



Ministry of
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FOUNDATION DESIGN SECTION

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 7802-86-01

DIST 19

HWY Municipal

STR SITE 48W-34

Kaministiquia River Bridge
Ware and Dawson Road - Goldie L.R.B.

**foundation
investigation and
design report**

ENGINEERING MATERIALS OFFICE
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WP 7802-86-01 DIST 19
HWY Municipal STR SITE 48W-34

Kaministikwia River Bridge
Ware and Dawson Road - Goldie L.R.B.

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FOUNDATION INVESTIGATION REPORT
For
W.P. 7802-86-01; Site 48W-34
Kaministiquia River Bridge
Ware and Dawson Road - Goldie L.R.B.
District 19, Thunder Bay

INTRODUCTION

This report summarizes the foundation investigation for the proposed bridge at this site.

The fieldwork was carried out between 86 07 14 and 86 07 29 utilizing a continuous flight auger machine equipped with 82 mm I.D. hollow-stem augers, H, N and B casing, tri-cone bits and a B core barrel.

The investigation consisted of 3 sampled boreholes/cone penetration tests and 4 sampled boreholes. Bedrock was cored at 4 boreholes. The range of borehole depths was 6.5 m to 20.3 m.

On each side of the river 2 boreholes were advanced to bedrock near the limits of the proposed abutment as well as an additional borehole to determine subsurface conditions at the approach. An attempt to arrange a borehole at the proposed pier location was precluded by the fast flowing river conditions, and it was necessary to resort to a borehole drilled through the existing bailey bridge to estimate conditions at the pier.

SITE DESCRIPTION

The site is located approximately 5 km east of the intersection of Hwy.17/Hwy.102 along Hwy. 102, and approximately 2 km north along Silver Falls Road. At this location there is an existing 38.4±m single lane 3 span bailey bridge which crosses the Kaministiquia River in an east-west direction to connect Silver Falls Road to Forbes River Road.

The alignment of the proposed bridge is 10 m south of the C/L of the existing bailey bridge. Downstream (south) from the bailey bridge, the current of the river is very strong, the river bed and banks are strewn with boulders and there are rapids. The elevation of the existing bridge and its approaches is 305±m, while the river bottom is at elevation 300±m. The depth of water in the river at the proposed alignment was 1.5±m at the time of the investigation.

SUBSURFACE CONDITIONS

The Record of Borehole sheets in the Appendix illustrate the subsurface conditions at the borehole locations. The boreholes are referenced as BH#1 to #7. The locations and elevations of the boreholes, and stratigraphical profiles based on the borehole data, are shown on Drawing No. 78028601-A.

Essentially the overburden consists of 11m to 20m of silty sand containing occasional to frequent boulders. The groundwater elevation is approximately equivalent to the river level at 301.8 m.

OVERBURDEN

Silty Sand, Some Gravel, Trace Clay

This material is probably a fill. It was encountered at the surface at BH #6 and extended to a depth of 3.1 m. Below a depth of 2.8 ± m the material was slightly cohesive and contained organics.

Based on 'N' values ranging from 2 to 10, the denseness of the material is very loose to loose.

Figure 1 illustrates a typical grain size distribution for this material. It is susceptible to boiling under conditions of unbalanced hydrostatic head.

Sand, Trace/Some Silt, Gravel, Trace Clay

This material was encountered at the surface at all boreholes locations except BH #6 where it underlies the Silty Sand fill. The thickness of the deposit varies from 2.9 m to 6.5 m at the borehole locations.

Occasional to frequent bouldery zones occur within the deposit.

Based on results of the Standard Penetration Test, with 'N' values ranging from 11 to over 100, the denseness of the deposit is compact to very dense.

Figure 2 illustrates a typical grain size distribution for this material. It is susceptible to boiling under conditions of unbalanced hydrostatic head.

Sand and Gravel, Trace Silt, Clay, Occasional Cobbles and Boulders

This deposit overlies the bedrock and is the main deposit at the site. Its thickness was determined at BH#'s 1, 2, 4, 5, 7 and ranges from 8.4 m to 12.8 m.

Occasional to frequent bouldery zones occur within the deposit.

Based on 'N' values ranging from 26 to over 100, the denseness of the material is compact to very dense. In view of the drilling techniques required to advance through this deposit, the material is generally very dense and would present difficulties for pile driving.

Figure 3 illustrates a typical grain size distribution for this material.

BEDROCK

The bedrock is unweathered greywacke. Refer to the geologist's Description of Rock Core in Table 1 of the Appendix for detailed descriptions of the core samples.

