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CONT. No. 90-36

W. O. No.

STR. SITE No.

HWY. No. 417

LOCATION W.B. Hwy 417 over Acres Rd.
(Structure #7)

No. of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

RPN

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

CONT. 90-36

WP 120-87-10

DIST 9

HWY 417

STR SITE 3-536

Hwy. 417 W.B. Overpass Structure
at Acres Road and Associated Ramps

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FOUNDATION INVESTIGATION REPORT
For
Hwy. 417 W.B. Overpass Structure
at Acres Road and Associated Ramps
Structure No. 7
WP 120-87-10, Site No. 3-536
Hwy. 417, District 9, Ottawa

INTRODUCTION

This report summarizes the results obtained from a Foundation Investigation implemented at the aforementioned site. A two span structure is proposed to carry Hwy. 417 WB and the Richmond Road to Hwy. 417 WB ramp over the realigned Acres Road.

Discussion and recommendations pertaining to the subsurface conditions, structure foundations, approach embankments and related earthworks are provided in this report.

SITE DESCRIPTION AND GEOLOGY

The site of the proposed structure is located immediately south of the existing Hwy. 417 WB and bisected by the existing Hwy. 417 EB in the City of Nepean, Ottawa-Carleton Municipality. It is located immediately east and adjacent to the existing Acres Road overpass. The median between Hwy. 417 WB and Hwy. 417 EB exists within the site and consists of grassland and contains a storm sewer that is aligned parallel to the existing Hwy. 417.

The terrain surrounding the site is generally flat to gently undulating. Immediately south of the proposed structure, the land is used primarily for agriculture. Residential developments exist north of the site.

Physiographically, the site lies in the area known as the Ottawa Valley Clay Plains founded in the Lowlands of the St. Lawrence. The deposit consists of clay plains interrupted by ridges of rock or sand. Fault scarps are also evident within the area, an illustration of the numerous normal faults that dominate the region.

The bedrock in the area is of the Gull River Formation of the Middle Ordovician Period. It consists of interbedded silty dolostone, shaley limestone and fine grained quartz sandstone. The overburden was deposited during and immediately following the Wisconsin glaciation at which time the area was depressed from the effect of the glaciation. Following the retreat of the glacier, the brackish waters of the Champlain Sea flooded the area and then gradually receded as the land rebounded with the deposition of sediments to its present level.

FIELD INVESTIGATION

The fieldwork for the investigation was carried out between 88 07 18 and 88 07 23 and consisted of 10 sampled boreholes accompanied by dynamic cone penetration tests. Continuous flight hollow stem auger equipment and washboring techniques were used to advance the boreholes in the overburden. Subsoil samples were retrieved at selected intervals by a split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586) and by shelby tubes, manually or hydraulically advanced. Samples were identified in the field and then returned to the laboratory for applicable testing. Bedrock was proven at a number of locations using conventional rock coring methods.

Water levels were obtained in the open boreholes until approximate stabilized levels were observed.

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

LABORATORY ANALYSIS

To identify the behaviour, gradation, properties and characteristics of the soil, various laboratory testing were performed. Tests included:

- 1) Atterberg Limit Tests
- 2) Grain Size Analyses
- 3) Natural Moisture Contents
- 4) Undrained Unconsolidated Tests (Quick Triaxial)
- 5) Unconfined Compression Tests
- 6) Consolidation Tests

Laboratory test results have been summarized and are included in the Appendix of this report.

SUBSURFACE CONDITIONS

Subsoil conditions are generally uniform across the site. The surficial layer consists of a generally firm to stiff cohesive silty clay to clay and extends to a maximum thickness of 3.8 metres. Underlying this layer is a deposit of clayey silt interbedded with irregular layers or seams of silty sand. The maximum thickness of this deposit is 7.7 metres. A deep deposit (maximum 19.8 m) of sand to silty sand is the subsequent underlying deposit and this in turn is underlain by a heterogeneous mixture of sand, gravel and boulders (glacial till). Approximately 1.5 to 4 metres of the till deposit was penetrated before encountering the silty dolostone bedrock.

Two isolated areas of fill material were also discovered in the investigation. A mixture of clayey silt, sand and gravel was encountered at the location of the existing Acres Road Overpass south approach. Fill material consisting of sand and gravel was encountered adjacent to the existing Graham Creek Culvert.

The boundaries between the various soil types, in situ and laboratory test results as well as stabilized ground water levels, are shown on the attached Record of Borehole Sheets in the Appendix. A plan of the site illustrating the locations and elevations of the boreholes and subsoil stratigraphical sections are also provided on Dwg. 1208710-A & 1208710-B.

A detailed description of the subsurface conditions encountered is given below.

Fill Material

As mentioned above, fill material was encountered at two areas of the site and its composition varied at either location. A cohesive mixture of clayey silt, sand and gravel was sampled adjacent to the existing Acres Road Overpass (BH 7-3) which is the location of the proposed structure's west approach. Approximately 2.1 metres of stiff to very stiff fill material was encountered. Cohesionless sand and gravel fill material underlying a thin crust of clayey

silt, sand and gravel fill was encountered in the area of the existing Graham Creek culvert. This area is within the proposed structure's east approach. The fill penetrates to a depth of 6.6 metres.

Grain Size Distribution curves for the varying fill materials are provided in Figure 1 in the Appendix.

Silty Clay to Clay

The native surficial deposit spread across the site consists of a cohesive silty clay to clay ranging in thickness from 1.7 metres to 3.8 metres.

Atterberg Limit were obtained to evaluate the behaviour of this cohesive deposit and the results are plotted in Figure 2. A summary of the indices is provided in Table 1 & 2 below. Unit weights are also included:

Table 1 - Clay

	<u>Range</u>	<u>Avg.</u>
Natural Moisture Content (w%)	32-48	40
Liquid Limit (w _L %)	51-65	57
Plastic Limit (I _p %)	30-45	37
Unit Weight (kN/m ³)	17.4-18.8	18.3

Table 2 - Silty Clay

	<u>Range</u>	<u>Avg.</u>
Natural Moisture Content (w%)	35-48	40
Liquid Limit (w _L %)	35-45	40
Plastic Limit (w _p %)	19-29	25
Unit Weight (kN/m ³)	17.7-19.9	18.6

The test results reveal that the deposit varies randomly in plasticity ranging from intermediate (silty clay) to high (clay).

A grain size distribution envelope for this deposit as determined by mechanical analysis is given in Figure 3.

Undrained shear strengths of the soil were determined both by in situ vane tests and by laboratory tests, namely undrained unconsolidated (quick triaxial) and unconfined compression tests. The results are plotted on the Record of Boreholes in the Appendix and summarized in Table 3 below:

Table 3

Test Method	*Undrained Shear Strength (C _u) (kPa)	Sensitivity (S _e)
	Range	Range
Field Vane	70->120	2-5
Unconfined Compression	20-60	-
Undrained Unconsolidated	25-70	-

*Test data of similar soil from adjacent investigations (WP 120-87-06, 07, 08) incorporated in results.

Results reveal that the soil has a generally firm to stiff consistency and is of low to moderate sensitivity. It can be concluded from the results that the laboratory testing produced lower values attributable to disturbance induced during sampling and transportation. Consequently, shear strength values for design purposes can be safely assumed to be within the range of 60 to 70 kPa.

The results (e-log p curves) of two consolidation tests on representative samples obtained in the silty clay to clay deposit are shown in Figure 4. These tests indicated that this cohesive stratum has been preconsolidated in the past to an effective pressure ranging from 130 kPa to 220 kPa in excess of the existing effective overburden pressure.

Clayey Silt interbedded with Silty Sand

Underlying the native surficial deposit of silty clay to clay there exists a deposit of clayey silt interbedded with silty sand. This stratum extends to depths ranging from 4.6 metres to 10.7 metres below ground surface. The thickness of the stratum varies from 1.7 metres to 7.7 metres.

The major portion of the deposit may be described as cohesive clayey silt. Atterberg Limits were obtained to evaluate the soil's behaviour and the results are plotted in Figure 5. A summary of the indices is provided in Table 4 below. Unit weights are also included:

Table 4

	<u>Range</u>	<u>Avg.</u>
Water Content (w%)	25-45	32
Liquid Limit (w _L %)	21-34	27
Plastic Index (I _p %)	8-18	13
Liquid Index (I _L)	1.1-2.9	1.7
Unit Weight (kN/m ³)	16.6-18.4	17.8

The results reveal that the cohesive portion of the deposit is of low plasticity. In addition, the in-situ moisture contents generally exceed the liquid limit of the cohesive soil revealing that the soil is generally, very soft and of low shear strength.

A grain size distribution envelope for this deposit as determined by mechanical analyses is given in Figure 6.

Undrained shear strength measurements were determined both by in-situ vane tests and by laboratory tests, namely undrained unconsolidated (quick triaxial) and unconfined compression tests. The results are plotted on the Record of Boreholes in the Appendix and summarized in Table 5 below:

Table 5

Test Method	Undrained Shear Strength	Sensitivity
	(C _u) (kPa)	(S _t)
	Range	Range
Field Vane	44-100	3-7.5
Unconfined Compression	20-30	-
Undrained Unconsolidated	30-60	-

Due to the irregular nature of the deposit, that reveals numerous seams and layers of silty sand ranging in thickness from a few millimetres to 100 millimetres, interbedded within the clayey silt, the results provided in Table 5 are not necessary indicative of the shear strength of the clayey silt portion. In view of this consideration, the consistency of the clayey silt portion can be described as very soft to firm. The silty sand portion was generally very loose in relative density. For design purposes, an undrained shear strength of 40 kPa can be assumed for this stratum.

The results (e-log p curve) of a consolidation test on a representative sample of the clayey silt portion is shown in Figure 7. These tests indicated that the clayey silt has been preconsolidated in the past to an effective pressure some 230 kPa in excess of the existing effective overburden pressure.

Sand

Underlying the clayey silt with interbedded silty sand stratum is a deep deposit of cohesionless sand with traces of silt. The deposit ranges in thickness from 12.2 m to 20.2 m and contains minor variations in gravel content throughout its thickness. Generally, the deposit contains traces of gravel but at some locations, considerable gravel (in excess of 40%) was encountered. A grain size distribution envelope for this deposit is provided in Figure 8 in the Appendix.

The relative density of the cohesionless deposit varies from loose to very dense with 'N' values obtained from the Standard Penetration Test ranging from 2 blows/0.3 m to 104 blows/.15 m. Generally, the deposit is in a loose to compact state of condition in the upper portions and becomes increasingly dense with depth.

Heterogeneous Mixture of Sand, Gravel and Boulders (Glacial Till)

Underlying the sand deposit at a depth ranging from 21.3 m to 24.8 m a heterogeneous mixture of sand, gravel and boulders of glacial origin is present. The thickness of this deposit ranges from 1.6 m to 4.0 m and rock coring techniques were required to penetrate this stratum.

Bedrock

The glacial till deposit is directly underlain by bedrock of the Gull River Formation and was proven at various locations by obtaining up to 2.6 metres of rock core samples. The bedrock consists of a silty dolostone which is a clastic sedimentary rock. Minor beds of sandstone and limestone were also found interbedded in the rock formation. Detailed descriptions of the rock are attached in the Appendix entitled "Description of Rock Core".

Core recoveries and rock quality designation (RQD) were determined in-situ and also in the laboratory to evaluate the competence and integrity of the rock. Rock recoveries varred between 38 and 100% while RQD's varied between 11 and 100%. Based on the results, the rock can be classified as medium strong to strong rock and predominantly unweathered.

Groundwater Conditions

Observation of the groundwater level was carried out by measuring the water level in the open boreholes. Measurements revealed stabilized levels at an elevation ranging from 60.5 m to 64.0 m which corresponds to depths of 1.8 m to 5.5 m below the existing ground surface.

DISCUSSION AND RECOMMENDATIONS

It is proposed to construct an overpass structure that will carry Hwy. 417 westbound lanes and the Richmond Road to Hwy. 417 WB ramp over the realigned Acres Road. This structure is a component of the proposed Hwy. 416/417 interchange which involves numerous structure proposals. The new structure will be located slightly east of the existing Acres Road in the area of the existing Hwy. 417 EB.

The proposed structure is a two-span structure having an approximate total length and width of 91 m and 44 m respectively. The proposed profile grade of the Hwy. 417 WB lanes and integrated Richmond ramp is approximately 72.6 metres which requires approach embankment fill heights of approximately 7.0 metres. In addition, a minimum vertical clearance of 5.0 metres has been proposed between the structure's deck soffit and the proposed profile grade of the realigned Acres Road. An excavation cut of approximately 2 metres will be required to achieve the realigned Acres Road profile grade of 64.2 m.

Recommendations pertaining to the following geotechnical considerations are provided:

Approach Embankments

- stability
- settlements
- lateral earth pressures on structure

Structure Foundations

In view of the presence of the compressible, firm to stiff surficial layer of silty clay to clay and the underlying clayey silt with interbedded silty sand seams which is of low shear strength, stability and settlement of the approach embankments are the major problems anticipated at this site and consequently, these will be initially discussed.

APPROACH EMBANKMENTS

Stability Considerations

Stability computations were carried out to evaluate the effect of the approach fills to the overall stability both in the longitudinal and transverse directions, the internal stability of the fills, and the stability of the excavation cut required for the realigned Acres Road.

Stability analyses were carried out in terms of total stress to evaluate the overall and internal stability of the fills whereas for the cuts, analysis was carried out in terms of effective stress. A minimum factor of safety of 1.3 was incorporated for all analyses. Based on the analysis, the following conclusions have been derived:

Approach fills up to 8.0 metres in height both in the longitudinal and transverse directions at the east and west approaches will be stable provided they are constructed with standard 2H:1V slopes. For fills exceeding 8.0 metres, nominal mid-height stabilizing berms will be required. The berm length requirements for various heights of fill and the soil parameters, surface geometry and groundwater levels used in the analysis is provided in Figure 9 and 10 in the appendix for both the longitudinal and transverse directions respectively.

Any localized softened and/or surficial organic soil should be removed within the planned limits of the fill prior to its placement. The fills should be placed and compacted according to MTO standards. An adequate surface erosion protection scheme should also be designed to preserve the surficial embankment slopes. Topsoil and sodding is one method of achieving this protection.

The excavation cut for the proposed realigned Acres Road will penetrate approximately 2 metres into the surficial silty clay to clay layer. No

stability problems are anticipated both in the short and long term provided the slopes are constructed at 2H:1V. No dewatering problems are anticipated in view of the fact that the groundwater level is below the excavation cut and the deposit is impervious in nature. Conventional pumping techniques will suffice in discharging any localized seepage. The cut slopes should be protected against surface erosion. Topsoil and sodding is one recommended method of achieving this protection.

Earthquake forces were also incorporated in the stability analysis. A value of 0.2 g (g = acceleration due to gravity) was used as the peak horizontal ground acceleration. Based on the results the proposed approach fills are considered to be statically and dynamically stable.

Settlement Considerations

Anticipated settlements are based on laboratory results obtained from Taylor's (1948) (Square Root Fitting Method) Consolidation testing procedures and employing Osterberg (1957) solution to determine the increase in vertical stress due to embankment loading. The total settlement anticipated as a result of elastic and consolidation settlement of the silty clay to clay layer, clayey silt with interbedded sand layer and settlement of the fill under its own weight is approximately 260 mm for approach fills 7 m in height. The elastic settlements were computed using Steinbrenner's (1934) method and comprise approximately 5-6 percent of the total settlement (15 mm). These settlements will be immediate in nature and will be realized during construction of the embankments. In addition, in view of the slightly preconsolidated nature of both strata, a further 75 mm of settlement will be due to the recompression of the soil and consequently will occur during or immediately after construction. This results in net consolidation (time-dependent) settlements in the order of 100 mm.

