

June 23, 2014

Reference No. 1314470477-002-L-Rev0

Sze Pui Kong, P.Eng.
Ministry of Transportation and Infrastructure
Suite 310 - 1500 Woolridge Street
Coquitlam, BC
V3K 0B8

**SUPPLEMENTAL GEOTECHNICAL LABORATORY TESTING
GEORGE MASSEY TUNNEL REPLACEMENT PROJECT, RICHMOND & DELTA, BC**

Dear Ms. Kong,

As requested by the Ministry of Transportation and Infrastructure (MoTI), in email correspondence dated April 28 and May 2, 2014, we are pleased to provide the results of supplemental laboratory testing carried out on samples collected during Golder's geotechnical investigation, between November 2013 and January 2014, as part of the George Massey Tunnel Replacement Project. Details of the geotechnical investigation are presented in Golder's factual report, dated April 24, 2014. Supplemental Atterberg limit (ASTM D4318-10), water content (ASTM D4959-07), and one-dimensional consolidation (ASTM D2435/D2435M-11, Method A) testing have been performed on five relatively undisturbed 76 mm piston tube and 64 mm Shelby tube samples, selected by MoTI. At the request of MoTI, the one-dimensional consolidation test load schedule was modified from standard procedure to include an unload-reload cycle at a maximum load of 2000 kPa.

This letter is limited to presentation of the attached laboratory testing data, and Golder has provided no geotechnical interpretation of the results. Soil classification presented on the consolidation test results is based on visual description and plasticity testing only, and no additional particle size analysis of the soils has been performed.

Should you have any questions or comments, please do not hesitate to contact the undersigned.

Yours very truly,

GOLDER ASSOCIATES LTD.

ORIGINAL SIGNED

Chase Reid, EIT
Geological Engineer

CAR/TCB/do

Attachment: Geotechnical Lab Testing Results

ORIGINAL SIGNED

Tom Bryski, P.Eng.
Associate

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LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS		Reference(s) ASTM D 4318-10
Client: Ministry of Transportation and Infrastructure		Borehole ID: BH13-01
Project: George Massey Tunnel Replacement Project		Sample No.: 28
Location: Richmond, B.C.		Depth Interval (m): 51.82 to 52.43
Project No.: 13-1447-0477 Phase: 3000		Lab Schedule No.: 18

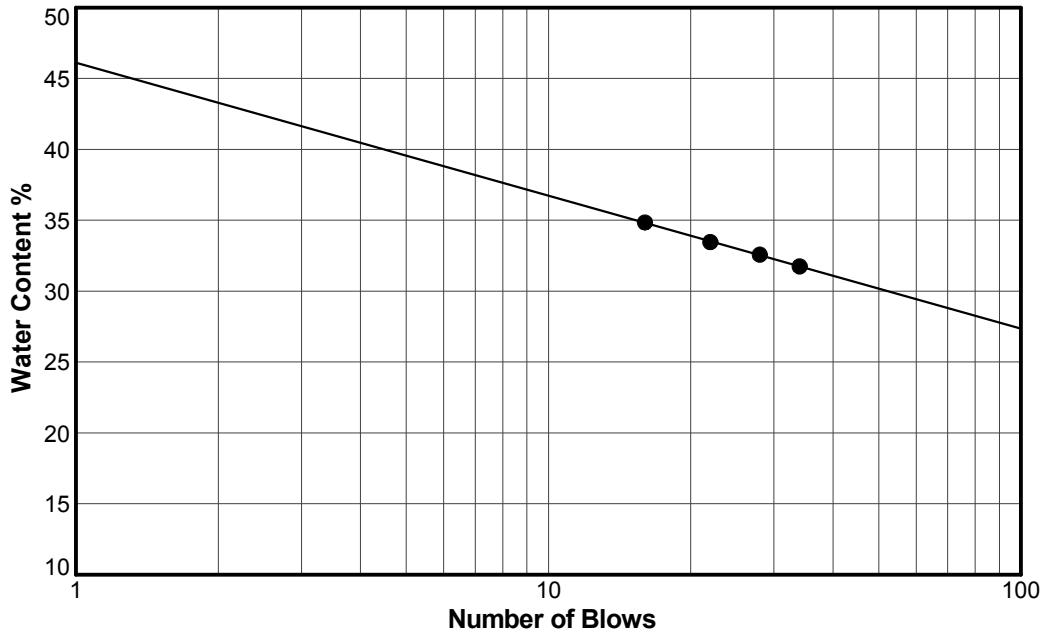
Classification and Definition: CI - Inorganic SILTY CLAY of medium plasticity, sandy or gravelly SILTY CLAY.

Other Remarks: N/A

Test Method: A-Multi Point **Preparation Method:** Wet

SUMMARY	
Percent Passing #40 Sieve (%)	ND
Liquid Limit	33
Plastic Limit	21
Plasticity Index	12
Natural Water Content (%)	31.2
Liquidity Index	0.9

NP - NON-PLASTIC RESULT
ND - NOT DETERMINED



Note: The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

OA/DC	5/8/2014	LP	5/20/2014
Tech	Date	Checked	Date

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LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS		Reference(s) ASTM D 4318-10
Client: Ministry of Transportation and Infrastructure		Borehole ID: BH13-01
Project: George Massey Tunnel Replacement Project		Sample No.: 32
Location: Richmond, B.C.		Depth Interval (m): 64.01 to 64.62
Project No.: 13-1447-0477 Phase: 3000		Lab Schedule No.: 18

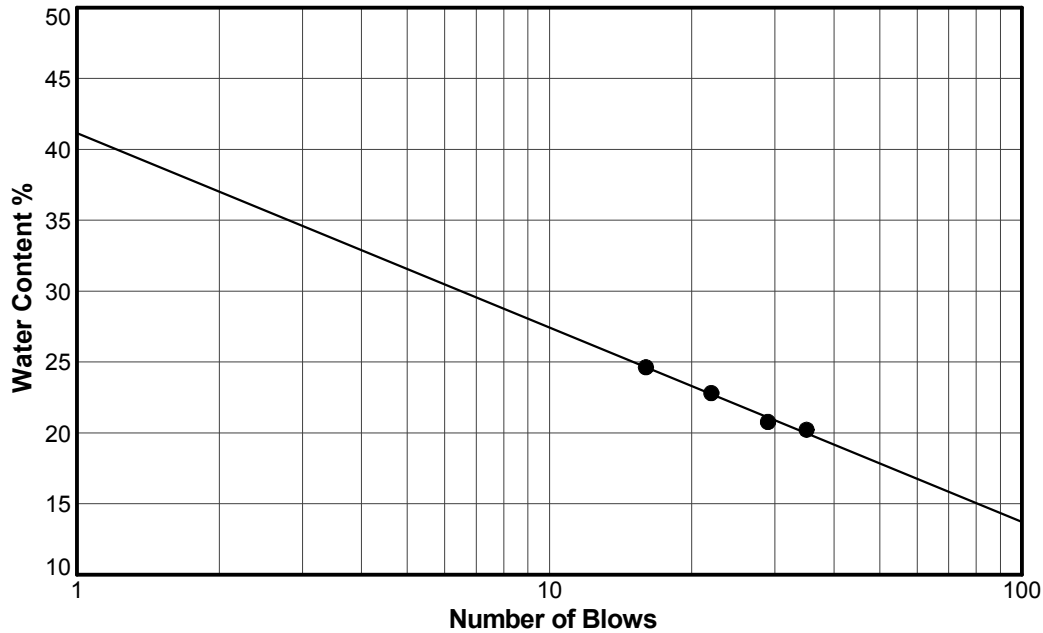
Classification and Definition: ML - Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.

