.0
11 PROB. B/R EL. 498.2
16 B/R EL. 500.2
12 PROB. B/R EL. 500.0
15 B/R EL. 500.8
14 PROB. B/R EL. 507.7
N
PLAN
SCALE 1" = 200'
REV. 15 MAR 1967
DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO
PROPOSED NEW CANAL - WELLAND, ONTARIO
FORKS ROAD - LINES 'A' & 'B'
BOREHOLE LOCATIONS & BEDROCK ELEVATIONS
DATE 14 FEB. 1967
APPROVED
DRAWING NO. 66-F-111



FORKS ROAD
LINE 'A'
LYONS CREEK
CANADIAN NATIONAL RAILWAYS
APPROX. ℄ NEW CANAL
LINE 'B'
H.E.P.C.
N
30 + 00
20 + 00
10 + 00
340 + 00
330 + 00
320 + 00
310 + 00
342+09± CANAL
= 23+55± LINE 'A'
322+09 ± CANAL
= 15+00 LINE 'B'
6 B/R EL. 458·5
7 B/R EL. 472·2
8 B/R EL. 482·4
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16 B/R EL. 500·2
12 PROB. B/R EL. 500·0
15 B/R EL. 500·8
14 PROB. B/R EL. 507·7
PLAN
SCALE 1" = 200'
REV. 15 MAR 1967
DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION
ONTARIO
PROPOSED NEW CANAL – WELLAND, ONTARIO
FORKS ROAD – LINES 'A' & 'B'
BOREHOLE LOCATIONS & BEDROCK ELEVATIONS
DATE 14 FEB. 1967
APPROVED
DRAWING No. 66-F-111

HON. GEORGE E. GOMME
MINISTER

A. T. C. McNAB
DEPUTY MINISTER

DEPARTMENT OF HIGHWAYS

Bridge Division,
Downsview, Ontario,
August 29th, 1967.

66-F-111

Road Rail Tunnel - WP.242-56

Meeting at Department of Highways, Downsview, August 25th, 1967.

Attending for D.H.O. :

R. G. Burnfield (Roye)	Reg. Funct. Plan. Eng.
H. Clelland (Hugh)	Project Plan. Eng.
J. Blevins (Jim)	Sr. Road Design Eng.
B. R. Davis (Bruce)	Bridge Engineer.
C. S. Grebski (Ches)	Bridge Design Engineer.
B. S. Richardson (Brian)	Sr. Bridge Project Eng.
L. N. Francis (Les)	Bridge Project Eng.
F. I. Hewson (Ted)	Sr. Bridge Liaison Eng.
A. G. Stermac (Tony)	Principal Foundation Eng.
L. Palmer (Vern)	Project Foundation Eng.

For Acres:

S. Tibshirani (Sami)

A.L.McKechnie (Archie

J. C. Rea (John)

R. J. Conlon (Bob)

1. A proposed layout for a bridged crossing was shown using 3:1 slopes. It is now believed that such slopes are unrealistic. A more probable criterion would be a 15:1 effective slope from top of fill to bottom of cut. At the C.N.R. crossing west of the new canal this would require 15 (30' fill + 60' cut) = 1350' which is not possible within the property restrictions.

It was agreed that the length of trestle approaches make the bridge scheme uneconomic.

2. Acres estimates were given to D.H.O. for comment. D.H.O. will suggest unit prices.

3. Acres will study how Southworth can best be connected to the tunnel approach.

4. D.H.O. will study all other connections required, both for the present and future needs, to the road crossing the canal.