GROUNDWATER

Groundwater elevations across the entire site are essentially at river level, which at the time of the field investigation was 301.8 m.

DISCUSSION AND RECOMMENDATIONS

It is proposed to construct a 2-span (25m, 25m) bridge across the Kaministikwia River along an alignment 10 m south of the centre line of the existing bailey bridge. At this location the river is approximately 41 m wide. No details of the proposed grade have been provided, and it is assumed that the grade of the new bridge will be the same as the existing bridge (305±m).

Structure Foundations

The structure may be supported on spread footings, steel H-piles, concrete filled open-ended steel tube piles or reinforced caissons with liners.

The alternative, or combination, which leads to the least expensive design is recommended.

Perched abutments on rock fill were also considered, but at the assumed grade of 305 m the elevation difference to ground level is not sufficient to make this a practical alternative. Also, some differential settlements at the abutments would be anticipated which may not be compatible with a 2-span design.

1) SPREAD FOOTINGS

The abutments and the pier may be founded on spread footings on natural overburden at the bearing capacity loadings and at or below the founding elevations indicated in the following table. The founding elevations have been determined from foundation loading requirements and may not reflect scour and hydrologic requirements.

Location	Founding Elevation (m)	Factored Bearing Capacity at U.L.S.	Bearing Capacity at S.L.S. Type II
West Abutment Sta.10+075±	northside 303.0 southside 298.6	840 kPa	350 kPa
Centre Pier Sta.10+050±	297.0	840 kPa	350 kPa
East Abutment Sta.10+025±	300.0	840 kPa	350 kPa

To facilitate construction at the west abutment, the footing may be stepped at the centre line and the lower excavation on the south side may be built up to the base of the north side excavation with mass concrete.

2) STEEL H-PILES

The abutments and the pier may be supported on 310 HP 110 steel H-piles, equipped with driving shoes and driven in accordance with MTC Standard SS103-10 or SS103-11 but at least to the elevations indicated.

Pile driving will be complicated by the presence of cobbles and boulders within the overburden and penetration to bedrock is not considered to be feasible.

The following ultimate capacities and pile tip elevations are recommended for control of driving using MTC Standard SS103-10 or SS103-11.

Location	Pile Tip Elevation	Ultimate Capacity
West Abutment Sta.10+075±	296 m	1800 kN
Centre Pier Sta.10+050±	295 m	1800 kN
East Abutment Sta.10+025±	296 m	1800 kN

The following design values are recommended for piles driven in accordance with the above-noted recommendations:

<u>Pile Type</u>	<u>Factored Capacity at U.L.S.</u>	<u>Capacity at S.L.S. Type II</u>
310 HP 110	900 kN	600 kN

It may be advantageous, especially at the proposed pier locations, to consider pile bent construction so that dewatering can be eliminated.

3) OPEN-ENDED STEEL TUBE PILES

The abutments and the pier may be supported on concrete filled steel tube piles.

Pile driving will be complicated by the presence of cobbles and boulders and the tube piles should be installed open-ended, as a combination of driving and drilling or churn drilling will be necessary to advance through bouldery zones. When required, the drilling operations can be carried out through the tube pile. After the piles have been seated, they should be cleaned out and filled with concrete placed by tremie methods (without dewatering).

The tube piles may be founded on bedrock, or alternatively on overburden at reduced loadings with pile driving controlled by MTC Standard SS103-10 or SS103-11.

For tube piles seated on bedrock, the following design values are recommended:

<u>Pile Type</u>	<u>Factored Capacity at U.L.S.</u>	<u>Capacity at S.L.S. Type II</u>
Steel Tube 324 mm x 9.5 mm	1600 kN per pile	NA*

*The capacity at S.L.S. Type II will not govern design as the bedrock will not settle. However, the allowable structural capacity of the pile should not exceed the U.L.S. value recommended.

For tube piles seated within the overburden at or below the elevations indicated, the following ultimate capacities are recommended for control of driving using MTC Standard SS103-10 or SS103-11.

Location	Pile Tip Elevation	Ultimate Capacity
West Abutment Sta.10+075±	296 m	1800 kN
Centre Pier Sta.10+050±	295 m	1800 kN
East Abutment Sta.10+025±	296 m	1800 kN

The following design values are recommended for piles driven in accordance with the above-noted recommendations:

<u>Pile Type</u>	<u>Factored Capacity at U.L.S.</u>	<u>Capacity at S.L.S. Type II</u>
Steel Tube 324 mm x 9.5 mm	900 kN per pile	600 kN per pile

Again, for this alternative, it may be advantageous, especially at the proposed pier location to consider pile bent construction so that dewatering can be eliminated.

