

REPORT ON

**FOUNDATION INVESTIGATION
AND DESIGN REPORT
OVERHEAD SIGN NO. 5
HIGHWAY 401 WIDENING AND REHABILITATION
GWP 288-99-00
FROM 2.0 KM WEST OF REGIONAL ROAD 97
EAST TO 1.3 KM WEST OF
HOMER WATSON BOULEVARD
REGIONAL MUNICIPALITY OF WATERLOO**

Submitted to:

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001-3230-6
Geocres No. 40P8-126

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LIST OF ABBREVIATIONS

LIST OF SYMBOLS

RECORDS OF BOREHOLES

DRAWING 1 - Overhead Sign Location, Borehole Locations

FIGURE 1 - Grain Size Distribution Curve, Sand

FIGURE 2 - Grain Size Distribution Curve, Clayey Silt

1.0 INTRODUCTION

Golder Associates Ltd. (Golder Associates) has been retained by Dillon Consulting Limited on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the proposed overhead signs on Highway 401 within GWP 288-99-00. The overhead signs are to be constructed at the following locations:

<u>DESIGNATION</u>	<u>LOCATION</u>
OS 1	Station 13+550 (Eastbound)
OS 2	Station 14+165 (Eastbound)
OS 3	Station 14+360 (Westbound)
OS 4	Station 14+975 (Westbound)
OS 5	Station 10+415 (Eastbound)

This report addresses the subsurface conditions at the location of OS 5. Drawing 1 shows the location of the overhead sign in plan.

2.0 INVESTIGATION PROCEDURES

The subsurface investigation for the overhead sign was carried out on June 6, 2002, at which time one borehole was drilled at the proposed sign location. Also, a median borehole (borehole 101) from the pavement investigation has been included for the proposed overhead sign location. The boreholes were located as follows:

<u>BOREHOLE</u>	<u>LOCATION</u>	<u>OFFSET</u>
1	Station 10+415	4.5 m Right of right edge of EBL pavement
101	Station 10+400	Centreline of median

The boreholes were advanced using a rubber tire mounted CME 750 drilling machine supplied and operated by a specialist drilling contractor utilizing hollow stem augers. Samples were obtained at regular intervals of depth using 50 millimetre outside diameter split spoon sampling equipment in accordance with the Standard Penetration Test procedure. The water levels in the boreholes were observed and recorded throughout the drilling operations. A perforated standpipe was installed in borehole 1 following the completion of drilling.

The field work was supervised on a full-time basis by a member of our engineering staff who arranged for underground service locates, designated the borehole locations in the field, directed the drilling, sampling and in situ testing operations, logged the boreholes and cared for the samples obtained. The soil samples were identified in the field, placed in labeled containers and transported to Golder Associates London laboratory for further examination and routine testing. Index and classification tests consisting of water content determinations and grain size distribution analyses were carried out on selected samples.

Temporary traffic control was provided by a specialist contractor in accordance with the Ontario Traffic Manual, Temporary Conditions, Book 7, dated March 2001.

Survey control was provided by Golder Associates. Ground surface elevations at the borehole locations are understood to be referenced to geodetic datum.

3.0 SITE GEOLOGY AND STRATIGRAPHY

3.1 Regional Geological Conditions

Highway 401 in the area of the project crosses the Waterloo Hills geographic region, which is identified in the Physiography of Southern Ontario by Chapman and Putnam (1984). This region is predominantly characterized by hilly terrain, which is the result of the convergence of three lobes of the Laurentian Ice sheet, in the vicinity of the cities of Kitchener and Waterloo. The Ontario Lobe advanced from the east, the Georgian Bay Lobe from the north and the Huron Lobe from the north-northwest during an approximate 1,000 year period some 13,000 to 14,000 years ago. This glacial activity resulted in ice contact deposits, such as kames, which occasionally appear as high conical hills, hummocky kame moraines and a few eskers made up mainly of sand and gravel. There are also lateral and end moraine ridges consisting of sandy silt tills. During the melting of the ice lobes, major outwash deposits and spillways were formed in the low areas between the hills which contain a significant amount of sand and gravel.

