PROPOSED

BRIDGE

LOWER TOWN

WINGHAM

40P14-10

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CONSULTING ENGINEERS
41 WEST STREET
GODERICH ONTARIO

Report on SOIL INVESTIGATION for PROPOSED BRIDGE LOWER TOWN WINGHAM M.T.C. SITE NO. 12-54

by

Dominion Soil Investigation Limited
1220 Trafalgar Street
London Ontario

Ref: 74-3-L12
June 25, 1974

C O N T E N T S

E N C L O S U R E S

I INTRODUCTION

In accordance with a letter of authorization dated March 27, 1974, from B.M. Ross & Associates Limited, Consulting Engineers, a soil investigation has been carried out in Lower Town Wingham, where it is proposed to replace an existing bridge with a new structure. The structure is designated by the Ministry of Transportation and Communications as Site no. 12-54.

It is understood that the road will be realigned slightly to the north of the existing road, and that the new structure will have 3 spans. The purpose of the investigation was to reveal the subsurface conditions at the proposed abutment locations, and to determine the relevant soil properties for the design and construction of the new foundations.

II FIELD WORK

The field work, consisting of two boreholes

accompanied by two dynamic penetration tests, was carried out on May 30, 1974, at the locations shown on Enclosure 2. The holes were advanced by a self-propelled drilling machine which was equipped with hollow-stem augers for soil sampling.

Standard penetration tests were performed at frequent intervals of depth, as detailed in Appendix 'A', and the results are recorded on the borehole logs as 'N' values. The split-spoon samples were stored in air-tight containers and transferred to our London laboratory for classification, testing and storage.

The dynamic cone penetration tests were performed adjacent to the borehole locations to obtain a continuous profile of soil density and strata changes with depth. The energy used to drive the cone was the same as was used for the standard penetration tests.

Insitu vane shear tests were performed in the cohesive subsoil to determine the undrained shear strength. The procedure followed in this test is outlined in Appendix 'B'. The field work was supervised by a soils engineer, who also related the ground surface elevations to a local benchmark. The benchmark was taken as a cut-cross on the existing northeast wingwall, which was given the Geodetic elevation 1006.91 feet.

III SUBSURFACE CONDITIONS

Detailed descriptions of the strata, which were encountered in each borehole, are given on the borehole logs comprising Enclosures 3 and 4, and a general picture of the soil stratigraphy is prese ed in the form of a Subsurface Profile on Enclosure 2. The following notes are intended only to amplify this data.

Both boreholes encountered surface layers of sand fill, which extend down to El. 990.4 and El. 991.7 in boreholes 1 and 2 respectively. The fill is

associated with the construction of the approaches to the existing bridge. 'N' values within the fill range from 1 to 8 blows per foot, which indicates that the relative density of the sand is in the 'loose' range.

The natural soil profile consists of sandy silt, sand and sandy gravel layers, in which the existing river bed is formed, overlying a deep silty clay stratum which extends down to El. 955±. Borehole 2 was terminated in the silty clay stratum at El. 972±. The consistency of the silty clay is described as 'very stiff' based on 'N' values ranging from 14 to 23 blows per foot, which were confirmed by undrained shear strengths of 2800 and 3200 p.s.f.

Atterberg limit tests were performed on three samples of the silty clay giving values of Liquid Limit ranging from 20% to 28%, Plastic Limit ranging from 16% to 20%, and Plasticity Index ranging from 4% to 8%. The natural moisture content is generally lower than the Plastic Limit values, which confirms

the 'very stiff' consistency obtained from visual and tactile examination.

Borehole 2 encountered a clayey sandy silt till stratum at a depth of 55 feet, and the till was found to contain gravel and cobble sizes which required the use of diamond drilling techniques to effect penetration. Core recoveries of 15% and 20% were obtained from the larger size constituents.

IV GROUNDWATER CONDITIONS

An equilibrium water level was observed in borehole 1 at El. 994, and in borehole 2 insufficient time was available for the wash water used for diamond drilling to reach an equilibrium state. The water level in the adjacent river was observed at El. 992.9 feet at the time the field work was carried out. Due to the granular nature of the soil above El. 990, the prevailing groundwater table will be closely related to the water level in the river at any particular time.

