APPENDIX D

ROCK LABORATORY TESTING

TABLE 1
SUMMARY OF ROCK POINT LOAD TESTING

Borehole Number	Approximate Sample Depth (m)	Test Type (D or A)[1]	Core Diameter (mm)	Force at Failure (kN)	Estimated UCS (MPa)	Rock Strength Designation (R value)
B-2010-660	4.6	D	47	16.87	170	R5
B-2010-2750	5.5	D	47	25.76	260	R6
B-2010-4210	15.9	D	47	19.11	193	R5
B-2010-4802	5.2	D	47	34.04	344	R6
B-2010-5288	4.6	D	47	25.42	257	R6
B-2010-7190	12.5	D	47	21.59	218	R5
B-2010-8342	6.4	D	47	23.48	237	R5

Notes:
1. D = Diametral, A = Axial.

TABLE 2
SUMMARY OF LABORATORY TEST RESULTS FOR POTENTIAL BEDROCK SITES

Sample Location	Boreholes or Surface Samples	Rock Type	ASTM C 142	ASTM C 535	ASTM C 88	ASTM D 5312	ASTM C 127		ASTM C 295	Comments
			Clay Lumps and Friable Particles (%)	L.A. Abrasion (1000 revs), % Loss	Soundness, Sodium Sulfate, Weighted Loss %	Freeze-Thaw, % Loss	Relative Density & Adsorption of Coarse Aggregate		Petrographic Number (PN)	
							Relative Density (Dry Basis)	Adsorption (%)		
Acceptance Requirements			0.5% Max (1)	25% for traprock (1)	5.0 % Max (1)	5.0% Max (2)	2.6 (1)	1.0% Max (1)	125 Max (3)	---
MS 13+000	M-2010-0380 M-2010-0400 RS-007-E126-01	Gneiss	0.0	25.9	0.1, 0.1, 4.5	0.0	2.64	0.6	111	L.A. Abrasion test result slightly exceeds AREMA acceptance requirements
MS 24+400	M-2010-0710 M-2010-0730	Plutonic rock types, Gneiss	---	---	0.1	---	---	---	107	Parameters tested to date meet AREMA acceptance requirements
MS 26+000	Surface Sample Only RS-006-E101-1	Gabbro	0.0	12.9	0.1	0.2	2.99	0.6	106	Parameters tested to date meet AREMA acceptance requirements
MS 39+400	M-2010-1130 M-2010-1150	Gneiss	---	---	0.1	---	---	---	110	Parameters tested to date meet AREMA acceptance requirements
MS 41+800	M-2010-1210 M-2010-1230 RS-E11-E066-01	Granite, Gneiss	0.0	26.2	0.1	0.0	2.60	0.5	120, 135	L.A. Abrasion test result slightly exceeds AREMA acceptance requirements. In addition, the petrographic number exceeds 125 on one test.
MS 43+100	M-2010-1270 M-2010-1280	Granitic Gneiss	---	---	0.5	---	---	---	176	The petrographic number exceeds 125. Composite surface sample may not be representative of deeper rock.
MS 43+800	M-2010-1300 M-2010-1320 RS-E11-E066-01		---	---		---	---	---		
MS 44+400	M-2010-1340 M-2010-1360		---	---		---	---	---		
MS 82+000	M-2010-2450 R-2010-2460 M-2010-2470	Granitic Gneiss	---	18.5, 37.2	0.1, 0.2	0.1	---	---	109, 151	L.A. Abrasion test result for one sample exceeds AREMA acceptance requirements. In addition, the petrographic number for one test exceeds 125.
MS 85+800	M-2010-2590 M-2010-2600 M-2010-2610	Granitic Gneiss	---	23.5	0.2	0.1	---	---	105	Parameters tested to date meet AREMA acceptance requirements
MS 86+800	M-2010-2630 M-2010-2650	Granitic Gneiss	---	24.7, 26.3	---	0.1	---	---	110, 159	L.A. Abrasion test result for one sample slightly exceeds AREMA acceptance requirements. In addition, the petrographic number exceeds 125 on one of two tests.
MS 279+400	M-2010-7580 M-2010-7590 M-2010-7600 RS-003-N249-01	Diorite	0.0	13.1	0.9	0.0	2.95	0.3	100	Parameters tested to date meet AREMA acceptance requirements

Notes:
--- Not tested
(1) AREMA Manual for Railway Engineering (Table 1-2-1)
(2) Corps of Engineers
(3) CSA A23.2-15A, railroad ballast

MS 13+000

PETROGRAPHIC EXAMINATION OF COARSE AGGREGATE

CSA A23.2-15A / ASTM C 295

August 16, 2010

Project number: 093-81042-00011

GOLDER ASSOCIATES INC
4438 Haines Road,
Duluth, MN
USA 55811

ATTENTION: Amy Thorson

Sample	G-10-121 (M-2010-0380/0400-BULK)

Date Received: June 21, 2010 **Sampled by:** Client

	PETROGRAPHIC DESCRIPTION/ PHYSICAL QUALITY	PERCENT BY MASS	MULTI-PLIER	PN CONTR.
GOOD	**Granite 1** - red/pink, quartz, feldspar, biotite. Fine-medium grained, euhedral to subhedral crystals, dense, strong.	12.7	1	**12.7**
GOOD	**Granite 2** – pale pink-grey/white/black, quartz, feldspar, biotite. Fine-medium grained, euhedral to subhedral crystals, dense, strong.	58.8	1	**58.8**
GOOD	**Gneiss** – granitic composition, banded-zoned, medium to coarse grained, pink/grey/black.	23.1	1	**23.1**
GOOD	***Subtotal***	**94.6**		**94.6**
FAIR	**Granite 1** – as above, weathered, medium strength	0.7	3	**2.1**
FAIR	**Granite 2** – as above, weathered, medium strength	1.8	3	**5.4**
FAIR	**Granite 3** – as above, weathered, medium strength	1.1	3	**3.3**
FAIR	**Gneiss** – as above, weathered, medium strength.	1.8	3	**5.4**
FAIR	***Subtotal***	**5.4**		**16.2**
	TOTALS	**100.0**	**PN**	**110.8**

Note: 1. The PN is not related to potential for Alkali-Aggregate Reaction. AAR must be assessed separately.

PETROGRAPHER: _____
For F. Shrimer, P. Geo.

G-10-121(M-2010-0380/0400-BULK)

General

The sample consisted of crushed stone. The material was split, quartered and washed to remove surficial dust, in preparation for the examination.

The particle geometry was primarily cubical with some flat particles, and had an angular to subangular shape. The particle surface textures were generally moderately rough.

Lithologic Composition

Identification of rock types and minerals was done using a stereomicroscope with magnifications from 8x to about 60x, supplemented by basic geologic diagnostic methods. Thin sections were prepared from selected samples and examined, but no chemical analyses were undertaken to assist in the identification of the rock types.

The sample consisted of granite and gneiss. The granite was subdivided into two subtypes, the first being a red to bright orange-pink granite of fine to medium grain size, while the second was similar but contained more quartz and was lighter in colour and was typically pink and grey with black.

The crystals forming the rock were euhedral to subhedral in thin-section, and consisted of feldspar, quartz and biotite mica, with minor amounts of other minerals. The two varieties of granite comprised about 75% of the sample.

The gneiss was granitic in composition. The gneiss was medium- to coarse-grained in texture, and was commonly banded, with concentrations of quartz-feldspar and biotite alternating with each other. Gneiss accounted for some 25% of the sample. Most of this rock type was of good strength.

Engineering Characteristics

In addition to the geologic classification of the aggregate, the sample was also examined for characteristics relevant to engineering uses. Aspects such as porosity, strength, tenacity, presence or absence of vugs, voids, fissures, cracks, coatings and impurities in the particles were considered in the assignment of individual particles into various quality classifications.

Most of the particles examined were found to be of good engineering quality, being dense, strong and unweathered.

On the basis of this sorting of the sample, the relative amounts of "Good" and "Fair" quality material were determined. This enabled the determination of a Petrographic Number (or "PN"), in accordance with the method given in CSA A23.2-15A. The PN is an index of a coarse aggregate's overall physical-mechanical quality. The PN for this sample was "111".

For reference, the PN scale referenced in CSA A23.2-15A, Attachment A2, is as follows:

PN LIMITS	PRODUCT TYPE
125	Concrete Class C1, C2, F1
140 max	Other concrete classes

PN LIMITS	PRODUCT TYPE
125	Shotcrete
125	Railroad ballast
150	Granular base
160	Select Granular sub-base

The G-10-121 crushed stone sample would be considered to be of suitable quality for all uses noted above, including for use as railroad ballast, as well as other applications, including concrete, asphalt and road base materials, subject to compliance with applicable specification requirements.

