

DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 40P1-85

DIST. 4 REGION                     

W.P. No. 65-67-04

CONT. No. 94-55

W. O. No.                     

STR. SITE No. 36-260

HWY. No. 403

LOCATION Hwy 403 & Hwy 52  
Underpass

No. of PAGES -                     

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.                     

REMARKS:

ENGINEERING MATERIALS OFFICE  
FOUNDATION DESIGN SECTION

*CONT 94-55*

WP 65-67-04

DIST 4

HWY 403

STR SITE 36-260

Hwy. 403 & Hwy. 52 Underpass

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# FOUNDATION INVESTIGATION REPORT

For

Hwy. 403 & Hwy. 52 Underpass

W.P. 65-67-04, Site 36-260

District 4, Burlington

## INTRODUCTION

This report summarizes the results of a foundation investigation conducted at the abovementioned site. It is proposed to construct a two span structure to facilitate the Hwy. 403 underpass beneath the existing Hwy. 52. The site and subsurface conditions pertaining to the structure foundations and related earthworks are contained in this report.

## SITE DESCRIPTION AND GEOLOGY

The site is located at Hwy. 52 situated approximately at mid-distance between Hwy. 2 and Jerseyville Road in the Town of Ancaster, Regional Municipality of Hamilton-Wentworth. At the site, Hwy. 52, an existing two lane asphaltic highway with narrow shoulders is supported on an earth embankment that spans an existing valley. The embankment is approximately 100 m in length and varies in height above the original valley ground surface up to a maximum of approximately ten (10) m. Side slopes are constructed at 2H:1V and generally covered by grassland and low lying shrubs. However, some historical surficial slope instabilities is indicated by coarse gravel present at the surface of the east embankment slope. It is suspected that the gravel revetment was placed subsequent to some embankment surface erosion that took place.

The valley continues on either side of the Hwy. 52 embankment location with a maximum depth and width equivalent approximately to the maximum dimensions of the embankment. The slopes are relatively flat and estimated at approximately flatter than 5H:1V. The valley slopes are generally covered by crop vegetation and grassland. At the southeast portion of the site, tall trees are present on the existing valley slope. The valley floor contains a small meandering creek that was dry at the time of the investigation. Water in the creek is transmitted beneath the Hwy. 52 via a circular steel corrugated pipe culvert. The valley floor is covered by a combination of tall grasses and tall deciduous trees.

The terrain beyond the site area consists of rolling hills and valleys. Land use is primarily agricultural and both corn and alfalfa were crops noticed in the area.

Physiographically, the site is located within the geological domain known as the Haldimand clay plain. The Haldimand clay plain occupies the area lying between the Niagara Escarpment and Lake Erie. The entire area was submerged in Lake Warren, a glacial lake formed during the retreat of the Wisconsin glacialiation (approximately 12,000 years ago). Lacustrine clays and silts were deposited as the lake gradually receded due to the deposition of sediments during isostatic land rebound.

Drainage of this belt is controlled by the Grand River which has cut a deep valley in the clay and silt. Consequently, there has been much dissection by tributary drainage.

The underlying bedrock at the site consists of hard dolomites of the Paleozoic era. At the site, the overburden has a thickness of approximately 37 m.

#### INVESTIGATION PROCEDURE

Soil and rock data and inherent properties were obtained by conducting both an in situ field investigation and laboratory analyses. Details of the field investigation and laboratory program are discussed below.

#### Field Investigation

The fieldwork for this project was carried out under two separate stages. The initial stage, was implemented between 76 03 25 to 76 03 26 inclusive and consisted of one sampled borehole (BH 6, formerly BH 13) advanced to a depth of 37.3 m. This initial first stage provided information to facilitate the planning and design of the proposed Hwy. 403 route between the towns of Ancaster and Brantford.

The second stage of the fieldwork was carried out between 91 07 08-16 inclusive and consisted of a total of seven (7) sampled boreholes reflecting the greater extent of this subsequent fieldwork. The scope of the second stage of the fieldwork was to provide detailed soils/rock data to facilitate the design and construction of the proposed structure and related earthworks. Two (2)

boreholes were advanced at the proposed north abutment structure foundation location, and one (1) borehole was advanced at each of the proposed pier and south abutment foundation locations. Two approach boreholes were also advanced for purposes of the proposed Hwy. 52 north and south approach widening. The boreholes at the structure locations were advanced to depths ranging from 38.5 m to 39.9 m whilst the dynamic cone penetration test advanced at the structure foundation locations were driven to depths ranging from 3.4 m to 5.7 m. The approach boreholes were advanced to depths of 12.6 m.

The boreholes were advanced through overburden using track mounted boring units employing conventional continuous flight hollow stem augering techniques. Conventional rock coring techniques were used to retrieve up to 3 m of rock core.

In general, subsoil samples were retrieved at 0.7 m to 1.5 m for the surficial 15 m and at 3.0 m intervals thereafter. At the approach locations, subsoil samples were retrieved at 1.5 m intervals within the existing approach fills and at 0.7 m intervals within the native subsoil.

Subsoil samples were generally retrieved in accordance with the Standard Penetration Test (ASTM D 1586) and hence were disturbed during the testing. All subsoil samples were identified in the field and then properly sealed in plastic containers to preserve natural moisture contents. The samples were then transported to the laboratory where additional visual classifications were carried out and pertinent laboratory tests were conducted.

Rock core samples were also identified in the field and rock recoveries and Rock Quality Designations (RQD) measured. The rock cores were then transported to the laboratory in conventional core boxes and detailed rock core logs were produced by an in-house geologist.

In situ vane tests were also carried out to determine the undrained shear strength of the weaker cohesive soils at the site. The test was carried out in accordance with ASTM D 2573 using the standard MTO 'N' vane. Remoulded shear strengths were also obtained where applicable.

Groundwater levels were obtained by monitoring the levels in the open boreholes throughout the duration of the field investigation. All open boreholes were backfilled at the completion of the fieldwork.

Survey information related to the location and elevation of boreholes was provided by Central Region Surveys and Plans.

#### Laboratory Analyses

To determine the pertinent physical properties of the soil, various laboratory tests were conducted. These tests included:

- 1) Natural Moisture Contents
- 2) Atterberg Limits
- 3) Grain Size Analyses

Laboratory test results are shown on the borehole logs and corresponding figures attached in the Appendix. These results have been summarized in the subsequent section of this report entitled 'Subsurface Conditions'.

#### SUBSURFACE CONDITIONS

The variation of the subsurface conditions at the site are a reflection of the rolling terrain that consists of alternating hills and valleys present in the area. At the proposed north abutment location, a ridge of native soil exists covered by a shallow thickness of fill material. The fill material varies in thickness from approximately 3.5 m at the western location (BH 1) to approximately 2 m at the eastern location (BH 2). Beyond this ridge, extensive thicknesses of fill material spanning previously existing valleys are present. South of the ridge, the fill material has a thickness ranging up to 9.3 m. North of the ridge, the fill material has a thickness ranging up to 4.7 m.

The composition of the fill material varies from a sand with a trace to some silt and a trace gravel located within approximately 2 to 3 m of the surface underlain by a fill material composed primarily of silt with random zones of clayey silt. The fill material denseness ranges from very loose to dense but generally is in a loose to compact state of denseness.

The fill material has been placed on a native deposit of cohesionless silt with traces of sand and clay. This silt stratum has a thickness ranging from approximately 1.5 m to 7.9 m and has a loose to very dense denseness.

The silt stratum is underlain by a thin layer of a very stiff clayey silt material. This layer is approximately 0.7 m to 1.6 m in thickness.

A second lower deposit of silt underlies the cohesive clayey silt stratum and extends for thicknesses in the order of 20 m. The deposit contains random layers of silty sand to sandy silt approximately 0.7 m in thickness and also contains interbeds of clayey silt of 12.5 mm to 25 mm in thickness within approximately the lower 6 metres of the deposit. The denseness of the cohesionless material varies generally from loose to compact with random dense to very dense zones.

The lower silt deposit is underlain by a second cohesive stratum of clayey silt. This stratum extends to bedrock and has a thickness of approximately 6 m.

Bedrock exists at an elevation ranging from 193.0 m to 194.1 m, at depths ranging from 36 to 37.8 m below existing ground surface. Bedrock consists of dolostone of the Amabel Formation.

A contour plan of the site illustrating the locations and elevations of the boreholes is shown on Drawing No. 656704-A in the Appendix. A subsoil stratigraphical profile illustrating the subsurface conditions at the site is also provided. The boundaries between the various soil types, in situ and laboratory test results as well as groundwater levels established at the time of investigation are shown on the stratigraphical profile and also on the individual Record of Borehole sheets in the Appendix.

Sand, trace/and Silt, trace Gravel, trace Clay (Fill Material)

At the boreholes advanced within the existing Hwy. 52 right-of-way, a cohesionless, brown sand with traces of gravel and silt percentages varying from traces (0-10%) to approximately equal silt and sand percentages exists beneath the asphaltic road surface. This fill material serves as a subbase and base for the existing highway and has a thickness of 2 to 3.5 m. Traces of organics, clay and asphalt are also present within this fill material. Grain size distribution curves as determined by mechanical sieve analysis, representative of the gradation of this material is shown on Figure 1 in the Appendix. Natural moisture contents of the material range from 11 to 13%.

Based on 'N' values derived from the Standard Penetration Test ranging from 6 blows/0.3 m to 35 blows/0.3 m, it appears that this material has been placed and compacted to a denseness ranging from loose to dense. In general, 'N' values are between 10 blows/0.3 m and 30 blows/0.3 m and hence the material is in a compact state of denseness.

Silt with Random Zones of Clayey Silt (Fill Material)

The cohesionless sand with traces/and silt and traces of gravel fill material is underlain by a fill material consisting of primarily silt with random zones of clayey silt at the existing embankment fill locations beyond the abovementioned ridge located at the proposed north abutment location. Traces of black asphalt, organics and gravel were also found within this fill material. The thickness of this fill varies between 4.1 m and 7.3 m within the embankment south of the ridge and has a thickness of up to 2.7 m north of the ridge. Approximately 2 m of this fill material was also found at the surface of the ridge (BH 2). A grain size distribution envelope illustrating the range of the gradation of this fill material is shown on Figure 2 in the Appendix. The colour of this material is brown with random zones of grey and natural moisture contents ranged from 15 to 27%.

Atterberg Limit Tests were also carried out to determine the plasticity of the random cohesive zones within the non-plastic silt material. These results are illustrated on Figure 3 in the Appendix. The results reveal that the random cohesive zones are of low plasticity and hence can be classified as a clayey silt.



The denseness and consistency of the cohesionless silt and cohesive clayey silt was determined by the evaluation of 'N' values derived from the Standard Penetration Test. Based on 'N' values ranging from 8 blows/0.3 m to 39 blows/0.3 m in the cohesionless silt, this material can be described as having a loose to very dense denseness. In the cohesive material, 'N' values ranged from 17 blows/0.3 m to 23 blows/0.3 m revealing a very stiff consistency.

#### Silt, trace/some Sand to Silt

The fill material is underlain by a stratum of native silt to a silt that contains traces to some sand and also traces of clay. This cohesionless deposit is primarily oxidized and hence brown in colour although the lower 2 m of the deposit has been oxidized to a grey colour at some locations. The thickness of this deposit ranges from 1.5 m at the original valley location (BH 4) to 7.9 m at the ridge of the valley (BH 2). A grain size distribution envelope as determined by mechanical sieve and hydrometer analysis is shown on Figure 4 in the Appendix.

The 'N' values measured by carrying out the Standard Penetration Test in this stratum varied between 7 blows/0.3 m and 80 blows/0.3 m, indicating a denseness ranging from loose to very dense. The 'N' values at the ridge located at the north abutment location were generally larger and greater than 30 blows/0.3 m and consequently, the silt material at this location can be defined as having a dense to very dense denseness. Elsewhere within this stratum 'N' values are generally less than 30 blows/0.3 m. The lower 'N' values obtained in this material across the site were generally measured beneath the groundwater table in the open borehole. Hence, it is suspected that the low 'N' values may be attributable to the unbalanced hydrostatic head conditions and are not necessarily representative of the state of denseness of this deposit that arise. It is therefore concluded that the material beyond the ridge is in a compact state of denseness.

#### Clayey Silt

The native silt deposit is underlain by a thin stratum of cohesive clayey silt. This stratum is grey in colour and has a thickness in the order of 0.7 m to 1.6

m. The surface of this stratum exists at an elevation ranging from 220.0 m to 220.8 m.

A grain size distribution envelope illustrating the gradation of this material is shown on Figure 5 in the Appendix. The envelope illustrates that this soil is composed of fine grained material and hence, in accordance with the MTO Soil Classification System categorized according to its behaviour. Atterberg Limit Tests were carried out on representative samples to determine the behaviour and plasticity of this material and the results are plotted on Figure 6 in the Appendix and summarized in Table 1 below. The results reveal that the soil is of low plasticity and hence is identified as a clayey silt.

Table 1 - Clayey Silt

	<u>Range</u>	<u># of Tests</u>
Natural Moisture Content (w%)	24-30	4
Liquid Limit ( $w_L$ %)	32-35	4
Plastic Limit ( $w_p$ %)	15-18	4
Plasticity Index ( $I_p$ %)	15-19	4

The 'N' values as measured in accordance with the Standard Penetration Test ranged from 10 blows/0.3 m to 24 blows/0.3 m. In Situ Vane Tests attempted in this material could not be torqued and hence, it is concluded that this stratum has an undrained shear strength exceeding 100 kPa and therefore of very stiff consistency.

