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HWY. No.

LOCATION Proposed New Bridge

Lots 15/16, Concession 5

No. of Pages - Twp of Stephen

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

73-F-217 M

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GEOCRES No.

STRUCTURE SITE No. 12-267

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B.M. ROSS & ASSOCIATES LIMITED
CONSULTING ENGINEERS
GODERICH ONTARIO

40P5-7
GEOCRES No.

DIST. 3

Report On SOIL INVESTIGATION for PROPOSED NEW BRIDGE LOTS 15/16, CONCESSION 5 TOWNSHIP OF STEPHEN

73-F-217 M

by

Dominion Soil Investigation Limited
1220 Trafalgar Street
London Ontario

Ref: 73-7-L8
Sept. 25, 1973

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 July 24, 1973, from B.M. Ross & Associates Limited, Consulting Engineers, a soil investigation has been carried out in the Township of Stephen, where it is proposed to construct a new bridge across the Ausable River.

The existing steel-truss structure, now collapsed, is located at Lots 15/16, Concession 5 of the Township, and it is understood that the new bridge will be constructed about 70 feet to the north of the existing bridge to allow for realignment of the road. It is also understood that the new bridge will have an approximate span of 95 feet and will consist of prestressed concrete beams. The requirements of the project were discussed with Mr. K.G. Dunn, P.Eng., who supplied the foregoing information and a plan-profile of the new bridge location.

The purpose of the investigation was to reveal the subsurface soil and groundwater conditions at the site, 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 and two dynamic cone penetration tests, was carried out on August 15, 1973, at the locations shown on Enclosure 2. The holes were advanced to the sampling depths by a self-propelled continuous flight auger 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 and testing.

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

The field work was supervised by a soils engineer, who also determined the pertinent ground surface elevations. These were referred to a nail in a hydro pole at the location shown on Enclosure 2. The benchmark was established by the client and given a Geodetic El. 797.54 feet.

III SUBSURFACE CONDITIONS

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

Borehole 1 was put down on the east bank of the river and penetrated a 6 inch layer of topsoil and a layer of brown silt to a depth of 3 feet.

Borehole 2, on the west bank of the river, encountered a 12 inch layer of silt overlying grey-green sandy silt with a trace of clay which extends to a depth of 3 feet.

Fine Sand

This stratum of fine sand underlying the layers of silt and sandy clayey silt was penetrated to depths of 12.0 and 9.0 feet in boreholes 1 and 2 respectively. Traces of silt, gravel, shells and wood were also found within the fine sand. The relative density of the fine sand is described as 'loose' to 'dense' as estimated from 'N' values ranging from 2 to 33 blows per foot. Two sieve analyses were performed on representative samples of the fine sand, and the results are plotted as grading curves on Enclosure 5 of this report.

Cemented Silty Sand and Gravel

This silty sand and gravel layer, found in borehole 1 only, underlies the fine sand and well-graded sand layers and extends from 12 to 14½ feet below the ground surface. The relative density of the sand and gravel is described as 'dense' based on an 'N' value of 60 blows per foot.

Grey Silty Clay

A glacial silty clay stratum was found to underly the granular deposits, and it extends to depths of 29 feet in borehole 1 and 22 feet in borehole 2. This type of subsoil is commonly referred to as 'Glacial Till'. Due to the clay content the till should be regarded as a plastic and cohesive material, and the consistency is described as 'very stiff' to 'hard' based on undrained shear strengths ranging from 2200 p.s.f. to 3600 p.s.f., which were confirmed by 'N' values ranging from 19 to 40 blows per foot.

Atterberg Limit tests were performed on a sample of the silty clay giving values of Liquid Limit of 27%, Plastic Limit of 15%, and Plasticity Index of 12%. These values, when plotted on the Casagrande Plasticity Chart, indicate that the silty clay has a low plasticity and compressibility. The natural moisture content of the silty clay ranges from 10% to 18%, which is close to the Plastic Limit of the soil and confirms the 'very stiff' to 'hard' consistency obtained from visual and tactile examination.