The aggregate would be anticipated to provide durability and strength commensurate with these ratings, when used as construction-grade aggregate.

Alkali-Aggregate Reaction (AAR) Potential

Some of the rock material comprising the sample could have a potential to be alkali-aggregate reactive in concrete. Should the material be considered for use as Portland cement concrete aggregate, it is recommended that its potential for AAR be evaluated using the procedures given in CSA as A23.2-14A (or ASTM as C 1293) ("Concrete Prism") and A23.2-25A (ASTM C 1260) ("Accelerated Mortar Bar").

Summary

The G-10-121 crushed stone sample consisted of granite and gneiss and had a PN of 111.

On the basis of the Petrographic Examination, the aggregate is judged suitable for use in a variety of applications, subject to satisfactory compliance with applicable specifications.

Reviewed by:

FOR F. Shrimer, P. Geo.

A. Briggs, M. Sc., GIT

MS 13+000

RELATIVE DENSITY AND ABSORPTION OF COARSE AGGREGATE (ASTM C127)

Job Number: 093-81042-011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-007-E126-01

Date Received: February, 2010
Date Tested: February 26, 2010

Sampled by: N/A
Golder Lab No.: G-10-041

Sieve Fraction (mm)	Relative Density (dry basis)	Relative Density (SSD basis)	Apparent Relative Density	Absorption (%)
50.0 – 19.0	2.64	2.66	2.69	0.6

Remarks: 1. The minimum allowable bulk specific gravity of 2.60 is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.
2. The maximum allowable absorption of 1.0% is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: March 29, 2010

MS 13+000

CLAY LUMPS AND FRIABLE PARTICLES (ASTM C142)

Job Number: 093-81042-011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-007-E126-01

Date Received: February, 2010
Date Tested: February 26, 2010

Sampled by: N/A
Golder Lab No.: G-10-041

Sieve Fraction (mm)	Mass of Sample (g)	Clay Lumps (%)	Acceptance Requirement [1]
50.0 – 19.0	4997.1	0.0	0.5 Max.

Remarks: 1.The acceptance requirement is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: March 29, 2010

MS 13+000

RESISTANCE TO DEGRADATION OF LARGE-SIZE AGGREGATE BY ABRASION AND IMPACT IN LOS ANGELES MACHINE (ASTM C535)

Job Number: 093-81042-011

Golder Associates Inc.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	**RS-007-E126-01**

Date Received: February, 2010
Date Tested: March 18, 2010

Sampled by: N/A
Golder Lab Number: G-10-041

Grading	3
Sieve Sizes	37.5mm – 19.0mm
Mass – Before test (g)	10003.5
Number of revolutions	1000
Number of spheres (g)	12
Mass of spheres (g)	4996.9
Mass after 1000 revolutions (g)	7412.8
Loss after 1000 revolutions (%)	**25.9**

Remarks: **1.** The maximum allowable loss of 35% for granite is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: March 29, 2010

MS 13+000

CLAY LUMPS AND FRIABLE PARTICLES (ASTM C142)

Job Number: 093-81042-011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-007-E126-01

Date Received: February, 2010
Date Tested: February 26, 2010

Sampled by: N/A
Golder Lab No.: G-10-041

Sieve Fraction (mm)	Mass of Sample (g)	Clay Lumps (%)	Acceptance Requirement [1]
50.0 – 19.0	4997.1	0.0	0.5 Max.

Remarks: 1.The acceptance requirement is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: March 29, 2010

RESISTANCE TO DEGRADATION OF LARGE-SIZE AGGREGATE BY ABRASION AND IMPACT IN LOS ANGELES MACHINE (ASTM C535)

Job Number: 093-81042-011

Golder Associates Inc.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	**RS-007-E126-01**

Date Received: February, 2010
Date Tested: March 18, 2010

Sampled by: N/A
Golder Lab Number: G-10-041

Grading	3
Sieve Sizes	37.5mm – 19.0mm
Mass – Before test (g)	10003.5
Number of revolutions	1000
Number of spheres (g)	12
Mass of spheres (g)	4996.9
Mass after 1000 revolutions (g)	7412.8
Loss after 1000 revolutions (%)	**25.9**

Remarks: **1.** The maximum allowable loss of 35% for granite is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: March 29, 2010

MS 13+000

SOUNDNESS OF COARSE AGGREGATE USE OF SODIUM SULFATE (ASTM C88)

Job Number: 093-81042-011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-007-E126-01

Date Received: February, 2010
Date Tested: March 22 – March 29, 2010

Sampled by: N/A
Golder Lab No.: G-10-041

Sieve Fraction (mm)	Original Grading	Mass per fraction before test (g)	Loss (%)	Weighted Loss (%)	Acceptance Requirement [1]
50.0 – 37.5	0.054	2004.4	0.2	0.0	5.0 Max.
37.5 – 25.0	0.620	1008.5	0.1	0.1	
25.0 – 19.0	0.326	509.9	0.1	0.0	
	1.000		**TOTAL**	**0.1**	

Remarks: 1.The acceptance requirement is taken from Table 1-2-1of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: April 19, 2010

MS 13+000

EVALUATION OF DURABILITY OF ROCK FOR EROSION CONTROL UNDER FREEZING AND THAWING CONDITIONS (ASTM C5312)

Job Number: 093-81042-00011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-007-E126-01

Date Received: February, 2010
Date Started: March 01, 2010 for 30 cycles

Sampled by: N/A
Golder Lab No.: G-10-041

Sample No.	Mass of rock before test (g)	Mass of rock after test (g)	Loss (%)
41A	1775.5	1774.8	0.0
41B	1483.5	1483.2	0.0
41C	1688.1	1687.8	0.0
41D	1160.8	1160.1	0.1
41E	1906.2	1905.9	0.0

Remarks:

Reviewed by: _____ Date: May 27, 2010
John A. Watkins, Laboratory Services Manager

SOUNDNESS OF COARSE AGGREGATE USE OF SODIUM SULFATE (ASTM C88)

Job Number: 093-81042-011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	M2010-380-400-Bulk (Bucket Number 150-151)

Date Received: May, 2010
Date Tested: July 15 – July 22, 2010

Sampled by: N/A
Golder Lab No.: G-10-121

Sieve Fraction (mm)	Original Grading	Mass per fraction before test (g)	Loss (%)	Weighted Loss (%)	Acceptance Requirement [1]
50.0 – 37.5	0.054	2005.2	7.8	0.4	5.0 Max.
37.5 – 25.0	0.620	1003.9	17.0	10.5	
25.0 – 19.0	0.326	510.8	8.3	2.7	
	1.000		**TOTAL**	**4.5**	

Remarks: 1.The acceptance requirement is taken from Table 1-2-1of the AREMA Manual for Railway Engineering.

Reviewed by: _____
Jeremy Rose, Laboratory Manager

Date: July 27, 2010

PETROGRAPHIC EXAMINATION OF COARSE AGGREGATE

CSA A23.2-15A / ASTM C 295

August 19, 2010 Project number: 093-81042-00011

GOLDER ASSOCIATES INC
4438 Haines Road,
Duluth, MN
USA 55811

ATTENTION: Amy Thorson

Sample	G-10-120 (M-2010-0710/0730-BULK)

Date Received: June 21, 2010 **Sampled by:** Client

	PETROGRAPHIC DESCRIPTION/ PHYSICAL QUALITY	PERCENT BY MASS	MULTI-PLIER	PN CONTR.
GOOD	**Gabbro/Diorite/Amphibolite** – fine-grained, dark grey to black; commonly with zones of epidote, occasional quartz veins, dense, strong.	25.5	1	**25.5**
GOOD	**Quartz diorite - granite** – slightly to moderately gneissic, medium-grained, medium grey, dense, strong.	31.3	1	**31.3**
GOOD	**Gneiss 1** – light grey, medium grained, quartz-feldspar-biotite; quartz-rich bands, dense, strong.	18.8	1	**18.8**
GOOD	**Gneiss 2** – granitic composition, banded-zoned, medium to coarse grained, dense and strong, pink/grey/black.	21.0	1	**21.0**
GOOD	***Subtotal***	**96.6**		**96.6**
FAIR	**Gabbro/Amphibolite** – as above, weathered, medium strength	0.3	3	**0.9**
FAIR	**Diorite-Granite** – as above, weathered, medium strength	0.3	3	**0.9**
FAIR	**Gneiss 1** – as above, weathered, medium strength	1.1	3	**3.3**
FAIR	**Gneiss 2** – as above, weathered, medium strength.	1.7	3	**5.4**
FAIR	***Subtotal***	**3.4**		**10.2**
	TOTALS	**100.0**	**PN**	**106.8**

Note: 1. The PN is not related to potential for Alkali-Aggregate Reaction. AAR must be assessed separately.