Silt with Random Layers of Silty Sand and Layers of Clayey Silt

The cohesive clayey silt stratum is underlain by a deposit comprised of material ranging from silt to silt with traces to some sand. The deposit also contains random layers of silty sand to sandy silt and within the lower 3 to 9 metres of the deposit random layers of clayey silt also exist. The deposit has a thickness ranging from 16.3 m to 19.8 m extending to an elevation ranging from 199.6 m to 202.9 m. The layers of silty sand to sandy silt are approximately 0.8 m in thickness and the clayey silt layers are generally 10 to 50 mm in thickness. A grain size distribution envelope illustrating the silt deposit is shown on Figure 7 in the Appendix. Grain size distribution curves depicting the gradation of a typical sandy silt layer and clayey silt layer is also shown on Figure 7.

An Atterberg Limit Test was carried out on a representative sample of the cohesive interlayers at the lower depth of the deposit (BH 2, SS16). The results of the test reveal a liquid limit ( $w_L$ ) equivalent to 25% and a plasticity index ( $I_p$ ) equivalent to 10%. This confirms that the interlayer is of low plasticity and hence can be identified as clayey silt.

Based on the interpretation of Standard Penetration Test 'N' values ranging from 6 blows/0.3 m to 83 blows/0.3 m, the silt with random layers of silty sand to sandy silt can be described as having a denseness ranging from loose to very dense. In general, 'N' values range from 10 blows/0.3 m to 50 blows/0.3 m indicating a compact to dense state of denseness.

Lower 'N' values were measured in the lower depths of the deposit where the silt is interbedded with layers of clayey silt. The 'N' values ranged from 6 blows/0.3 m to 26 blows/0.3 m suggesting a loose to compact silt with interbeds of stiff to very stiff clayey silt.

#### Clayey Silt

The silt deposit with layers of silty sand to sandy silt and layers of clayey silt is underlain by the lowermost overburden stratum at the site consisting of a cohesive clayey silt. This stratum, which also contains seams of silt approximately 25 mm in thickness extends to the bedrock surface. A grain size distribution envelope for the deposit as determined by mechanical sieve and hydrometer analysis is provided on Figure 8 in the Appendix.

Atterberg Limit Tests were carried out to define the behaviour and plasticity of this fine grained stratum and the results are illustrated on Figure 9 in the Appendix and summarized in Table 2 below. The results reveal that the soil has a low plasticity and hence can be described as a clayey silt in accordance with the MTO soil classification system. Natural moisture contents are generally within the Plastic Limit ( $w_p$ )-Liquid Limit ( $w_L$ ) range and hence the soil is in a plastic state of condition.

Table 2 - Clayey Silt

	<u>Range</u>	<u># of Tests</u>
Natural Moisture Content ( $w$ )	26-30	7
Liquid Limit ( $w_L$ )	21-34	7
Plastic Limit ( $w_p$ )	15-18	7
Plasticity Index ( $I_p$ )	6-18	7

The 'N' values measured in accordance with the Standard Penetration Test ranged from 12 blows/0.3 m to 20 blows/0.3 m. In situ vane tests conducted within this

material revealed undrained shear strengths ranging from 90 kPa to values exceeding 100 kPa. In general, the vane could not be torqued within the limits of the test and hence, undrained shear strengths generally exceed 100 kPa. It can therefore be concluded from the in situ testing carried out within this stratum, that the soil has a stiff to very stiff consistency.

### Bedrock

The overburden at the site is underlain by dolostone bedrock of the Amabel Formation at an elevation of approximately 193 m to 194.1 m. The bedrock surface is relatively flat and uniform across the site. The bedrock was cored in BQ and BXL size up to 3 m in depth at the proposed structure foundation locations.

The dolostone bedrock is a fine to medium grained chemical sedimentary rock that typically is composed of magnesium carbonate compounds and calcite crystals. The rock is unweathered, that is featured by a porous 'vug' texture and stylolites. The rock is light to medium dark grey in colour and contains thin horizontal beds and closely spaced vertical fractures. Detailed descriptions of the bedrock are attached in the Appendix in a report entitled 'Description of Rock Core'.

An assessment of the quality and strength of the rock was carried out by measuring Core Recoveries and Rock Quality Designation (RQD) in the field and hardness testing in the laboratory. Recoveries ranged from 94% to 100% and RQD's ranged from 80% to 95% indicating that the rock is of good to excellent quality. Rock strengths can be described as medium strong.

### Groundwater Conditions

Observation of the groundwater level was carried out by measuring the water levels in the open boreholes throughout the duration of the field investigation. Groundwater levels determined at the time of investigation ranged from approximately 6.3 m to 9.4 m below the existing ground surface (elevation 224.3 m to 221.3 m). This groundwater elevation appears to coincide approximately with the native soil-fill material interface at the proposed pier and south abutment and approach locations. These elevations including the groundwater elevations at the north abutment ridge, also appear to be at the valley floor elevation.

Groundwater levels in general, are subject to seasonal fluctuations and hence can vary from the values given in this report.

## DISCUSSION AND RECOMMENDATIONS

It is proposed to construct a two (2) equal span structure (approximately 33 m-33 m) that will carry the existing Hwy. 52 over the proposed Hwy. 403. The Hwy. 52 will remain along its present alignment but will be widened to a four lane median divided highway with shoulders on either side and 1.5 m sidewalk on the east side. A typical deck section will have an overall width of approximately 19.5 m.

The proposed Hwy. 403 will be initially a six (6) lane median divided highway with 2.5 m shoulders and ultimate plans of widening to possibly ten (10) lanes. The highway is almost at right angles to the Hwy. 52. Ramps N-E and S-W have also been proposed at this highway interchange.

The proposed profile grade at Hwy. 52 will remain unaltered at approximately elevation 231 m at the structure location. The proposed Hwy. 403 profile grade is approximately at elevation 224 m. The existing ground surface elevation varies at the site because of the existing embankment slope and valley slope geometry from elevation 230.8 m to 222 m. Consequently, excavation and approach fills in the order of 7 m will be required at the abutment locations and fills in the order of 2 m will be required to facilitate the advancement of Hwy. 403.

A plan illustrating the highway alignments superimposed on an existing contour plan and the proposed structure foundation locations is attached in the Appendix (Drawing No. 656704-A). The proposed profile grades have also been indicated on the stratigraphical sectional profile of the site illustrated on this drawing.

To facilitate the design and construction of the proposed structure foundations and related earthworks, the following foundation and geotechnical recommendations are provided in the scope of this report.

- 1) Structure Foundations
- 2) Reinforced Earth Walls
- 3) Approach Embankments
- 4) Construction Considerations

# 1) STRUCTURE FOUNDATIONS

The surficial fill materials and the underlying native surficial silt deposit are considered unsuitable for the support of economical conventional shallow foundations. Consequently, it is recommended that all foundations be founded on deep foundation units. The bedrock present at this site provides an end-bearing stratum and consequently, structure foundations can be supported on end-bearing steel H-piles driven to the bedrock surface. Table 3 provides recommended axial bearing capacities for steel H-piles driven to bedrock. The capacities, however, apply to vertical piles and appropriate considerations shall be given to inclined piles. Any reduction to account for inclined loadings shall be carried out in conformance with the factors given in Section 6-8.3.4.3 of the O.H.B.D.C.

Table 3 - Axial Capacities

<u>Structure Foundation</u>	<u>Pile Type</u>	<u>Factored Bearing at U.L.S. (kN)</u>	<u>Bearing Capacity at S.L.S. Type II (kN)</u>	<u>Estimated Pile Tip El. (m)</u>
North Abutment	HP310x110	1600	1150	193.6±
	HP310x79	1150	890	
Pier	HP310x110	1600	1150	193.7±
	HP310x79	1150	890	
South Abutment	HP310x110	1600	1150	193.0±
	HP310x79	1150	890	

Resistance to lateral loads can be achieved by inclining the piles at a batter. The lateral resistance for vertical and battered piles shall be computed in accordance with Section 6.8.3.8 of the O.H.B.D.C.

Pile spacing shall conform with Section 6.8.3.10 of the O.H.B.D.C. Adjacent piles should be checked for heaving during pile installation. For centrally

loaded piles equal load sharing on the deep foundation units can be assumed. The design of eccentric loaded deep foundation units shall comply with Section 6.8.3.4.2 of the O.H.B.D.C.

All pile caps shall be protected against frost penetration by providing a minimum 1.2 m earth cover or equivalent frost protection.

To avoid dewatering requirements during pile installation and construction of the pile caps major consideration should be given to 'perching' the abutment pile caps above the native cohesionless native soils submerged beneath the groundwater table at the site. This can be achieved by constructing the pile caps within the surficial native silt deposit above the groundwater table at the north abutment and within the fill material at the south abutment. Any excavation within the cohesionless silt deposit submerged beneath the groundwater table, which is likely at the pier locations, will require an advanced dewatering scheme. Recommended dewatering schemes are discussed under the heading 'Construction Considerations' in a later section of this report.

All piles shall be driven to the bedrock surface. To facilitate the installation of the steel H-piles, it is recommended that the piles be equipped with reinforced tips as illustrated on MTO Standard Drawing DD-3301. The steel H-piles shall be spliced in accordance with OPSS 903.07.01.03 and as shown on the abovementioned Drawing DD-3301.

## 2) REINFORCED EARTH WALLS

Should the application of reinforced earth walls prove to be an economical alternative, consideration can be given to employing reinforced earth abutment and/or retaining walls. Recommendations for the foundation, preparation and foundation bearing capacities are summarized below. All foundations shall be given a 1.2 m earth frost protection cover or equivalent and a Non-Standard Special Provision (NSSP) specifying the supply and installation of the reinforced earth wall shall be included in the contract documents.

### North Abutment

At the north abutment, the reinforced earth module can be founded directly on the native silt stratum as summarized in Table 4 below. The bearing capacities given are applicable to foundations positioned a minimum 3 m recessed back from any slope. The slope shall be at 2H:1V or flatter and can be either a natural slope of an engineered fill slope composed of Granular 'A' material. Engineered fill slopes are to be 'benched' into existing slopes in accordance with OPSD 208.01.

Table 4 - R/E Wall on Native Soil - North Abutment

<u>Founding Elevation (m)</u>	<u>Factored Capacity at U.L.S. (kPa)</u>	<u>Bearing Capacity at S.L.S. Type II (kPa)</u>
227-228	900	250

The magnitude of settlement anticipated as result of the applied pressures are expected to be within 25 mm.

### South Abutment

Reinforced Earth Walls can be also be applied at the south abutment by removing the existing fill material and then constructing a compacted Granular 'A' pad as illustrated on Figure 10 in the Appendix. It is recommended that the subexcavation be taken to an elevation of 222 m and proof-rolling of the soil at this depth conducted. Any additional loosened/softened and/or organics material shall be additionally removed beyond this elevation. The granular pad shall be constructed to a minimum 1 m edge distance from the top of the footing to the crest of the pad and with 1H:1V slopes. The Granular 'A' material must be placed and compacted to achieve 100% of the Proctor maximum dry density as outlined in OPSS 501.08.02 (Method A). Quality Control in the form of material inspection and field density measurements shall be conducted.

For purposes of the O.H.B.D.C. and for the conditions described above, the bearing capacities tabulated in Table 5 below can be used in the foundation design. The Granular 'A' pad shall have a minimum thickness of 4 m.



Table 5 - R/E Wall on Granular 'A' Pad

Factored Capacity at U.L.S. = 900 kPa

Bearing Capacity at S.L.S. Type II = 200 kPa

Settlement of the granular pad foundation as a result of the applied footing pressure will be elastic in nature and consequently is expected to take place during or immediately following the construction period. The magnitude of this settlement is anticipated to be within 25 mm, provided the granular and native materials are not loosened by construction or related activities.

### 3) APPROACH EMBANKMENTS

Approach fills in the order of 7 m will be required for the widening of the Hwy. 52 approaches and to facilitate the advancement of the Hwy. 403 underpass, excavation of the existing Hwy. 52 embankment to depths of up to 7 m will also be required within the proposed Hwy. 403 roadway. Approximately two (2) m of fill material will also be required along the Hwy. 403 to raise the existing valley ground surface elevations to the proposed Hwy. 403 profile grade. Discussion pertaining to the stability and settlement of the approach embankments, lateral earth pressures exerted by approach fills on abutment and/or retaining walls and construction of the approach embankments are provided below.

#### a) Stability

##### Fills

There are no deep-seated (external) stability problems anticipated at this site for the proposed fill heights in view of the cohesionless nature of the native silt materials and the very stiff consistency of the native cohesive soils provided the fills are constructed at 2H:1V slopes, both in the longitudinal and transverse directions. However, to avoid surficial and internal slope stabilities, it is recommended that for any fill heights exceeding 8 m, the embankments be constructed at 2H:1V slopes with a nominal 2 m midheight berm

sloped at a 2% gradient to facilitate surface runoff away from the slope. Also, the new fill slopes shall be 'benched' into existing slopes in accordance with OPSD 208.01.

Based on the abovementioned recommended slope geometry, the existing embankment fills will have to be excavated to comply with this geometry. All exposed slopes should be protected from erosional forces by providing an effective erosional control protection scheme.

### Cuts

Any excavation cut up to a depth of 8 m that may be required to facilitate the Hwy. 403 advancement, as for instance that may be required at the north abutment beyond the structure itself, can be excavated at 2H:1V or flatter slopes. An erosion protection scheme shall also be applied to these slopes.