V DISCUSSION AND RECOMMENDATIONS

Spread Footing Foundations

The existing creek bed extends down to El. 990±, therefore to provide a 4 foot depth of soil cover for protection against frost action, the footing grade would require to be established at or below El. 986. This level lies within the dense sandy gravel at borehole 1 location, and within the very stiff silty clay stratum at borehole 2 location. In order to provide a similar subgrade for the two abutments, the footing grade would have to be lowered at borehole 1 location to El. 982, and footings supported by the very stiff silty clay may be designed to an allowable soil pressure of 5,000 p.s.f. This pressure incorporates a factor of safety of 3 against shear failure of the underlying soil, and total settlement of footings up to 15 feet in width is estimated to be 1-inch or less.

The adhesion between the footings and the silty clay subsoil may be taken as 1,700 p.s.f. or 35% of the vertical load, whichever is the lower value, and the factor of safety against horizontal sliding of the abutments must be at least 1.5.

In order to carry out the excavations to the recommended founding levels, special dewatering techniques will be required to prevent sloughing-in of the sides of the excavation. Due to the presence of the impervious silty clay subsoil, closed sheeting would appear to be the most suitable method, and it should be driven into the silty clay to seal the bottom of the excavation. After construction of the enclosure, dewatering may be carried out by normal pumping procedures.

Piled foundation

In view of the problems associated with the excavating through the saturated granular subsoil, consideration should be given to a pile foundation and the use of stub abutments. Any type of driven

pile would be suitable, however steel tube piles would be preferable to H-piles because of the greater base area and higher end bearing capacity. Working loads of 50 and 65 tons per pile may be used for 10.75 and 12.75 inch diameter tubes respectively. The pile should be driven to refusal which is considered to be reached when 5 blows of an adequate hammer produce a total penetration of 1/4 inch.

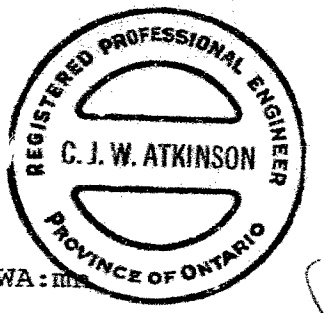
Based on the borehole results it is estimated that a suitable set would be achieved within the very dense clayey sandy silt till stratum between El. 950 and El. 945. The rating of the pile driving equipment should not be less than 10,000 foot pounds per blow for 50 ton capacity piles and not less than 13,000 foot pounds per blow for 65 ton capacity piles.

The above working loads and sets are based on theoretical estimates, and in practice the assumed working loads should be checked by the

use of an approved dynamic pile driving formula. If the desired working load is not achieved with the anticipated depths of penetration, the piles should be extended or additional piles driven to provide the required support for the structure.

Yours very truly,

DOMINION SOIL INVESTIGATION LIMITED



C.J.W. Atkinson, M.Sc.,P.Eng.
Branch Manager

CJWA:

APPENDIX 'A'

THE STANDARD PENETRATION TEST

In order to determine the relative density of non-cohesive soils, such as sands and gravels, the standard penetration test has been adopted. The test also gives an indication of the consistency of cohesive soils.

A two inch external diameter thick-walled sample tube is driven into the ground at the bottom of the borehole by means of a 140 lb. hammer falling freely through 30 inches. The tube is first driven an initial 6 inches to allow for the presence of disturbed material at the bottom of the borehole. The number of standard blows (N) required to drive the sampler a further 12 inches is recorded. The sample tube is one originally developed by Raymond Concrete Pile Company in the United States, where a sufficient number of tests have been made in conjunction with field investigations to show that the results, although essentially empirical, may be applied to foundation design.

For Sands:-

Values of 'N'	Density
Less than 10	Loose
Between 10 and 30	Compact
Between 30 and 50	Dense
Greater than 50	Very Dense

APPENDIX 'B'

INSITU VANE SHEAR TEST

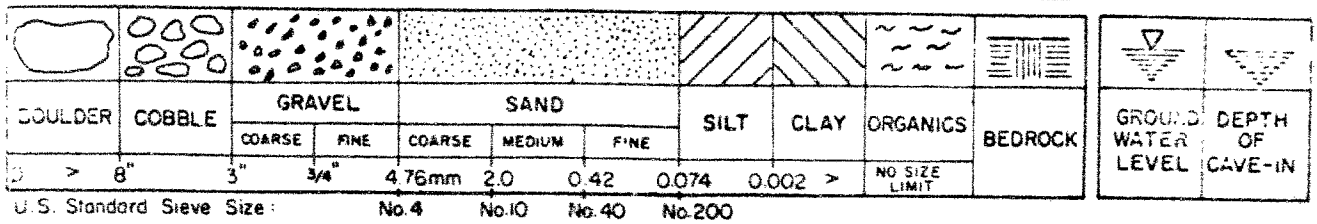
In soft to stiff clays, and particularly sensitive clay soils such as frequently occur in alluvial deposits, it is difficult to obtain reasonable undisturbed samples for the determination of the undrained shear strength. In order to overcome this difficulty, the vane test was developed as an in-situ method of measuring the shear strength.