PETROGRAPHER: _____
FOR F. Shrimer, P. Geo.

G-10-120

General

The sample consisted of crushed stone. The material was split, quartered and washed to remove surficial dust, in preparation for the examination.

The particle geometry was primarily cubical with some flat particles, and had an angular to subangular shape. The particle surface textures were generally moderately rough.

Lithologic Composition

Identification of rock types and minerals was done using a stereomicroscope with magnifications from 8x to about 60x, supplemented by basic geologic diagnostic methods. Thin sections were prepared from selected samples and examined, but no chemical analyses were undertaken to assist in the identification of the rock types.

The sample consisted of four distinct rock types – a dark-coloured gabbro/amphibolite, a quartz diorite-granite, and two types of gneiss.

The gabbro/amphibolite varied somewhat in terms of mineralogy, but was characteristically fine-grained and near black or black. Amphiboles and feldspar, along with some biotite, dominated the mineralogy of this rock, but bands of quartz and/or epidote were fairly common. Iron oxide alteration of the mafic minerals was observed in thin-section. Gabbro/amphibolites represented some 26% of the sample.

Quartz diorite and granite were typically medium-grained, medium grey rocks, with minor alteration, and generally dense and strong. These rocks accounted for just under 32% of the sample.

The two varieties of gneiss were distinguished on the basis of colour, texture and structure of the rocks. The Gneiss 1 rocks were more homogeneous in terms of distributions of minerals, while the Gneiss 2 types tended to exhibit concentrated zones of minerals, imparting a banded appearance. In total, gneiss accounted for 42% of the sample.

Slightly to moderately weathered/altered varieties of these rocks were of somewhat lower physical quality and strength and were separately classified, as described below.

Engineering Characteristics

In addition to the geologic classification of the aggregate, the sample was also examined for characteristics relevant to engineering uses. Aspects such as porosity, strength, tenacity, presence or absence of vugs, voids, fissures, cracks, coatings and impurities in the particles were considered in the assignment of individual particles into various quality classifications.

Most of the particles examined were found to be of good engineering quality, being dense, strong and unweathered.

On the basis of this sorting of the sample, the relative amounts of "Good" and "Fair" quality material were determined. This enabled the determination of a Petrographic Number (or "PN"), in accordance with the method given in CSA A23.2-15A. The PN is an index of a coarse aggregate's overall physical-mechanical quality. The PN for this sample was "107".

For reference, the PN scale referenced in CSA A23.2-15A, Attachment A2, is as follows:

PN LIMITS	PRODUCT TYPE
125	Concrete Class C1, C2, F1
140 max	Other concrete classes
125	Shotcrete
125	Railroad ballast
150	Granular base
160	Select Granular sub-base

The G-10-120 crushed stone sample would be considered to be of suitable quality for all uses noted above, including for use as railroad ballast, as well as other applications, including concrete, asphalt and road base materials, subject to compliance with applicable specification requirements.

The aggregate would be anticipated to provide durability and strength commensurate with these ratings, when used as construction-grade aggregate.

Alkali-Aggregate Reaction (AAR) Potential

Some of the rock material comprising the sample could have a potential to be alkali-aggregate reactive in concrete. Should the material be considered for use as Portland cement concrete aggregate, it is recommended that its potential for AAR be evaluated using the procedures given in CSA as A23.2-14A (or ASTM as C 1293) ("Concrete Prism") and A23.2-25A (ASTM C 1260) ("Accelerated Mortar Bar").

Summary

The G-10-120 crushed stone sample consisted of plutonic rock types and gneiss and had a PN of 107.

On the basis of the Petrographic Examination, the aggregate is judged suitable for use in a variety of applications, subject to satisfactory compliance with applicable specifications.

FOR _____
F. Shrimer, P. Geo.

Reviewed by:

_____
A. Briggs, M. Sc., GIT

SOUNDNESS OF COARSE AGGREGATE USE OF SODIUM SULFATE (ASTM C88)

Job Number: 093-81042-011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	M2010-710/730-Bulk (Bucket Number 146-148)

Date Received: May, 2010
Date Tested: June 21 – June 30, 2010

Sampled by: N/A
Golder Lab No.: G-10-120

Sieve Fraction (mm)	Original Grading	Mass per fraction before test (g)	Loss (%)	Weighted Loss (%)	Acceptance Requirement [1]
50.0 – 37.5	0.054	2000.0	0.11	0.0	5.0 Max.
37.5 – 25.0	0.620	1014.0	0.11	0.1	
25.0 – 19.0	0.326	505.5	0.08	0.0	
	1.000		**TOTAL**	**0.1**	

Remarks: 1.The acceptance requirement is taken from Table 1-2-1of the AREMA Manual for Railway Engineering.

Reviewed by: _____ Date: July 15, 2010
John A. Watkins, Laboratory Services Manager

PETROGRAPHIC EXAMINATION OF COARSE AGGREGATE

CSA A23.2-15A / ASTM C 295

July 23, 2010
Project number: 093-81042-00011

GOLDER ASSOCIATES INC
4438 Haines Road,
Duluth, MN
USA 55811

ATTENTION: Amy Thorson. P.E.

PROJECT: Aggregate Testing – Canada Chrome

Sample	**G-10-040 (RS-006-E101-1)**

Date Received: June 21, 2010 **Sampled by:** Client

	PETROGRAPHIC DESCRIPTION/ PHYSICAL QUALITY	PERCENT BY MASS	MULTI-PLIER	PN CONTRIBUTION
GOOD	**Gabbro –** Plagioclase, calcic clinopyroxene with amphibole rims, magnetite, minor quartz. Medium grained. Fresh, with minor oxidation.	75.2	1	**75.2**
GOOD	**Gabbro** – as above, with two or more surfaces showing weathering and/or oxidation.	21.9	1	**21.9**
GOOD	***Subtotal***	**97.1**		**97.1**
FAIR	**Gabbro** – medium strength, significant oxidation	2.9	3	**8.7**
FAIR	***Subtotal***	**2.9**		**8.7**
	TOTALS	**100.0**	**PN**	**105.8**

Note: 1. The PN is not related to potential for Alkali-Aggregate Reaction. AAR must be assessed separately.

PETROGRAPHER: _____
A. Briggs, M.Sc., GIT

Notice: The data given in this report pertain to the sample provided, and may not be applicable to samples from earlier or subsequent production. This report comprises a testing service only. Interpretation may be provided upon written request.

G-10-040 (RS-006-E101-1)

General

The sample consisted of crushed quarried stone. The material was split, quartered and washed to remove a light coating of surficial dust, in preparation for the examination.

The particle geometry was primarily cubical with an angular to subangular shape. The particle surface textures ranged from moderately smooth to moderately rough.

Lithologic Composition

Identification of rock types and minerals was done using a stereomicroscope with magnifications from 8x to about 60x, supplemented by basic geologic diagnostic methods. Thin sections were examined but no chemical analyses were undertaken to aid in the identification of the rock types.

The sample was composed entirely of gabbro, which commonly exhibited oxidation on the particle surfaces. In most cases, such oxidation was of minor to moderate thickness, and in only a small proportion of the sample was the extent of oxidation such that it affected the strength of the particles. Most of the gabbro was dense and strong.

The gabbro had a grain size of 0.4-2 mm and consisted of calcic clinopyroxene, plagioclase and magnetite/ilmenite. Some of the pyroxenes were altered to amphiboles and biotite and the plagioclase exhibited some sericite alteration, which did not have a detrimental effect on the strength of the rock material.

Engineering Characteristics

In addition to the geologic classification of the aggregate, the sample was also examined for characteristics relevant to engineering uses. Aspects such as porosity, strength, tenacity, presence or absence of vugs, voids, fissures, cracks, coatings and impurities in the particles were considered in the assignment of individual particles into various quality classifications.

Most of the particles examined were found to be of good engineering quality, being dense, strong and unweathered.

On the basis of this sorting of the sample, the relative amounts of "Good", and "Fair" quality material were determined. This enabled the determination of a Petrographic Number (or "PN"), in accordance with the method given in CSA A23.2-15A. The PN is an index of a coarse aggregate's overall physical-mechanical quality. The PN for this sample was "106".