Other Remarks: N/A

Test Method: A-Multi Point **Preparation Method:** Air Dried

SUMMARY	
Percent Passing #40 Sieve (%)	ND
Liquid Limit	22
Plastic Limit	19
Plasticity Index	3
Natural Water Content (%)	31.1
Liquidity Index	4.0

NP - NON-PLASTIC RESULT
ND - NOT DETERMINED



Note: The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

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Tech	Date	Checked	Date

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LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS		Reference(s) ASTM D 4318-10
Client: Ministry of Transportation and Infrastructure		Borehole ID: BH13-01
Project: George Massey Tunnel Replacement Project		Sample No.: 41
Location: Richmond, B.C.		Depth Interval (m): 109.73 to 110.34
Project No.: 13-1447-0477 Phase: 3000		Lab Schedule No.: 18

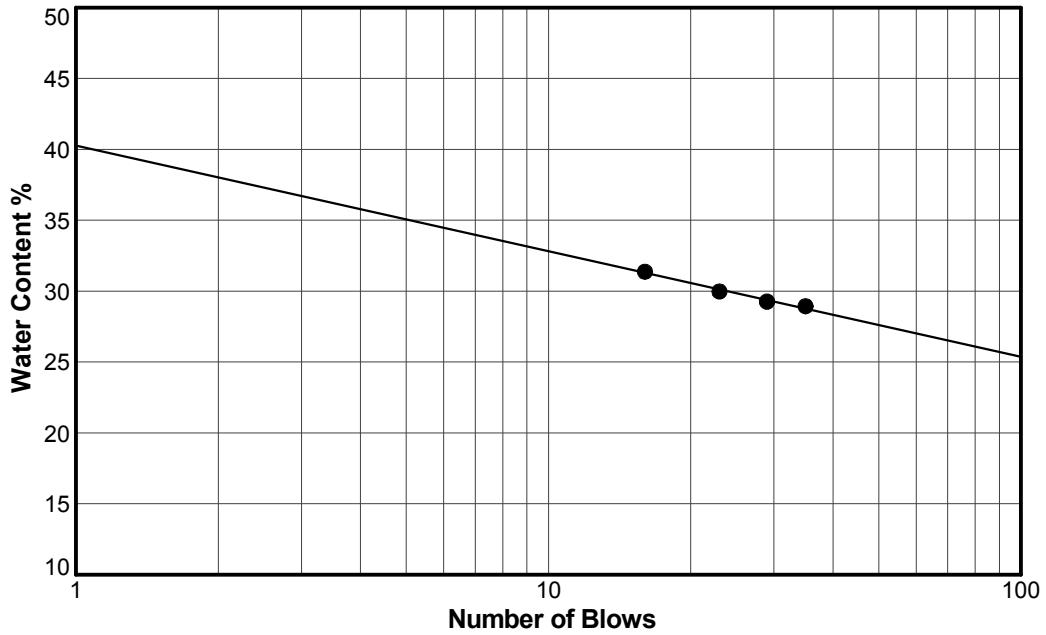
Classification and Definition: CL - Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.

Other Remarks: N/A

Test Method: A-Multi Point **Preparation Method:** Wet

SUMMARY	
Percent Passing #40 Sieve (%)	ND
Liquid Limit	30
Plastic Limit	19
Plasticity Index	11
Natural Water Content (%)	28.7
Liquidity Index	0.9

NP - NON-PLASTIC RESULT
ND - NOT DETERMINED



Note: The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

OA/DC	5/12/2014	LP	5/20/2014
Tech	Date	Checked	Date

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LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS		Reference(s) ASTM D 4318-10
Client: Ministry of Transportation and Infrastructure		Borehole ID: BH13-02
Project: George Massey Tunnel Replacement Project		Sample No.: 30
Location: Richmond, B.C.		Depth Interval (m): 57.91 to 58.52
Project No.: 13-1447-0477 Phase: 3000		Lab Schedule No.: 18

Classification and Definition: CI - Inorganic SILTY CLAY of medium plasticity, sandy or gravelly SILTY CLAY.

Other Remarks: N/A

Test Method: A-Multi Point **Preparation Method:** Wet

SUMMARY	
Percent Passing #40 Sieve (%)	ND
Liquid Limit	31
Plastic Limit	20
Plasticity Index	11
Natural Water Content (%)	30.4
Liquidity Index	0.9

NP - NON-PLASTIC RESULT
ND - NOT DETERMINED



Note: The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

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LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS		Reference(s) ASTM D 4318-10
Client: Ministry of Transportation and Infrastructure		Borehole ID: BH13-02
Project: George Massey Tunnel Replacement Project		Sample No.: 35
Location: Richmond, B.C.		Depth Interval (m): 77.72 to 78.33
Project No.: 13-1447-0477 Phase: 3000		Lab Schedule No.: 18

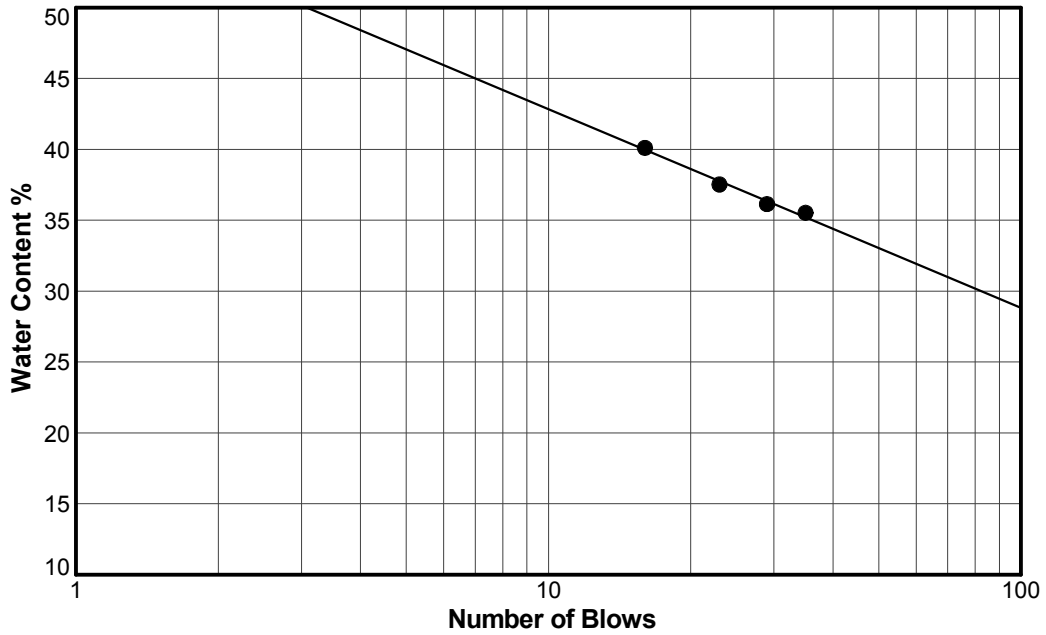
Classification and Definition: CI - Inorganic SILTY CLAY of medium plasticity, sandy or gravelly SILTY CLAY.

Other Remarks: N/A

Test Method: A-Multi Point **Preparation Method:** Wet

SUMMARY	
Percent Passing #40 Sieve (%)	ND
Liquid Limit	37
Plastic Limit	20
Plasticity Index	17
Natural Water Content (%)	30.3
Liquidity Index	0.6

NP - NON-PLASTIC RESULT
ND - NOT DETERMINED



Note: The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

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Tech	Date	Checked	Date

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WATER CONTENT DETERMINATION

 Reference(s)
ASTM D 4959
Client: Ministry of Transportation and Infrastructure **Project No.:** 13-1447-0477 **Phase:** 3000

Project: George Massey Tunnel Replacement Project **Lab Schedule No.:** 18

Location: Richmond, B.C.

Sample Location	Sample No.	Specimen No.	Depth Interval		Water Content (%)
			Depth (m)	Bottom (m)	
BH13-01	28		51.82	52.43	31.2
BH13-01	32		64.01	64.62	31.1
BH13-01	41		109.73	110.34	28.7
BH13-02	30		57.91	58.52	30.4
BH13-02	35		77.72	78.33	30.3