The apparatus consists of a 4-inch long by 2-inch wide rectangular 4-bladed rotating vane attached to a thin rod, which is pushed into the undisturbed soil below the bottom of the bore-hole to the depth at which the test is to be made.

A torque is then applied to the vane and the maximum torque when failure occurs is recorded. The vane is then rotated 10 times to remould the soil and after one minute the torque test is repeated. The shear strength of the soil can then be calculated from the torque and the dimensions of the vane, and the sensitivity of the material estimated from the ratio of the original torque to the final torque after remoulding.

LIST OF SYMBOLS, ABBREVIATIONS AND NOMENCLATURE.

SOIL COMPONENTS AND GROUND WATER CONDITIONS.



SAMPLE TYPES.

AS	Auger sample	RC	Rock core	TP	Piston, thin walled tube sample
CS	Sample from casing	%	Recovery	TW	Open, thin walled tube sample
ChS	Chunk sample	SS	Split spoon sample	WS	Wash sample

SAMPLER ADVANCED BY static weight : w
" pressure : p
" topping : t

OBSERVATIONS MADE WHILE CORING: Steady pressure; No pressure; Intermittent pressure

Washwater returns

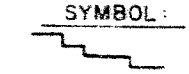
Washwater lost

PENETRATION RESISTANCES.

DYNAMIC PENETRATION RESISTANCE : to drive a 2"ø, 60° cone attached to the end of the drilling rods into the ground, expressed in blows per foot

STANDARD PENETRATION RESISTANCE, -N- : to drive a 2" outside dia, split spoon sampler 1 foot into the ground, expressed in blows per foot.

SYMBOL :



EXTRAPOLATED -N- VALUE

The energy for the penetration resistances is supplied by a 140 lb. hammer falling 30 inches

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SOIL PROPERTIES.

W %	Water content	γ	Natural bulk density (unit weight)	k	Coeff of permeability
LL %	Liquid limit	e	Void ratio	C	Shear strength — in terms of total stress
PL %	Plastic limit	RD	Relative density	ϕ	Angle of int friction — in terms of total stress
PI %	Plasticity index	C_v	Coeff. of consolidation	C'	Cohesion — in terms of effective stress
LI	Liquidity index	m_v	Coeff of volume compressibility	ϕ'	Angle of int friction — in terms of effective stress

UNDRAINED SHEAR STRENGTH.