4) REINFORCED CONCRETE CAISSONS WITH LINERS

The abutments and the pier may be founded on reinforced concrete caissons.

The caissons may be constructed by advancing a steel liner through the overburden. This operation will require churn drilling in order to penetrate through cobbles and boulders in the overburden. After the liner has been cleaned out and the required reinforcing has been installed the concrete may be placed by tremie techniques. The steel liner should remain in place after construction of the caisson has been completed.

The caissons may be founded on bedrock or alternatively on overburden at reduced loadings.

For caissons founded on bedrock, the following design values are recommended:

<u>Caisson Diameter</u>	<u>Factored Capacity at U.L.S.</u>	<u>Capacity at S.L.S. Type II</u>
0.76 m	3000 kN	NA*

*The capacity at S.L.S. Type II will not govern design as the bedrock will not settle. However, the allowable structural capacity of the caisson should not exceed the U.L.S. value recommended.

For caissons founded within the overburden at or below the elevations indicated, the following design values are recommended for 0.76 m diameter caissons.

Location	Founding Elevation (m)	Factored Bearing Capacity at U.L.S.	Bearing Capacity at S.L.S. Type II
West Abutment Sta.10+075±	296 m	1500 kN	1000 kN
Centre Pier Sta.10+050±	295 m	1500 kN	1000 kN
East Abutment Sta.10+025±	296 m	1500 kN	1000 kN

As with the pile alternatives, consideration should be given to extending the caissons to the underside of the bridge, especially at the pier, so that dewatering can be eliminated.

Lateral Resistance

For spread footings, sliding resistance between the base of the concrete and the underlying foundation material should be calculated in accordance with Section 6-7.3.3.2 of the O.H.B.D.C. assuming an unfactored ϕ value of 30°.

For piles and caissons, resistance to lateral loads shall be computed in accordance with Section 6-8.3.8 of the O.H.B.D.C.

Earth Pressure

Backfill to structures should consist of granular material in accordance with MTC Standard Special Provision #121 (83 10).

Computation of earth pressures should be in accordance with Section 6.6.1.2 of the O.H.B.D.C. For design purposes, the following physical properties for backfill can be assumed:

<u>Material</u>	<u>ϕ</u>	<u>γ</u>
Granular 'A'	35°	22.0 kN/m ³
Granular 'B'	30°	21.2 kN/m ³

For the foundation alternatives supported on overburden, the foundation is considered to be yielding and the active case applies for lateral earth pressure calculations.

For the foundation alternative supported on bedrock, the foundation is considered to be non-yielding and the at-rest case applies for lateral earth pressure calculations.

Slope Stability

No stability problems are anticipated for approach embankments for the assumed grade of 305 m.

Earth fill slopes should be 2H:1V or flatter. Rock fill slopes should be 1.5H:1V or flatter.

Settlement

Total and differential settlements will be negligible for structure foundations constructed in accordance with the recommendations provided in this report.

Settlements within approach embankments will be negligible.

Frost Protection

A minimum of 2.2 m of earth cover, or equivalent, is required to the base of the footing or pile cup.

Dewatering

The soil at this site is susceptible to boiling under conditions of unbalanced hydrostatic head. Dewatering would be a problem for any excavation below the prevailing groundwater level. The cobbles and boulders in the overburden will create difficult sheet pile driving conditions. Consequently it would be difficult to construct a cofferdam that penetrates deep enough into the overburden to permit dewatering. Considering the high permeability of the foundation soil, and the difficulties anticipated with constructing a cofferdam, it would be difficult to completely dewater a flooded excavation.

For this reason we recommend that tremie concreting techniques should be used for excavations below the groundwater or river level. The footing or pier cap could be constructed by excavating for a water-tight prefabricated steel box that extends from the base of the excavation to a reasonable height above the water level. After a pad of tremie concrete, thick enough to balance the hydrostatic head of water, is placed at the bottom of the excavation, the excavation could be dewatered and construction of the footings/pile caps could proceed in the dry. The connection between the tremie and in the dry concrete should be constructed to provide required base support. Cleaning and roughing of the tremie surface and anchoring at the tremie/in the dry interface may be required.

Dewatering problems would be eliminated if excavations were located above the groundwater/river level.