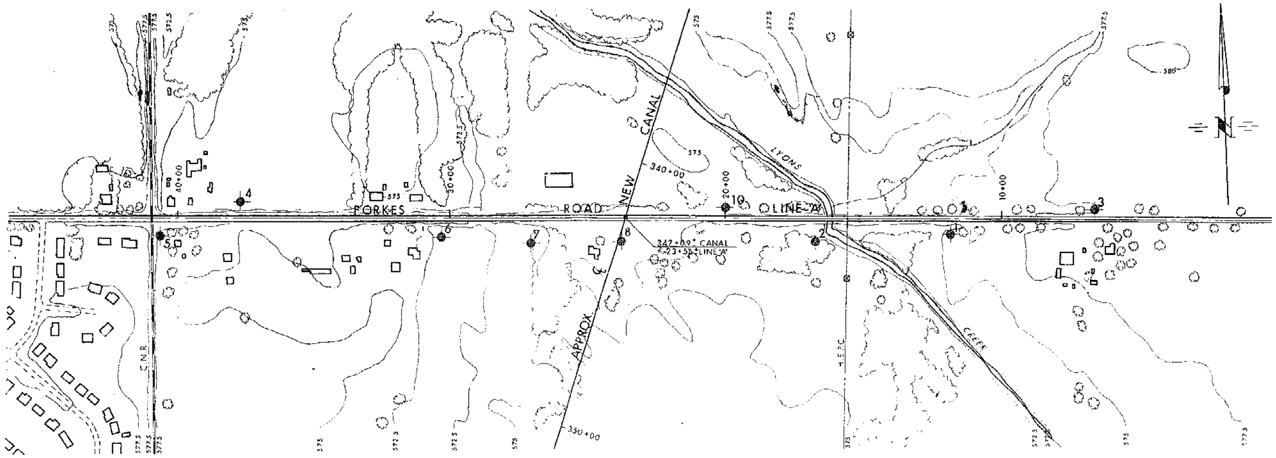
5. Acres will see whether the N.Y C. spur line along Town Line Road can be eliminated.

6. D.H.O. are to decide whether a road crossing is to be built in this vicinity or not and, if it is, which scheme is to be adopted.

F. I. Hewson,
Secretary.

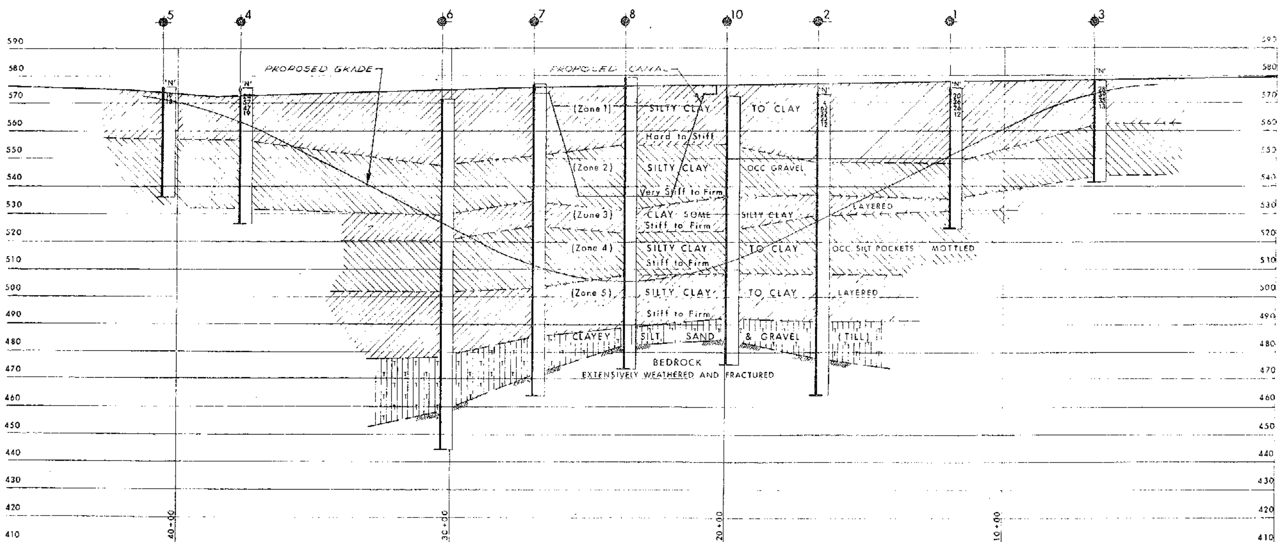
cc/ to all those present
plus: Mr. J. Walter
Mr. H. Greenland

#66-F-111
W.P. #242-66
FORKES ROAD
WELLAND
CANAL



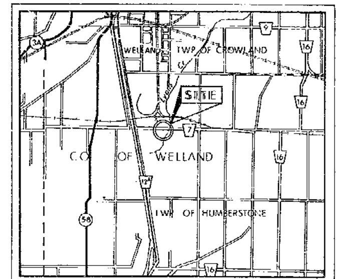
PLAN

200 100 0 200 300 FT
SCALE



℄ PROFILE LINE 'A'

200 100 0 200 400 FT. HOR.
20 10 0 20 40 FT. VERT.
SCALE



KEY PLAN

SCALE IN MILES

LEGEND

- Bore Hole
- Cone Penetration Hole
- Bore & Cone Penetration Hole
- Water Levels established at time of field investigation.

