

GEOCRES No. 31G-166DIST. 9 REGION W.P. No. CONT. No. W. O. No. 73-11207MSTR. SITE No. 3-181HWY. No. CRLOCATION GREY'S CREEKBRIDGE STRUCTURE No 8236No. of PAGES - 1OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. REMARKS:

**Golder Associates**

STRUCTURE SITE No. 3-181

GEOC. N<sup>o</sup> 31G-166

31G-166

GEOCRES No.

THE REGIONAL MUNICIPALITY OF  
OTTAWA-CARLETON

73-F-207 M  
SOIL INVESTIGATION

PROPOSED GREY'S CREEK BRIDGE  
STRUCTURE NO.8236  
REGIONAL ROAD NO.25      OSGOODE TWP.

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April, 1971

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April 27, 1971.

The Regional Municipality of Ottawa-Carleton,  
233 Gilmour Street,  
Ottawa 4, Ontario.

Attention: Mr. G. F. Weatherall, P. Eng.  
Roads Commissioner

RE: SOIL INVESTIGATION,  
PROPOSED GREY'S CREEK BRIDGE REPLACEMENT,  
REGIONAL ROAD NO.25, STRUCTURE NO.8236,  
OSGOODE TOWNSHIP, ONTARIO.

Dear Sirs:

This letter reports the results of an investigation carried out at the bridge crossing of the Middle Castor River by Regional Road No.25 in Osgoode Township about 5 miles south of South Gloucester, Ontario. The purpose of the investigation was to determine the subsoil and groundwater conditions at the site and, based on this information, to make recommendations for the foundation design and construction of a proposed bridge replacement structure.

## PROCEDURE

The field work for this investigation was carried out on February 4 and 5, 1971. Two boreholes, one each at the north and south abutment locations of the proposed structure, were put down to about 10 feet below the proposed footing elevation using a machine drill rig supplied and operated by the F. E. Johnston Drilling Co. Ltd., Ottawa. A standpipe was installed in borehole 1 to measure the groundwater level at the site. The field work was supervised throughout by a

member of our engineering staff.

The locations of the borings, together with a stratigraphic section along the centerline of the proposed bridge, are shown on Fig. 1. A detailed log of each boring is given on the Record of Borehole sheets following the text of this report.

The soil samples were brought to our laboratory for detailed examination. Laboratory testing of representative samples of the overburden at the site was carried out by the Testing Laboratory of the Regional Municipality of Ottawa-Carleton. The results of this testing are shown on Fig. 2.

The elevations given in this report are referred to a nail in the west root of a 2 ft. maple tree some 30 ft. left of Station 8+19. The elevation of this bench mark was given to us as 500.00, as referenced to a local datum.

#### SITE AND GEOLOGY

The site is located at the crossing of the Middle Castor River by Regional Road No.25, about 5 miles south of South Gloucester and 5 miles west of Metcalfe, Ontario. In the general area of the bridge site, Regional Road No.25 runs along an undulating ridge of land with the land to the east and west of the bridge site being relatively flat. At the bridge site, the Middle Castor River has cut a channel through this ridge of land.

From available geological information it is known that the site is within the Physiographic region known as the North Gower Drumlin Field. This area is characterized by drumlins and elongated gravel ridges. The lower land between the drumlins and gravel ridges is generally covered with clay and silt deposits of marine origin. The underlying bedrock in the area is believed to be limestone of the Oxford formation.

#### SUBSURFACE CONDITIONS

The detailed stratigraphy encountered in the boreholes is given on the Record of Borehole sheets and is illustrated on the stratigraphic section on Fig. 1. Following is a summarized account of the subsurface conditions at the site.

The boreholes, put down at the side of the road through the existing approach embankments, encountered about 1 ft. of granular roadway material underlain by some 5 to 7 ft. of very loose to compact silty sand embankment fill. This fill also contained some gravel, cobble, and boulder size material. The embankment fill was found to be underlain at both borehole locations by about 2 to 3 ft. of compact grey silty sand alluvium.

The approach embankments and river bed alluvium are underlain by a deposit of grey fine to coarse sand and gravel with some silt. The results of three grading analyses carried out on samples of this deposit are shown on Fig. 2 and indicate the relatively coarse and well-graded nature of the deposit. Standard penetration tests carried out in the sand and gravel gave N values ranging from 28 to 66 blows/ft. indicating that the relative density of the sand and gravel is compact to very dense.

The groundwater level in the sand and gravel, as measured in the open borehole and in the standpipe in borehole 1, was at about elevation 491, or some 5 ft. below the roadway level. The ice level in the river at the time of the investigation was measured at elevation 489.

#### PROPOSED STRUCTURE

##### a) General

It is understood that it is planned to replace the existing one span bridge by a new and wider structure. As presently planned, the new structure will be either a single span, rigid frame structure or a multiple steel culvert structure. The roadway grade at the bridge crossing will be raised by about 1 ft.