Consolidation settlement curves for varying heights of fill are provided in Figure 11 in the appendix. Estimates of the time rate settlement indicate that the total anticipated consolidation settlements should be realized within a period of 9 years after application of the embankment loading. It is also estimated that about 30 to 40 percent of the total consolidation settlement will be realized within a period of 6-9 months after construction of the embankments. In view of this, consideration should be given in constructing the approach fills as far in advance of the structure foundations as scheduling, feasibility and economics permit and also in delaying the final paving operations as long as possible.

Lateral Earth Pressures on Structure

Free draining material such as Granular 'A' or Granular 'B' is recommended as appropriate backfill to the abutments to prevent hydrostatic pressure build-up. Design parameters of the soil are given below:

	<u>Granular 'A'</u>	<u>Granular 'B'</u>
Angle of Internal Friction (ϕ)	35°	30°
Unit Weight (kN/m ³)	22.8	21.2
Coefficient of Active Earth Pressure (K_a)	0.27	0.33
Coefficient of Earth Pressure at Rest (K_0)	0.43	0.5

The earth pressure coefficient at rest is to be used in design if the abutment walls are rigid and unyielding. Weep holes in the abutment walls should be designed to drain any accumulation of water in the backfill.

STRUCTURE FOUNDATIONS

In view of the low strength and compressibility of the silty clay to clay layer and underlying clayey silt with interbedded silty sand, conventional spread footing shallow foundations are not suitable at this site. It is therefore recommended that the structure foundations be founded on end-bearing piles, equipped with reinforced tips (to facilitate pile penetration through the basal glacial till stratum) and driven to bedrock.

In consideration of the negative skin friction forces (additional downdrag forces) which will be induced as a result of the consolidation of the cohesive deposits at the approaches, the following design parameters are suggested:

Table 6

<u>Structure</u>	<u>Pile Type</u>	<u>Axial Capacity at S.L.S. Type II (kPa)</u>	<u>Factored Axial Capacity at U.L.S. (kPa)</u>	<u>Estimated Pile Tip El. (m)</u>
W. Abutments	HP310x79	800	1050	40±
	HP310x110	1050	1450	
Piers	HP310x79	900	1150	40±
	HP310x110	1150	1600	
E. Abutments	HP310x79	800	1050	40±
	HP310x110	1050	1450	

In view of the extreme denseness of the glacial till stratum located immediately above the bedrock, some piles may not penetrate this dense stratum. In such a case, the pile capacity should be controlled in the field using current MTO pile driving standards. However, attempts should be made in all cases to drive the piles to the bedrock surface.

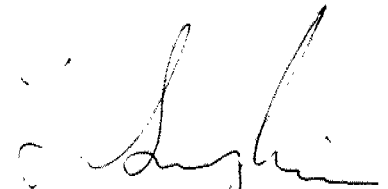
Lateral strains induced by the settlement of the cohesive deposit shall be accounted for in the design of the abutments. To resist the potential lateral displacement and rotational forces caused by this settlement, it is recommended that the extreme ends of the wing walls should also be supported on end-bearing piles driven to bedrock using values as identified in Table 6. Resistance to lateral load shall be computed in accordance with Section 6.8.3.8 of the O.H.B.D.C.

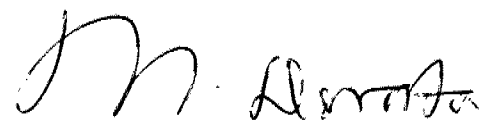
Pile caps may be perched within the embankment fill provided that particle sizes in the fill immediately beneath the pile locations does not exceed 75 mm. This is required to avoid impediment of pile driving. Alternatively, the pile caps may be founded within the surficial cohesive deposit. No dewatering problems are anticipated for this excavation. Conventional pumping techniques will suffice in discharging any localized seepage. The pile caps should be protected against frost penetration by providing a minimum 1.8 metres earth cover.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of J. Fellenius, Student Engineer and T. Sangiuliano, Foundation Engineer, utilizing equipment owned and operated by Marathon Drilling and Johnston Drilling. The description of bedrock core samples was carried out by S. Senior, Geologist. This report was written by T. Sangiuliano and reviewed by Mr. M.S. Devata, Chief Foundation Engineer.

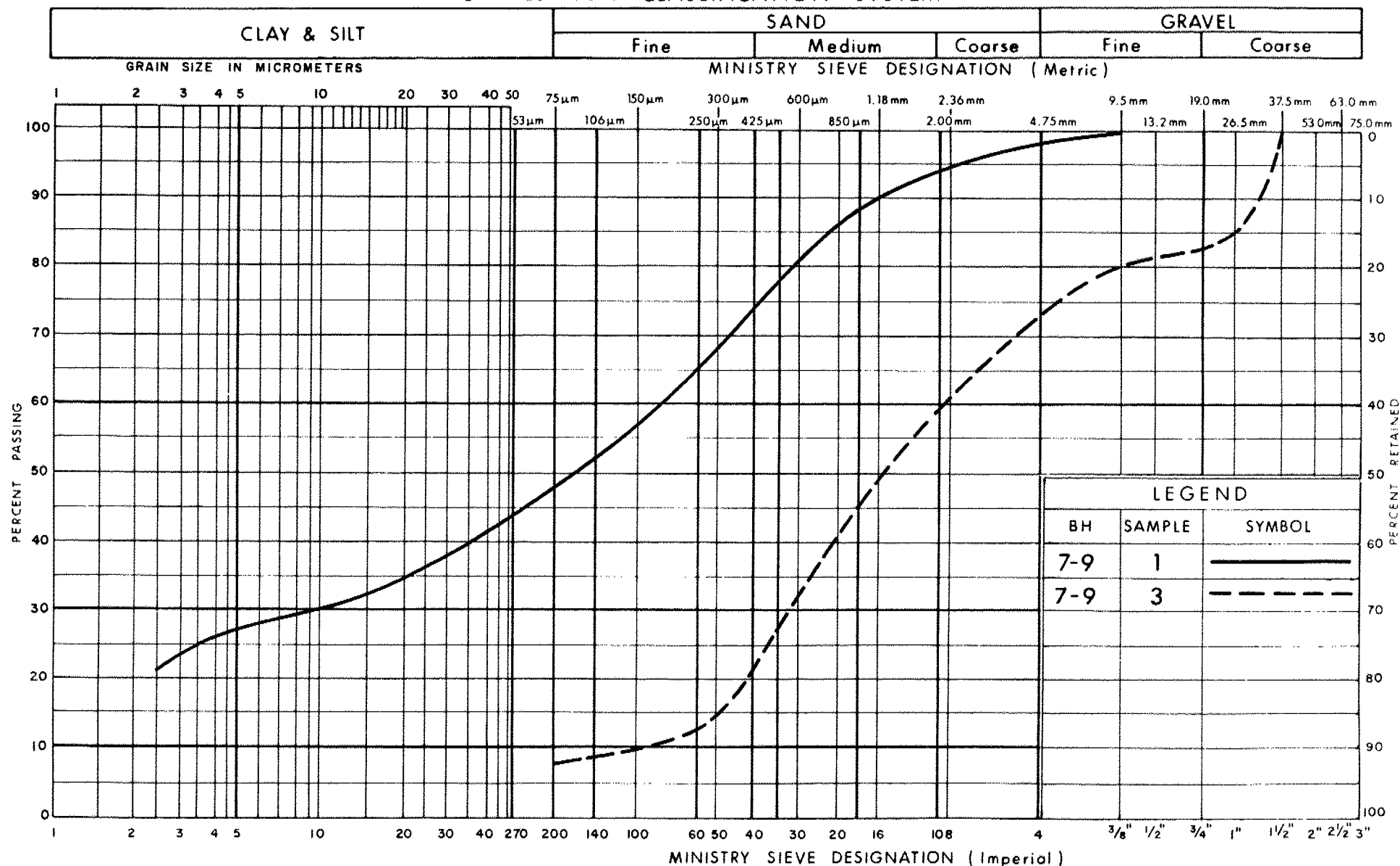



T. Sangiuliano, P.Eng.
Foundation Engineer


M.S. Devata, P.Eng.
Chief Foundation Engineer

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM

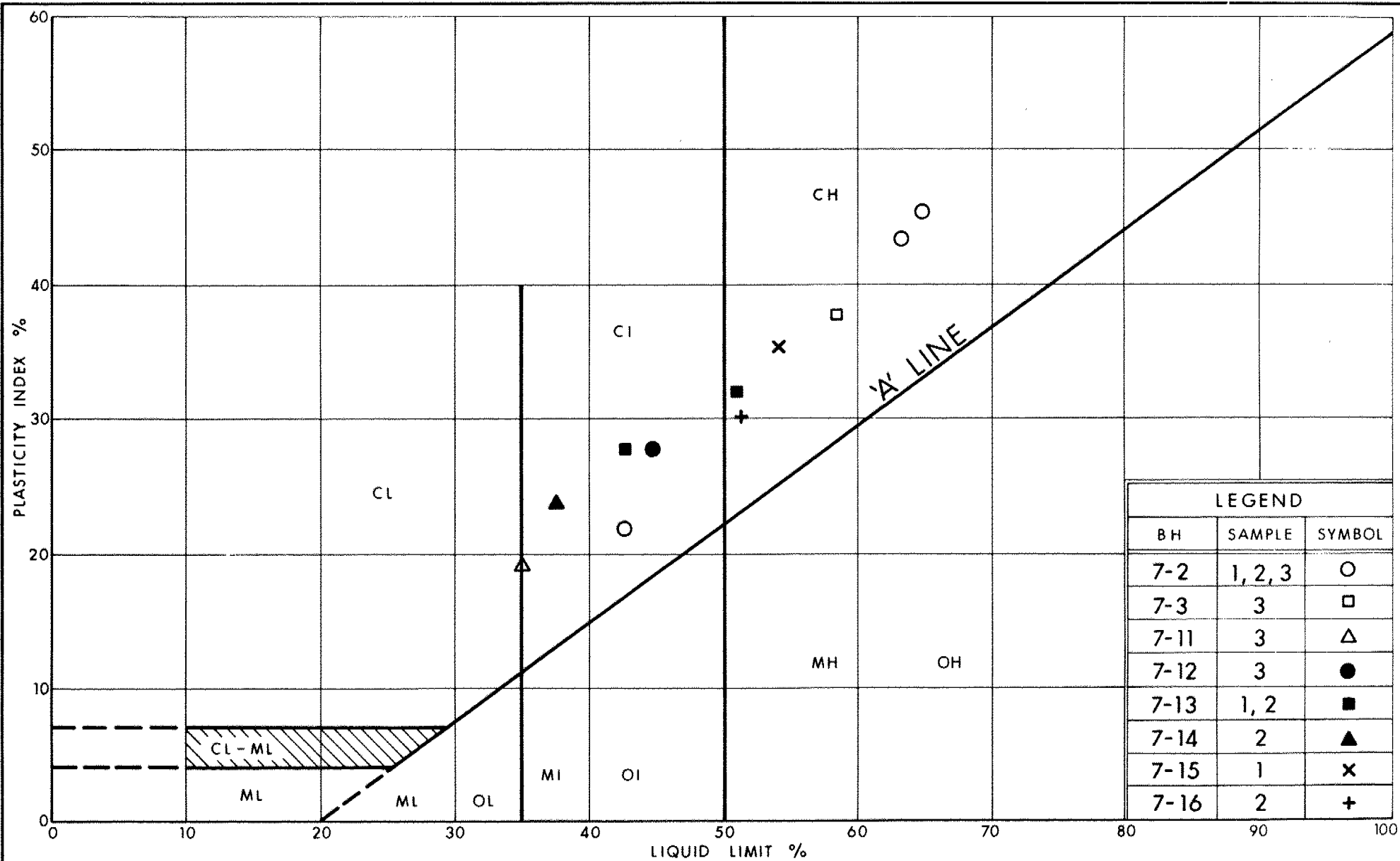


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GRAIN SIZE DISTRIBUTION
MIXTURE OF CLAYEY SILT, SAND & GRAVEL /
SAND, SOME GRAVEL (Fill)

FIG No 1

W P 120-87-10



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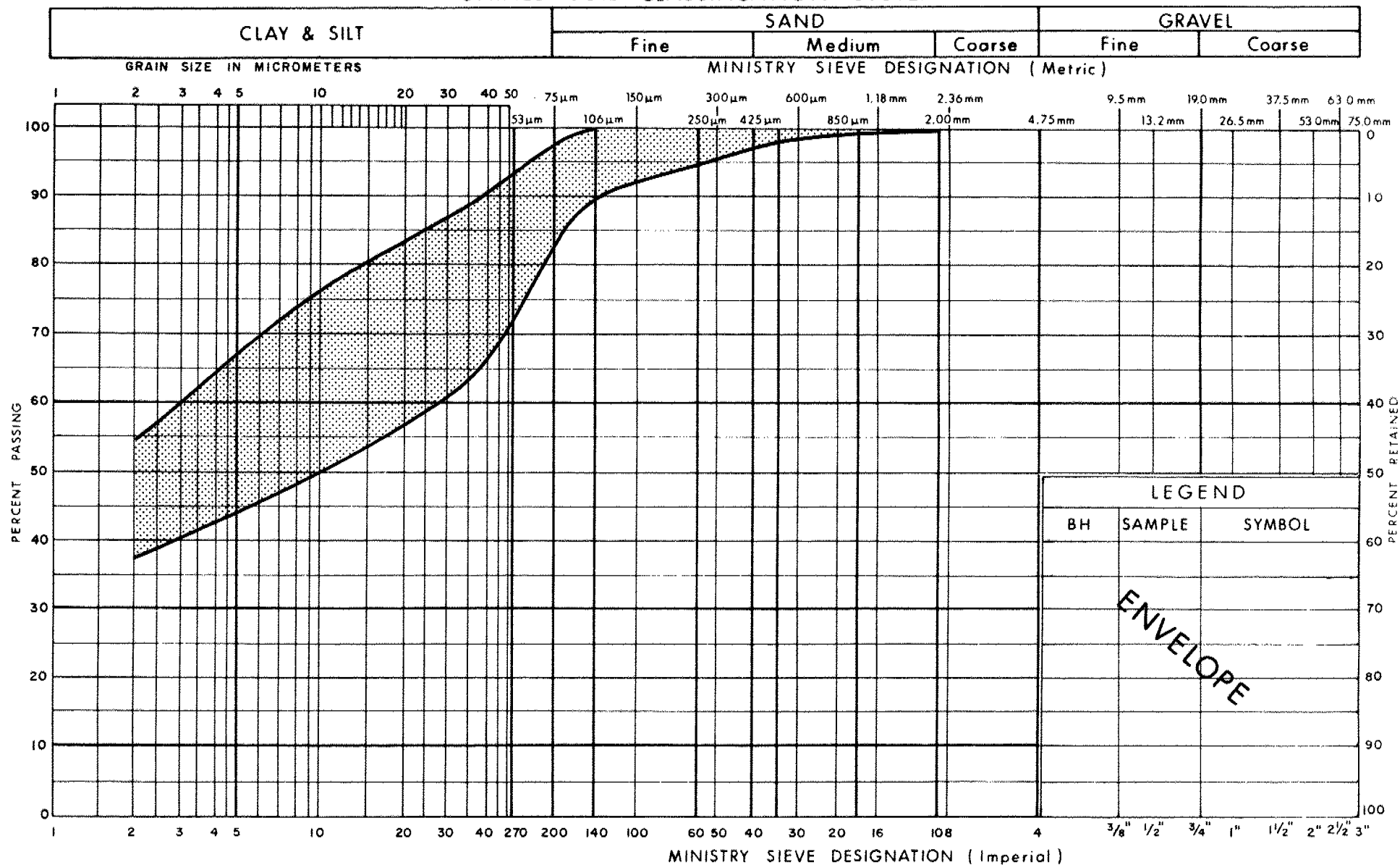
Ontario