This portion of the project is located in outwash and kame moraine deposits and the underlying soils consist predominantly of sands and gravels. The underlying bedrock is the Late Silurian Salina Formation, consisting of shales, shaley limestones, some gypsum and anhydrite deposits.

3.2 Site Stratigraphy

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of the in situ and laboratory testing are given on the attached Record of Borehole sheets. The stratigraphic boundaries shown on the Record of Boreholes are inferred from non-continuous sampling and represent transitions between soil types rather than exact planes of geological change. Subsurface conditions may vary significantly between and beyond the borehole locations.

A description of the subsurface conditions encountered in the boreholes at the sign location is provided in the following sections.

3.2.1 Topsoil and Fill

A layer of sand and sand and gravel fill 0.5 metres thick was encountered at ground surface in borehole 1, which was underlain by 0.9 metres of compact sand fill with some gravel. In borehole 101, a 0.2 metre thick layer of silty topsoil was encountered at ground surface.

The sand fill had an N value, as measured in the standard penetration testing, of 17 blows per 0.3 metres penetration and a measured natural water content of about 6 per cent.

3.2.2 Peat

Beneath the sand fill in borehole 1, a 1.7 metre thick layer of soft peat was encountered at elevation 298.6 metres. The peat had measured N values of 3 and 4 blows per 0.3 metres and natural water contents of 107 and 131 per cent.

3.2.3 Sand

Beneath the peat in borehole 1 and the topsoil in borehole 101, layers of loose to compact sand 0.4 to 2.1 metres thick were encountered. The surface of the sand layers varied from elevation 297.0 to 299.8 metres. Borehole 101 was terminated in a dense to very dense sand layer at elevation 297.0, a depth of 3.1 metres, after exploring the layer for some 1.7 metres. The sands had N values between 9 and 21 blows per 0.3 metres and natural water contents of 19 and 21 per cent.

A typical grain size distribution curve for a sample of the sand recovered from the standard penetration testing in borehole 1 is provided on Figure 1.

3.2.4 Sand and Gravel

Some 0.8 metres of dense sand and gravel was encountered at elevation 294.8 metres beneath the sand in borehole 1 and at elevation 299.4 metres between the sand layers in borehole 101. The sand and gravel was noted to contain cobbles in borehole 1 and had a single measured N value of 36 blows per 0.3 metres in borehole 101.

3.2.5 Clayey Silt

A layer of very stiff clayey silt was encountered beneath the sand and gravel in borehole 1 at elevation 294.1 metres. The borehole was terminated in the clayey silt layer at a depth of 10.8 metres after exploring it for some 4.9 metres. The clayey silt had N values between 18 and 25 blows per 0.3 metres and natural water contents of about 17 per cent. Based on a single Atterberg limits determination, the clayey silt material had plastic and liquid limits of about 15 and 28 per cent, respectively.

A typical grain size distribution curve for a sample of the clayey silt recovered from the standard penetration testing in borehole 1 is provided on Figure 2.

3.3 Groundwater Conditions

Groundwater conditions were observed during and upon completion of drilling operations. A standpipe was installed in borehole 1 to monitor the groundwater conditions at the site. Details of the standpipe installation are provided on the attached Record of Borehole sheet. The table below summarizes the groundwater conditions in the boreholes. Groundwater levels are expected to fluctuate seasonally and are expected to be higher during wet periods.

Groundwater was encountered in borehole 1 at elevation 298.6 metres, or some 1.4 metres below ground surface. The water level measured in the standpipe was at elevation 296.5 metres, or 3.5 metres below ground surface, on June 21, 2002, two weeks after drilling.

Borehole 101 remained dry during drilling on March 7, 2001. A summary of the observed and subsequently measured groundwater levels in the boreholes is provided below:

<u>BOREHOLE NUMBER</u>	<u>GROUND SURFACE ELEVATION</u> (m)	<u>GROUNDWATER LEVEL IN OPEN BOREHOLE ON COMPLETION OF DRILLING</u> Depth Below Existing <u>Ground Surface</u> <u>Elevation</u> (m) (m)		<u>GROUNDWATER LEVEL IN STANDPIPE ON JUNE 21, 2002</u> Depth Below Existing <u>Ground Surface</u> <u>Elevation</u> (m) (m)	
1	300.00	1.37	298.63	3.54	296.46
101	300.00	Dry	-	-	-

The corresponding water level in the adjacent creek was at elevation 296.39 metres.