##### b) Foundations

###### 1) Bridge Structure

The significant foundation stratum at this site, for the support of the proposed bridge structure, is the compact to very dense fine to coarse sand and gravel stratum which exists below the alluvial river bed. In order to provide frost and scour protection for the structure as planned,

spread footings founded on the sand and gravel should be taken down at least 5 ft. below the river bed. The N values obtained within the sand and gravel at and below the proposed foundation level were generally in excess of 30 blows/ft. Based on these values, an allowable bearing pressure of 3 tons/sq.ft. may be used in the design of spread footings founded on the sand and gravel, provided that precautions (as outlined below) are taken during construction to prevent loosening of the granular soil at and below foundation grade.

Based on the measured natural groundwater level at the site, excavation of about 7 ft. below river level will be required for spread footing design. Control of groundwater will therefore be required for footing excavations in this granular soil to prevent a reduction in the in situ density of the subsoil due to the upward seepage of groundwater. This control could be obtained by excavation within a steel sheet piled cofferdam, the sheeting being driven to a penetration below final excavation equal to the depth of excavation below the water level. The groundwater level by this method would be controlled within the abutment areas only. The mud sills should be carried down through any loose silty sand alluvium forming the river bed and should be founded on the dense sand and gravel.

Closed end abutments should be backfilled for a distance of at least 5 ft. horizontally with a free-draining and non-frost-susceptible granular material. Provision should be made for drainage from the backfill to prevent hydrostatic or ice pressure build up behind the walls. With full effective drainage of the backfill, a coefficient of lateral earth pressure at rest,  $K_0$ , = 0.4 and a total unit weight of 130 lb/cu.ft. should be used for the compacted granular backfill in the design of the abutments of this rigid frame structure.

To avoid the need for extensive dewatering, consideration could be given to the use of a one span, simply supported bridge structure at this site, with rip rap on a front slope protecting the abutment footings. The abutment footings may then be founded within earth cofferdams at about river bed level on the dense sand and gravel. The water inflow into the foundation excavation could be handled by pumping from well filtered sumps.

In the computation of sliding resistance between a rough concrete footing base and the undisturbed sand and gravel subsoil, a coefficient of friction of 0.5, which is a limiting value, may be used in design.

#### 11) Culvert Structure

An alternative replacement structure at this site would be the use of flexible steel culverts. In this case, either circular or pipe arch shapes could be used. If a pipe arch section is used, the haunches of the culvert would receive adequate support from the underlying dense sand and gravel and the compacted granular bedding and backfill. A bedding blanket thickness of about 2 ft. should be provided for either circular culverts or pipe arches.

#### c) Approach Embankments

It is understood that the grade of the approach embankments will be raised about 1 ft. and widened. It is recommended that all organic material be stripped from within the construction area. Due to the granular and competent nature of the subsoil there should be no stability problem with the roadway approach embankments using 2 horizontal to 1 vertical side slopes, provided they are constructed of suitable granular material properly compacted in place.

We trust that this report contains sufficient information for your design purposes. If we can be of any further assistance to you on this project, please call us.

Yours very truly,

H. Q. GOLDER & ASSOCIATES LTD.

*F. J. Jefferson*

for R. A. Montgomery, P. Eng.

RAM/ml  
70758J  
April, 1971.



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## LIST OF ABBREVIATIONS

The abbreviations commonly employed on each "Record of Borehole," on the figures and in the text of the report, are as follows:

### I. SAMPLE TYPES

*AS* auger sample  
*CS* chunk sample  
*DO* drive open  
*DS* Denison type sample  
*FS* foil sample  
*RC* rock core  
*ST* slotted tube  
*TO* thin-walled, open  
*TP* thin-walled, piston  
*WS* wash sample

### II. PENETRATION RESISTANCES

**Dynamic Penetration Resistance:** The number of blows by a 140-pound hammer dropped 30 inches required to drive a 2-inch diameter, 60 degree cone one foot, where the cone is attached to 'A' size drill rods and casing is not used.

**Standard Penetration Resistance, *N*:** The number of blows by a 140-pound hammer dropped 30 inches required to drive a 2-inch drive open sampler one foot.