NO.	ELEVATION	STATION	OFFSET
1	575.00	11+89	59' LT.
2	575.40	16+68	63' LT.
3	578.10	6+66	45' RT.
4	575.10	37+73	60' RT.
5	576.00	40+62	63' LT
6	571.90	30+33	72' LT.
7	576.82	26+91	71' LT.
8	579.30	23+65	69' LT.
10	572.30	19+92	52' RT

- NOTE -

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

PRINT RECORD		
NO.	FOR	DATE

REVISIONS		
DATE	BY	DESCRIPTION

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION - FOUNDATION SECTION

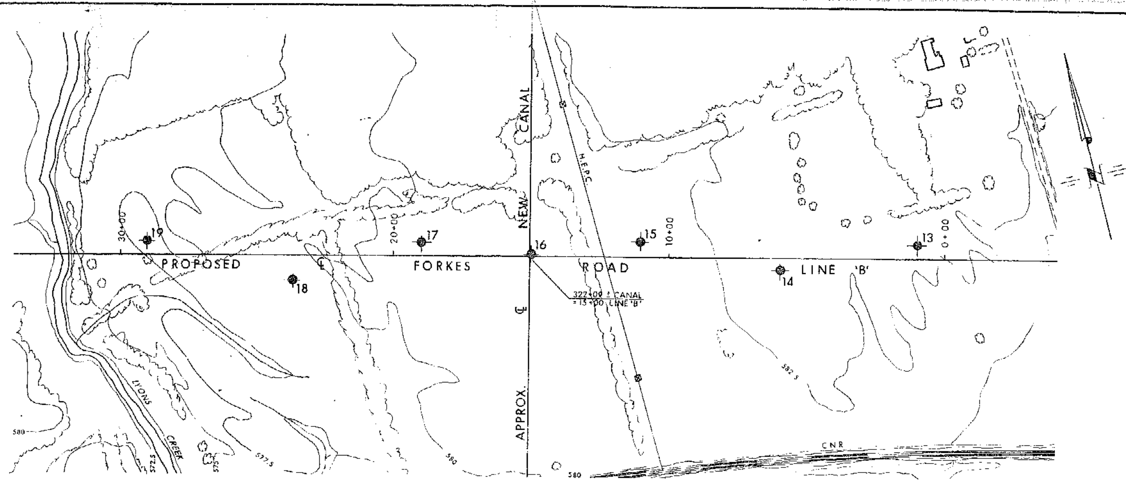
PROPOSED WELLAND CANAL

FORKES ROAD LINE 'A'

KING'S HIGHWAY NO. ______ DIST. NO. 4
CO. ~~WELLAND~~ NIAGARA CITY OF WELLAND
TWP. ______ LOT ______ CON. ______

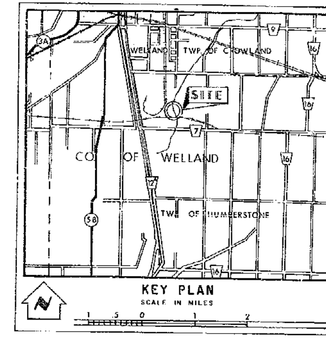
BORE HOLE LOCATIONS & SOILS STRATA

SUBM'D L.P.	CHECKED	W.P. NO. 242-66	M.&T. DRAWING NO. 66-F-111-A
DRAWN B.S.	CHECKED	JOB NO. 66-F-111	
DATE 29 MARCH 67		SITE NO	BRIDGE DRAWING NO.
APPROVED (signature) PRINCIPAL FOUNDATION ENGINEER		CONT. NO.	