#### b) Settlements

Settlements in the order of magnitude of 50 mm are expected at the Hwy. 52 widening approach embankments as a result of the elastic compression of the native subsoils and existing fills and also as a result of settlements within the fill material itself. Settlements as a result of the Hwy. 403 fills are expected to be approximately 5 mm to 10 mm in magnitude due to the elastic compression of the native subsoils.

All settlements are expected to be immediate in nature should granular fills be employed. For fill materials that are cohesive, settlements will be more time dependent, but should be realized within a three (3) month time period following the fill placement.

#### c) Backfill to Structure

It is recommended that Granular 'A' or Granular 'B' be used within a wedge behind the abutments and retaining walls bounded by a plane rising at 60° to the horizontal as shown in Figure 6-9.9.6.1 of the O.H.B.D.C. The application of

granular material combined with weep holes in the abutment walls to drain any accumulation of water in the backfill will prevent hydrostatic pressure build-up. Design parameters of the soil are given in Table 6 below.

Table 6 - Backfill Properties

	<u>Granular 'A'</u>	<u>Granular 'B'</u>
Angle of Internal Friction ( $\phi$ ) (Unfactored)	35°	30°
Unit Weight (kN/m <sup>3</sup> ) $\gamma$	22.8	21.2
*Coefficient of Active Earth Pressure (Ka)		
- S.L.S.	0.27	0.33
- U.L.S.	0.33	0.4
*Coefficient of Earth Pressure at Rest (Ko)		
- S.L.S.	0.43	0.5
- U.L.S.	0.5	0.58

\*These earth pressure coefficients apply to horizontal backfill surfaces only. The appropriate consideration shall be given to account for sloping backfill.

The coefficient of earth pressure at rest shall be applied for rigid and unyielding walls.

d) Embankment Construction

As previously discussed, the embankment construction of the Hwy. 52 approaches will consist of both the excavation of the existing fill material at the site and the placement of new fill material in conjunction with the proposed widening. All organic material shall be removed and the subgrade effectively proof-rolled prior to fill placement. Embankment fills shall be placed and compacted as specified in OPSS 206.07.07 and OPSS 501 series. In addition, it is hereby reiterated that new slopes shall be 'benched' into existing slopes in accordance with OPSD 208.01.

Any subexcavation within the native silt deposit below the prevailing groundwater table will require a dewatering scheme. One method of achieving

this subexcavation is to excavate an initial pilot trench within the central area of the planned area and sump pumping the drained water seepage from this trench. The excavation can then proceed laterally in sequence until the entire area is effectively drained to facilitate the excavation. This dewatering scheme, illustrated on Figure 11 in the Appendix, controls and contains any soil sloughing within the confines of the excavation.

The contractor shall submit his proposal of subexcavation and dewatering for review by this office prior to construction.

#### 4) Construction Considerations

##### 1) Dewatering

As previously discussed, any excavation within the native surficial cohesionless silts submerged below the prevailing groundwater table will require a dewatering scheme. A dewatering scheme is therefore required not only for any subexcavation within the approach fill area, but also for any pile cap construction within this material. It is hereby reiterated that a dewatering scheme can be avoided should the abutments be perched above the submerged silts as previously discussed. Alternatively, two dewatering schemes are suggested below. The alternative that is the most economical and technically feasible shall be selected. It is recommended that the contractor submit any dewatering proposal for review by this office.

##### Gravity Drainage

A gravity drainage scheme within an oversized excavation similar to the procedure discussed previously in conjunction with the approach area subexcavation is also applicable for the excavation of pile caps. Drainage can be achieved by employing perimeter ditches within a gravity system in conjunction with a sumping discharge system. An illustration of this scheme is provided on Figure 12 in the Appendix.

### Cofferdam Construction

Alternatively, dewatering may be achieved by carrying out the excavation from within an enclosure formed of interlocking steel sheeting (cofferdam). In order to prevent 'boiling' at the base of the excavation, it is recommended that the sheeting be driven to a depth below the footing base equal to the unbalanced hydrostatic head existing above this level (see Figure 13).

### 2) Traffic Maintenance

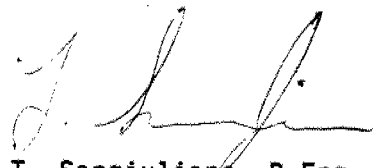
Various schemes of maintaining traffic along Hwy. 52 during construction can be considered, including the construction of temporary detours or a temporary shoring scheme. It is recommended that our office be included in the preliminary discussion of any contemplated scheme because of the anticipated associated foundation and geotechnical considerations.

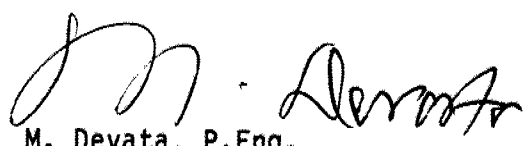
### MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano, Foundation Engineer, and L. Dametto, Engineering Student, utilizing equipment owned and operated by Atcost Soil Drilling Ltd. Logging of rock core in the laboratory was carried out by D. Williams, Petrographer.

The project was carried out by T. Sangiuliano under the general supervision of P. Payer, Senior Foundation Engineer. The report was written by T. Sangiuliano, reviewed by P. Payer and approved by M. Devata, Chief Foundation Engineer.

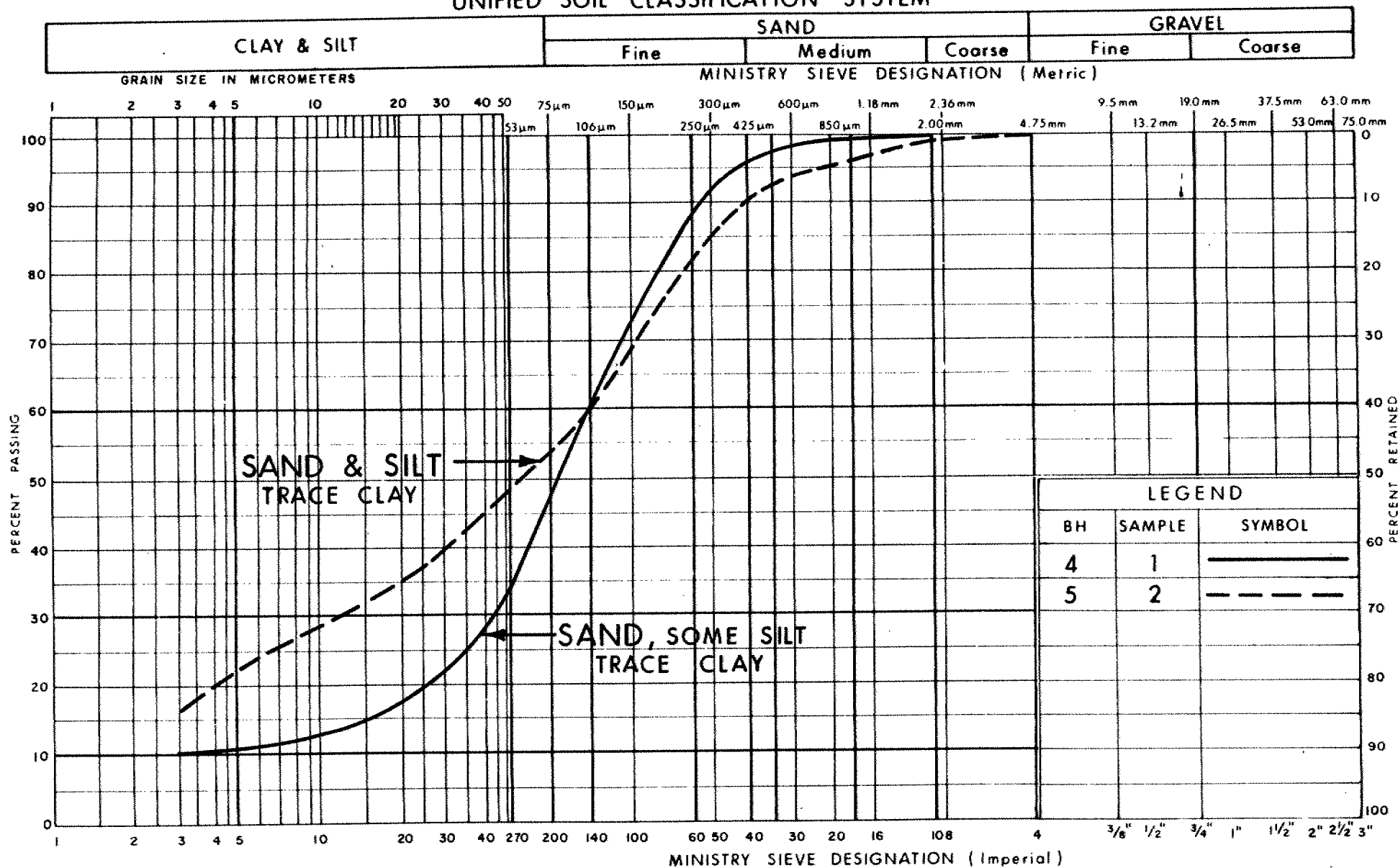


  
T. Sangiuliano, P.Eng.  
Foundation Engineer

  
M. Devata, P.Eng.  
Chief Foundation Engineer

APPENDIX

## UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION  
SAND, SOME /AND SILT, TRACE CLAY, GRAVEL  
(FILL MATERIAL)