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5/20/2014

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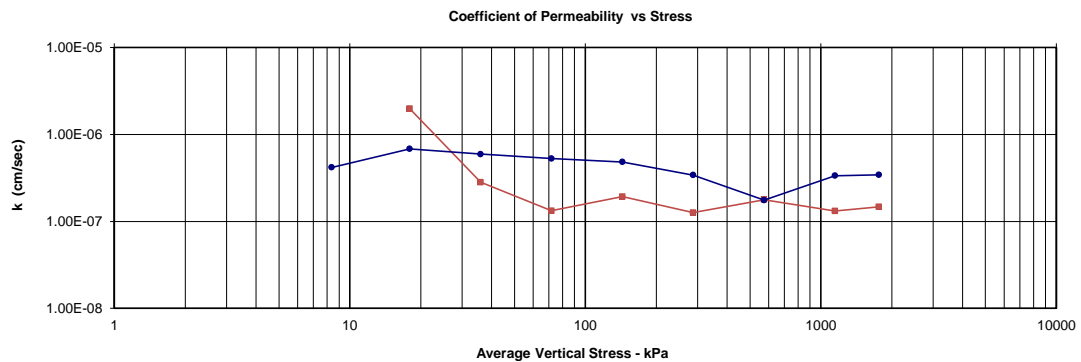
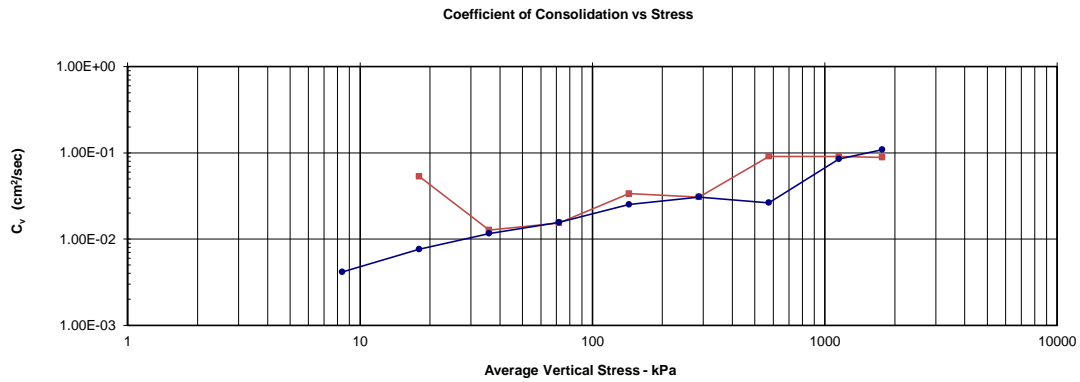
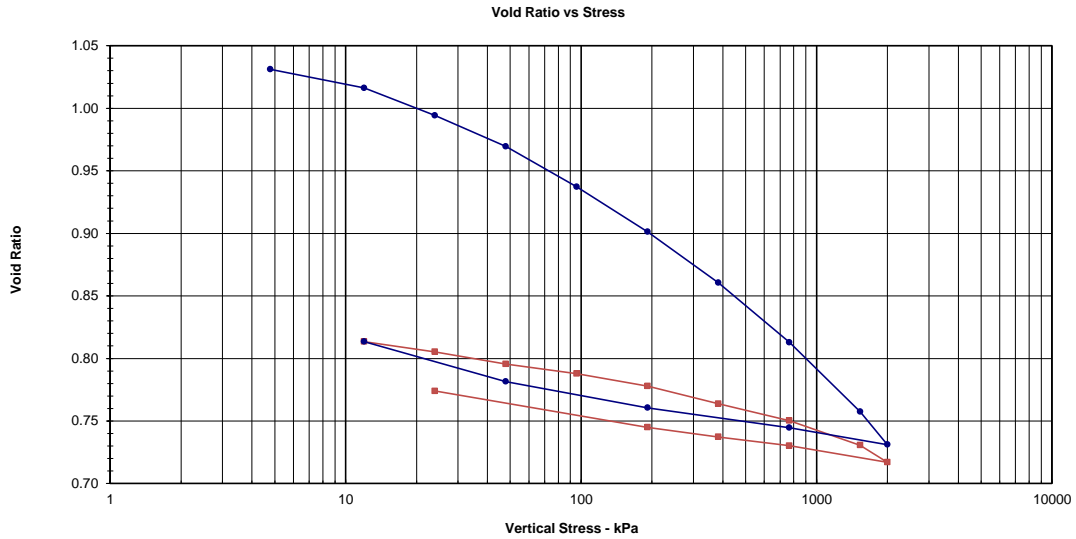
Date

Golder Associates Ltd.

 300-3811 North Fraser Way Burnaby, British Columbia Canada V5J 5J2
 Tel: (604) 412 6899 Fax: (604) 412 6816 www.golder.com

Golder Associates: Operations in Africa, Asia, Australasia, Europe, North America and South America

One-Dimensional Consolidation Properties of Soils				Reference(s) ASTM D 2435/D 2435M-11	
Project No. :	13-1447-0477 Phase: 4000	Client :	Ministry of Transportation and Infrastructure	Borehole:	BH13-01
Sch No.	157	Project :	George Massey Tunnel Replacement Project	Sample:	TP28
Lab Work:	TM/MM	Location:	Richmond and Delta, BC	Depth (m) :	51.82 - 52.43

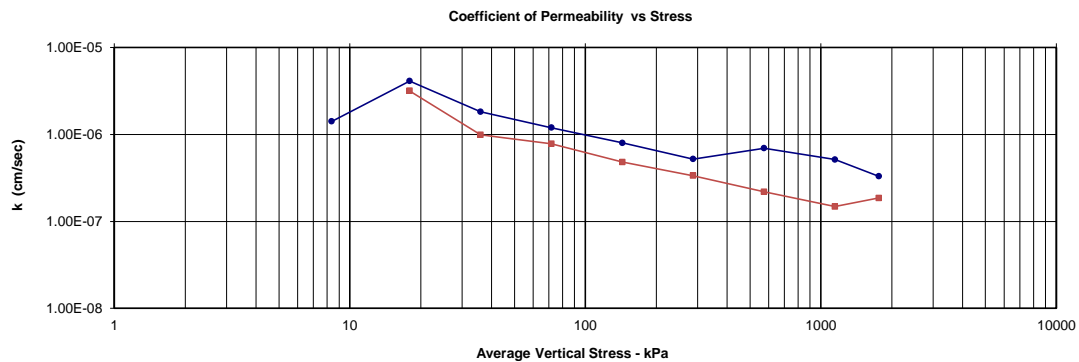
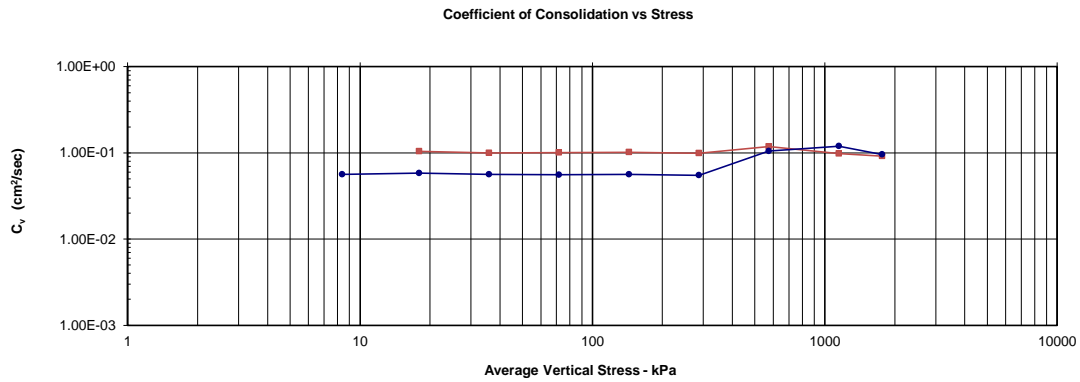
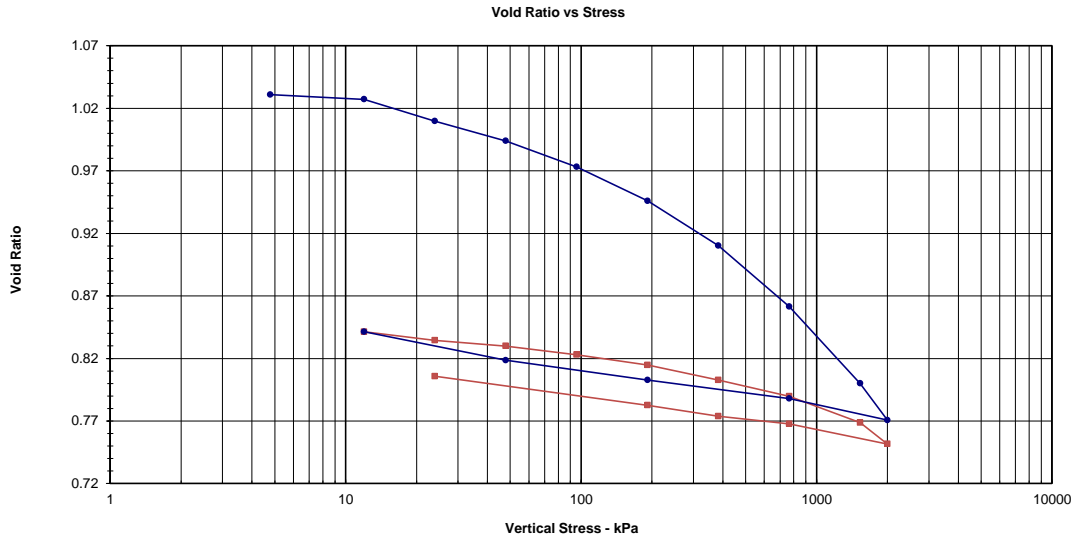