Dense to Very Dense Grey Silt

A stratum of grey silt with seams and/or pockets of silty clay underlies the silty clay till stratum and extends to depths of 31.3 feet and 25.0 feet in boreholes 1 and 2 respectively. The relative density of the silt is described as 'dense' to 'very dense' as indicated by 'N' values of 41 and 77 blows per foot.

Both holes were terminated in a silty clay subsoil at depths of 31½ and 25½ feet.

IV GROUNDWATER CONDITIONS

Water levels were observed at El. 785.7 and El. 781.8 in boreholes 1 and 2 respectively, and the water level in the Ausable River was observed at El. 784.8.

The water level observed in borehole 2 indicates that insufficient time was available for the equilibrium condition to be achieved.

V DISCUSSION AND RECOMMENDATIONS

Spread Footing Foundations

The natural soil profile below the creek bed consists of 'loose' to 'dense' fine sand strata followed by 'very stiff' to 'hard' silty clay till. The sand is not suitable for the support of normal spread footing foundations, therefore it is recommended that the footing grade be established at or below El. 777 to provide a competent bearing stratum. On the basis of the borehole results a maximum allowable soil pressure of 5500 p.s.f. may be used for the design of the footing and this soil pressure incorporates a factor of safety of 3 against shear failure.

The proposed footing grade is about 9 feet below the present stream bottom therefore there will be adequate protection against frost action.

The adhesion between the footings and the clay sub-soil at borehole 2 location may be taken as 2000 p.s.f. or 35% of the vertical load, whichever is the lower value, and the coefficient of friction between the footings and the silty sand and gravel at borehole 1 location may be taken as 0.4. The factor of safety against horizontal sliding of the abutments must be at least 1.5.

It is estimated that the total settlement of the structure will not exceed 1 inch and that no appreciable differential settlement is anticipated.

Due to the pervious nature of the fine sand and silty sand and gravel strata it is recommended that sheet piling enclosures be driven into the impervious silty clay subsoil to seal the bottom of the excavations and prevent boiling of the subgrade during excavation. Afterwards the sheeting may be left in place as a positive means of scour protection. Excavations can then be carried out within the enclosures to El. 777, and dewatering can be handled by normal pumping procedures. Care should be taken to ensure that the recommended footing grade be left as undisturbed as possible at both abutment locations. The spread footings should be poured as soon after excavating as possible.

Piled Foundation

Due to the difficulties and cost of constructing deep spread footing foundations, it may be worthwhile to consider the use of abutments supported by piled foundations. The 'very stiff' to 'hard' silty clay subsoil makes the use of friction piles quite practical with the working load being mobilized partly by end-bearing and partly by friction along the side of the pile.

Timber piles designed to a working load of 20 tons would require to penetrate 20 feet into the silty clay, and silt subsoil, and the tips would therefore be at El. 755±.

Steel tube piles are also suitable and would be preferred against H-piles due to their greater displacement and end-bearing capacity. The working load of a 12 inch diameter tube pile may be calculated on the basis of 1 ton per foot of penetration into the clay-silt subsoil plus a 7 ton end-bearing component. A 40 ton capacity pile would therefore require a tip penetration to El. 745±.

The calculated working capacities incorporate a factor of safety of 2, and any friction within the upper fine sand layers has been ignored. The embedment predictions however are theoretical and it is recommended that a pile loading test be carried out to confirm that the design capacity has been achieved. Dynamic pile driving formulas should not be used due to the cohesive nature of the subsoil.

Total settlement of a piled foundation is estimated to be in the range 0.25 to 0.5 inch.

Yours very truly,

DOMINION SOIL INVESTIGATION LTD.

REGISTERED PROFESSIONAL ENGINEER
C. J. W. ATKINSON
PROVINCE OF ONTARIO

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

CJWA:eg

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-ins. 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-in. 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

LIST OF SYMBOLS, ABBREVIATIONS AND NOMENCLATURE.

SOIL COMPONENTS AND GROUND WATER CONDITIONS.