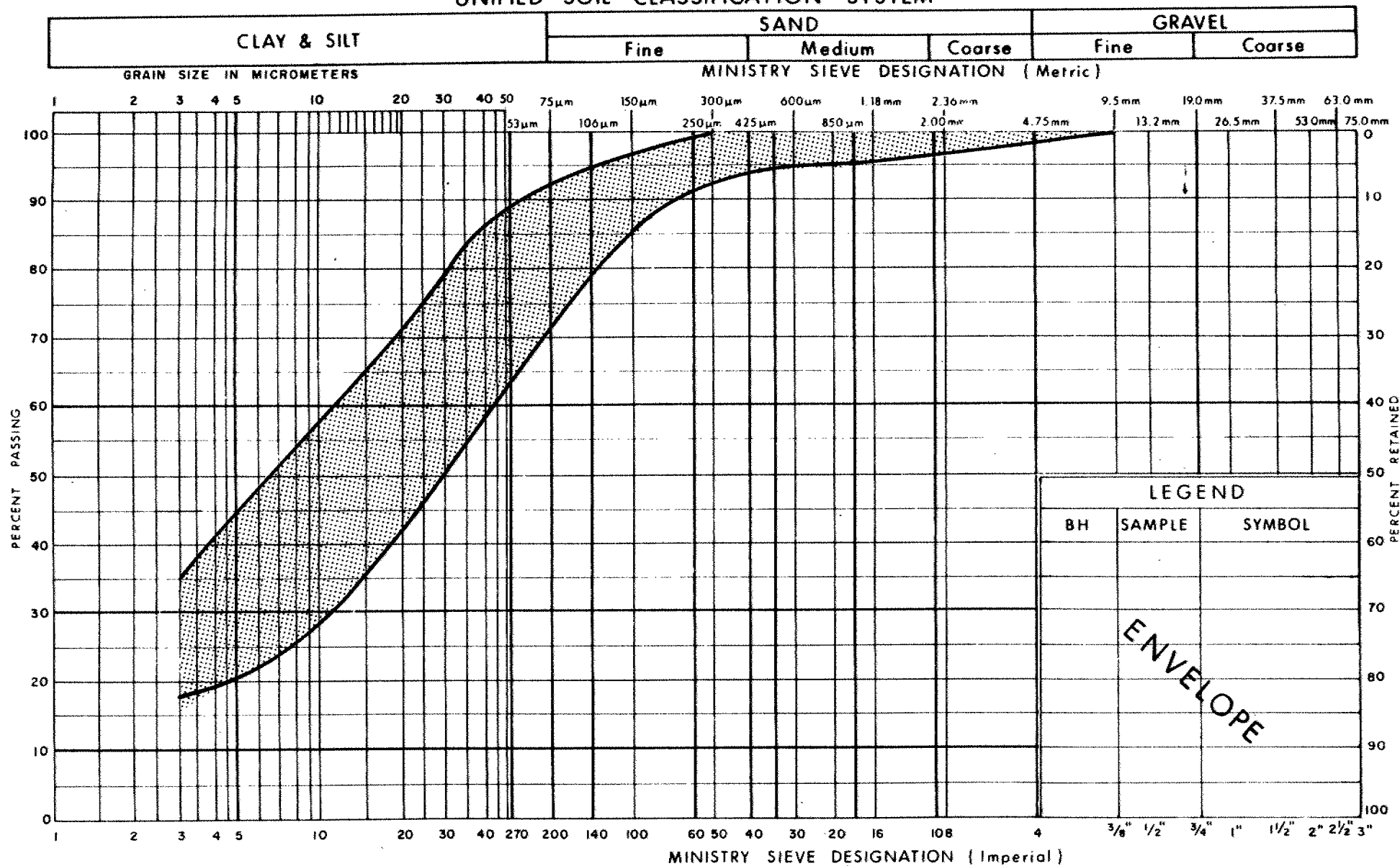
FIG No 1

W P 65-67-04



Ministry of  
Transportation

## UNIFIED SOIL CLASSIFICATION SYSTEM



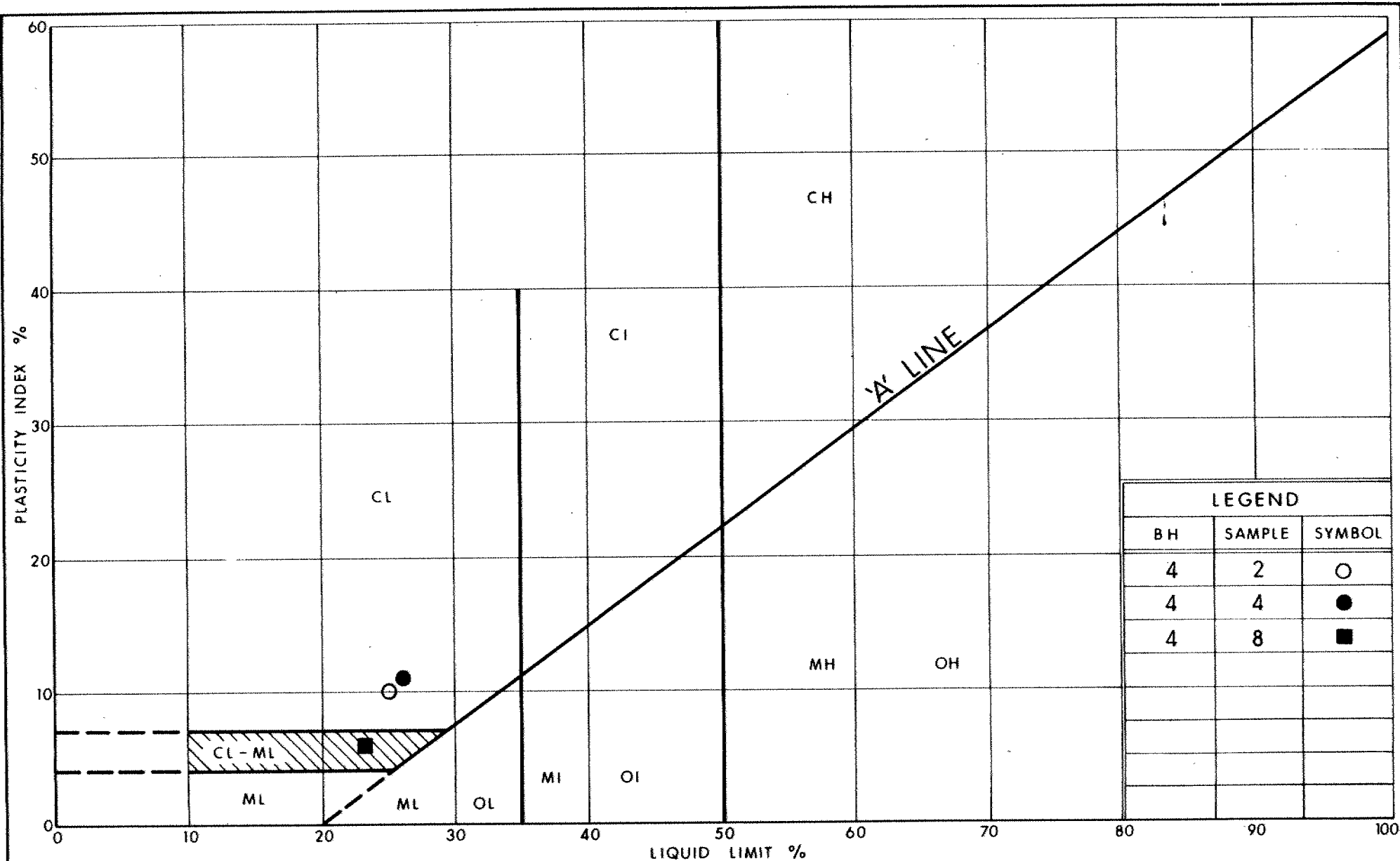
Ministry of  
Transportation

**GRAIN SIZE DISTRIBUTION**  
**SILT WITH RANDOM ZONES OF CLAYEY SILT**  
**( FILL MATERIAL )**

FIG No 2

W P 65-67-04





Ministry of  
Transportation

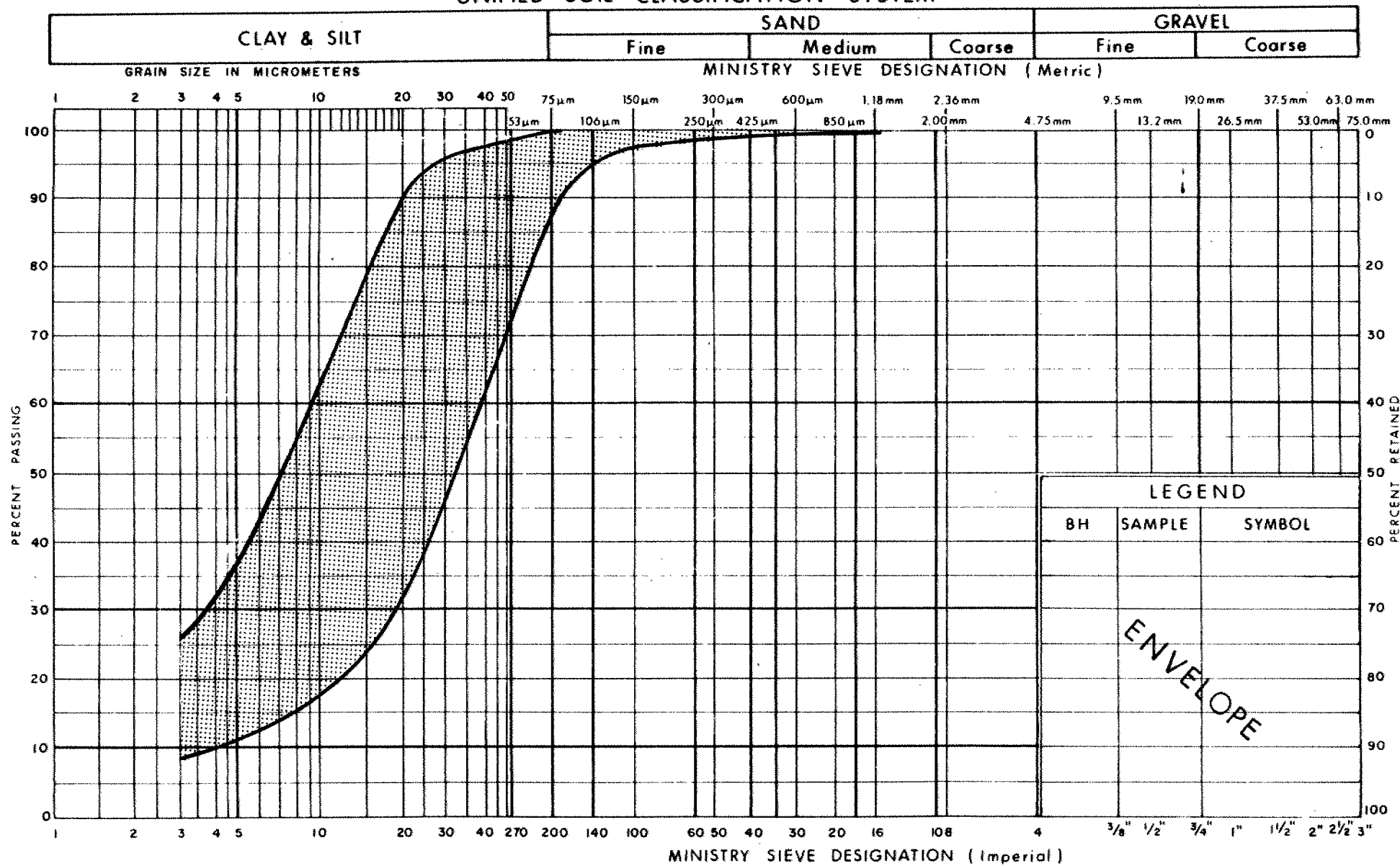
Ontario

# PLASTICITY CHART SILT WITH RANDOM ZONES OF CLAYEY SILT ( FILL MATERIAL )

FIG No 3

W P 65-67-04

## UNIFIED SOIL CLASSIFICATION SYSTEM



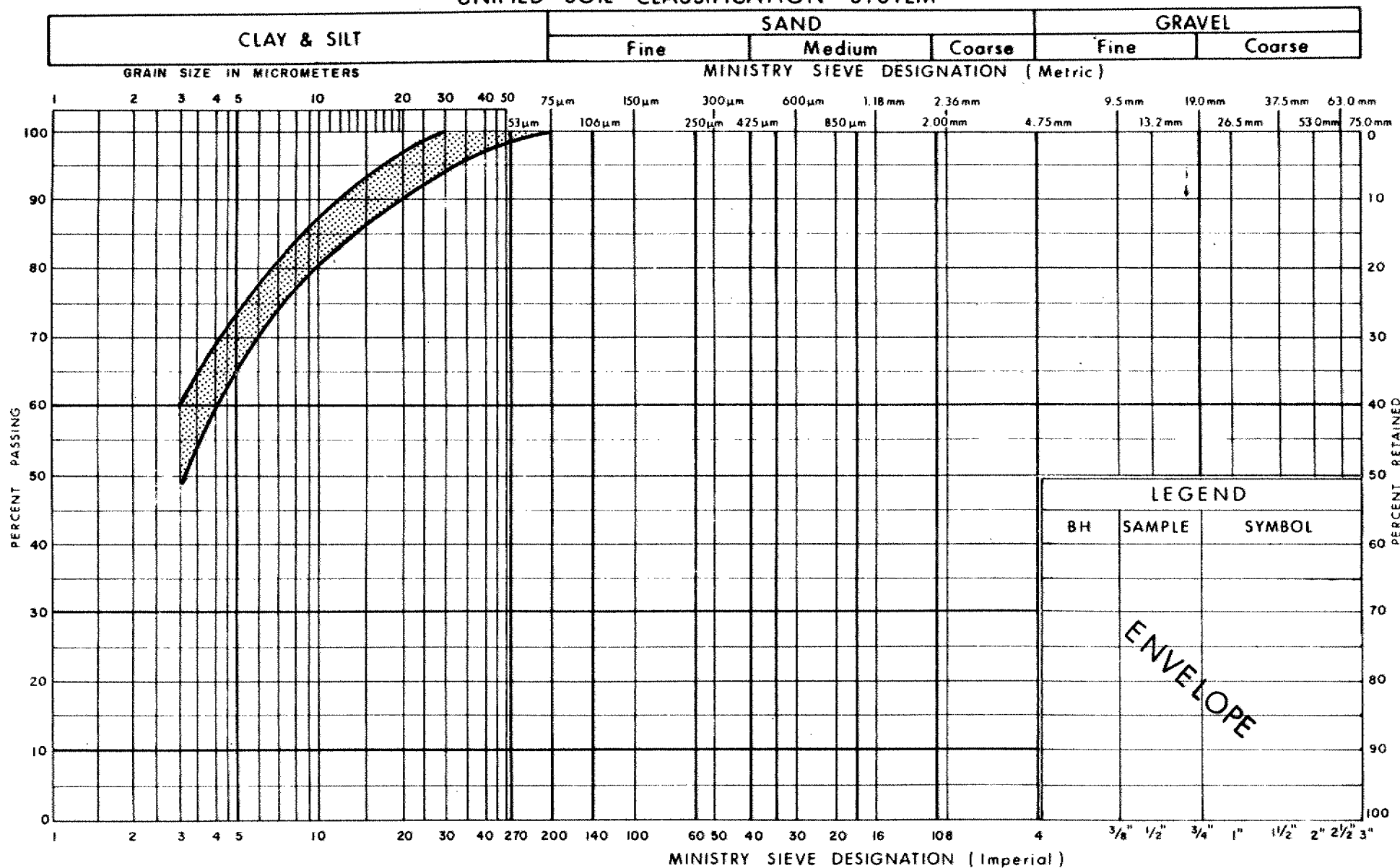
Ministry of  
Transportation

**GRAIN SIZE DISTRIBUTION**  
SILT, TRACE / SOME SAND TO SILT

FIG No 4

W P 65-67-04

## UNIFIED SOIL CLASSIFICATION SYSTEM



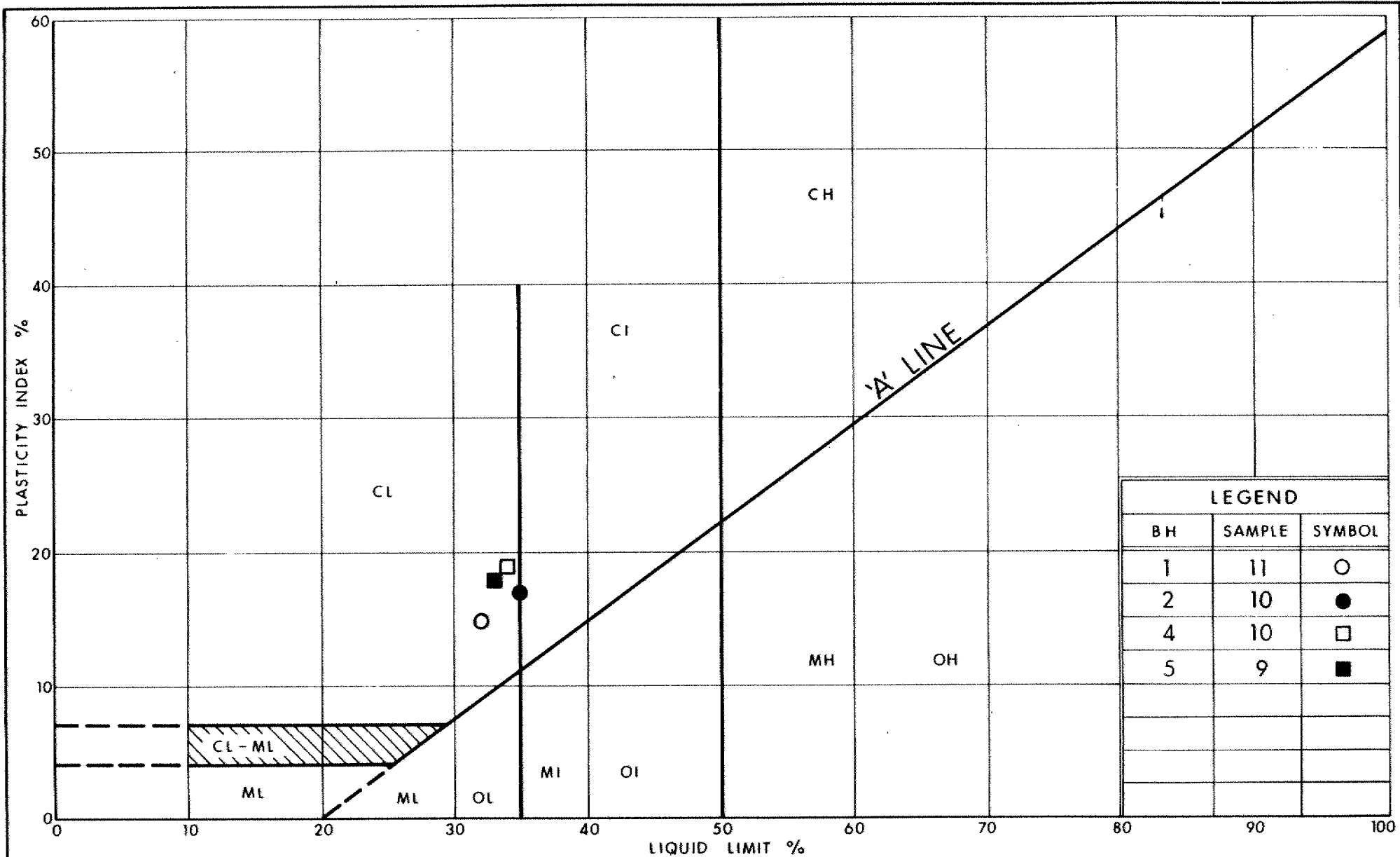
Ministry of  
Transportation

## GRAIN SIZE DISTRIBUTION

### CLAYEY SILT

FIG No 5