TM/MM	May 2, 2014	MS	June 20, 2014
TESTED BY	DATE	CHECKED BY	DATE



One-Dimensional Consolidation Properties of Soils										Reference(s)																																																				
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<table border="0" style="width:100%"> <tr> <td style="width:33%"> Equipment Machine: <u>Sigma-1</u> Mach No. <u>Station 1</u> Ring No. <u>B1</u> Drainage: <u>Double-sided</u> </td> <td style="width:33%"> Specimen Geometry <table border="0"> <tr> <td></td> <td>Initial</td> <td>Final</td> </tr> <tr> <td>Height (mm) =</td> <td>22.07</td> <td>19.25</td> </tr> <tr> <td>Diameter (mm) =</td> <td>63.41</td> <td>63.41</td> </tr> <tr> <td>Area (cm²) =</td> <td>31.58</td> <td>31.58</td> </tr> <tr> <td>Volume (cm³) =</td> <td>69.70</td> <td>60.79</td> </tr> </table> </td> <td style="width:33%"> Phase Relationships <table border="0"> <tr> <td></td> <td>Initial</td> <td>Final</td> </tr> <tr> <td>Wet Wt (g) =</td> <td>128.18</td> <td>120.90</td> </tr> <tr> <td>Dry Wt (g) =</td> <td>95.95</td> <td>95.95</td> </tr> <tr> <td>w (%) =</td> <td>33.59</td> <td>26.00</td> </tr> <tr> <td>e =</td> <td>1.03</td> <td>0.77</td> </tr> <tr> <td>ρ_{wet} (kg/m³) =</td> <td>1839</td> <td>1989</td> </tr> <tr> <td>ρ_{dry} (kg/m³) =</td> <td>1377</td> <td>1578</td> </tr> <tr> <td>S (%) =</td> <td>91</td> <td>94</td> </tr> </table> </td> </tr> <tr> <td colspan="3"> Remarks ASTM Method: <u>A - Constant Time Increment</u> Method for Cv : <u>Taylor</u> H_{avg} : <u>Half the specimen height</u> Time Increment: <u>1440 min</u> Estimated Preconsolidation Stress: <u>N/A</u> </td> <td colspan="3"> Sample Properties G_s = <u>2.80</u> Assumed H_s (mm) = <u>10.85</u> </td> <td colspan="3"> Atterberg Limits Liquid Limit: <u>33</u> Plastic Limit: <u>21</u> Plasticity Index: <u>12</u> Soil Classification: <u>CI</u> </td> </tr> </table>												Equipment Machine: <u>Sigma-1</u> Mach No. <u>Station 1</u> Ring No. <u>B1</u> Drainage: <u>Double-sided</u>	Specimen Geometry <table border="0"> <tr> <td></td> <td>Initial</td> <td>Final</td> </tr> <tr> <td>Height (mm) =</td> <td>22.07</td> <td>19.25</td> </tr> <tr> <td>Diameter (mm) =</td> <td>63.41</td> <td>63.41</td> </tr> <tr> <td>Area (cm²) =</td> <td>31.58</td> <td>31.58</td> </tr> <tr> <td>Volume (cm³) =</td> <td>69.70</td> <td>60.79</td> </tr> </table>		Initial	Final	Height (mm) =	22.07	19.25	Diameter (mm) =	63.41	63.41	Area (cm ²) =	31.58	31.58	Volume (cm ³) =	69.70	60.79	Phase Relationships <table border="0"> <tr> <td></td> <td>Initial</td> <td>Final</td> </tr> <tr> <td>Wet Wt (g) =</td> <td>128.18</td> <td>120.90</td> </tr> <tr> <td>Dry Wt (g) =</td> <td>95.95</td> <td>95.95</td> </tr> <tr> <td>w (%) =</td> <td>33.59</td> <td>26.00</td> </tr> <tr> <td>e =</td> <td>1.03</td> <td>0.77</td> </tr> <tr> <td>ρ_{wet} (kg/m³) =</td> <td>1839</td> <td>1989</td> </tr> <tr> <td>ρ_{dry} (kg/m³) =</td> <td>1377</td> <td>1578</td> </tr> <tr> <td>S (%) =</td> <td>91</td> <td>94</td> </tr> </table>		Initial	Final	Wet Wt (g) =	128.18	120.90	Dry Wt (g) =	95.95	95.95	w (%) =	33.59	26.00	e =	1.03	0.77	ρ _{wet} (kg/m ³) =	1839	1989	ρ _{dry} (kg/m ³) =	1377	1578	S (%) =	91	94	Remarks ASTM Method: <u>A - Constant Time Increment</u> Method for Cv : <u>Taylor</u> H _{avg} : <u>Half the specimen height</u> Time Increment: <u>1440 min</u> Estimated Preconsolidation Stress: <u>N/A</u>			Sample Properties G _s = <u>2.80</u> Assumed H _s (mm) = <u>10.85</u>			Atterberg Limits Liquid Limit: <u>33</u> Plastic Limit: <u>21</u> Plasticity Index: <u>12</u> Soil Classification: <u>CI</u>		
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Load #	Stress (kPa)	ΔH (mm)	Corrected d _f (mm)	ε Σ ΔH / H ₀ (%)	H-H _s (mm)	e (H-H _s)/H _s	Stress _{avg} (kPa)	e _{avg}	H _{avg} (mm)	t 90 (min)	C _v (cm ² /sec)	k (cm/sec)																																																		
1	5	0.03	22.04	0.14	11.19	1.03																																																								
2	12	0.22	21.88	0.87	11.03	1.02	8	1.02	10.98	4.10	4.2E-03	4.2E-07																																																		
3	24	0.30	21.64	1.95	10.79	0.99	18	1.01	10.88	2.20	7.6E-03	6.8E-07																																																		
4	48	0.30	21.37	3.17	10.52	0.97	36	0.98	10.75	1.41	1.2E-02	5.9E-07																																																		
5	96	0.40	21.02	4.75	10.17	0.94	72	0.95	10.60	1.02	1.6E-02	5.3E-07																																																		
6	192	0.45	20.63	6.53	9.78	0.90	144	0.92	10.41	0.61	2.5E-02	4.8E-07																																																		
7	383	0.52	20.19	8.53	9.34	0.86	287	0.88	10.21	0.48	3.1E-02	3.4E-07																																																		
8	766	0.62	19.67	10.87	8.82	0.81	575	0.84	9.97	0.53	2.6E-02	1.8E-07																																																		
9	1532	0.78	19.07	13.59	8.22	0.76	1149	0.79	9.69	0.16	8.5E-02	3.4E-07																																																		
10	2000	0.36	18.79	14.89	7.93	0.73	1766	0.74	9.46	0.12	1.1E-01	3.4E-07																																																		
11	766	-0.30	18.93	14.22	8.08	0.74																																																								
12	192	-0.35	19.11	13.44	8.25	0.76																																																								
13	48	-0.33	19.33	12.41	8.48	0.78																																																								
14	12	-0.41	19.68	10.84	8.83	0.81																																																								
15	24	0.11	19.59	11.24	8.74	0.81	18	0.81	9.82	0.26	5.3E-02	2.0E-06																																																		
16	48	0.11	19.48	11.72	8.63	0.80	36	0.80	9.77	1.06	1.3E-02	2.8E-07																																																		
17	96	0.13	19.40	12.09	8.55	0.79	72	0.79	9.72	0.87	1.5E-02	1.3E-07																																																		
18	192	0.16	19.29	12.59	8.44	0.78	144	0.78	9.67	0.39	3.4E-02	1.9E-07																																																		
19	383	0.20	19.14	13.28	8.29	0.76	287	0.77	9.61	0.42	3.1E-02	1.3E-07																																																		
20	766	0.26	18.99	13.94	8.14	0.75	575	0.76	9.53	0.14	9.1E-02	1.8E-07																																																		
21	1532	0.37	18.78	14.91	7.93	0.73	1149	0.74	9.44	0.14	9.1E-02	1.3E-07																																																		
22	2000	0.22	18.63	15.58	7.78	0.72	1766	0.72	9.35	0.14	8.9E-02	1.5E-07																																																		
23	766	-0.30	18.78	14.93	7.92	0.73																																																								
24	383	-0.16	18.85	14.58	8.00	0.74																																																								
25	192	-0.17	18.94	14.21	8.08	0.75																																																								
26	24	-0.46	19.25	12.78	8.40	0.77																																																								
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One-Dimensional Consolidation Properties of Soils				Reference(s) ASTM D 2435/D 2435M-11	
Project No. :	13-1447-0477 Phase: 4000	Client :	Ministry of Transportation and Infrastructure	Borehole:	BH13-01
Sch No.	157	Project :	George Massey Tunnel Replacement Project	Sample:	TP32
Lab Work:	TM/MM	Location:	Richmond and Delta, BC	Depth (m) :	64.01 - 64.62