BOULDER	COBBLE	GRAVEL COARSE	GRAVEL FINE	SAND COARSE	SAND MEDIUM	SAND FINE	SILT	CLAY	ORGANICS	BEDROCK	GROUND WATER LEVEL	DEPTH OF CAVE-IN
Ø > 8"	8"–3"	3"–3/4"	3/4"–4.76mm	4.76mm–2.0	2.0–0.42	0.42–0.074	0.074–0.002	0.002 >	NO SIZE LIMIT			

U.S. Standard Sieve Size: No.4 (4.76mm), No.10 (2.0), No.40 (0.42), No.200 (0.074)

SAMPLE TYPES.

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

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

OBSERVATIONS MADE WHILE CORING: Steady pressure; No pressure; Intermittent pressure; Washwater returns; Washwater lost

PENETRATION RESISTANCES.

SYMBOL:

DYNAMIC PENETRATION RESISTANCE : to drive a 2"ϕ, 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.

EXTRAPOLATED -N- VALUE — 322

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

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 COMPRESSION TEST St; LABORATORY VANE TEST X St; FIELD VANE TEST + St; POCKET PENETROMETER TEST St

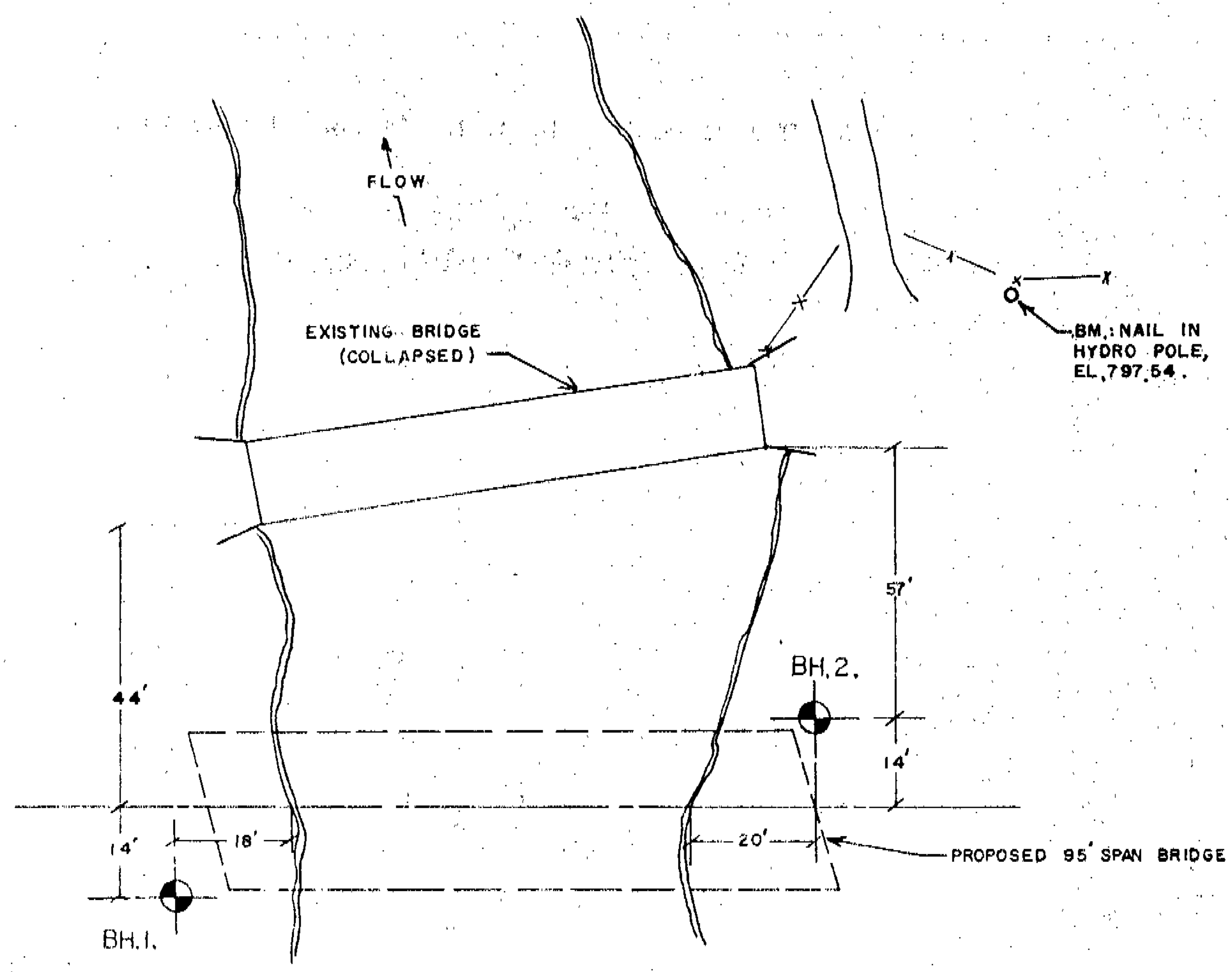
Strain at failure is represented by direction of stem: 20% (up), 5% (right), 10% (down), 15% (left)