W P 65-67-04



Ministry of  
Transportation

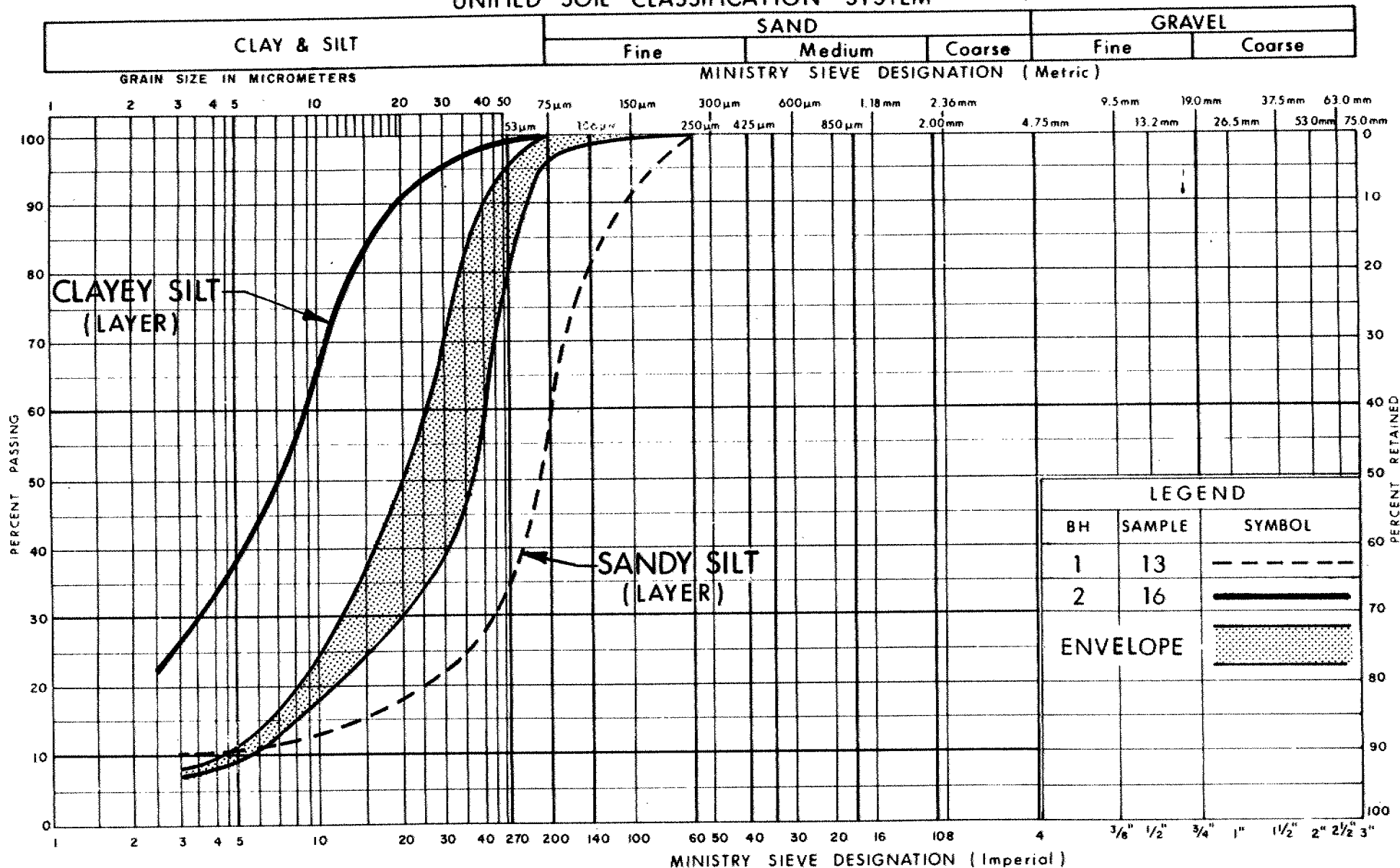
Ontario

# PLASTICITY CHART CLAYEY SILT

FIG No 6

W P 65-67-04

## UNIFIED SOIL CLASSIFICATION SYSTEM



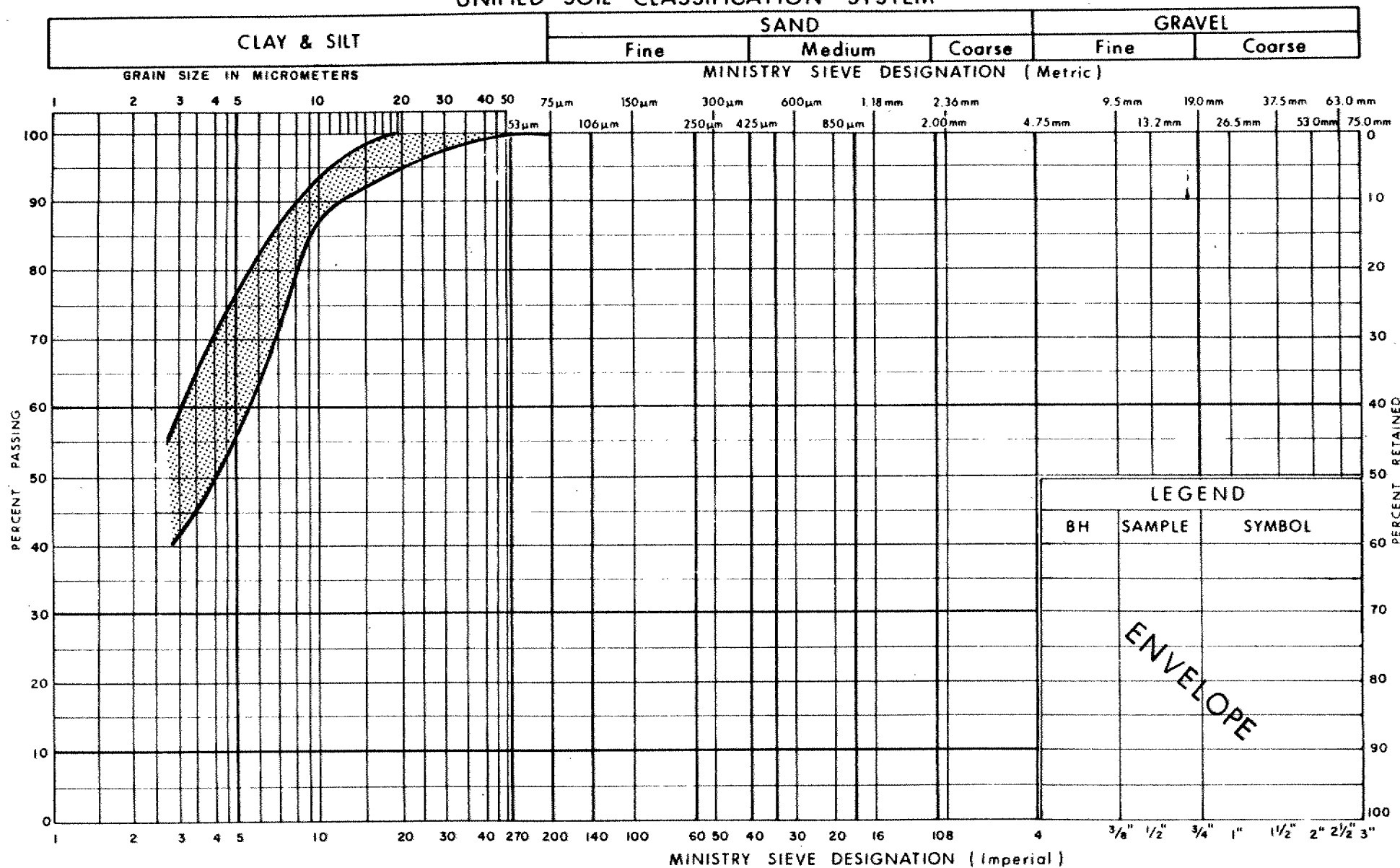
Ministry of  
Transportation

**GRAIN SIZE DISTRIBUTION**  
**SILT, WITH RANDOM LAYERS OF SILTY SAND**

FIG No 7

W P 65-67-04

## UNIFIED SOIL CLASSIFICATION SYSTEM

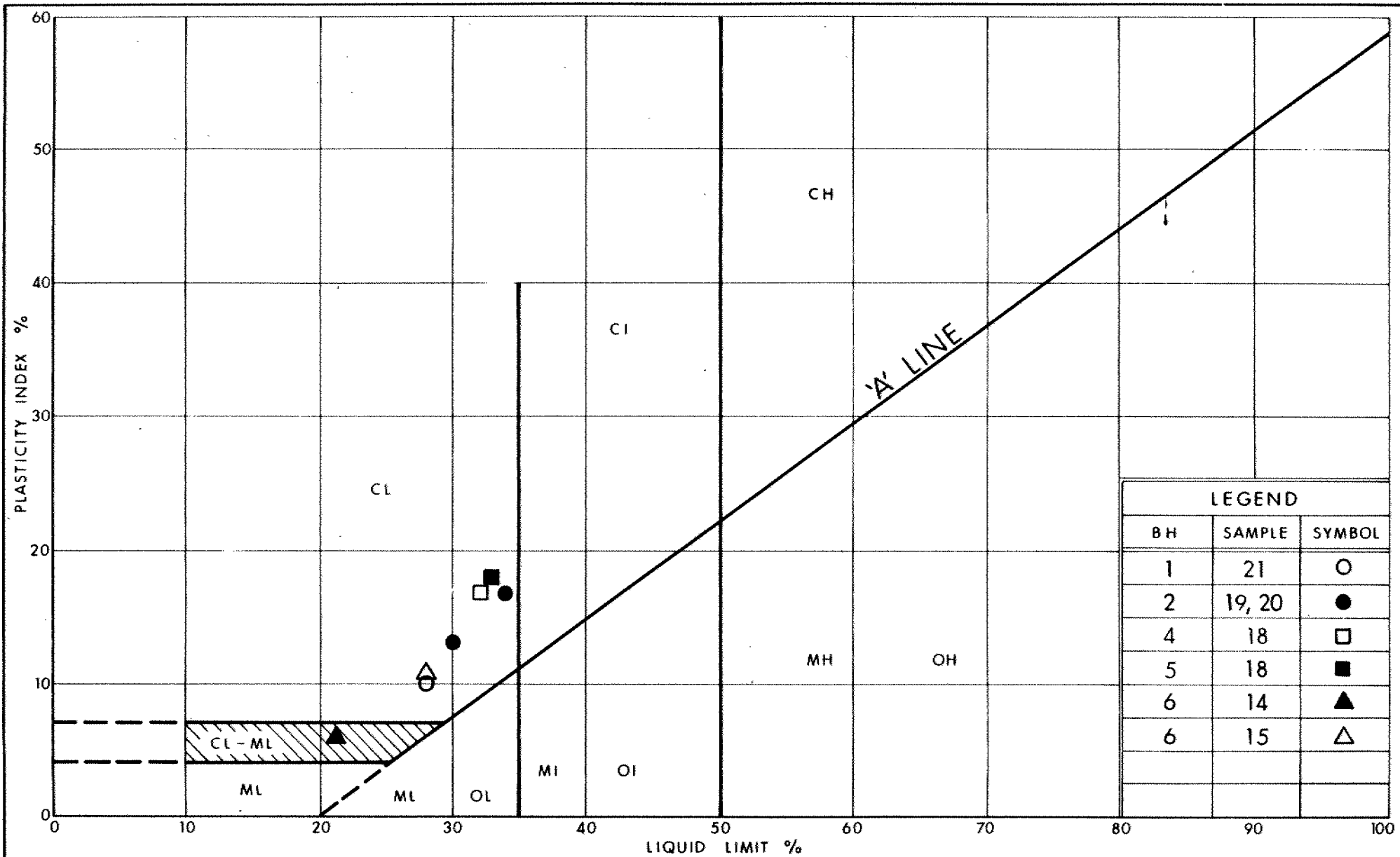


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Transportation

**GRAIN SIZE DISTRIBUTION**  
**CLAYEY SILT**  
WITH RANDOM LAYERS OF SILT

FIG No 8

W P 65-67-04

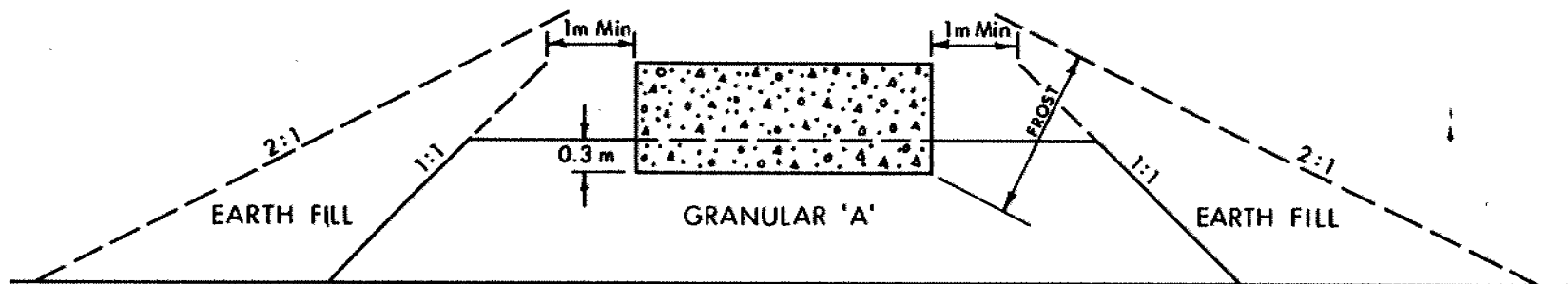


Ministry of  
Transportation

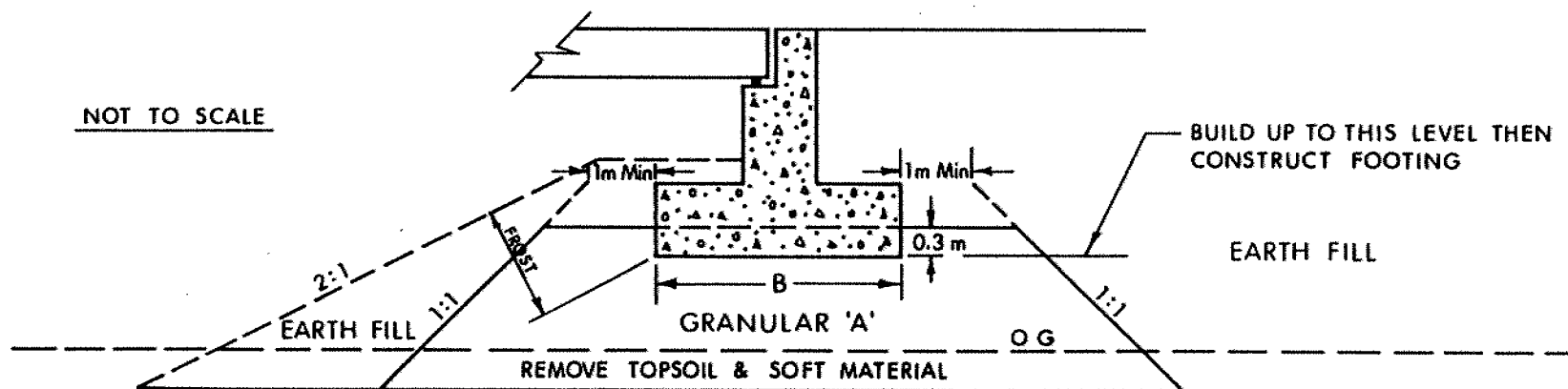
PLASTICITY CHART  
CLAYEY SILT  
WITH RANDOM LAYERS OF SILT

FIG No 9

W P 65-67-04



X SECTION



LONGITUDINAL SECTION

NOTES:

- 1 - REMOVE TOPSOIL &/OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' & EARTH FILL.
- 2 - PLACE GRANULAR 'A' & EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO CURRENT M T O STANDARDS.
- 3 - CONSTRUCT CONCRETE FOOTING.
- 4 - PLACE REMAINDER OF GRANULAR 'A' & EARTH FILL AS REQUIRED.



Ontario

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Transportation

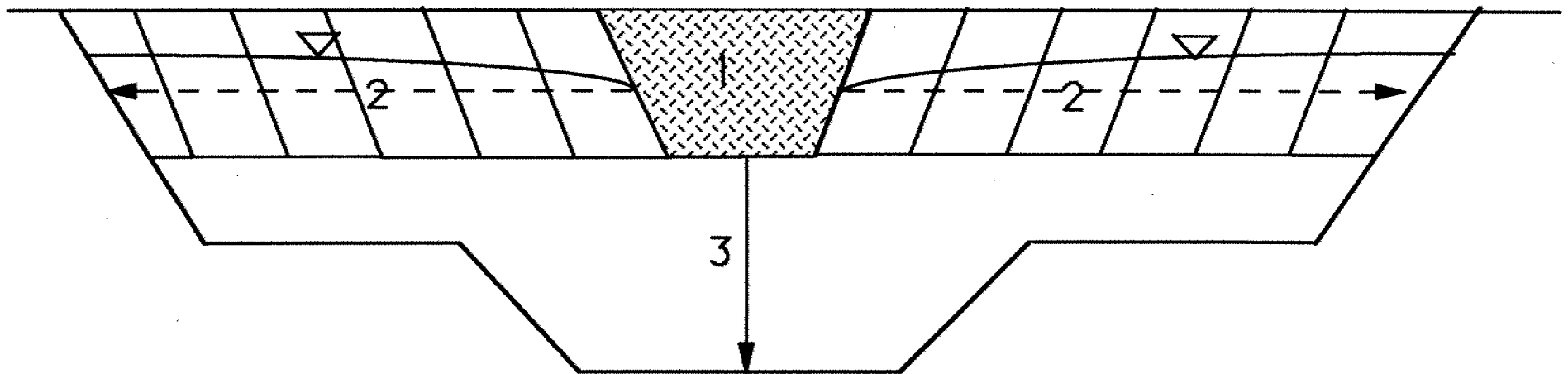
ABUTMENT ON COMPACTED FILL  
SHOWING GRANULAR 'A' CORE

FIG No 10

W P 65-67-04

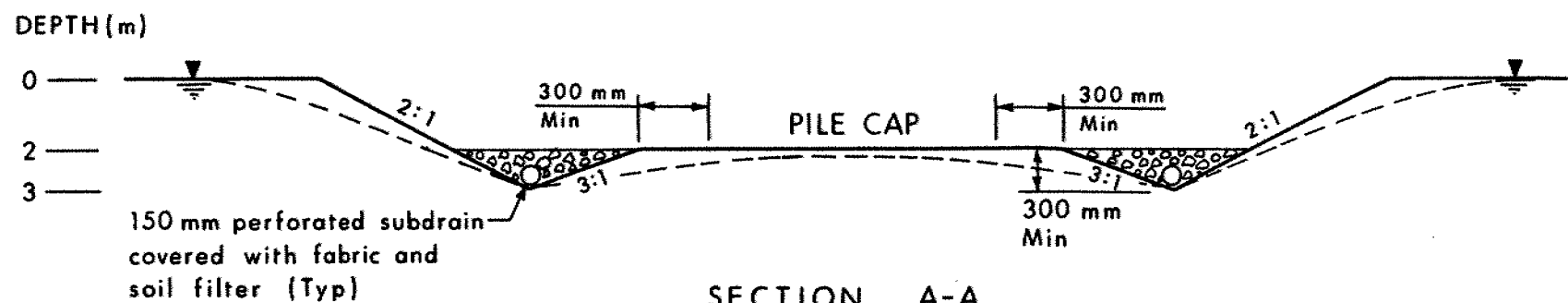
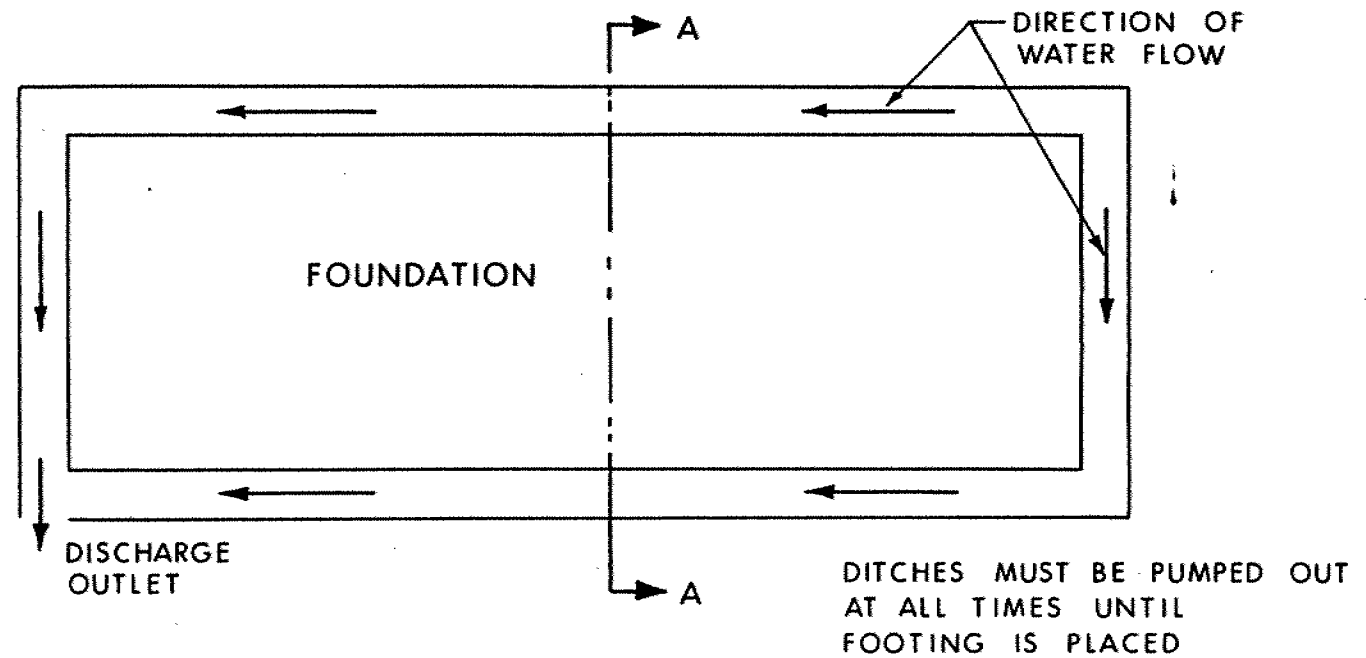


**FIG. 11 - GRAVITY DRAINAGE SCHEME**

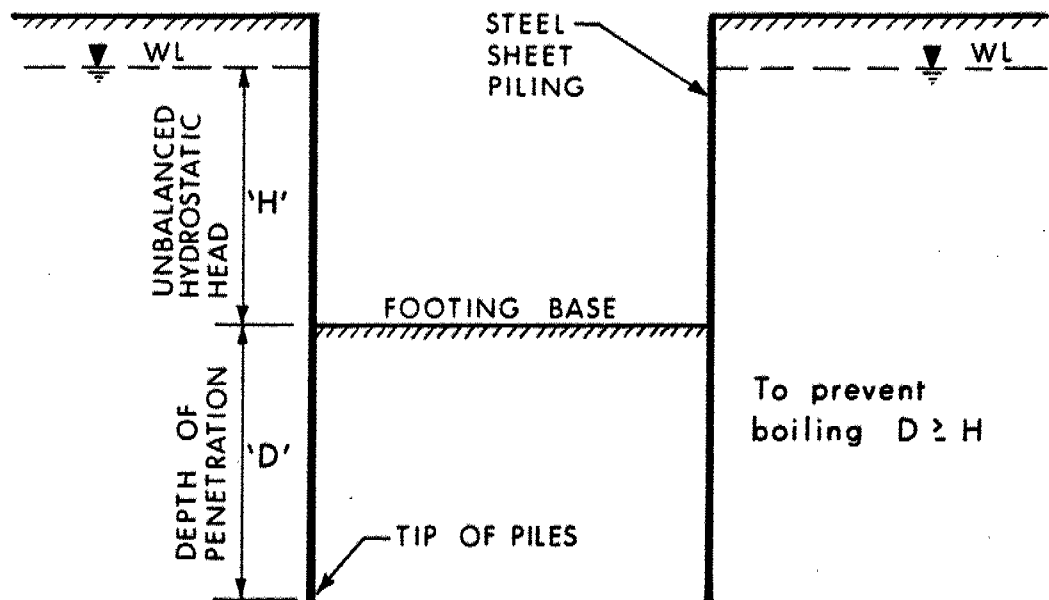


- 1 EXCAVATE INITIAL SUMP PUMP TRENCH AND ALLOW GRAVITY DRAINAGE
- 2 EXCAVATE Laterally TO EDGE OF EXCAVATION, ALLOWING GRAVITY DRAINAGE IN PROCESS
- 3 PROGRESS TO DESIGNED DEPTH BY REPEATING (1) AND (2)