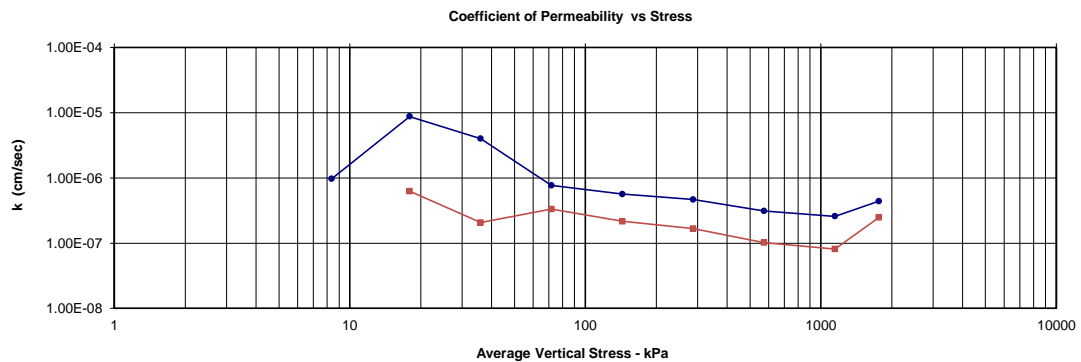
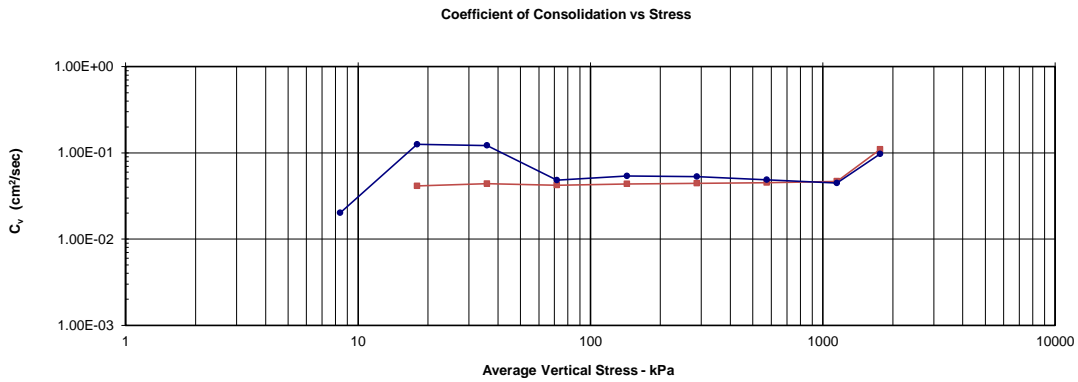
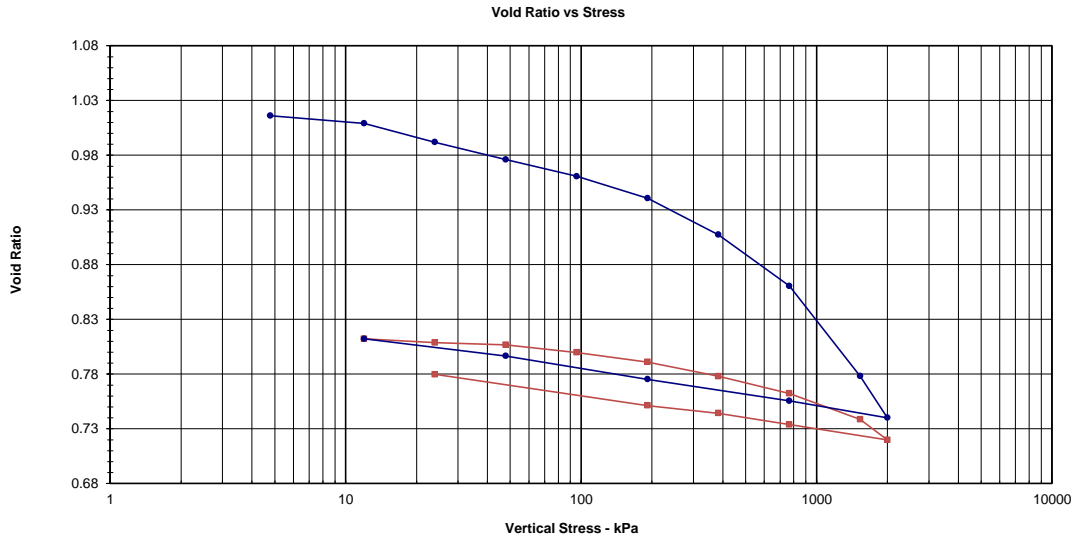


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1	5	0.03	22.00	0.11	11.17	1.03																																																								
2	12	0.18	21.96	0.29	11.13	1.03	8	1.03	10.99	0.30	5.6E-02	1.4E-06																																																		
3	24	0.23	21.77	1.15	10.94	1.01	18	1.02	10.93	0.29	5.8E-02	4.1E-06																																																		
4	48	0.24	21.60	1.92	10.77	0.99	36	1.00	10.84	0.29	5.6E-02	1.8E-06																																																		
5	96	0.27	21.37	2.95	10.54	0.97	72	0.98	10.74	0.29	5.6E-02	1.2E-06																																																		
6	192	0.35	21.08	4.29	10.25	0.95	144	0.96	10.61	0.28	5.6E-02	8.0E-07																																																		
7	383	0.46	20.69	6.04	9.86	0.91	287	0.93	10.44	0.28	5.5E-02	5.2E-07																																																		
8	766	0.61	20.16	8.44	9.33	0.86	575	0.89	10.21	0.14	1.0E-01	6.9E-07																																																		
9	1532	0.80	19.50	11.46	8.67	0.80	1149	0.83	9.92	0.12	1.2E-01	5.1E-07																																																		
10	2000	0.37	19.18	12.91	8.35	0.77	1766	0.79	9.67	0.14	9.6E-02	3.3E-07																																																		
11	766	-0.32	19.37	12.06	8.53	0.79																																																								
12	192	-0.27	19.53	11.33	8.69	0.80																																																								
13	48	-0.24	19.70	10.55	8.87	0.82																																																								
14	12	-0.28	19.94	9.43	9.11	0.84																																																								
15	24	0.08	19.87	9.77	9.04	0.83	18	0.84	9.95	0.13	1.0E-01	3.2E-06																																																		
16	48	0.06	19.82	9.99	8.99	0.83	36	0.83	9.92	0.14	1.0E-01	9.9E-07																																																		
17	96	0.10	19.75	10.33	8.92	0.82	72	0.83	9.89	0.14	1.0E-01	7.8E-07																																																		
18	192	0.14	19.66	10.74	8.82	0.81	144	0.82	9.85	0.13	1.0E-01	4.8E-07																																																		
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21	1532	0.34	19.16	13.00	8.33	0.77	1149	0.78	9.64	0.13	9.8E-02	1.5E-07																																																		
22	2000	0.23	18.97	13.84	8.14	0.75	1766	0.76	9.53	0.14	9.2E-02	1.9E-07																																																		
23	766	-0.31	19.15	13.05	8.32	0.77																																																								
24	383	-0.14	19.21	12.75	8.38	0.77																																																								
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Sch No.	157	Project :	George Massey Tunnel Replacement Project	Sample:	TP41
Lab Work:	TM/MM	Location:	Richmond and Delta, BC	Depth (m) :	109.73 - 110.34

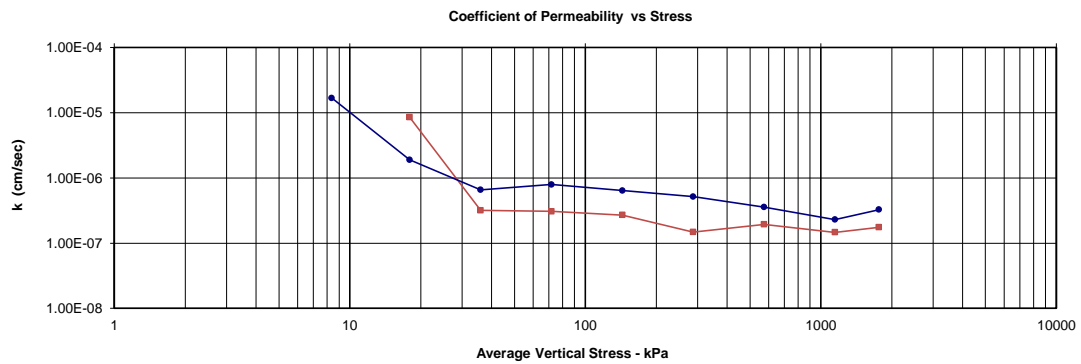
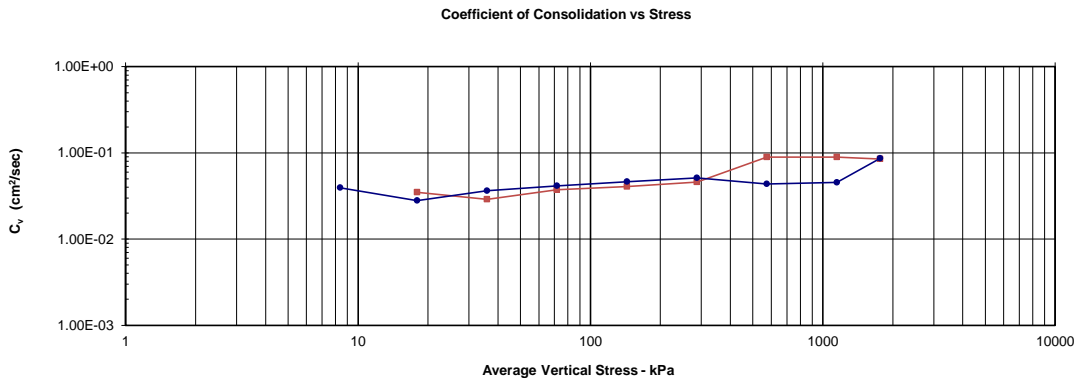
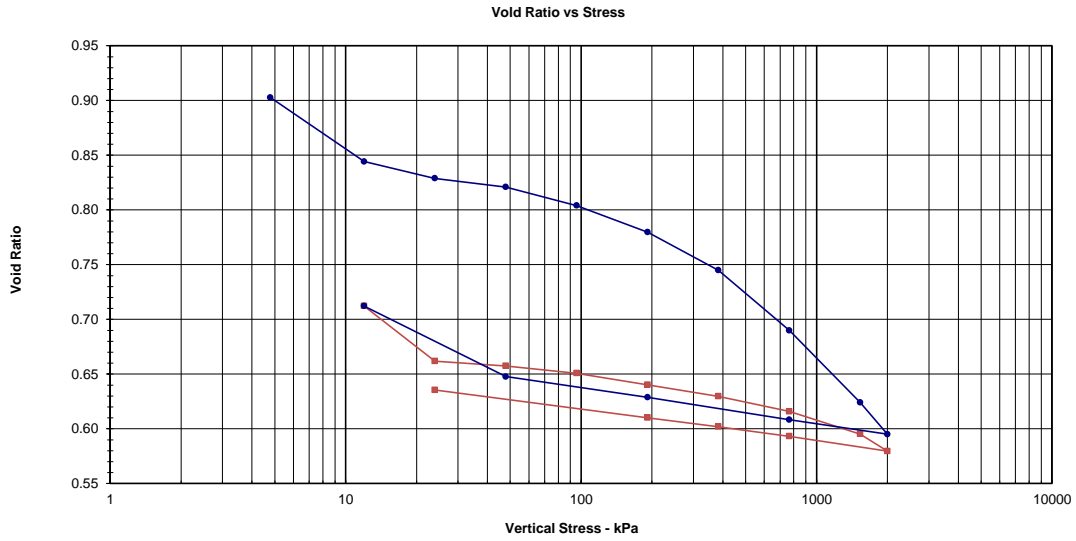