PLAN

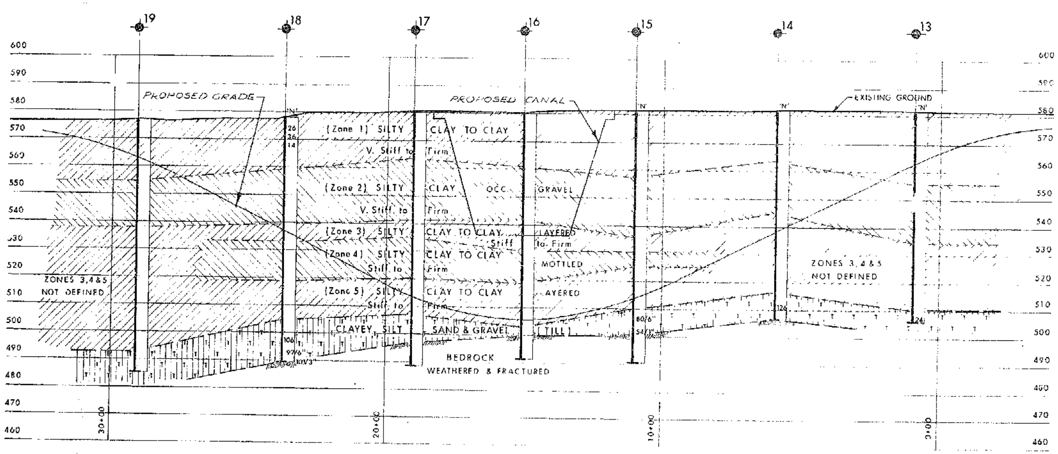
200 100 0 200 400 FT
SCALE



LEGEND

- Bore Hole
- Cone Penetration Hole
- Bore & Cone Penetration Hole
- Water Levels established at time of field investigation.

NO.	ELEVATION	STATION	OFFSET
13	582.2	00+99.5	49.5' LT.
14	581.6	05+98.5	49.0' LT.
15	580.9	10+99.5	51.0' RT.
16	580.7	15+00.5	05.0' RT.
17	580.1	19+00.5	41.5' RT.
18	578.7	23+75.0	89.0' LT.
19	577.5	29+01.0	49.5' RT.



℄ PROFILE LINE 'B'

HOR. 200 100 0 200 400 FT.
VERT. 20 10 0 20 40 FT.