**WP 65-67-04**



SECTION A-A  
(NTS)  
DEWATERING SCHEME - PERIMETER DITCHES



## COFFERDAM CONSTRUCTION

WP 65-67-04

FIG 13

## EXPLANATION OF TERMS USED IN REPORT

**N VALUE:** THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS  $\bar{N}$ .

**DYNAMIC CONE PENETRATION TEST:** CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

**CONSISTENCY:** COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH ( $c_u$ ) AS FOLLOWS:

$c_u$ (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

**DENSENESS:** COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

**RECOVERY:** SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

**MODIFIED RECOVERY:** SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

**JOINTING AND BEDDING:**

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### MECHANICAL PROPERTIES OF SOIL

$m_v$	$kPa^{-1}$	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	$m^2/s$	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_t$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	$kg/m^3$	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	$kN/m^3$	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	$kg/m^3$	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	$kN/m^3$	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	$kg/m^3$	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	$kN/m^3$	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	$kg/m^3$	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	$m^3/s$	RATE OF DISCHARGE
$\gamma_d$	$kN/m^3$	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
$\rho_{sat}$	$kg/m^3$	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
$\gamma_{sat}$	$kN/m^3$	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	$kg/m^3$	DENSITY OF SUBMERGED SOIL	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE	j	$kN/m^3$	SEEPAGE FORCE
$\gamma'$	$kN/m^3$	UNIT WEIGHT OF SUBMERGED SOIL						

# RECORD OF BOREHOLE No 1

1 OF 2

METRIC

W.P. 65-67-04 LOCATION Co-ords: N 4 784 548.0 E 260 498.0 ORIGINATED BY TS  
DIST 4 HWY 403 BOREHOLE TYPE HS Auger, BW Casing, Rock Coring COMPILED BY TS  
DATUM Geodetic DATE 91 07 10-11 CHECKED BY PP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
230.6	Asphaltic Roadway Surface															
0.0	Sand, trace to some Silt trace Gravel, trace Organics, trace Asphalt (Fill Material)		1	SS	14											
227.1	Brown with Black inclusions, Compact to Dense		2	SS	35											
3.5	Silt		3	SS	48											
			4	SS	74											
			5	SS	55											
	Dense to Very Dense		6	SS	38											
	Compact		7	SS	24											
	Brown		8	SS	13											
	Grey		9	SS	30											
220.7			10	SS	12											
9.9 219.9	Clayey Silt Grey, Very Stiff		11	SS	24											
10.7			12	SS	27											
	Sandy Silt		13	SS	42											
			14	SS	14											
			15	SS	6											
			16	SS	7											
	Silt, trace Sand		17	SS	18											
	Loose to Compact		18	SS	15											
	Random Interbedded Layers of Clayey Silt		19	SS	7											
200.1	Stiff to Very Stiff															

30.5

Continued

+3, x5: Numbers refer to  
Sensitivity

20  
15-5 (k) STRAIN AT FAILURE  
10

Continued

# RECORD OF BOREHOLE No 1

2 OF 2

METRIC

W.P. 65-67-04 LOCATION Co-ords: N 4 784 548.0 E 260 498.0 ORIGINATED BY TS  
 DIST 4 HWY 403 BOREHOLE TYPE HS Auger, BW Casing, Rock Coring COMPILED BY TS  
 DATUM Geodetic DATE 91 07 10-11 CHECKED BY PP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
200.1	Continued															
30.5	Cloey Silt		20	SS	12	200										
	Stiff to Very Stiff					198										
			21	SS	17	196										
193.6						194										
37.0	Bedrock - Dolostone		22	RC	REC											
192.1	Light to Medium Grey, Unweathered, Medium Strong				94%											RQD = 80%
38.5	End of Borehole															

# RECORD OF BOREHOLE No 1A

1 OF 1

METRIC

W.P. 65-67-04 LOCATION Co-ords: N 4 784 534.1 E 260 500.0 ORIGINATED BY TS  
 DIST 4 HWY 403 BOREHOLE TYPE HS Auger COMPILED BY LD  
 DATUM Ceodetic DATE 91 07 16 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
230.6	Asphaltic Roadway Surface																
0.0	Sand trace Silt, trace Gravel						230										
229.1	(Fill Material)																
1.5			1	SS	12												
	Silt trace Sand, trace Gravel		2	SS	14		228										
	(Fill Material)																
	Compact		3	SS	*		226										
224.5	Brown																
6.1	Grey		4	SS	38		224										
	Silt																
222.5	Compact to Dense		5	SS	24												
8.1	End of Borehole • Probable Boulder																

+3, x5: Numbers refer to  
Sensitivity

20  
15-20 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 2

1 OF 2

METRIC

W.P. 65-67-04 LOCATION Co-ords: N 4 784 558.8; E 260 509.3 ORIGINATED BY LD  
DIST 4 HWY 403 BOREHOLE TYPE HS Auger, BW Casing, Rock Coring COMPILED BY LD  
DATUM Geodetic DATE 91 07 08-09 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT 7 kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
230.1	Ground Surface													
0.0	Silt with Random Zones of Clayey Silt (Fill Material)					*								
228.1	Brown, Compact		1	SS	23									
2.0			2	SS	40									
	Silt, some Clay		3	SS	80									
	Dense to Very Dense		4	SS	81									
			5	22	36									1 7 78 14
			6	SS	39									0 0 86 14
			7	SS	68									
			8	SS	53									
220.2			9	SS	25									
9.9 219.4	Clayey Silt Grey, Very Stiff		10	SS	16									0 0 54 46
10.7			11	SS	38									
			12	SS	37									
			13	SS	42									
	Silt		14	SS	59									0 3 89 8
	with Random Layers of Silty Sand		15	SS	9									
	Dense to Very Dense		16	SS	11									0 0 80 20
			17	SS	26									
	Random Interbedded Layers of Clayey Silt		18	SS	10									
	Stiff to Very Stiff													
199.6 30.5														

Continued

+3, x5: Numbers refer to  
Sensitivity

20  
15-5 (%) STRAIN AT FAILURE  
10

Continued



# RECORD OF BOREHOLE No 2

2 OF 2

METRIC

W.P. 65-67-04 LOCATION Co-ords: N 4 784 558.8; E 260 509.3 ORIGINATED BY LD  
DIST 4 HWY 403 BOREHOLE TYPE HS Auger, BW Casing, Rock Coring COMPILED BY LD  
DATUM Geodetic DATE 91 07 08-09 CHECKED BY PP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
199.6	Continued		19	SS	13											0 0 55 45
30.5						198										
			20	SS	12											0 0 68 32
194.1	Bedrock - Dolostone Light to Medium Grey, Unweathered, Medium Strong		21	RC	REC 100%											RQD = 89%
36.0			22	RC	REC 100%	192										RQD = 80%
191.2																
38.9	End of Borehole															
	* C W L not Established															

# RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. 65-67-04 LOCATION Co-ords: N 4 784 455.2; E 260 516.2 ORIGINATED BY TS  
 DIST 4 HWY 403 BOREHOLE TYPE HS Auger COMPILED BY TS  
 DATUM Geodetic DATE 91 07 15 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20   40   60   80   100	20   40   60   80   100	W <sub>p</sub> W      W <sub>L</sub>	WATER CONTENT (%) 10   20   30			
230.7	Asphaltic Roadway Surface													
0.0	Sand, trace Silt, trace Gravel (Fill Material)					230								
227.7	Brown, Very Loose to Compact		1	SS	2									
3.0	Silt with Random Zones of Clayey Silt (Fill Material)  Brown, Loose to Compact		2	SS	14		228							
			3	SS	7		226							
			4	SS	26		224							
			5	SS	*		222							
221.3			6	SS	10		220							
9.4	Silt, trace Sand - Black Organics		7	SS	20									
220.0	Compact - Brown		8	SS	14									
10.7	Clayey Silt		9	SS	49									
219.3	Grey, Very Stiff	10	SS	28										
11.4	Silt with Layers of Silty Sand													
218.1	Grey, Compact to Dense													
12.6	End of Borehole  • Sampler Bouncing (Probable Boulder)													

# RECORD OF BOREHOLE No 4

1 OF 2

METRIC

W.P. 65-67-04 LOCATION Co-ords: N 4 784 484.0; E 260 520.0 ORIGINATED BY TS  
DIST 4 HWY 403 BOREHOLE TYPE HS Auger, BW Casing, Rock Coring COMPILED BY TS  
DATUM Geodetic DATE 91 07 10-11 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT 7 kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
230.8	Asphaltic Roadway Surface																
0.0	Sand, some Silt, trace Clay (Fill Material)						230										0 50 40 10
228.8	Compact		1	SS	28		228										0 10 70 20
2.0			2	SS	16		226										0 7 69 24
	Silt with Random Zones of Clayey Silt (Fill Material)		3	SS	46		224										2 28 53 17
	Brown to Grey, Compact		4	SS	17		222										0 21 62 17
221.5			5	SS	23		220										0 2 88 10
9.3	Silt, trace Sand Brown, Compact		6	SS	25		218										0 0 50 50
220.1			7	SS	23		216										
10.7	Clayey Silt Grey, Very Stiff		8	SS	17		214										
218.6			9	SS	20		212										
12.2			10	SS	13		210										
			11	SS	29		208										
	Dense to Very Dense		12	SS	58		206										
	Silt with Random Layers of Silty Sand		13	SS	32		204										
	Grey, Compact		14	SS	16		202										
	Random Interbedded Layers of Clayey Silt		15	SS	19												
	Stiff to Very Stiff		16	SS	12												
			17	SS	20												
200.3																	

30.5

Continued

+3, x<sup>5</sup>: Numbers refer to  
Sensitivity

20  
15-5 (%) STRAIN AT FAILURE  
10

Continued

# RECORD OF BOREHOLE No 4

2 OF 2 METRIC

W.P. 65-67-04 LOCATION Co-ords: N 4 784 484.0; E 260 520.0 ORIGINATED BY TS  
 DIST 4 HWY 403 BOREHOLE TYPE HS Auger, BW Casing, Rock Coring COMPILED BY TS  
 DATUM Geodetic DATE 91.07.10-11 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT 7 KN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
200.3	<b>Continued</b>		18	SS	20												
30.5	Clayey Silt with Random Layers of Silt  Very Stiff																
			19	SS	17												
193.0																	
37.8	Bedrock - Dolostone																
191.5	Light Gray to Medium Gray, Unweathered, Medium Strong		20	RC	REC 100%											RQD = 80%	
39.3	End of Borehole																

# RECORD OF BOREHOLE No 5

1 OF 2 METRIC

W.P. 65-67-04 LOCATION Co-ords: N 4 784 513.2; E 260 503.3 ORIGINATED BY TS  
 DIST 4 HWY 403 BOREHOLE TYPE HS Auger, BW Casing, Rock Coring COMPILED BY LD  
 DATUM Geodetic DATE 91 07 08-09 CHECKED BY PP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w <sub>p</sub> NATURAL MOISTURE CONTENT w LIQUID LIMIT w <sub>L</sub> WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE						
230.7	Ground Surface									
0.0	Sand and Silt, trace Gravel (Fill Material)		1	SS	6					
227.2	Brown, Loose to Compact		2	SS	13					0 46 42 12
3.5	Silt with Random Zones of Clayey Silt (Fill Material)		3	SS	34					
	Brown, Loose to Dense		4	SS	12					0 10 60 30
223.1			5	SS	9					
7.6	Silt, trace Sand		6	SS	7					
	Brown, Loose to Compact		7	SS	21					0 11 81 8
220.8			8	SS	21					
9.9	Clayey Silt		9	SS	10					0 0 60 40
219.9	Grey, Very Stiff		10	SS	24					
10.8			11	SS	22					
			12	SS	20					
	Silt with Random Layers of Silty Sand		13	SS	16					0 0 93 7
	Loose to Compact		14	SS	16					
			15	SS	18					
			16	SS	8					
	Random Interbedded Layers of Clayey Silt		17	SS	8					
	Stiff to Very Stiff									
200.2										

30.5

Continued

+3, x5: Numbers refer to Sensitivity

20 15-5 (%) STRAIN AT FAILURE 10

Continued

# RECORD OF BOREHOLE No 5

2 OF 2

METRIC

W.P. 85-67-04 LOCATION Co-ords: N 4 784 513.2; E 260 503.3 ORIGINATED BY TS  
 DIST 4 HWY 403 BOREHOLE TYPE HS Auger, BW Casing, Rock Coring COMPILED BY LD  
 DATUM Geodetic DATE 91 07 08-09 CHECKED BY PP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT 7 kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
200.2	Continued		18	SS	15	200										0 0 55 45
30.5						198										
193.7			19	TW	PH	196										
37.0						194										
190.8	Bedrock - Dolostone Light to Medium Grey, Unweathered, Medium Strong		20	RC	REC 95%	192										RQD = 95%
			21	RC	REC 96%											RQD = 85%
39.9	End of Borehole  * G W L not Established															