PLASTICITY CHART SILTY CLAY TO CLAY

FIG No 2

W P 120-87-10

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION
SILTY CLAY TO CLAY

FIG No 3

W P 120-87-10

VOID RATIO - PRESSURE CURVES

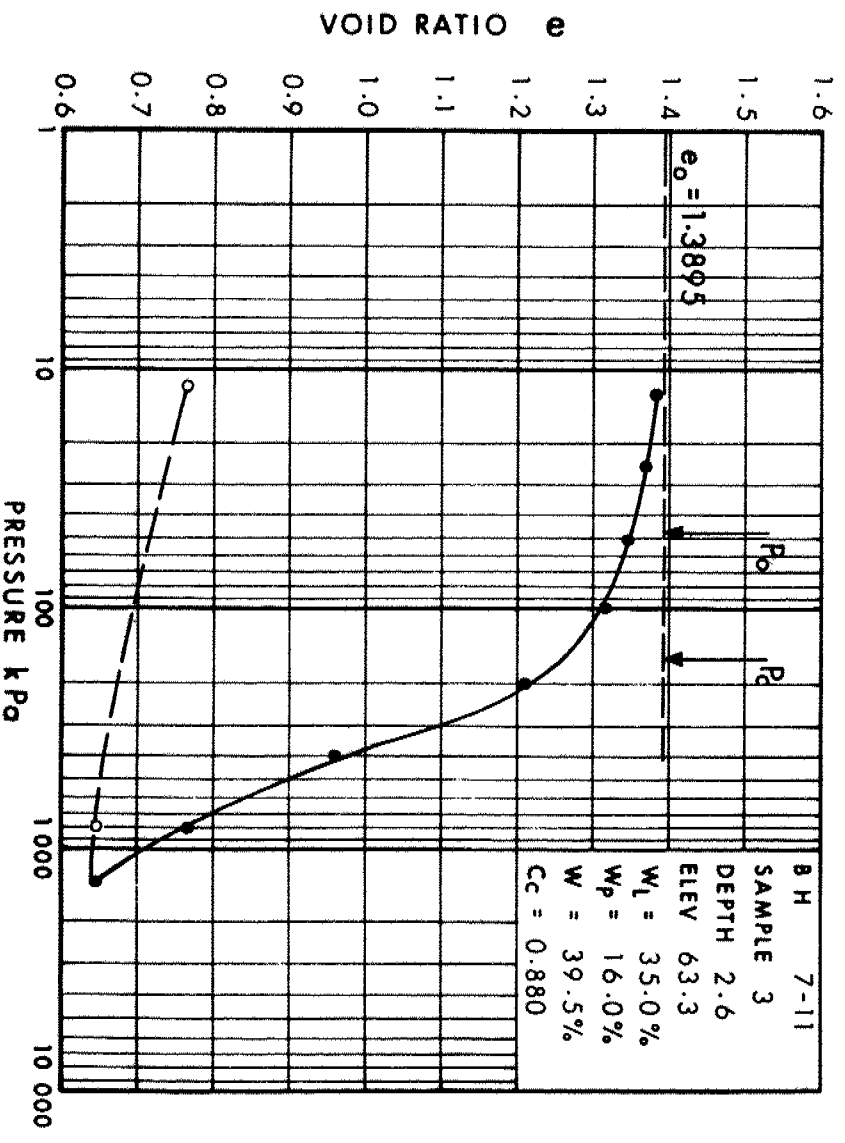
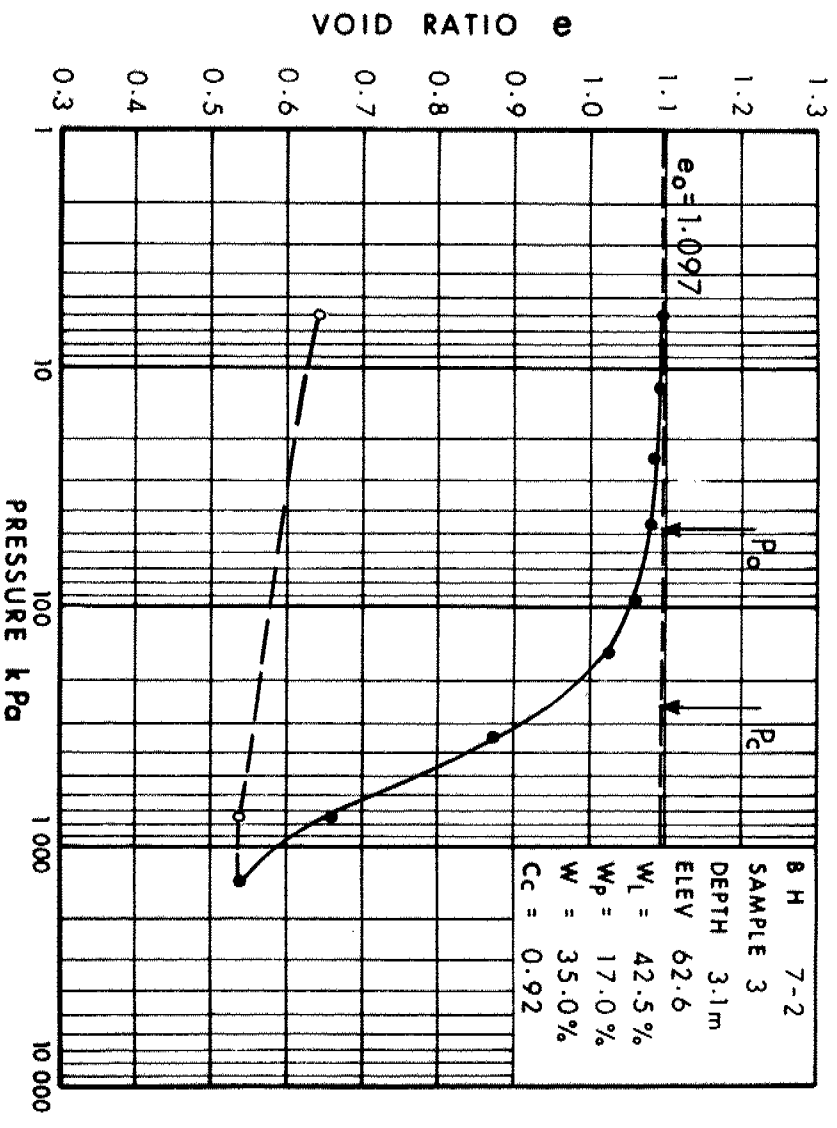
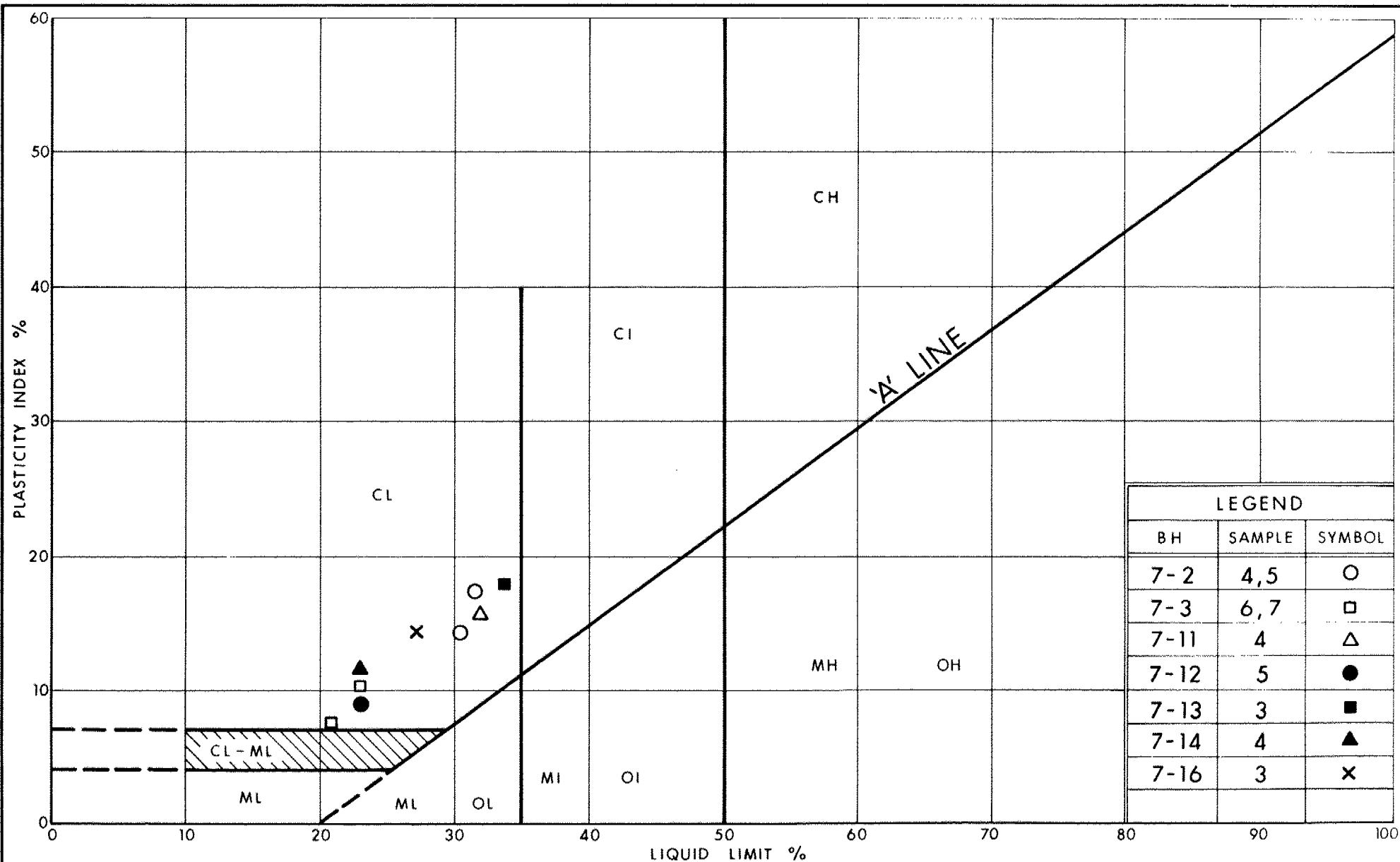


Fig 4

WP 120-87-10



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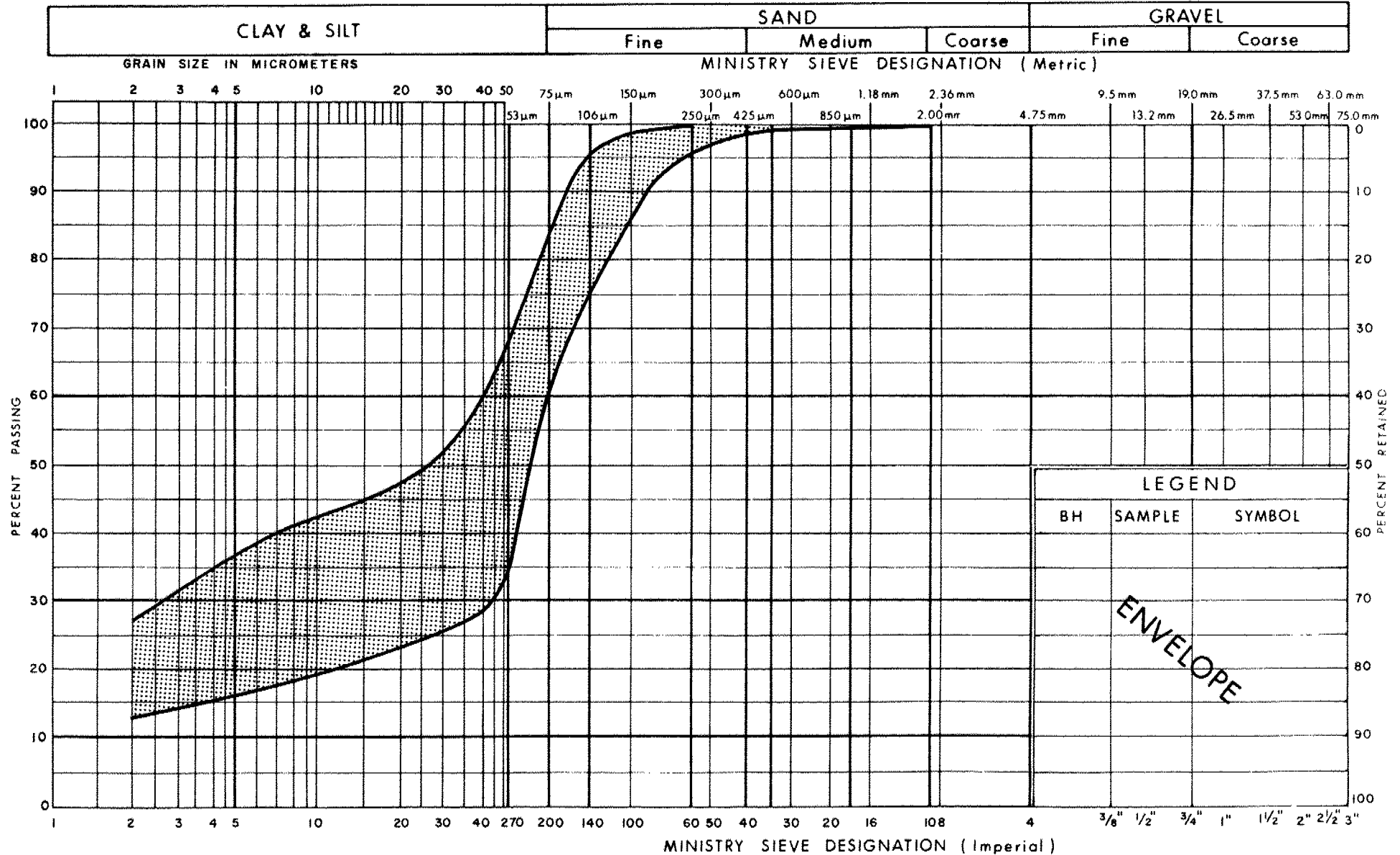
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PLASTICITY CHART CLAYEY SILT WITH INTERBEDDED SILTY SAND

FIG No 5

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UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION
CLAYEY SILT WITH INTERBEDDED SILTY SAND

FIG No 6

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VOID RATIO - PRESSURE CURVES