For reference, the PN scale referenced in CSA A23.2-15A, Attachment A2, is as follows:

PN LIMITS	PRODUCT TYPE
125	Concrete Class C1, C2, F1
140 max	Other concrete classes
125	Shotcrete

PN LIMITS	PRODUCT TYPE
125	Railroad ballast
150	Granular base
160	Select Granular sub-base

The G-10-040 crushed stone sample would thus be considered to be of suitable quality for all uses noted above, including as railroad ballast, and is judged to be of suitable physical-mechanical engineering quality for use in a variety of applications, including concrete, asphalt and road base materials, subject to compliance with applicable specification requirements. The aggregate would be anticipated to provide durability and strength commensurate with these ratings, when used as construction-grade aggregate.

Alkali-Aggregate Reaction Potential

The rock type that comprised this sample was classified as gabbro. This rock type contains no or very small amounts of quartz. Quartz is the primary mineral that reacts with the alkalis in the cement in the alkali-aggregate reaction and thereby causing expansion and cracking. The sample is not considered to be potentially reactive with respect to the alkali- aggregate reaction, since it contains no rock type with significant amounts of quartz.

Summary

The G-10-040 crushed stone sample consisted of gabbro, and had a PN of 106.

On the basis of the Petrographic Examination, the aggregate is judged suitable for use in a variety of applications, subject to satisfactory compliance with applicable specifications.

Reviewed by:

A. Briggs, M. Sc., GIT

F. Shrimer, P. Geo.

MS 26+000

RELATIVE DENSITY AND ABSORPTION OF COARSE AGGREGATE (ASTM C127)

Job Number: 093-81042-011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-006-E101-1

Date Received: February, 2010
Date Tested: February 26, 2010

Sampled by: N/A
Golder Lab No.: G-10-040

Sieve Fraction (mm)	Relative Density (dry basis)	Relative Density (SSD basis)	Apparent Relative Density	Absorption (%)
50.0 – 19.0	2.99	3.01	3.04	0.6

Remarks:
1. The minimum allowable bulk specific gravity of 2.60 is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.
2. The maximum allowable absorption of 1.0% is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: March 29, 2010

MS 26+000

CLAY LUMPS AND FRIABLE PARTICLES (ASTM C142)

Job Number: 093-81042-011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-006-E101-01

Date Received: February, 2010
Date Tested: February 26, 2010

Sampled by: N/A
Golder Lab No.: G-10-040

Sieve Fraction (mm)	Mass of Sample (g)	Clay Lumps (%)	Acceptance Requirement [1]
50.0 – 19.0	4995.5	0.0	0.5 Max.

Remarks: 1.The acceptance requirement is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: March 29, 2010

RESISTANCE TO DEGRADATION OF LARGE-SIZE AGGREGATE BY ABRASION AND IMPACT IN LOS ANGELES MACHINE (ASTM C535)

Job Number: 093-81042-011

Golder Associates Inc.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-006-E101-1

Date Received: February, 2010
Date Tested: March 18, 2010

Sampled by: N/A
Golder Lab Number: G-10-040

Grading	3
Sieve Sizes	37.5mm – 19.0mm
Mass – Before test (g)	10057.1
Number of revolutions	1000
Number of spheres (g)	12
Mass of spheres (g)	4996.9
Mass after 1000 revolutions (g)	8761.6
Loss after 1000 revolutions (%)	**12.9**

Remarks: **1.** The maximum allowable loss of 25% for traprock is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: March 29, 2010

MS 26+000

CLAY LUMPS AND FRIABLE PARTICLES (ASTM C142)

Job Number: 093-81042-011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-006-E101-01

Date Received: February, 2010
Date Tested: February 26, 2010

Sampled by: N/A
Golder Lab No.: G-10-040

Sieve Fraction (mm)	Mass of Sample (g)	Clay Lumps (%)	Acceptance Requirement [1]
50.0 – 19.0	4995.5	0.0	0.5 Max.

Remarks: 1.The acceptance requirement is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: March 29, 2010

RESISTANCE TO DEGRADATION OF LARGE-SIZE AGGREGATE BY ABRASION AND IMPACT IN LOS ANGELES MACHINE (ASTM C535)

Job Number: 093-81042-011

Golder Associates Inc.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-006-E101-1

Date Received: February, 2010
Date Tested: March 18, 2010

Sampled by: N/A
Golder Lab Number: G-10-040

Grading	3
Sieve Sizes	37.5mm – 19.0mm
Mass – Before test (g)	10057.1
Number of revolutions	1000
Number of spheres (g)	12
Mass of spheres (g)	4996.9
Mass after 1000 revolutions (g)	8761.6
Loss after 1000 revolutions (%)	**12.9**

Remarks: **1.** The maximum allowable loss of 25% for traprock is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: March 29, 2010

MS 26+000

SOUNDNESS OF COARSE AGGREGATE USE OF SODIUM SULFATE (ASTM C88)

Job Number: 093-81042-011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-006-E101-1

Date Received: February, 2010
Date Tested: March 22 – March 29, 2010

Sampled by: N/A
Golder Lab No.: G-10-040

Sieve Fraction (mm)	Original Grading	Mass per fraction before test (g)	Loss (%)	Weighted Loss (%)	Acceptance Requirement [1]
50.0 – 37.5	0.054	2047.8	0.2	0.0	5.0 Max.
37.5 – 25.0	0.620	1011.5	0.1	0.1	
25.0 – 19.0	0.326	517.2	0.2	0.0	
	1.000		**TOTAL**	**0.1**	

Remarks: 1.The acceptance requirement is taken from Table 1-2-1of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: April 19, 2010

MS 26+000

EVALUATION OF DURABILITY OF ROCK FOR EROSION CONTROL UNDER FREEZING AND THAWING CONDITIONS (ASTM C5312)

Job Number: 093-81042-00011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-006-E101-1

Date Received: February, 2010
Date Started: March 01, 2010 for 30 cycles

Sampled by: N/A
Golder Lab No.: G-10-040

Sample No.	Mass of rock before test (g)	Mass of rock after test (g)	Loss (%)
40A	1518.3	1517.5	0.1
40B	2380.7	2380.7	0.0
40C	2576.1	2576.1	0.0
40D	3127.4	3125.1	0.7
40E	3095.2	3095.1	0.0

Remarks:

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: May 27, 2010

PETROGRAPHIC EXAMINATION OF COARSE AGGREGATE

CSA A23.2-15A / ASTM C 295

August 16, 2010

Project number: 093-81042-00011

GOLDER ASSOCIATES INC
4438 Haines Road,
Duluth, MN
USA 55811

ATTENTION: Amy Thorson

Sample	G-10-119 (M-2010-1150-BULK 1/BULK/BULK 2)

Date Received: June 21, 2010 **Sampled by:** Client

	PETROGRAPHIC DESCRIPTION/ PHYSICAL QUALITY	PERCENT BY MASS	MULTI-PLIER	PN CONTR.
GOOD	**Gneiss 1** – granitic, quartz, feldspar, biotite. Pink/grey/black, dense, strong.	76.4	1	**76.4**
GOOD	**Gneiss 2** – granitic composition similar to above but more biotite, pale pink/grey/black.	18.8	1	**18.8**
GOOD	***Subtotal***	**95.2**		**95.2**
FAIR	**Gneiss 1** – as above, weathered, medium strength	4.2	3	**12.6**
FAIR	**Gneiss 2** – as above, weathered, medium strength.	0.6	3	**1.8**
FAIR	***Subtotal***	**4.8**		**14.4**
	TOTALS	**100.0**	**PN**	**109.6**

Note: 1. The PN is not related to potential for Alkali-Aggregate Reaction. AAR must be assessed separately.

PETROGRAPHER: _____
FOR F. Shrimer, P. Geo.

G-10-119 (M-2010-1150-BULK 1/BULK/BULK 2)

General

The sample consisted of crushed stone. The material was split, quartered and washed to remove a light coating of surficial dust, in preparation for the examination.

The particle geometry was primarily cubical with an angular to subangular shape. The particle surface textures ranged from rough to moderately rough.

Lithologic Composition

Identification of rock types and minerals was done using a stereomicroscope with magnifications from 8x to about 60x, supplemented by basic geologic diagnostic methods. Thin sections were examined but no chemical analyses were undertaken to aid in the identification of the rock types.

The sample consisted entirely of pink to grey/pink granitic gneiss. Most of this rock type was of good strength. Mineralogic composition ranged somewhat but was characteristically quartz-feldspar-biotite, in varying proportions. The rock had a well-defined gneissic texture, and crystals were euhedral to subhedral, and generally of medium granularity.

Engineering Characteristics

In addition to the geologic classification of the aggregate, the sample was also examined for characteristics relevant to engineering uses. Aspects such as porosity, strength, tenacity, presence or absence of vugs, voids, fissures, cracks, coatings and impurities in the particles were considered in the assignment of individual particles into various quality classifications.