# RECORD OF BOREHOLE No 6\*

1 OF 2

METRIC

W.P. 65-67-04 LOCATION Co-ords: N 4 784 515.7; E 260 511.0 ORIGINATED BY MK  
DIST 4 HWY 403 BOREHOLE TYPE HS Auger COMPILED BY MK  
DATUM Geodetic DATE 76 03 25-26 CHECKED BY PP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
230.6	Ground Surface															
0.0						230										
	Silt, some Sand, to Silty Sand (Fill Material)  Loose to Dense		1	SS	8	228										0 20 74 6
			2	SS	39	226										
			3	SS	17	224										6 47 41 6
			4	SS	33	222										0 17 78 7
223.3			5	SS	9	220										0 18 76 6
7.3	Silt, some Sand  Loose to Compact		6	SS	17	218										0 1 69 30
219.9			7	SS	19	216										0 0 92 8
10.7 219.2	Clayey Silt Very Stiff		8	SS	39	214										0 0 99 1
11.4			9	SS	54	212										0 0 98 2
			10	SS	83	210										0 7 87 6
	Silt, some Sand to Silt with Random Layers of Clayey Silt  Loose to Very Dense		11	SS	20	208										
			12	SS	24	206										0 0 95 5
			13	SS	6	204										
202.9			14	SS	9	202										
27.7																
200.1																
30.5																

Continued

+3, x5: Numbers refer to  
Sensitivity

20  
15-5 (%) STRAIN AT FAILURE  
10

Continued

RECORD OF BOREHOLE No 6\*

2 OF 2

METRIC

W.P. 65-67-04 LOCATION Co-ords: N 4 784 515.7; E 260 511.0 ORIGINATED BY MK  
DIST 4 HWY 403 BOREHOLE TYPE HS Auger COMPILED BY MK  
DATUM Geodetic DATE 76 03 25-26 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT 7 kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
200.1	Continued  Clayey Silt with Random Layers of Silt  Stiff to Very Stiff		15	SS	11		200										
30.5							198										
			16	TW	PH		196										
193.3			17	SS	9		194										
37.3	End of Borehole  * Formerly BH No 13 (WP 65-67-01)																



# RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 65-67-04 LOCATION Co-ords: N 4 784 578.0; E 260 498.0 ORIGINATED BY LD  
 DIST 4 HWY 403 BOREHOLE TYPE HS Auger COMPILED BY TS  
 DATUM Geodetic DATE 91 07 15 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
230.6	Asphaltic Roadway Surface																
0.0	Sand, trace Silt, trace Gravel (Fill Material)						230										
228.6	Brown, Dense		1	SS	38												
2.0	Silt, with Random Zones of Clayey Silt, some Organics (Fill Material)		2	SS	9		228										
225.9	Brown to Black, Loose						226										
4.7	Silt, some Sand  Brown, Compact Grey, Dense		3	SS	9												
			4	SS	12												
			5	SS	12												
			6	SS	15		224										
			7	SS	38												
			8	SS	30		222										
221.5			9	SS	12												
9.1	Clayey Silt																
219.9	Grey, Very Stiff						220										
10.7	Silt, some Sand with Layers of Silty Sand		10	SS	51												
			11	SS	56												
218.0	Grey, Dense to Very Dense		12	SS	46												
12.6	End of Borehole																

# **ROCK CORE DESCRIPTION** **WP 65-67-04**

Page 1 of 1

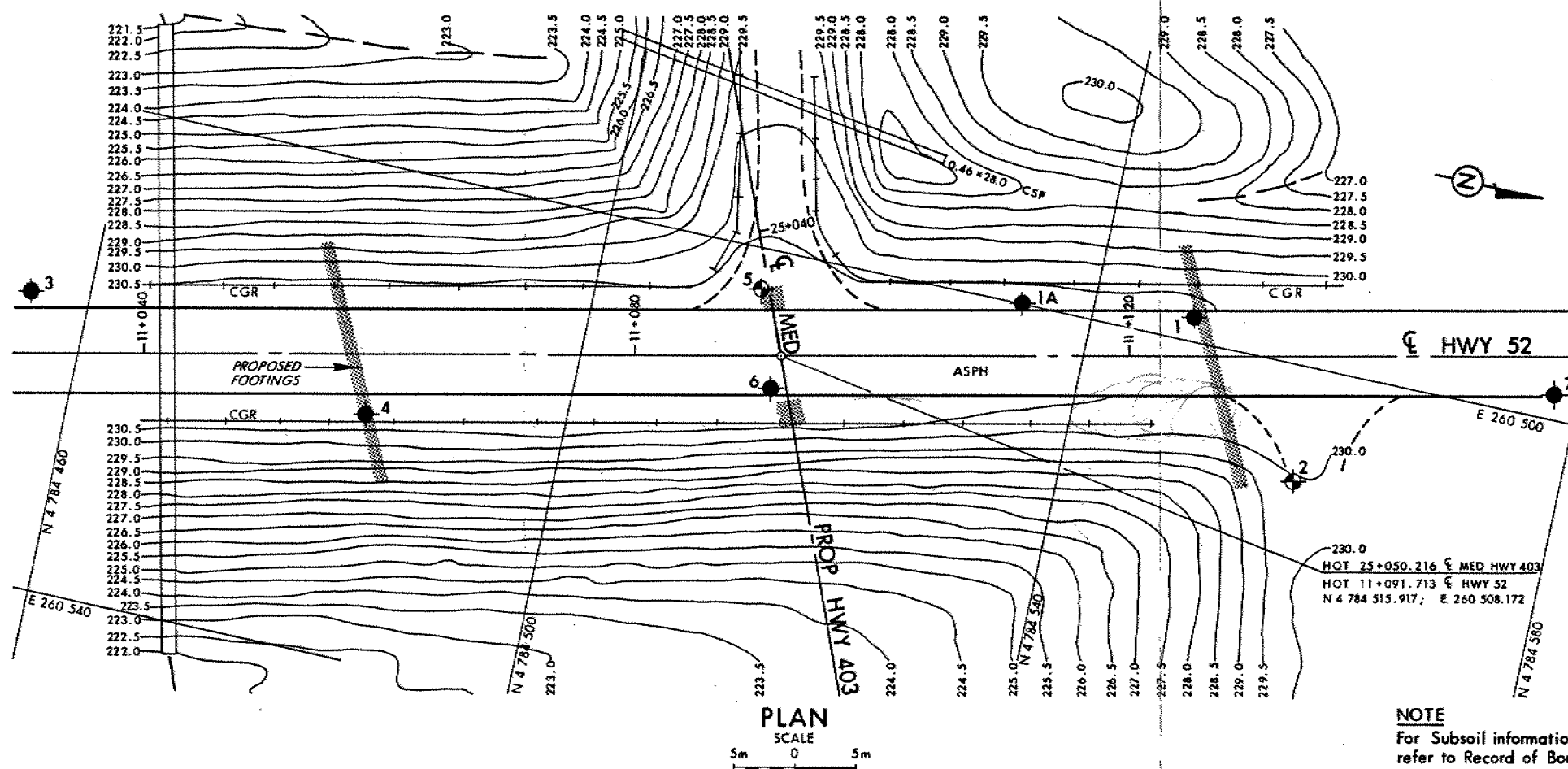
CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	22	36.96-38.48	94	80	36.96-38.48	<b>DOLOSTONE</b> with stylolites and abundant vugs containing calcite crystals, light grey to light olive grey to medium dark grey; fine to medium grained; medium strong; unweathered to slightly weathered; fractures moderately close to close spaced, flat to dipping, undulating, smooth to rough.
2	21	35.97-37.39	100	89	35.97-38.91	<b>DOLOSTONE</b> with stylolites and abundant vugs containing calcite crystals, light grey to light olive grey to medium dark grey; fine to medium grained; medium strong; unweathered to slightly weathered; fractures moderately close to very close spaced, flat to dipping, undulating, smooth to rough.
	22	37.39-38.91	100	80		
4	20	37.80-39.32	100	80	37.80-39.32	<b>DOLOSTONE</b> with stylolites and abundant vugs containing calcite crystals, light grey to light olive grey to medium dark grey; fine to medium grained; medium strong; unweathered to slightly weathered; fractures moderately close to close spaced, flat to dipping, undulating, smooth to rough.
5	20	37.03-38.56	95	95	37.03-39.93	<b>DOLOSTONE</b> with stylolites and abundant vugs containing calcite crystals, light grey to light olive grey to medium dark grey; fine to medium grained; medium strong; unweathered to slightly weathered; fractures moderately close to close spaced, flat to dipping, undulating, smooth to rough.
	21	38.56-39.93	96	85		

\*CR = CORE RECOVERY

\*RQD = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section



**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES UNLESS  
OTHERWISE SHOWN. STATIONS  
IN KILOMETRES + METRES.

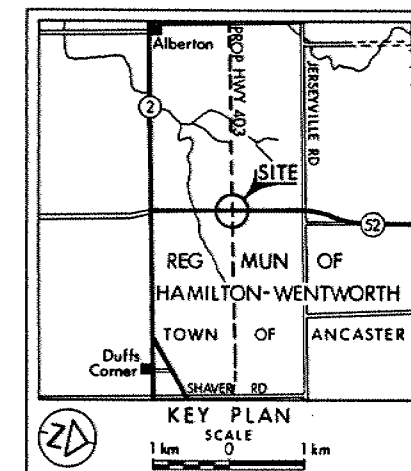
CONT No  
WP No 65-67-04

HWY 52 U'PASS

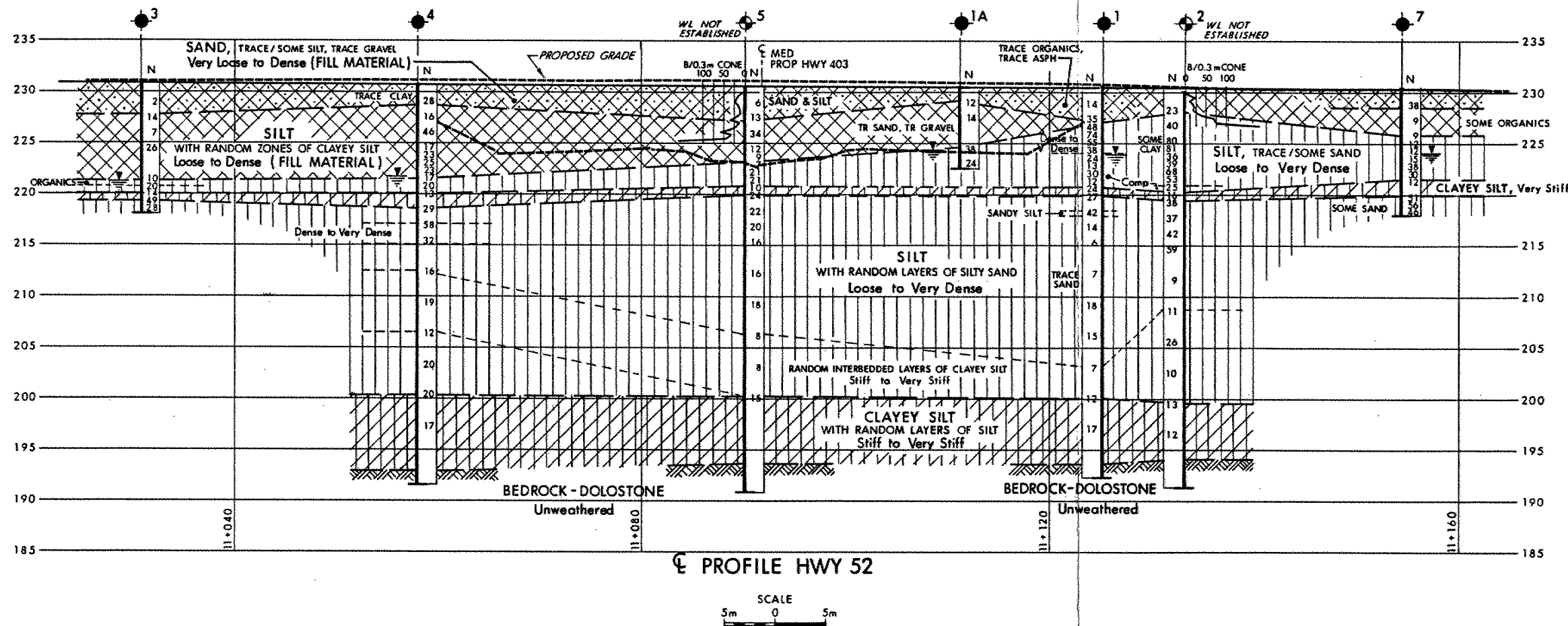
BORE HOLE LOCATIONS & SOIL STRATA



SHEET



**NOTE**  
For Subsoil information of BH No 6  
refer to Record of Borehole Sheets.



**LEGEND**

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊙ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W/L at time of investigation 1976 03 and 1991 07

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	230.6	4784 548.0	260 498.0
1A	230.6	4784 534.1	260 500.0
2	230.1	4784 558.8	260 509.3
3	230.7	4784 455.2	260 516.2
4	230.8	4784 484.0	260 520.0
5	230.7	4784 513.2	260 503.3
6	230.6	4784 515.7	260 511.0
7	230.6	4784 578.0	260 498.0

**NOTE**

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV	DATE	BY	DESCRIPTION
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Geacres No 40P1-85

HWY No 403	SUBM'D TS	CHECKED TS	DATE 1991 10 29	DIST 4
	DRAWN RS	CHECKED CP	APPROVED	SITE 36-260
				DWG 656704-A