— DERIVED FROM —

TRIAXIAL COMPRESSION TEST ◎

UNCONFINED TEST ○ St

LABORATORY VANE TEST × St

FIELD VANE TEST + St

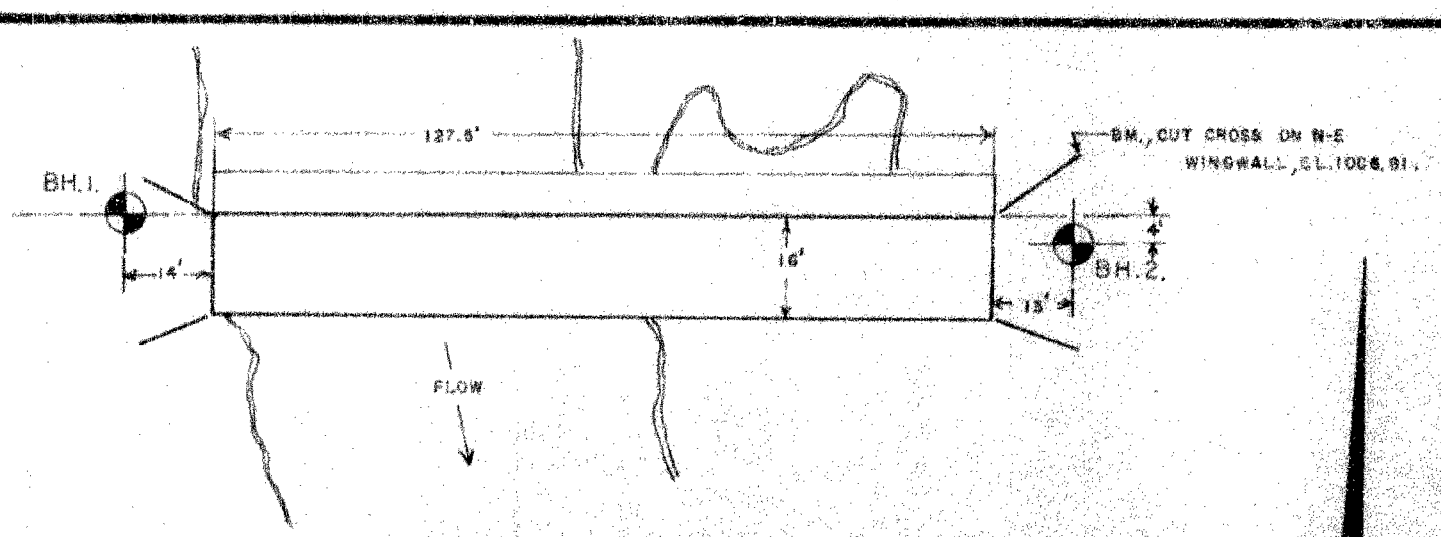
POCKET PENETROMETER TEST - St

Strain at failure is represented by direction of stem: 20%, 15%, 5%, 10%

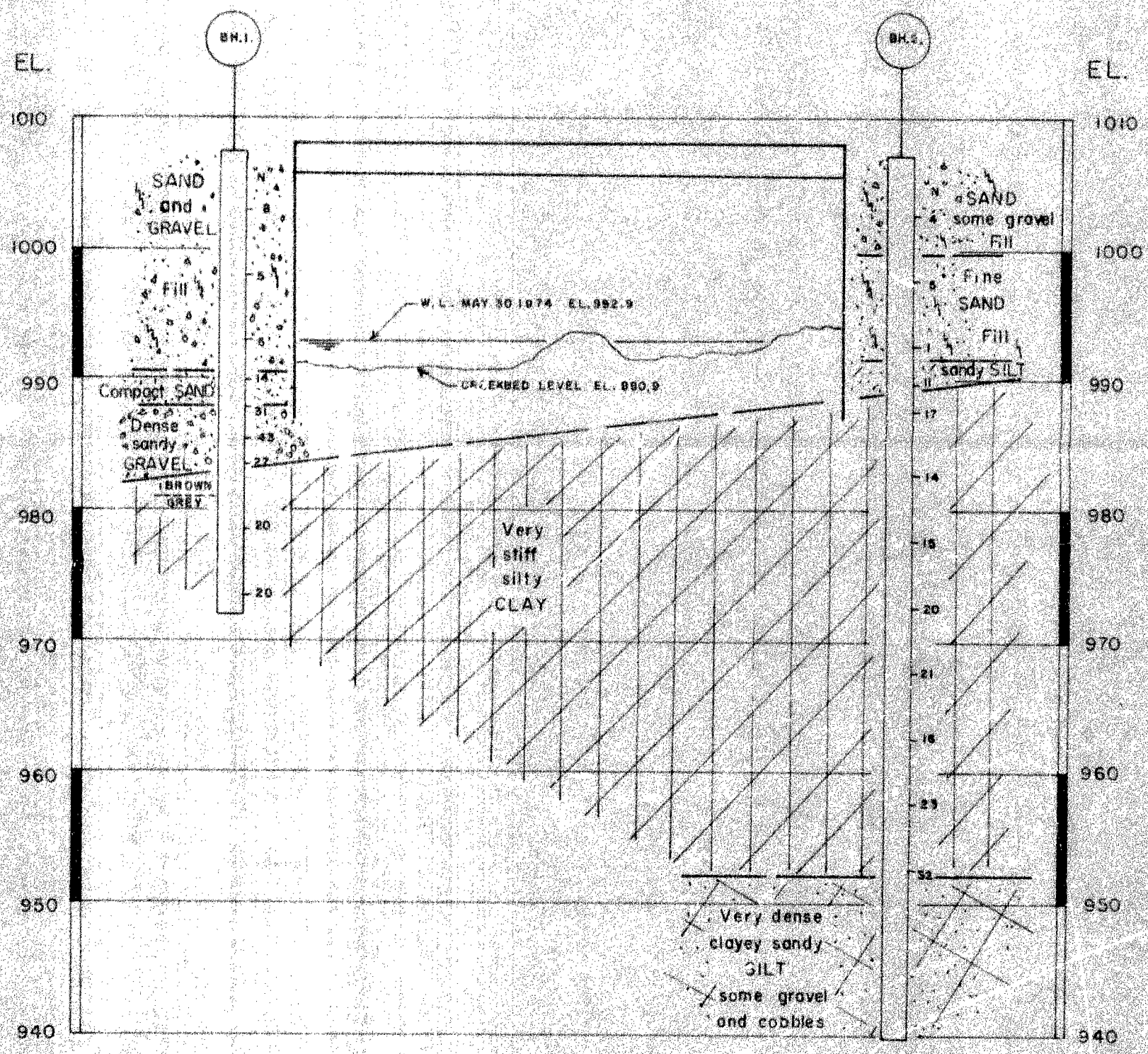
St : sensitivity = $\frac{\text{shear strength in undisturbed state}}{\text{shear strength in remoulded state}}$