*WH* sampler advanced by static weight—weight, hammer  
*PH* sampler advanced by pressure—pressure, hydraulic  
*PM* sampler advanced by pressure—pressure, manual

### III. SOIL DESCRIPTION

#### (a) *Cohesionless Soils*

<i>Relative Density</i>	<i>N, blows/ft.</i>
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

#### (b) *Cohesive Soils*

<i>Consistency</i>	<i>c<sub>u</sub>, lb./sq. ft.</i>
Very soft	Less than 250
Soft	250 to 500
Firm	500 to 1,000
Stiff	1,000 to 2,000
Very stiff	2,000 to 4,000
Hard	over 4,000

### IV. SOIL TESTS

*C* consolidation test  
*H* hydrometer analysis  
*M* sieve analysis  
*MH* combined analysis, sieve and hydrometer<sup>1</sup>  
*Q* undrained triaxial<sup>2</sup>  
*R* consolidated undrained triaxial<sup>2</sup>  
*S* drained triaxial  
*U* unconfined compression  
*V* field vane test

### NOTES:

<sup>1</sup>Combined analyses when 5 to 95 per cent of the material passes the No. 200 sieve.

<sup>2</sup>Undrained triaxial tests in which pore pressures are measured are shown as  $\bar{Q}$  or  $\bar{R}$ .

## LIST OF SYMBOLS

### I. GENERAL

$\pi$	= 3.1416
$e$	= base of natural logarithms 2.7183
$\log_e a$ or $\ln a$	natural logarithm of $a$
$\log_{10} a$ or $\log a$	logarithm of $a$ to base 10
$t$	time
$g$	acceleration due to gravity
$V$	volume
$W$	weight
$M$	moment
$F$	factor of safety

### II. STRESS AND STRAIN

$u$	pore pressure
$\sigma$	normal stress
$\sigma'$	normal effective stress ( $\bar{\sigma}$ is also used)
$\tau$	shear stress
$\epsilon$	linear strain
$\epsilon_{xy}$	shear strain
$\nu$	Poisson's ratio ( $\mu$ is also used)
$E$	modulus of linear deformation (Young's modulus)
$G$	modulus of shear deformation
$K$	modulus of compressibility
$\eta$	coefficient of viscosity

### III. SOIL PROPERTIES

#### (a) Unit weight

$\gamma$	unit weight of soil (bulk density)
$\gamma_s$	unit weight of solid particles
$\gamma_w$	unit weight of water
$\gamma_d$	unit dry weight of soil (dry density)
$\gamma'$	unit weight of submerged soil
$G_s$	specific gravity of solid particles $G_s = \gamma_s / \gamma_w$
$e$	void ratio
$n$	porosity
$w$	water content
$S_r$	degree of saturation

#### (b) Consistency

$w_L$	liquid limit
$w_P$	plastic limit
$I_P$	plasticity index
$w_S$	shrinkage limit
$I_L$	liquidity index = $(w - w_P) / I_P$
$I_C$	consistency index = $(w_L - w) / I_P$
$e_{max}$	void ratio in loosest state
$e_{min}$	void ratio in densest state
$D_r$	relative density = $(e_{max} - e) / (e_{max} - e_{min})$

#### (c) Permeability

$h$	hydraulic head or potential
$q$	rate of discharge
$v$	velocity of flow
$i$	hydraulic gradient
$k$	coefficient of permeability
$j$	seepage force per unit volume

#### (d) Consolidation (one-dimensional)

$m_v$	coefficient of volume change = $-\Delta e / (1 + e) \Delta \sigma'$
$C_c$	compression index = $-\Delta e / \Delta \log_{10} \sigma'$
$c_p$	coefficient of consolidation
$T_v$	time factor = $c_v t / d^2$ ( $d$ , drainage path)
$U$	degree of consolidation

#### (e) Shear strength

$\tau_f$	shear strength
$c'$	effective cohesion
$\phi'$	effective angle of shearing resistance, or friction
$c_u$	apparent cohesion*
$\phi_u$	apparent angle of shearing resistance, or friction
$\mu$	coefficient of friction
$S_i$	sensitivity

\*For the case of a saturated cohesive soil,  $\phi_u = 0$  and the undrained shear strength  $\tau_f = c_u$  is taken as half the undrained compressive strength.

RECORD OF BOREHOLE 1

LOCATION See Figure | BORING DATE FEBRUARY 4, 1971 DATUM LOCAL

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD	SOIL PROFILE			SAMPLES			ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. 20 40 60 80	COEFFICIENT OF PERMEABILITY, K, CM./SEC.				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
	ELEV'N. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FT.			WATER CONTENT, PERCENT					
									1x10	1x10	1x10	1x10		
WASH BORING NX CASING								STA. 9+79 - 12' RT.						
							500							
	496.6	GROUND SURFACE											GROUND SURFACE	
	495.6	BROWN SAND AND GRAVEL (EMBANKMENT FILL)												
	1.0	VERY LOOSE TO COMPACT BROWN SILTY SAND, SOME GRAVEL, COBBLES AND BOULDERS (EMBANKMENT FILL)		1	2" D.O.	25	495							
	488.1	COMPACT GREY SILTY SAND, TRACE GRAVEL AND ORGANIC MATERIAL (ALLUVIUM)		2	"	2	490							
	8.5			3	"	14								
486.1			4	"	28	485						MH PLASTIC TUBING		
10.3	COMPACT TO VERY DENSE GREY FINE TO COARSE SAND AND GRAVEL, SOME SILT		5	"	54	480						M		
			6	"	66									
							475						STANDPIPE	
			7	"	53									
	472.1	END OF HOLE					470						W.L. IN STANDPIPE AT ELEV. 491.2 FEB. 5, 1971	
	24.5													

0 10 5 Percent axial strain at failure

VERTICAL SCALE 1 IN. TO 5 FT.