Most of the particles examined were found to be of good engineering quality, being dense, strong and unweathered. Particles which exhibited some degree of weathering and were of lower strength were separately classified.

On the basis of this sorting of the sample, the relative amounts of "Good", and "Fair" quality material were determined. This enabled the determination of a Petrographic Number (or "PN"), in accordance with the method given in CSA A23.2-15A. The PN is an index of a coarse aggregate's overall physical-mechanical quality. The PN for this sample was "110".

For reference, the PN scale referenced in CSA A23.2-15A, Attachment A2, is as follows:

PN LIMITS	PRODUCT TYPE
125	Concrete Class C1, C2, F1
140 max	Other concrete classes
125	Shotcrete
125	Railroad ballast
150	Granular base
160	Select Granular sub-base

The G-10-119 crushed stone sample would be considered to be of suitable quality for all uses noted above, and is judged to be of suitable physical-mechanical engineering quality for use in a variety of applications, including as railroad ballast, concrete, asphalt and road base materials, subject to compliance with applicable specification requirements.

Alkali-Aggregate Reaction (AAR) Potential

Since the gneiss contains quartz that exhibits some degree of strain, the rock may have a potential to be alkali-aggregate reactive. Should the material be considered for use as Portland cement concrete aggregate, it is recommended that its potential for AAR be evaluated using the procedures given in CSA as A23.2-14A (or ASTM as C 1293) ("Concrete Prism") and A23.2-25A ("Accelerated Mortar Bar") (ASTM C 1260).

Summary

The G-10-119 crushed stone sample consisted of gneiss, and had a PN of 110.

On the basis of the Petrographic Examination, the aggregate is judged suitable for use in a variety of applications, subject to satisfactory compliance with applicable specifications.

Reviewed by:

FOR F. Shrimer, P. Geo.

A. Briggs, GIT

SOUNDNESS OF COARSE AGGREGATE USE OF SODIUM SULFATE (ASTM C88)

Job Number: 093-81042-011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	M2010-1150-Bulk (Bucket Number 139-140)

Date Received: May, 2010
Date Tested: June 21 – June 30, 2010

Sampled by: N/A
Golder Lab No.: G-10-119

Sieve Fraction (mm)	Original Grading	Mass per fraction before test (g)	Loss (%)	Weighted Loss (%)	Acceptance Requirement [1]
50.0 – 37.5	0.054	2016.7	0.13	0.0	5.0 Max.
37.5 – 25.0	0.620	1018.4	0.08	0.0	
25.0 – 19.0	0.326	506.0	0.18	0.1	
	1.000		**TOTAL**	**0.1**	

Remarks: 1.The acceptance requirement is taken from Table 1-2-1of the AREMA Manual for Railway Engineering.

Reviewed by: _____ Date: July 15, 2010
John A. Watkins, Laboratory Services Manager

PETROGRAPHIC EXAMINATION OF COARSE AGGREGATE

CSA A23.2-15A / ASTM C 295

July 22, 2010
Project number: 093-81042-00011

GOLDER ASSOCIATES INC
4438 Haines Road,
Duluth, MN
USA 55811

ATTENTION: Amy Thorson, P.E.

PROJECT: Aggregate Testing – Canada Chrome

Sample	**G-10-041 (RS-E11-E066-01)**

Date Received: June 21, 2010 **Sampled by:** Client

	PETROGRAPHIC DESCRIPTION/ PHYSICAL QUALITY	PERCENT BY MASS	MULTI-PLIER	PN CONTRIBUTION
GOOD	**Granite** - Quartz, potassium feldspar, biotite, muscovite. Pink, medium grained, some orange staining.	89.9	1	**89.9**
	Subtotal	**89.9**		**89.9**
FAIR	**Granite** – medium strength	10.1	3	**30.3**
	Subtotal	**10.1**		**30.3**
	TOTALS	**100.0**	**PN**	**120.2**

Note: 1. The PN is not related to potential for Alkali-Aggregate Reaction. AAR must be assessed separately.

PETROGRAPHER: _____
A. Briggs, M.Sc., GIT

G-10-041 (RS-E11-E066-01)

General

The sample consisted of crushed stone. The material was split, quartered and washed to remove a light coating of surficial dust, in preparation for the examination.

The particle geometry was primarily cubical with an angular to subangular shape. The particle surface textures ranged from moderately smooth to moderately rough.

Lithologic Composition

Identification of rock types and minerals was acheived using a stereomicroscope with magnifications from 8x to about 60x, supplemented by basic geologic diagnostic methods. Thin sections were examined but no chemical analyses were undertaken to aid in the identification of the rock types.

The sample consisted entirely of pink, medium grained granite. Most of this rock type was of good strength.

Engineering Characteristics

In addition to the geologic classification of the aggregate, the sample was also examined for characteristics relevant to engineering uses. Aspects such as porosity, strength, tenacity, presence or absence of vugs, voids, fissures, cracks, coatings and impurities in the particles were considered in the assignment of individual particles into various quality classifications.

Most of the particles examined were found to be of good engineering quality, being dense, strong and unweathered.

On the basis of this sorting of the sample, the relative amounts of "Good", and "Fair" quality material were determined. This enabled the determination of a Petrographic Number (or "PN"), in accordance with the method given in CSA A23.2-15A. The PN is an index of a coarse aggregate's overall physical-mechanical quality. The PN for this sample was "120".

For reference, the PN scale referenced in CSA A23.2-15A, Attachment A2, is as follows:

PN LIMITS	PRODUCT TYPE
125	Concrete Class C1, C2, F1
140 max	Other concrete classes
125	Shotcrete
125	Railroad ballast
150	Granular base
160	Select Granular sub-base

The G-10-041 crushed stone sample would be considered to be of suitable quality for all uses noted above, and is judged to be of suitable physical-mechanical engineering quality for use in a variety of applications, including rail road ballast, concrete, asphalt and road base materials, subject to compliance with applicable specification requirements. The aggregate would be anticipated to provide durability and strength commensurate with these ratings, when used as construction-grade aggregate.

Alkali-Aggregate Reaction (AAR) Potential

Due to its quartz content, the granite that constitutes the entire sample may have a potential to be alkali-aggregate reactive. Should the material be considered for use as concrete aggregate, periodic assessment of the aggregate's AAR characteristics is recommended utilizing the procedures given in CSA A23.2-14A (or ASTM as C 1293) ("Concrete Prism") and CSA A23.2-25A (ASTM C 1260) ("Accelerated Mortar Bar").

Summary

The G-10-041 crushed stone sample consisted of granite, and had a PN of 120.

On the basis of the Petrographic Examination, the aggregate is judged suitable for use for use in a variety of applications, including rail road ballast, subject to satisfactory compliance with applicable specifications.

Reviewed by:

A. Briggs, M. Sc., GIT

F. Shrimer, P. Geo.

PETROGRAPHIC EXAMINATION OF COARSE AGGREGATE

CSA A23.2-15A / ASTM C 295

July 22, 2010
Project number: 093-81042-00011

GOLDER ASSOCIATES INC
4438 Haines Road,
Duluth, MN
USA 55811

ATTENTION: Amy Thorson, P.E.

PROJECT: Aggregate Testing – Canada Chrome

Sample	**G-10-042 (RS-E11-E066-01)**

Date Received: June 21, 2010 **Sampled by:** Client

	PETROGRAPHIC DESCRIPTION/ PHYSICAL QUALITY	PERCENT BY MASS	MULTI-PLIER	PN CONTRIBUTION
GOOD	**Grey Granitic gneiss** – Quartz, feldspar, biotite, muscovite, minor epidote, trace fluorite/apatite. Fine to medium grained, white/light pink-black.	53.2	1	53.2
GOOD	**Pink Granitic gneiss** – Quartz, feldspar, some sericite-altered, biotite, muscovite, epidote, trace fluorite/apatite. Fine to medium grained, pink-black.	29.4	1	29.4
GOOD	***Subtotal***	**82.6**		**82.6**
FAIR	**Grey Granitic gneiss** – as above, but brittle	13.8	3	**41.1**
FAIR	**Pink Granitic gneiss** – as above, but medium strength	3.6	3	**10.8**
FAIR	***Subtotal***	**17.4**		**52.2**
	TOTALS	**100.0**	**PN**	**134.8**

Note: 1. The PN is not related to potential for Alkali-Aggregate Reaction. AAR must be assessed separately.

PETROGRAPHER: _____
A. Briggs, M.Sc., GIT

G-10-042 (RS-E11-E066-01)

General

The sample consisted of crushed stone.