- NOTE -

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

PRINT RECORD		
NO.	FOR	DATE

REVISIONS		
DATE	BY	DESCRIPTION

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION - FOUNDATION SECTION

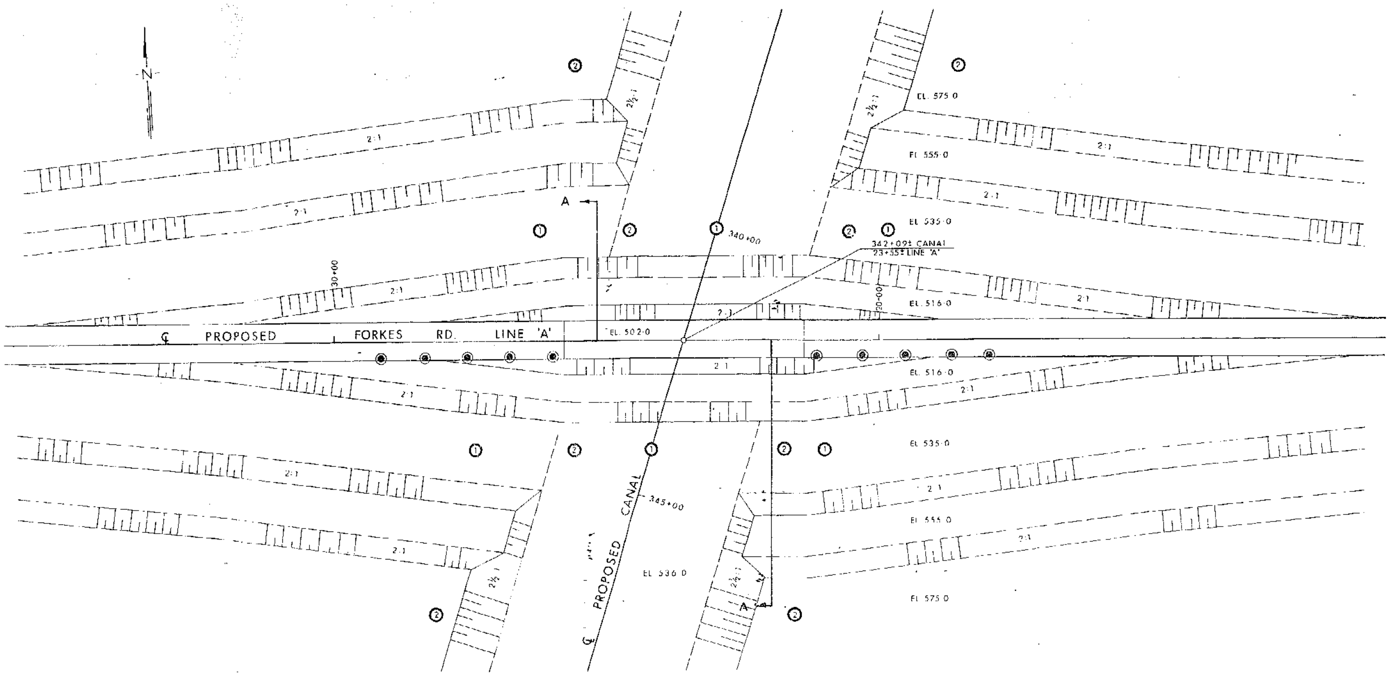
PROPOSED WELLAND CANAL

FORKES ROAD LINE 'B'

KING'S HIGHWAY NO. ______ DIST. NO. 4
CO. WELLAND CITY OF WELLAND
TWP. ______ LOT ______ CON. ______

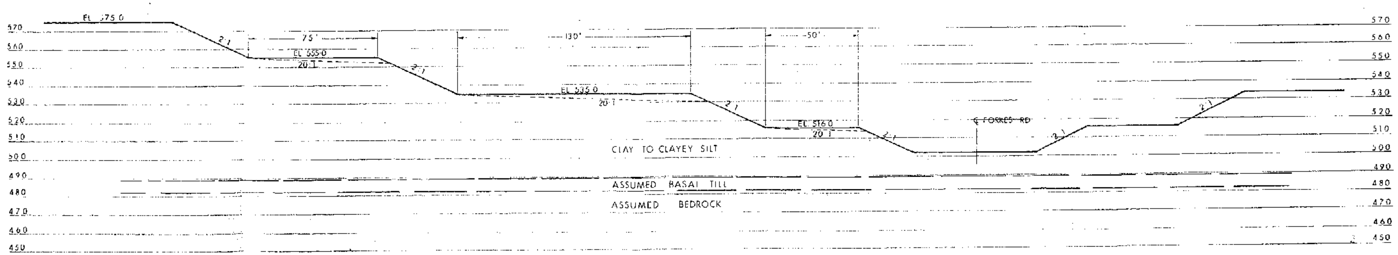
BORE HOLE LOCATIONS & SOIL STRATA

SUBM'D. L.P.	CHECKED L.P.	W.P. NO. 242-66	M.B.T. DRAWING NO. 66-F-111-B
DRAWN B.S.	CHECKED	JOB NO. 66-F-111	
DATE 9 SEPT. 1967		SITE NO.	BRIDGE DRAWING NO.
APPROVED PRINCIPAL FOUNDATION ENGINEER		CONT. NO.	



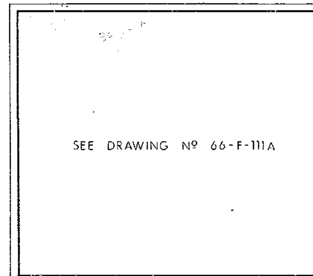
PLAN

SCALE 100 50 0 100 200 FT.



SECTION A-A

SCALE 30 15 0 30 60 FT.



KEY PLAN

SCALE IN MILES

LEGEND

- ◉ PERMANENT RELIEF WELLS
- ① PRESSURE RELIEF WELLS (SCHEME 1)
- ② PRESSURE RELIEF WELLS (SCHEME 2)

- NOTE -

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

REVISIONS	DATE	BY	DESCRIPTION

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION - FOUNDATION SECTION

PROPOSED DE-WATERING SCHEMES & EXCAVATION DETAILS

~~KING'S HIGHWAY NO.~~ FORKE'S ROAD LINE 'A' DIST. NO. 4

CO. WELLAND CITY OF WELLAND

TWP. LOT CON.

SUBM'D. L.P.	CHECKED	W.P. NO. 242-66	M.&T. DRAWING NO. 66-F-111C
DRAWN S.O.	CHECKED	JOB NO. 66-F-111	
DATE 2 SEPT. 1967		SITE NO.	BRIDGE DRAWING NO.
APPROVED (signature) PRINCIPAL FOUNDATION ENGINEER		CONT. NO.	

PRINT RECORD		
NO.	FOR	DATE