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DRAWN D.N. CHECKED F.J.H.

LOCATION See Figure

BORING DATE FEBRUARY 5, 1971

DATUM LOCAL

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.

PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

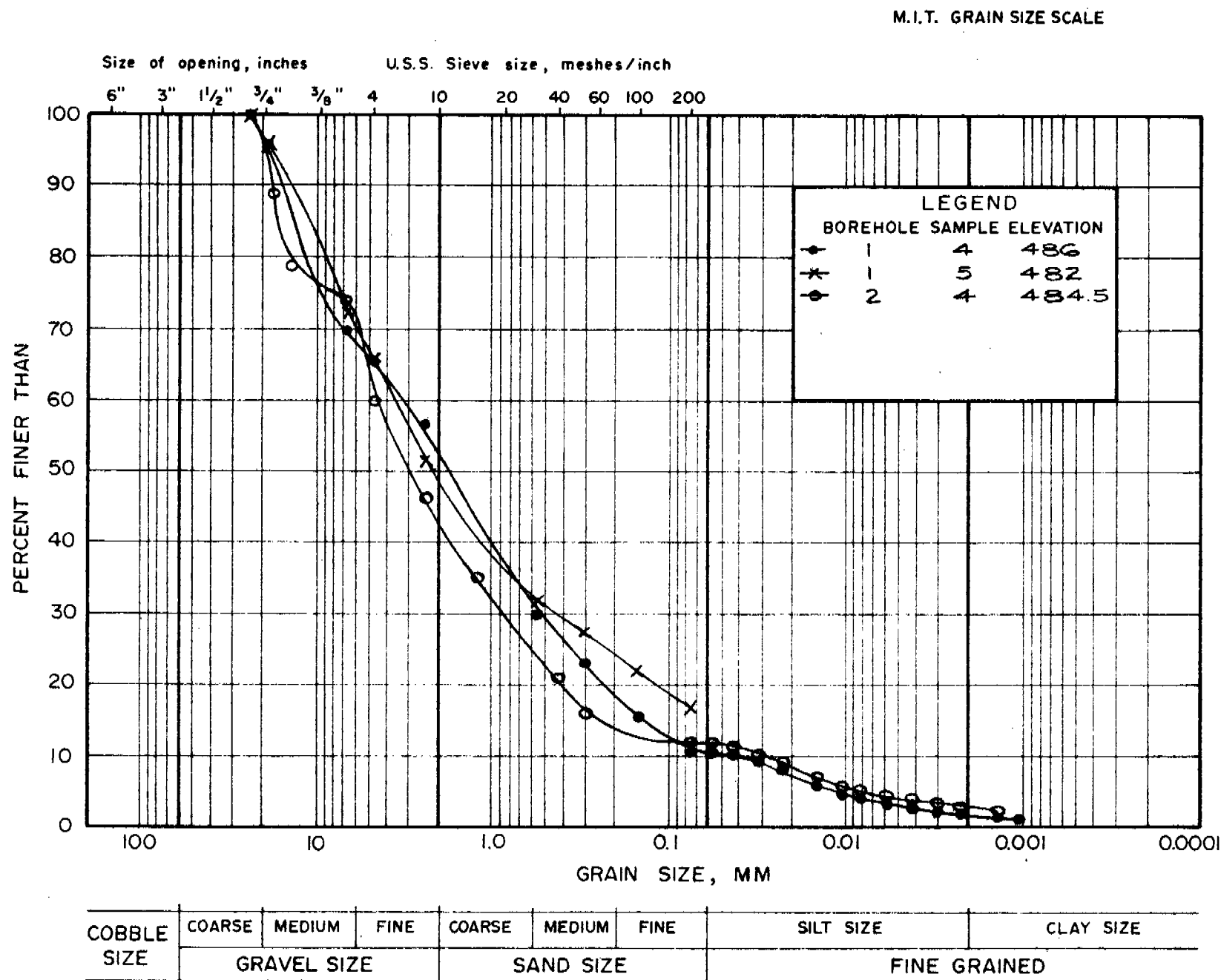
VERTICAL SCALE  
1 IN. TO 5 FT.

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DRAWN D.N.  
CHECKED F.J.H.

# OVERSIZE DRAWING(S)

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FINE TO COARSE SAND AND GRAVEL

GRAIN SIZE DISTRIBUTION

FIGURE 2