The particle geometry was primarily cubical with an angular to subangular shape. The particle surface textures ranged from rough to moderately rough.

Lithologic Composition

Identification of rock types and minerals was achieved using a stereomicroscope with magnifications from 8x to about 60x, supplemented by basic geologic diagnostic methods. Thin sections were examined but no chemical analyses were undertaken to aid in the identification of the rock types.

The sample was composed entirely of gneiss, which was further divided into sub-categories based on the dominant colour. Varying degrees of alteration characterized the gneiss. While most of the sample was of good strength, a significant portion of the sample was brittle and of medium strength. The brittle nature of some of the grey gneiss particles was interpreted to be a result of poorer intergranular bonding. The lower strength of some of the pink gneiss is thought to be attributable to a higher degree of weathering in these particles.

Engineering Characteristics

In addition to the geologic classification of the aggregate, the sample was also examined for characteristics relevant to engineering uses. Aspects such as porosity, strength, tenacity, presence or absence of vugs, voids, fissures, cracks, coatings and impurities in the particles were considered in the assignment of individual particles into various quality classifications.

Most of the particles examined were found to be of good engineering quality, being dense, strong and unweathered.

On the basis of this sorting of the sample, the relative amounts of "Good", and "Fair" quality material were determined. This enabled the determination of a Petrographic Number (or "PN"), in accordance with the method given in CSA A23.2-15A. The PN is an index of a coarse aggregate's overall physical-mechanical quality. The PN for this sample was "135".

For reference, the PN scale referenced in CSA A23.2-15A, Attachment A2, is as follows:

PN LIMITS	PRODUCT TYPE
125	Concrete Class C1, C2, F1
140 max	Other concrete classes
125	Shotcrete
125	Railroad ballast
150	Granular base
160	Select Granular sub-base

The G-10-042 crushed stone sample, as tested, would be considered to be of suitable quality for only some of the uses noted above, such as road base materials, subject to compliance with applicable specification requirements. The aggregate would be anticipated to provide durability and strength commensurate with these ratings, when used as construction-grade aggregate.

It is understood that the sample is under consideration for use as railroad ballast. Comparison with the suggested PN limits given in CSA, per the table above, indicates that the sample exceeds the suggested limit of 125. Thereby, the material may provide 'marginal' performance with respect to durability due to slightly excessive "fair" quality rock, as identified in this sample.

However, should the sample represent "surficial" and thus "weathered" rock material, it may be that the material located at depth, below the weathered outer rock, could be of higher quality. If the sample that was obtained incorporated some of this presumed weathered rock, the current sample may provide an overly negative view of the rock quality at this site. In order to confirm this possibility, we recommend that follow-up sampling and evaluation be undertaken in which fresh material is obtained.

Alkali-Aggregate Reaction Potential

All of the rocks comprising this sample have been identified as "potentially alkali-reactive", meaning that they may contribute under certain circumstances to a deleterious expansive reaction in concrete termed *"Alkali-Aggregate Reaction"* (AAR).

Should the material be considered for use as concrete aggregate, periodic assessment of the aggregate's AAR characteristics is recommended utilizing the procedures given in CSA A23.2-14A (or ASTM as C 1293) ("Concrete Prism") and CSA A23.2-25A (ASTM C 1260) ("Accelerated Mortar Bar").

Summary

The G-10-042 crushed stone sample consisted of gneiss, and had a PN of 135.

On the basis of the Petrographic Examination, the aggregate is judged suitable for certain applications, subject to satisfactory compliance with applicable specifications. Further qualification or assessment, as discussed above, may be warranted in order to accept or reject the material for potential use as railroad ballast material.

Reviewed by:

A. Briggs, M. Sc., GIT

FOR F. Shrimer, P. Geo.

RELATIVE DENSITY AND ABSORPTION OF COARSE AGGREGATE (ASTM C127)

Job Number: 093-81042-011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-E11-E066-01

Date Received: February, 2010
Date Tested: February 26, 2010

Sampled by: N/A
Golder Lab No.: G-10-042

Sieve Fraction (mm)	Relative Density (dry basis)	Relative Density (SSD basis)	Apparent Relative Density	Absorption (%)
50.0 – 19.0	2.60	2.61	2.63	0.5

Remarks:
1. The minimum allowable bulk specific gravity of 2.60 is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.
2. The maximum allowable absorption of 1.0% is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: March 29, 2010

CLAY LUMPS AND FRIABLE PARTICLES (ASTM C142)

Job Number: 093-81042-011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-E11-E066-01

Date Received: February, 2010
Date Tested: February 26, 2010

Sampled by: N/A
Golder Lab No.: G-10-042

Sieve Fraction (mm)	Mass of Sample (g)	Clay Lumps (%)	Acceptance Requirement [1]
50.0 – 19.0	5000.8	0.0	0.5 Max.

Remarks: 1.The acceptance requirement is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: March 29, 2010

RESISTANCE TO DEGRADATION OF LARGE-SIZE AGGREGATE BY ABRASION AND IMPACT IN LOS ANGELES MACHINE (ASTM C535)

Job Number: 093-81042-011

Golder Associates Inc.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-E11-E066-01

Date Received: February, 2010
Date Tested: March 18, 2010

Sampled by: N/A
Golder Lab Number: G-10-042

Grading	3
Sieve Sizes	37.5mm – 19.0mm
Mass – Before test (g)	10031.9
Number of revolutions	1000
Number of spheres (g)	12
Mass of spheres (g)	4996.9
Mass after 1000 revolutions (g)	7401.5
Loss after 1000 revolutions (%)	**26.2**

Remarks: **1.** The maximum allowable loss of 35% for granite is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: March 29, 2010

CLAY LUMPS AND FRIABLE PARTICLES (ASTM C142)

Job Number: 093-81042-011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-E11-E066-01

Date Received: February, 2010
Date Tested: February 26, 2010

Sampled by: N/A
Golder Lab No.: G-10-042

Sieve Fraction (mm)	Mass of Sample (g)	Clay Lumps (%)	Acceptance Requirement [1]
50.0 – 19.0	5000.8	0.0	0.5 Max.

Remarks: 1.The acceptance requirement is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: March 29, 2010

RESISTANCE TO DEGRADATION OF LARGE-SIZE AGGREGATE BY ABRASION AND IMPACT IN LOS ANGELES MACHINE (ASTM C535)

Job Number: 093-81042-011

Golder Associates Inc.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-E11-E066-01

Date Received: February, 2010
Date Tested: March 18, 2010

Sampled by: N/A
Golder Lab Number: G-10-042

Grading	3
Sieve Sizes	37.5mm – 19.0mm
Mass – Before test (g)	10031.9
Number of revolutions	1000
Number of spheres (g)	12
Mass of spheres (g)	4996.9
Mass after 1000 revolutions (g)	7401.5
Loss after 1000 revolutions (%)	**26.2**

Remarks: **1.** The maximum allowable loss of 35% for granite is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: March 29, 2010

SOUNDNESS OF COARSE AGGREGATE USE OF SODIUM SULFATE (ASTM C88)

Job Number: 093-81042-011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-007-E126-01

Date Received: February, 2010
Date Tested: April 05 – April 12, 2010

Sampled by: N/A
Golder Lab No.: G-10-042

Sieve Fraction (mm)	Original Grading	Mass per fraction before test (g)	Loss (%)	Weighted Loss (%)	Acceptance Requirement [1]
50.0 – 37.5	0.054	2017.6	0.1	0.0	5.0 Max.
37.5 – 25.0	0.620	1013.9	0.1	0.1	
25.0 – 19.0	0.326	501.2	0.3	0.0	
	1.000		**TOTAL**	**0.1**	

Remarks: 1.The acceptance requirement is taken from Table 1-2-1of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: April 19, 2010

MS 41+800

EVALUATION OF DURABILITY OF ROCK FOR EROSION CONTROL UNDER FREEZING AND THAWING CONDITIONS (ASTM C5312)

Job Number: 093-81042-00011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-E11-E066-01

Date Received: February, 2010
Date Started: March 01, 2010 for 30 cycles

Sampled by: N/A
Golder Lab No.: G-10-042

Sample No.	Mass of rock before test (g)	Mass of rock after test (g)	Loss (%)
42A	1423.2	1422.8	0.0
42B	1515.7	1515.0	0.1
42C	1454.9	1454.2	0.1
42D	1268.1	1267.8	0.0
42E	2138.6	2138.2	0.0

Remarks:

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: May 27, 2010

PETROGRAPHIC EXAMINATION OF COARSE AGGREGATE

CSA A23.2-15A / ASTM C 295

August 23, 2010

Project number: 093-81042-00011

GOLDER ASSOCIATES INC.
4438 Haines Road,
Duluth, MN
USA 55811

ATTENTION: Amy Thorson, P.E.