Because of the fast flow conditions in the river, we anticipate that construction of a pier would be difficult. For a bridge at the proposed locations, consideration should be given to reducing the flow if possible, or alternatively, adopting a single span design.

Erosion Protection

The abutments for the proposed bridge will require erosion protection in the form of a 0.6 m thickness of rock protection extending, in the horizontal plane, a minimum of 10 m on each side of the abutment foundation and, in the vertical plane, from a minimum of 2 m along the river bottom to 0.6 m above the high water level. The existing boulders on the river bottom may already provide a portion of the required protection.

Erosion protection is also required at the proposed pier. Because of the nature of the overburden a boulder blanket exists along the river bed, that may already provide some protection. However, river rapids are an erosional zone and sufficient protection should be provided to ensure the safety of the pier and also the required frost protection for the design life of the bridge.

The rate of scour and other hydrologic aspects should be considered in the design.

MISCELLANEOUS

The fieldwork for this project was carried out under the supervision of J. Duffield, Student Engineer, using equipment owned and operated by Dominion Soil Investigation Inc.

The overburden stratigraphy was prepared by M. Devata, Chief Foundations Engineer, East. The report was written by D. Dundas, Senior Foundations Engineer and reviewed by M. Devata.



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D. H. Dundas, P. Eng.
Senior Foundations Engineer

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Chief Foundations Engineer
(East)

October, 1986.

APPENDIX

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

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 = $\frac{c_u}{\tau_r}$

STRESS AND STRAIN

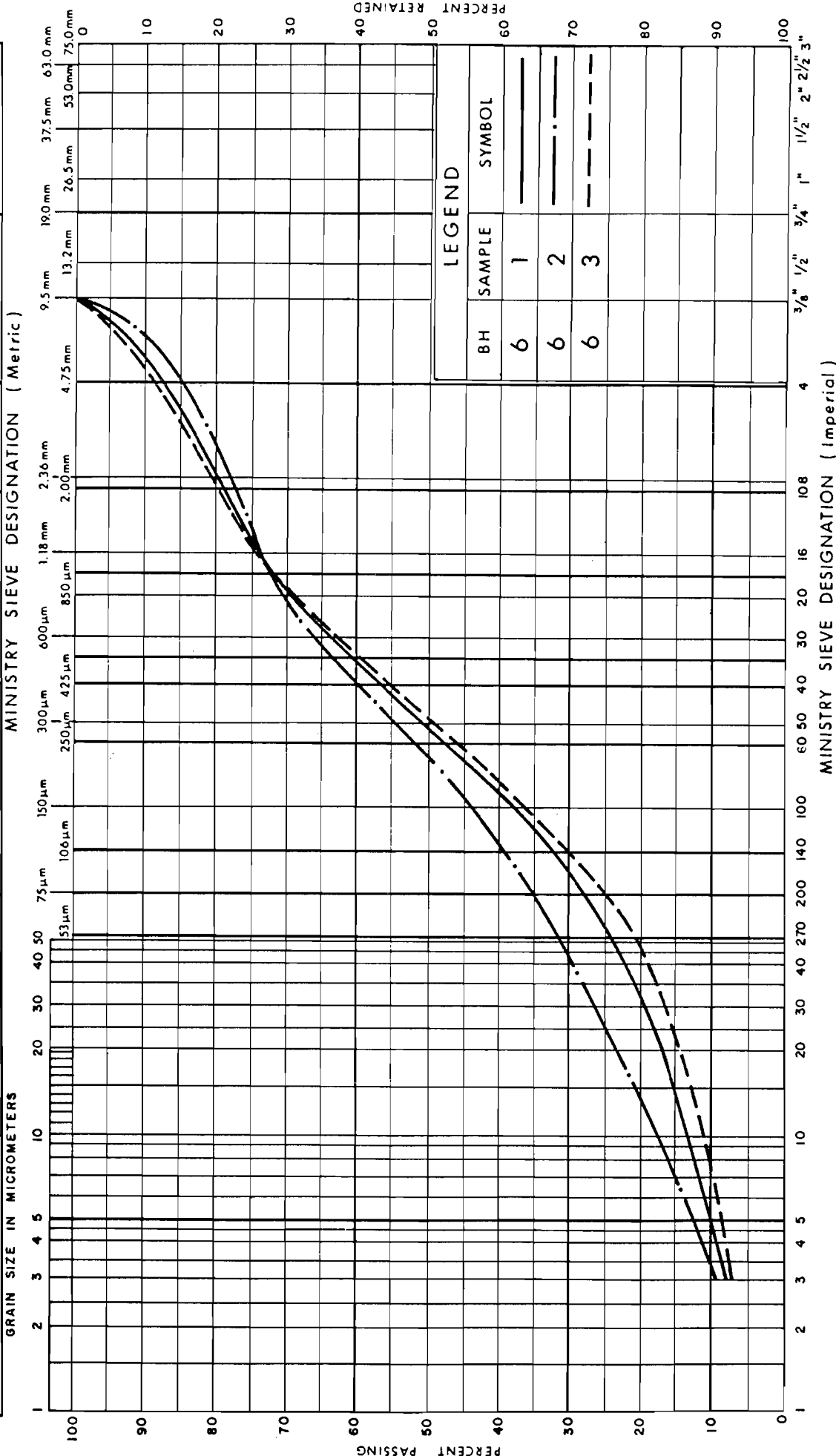
u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa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