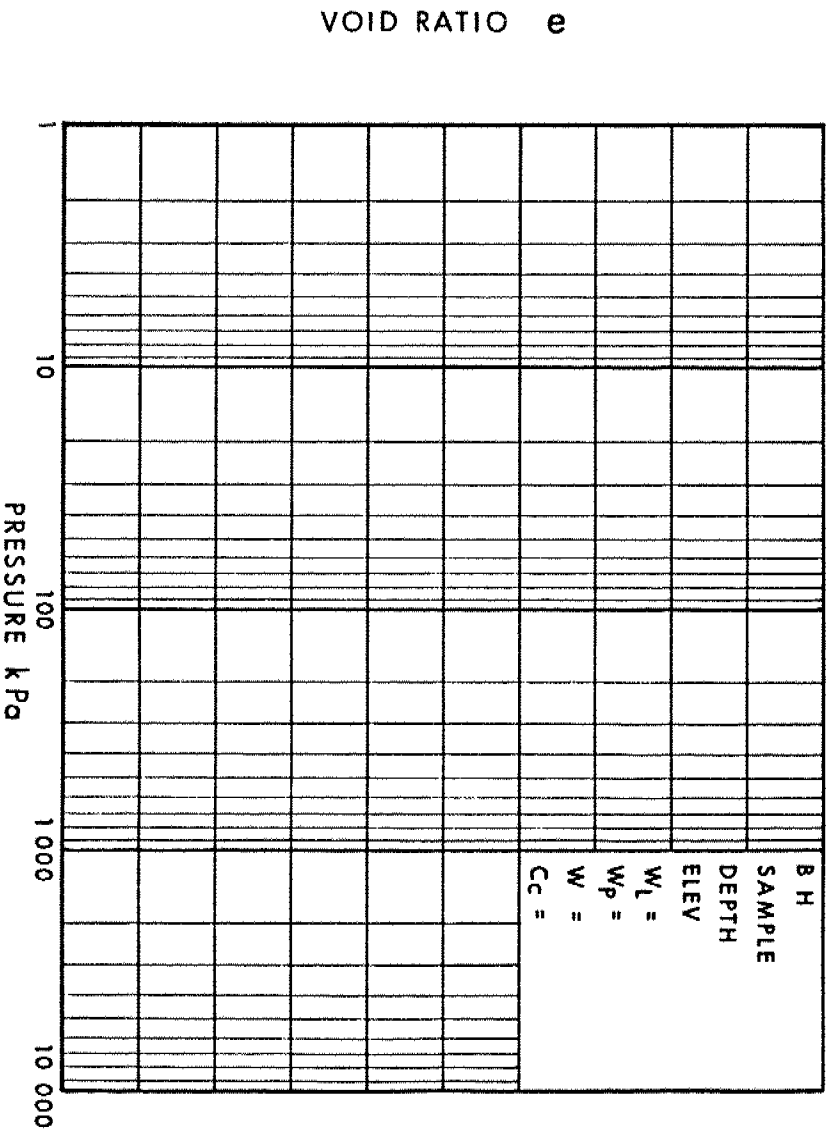
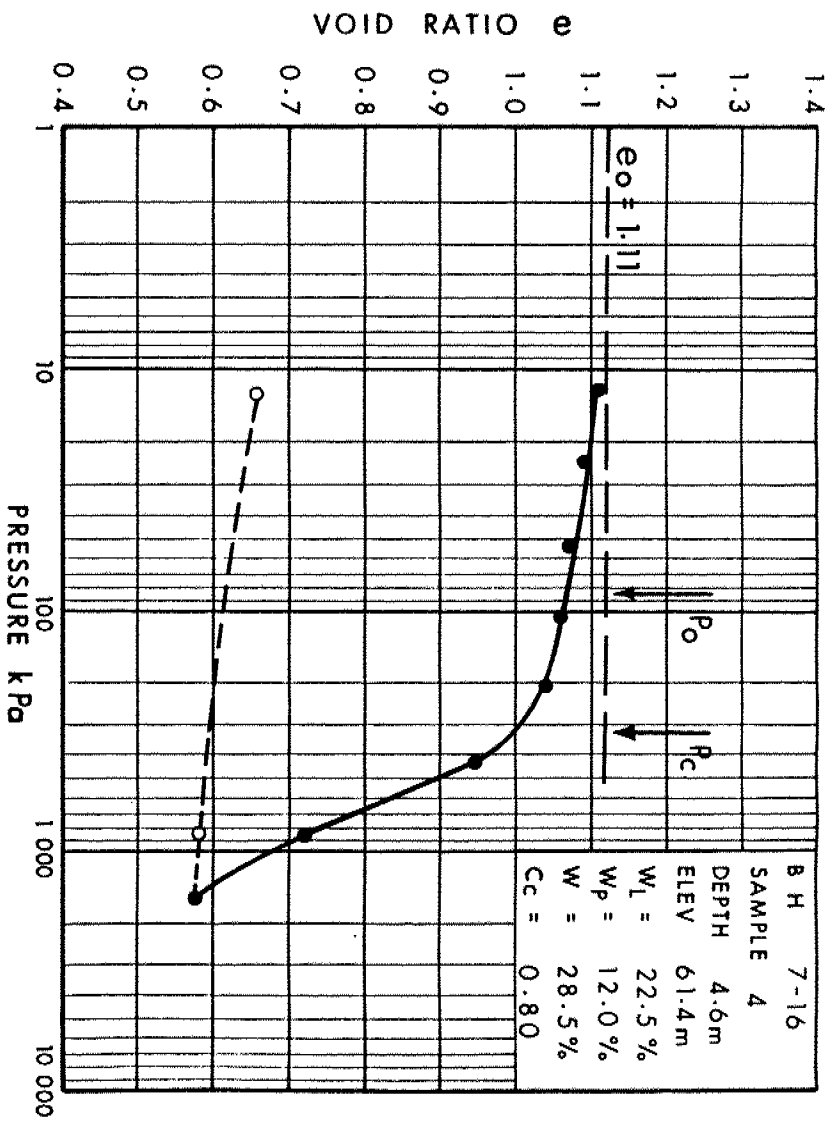
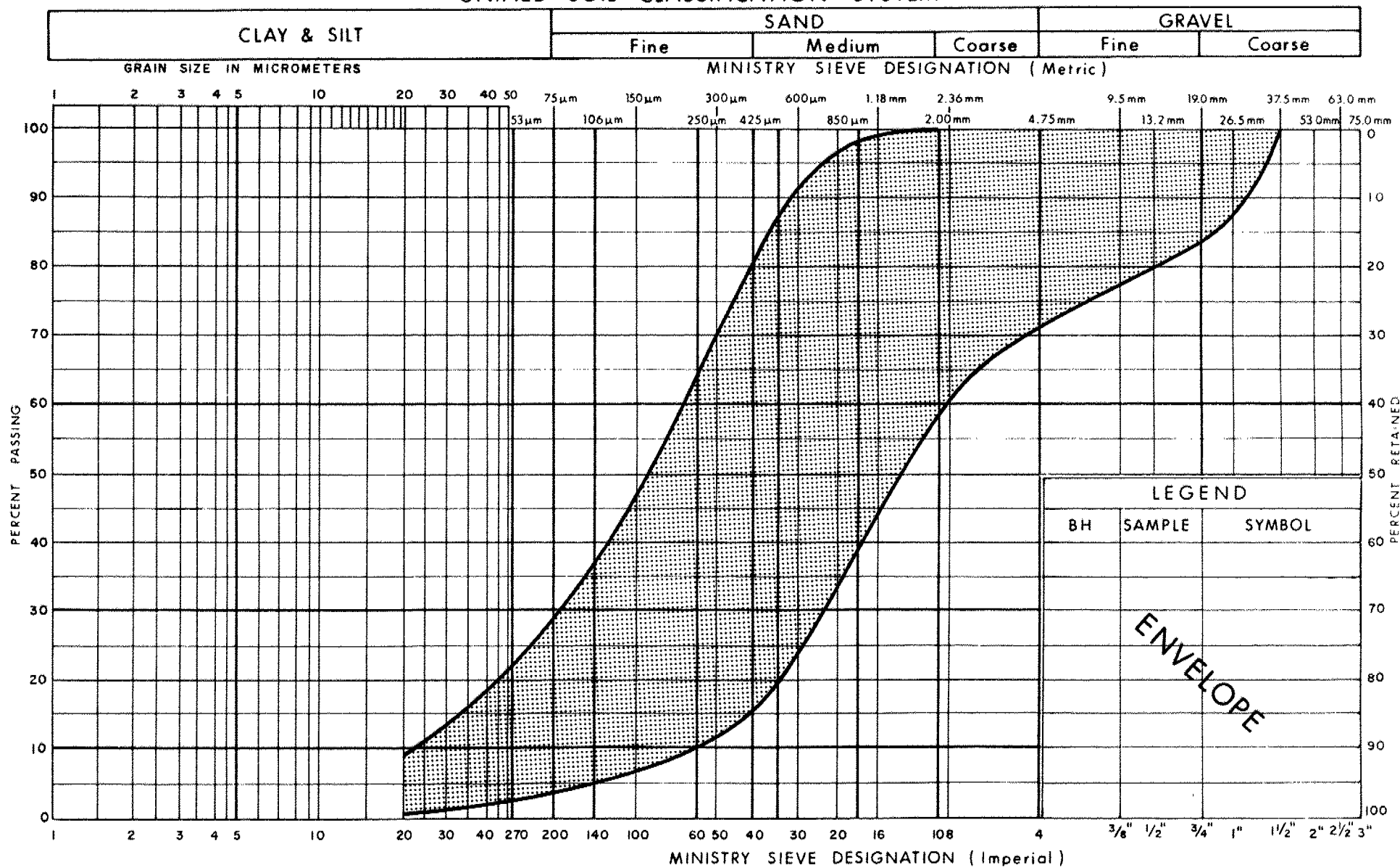


Fig 7

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UNIFIED SOIL CLASSIFICATION SYSTEM

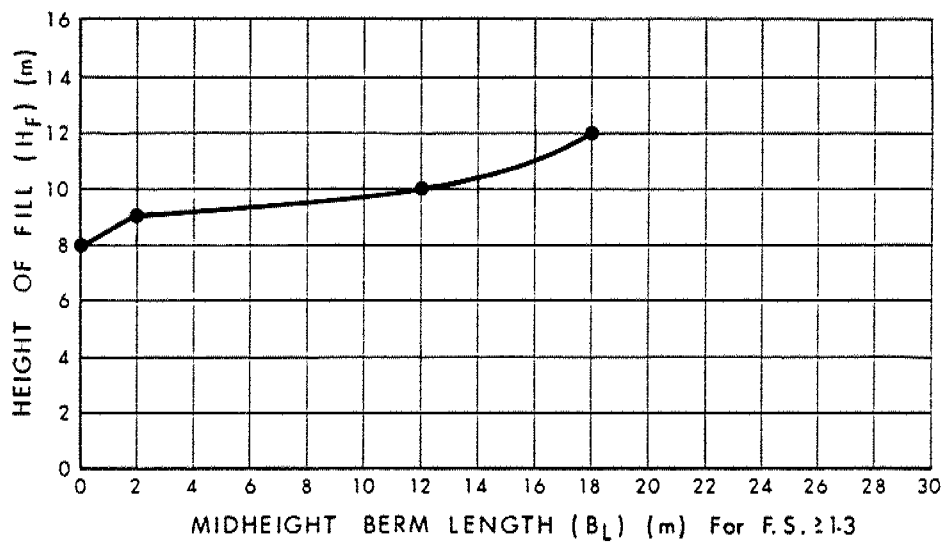
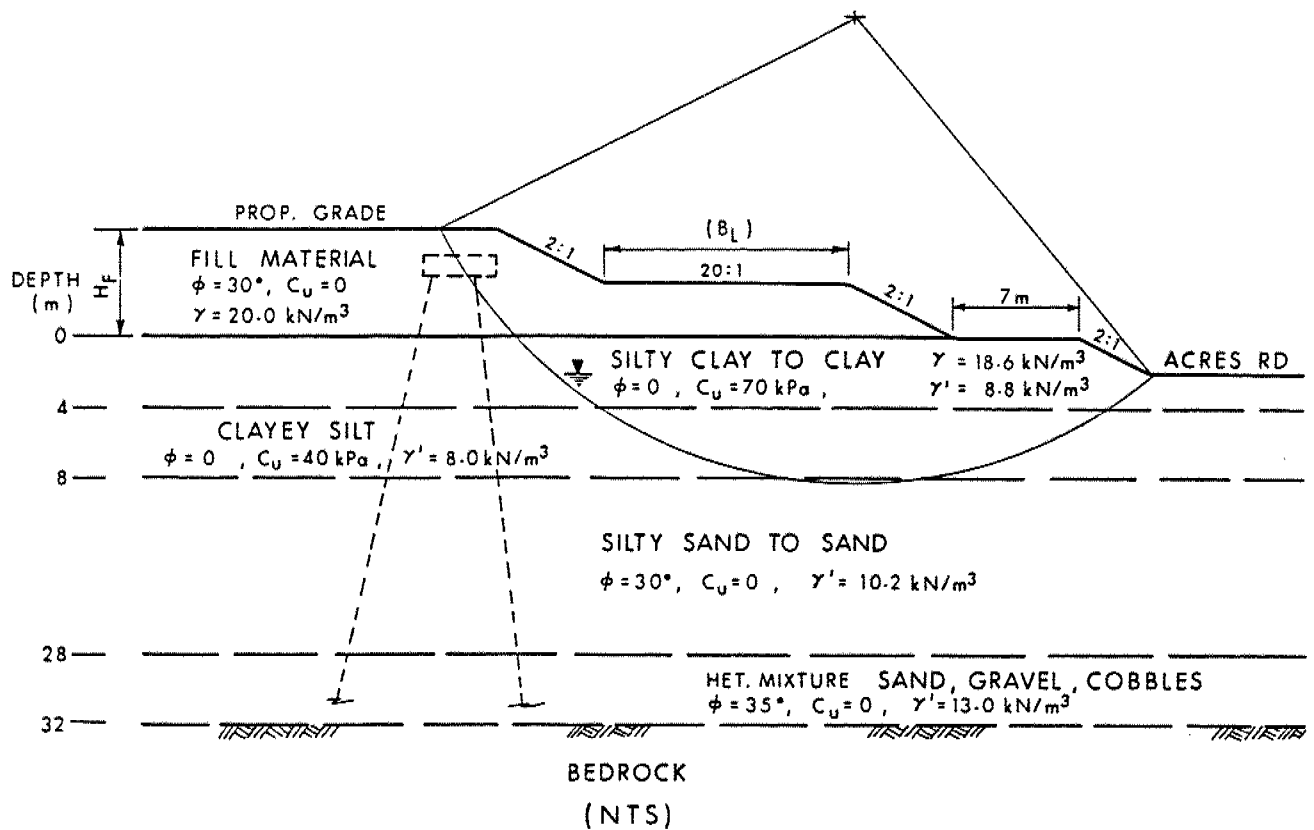