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

SOIL DESCRIPTION.

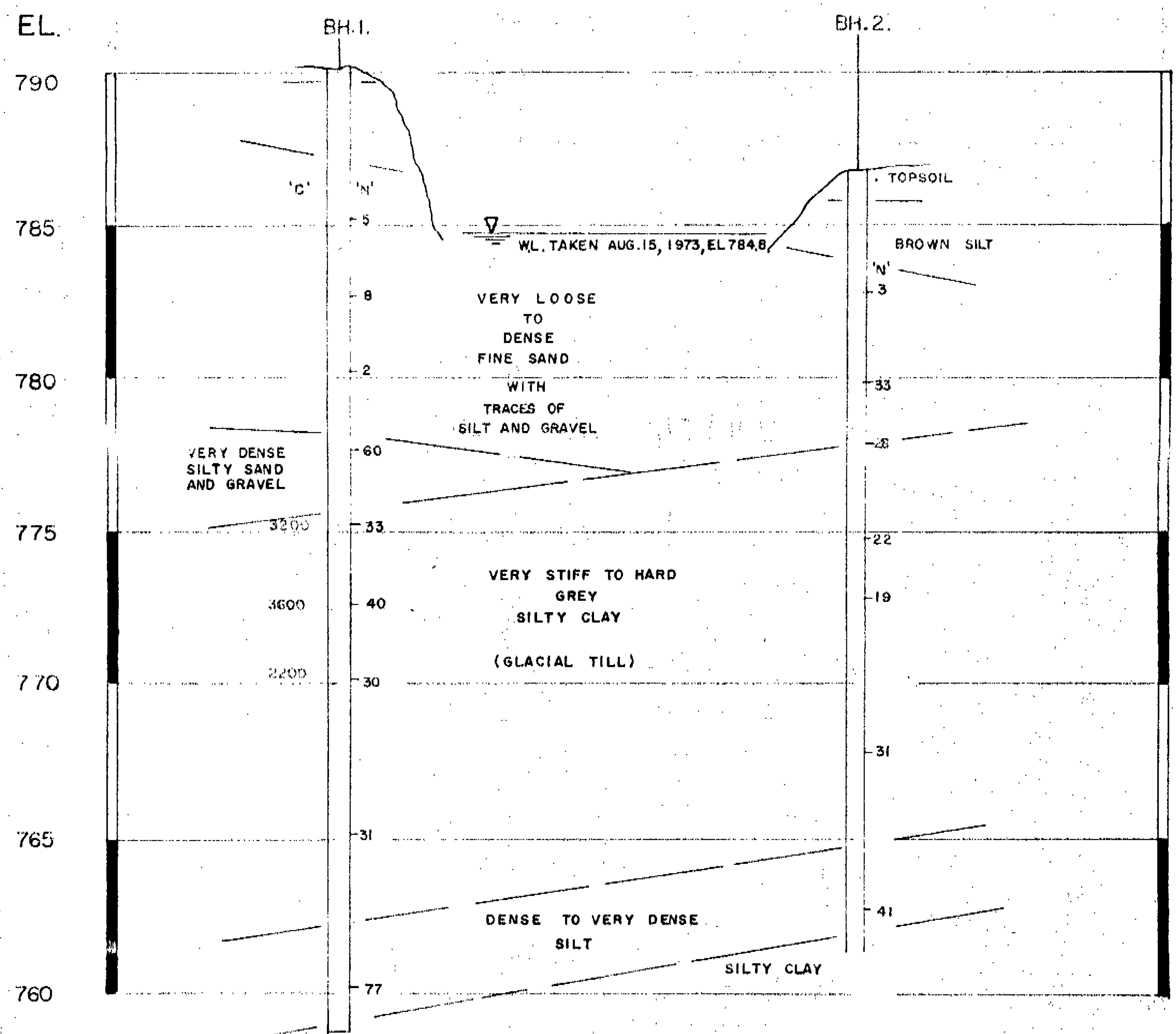
COHESIONLESS SOILS:	RD:
Very loose	0 – 15 %
Loose	15 – 35 %
Compact	35 – 65 %
Dense	65 – 85 %
Very dense	85 – 100 %