PHYSICAL PROPERTIES OF SOIL

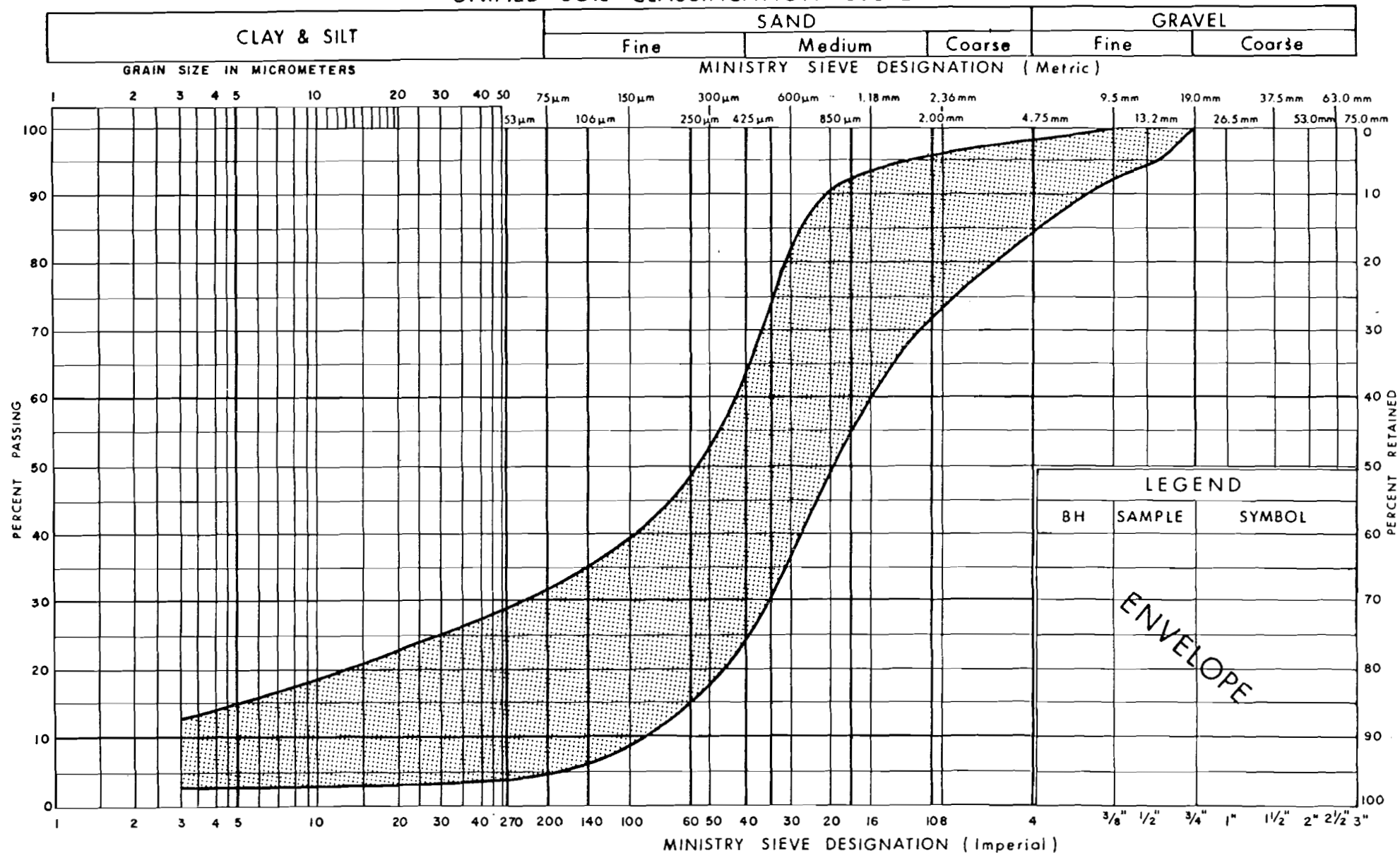
ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{\min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	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^2	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL	
		Fine	Medium	Coarse	Fine	Coarse