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GRAIN SIZE DISTRIBUTION
SILTY SAND TO SAND, SOME GRAVEL

FIG No 8

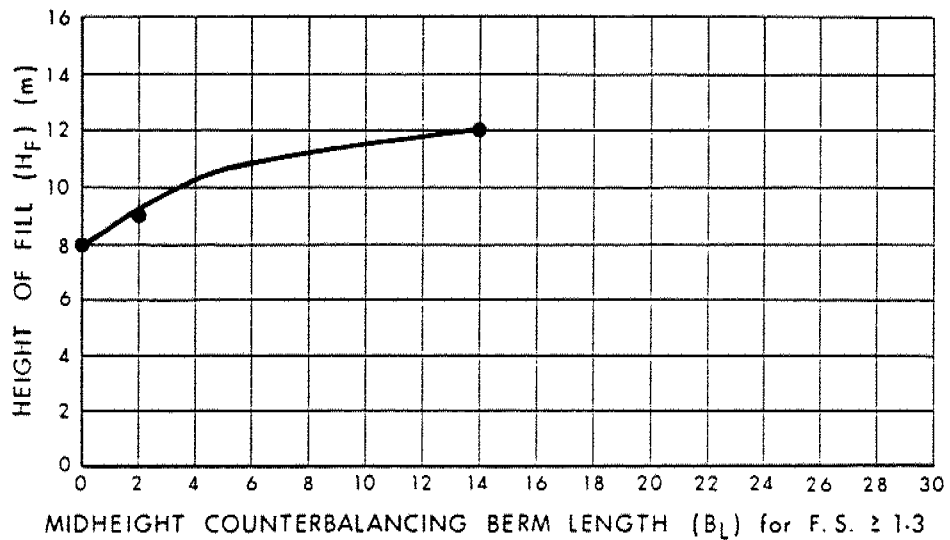
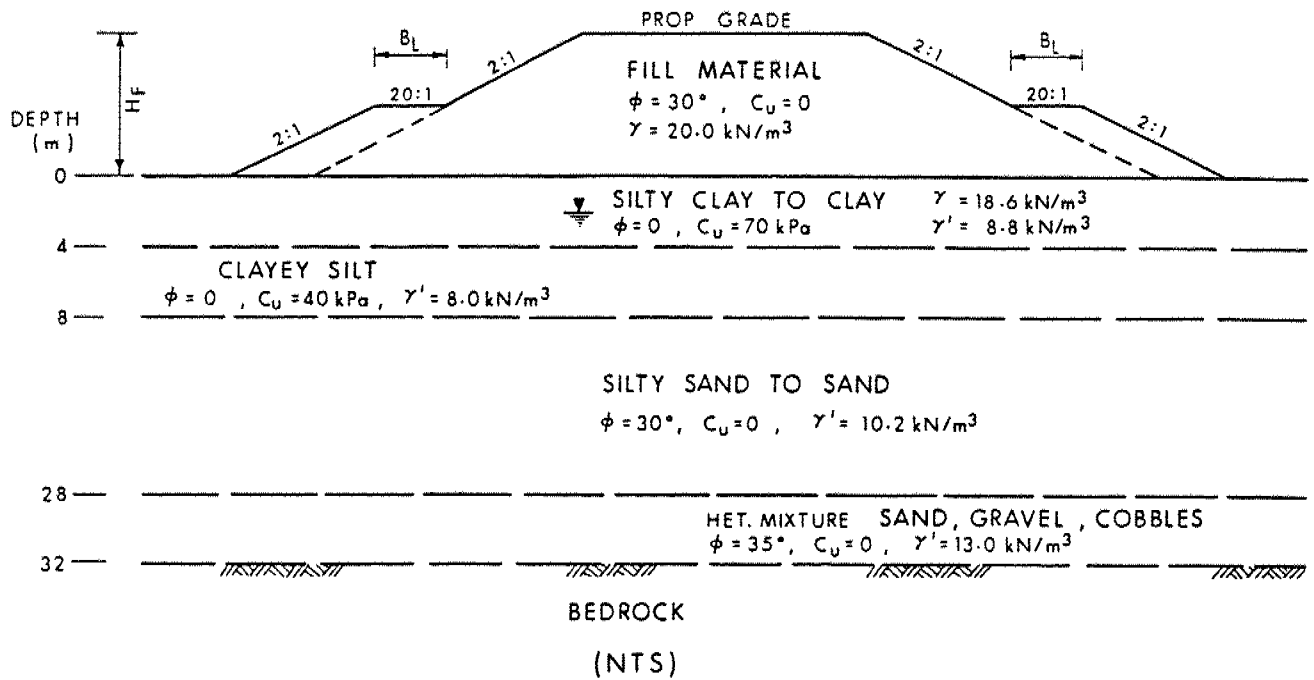
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WEST/EAST APPROACH EMBANKMENTS STABILITY ANALYSIS
LONGITUDINAL DIRECTION

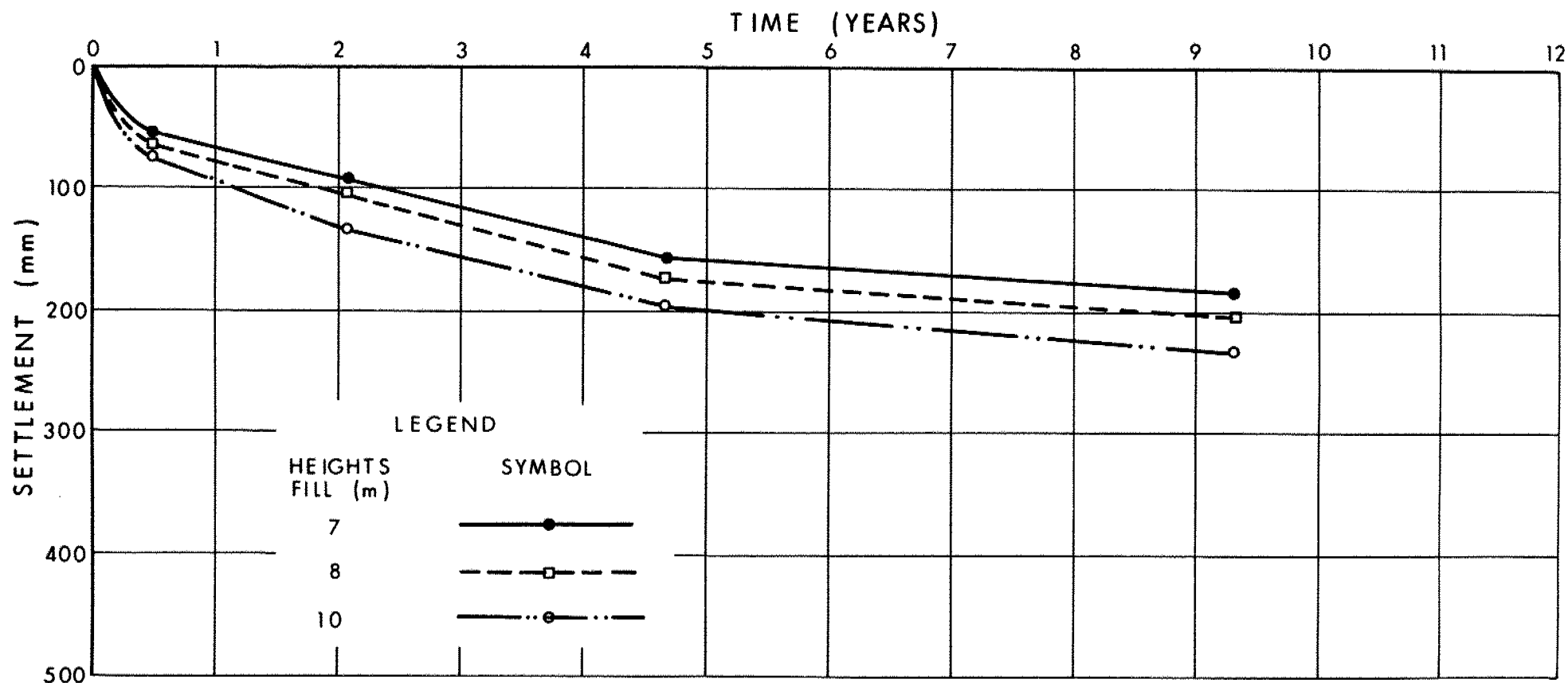
WP 120-87-10

FIG 9



WEST/EAST APPROACH EMBANKMENTS STABILITY ANALYSIS
TRANSVERSE DIRECTION

Fig 11- PREDICTED SETTLEMENT-TIME CURVES OF NATIVE SOILS
UNDERLYING APPROACH EMBANKMENTS



LEGEND

HEIGHTS
FILL (m)

SYMBOL

7

—●—

8

- - □ - -

10

- · · ○ · · -

ASSUMPTIONS

- 1) Unit Weight of Fill = 20 kN/m^3
- 2) Osterberg Stress Distribution
- 3) Single Drainage
- 4) Coefficient of Consolidation (C_v)

(a) Silty Clay to Clay ($0.026 \text{ m}^2/\text{day}$)

(b) Clayey Silt with interbedded Sand ($0.040 \text{ m}^2/\text{day}$)

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Fig 11

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
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	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_α	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
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kn/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kn/m ³	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kn/m ³	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m ³	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m ³ /s	RATE OF DISCHARGE
γ_d	kn/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{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
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kn/m ³	SEEPAGE FORCE
γ'	kn/m ³	UNIT WEIGHT OF SUBMERGED SOIL						

DESCRIPTION OF ROCK CORE - WP 120-87-10

CORE RECOVERY				CORE DESCRIPTION	
HOLE #	DEPTH (m)	%CR*	%RQD*	DEPTH (m)	DESCRIPTION
7-11	24.38-24.84	94	-	24.38-26.50	OVERBURDEN , containing local and foreign rock material.
	28.84-26.16	28	-	26.50-26.67	LITHOGRAPHIC LIMESTONE , tan, medium light grey; extremely fine grained; very dense; strong to very strong rock; slightly weathered to unweathered; very closely spaced fractures: flat irregular.
	26.16-27.69	38	11		
	27.69-28.70	98	33		
				26.67-28.70	SILTY DOLOSTONE , medium dark grey, fine grained; medium strong to strong rock; slightly weathered to unweathered; very close to close spaced fractures: (i) flat, rough, slightly open; (ii) near vertical irregular, undulating, calcite filled, continuous; interbedded with SHALE (11%), greyish black; very fine grained; medium strong rock; slightly to moderately weathered. <u>NOTE</u> : Interbedded shale accounts for high core loss in this section.
7-12	22.23-22.91	67	-	22.23-25.30	OVERBURDEN , containing local and foreign rock material. Boulders up to 0.61 m diameter.
	22.91-23.88	37	-	25.30-26.82	SILTY DOLOSTONE , medium dark grey, fine grained; thinly bedded; medium strong to strong rock; slightly weathered to unweathered; close to moderately close spaced fractures: flat, rough, irregular; interbedded with SHALE (8%) up to 10 cm beds; minor SANDSTONE bed (2 cm) at 26.19 m.
	23.88-25.30	39	-		
	25.30-26.82	100	85		

NOTE: Depths are approximated in zones of poor core recovery.

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

DESCRIPTION OF ROCK CORE - WP 120-87-10

CORE RECOVERY				CORE DESCRIPTION	
HOLE #	DEPTH (m)	%CR*	%RQD*	DEPTH (m)	DESCRIPTION
7-13	25.60-26.72	72	40	25.60-26.04	OVERBURDEN , foreign and local rock material up to 5 cm diameter.
	26.72-27.50	100	100	26.04-27.50	SILTY DOLOSTONE , medium dark grey, fine grained; thinly bedded; medium strong to strong rock; slightly weathered to unweathered; close to moderately close spaced fractures: flat, rough, irregular; interbedded with SHALE (11%); minor SANDSTONE bed (2 cm) at 26.75 m (Correlates with BH 7-12).
7-14	26.06-27.74	44	-	26.06-27.33	OVERBURDEN , foreign (igneous and metamorphic) and local (carbonate) rock material.
	27.74-28.40	100	38	27.33-28.50	LIMESTONE , dark grey to greyish black; crystalline; medium strong rock; slightly weathered to unweathered; close to very close spaced fractures: flat, rough, closed, slightly altered, clay free.
	28.40-29.92	88	85	28.50-29.92	SILTY DOLOSTONE , medium dark grey, fine grained; thinly bedded; medium strong to strong rock; slightly weathered to unweathered; moderately close spaced fractures: flat, rough, slightly open, slightly altered clay free.

NOTE: Depths are approximated in zones of poor core recovery.

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

DESCRIPTION OF ROCK CORE - WP 120-87-10

CORE RECOVERY				CORE DESCRIPTION	
HOLE #	DEPTH (m)	%CR*	%RQD*	DEPTH (m)	DESCRIPTION
7-15	23.47-24.49	50	-	23.47-26.15	OVERBURDEN , contains foreign and local rock material. Dolostone boulder up to 0.40 m diameter. Sand and gravel encountered in borehole from 25.65 - 26.15 m.
	24.49-24.84	29	-		
	24.84-25.45	58	-	26.15-27.48	SILTY DOLOSTONE , medium grey to medium light grey, spotted pink (dolomite), streaked white (calcite); medium to fine grained; medium strong rock; slightly weathered to unweathered; moderately close spaced fractures: flat, rough, open, slightly altered, clay free.
	25.45-25.65	100	-		
	25.65-27.48	78	70		
7-16	22.86-23.47	19	-	22.86-25.88	OVERBURDEN , contains foreign an locally derived bedrock material, up to 12 cm diameter.
	23.47-24.38	48	-		
	23.38-24.66	86	-	25.88-28.17	SILTY DOLOSTONE , medium grey; medium grained; medium strong rock; moderately weathered to unweathered, very close to close spaced fractures: flat (bedding joints), rough, undulating, slightly open, slightly altered, clay free, minor calcite mineralization.
	24.66-24.94	32	-		
	24.94-26.52	66	14		
	26.52-26.77	60	0		
	26.77-28.17	100	7		

NOTE: Depths are approximated in zones of poor core recovery.

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

RECORD OF BOREHOLE No 7-2

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 636.1; E 358 305.4 ORIGINATED BY JBF
 DIST 9 HWY 416/417 BOREHOLE TYPE Hollow Stem Auger, B Casing Washbore & Cone Test COMPILED BY JBF/TS
 DATUM Geodetic DATE 88 07 20 - 21 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W _p	W	W _L		
65.7	Ground Surface													
0.0	8cm Topsoil													
	Silty Clay to Clay		1	SS	19								18.8	0 3 42 55
	Soft to Hard		2	TW	PH								17.7	
	Grey													
			3	TW	PH								18.2	
61.7														
4.0	Clayey Silt		4	SS	3								18.4	0 0 55 45
	with interbedded													
	Silty Sand		5	SS	2								16.6	0 26 51 23
	V. Soft to Soft													
			6	SS	1									
55.0														
10.7	Sand with Gravel		7	SS	37									35 56 (9)
	V. Dense													
			8	SS	51									
51.5														
14.2	End of Borehole													
46.8														
18.9	End of Cone Test													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 7-3

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 648.1; E 358 394.8 ORIGINATED BY JBF/TS
 DIST 9 HWY 416/417 BOREHOLE TYPE Hollow Stem Augers, Washbore & Cone Test COMPILED BY JBF/TS
 DATUM Geodetic DATE 88 07 20 CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20 40 60 80 100	20 40 60 80 100	W _p	W	W _L		
66.6	Ground Surface												
0.0	Mix. of Clayey Silt Sand and Gravel Grey Stiff to Very Stiff (Fill)		1	SS	25								
64.5			2	SS	10								
2.1	Silty Clay to Clay Grey Very Soft to Stiff		3	TW	PH								
62.6			4	SS	3								
4.0	Clayey Silt with interbedded Silty Sand Soft to Stiff		5	TW	PH							19.0	
			6	SS	3								0 40 48 12
58.0			7	SS	2								1 22 56 21
8.6	Sand Trace of Silt Trace of Gravel Loose to Dense		8	SS	20								8 74 (18)
			9	SS	6								
			10	SS	23								
47.7	Some Gravel		11	SS	30								17 75 (8)
18.9	Het. Mixt. of Sand Gravel and Boulders (Glacial Till)		12	SS	90								44 52 (4)
46.3													
20.3	End of Borehole												

RECORD OF BOREHOLE No 7-9

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 765.3; E 358 681.4 ORIGINATED BY TS
 DIST 9 HWY 416/417 BOREHOLE TYPE Hollow Stem Auger, Washbore & Cone Test COMPILED BY TS
 DATUM Geodetic DATE 88 07 22 CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

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 x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES							
65.7	Ground Surface					*						
0.0	Mixt. of Clayey Silt Sand and Gravel Grey											
63.7	Very Stiff		1	SS	17		64					3 49 30 18
2.0	Sand Some Gravel Brown Compact (Fill)		2	SS	10		62					
			3	SS	10		60					28 64 (8)
59.1			4	SS	14		58					
6.6	Sand Trace Silt Grey		5	SS	9		56					0 98 (2)
	Loose		6	SS	7		54					
	Compact to Dense		7	SS	45		52					0 96 (4)
			8	SS	20		50					
50.0			9	SS	15		48					
15.7	End of Borehole						46					
							44					
							42					
							40					
38.6												
27.1	End of Cone Test											
	* Water Level not Established											