SOIL DESCRIPTION.

COHESIONLESS SOILS :	RD :	COHESIVE SOILS	C lbs/sq ft
Very loose	0 - 15 %	Very soft	less than 250
Loose	15 - 35 %	Soft	250 - 500
Compact	35 - 65 %	Firm	500 - 1000
Dense	65 - 85 %	Stiff	1000 - 2000
Very dense	85 - 100 %	Very stiff	2000 - 4000
		Hard	over 4000



LOCATION OF BOREHOLES
SCALE: 1"= 30'



SUBSURFACE PROFILE
SCALE HOR.: 1"= 30'
VERT.: 1"= 10'

GEOCRES No. 40-P14-10

LOG OF BOREHOLE 1

Our Reference No. 74-3-112

Enclosure No. 3

CLIENT: B.M. Ross and Associates Ltd.,
PROJECT: Proposed Bridge,
LOCATION: Lower Town Wingham
DATUM ELEVATION: Geodetic

DRILLING DATA
Method: Auger
Diameter: Hollow-stem
Date: May 30, 1974

ELEVATION Ft.	DEPTH Ft.	DESCRIPTION	SYMBOL	GROUND WATER	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' Blows/Ft.	REMARKS
1007.4	0.0	Ground Surface						
1005		Brown sand and gravel, trace of silt. FILL.			1	SS	8	
1000					2	SS	5	
995				▼	3	SS	5	
990	17.0	Compact fine to medium sand			4	SS	14	
	19.5	Dense sandy gravel, trace of silt			5	SS	31	
985					6	SS	43	
	24.5	Very stiff brown grey silty clay.			7	SS	27	
980					8	SS	20	
975					9	SS	20	
	35.5	End of Borehole						
970								

PENETRATION RESISTANCE Blows/Ft. 20 40 60 80 100

UNDRAINED SHEAR STRENGTH p.s.f. + FIELD VANE TEST ● COMPRESSION TEST 20 40 60 80 100

WATER CONTENT % PLASTIC LIMIT W_P NATURAL W LIQUID LIMIT W_L 10 20 30 40 50

2-inch dynamic cone

VERTICAL SCALE: 1 inch to 5 ft.

DOMINION SOIL INVESTIGATION LIMITED

DRAWN: CHECKED:

Our Reference No. 74-3-L12

Enclosure No. 4

CLIENT: B.M. Ross and Associates Ltd.,
PROJECT: Proposed Bridge,
LOCATION: Lower Town Wingham
DATUM ELEVATION: Geodetic

DRILLING DATA
Method: Auger
Diameter: Hollow-stem
Date: May 30, 1974

ELEVATION Ft.	DEPTH Ft.	DESCRIPTION	SYMBOL	GROUND WATER	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' Blows/Ft.
1007.2	0.0	Ground Surface					
		Brown sand, some gravel. FILL.			1	SS	4
	7.5	Dark brown fine sand. FILL.			2	SS	5
	15.5	Sandy silt with wood.			3	SS	1
	18.0	Very stiff grey silty clay, layers of silt.			4	SS	11
					5	SS	17
					6	SS	14
					7	SS	15
					8	SS	20
					9	SS	21
					10	SS	16
					11	SS	23
	55.0	Very dense clayey sandy silt, some gravel and cobbles.			12	SS	32
					13	Bx	15%
					14	Bx	20%
940	67.4						

PENETRATION RESISTANCE Blows/Ft. 20 40 60 80 100

UNDRAINED SHEAR STRENGTH p.s.f. + FIELD VANE TEST ● COMPRESSION TEST 20 40 60 80 100

WATER CONTENT % PLASTIC LIMIT W_P NATURAL W LIQUID LIMIT W_L 10 20 30 40 50

REMARKS

2-inch diameter dynamic cone

+St=2.5

+St=1.4

VERTICAL SCALE: 1 inch to 5 ft.