COHESIVE SOILS	C lbs/sq.ft.
Very soft	less than 250
Soft	250 – 500
Firm	500 – 1000
Stiff	1000 – 2000
Very stiff	2000 – 4000
Hard	over 4000



LOCATION OF BOREHOLES

SCALE 1" = 30'



INFERRED SUBSURFACE PROFILE

SCALE HOR. 1" = 30'
VERT. 1" = 5'

LOG OF BOREHOLE 1

Our Reference No. 73-7-L8

Enclosure No. 3

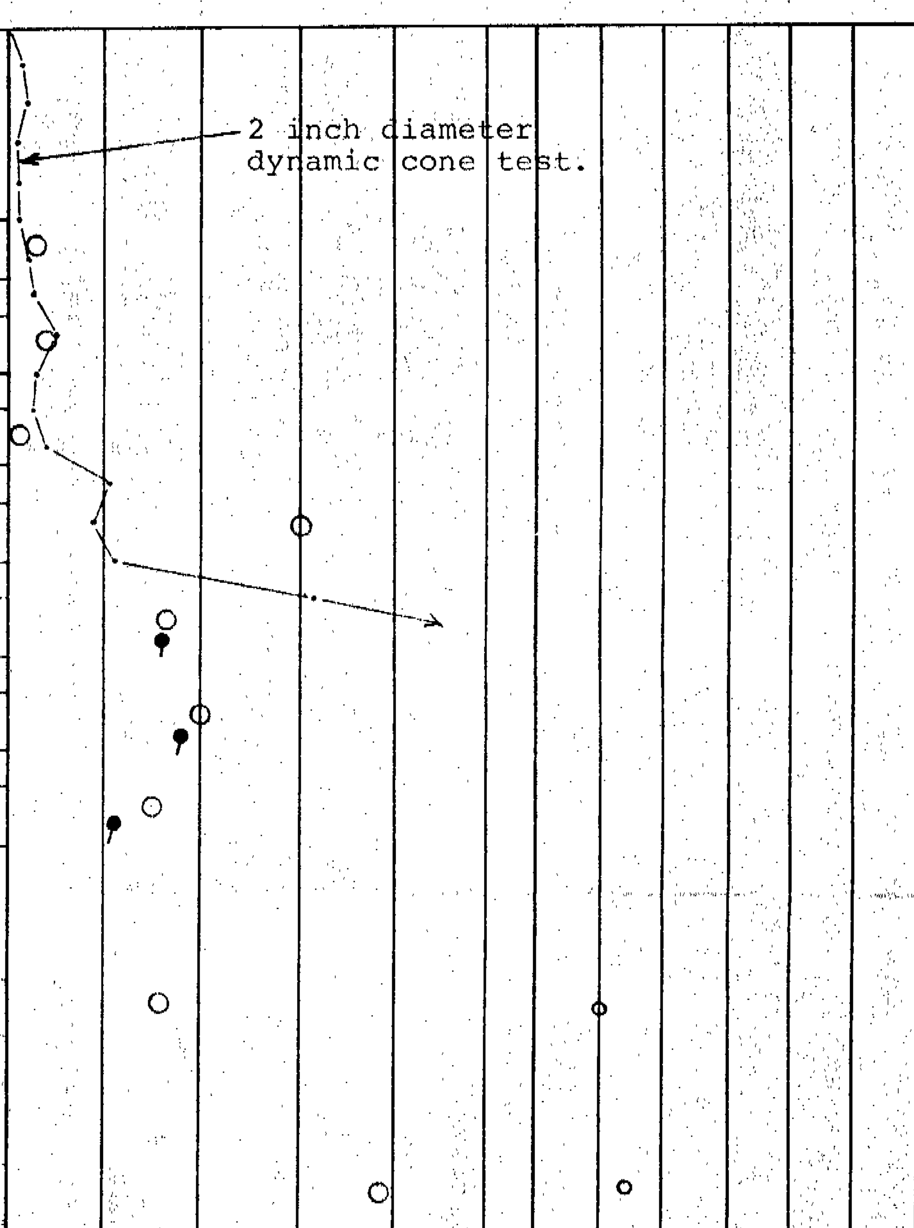
CLIENT: B.M. Ross and Associates Limited
PROJECT: Proposed Bridge, Br. 323
LOCATION: Township of Stephen
DATUM ELEVATION: See Enclosure 2.