RECORD OF BOREHOLE No 7-10

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 771.4; E 358 729.2 ORIGINATED BY TS
 DIST 9 HWY 416/417 BOREHOLE TYPE Hollow Stem Auger, Washbore & Cone Test COMPILED BY TS
 DATUM Geodetic DATE 88 07 22 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
65.9	Ground Surface												
0.0	Sand, Tr. Gravel					*							
65.0	Brown, Compact (Fill)												
0.9	Clayey Silt, Tr. Sand												
63.9	Brown, Stiff		1	SS	10								0 32 41 27
2.0	Sand		2	SS	15								5 66 17 12
	Trace of Silt												
	Trace of Gravel		3	SS	60								
	Occ. Gravelly Zones		4	SS	38								28 61 (11)
	Compact to		5	SS	30								7 83 (10)
	Very Dense		6	SS	30								1 91 (8)
			7	SS	40								
53.2			8	SS	31								
12.7	End of Borehole												
	* Water Level not Established												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 7-12

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 725.2; E 358 531.7 ORIGINATED BY TS
DIST 9 HWY 416/417 BOREHOLE TYPE H.S. Auger, B-Casing, Washbore, Rock Core & Cone Test COMPILED BY TS
DATUM Geodetic DATE 88 07 18 - 20 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				NATURAL MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa				W _p	W	W _L		
65.8	Ground Surface							20 40 60 80 100								
0.0	Clayey Silt to Silty Clay		1	SS	6										19.0	
	Soft to Stiff		2	SS	4										18.0	0 8 61 31
	Grey		3	TW	PH											0 1 52 47
62.0																
3.8	Clayey Silt with interbedded Silty Sand		4	TW	PH											0 17 56 27
	V. Soft to Firm		5	SS	2											0 31 48 21
			6	SS	1											
56.7																
9.1	Sand		7	SS	11											13 69 (18)
	Trace of Silt		8	SS	64											
	Trace to some Gravel		9	SS	13											0 97 (3)
	Compact to V. Dense															
			10	SS	43											5 90 (5)
			11	SS	80											0 96 (4)
44.5																
21.3	Het. Mixt. of Sand Gravel & Boulders (Glacial Till)		12	SS	56											
			13	RC	REC 67%											RQD = 0
			14	RC	REC 37%											RQD = 0
			15	RC	REC 39%											RQD = 0
40.5																
25.3	Bedrock Silty dolostone		16	RC	REC 100%											RQD = 85%
39.0																
26.8	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 7-13

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 737.6; E 358 578.6 ORIGINATED BY TS
DIST 9 HWY 416/417 BOREHOLE TYPE H.S. Auger, B-Casing, Washbore, Rock Core, & Cone Test COMPILED BY TS
DATUM Geodetic DATE 88 07 20 -21 CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

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 x LAB VANE 20 40 60 80 100	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
66.1	Ground Surface										
0.0	Topsoil		1	SS	5		66			17.4	0 12 43 45
	Silty Clay to Clay		2	TW	PH		64				0 5 55 40
	Firm to Stiff										
63.0			3	TW	PH		62	5.2			
3.1	Clayey Silt with interbedded Silty Sand		4	SS	2		60				
	Soft to Firm		5	SS	2						
58.5			6	SS	60/	7cm	58				
7.6			7	SS	13		56				3 80 (17)
	Sand						54				
	Trace of Silt		8	SS	20		52				
	Trace of Gravel						50				
	Occ. Gravel Zones		9	SS	27		48				
	Compact		10	SS	14		46				
			11	SS	26		44				
41.7							42				
24.4	Het. Mixt. of Sand, Gravel & Boulders (Glacial Till)		12	SS	93		40				
40.1											
26.0	Bedrock		13	RC	REC 72%						RQD = 40%
38.6	Silty Dolostone		14	RC	REC 100%						RQD = 100%
27.5	End of Borehole										

RECORD OF BOREHOLE No 7-14

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 721.1; E 358 611.8 ORIGINATED BY JFB
 DIST 9 HWY 416/417 BOREHOLE TYPE H.S. Auger, B-Casing, Washbore & Cone Test COMPILED BY JFB
 DATUM Geodetic DATE 88 07 18 - 19 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
66.0	Ground Surface							20 40 60 80 100		20 40 60					
0.0	Silty Clay		1	SS	8							19.7	0 11 44 45		
64.3	Grey Firm		2	TW	PH										
1.7	Clayey Silt with interbedded Silty Sand		3	SS	2										0 20 55 25
			4	SS	2										
	Soft		5	SS	2										
61.4		6	SS	25										22 57 13 8	
4.6		7	SS	29										21 73 (6)	
	Sand	8	SS	29											
	Trace of Silt	9	SS	51										0 99 (1)	
	Trace to Some Gravel	10	SS	24										28 64 (8)	
		11	SS	57											
	Compact to V. Dense	12	SS	100											
		13	SS	80/10cm										0 99 (1)	
41.2		14	SS	91										28 66 (6)	
24.8	Het. Mixt. of Sand, Gravel & Boulders (Glacial Till)	15	RC	REC 44%										RQD = 0%	
38.7		16	RC	REC 100%										RQD = 38%	
27.3	Bedrock	17	RC	REC 88%										RQD = 85%	
36.1	Limestone Silty Dolostone														

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 7-15

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 706.4; E 358 575.0 ORIGINATED BY JBF
 DIST 9 HWY 416/417 BOREHOLE TYPE H.S. Auger, B-Casing, Washbore, Rock Core & Cone Test COMPILED BY JBF
 DATUM Geodetic DATE 88 07 18 - 19 CHECKED BY

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	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 _p	W		
65.2	Ground Surface												
0.0	Silty Clay to Clay Soft to Firm		1	SS	2							19.0	0 7 50 43
63.2	Grey		2	TW	PH							17.8	
2.0	Clayey Silt with interbedded Silty Sand Soft		3	SS	6								0 32 48 20
			4	SS	1								
			5	SS	1								
			6	SS	2								
			7	SS	1								0 54 28 18
56.1			8	SS	14								30 65 (5)
9.1	Sand Trace of Silt Trace to some Gravel Loose to Compact		9	SS	6								1 94 (5)
			10	RC	-								
	Boulder		11	SS	18								
			12	SS	18								14 77 (9)
			13	SS	9								
41.7			14	RC	REC								RQD = 0
23.5	Het. Mixt. of Sand Gravel & Boulders (Glacial Till)		15	RC	REC	29%							RQD = 0
			16	RC	REC	58%							RQD = 0
			17	RC	REC	100%							RQD = 0
39.0			18	RC	REC	78%							RQD = 70%
26.2	Bedrock												
37.7	Silty Dolostone												
27.5	End of Borehole												



RECORD OF BOREHOLE No 7-16

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 691.2; E 358 532.7 ORIGINATED BY JBF
DIST 9 HWY 416/417 BOREHOLE TYPE N-Casing, B-Casing, HS Auger, Washbore, Rock Core and COMPILED BY JBF
DATUM Geodetic DATE 88 07 18 - 21 Cone Test CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	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 _p	W	W _L		
66.0	Ground Surface													
0.0	Silty Clay to Clay Grey Firm to Stiff		1	SS	15								18.4	
			2	SS	5								18.7	0 4 52 44
63.0	Clayey Silt with Interbedded Silty Sand Very Soft to Firm		3	TW	PH									
3.0			4	TW	PH									
			5	TW	2									0 34 50 16
			6	SS	2									0 37 46 17
55.3			7	SS	40									28 58 (14)
10.7			8	SS	52									
	Sand Trace of Silt Some Gravel		9	SS	50									16 81 (3)
			10	SS	104	15 cm								
			11	SS	59									0 100 (0)
43.1	Het. Mixture of Sand, Gravel and Boulders (Glacial Till)		12	RC	REC	19%								RQD = 0%
22.9			13	RC	REC	48%								RQD = 0%
			14	RC	REC	86%								RQD = 0%
			15	RC	REC	32%								RQD = 0%
40.1	Bedrock Silty Dolostone		16	RC	REC	66%								RQD = 14%
25.9			17	RC	REC	60%								RQD = 0%
			18	RC	REC	100%								RQD = 7%
37.8	End of Borehole													
28.2														

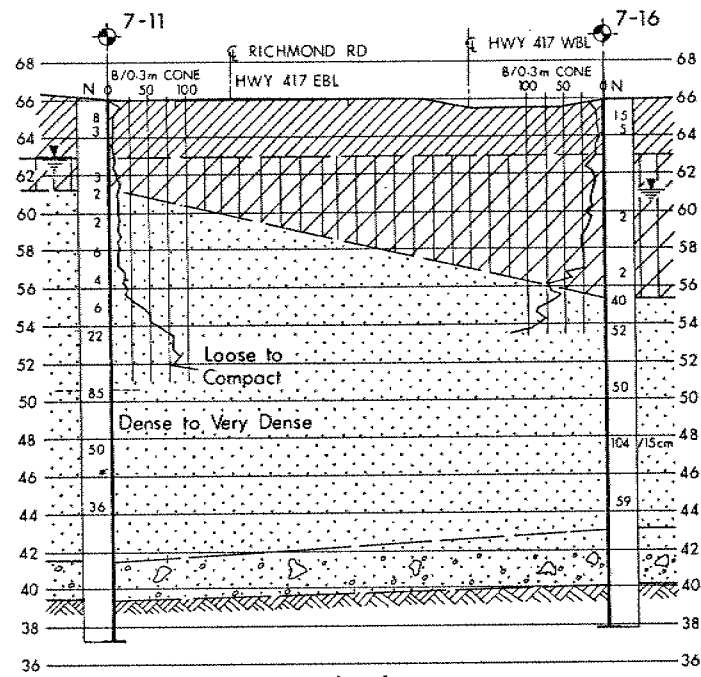


RECORD OF BOREHOLE No 14-2

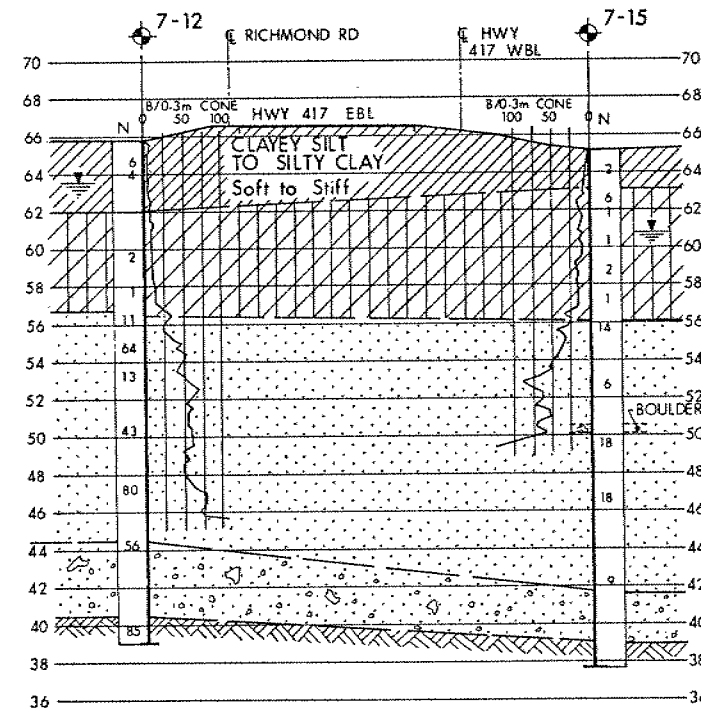
METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 758.9; E 358 645.1 ORIGINATED BY TS
DIST 9 HWY 416/417 BOREHOLE TYPE Cone Test, H-S Auger, B-Casing, Washbore COMPILED BY TS
DATUM Geodetic DATE 88 07 22-23 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
65.6	Ground Surface												
0.0	Mixture of Clayey Silt, Sand and Gravel (Fill) Brown Compact		1	SS	18		64						2 72 19 7
			2	SS	15		62						6 70 20 4
60.6			3	SS	21		60						5 88 (7)
5.0	Brown Grey Sand Trace Silt Trace Gravel Compact to Very Dense		4	SS	5		58						4 90 (6)
			5	SS	12		56						1 90 (9)
			6	SS	23		54						1 90 (9)
			7	SS	25		52						0 91 (9)
			8	SS	19		50						
			9	SS	30		48						
			10	SS	55		46						
			11	SS	38		44						13 78 (9)
			12	SS	33		42						
			13	SS	32		40						
			14	SS	36		38						
			15	SS	97								
41.2			16	SS	54								
24.4	Het. Mixture of Sand, Gravel and Boulders (Glacial Till)		17	RC	REC	100%							RQD = 41%
39.1	Bedrock		18	RC	REC	95%							RQD = 64%
26.5	Dolostone												
37.9	Unweathered												
27.7	End of Borehole												
	* Water Level Not Established Hole caved in at 2.1 m depth												