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Dry Wt (g) =	97.41	97.41																																																												
w (%) =	34.58	27.80																																																												
e =	1.01	0.78																																																												
ρ _{wet} (kg/m ³) =	1878	2011																																																												
ρ _{dry} (kg/m ³) =	1395	1574																																																												
S (%) =	96	100																																																												
Remarks ASTM Method: <u> A - Constant Time Increment </u> Method for Cv : <u> Taylor </u> H _{avg} : <u> Half the specimen height </u> Time Increment: <u> 1440 min </u> Estimated Preconsolidation Stress: <u> 600 kPa </u>			Sample Properties G _s = <u> 2.80 </u> Assumed H _s (mm) = <u> 11.00 </u>			Atterberg Limits Liquid Limit: <u> 30 </u> Plastic Limit: <u> 19 </u> Plasticity Index: <u> 11 </u> Soil Classification: <u> CL </u>																																																								
Load #	Stress (kPa)	ΔH (mm)	Corrected d _f (mm)	ε Σ ΔH / H ₀ (%)	H-H _s (mm)	e (H-H _s)/H _s	Stress _{avg} (kPa)	e _{avg}	H _{avg} (mm)	t ₉₀ (min)	C _v (cm ² /sec)	k (cm/sec)																																																		
1	5	-0.06	22.18	-0.50	11.18	1.02																																																								
2	12	0.11	22.11	-0.15	11.10	1.01	8	1.01	11.07	0.86	2.0E-02	9.7E-07																																																		
3	24	0.20	21.92	0.70	10.91	0.99	18	1.00	11.01	0.14	1.3E-01	8.8E-06																																																		
4	48	0.19	21.74	1.50	10.74	0.98	36	0.98	10.92	0.14	1.2E-01	4.0E-06																																																		
5	96	0.21	21.57	2.26	10.57	0.96	72	0.97	10.83	0.34	4.8E-02	7.7E-07																																																		
6	192	0.26	21.35	3.26	10.35	0.94	144	0.95	10.73	0.30	5.4E-02	5.7E-07																																																		
7	383	0.43	20.99	4.91	9.98	0.91	287	0.92	10.59	0.30	5.3E-02	4.7E-07																																																		
8	766	0.65	20.47	7.26	9.47	0.86	575	0.88	10.36	0.31	4.9E-02	3.1E-07																																																		
9	1532	1.06	19.57	11.36	8.56	0.78	1149	0.82	10.01	0.32	4.5E-02	2.6E-07																																																		
10	2000	0.47	19.15	13.26	8.14	0.74	1766	0.76	9.68	0.14	9.7E-02	4.4E-07																																																		
11	766	-0.31	19.32	12.49	8.31	0.76																																																								
12	192	-0.32	19.53	11.50	8.53	0.78																																																								
13	48	-0.30	19.77	10.44	8.76	0.80																																																								
14	12	-0.21	19.94	9.66	8.94	0.81																																																								
15	24	0.04	19.90	9.83	8.90	0.81	18	0.81	9.96	0.34	4.1E-02	6.3E-07																																																		
16	48	0.04	19.88	9.93	8.88	0.81	36	0.81	9.95	0.32	4.4E-02	2.1E-07																																																		
17	96	0.10	19.80	10.28	8.80	0.80	72	0.80	9.92	0.33	4.2E-02	3.3E-07																																																		
18	192	0.13	19.71	10.71	8.70	0.79	144	0.80	9.88	0.32	4.4E-02	2.2E-07																																																		
19	383	0.19	19.56	11.37	8.56	0.78	287	0.78	9.82	0.31	4.4E-02	1.7E-07																																																		
20	766	0.25	19.39	12.15	8.39	0.76	575	0.77	9.74	0.30	4.5E-02	1.0E-07																																																		
21	1532	0.37	19.13	13.33	8.13	0.74	1149	0.75	9.63	0.28	4.7E-02	8.1E-08																																																		
22	2000	0.26	18.92	14.27	7.92	0.72	1766	0.73	9.51	0.12	1.1E-01	2.5E-07																																																		
23	766	-0.29	19.08	13.57	8.07	0.73																																																								
24	383	-0.16	19.19	13.05	8.19	0.74																																																								
25	192	-0.13	19.27	12.70	8.27	0.75																																																								
26	24	-0.40	19.58	11.28	8.58	0.78																																																								
Comments: <u> Void Ratio Vs. Stress computed for end of loading. </u> <u> </u> <u> </u>																																																														
Description: <u> (CL) SILT, some clay; some fine sand </u> <u> </u> <u> </u>																																																														
TM/MM			May 9, 2014			MS			June 20, 2014																																																					
TESTED BY			DATE			CHECKED BY			DATE																																																					

One-Dimensional Consolidation Properties of Soils				Reference(s) ASTM D 2435/D 2435M-11	
Project No. :	13-1447-0477 Phase: 4000	Client :	Ministry of Transportation and Infrastructure	Borehole:	BH13-02
Sch No.	157	Project :	George Massey Tunnel Replacement Project	Sample:	TP30
Lab Work:	TM/MM	Location:	Richmond and Delta, BC	Depth (m) :	57.91 - 58.52