UNIFIED SOIL CLASSIFICATION SYSTEM



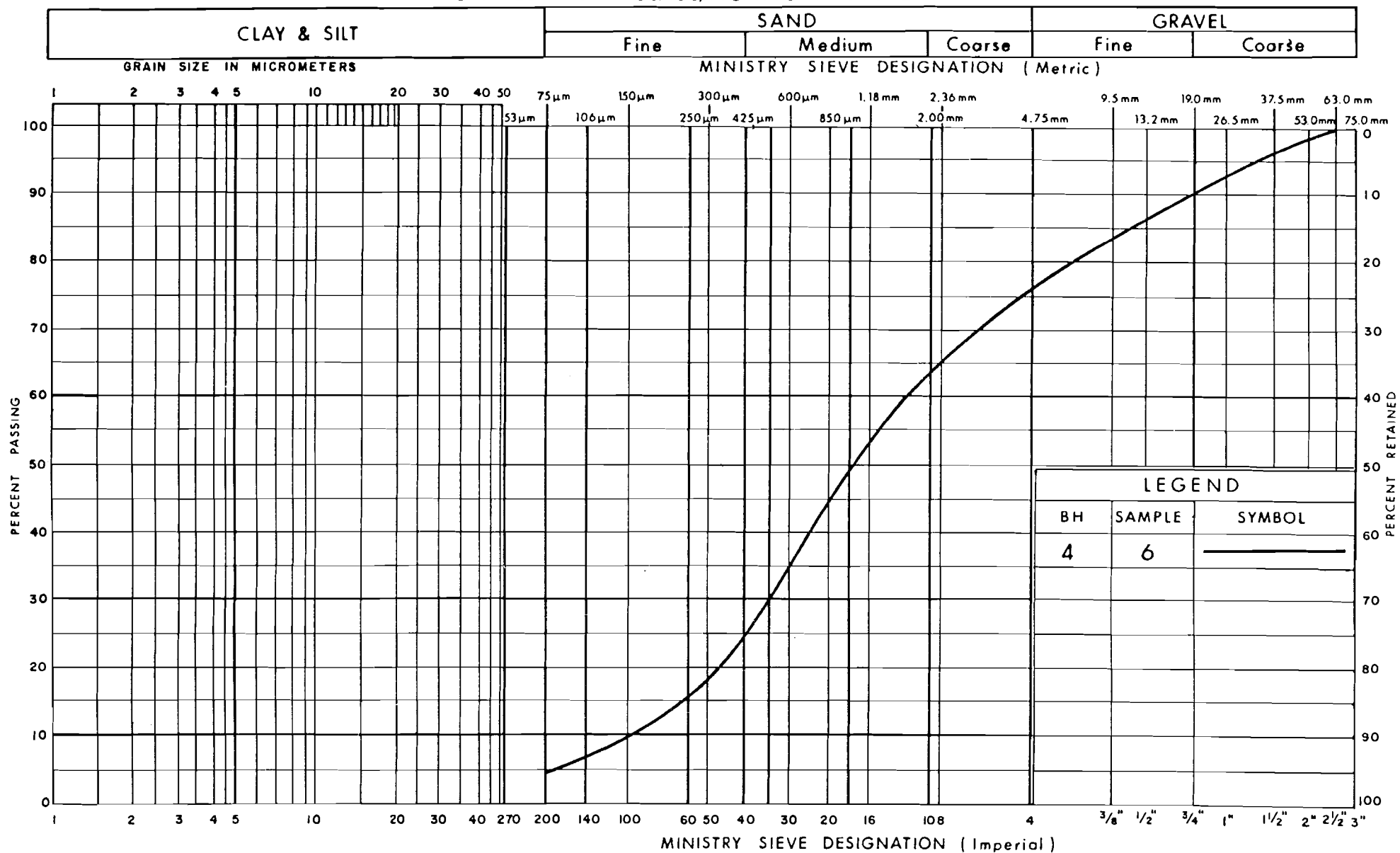
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GRAIN SIZE DISTRIBUTION
SAND, TRACE TO SOME SILT, GRAVEL TRACE OF CLAY