DOMINION SOIL INVESTIGATION LIMITED

DRAWN: CHECKED:

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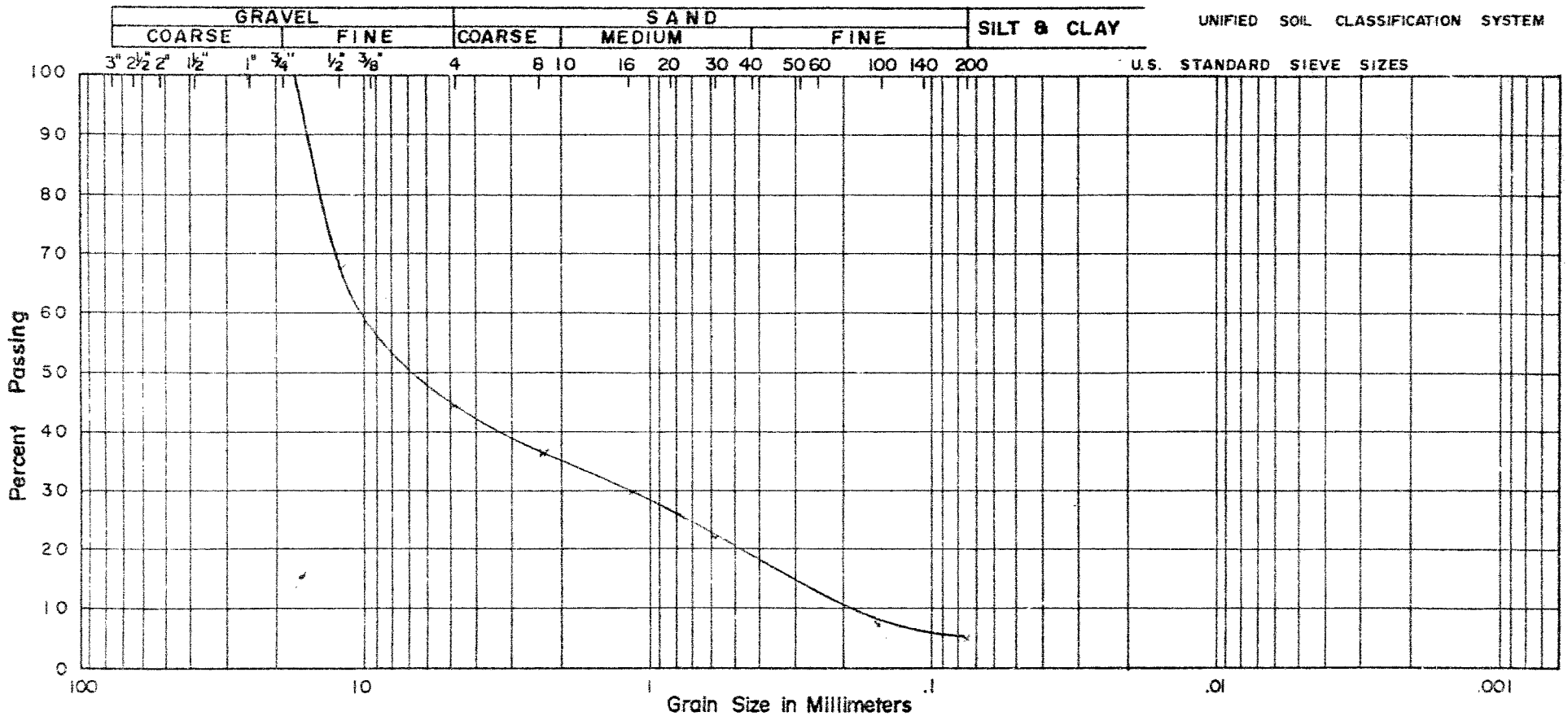
GRAIN SIZE DISTRIBUTION

OUR REFERENCE Nº 7.4-3-11



PROJECT: Proposed Bridge
LOCATION: Lower Town Wingham
BOREHOLE Nº: 1
SAMPLE Nº: 6
DEPTH: 23 feet
ELEVATION: 985 feet

COEFFICIENT OF UNIFORMITY :
COEFFICIENT OF CURVATURE :

Classification of Sample and Group Symbol:
Sandy gravel with a trace of silt.

PLASTIC PROPERTIES
LIQUID LIMIT % =
PLASTIC LIMIT % =
PLASTICITY INDEX % =
MOISTURE CONTENT % =

ENCLOSURE Nº 5