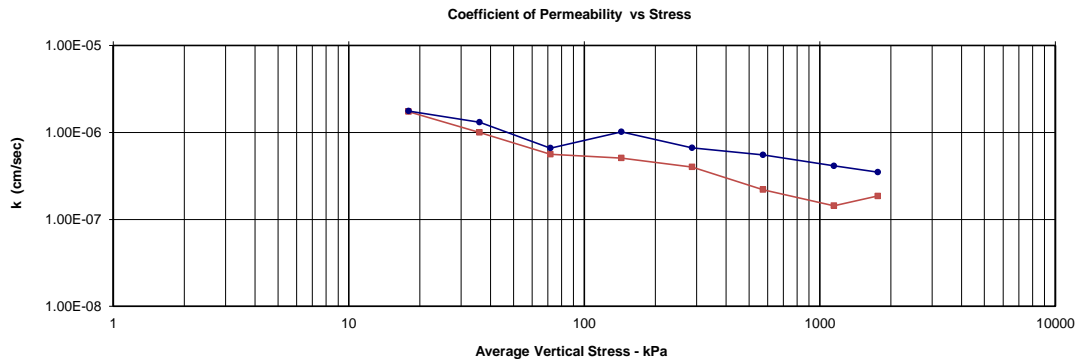
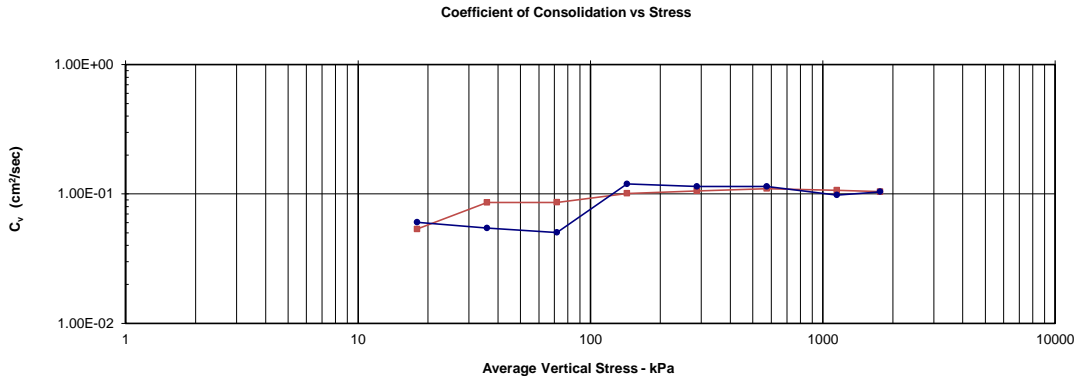
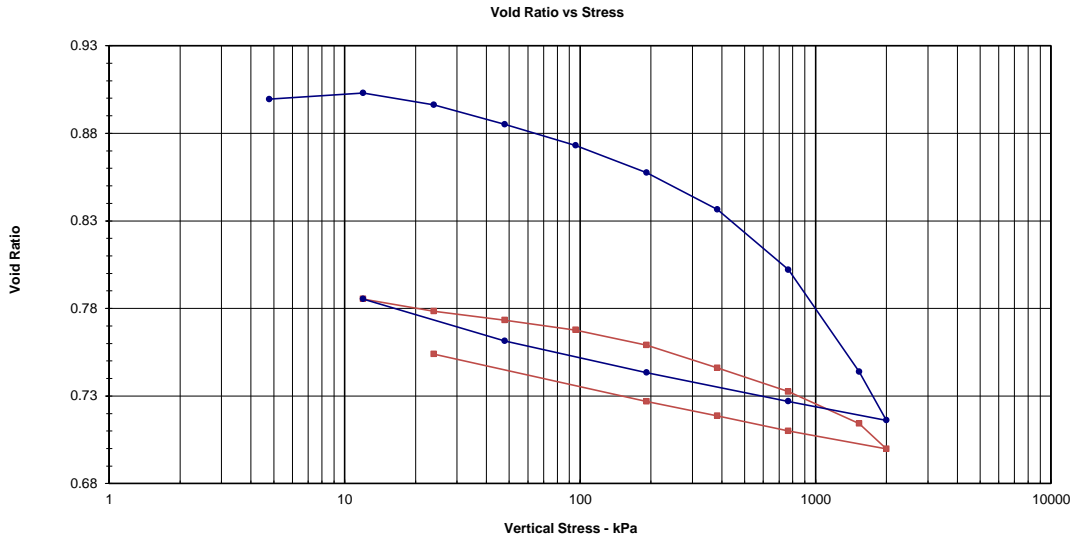
TM/MM	May 2, 2014	MS	June 20, 2014
TESTED BY	DATE	CHECKED BY	DATE



One-Dimensional Consolidation Properties of Soils										Reference(s)																																																				
										ASTM D 2435/D 2435M-11																																																				
Project No. :	13-1447-0477 Phase: 4000			Client :	Ministry of Transportation and Infrastructure			Borehole:	BH13-02																																																					
Sch No. :	157			Project :	George Massey Tunnel Replacement Project			Sample:	TP30																																																					
Lab Work:	TM/MM			Location:	Richmond and Delta, BC			Depth (m) :	57.91 - 58.52																																																					
<table border="0" style="width:100%"> <tr> <td style="width:33%"> Equipment Machine: <u> Sigma-1 </u> Mach No. <u> Station 3 </u> Ring No. <u> C2 </u> Drainage: <u> Double-sided </u> </td> <td style="width:33%"> Specimen Geometry <table border="0"> <tr> <td></td> <td>Initial</td> <td>Final</td> </tr> <tr> <td>Height (mm) =</td> <td>22.10</td> <td>19.61</td> </tr> <tr> <td>Diameter (mm) =</td> <td>63.49</td> <td>63.49</td> </tr> <tr> <td>Area (cm²) =</td> <td>31.65</td> <td>31.65</td> </tr> <tr> <td>Volume (cm³) =</td> <td>69.96</td> <td>62.07</td> </tr> </table> </td> <td style="width:33%"> Phase Relationships <table border="0"> <tr> <td></td> <td>Initial</td> <td>Final</td> </tr> <tr> <td>Wet Wt (g) =</td> <td>132.78</td> <td>126.21</td> </tr> <tr> <td>Dry Wt (g) =</td> <td>101.83</td> <td>101.83</td> </tr> <tr> <td>w (%) =</td> <td>30.39</td> <td>23.94</td> </tr> <tr> <td>e =</td> <td>0.91</td> <td>0.69</td> </tr> <tr> <td>ρ_{wet} (kg/m³) =</td> <td>1898</td> <td>2033</td> </tr> <tr> <td>ρ_{dry} (kg/m³) =</td> <td>1456</td> <td>1640</td> </tr> <tr> <td>S (%) =</td> <td>93</td> <td>96</td> </tr> </table> </td> </tr> <tr> <td colspan="3"> Remarks ASTM Method: <u> A - Constant Time Increment </u> Method for Cv : <u> Taylor </u> H_{avg} : <u> Half the specimen height </u> Time Increment: <u> 1440 min </u> Estimated Preconsolidation Stress: <u> 450 kPa </u> </td> <td colspan="3"> Sample Properties G_s = <u> 2.78 </u> Calculated H_s (mm) = <u> 11.57 </u> </td> <td colspan="3"> Atterberg Limits Liquid Limit: <u> 31 </u> Plastic Limit: <u> 20 </u> Plasticity Index: <u> 11 </u> Soil Classification: <u> CI </u> </td> </tr> </table>												Equipment Machine: <u> Sigma-1 </u> Mach No. <u> Station 3 </u> Ring No. <u> C2 </u> Drainage: <u> Double-sided </u>	Specimen Geometry <table border="0"> <tr> <td></td> <td>Initial</td> <td>Final</td> </tr> <tr> <td>Height (mm) =</td> <td>22.10</td> <td>19.61</td> </tr> <tr> <td>Diameter (mm) =</td> <td>63.49</td> <td>63.49</td> </tr> <tr> <td>Area (cm²) =</td> <td>31.65</td> <td>31.65</td> </tr> <tr> <td>Volume (cm³) =</td> <td>69.96</td> <td>62.07</td> </tr> </table>		Initial	Final	Height (mm) =	22.10	19.61	Diameter (mm) =	63.49	63.49	Area (cm ²) =	31.65	31.65	Volume (cm ³) =	69.96	62.07	Phase Relationships <table border="0"> <tr> <td></td> <td>Initial</td> <td>Final</td> </tr> <tr> <td>Wet Wt (g) =</td> <td>132.78</td> <td>126.21</td> </tr> <tr> <td>Dry Wt (g) =</td> <td>101.83</td> <td>101.83</td> </tr> <tr> <td>w (%) =</td> <td>30.39</td> <td>23.94</td> </tr> <tr> <td>e =</td> <td>0.91</td> <td>0.69</td> </tr> <tr> <td>ρ_{wet} (kg/m³) =</td> <td>1898</td> <td>2033</td> </tr> <tr> <td>ρ_{dry} (kg/m³) =</td> <td>1456</td> <td>1640</td> </tr> <tr> <td>S (%) =</td> <td>93</td> <td>96</td> </tr> </table>		Initial	Final	Wet Wt (g) =	132.78	126.21	Dry Wt (g) =	101.83	101.83	w (%) =	30.39	23.94	e =	0.91	0.69	ρ _{wet} (kg/m ³) =	1898	2033	ρ _{dry} (kg/m ³) =	1456	1640	S (%) =	93	96	Remarks ASTM Method: <u> A - Constant Time Increment </u> Method for Cv : <u> Taylor </u> H _{avg} : <u> Half the specimen height </u> Time Increment: <u> 1440 min </u> Estimated Preconsolidation Stress: <u> 450 kPa </u>			Sample Properties G _s = <u> 2.78 </u> Calculated H _s (mm) = <u> 11.57 </u>			Atterberg Limits Liquid Limit: <u> 31 </u> Plastic Limit: <u> 20 </u> Plasticity Index: <u> 11 </u> Soil Classification: <u> CI </u>		
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Load #	Stress (kPa)	ΔH (mm)	Corrected d _f (mm)	ε Σ ΔH / H ₀ (%)	H-H _s (mm)	e (H-H _s)/H _s	Stress _{avg} (kPa)	e _{avg}	H _{avg} (mm)	t 90 (min)	C _v (cm ² /sec)	k (cm/sec)																																																		
1	5	0.09	22.02	0.37	10.45	0.90																																																								
2	12	0.70	21.34	3.43	9.77	0.84	8	0.87	10.84	0.42	3.9E-02	1.7E-05																																																		
3	24	0.21	21.16	4.23	9.59	0.83	18	0.84	10.63	0.57	2.8E-02	1.9E-06																																																		
4	48	0.21	21.07	4.65	9.50	0.82	36	0.82	10.56	0.43	3.6E-02	6.6E-07																																																		
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8	766	0.73	19.55	11.51	7.98	0.69	575	0.72	9.94	0.32	4.4E-02	3.6E-07																																																		
9	1532	0.94	18.79	14.96	7.22	0.62	1149	0.66	9.59	0.29	4.5E-02	2.3E-07																																																		
10	2000	0.42	18.46	16.48	6.89	0.60	1766	0.61	9.31	0.14	8.6E-02	3.3E-07																																																		
11	766	-0.38	18.61	15.78	7.04	0.61																																																								
12	192	-0.35	18.85	14.71	7.28	0.63																																																								
13	48	-0.26	19.07	13.72	7.49	0.65																																																								
14	12	-0.82	19.81	10.34	8.24	0.71																																																								
15	24	0.59	19.23	12.97	7.66	0.66	18	0.69	9.76	0.39	3.5E-02	8.5E-06																																																		
16	48	0.08	19.18	13.21	7.61	0.66	36	0.66	9.60	0.45	2.9E-02	3.2E-07																																																		
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Comments: <u> Void Ratio Vs. Stress computed for end of loading. Final height measured after unloading. </u> <u> </u> Description: <u> (CL) SILT, some clay, some fine sand </u> <u> </u> <u> </u>																																																														
TM/MM			May 2, 2014			MS			June 20, 2014																																																					
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One-Dimensional Consolidation Properties of Soils				Reference(s) ASTM D 2435/D 2435M-11	
Project No. :	13-1447-0477 Phase: 4000	Client :	Ministry of Transportation and Infrastructure	Borehole:	BH13-02
Sch No.	157	Project :	George Massey Tunnel Replacement Project	Sample:	TP35
Lab Work:	TM/MM	Location:	Richmond and Delta, BC	Depth (m) :	77.72 - 78.33