FIG No 2

W P 7802 - 86 - 01

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION
SAND & GRAVEL TRACE OF SILT, CLAY

FIG No 3

W P 7802-86-01

TABLE 1

DESCRIPTION OF ROCK CORE - W.P. 7802-86-01

BOREHOLE NUMBER				CORE DESCRIPTION	
	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	14.43 - 15.93	98	97	14.43 - 15.93	GREYWACKE, grey, unweathered, widely spaced joints
2	14.75 - 16.25 16.25 - 17.80	92 100	88 100	14.76 - 17.80	GREYWACKE, grey, unweathered, medium spaced to widely spaced joints
4	15.61 - 16.95	96	91	15.61 - 16.95	GREYWACKE, grey, unweathered, very widely spaced joints
5	11.35 - 11.51 11.51 - 12.88 12.88 - 14.10	100 98 100	0 93 100	11.35 - 11.58 11.58 - 14.10	GREYWACKE, grey, unweathered, very closely spaced joints GREYWACKE, grey, unweathered, very widely spaced joints

* CR = CORE RECOVERY ; RQD = ROCK QUALITY DESIGNATION

TABLE 1



RECORD OF BOREHOLE No 1

METRIC

W P 7802-86-01 LOCATION Sta. 10 + 077.7; O/S 5.0 m Lt Bridge ORIGINATED BY JD
DIST 19 HWY Local Rd. BOREHOLE TYPE HS Auger, B Casing, BXL Core COMPILED BY GP
DATUM Assumed DATE 86 07 16 and 17 CHECKED BY MD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					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						
304.3	Ground Surface													
0.0						*	304							
	Sand, trace to some silt, gravel trace of clay Dense to Very Dense		1	SS	39	10 cm								10 68 17 5
			2	SS	60/									9 65 16 10
			3	SS	67		302							
300.9			4	SS	79									
3.4														
	Sand and Gravel Trace of silt, clay		5	SS	77		300							
	Occasional Cobbles and Boulders Compact to Very Dense		6	SS	23		298							
	Medium to Coarse Sand		7	SS	26									
			8	SS	59		296							
	Silty Sand Trace of Gravel		9	SS	36		294							
			10	SS	96		292							
			11	SS	51		290							
289.9														
14.4	Greywacke Bedrock Unweathered		12	BXL RC	98% REC									RQD = 97%
288.4														
15.9	End of Borehole													
	* Water Level not established Note: Bi-cone drilling techniques adopted to penetrate occ. cobbles and boulders below Elev. 302±													

RECORD OF BOREHOLE No 2

METRIC

W P	7802-86-01	LOCATION	Sta. 10 + 081.0; O/S 13.5 m Lt. <u>4</u> Bridge	ORIGINATED BY	JD
DIST	19 HWY Local Rd.	BOREHOLE TYPE	HS Auger, B Casing, BXL Core & Cone Test	COMPILED BY	GP
DATUM	Assumed	DATE	86 07 15 and 16	CHECKED BY	MD

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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100							WATER CONTENT (%) 10 20 30					
								SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE												
305.0	Ground Surface																			
0.0	Sand, trace to some silt, gravel trace of clay Compact to Dense	[Stratigraphic Column]	1	SS	25	*	[Cone Penetration Plot]							3 79 12 6						
			2	SS	18															
			3	SS	11															
			4	SS	17															
			5	SS	36															
			6	SS	13															
			7	SS	12															
			8	SS	47															
298.6	Sand and Gravel trace of silt, clay Occasional Cobbles and Boulders Dense to Very Dense	[Stratigraphic Column]	9	SS	36									2 87 3 8 11 81 5 3 15 77 5 3 5 83 9 3						
6.4			10	SS	61															
			11	SS	38															
			12	SS	52															
			13	SS	86															
			14	BXL RC	92% REC															
290.2	Greywacke Bedrock Unweathered	[Stratigraphic Column]	15	BXL RC	100% REC								RQD = 88%							
14.8																				
287.2	End of Borehole																			
17.8	* Water Level Not Established Note: Bi-cone drilling techniques adopted to penetrate occasional cobbles and boulders below Elev. 298±																			

+3, x5: Numbers refer to Sensitivity



RECORD OF BOREHOLE No 3

METRIC

W P 7802-86-01 LOCATION Sta. 10 + 087.5; O/S 11.4 m Lt. 4 Bridge ORIGINATED BY JD
DIST 19 HWY Local Rd. BOREHOLE TYPE HS Auger, B Casing & Cone Test COMPILED BY GP
DATUM Assumed DATE 86 07 14 CHECKED BY MD