DRILLING DATA
Method: Hollow-stem auger.
Diameter: 8-inches
Date: August 15, 1973.

ELEVATION Ft.	DEPTH Ft.	DESCRIPTION	SYMBOL	GROUND WATER	NUMBER	TYPE	'N' Blows/Ft.
790.2	0.0	Ground Surface					
	0.5	6" Topsoil					
		Brown silt.					
	3.0	Loose brown silty fine sand.		▼	1	SS	5
785							
	7.0	Loose grey fine sand, trace of silt. Some med. to coarse sand.			2	SS	8
780					3	SS	2
	12.0	Dense grey cemented silty sand & gravel.			4	SS	60
775	14.5	Very stiff to hard grey silty clay, traces of embedded sand and gravel.			5	SS	33
					6	SS	40
770					7	SS	30
765					8	SS	31
	26.0	Very dense grey silt with seams and/or pockets of silty clay.			9	SS	77
760							
	31.3	Grey silty clay.					
	31.5	End of Borehole					

PENETRATION RESISTANCE Blows/Ft. 20 40 60 80 100
UNDRAINED SHEAR STRENGTH 100 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



VERTICAL SCALE: 1 inch to 5ft.

DOMINION SOIL INVESTIGATION LIMITED

DRAWN:

CHECKED:

LOG OF BOREHOLE ....2....

Our Reference No. 73-7-L8

Enclosure No. 4

CLIENT: B.M. Ross and Associates Limited
PROJECT: Proposed Bridge, Br. 323
LOCATION: Township of Stephen
DATUM ELEVATION: See Enclosure 2.

DRILLING DATA
Method: Hollow-stem auger.
Diameter: 8-inches
Date: August 15, 1973.

ELEVATION Ft.	DEPTH Ft.	DESCRIPTION	SYMBOL	GROUND WATER	NUMBER	TYPE	'N' Blows/Ft.	REMARKS
787.8	0.0	Ground Surface						
	1.0	Brown silt.						
785	3.0	Grey/green sandy clayey silt.						
780	9.0	Loose to dense grey fine sand, trace of silt.		▼	1	SS	3	
					2	SS	33	
775		Very stiff to hard grey silty clay, traces of embedded sand and gravel.			3	SS	28	
770					4	SS	22	
					5	SS	19	
					6	SS	31	
765	22.0	Dense grey silt with pockets or seams of silty clay.						
		Grey silty clay.			7	SS	41	
760		End of Borehole						

PENETRATION RESISTANCE Blows/Ft.: 20 40 60 80 100

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

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

2-inch diameter dynamic cone

VERTICAL SCALE: 1 inch to 5 ft.