PROJECT: Aggregate Testing - Canada Chrome

Sample	**G-10-118 (M-2010-1270/1280/1300/1320/1340/1360-BULK)**

Date Received: June 21, 2010 **Sampled by:** Client

	PETROGRAPHIC DESCRIPTION/ PHYSICAL QUALITY	PERCENT BY MASS	MULTI-PLIER	PN CONTRI-BUTION
GOOD	**Granite** – red-dark pink, slightly gneissic texture. Fine-medium grained, dense, strong.	5.6	1	5.6
GOOD	**Gneiss 1** – granitic, quartz/feldspar/biotite. Red-pink/black, banded, fine- to coarse-grained, dense, strong	20.2	1	20.2
GOOD	**Gneiss 2** – granitic, quartz, feldspar, biotite. White-grey-black, occasionally pink, strongly banded appearance, dense, strong	48.4	1	48.4
GOOD	***Subtotal***	**74.2**		**74.2**
FAIR	**Gneiss 1** – as above, weathered, medium strength.	3.6	3	**10.8**
FAIR	**Gneiss 2** – as above, weathered (strong development of iron oxides on biotite, some alteration of feldspar to clay, medium strength.	14.2	3	**42.6**
FAIR	***Subtotal***	**17.8**		**53.4**
POOR	**Gneiss 2** – as above, deeply weathered, weak/friable.	8.0	6	**48.0**
POOR	***Subtotal***	**8.0**		**48.0**
	TOTALS	**100.0**	**PN**	**175.6**

Note: 1. The PN is not related to potential for Alkali-Aggregate Reaction. AAR must be assessed separately.

PETROGRAPHER: _____
FOR: F. Shrimer, P. Geo.

G-10-118 (M-2010-1270/1280/1300/1320/1340/1360-BULK)

General

The sample consisted of crushed stone. The material was split, quartered and washed to remove surficial dust, in preparation for the examination.

The particle geometry was primarily cubical with some flat particles, and particles had an angular to subangular shape. The particle surface textures were generally moderately rough.

Lithologic Composition

Identification of rock types and minerals was done using a stereomicroscope with magnifications from 8x to about 60x, supplemented by basic geologic diagnostic methods. Thin sections were prepared from selected samples and examined, but no chemical analyses were undertaken to assist in the identification of the rock types.

The sample consisted of granite and granitic gneiss. The mineralogy of these rocks was generally quartz/feldspar/biotite, although texture varied from fine to coarse grained between as well as within the various groups. Alteration ranged from none to slight to deeply weathered.

Gneissic texture was generally absent in the granites, although in some pieces, a slight gneissic texture was observed. Where gneissic texture was characteristic, the rocks were classified as 'gneiss'; within these rocks, differentiation of minerals within bands was often observed.

Colour for the granite was typically red or dark pink with minor black, grey/white, while the gneisses ranged from red-pink/black to white/grey/black with little pink. Where biotites were altered to iron oxides, colours were characteristically tinted with rust/brown hues.

Engineering Characteristics

In addition to the geologic classification of the aggregate, the sample was also examined for characteristics relevant to engineering uses. Aspects such as porosity, strength, tenacity, presence or absence of vugs, voids, fissures, cracks, coatings and impurities in the particles were considered in the assignment of individual particles into various quality classifications.

On the basis of this sorting of the sample, the relative amounts of "Good", "Fair" and "Poor" quality material were determined. This enabled the determination of a Petrographic Number (or "PN"), in accordance with the method given in CSA A23.2-15A. The PN is an index of a coarse aggregate's overall physical-mechanical quality. The PN for this sample was "176".

For reference, the PN scale referenced in CSA A23.2-15A, Attachment A2, is as follows:

PN LIMITS	PRODUCT TYPE
125	Concrete Class C1, C2, F1
140 max	Other concrete classes
125	Shotcrete
125	Railroad ballast

PN LIMITS	PRODUCT TYPE
150	Granular base
160	Select Granular sub-base

The G-10-118 crushed stone sample would not be considered to be of suitable quality for uses as railroad ballast and for most of the uses noted above, with the possible exception of some types of structural fill / granular base, only if complying with applicable specification requirements.

The PN of 176 suggests that the use of this material as railroad ballast, concrete and asphalt aggregate would be precluded.

Alkali-Aggregate Reaction (AAR) Potential

Most of the rock material comprising the sample could have a potential to be alkali-aggregate reactive in concrete, due to the presence of quartz exhibiting undulatory extinction as seen in thin-section.

Were the material considered for use as Portland cement concrete aggregate, it would be recommended that its potential for AAR be evaluated using the procedures given in CSA as A23.2-14A (or as ASTM C 1293) ("Concrete Prism") and A23.2-25A (ASTM C 1260) ("Accelerated Mortar Bar").

Discussion

We note that the sample contains some 26% of material that has been classified as being of "Fair" or "Poor" quality. Much of this material was observed to contain significant weathering/alteration products, as is commonly seen in surface rock in outcrop; additionally, lichens and other biologic materials were observed encrusting these Fair/Poor rock materials.

We therefore consider that the sampling procedures may have inadvertently incorporated these materials into the sample submitted for testing. This surficial weathered material is likely not representative of the rock forming the deposit(s) at depth.

If much of this material (e.g., say 20%) was theoretically excluded from the Petrographic Examination sample, we note that the PN would be recalculated for this sample to about 110 – 115, which is indicative of better quality rock. It would be recommended to resample and retest samples from this location in order to verify this.

Summary

The G-10-118 crushed stone sample, as tested, consisted of granitic gneiss and had a PN of 176, and would not be judged suitable for use as railroad ballast, concrete aggregate or asphalt aggregate. We suggest that the PN may reflect incorporation of excessive weathered, surficial rock that does not represent the true nature of the rock at depth, and thus resampling may be in order.

Reviewed by:

FOR: F. Shrimer, P. Geo.

A. Briggs, M. Sc., GIT

SOUNDNESS OF COARSE AGGREGATE USE OF SODIUM SULFATE (ASTM C88)

Job Number: 093-81042-011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	M2010-1270/1280/1300/1340/1360-Bulk (Bucket Number 131-137)

Date Received: May, 2010
Date Tested: June 10 – June 18, 2010

Sampled by: N/A
Golder Lab No.: G-10-118

Sieve Fraction (mm)	Original Grading	Mass per fraction before test (g)	Loss (%)	Weighted Loss (%)	Acceptance Requirement [1]
50.0 – 37.5	0.054	2021.5	0.22	0.0	5.0 Max.
37.5 – 25.0	0.620	1016.6	0.30	0.2	
25.0 – 19.0	0.326	5016.8	0.75	0.3	
	1.000		**TOTAL**	**0.5**	

Remarks: 1.The acceptance requirement is taken from Table 1-2-1of the AREMA Manual for Railway Engineering.

Reviewed by: _____ Date: July 15, 2010
John A. Watkins, Laboratory Services Manager

Golder Associates

PETROGRAPHIC EXAMINATION OF COARSE AGGREGATE

CSA A23.2-15A / ASTM C 295

August 16, 2010

Project number: 093-81042-00011

GOLDER ASSOCIATES INC
4438 Haines Road,
Duluth, MN
USA 55811

ATTENTION: Amy Thorson

Sample	G-10-051 (M-2010-2450-BULK)

Date Received: June 21, 2010 **Sampled by:** Client

	PETROGRAPHIC DESCRIPTION/ PHYSICAL QUALITY	PERCENT BY MASS	MULTI-PLIER	PN CONTR.
GOOD	**Gneiss 1** – granitic, weakly gneissic texture, quartz, feldspar, biotite, rare to occasional accessory/alteration minerals (chlorite, pyrite, epidote), subhedral to euhedral crystals, salt-pepper appearance with some pinkish particles, dense, strong.	51.1	1	**51.1**
	Gneiss 2 – granitic composition similar to above but more pronounced gneissic texture, zoned/banded structure with concentrations of quartz-feldspar and biotite, pink/grey/black. Strong, dense.	44.5	1	**44.5**
	Subtotal	**95.6**		**95.6**
FAIR	**Gneiss 1** – as above, weathered with significant development of secondary alteration (Fe-ox, clay minerals), medium strength	2.8	3	**8.4**
	Gneiss 2 – as above, weathered, medium strength.	1.6	3	**4.8**
	Subtotal	**4.4**		**13.2**
	TOTALS	**100.0**	**PN**	**108.8**

Note: 1. The PN is not related to potential for Alkali-Aggregate Reaction. AAR must be assessed separately.