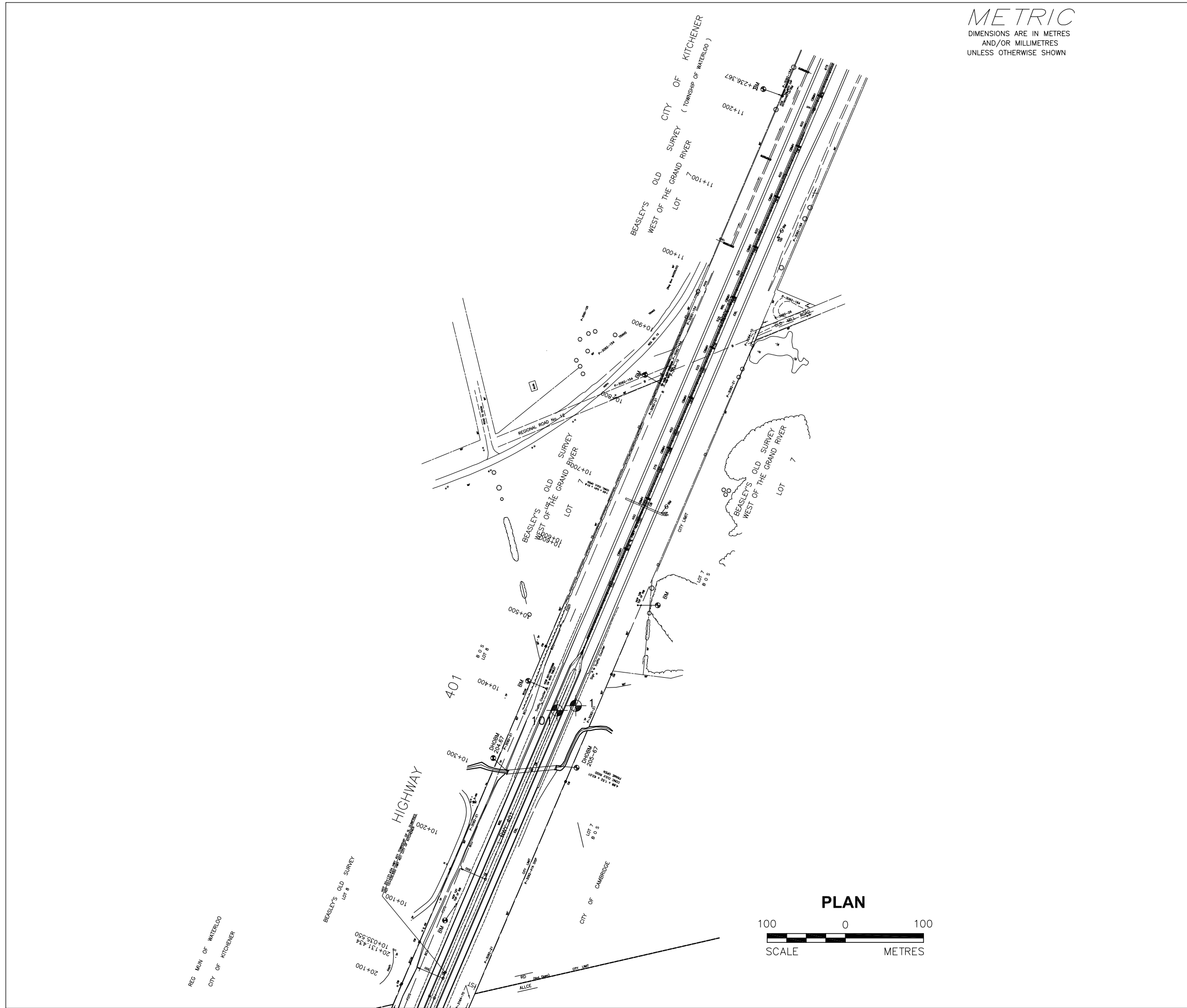
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001323060001.DWG



DIST HWY. 401

CONT. No.