DOMINION SOIL INVESTIGATION LIMITED

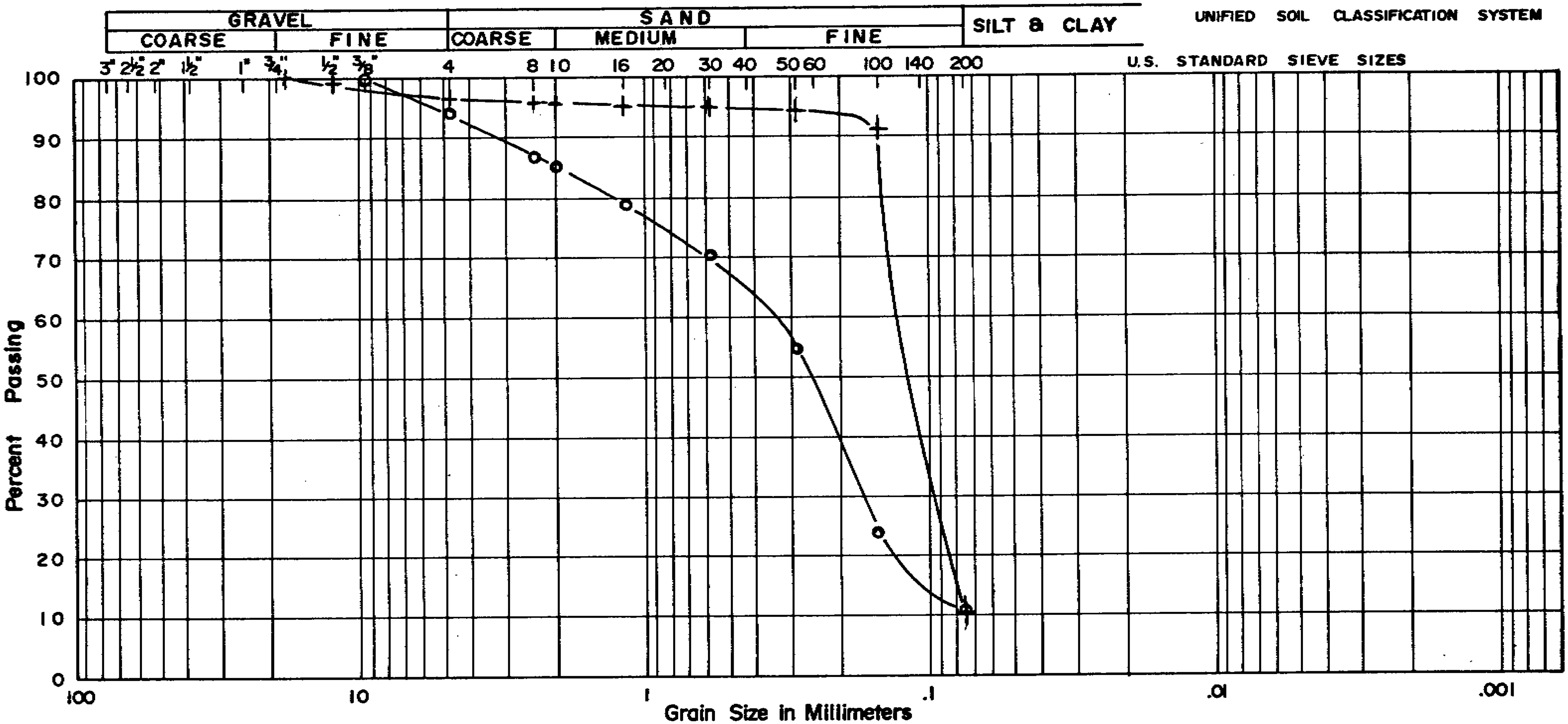
DRAWN:

CHECKED:

DOMINION SOIL INVESTIGATION LIMITED

GRAIN SIZE DISTRIBUTION

OUR REFERENCE Nº 73-7-L8



PROJECT: Proposed Bridge, Br.323

LOCATION: Township of Stephen

BOREHOLE Nº: 1 2

SAMPLE Nº: 3 2

DEPTH:

ELEVATION:

Legend O +

COEFFICIENT OF UNIFORMITY:

COEFFICIENT OF CURVATURE:

Classification of Sample and Group Symbol:

O -Fine to coarse sand, trace of silt and gravel.

+ -Fine sand, trace of silt.

PLASTIC PROPERTIES

LIQUID LIMIT % =

PLASTIC LIMIT % =

PLASTICITY INDEX % =

MOISTURE CONTENT % =

ENCLOSURE Nº 5