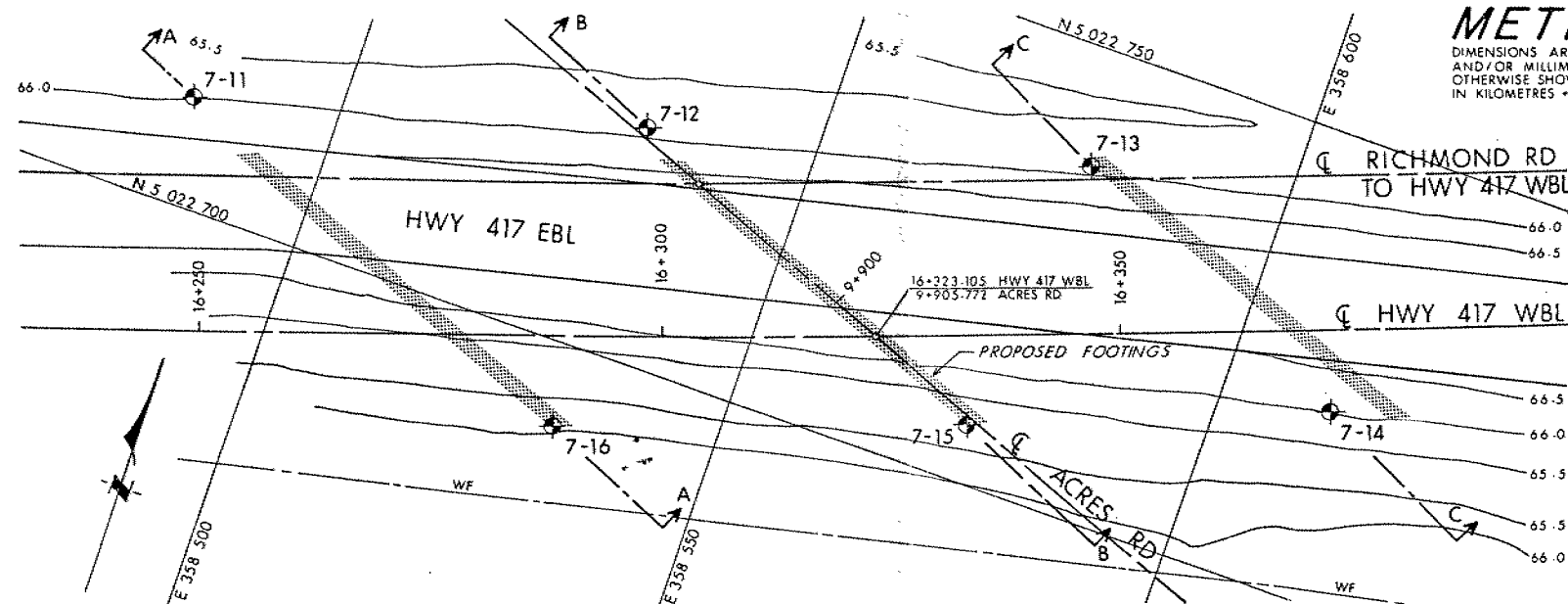
A-A



B-B

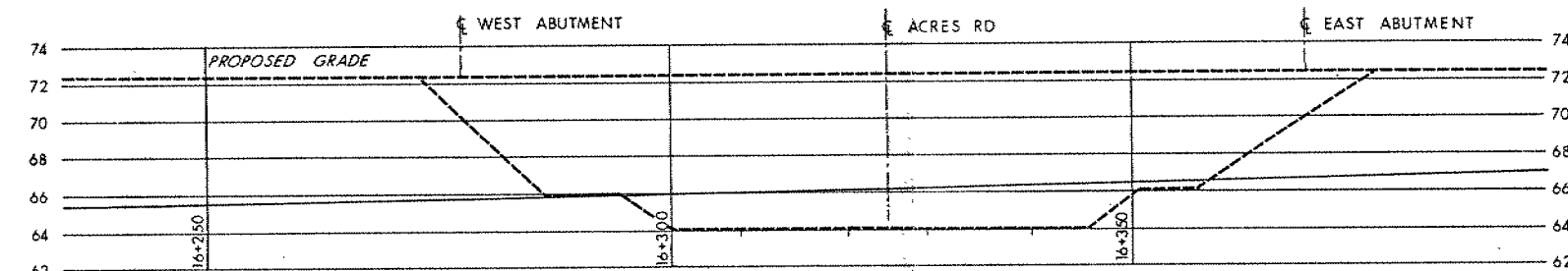
SECTIONS

SCALE
8m 4 0 8m Hor
4m 2 0 4m Vert



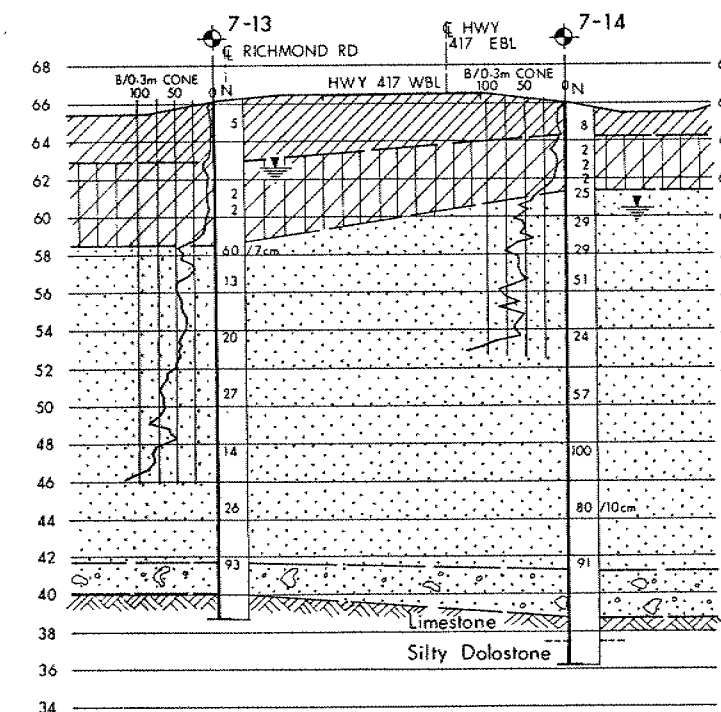
PLAN

SCALE
8m 4 0 8m



PROFILE HWY 417 WBL

SCALE
8m 4 0 8m Hor
4m 2 0 4m Vert



C-C

SOIL STRATIGRAPHY LEGEND

- SILTY CLAY TO CLAY
Soft to Stiff
- CLAYEY SILT
WITH INTERBEDDED SILTY SAND
Very Soft to Firm
- SAND
TRACE TO SOME GRAVEL
Loose to Very Dense
- HETEROGENEOUS MIXTURE OF
SAND, GRAVEL & BOULDERS
(GLACIAL TILL)
- SILTY DOLOSTONE
BEDROCK

METRIC

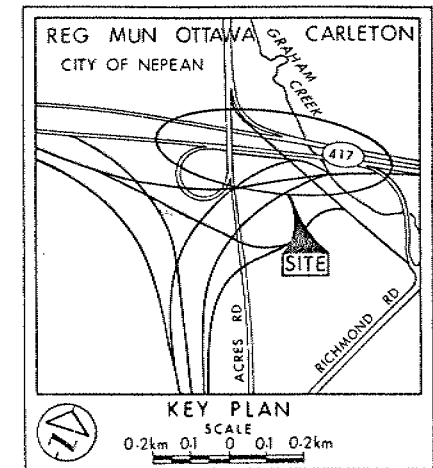
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES - METRES.

CONT No
WP No 120-87-10

HWY 417 WBL OVERPASS
AT ACRES RD
BORE HOLE LOCATIONS & SOIL STRATA



SHEET



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)
- WL at time of investigation 88 07

No	ELEVATION	CO-ORDINATES NORTH	EAST
7-11	65.9	5 022 711.9	358 484.4
7-12	65.8	5 022 725.2	358 531.7
7-13	66.1	5 022 737.6	358 578.6
7-14	66.0	5 022 721.1	358 611.8
7-15	65.2	5 022 706.4	358 575.0
7-16	66.0	5 022 691.2	358 532.7

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
1	88 09 22		
Geocres No 31G5-145			
HWY No 417		DIST 9	
SUBM'D T5	CHECKED	DATE 88 09 22	SITE 3-536
DRAWN DT	CHECKED	APPROVED	DWG1208710-A

METRIC

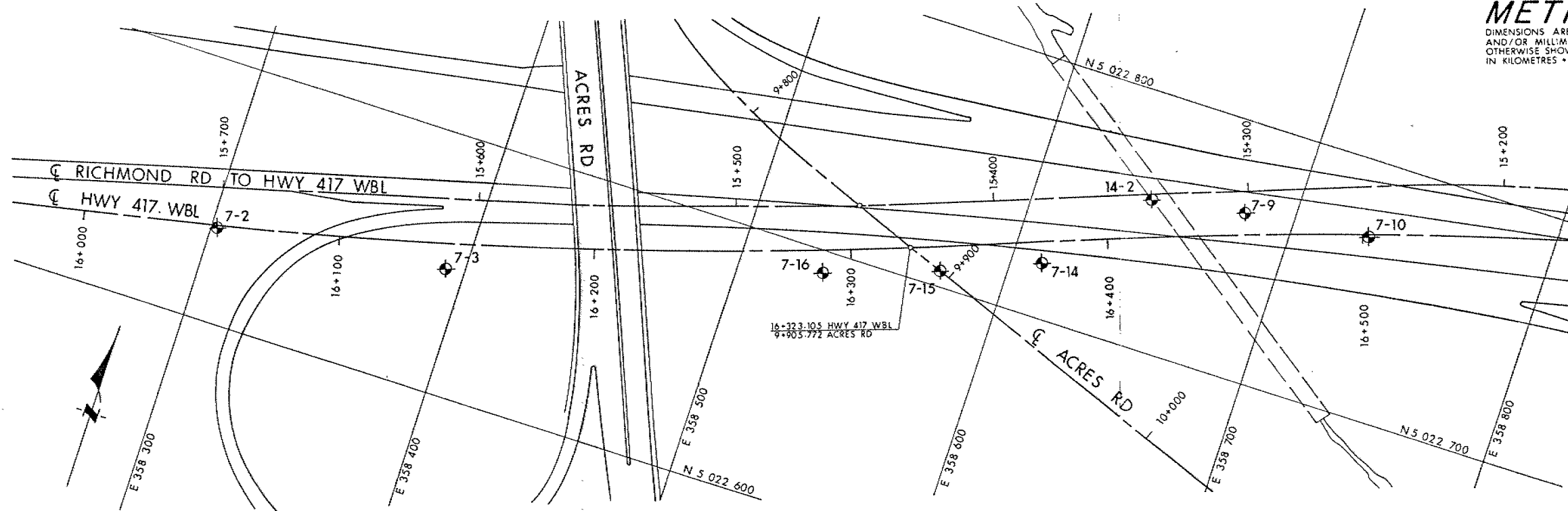
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

CONT No
WP No 120-87-10

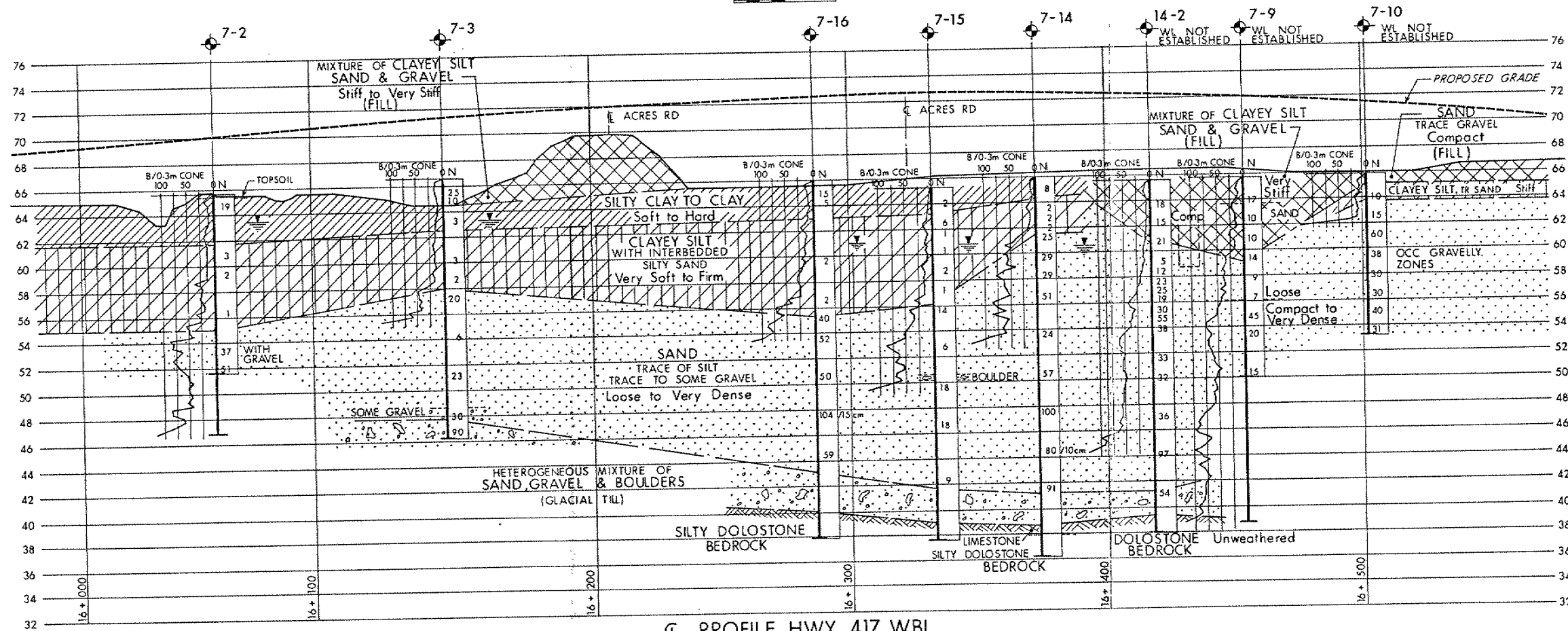
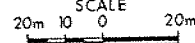
HWY 417 WBL OVERPASS
AT ACRES RD
BORE HOLE LOCATIONS & SOIL STRATA



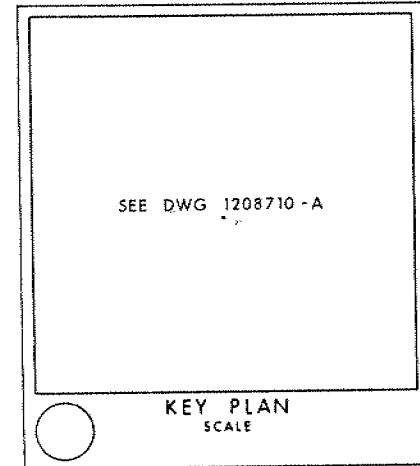
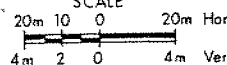
SHEET



PLAN
SCALE



PROFILE HWY 417 WBL
SCALE



KEY PLAN
SCALE

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)
- WL at time of investigation 88 07

No	ELEVATION	CO-ORDINATES NORTH	EAST
7-2	65.7	5 022 636.1	358 305.4
7-3	66.6	5 022 648.1	358 394.8
7-9	65.7	5 022 765.3	358 681.4
7-10	65.9	5 022 771.4	358 729.2
7-14	66.0	5 022 721.1	358 611.8
7-15	65.2	5 022 706.4	358 575.0
7-16	66.0	5 022 691.2	358 532.7
14-2	65.6	5 022 758.9	358 645.1

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
-----	------	----	-------------

Geocres No 31G5-145			
HWY No 417	SUBM'D TS		DIST 9
CHECKED	DATE 88 09 28	CHECKED	SITE 3-536
DRAWN DT	CHECKED	APPROVED	DWG 1208710-B

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

DIST. No. 9
CONT. No.
WP. No.120-87-10



HWY. 417 W.B. OVERPASS - No. 7A
RICHMOND ROAD RAMP W.B. OVERPASS
- No. 7B OVER ACRES ROAD
GENERAL ARRANGEMENT

Morrison Hershfield Limited
Consulting Engineers

GENERAL NOTES

- CLASS OF CONCRETE
1. DECK
REMAINDER (UNLESS NOTED) 35 MPa
30 MPa
- REINFORCING STEEL
2. REINFORCING STEEL SHALL BE GRADE 400 UNLESS OTHERWISE
SPECIFIED. BAR MARKS WITH SUFFIX 'C' DENOTE COATED BARS.
- CLEAR COVER TO REINFORCING STEEL
3. FOOTINGS 100±25
ABUTMENTS, WINGWALLS AND RETAINING WALLS
FRONT FACE 80±20
BACK FACE 70±20
PIERS 80±20
DECK SLAB
TOP 70±20
BOTTOM AND SIDES 50±10
REMAINDER (UNLESS NOTED) 70±20
- CONSTRUCTION NOTES:
IF THE ACTUAL BEARING HEIGHTS ARE DIFFERENT FROM
THE ASSUMED HEIGHTS GIVEN WITH THE BEARING DESIGN
DATA, THE CONTRACTOR SHALL ADJUST THE BEARING
SEAT ELEVATIONS AND THE REINFORCING STEEL TO SUIT
THE ACTUAL HEIGHTS.
COMPACTED FILL, MAXIMUM GRAIN SIZE 50mm SHALL BE
PLACED UP TO THE BOTTOM OF WINGWALLS AND RETAINING
WALL FOOTING ELEVATION PRIOR TO DRIVING PILES.