TM/MM	May 8, 2014	MS	June 20, 2014
TESTED BY	DATE	CHECKED BY	DATE



One-Dimensional Consolidation Properties of Soils										Reference(s)																																								
										ASTM D 2435/D 2435M-11																																								
Project No. :	13-1447-0477 Phase: 4000			Client :	Ministry of Transportation and Infrastructure			Borehole:	BH13-02																																									
Sch No. :	157			Project :	George Massey Tunnel Replacement Project			Sample:	TP35																																									
Lab Work:	TM/MM			Location:	Richmond and Delta, BC			Depth (m) :	77.72 - 78.33																																									
<p>Equipment</p> <p>Machine: <u>Sigma-1</u> Mach No. <u>Station 5</u> Ring No. <u>G</u> Drainage: <u>Double-sided</u></p> <p>Specimen Geometry</p> <table border="1"> <tr> <td></td> <td>Initial</td> <td>Final</td> </tr> <tr> <td>Height (mm) =</td> <td>22.30</td> <td>20.60</td> </tr> <tr> <td>Diameter (mm) =</td> <td>63.41</td> <td>63.41</td> </tr> <tr> <td>Area (cm²) =</td> <td>31.58</td> <td>31.58</td> </tr> <tr> <td>Volume (cm³) =</td> <td>70.42</td> <td>65.05</td> </tr> </table> <p>Phase Relationships</p> <table border="1"> <tr> <td></td> <td>Initial</td> <td>Final</td> </tr> <tr> <td>Wet Wt (g) =</td> <td>134.58</td> <td>130.43</td> </tr> <tr> <td>Dry Wt (g) =</td> <td>103.12</td> <td>103.12</td> </tr> <tr> <td>w (%) =</td> <td>30.51</td> <td>26.48</td> </tr> <tr> <td>e =</td> <td>0.90</td> <td>0.75</td> </tr> <tr> <td>ρ_{wet} (kg/m³) =</td> <td>1911</td> <td>2005</td> </tr> <tr> <td>ρ_{dry} (kg/m³) =</td> <td>1464</td> <td>1585</td> </tr> <tr> <td>S (%) =</td> <td>94</td> <td>98</td> </tr> </table> <p>Remarks</p> <p>ASTM Method: <u>A - Constant Time Increment</u> Method for Cv : <u>Taylor</u> H_{avg} : <u>Half the specimen height</u> Time Increment: <u>1440 min</u></p> <p>Estimated Preconsolidation Stress: <u>600 kPa</u></p> <p>Sample Properties</p> <p>G_s = <u>2.78</u> Assumed H_s (mm) = <u>11.75</u></p> <p>Atterberg Limits</p> <p>Liquid Limit: <u>37</u> Plastic Limit: <u>20</u> Plasticity Index: <u>17</u> Soil Classification: <u>CI</u></p>													Initial	Final	Height (mm) =	22.30	20.60	Diameter (mm) =	63.41	63.41	Area (cm ²) =	31.58	31.58	Volume (cm ³) =	70.42	65.05		Initial	Final	Wet Wt (g) =	134.58	130.43	Dry Wt (g) =	103.12	103.12	w (%) =	30.51	26.48	e =	0.90	0.75	ρ _{wet} (kg/m ³) =	1911	2005	ρ _{dry} (kg/m ³) =	1464	1585	S (%) =	94	98
	Initial	Final																																																
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	Initial	Final																																																
Wet Wt (g) =	134.58	130.43																																																
Dry Wt (g) =	103.12	103.12																																																
w (%) =	30.51	26.48																																																
e =	0.90	0.75																																																
ρ _{wet} (kg/m ³) =	1911	2005																																																
ρ _{dry} (kg/m ³) =	1464	1585																																																
S (%) =	94	98																																																
Load #	Stress (kPa)	ΔH (mm)	Corrected d _r (mm)	ε Σ ΔH / H ₀ (%)	H-H _s (mm)	e (H-H _s)/H _s	Stress _{avg} (kPa)	e _{avg}	H _{avg} (mm)	t 90 (min)	C _v (cm ² /sec)	k (cm/sec)																																						
1	5	-0.01	22.31	-0.05	10.57	0.90																																												
2	12	0.07	22.35	-0.24	10.61	0.90																																												
3	24	0.13	22.27	0.12	10.53	0.90	18	0.90	11.16	0.29	6.0E-02	1.8E-06																																						
4	48	0.18	22.14	0.70	10.40	0.89	36	0.89	11.10	0.32	5.4E-02	1.3E-06																																						
5	96	0.19	22.00	1.34	10.26	0.87	72	0.88	11.04	0.34	5.0E-02	6.6E-07																																						
6	192	0.25	21.82	2.16	10.07	0.86	144	0.87	10.96	0.14	1.2E-01	1.0E-06																																						
7	383	0.33	21.57	3.26	9.83	0.84	287	0.85	10.85	0.15	1.1E-01	6.6E-07																																						
8	766	0.52	21.17	5.08	9.42	0.80	575	0.82	10.69	0.14	1.1E-01	5.5E-07																																						
9	1532	0.89	20.49	8.14	8.74	0.74	1149	0.77	10.41	0.16	9.8E-02	4.1E-07																																						
10	2000	0.42	20.16	9.60	8.41	0.72	1766	0.73	10.16	0.14	1.0E-01	3.5E-07																																						
11	766	-0.38	20.29	9.04	8.54	0.73																																												
12	192	-0.36	20.48	8.17	8.73	0.74																																												
13	48	-0.30	20.69	7.22	8.94	0.76																																												
14	12	-0.34	20.97	5.95	9.23	0.79																																												
15	24	0.10	20.89	6.33	9.14	0.78	18	0.78	10.47	0.29	5.3E-02	1.7E-06																																						
16	48	0.09	20.83	6.59	9.08	0.77	36	0.78	10.43	0.18	8.6E-02	1.0E-06																																						
17	96	0.11	20.76	6.89	9.02	0.77	72	0.77	10.40	0.18	8.6E-02	5.6E-07																																						
18	192	0.15	20.66	7.34	8.92	0.76	144	0.76	10.36	0.15	1.0E-01	5.1E-07																																						
19	383	0.21	20.51	8.03	8.76	0.75	287	0.75	10.29	0.14	1.1E-01	4.0E-07																																						
20	766	0.26	20.35	8.74	8.60	0.73	575	0.74	10.22	0.13	1.1E-01	2.2E-07																																						
21	1532	0.40	20.14	9.70	8.39	0.71	1149	0.72	10.12	0.14	1.1E-01	1.4E-07																																						
22	2000	0.26	19.97	10.47	8.22	0.70	1766	0.71	10.03	0.14	1.0E-01	1.9E-07																																						
23	766	-0.37	20.09	9.93	8.34	0.71																																												
24	383	-0.20	20.19	9.47	8.44	0.72																																												
25	192	-0.17	20.28	9.04	8.54	0.73																																												
26	24	-0.43	20.60	7.61	8.86	0.75																																												
<p>Comments: <u>Void Ratio Vs. Stress computed for end of loading.</u></p> <p>Description: <u>(CL) SILT, some clay, trace fine sand.</u></p>																																																		
TM/MM			May 8, 2014			MS			June 20, 2014																																									
TESTED BY			DATE			CHECKED BY			DATE																																									