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40						60	80	100
								SHEAR STRENGTH							WATER CONTENT (%)		
305.1	Ground Surface																
0.0	Cobbles & Boulders Sand, trace to some silt gravel trace of clay Compact to Very Dense		1	SS	29	* 23 cm								2 83 10 5			
			2	SS	115												
			3	SS	59												
			4	SS	28												
			5	SS	25												
			6	SS	20												
298.6			7	SS	28												
6.5	End of Borehole																
	* Water Level Not Established																
	Note: Bi-cone drilling techniques adopted to clear cobbles and boulders around Elev. 304																

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No 4

METRIC

W P 7802-86-01 LOCATION Sta. 10 + 028.4; O/S 15.1 m Lt. Bridge ORIGINATED BY JD
DIST 19 HWY Local Rd. BOREHOLE TYPE HS Auger, N Casing, B Casing, BXL Core COMPILED BY GP
DATUM Assumed DATE 86 07 23 and 29 CHECKED BY MD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					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						
301.9 0.0	Ground Surface													
	Sand, trace to some silt, gravel trace of clay		1	SS	15									8 78 9 5
	Compact to Very Dense		2	SS	100/	28 cm	300							
298.8 3.1			3	SS	60/	0 cm								
			4	SS	60/	10 cm								
			5	SS	60/	0 cm	298							
			6	SS	55									25 69 (6)
			7	SS	33									
	Sand and Gravel trace of silt, clay		8	SS	56		296							
	Occasional Cobbles and Boulders		9	SS	118		294							
	Dense to Very Dense		10	SS	93									
			11	SS	82		292							
			12	SS	60/	0 cm	290							
			13	SS	35		288							
286.3 15.6	Greywacke Bedrock Unweathered		14	BXL RC	96% REC		286							RQD = 91%
285.0 16.9	End of Borehole													
	Note: Bi-cone and Tri-cone drilling techniques adopted to penetrate coarse gravel, cobbles and boulders below Elev, 300±													

+3, x5 : Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 5

METRIC

W P 7802-86-01 LOCATION Sta. 10 + 027.8; O/S 7.9 m Lt. 4 Bridge ORIGINATED BY JD
DIST 19 HWY Local Rd. BOREHOLE TYPE HS Auger, N Casing, B Casing, BXL Core & Cone Test COMPILED BY GP
DATUM Assumed DATE 86 07 21 and 22 CHECKED BY MD

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
302.6	Ground Surface													
0.0	Sand, trace to some silt, gravel trace of clay Compact to Very Dense		1	SS	47		302							6 63 21 10
			2	SS	71									
299.7			3	SS	41		300							
2.9	Sand and Gravel trace of silt, clay Occasional Cobbles and Boulders Dense to Very Dense		4	SS	31									
			5	SS	62									
			6	SS	60		298							
			7	SS	72									
	Sand some gravel		8	SS	101		296							
			9	SS	102									
			10	SS	88		294							
			11	SS	71		292							
291.2			12	RC	100%									RQD = 0%
11.4	Greywacke Bedrock Unweathered		13	BXL RC	98% REC		290							RQD = 93%
			14	BXL RC	100% REC									RQD = 100%
288.5														
14.1	End of Borehole													
	Note: Bi-cone and tri-cone drilling techniques adopted to penetrate coarse gravel cobbles and boulders below Elev. 301±													

+3, x5: Numbers refer to
Sensitivity

20
15
10

5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 6

METRIC

W P 7802-86-01 LOCATION Sta. 10 + 019.2; O/S 9.0 m Lt. 4 Bridge ORIGINATED BY JD
 DIST 19 HWY Local Rd. BOREHOLE TYPE HS Auger, B Casing COMPILED BY GP
 DATUM Assumed DATE 86 07 18 CHECKED BY MD

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
304.7	Ground Surface																GR SA SI CL
0.0	Silty Sand some gravel trace of clay (Probably Fill Material) Very Loose to Loose		1	SS	2		304										13 59 22 6
			2	SS	10												15 49 31 5
301.6	slightly cohesive with org.		3	SS	4		302										13 61 20 6
3.1			4	SS	22												
	Sand, trace to some silt, gravel trace of clay Compact to Very Dense		5	SS	23												
			6	SS	64		300										
			7	SS	23												
298.1			8	SS	29												
6.6	End of Borehole																

+³, x⁵: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10