LIST OF DRAWINGS

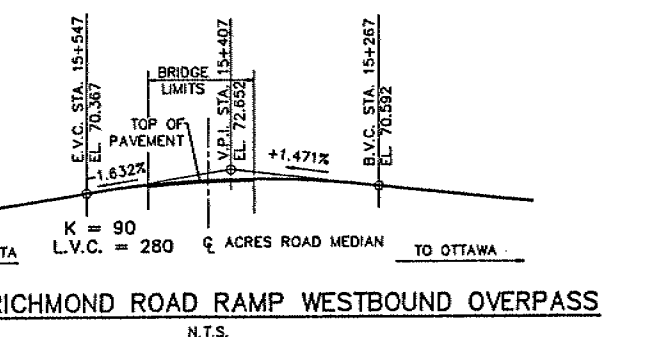
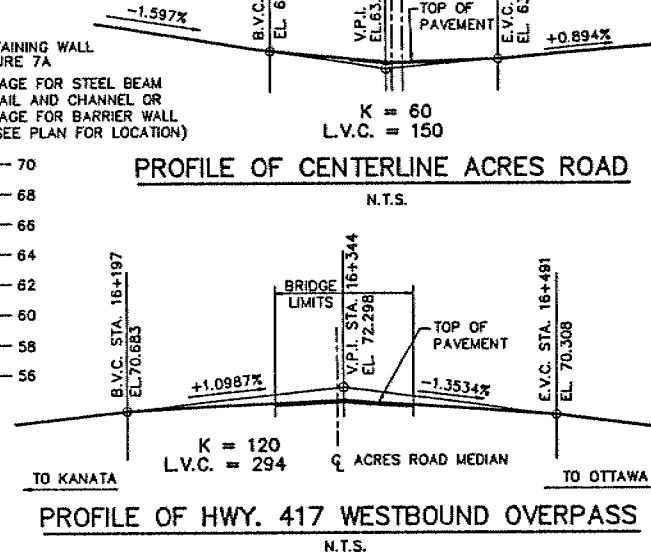
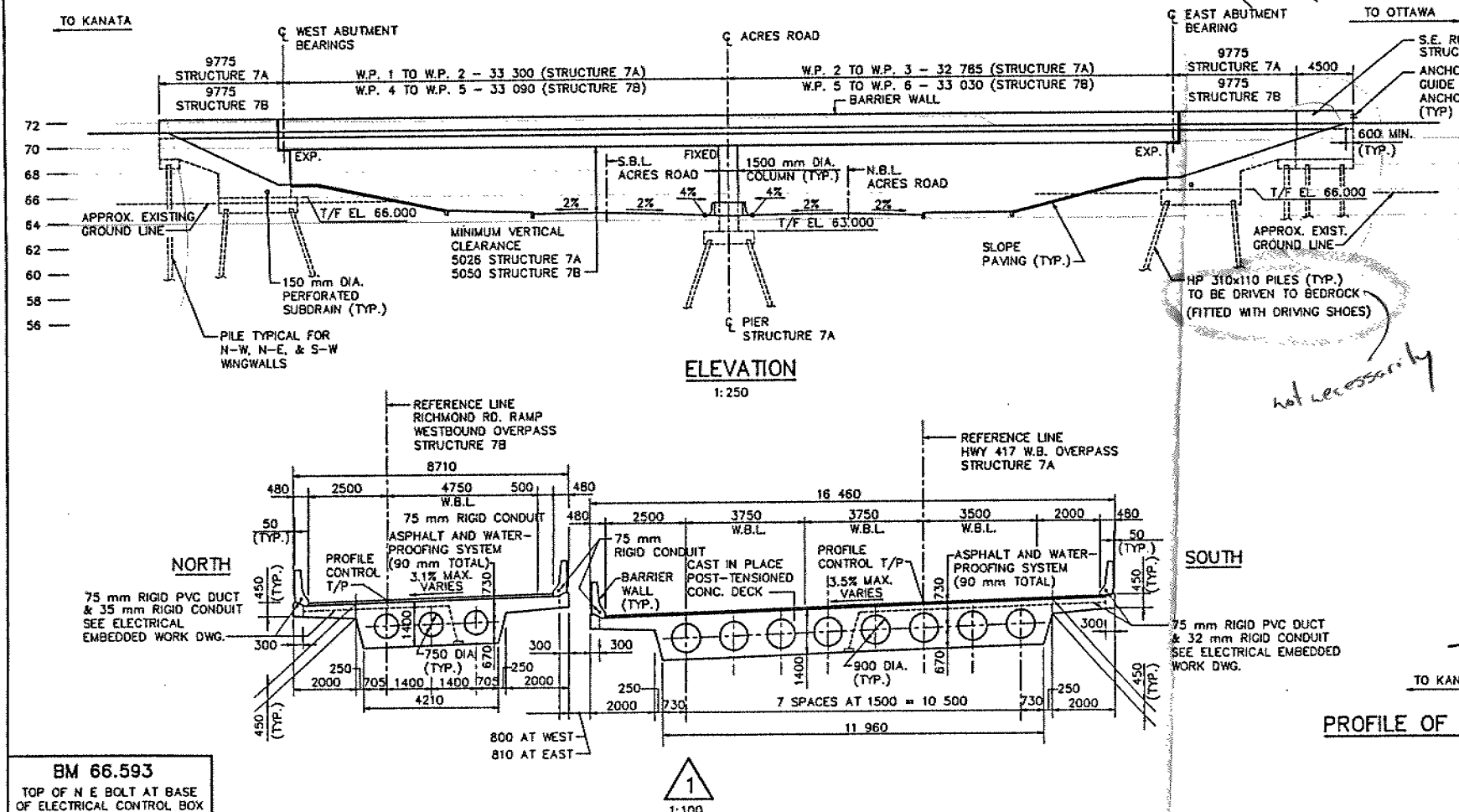
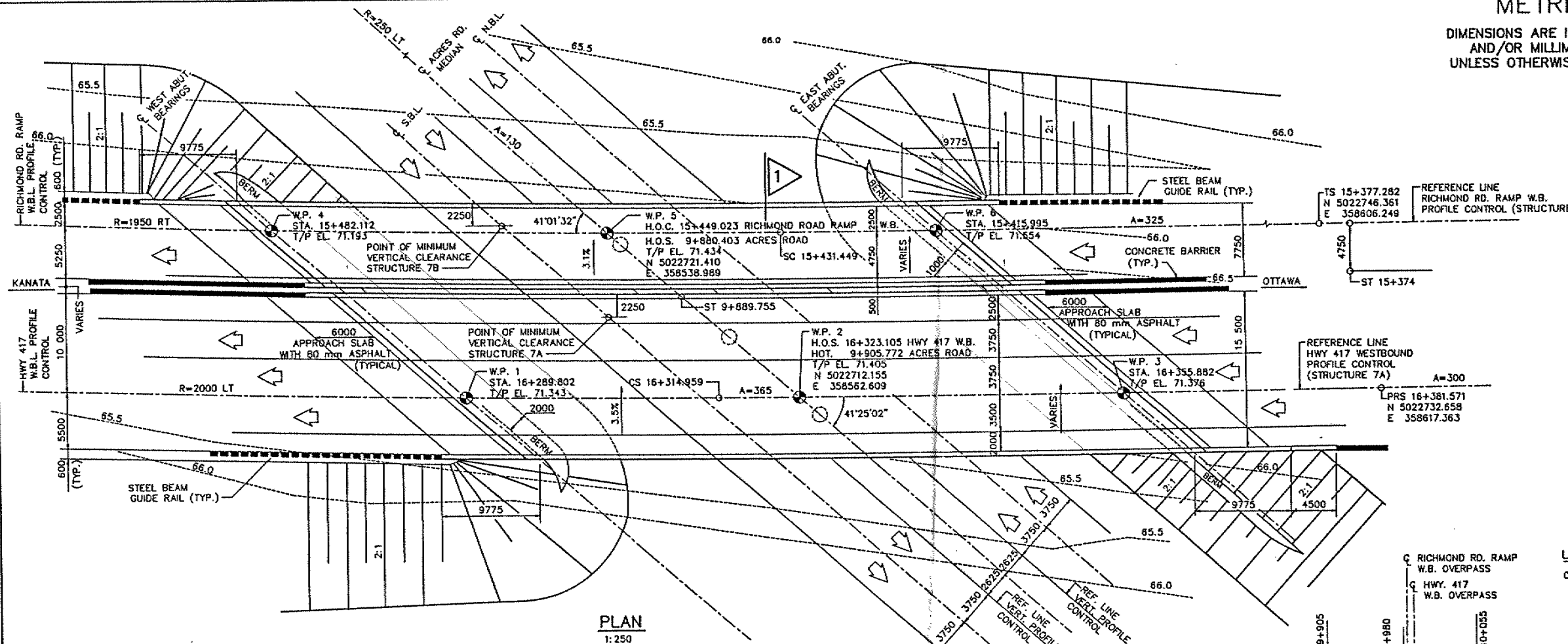
- 03-536-1. GENERAL ARRANGEMENT.
2. BOREHOLE LOCATIONS AND SOIL STRATA.
3. FOOTING LAYOUT.
4. WINGWALLS - I
5. WINGWALLS - II
6. EAST ABUTMENT - STRUCTURE 7A.
7. WEST ABUTMENT - STRUCTURE 7A.
8. EAST ABUTMENT - STRUCTURE 7B.
9. WEST ABUTMENT - STRUCTURE 7B.
10. EAST AND WEST ABUTMENT WINGWALLS.
11. RETAINING WALL AND DETAILS.
12. PIER AND BEARING DETAILS.
13. DECK LAYOUT AND SKEED ELEVATIONS - STRUCTURES 7A & 7B.
14. LONGITUDINAL STRESSING - STRUCTURE 7A.
15. LONGITUDINAL STRESSING - STRUCTURE 7B.
16. TRANSVERSE STRESSING - STRUCTURE 7A.
17. TRANSVERSE STRESSING - STRUCTURE 7B.
18. DECK REINFORCING - STRUCTURE 7A.
19. DECK REINFORCING - STRUCTURE 7B.
20. DECK REINFORCING DETAIL I - STRUCTURE 7A.
21. DECK REINFORCING DETAIL II - STRUCTURE 7A.
22. DECK REINFORCING DETAIL III - STRUCTURE 7B.
23. JOINT ANCHORAGE AND ARMOURING.
24. BARRIER WALL - STRUCTURE 7A.
25. BARRIER WALL - STRUCTURE 7B.
26. 6000 mm APPROACH SLAB.
27. FLAGSTONE/CONCRETE SLOPE PAVING.
28. STANDARD DETAILS
29. BRIDGE DATE AND SITE NUMBER DATA.
30. AS CONSTRUCTED ELEVATIONS AND DIMENSIONS.
31. ELECTRICAL EMBEDDED WORK.
32. QUANTITIES SHEET I - STRUCTURE 7A
33. QUANTITIES SHEET II - STRUCTURE 7A
34. QUANTITIES SHEET I - STRUCTURE 7B
35. QUANTITIES SHEET II - STRUCTURE 7B.

LEGEND

T/F - TOP OF FOOTING
T/C - TOP OF CONCRETE
T/P - TOP OF PAVEMENT
W.P. - WORKING POINT

APPLICABLE STANDARD DRAWINGS

- DD-3501 MINIMUM GRANULAR BACKFILL REQUIREMENTS
DD-3504 RETAINING WALL BACKFILL REQUIREMENTS
OPSD 508.02 BRIDGE DECK WATERPROOFING



BM 66.593
TOP OF N.E. BOLT AT BASE
OF ELECTRICAL CONTROL BOX
14.27 RT 16+245.5 WBLN

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	CL	CHK. ATC	CODE 04BDC-83 [LOAD CLASS A] DATE FEB./90
DRAWN	HT	CHK. ATC	SITE 03-536 [STRUCT. SCHEME] DWG. 1

METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

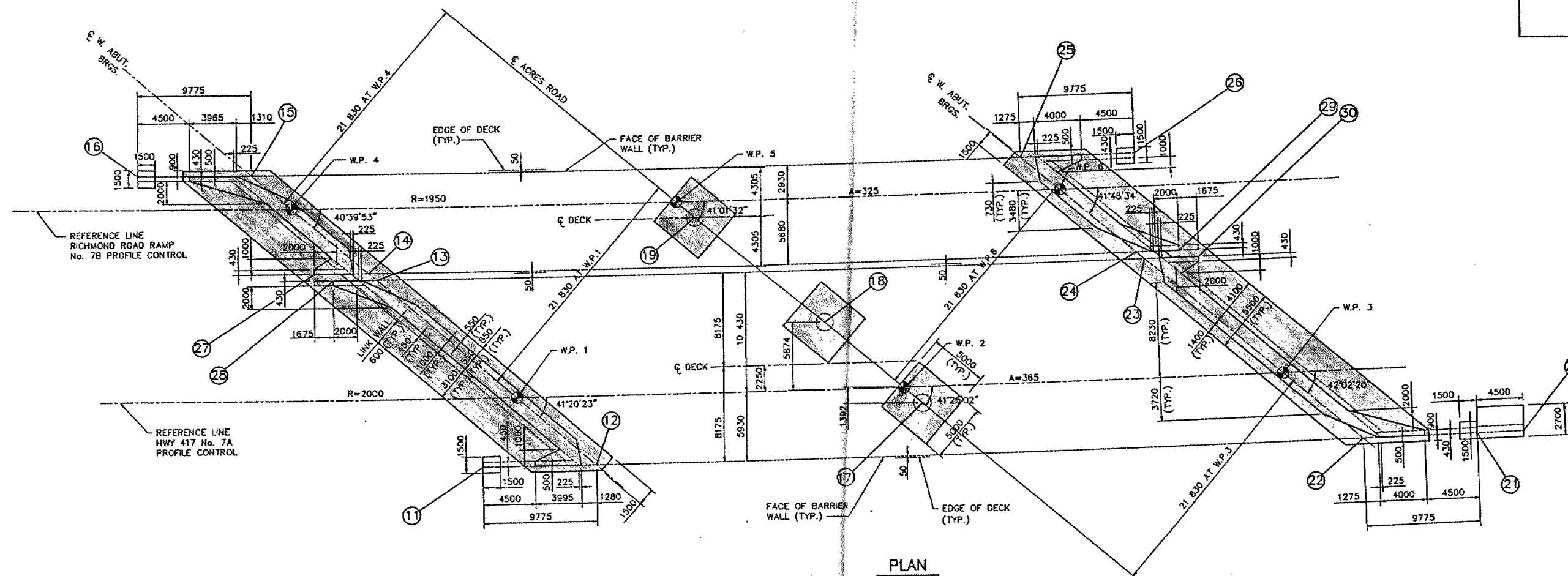
DIST. No. 9
CONT. No.
WP. No.120-87-10



HWY 417 W.B. OVERPASS - No. 7A
RICHMOND ROAD RAMP W.B. OVERPASS
- No. 7B OVER ACRES ROAD
FOOTING LAYOUT

Morrison Hershfield Limited
Consulting Engineers

SHEET



PLAN
1:200

CO-ORDINATES OF WORKING POINTS			
W.P.	STATION	NORTH CO-ORDINATE	EAST CO-ORDINATE
1	16+289.802	5 022 701.000	358 531.235
2	16+323.105	5 022 712.155	358 562.609
3	16+355.882	5 022 723.569	358 593.339
4	15+482.112	5 022 710.625	358 507.707
5	15+449.023	5 022 721.410	358 538.989
6	15+415.995	5 022 732.693	358 570.030

W.P. 7 TO W.P. 10 NOT USED.

CO-ORDINATES OF REFERENCE POINTS		
REF. P.	NORTH CO-ORDINATE	EAST CO-ORDINATE
11	5 022 694.400	358 530.290
12	5 022 697.608	358 539.525
13	5 022 706.997	358 516.570
14	5 022 707.338	358 515.736
15	5 022 712.326	358 503.549
16	5 022 709.254	358 494.269
17	5 022 711.390	358 564.563
18	5 022 715.398	358 554.320
19	5 022 720.641	358 540.936
20	5 022 725.394	358 614.931
21	5 022 723.799	358 610.723
22	5 022 720.343	358 601.579
23	5 022 729.260	358 578.801
24	5 022 729.591	358 577.953
25	5 022 734.299	358 565.927
26	5 022 737.712	358 575.087
27	5 022 705.830	358 511.276
28	5 022 705.805	358 513.051
29	5 022 730.879	358 581.384
30	5 022 730.897	358 583.172

NOTES:

1. ALL PROFILE CONTROL LINES AND OFFSET LINES ARE ON CURVES.
2. LINES BETWEEN W.P. 1 TO W.P. 4
W.P. 3 TO W.P. 6
ARE STRAIGHT LINES.
3. (22) DENOTES REFERENCE POINT 22.



DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS		DATE	BY	DESCRIPTION
DESIGN CL	CHK.ATC	CODE OHBDC-83	LOAD CLASS A	DATE FEB./90
DRAWN HT	CHK.ATC	SITE 03-536	STRUCT.	SCHEME DWG. 3