GWP No. 288-99-00

SHEET

OVERHEAD SIGN LOCATION

BOREHOLE LOCATIONS

Golder Associates

Golder Associates Ltd.
LONDON, ONTARIO, CANADA

REFERENCE

DRAWING SUPPLIED BY DILLON CONSULTING
ENTITLED HWY 401, GENERAL ARRANGEMENT

KEY PLAN

LEGEND

Borehole

Seal

Piezometer

Blows/0.3m (Std. Pen. Test, 475 j/blow)

WL in piezometer

WL during drilling

No.	ELEVATION (metres)	LOCATION STATION & o/s \mathcal{Q} OF MEDIAN
1	300.00	10+415 o/s 19.4m RIGHT
101	300.00	10+400 ON CL

NOTES

The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

NO.	DATE	BY	REVISION

Geocres No. 40P8-126

HWY. No. 401	PROJECT NO.: 001-3230-6
SUBM'D. -	CHKD: AMH DATE: JUNE 2002
DRAWN: WDF	CHKD: AMH APPD: PRB DWG. 1

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

<i>AS</i>	auger sample
<i>CS</i>	chunk sample
<i>DO</i>	drive open
<i>DS</i>	Denison type sample
<i>FS</i>	foil sample
<i>RC</i>	rock core
<i>ST</i>	slotted tube
<i>TO</i>	thin-walled, open
<i>TP</i>	thin-walled, piston
<i>WS</i>	wash sample
<i>SS</i>	split spoon

II. PENETRATION RESISTANCES

Dynamic Penetration Resistance:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 0.3 m (12 in.).

Standard Penetration Resistance, N:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 0.3 m (12 in.).

<i>WH</i>	sampler advanced by static weight-weight, hammer
<i>PH</i>	sampler advanced by hydraulic force
<i>PM</i>	sampler advanced by manual force

III. SOIL DESCRIPTION

(a) Cohesionless Soils

	"N" Blows/0.3 m or <u>Blow/ft.</u>
Relative Density	
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

	"Cu" = "Su" <u>kPa</u>	<u>psf.</u>
Consistency		
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1000
Stiff	50 to 100	1000 to 2000
Very stiff	100 to 200	2000 to 4000
Hard	over 200	over 4000

IV. SOIL TESTS

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

NOTES:

1. Combined analyses when 5 to 95 per cent of the material passes the No. 200 sieve.
2. Undrained triaxial tests in which pore pressures are measured are shown as Q or R.

LIST OF SYMBOLS

I. GENERAL

π	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	mass
M	moment
F	factor of safety

II. STRESS AND STRAIN

u	pore pressure
σ	normal stress
σ'	normal effective stress (σ is also used)
τ	shear stress
ϵ	linear strain
ϵ_{sy}	shear strain
ν	Poisson's ration (μ is also used)
E	modulus of linear deformation (Young's modulus)
G	modulus of shear deformation
K	modulus of compressibility
η	coefficient of viscosity

III. SOIL PROPERTIES

(a) Unit weight

γ	unit weight of soil (bulk density)
γ_s	unit weight of solid particles
γ_w	unit weight of water
γ_d	unit dry weight of soil (dry density)
γ'	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
κ	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_v	coefficient of consolidation
T_F	time factor $= c_v t/d^2$ (d , drainage path)
U	degree of consolidation

(e) Shear strength

τ_f	shear strength	in terms of effective stress $\tau_f = c' + \sigma' \tan \phi$
c'	effective cohesion intercept	
ϕ'	effective angle of shearing resistance, or friction	
S_u	apparent cohesion*	in terms of total stress $\tau_f = cu + \sigma \tan \phi_u$
ϕ_u	apparent angle of shearing resistance, or friction	
μ	coefficient of friction	
S_t	sensitivity	

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