PETROGRAPHER: _____
FOR F. Shrimer, P. Geo.

G-10-051 (M-2010-2450-BULK)

General

The sample consisted of crushed stone. The material was split, quartered and washed to remove surficial dust, in preparation for the examination.

The particle geometry was primarily cubical with an angular to subangular shape. The particle surface textures ranged from rough to moderately rough.

Lithologic Composition

Identification of rock types and minerals was done using a stereomicroscope with magnifications from 8x to about 60x, supplemented by basic geologic diagnostic methods. Thin sections were examined but no chemical analyses were undertaken to aid in the identification of the rock types.

The sample consisted of granitic gneiss. The rock was subdivided into two subtypes, based upon the type and intensity of the gneissic texture. The two subtypes represented 54% ("weakly gneissic texture") and 46% ("strongly gneissic") respectively of the sample.

Some rocks possessed fine to medium grain size, while others were of coarser texture. Mineralogic composition was within broad ranges, consisting of quartz, feldspar and biotite, with minor/variable amounts of epidote, pyrite and chlorite/sericite.

More weathered/altered varieties were characterized by significant development of iron-oxide haloes on biotite crystals/masses, and clay minerals after feldspars. These weathered rocks tended to be of somewhat lower strength.

Engineering Characteristics

In addition to the geologic classification of the aggregate, the sample was also examined for characteristics relevant to engineering uses. Aspects such as porosity, strength, tenacity, presence or absence of vugs, voids, fissures, cracks, coatings and impurities in the particles were considered in the assignment of individual particles into various quality classifications.

Most of the particles examined were found to be of good engineering quality, being dense, strong and unweathered. Particles which exhibited some degree of weathering and were of lower strength were separately classified.

On the basis of this sorting of the sample, the relative amounts of "Good", and "Fair" quality material were determined. This enabled the determination of a Petrographic Number (or "PN"), in accordance with the method given in CSA A23.2-15A. The PN is an index of a coarse aggregate's overall physical-mechanical quality. The PN for this sample was "109".

For reference, the PN scale referenced in CSA A23.2-15A, Attachment A2, is as follows:

PN LIMITS	PRODUCT TYPE
125	Concrete Class C1, C2, F1
140 max	Other concrete classes

PN LIMITS	PRODUCT TYPE
125	Shotcrete
125	Railroad ballast
150	Granular base
160	Select Granular sub-base

The G-10-051 crushed stone sample would be considered to be of suitable quality for all uses noted above, and is judged to be of suitable physical-mechanical engineering quality for use in a variety of applications, including as railroad ballast, concrete, asphalt and road base materials, subject to compliance with applicable specification requirements.

Alkali-Aggregate Reaction (AAR) Potential

Since the gneiss contains quartz that exhibits some degree of strain, the rock may have a potential to be alkali-aggregate reactive. Should the material be considered for use as Portland cement concrete aggregate, it is recommended that its potential for AAR be evaluated using the procedures given in CSA as A23.2-14A (or ASTM as C 1293) ("Concrete Prism") and A23.2-25A ("Accelerated Mortar Bar") (ASTM C 1260).

Summary

The G-10-051 crushed stone sample consisted of granitic gneiss, and had a PN of 109.

On the basis of the Petrographic Examination, the aggregate is judged suitable for use for use in a variety of applications, subject to satisfactory compliance with applicable specifications

Reviewed by:

FOR F. Shrimer, P. Geo.

A. Briggs, GIT

Golder Associates

PETROGRAPHIC EXAMINATION OF COARSE AGGREGATE

CSA A23.2-15A / ASTM C 295

August 19, 2010 Project number: 093-81042-00011

GOLDER ASSOCIATES INC.
4438 Haines Road,
Duluth, MN
USA 55811

ATTENTION: Amy Thorson, P.E.

PROJECT: Aggregate Testing – Canada Chrome

Sample	**G-10-054 (M-2010-2470-BULK)**

Date Received: June 21, 2010 **Sampled by:** Client

	PETROGRAPHIC DESCRIPTION/ PHYSICAL QUALITY	PERCENT BY MASS	MULTI-PLIER	PN CONTRI-BUTION
GOOD	**Gneiss** – Granitic, quartz, feldspar, biotite. Pink-white-black, medium grained, dense, strong.	77.8	1	77.8
	Subtotal	**77.8**		**77.8**
FAIR	**Gneiss –** granitic, quartz-feldspar-biotite, iron-oxide alteration common, medium strength.	20.1	3	**60.3**
	Subtotal	**20.1**		**60.3**
POOR	**Gneiss –** weathered, alteration common to pronounced, low strength	2.1	6	**12.6**
	Subtotal	**2.1**		**12.6**
TOTALS		**100.0**	**PN**	**150.7**

Note: 1. The PN is not related to potential for Alkali-Aggregate Reaction. AAR must be assessed separately.

PETROGRAPHER: _____
FOR F. Shrimer, P. Geo.

CCIL

Notice: The data given in this report pertain to the sample provided, and may not be applicable to samples from earlier or subsequent production. This report comprises a testing service only. Interpretation may be provided upon written request.

G-10-054 (M-2010-2470-BULK)

General

The sample consisted of crushed stone. The material was split, quartered and washed to remove surficial dust, in preparation for the examination.

The particle geometry was primarily cubical with some flat particles, and had an angular to subangular shape. The particle surface textures were generally moderately rough.

Lithologic Composition

Identification of rock types and minerals was done using a stereomicroscope with magnifications from 8x to about 60x, supplemented by basic geologic diagnostic methods. Thin sections were prepared from selected samples and examined, but no chemical analyses were undertaken to assist in the identification of the rock types.

The sample consisted of granitic gneiss, generally consisting of a quartz/feldspar/biotite mineralogy, with overall medium grain size with euhedral to subhedral crystals. Some 78% of the sample was composed of gneiss that was dense, strong and with little significant weathering/alteration.

The remaining material was composed of gneiss that was higher in biotite content, and in which biotite was significantly altered to iron oxides, thereby resulting in weaker rocks.

Engineering Characteristics

In addition to the geologic classification of the aggregate, the sample was also examined for characteristics relevant to engineering uses. Aspects such as porosity, strength, tenacity, presence or absence of vugs, voids, fissures, cracks, coatings and impurities in the particles were considered in the assignment of individual particles into various quality classifications.

On the basis of this sorting of the sample, the relative amounts of "Good", "Fair" and "Poor" quality material were determined. This enabled the determination of a Petrographic Number (or "PN"), in accordance with the method given in CSA A23.2-15A. The PN is an index of a coarse aggregate's overall physical-mechanical quality. The PN for this sample was "151".

For reference, the PN scale referenced in CSA A23.2-15A, Attachment A2, is as follows:

PN LIMITS	PRODUCT TYPE
125	Concrete Class C1, C2, F1
140 max	Other concrete classes
125	Shotcrete
125	Railroad ballast
150	Granular base
160	Select Granular sub-base

The G-10-054 crushed stone sample, as tested, would not be considered to be of suitable quality for the uses noted above, except for various types of granular base, subject to demonstrated compliance with applicable specification requirements.

For uses such as railroad ballast, concrete and asphalt aggregate, the material would not be recommended for use, based solely upon its PN.

However, should the sample represent "surficial" and thus "weathered" rock material, it may be that the material located at depth, below the weathered outer rock, could be of higher quality. If the sample that was obtained incorporated some of this presumed weathered rock, the current sample may provide an overly negative view of the rock quality at this site. In order to confirm this possibility, we recommend that follow-up sampling and evaluation be undertaken in which fresh material is obtained.

Alkali-Aggregate Reaction (AAR) Potential

Most of the rock material comprising the sample could have a potential to be alkali-aggregate reactive in concrete, due to the presence of quartz exhibiting undulatory extinction as seen in thin-section.

If the material was considered for use as Portland cement concrete aggregate, it is recommended that its potential for AAR be evaluated using the procedures given in CSA as A23.2-14A (or ASTM as C 1293) ("Concrete Prism") and A23.2-25A (ASTM C 1260) ("Accelerated Mortar Bar").

Summary

The G-10-054 crushed stone sample consisted of granitic gneiss and had a PN of 151.

On the basis of the Petrographic Examination, the aggregate is not judged to be suitable for use as railroad ballast, concrete aggregate or asphalt aggregate. However, as noted above, if it is considered that the sample may have been negatively biased as a result of sampling of weathered, surface rock, it may be appropriate to resample and retest this site.

Reviewed by:

FOR

F. Shrimer, P. Geo.

A. Briggs, M. Sc., GIT

MS 82+000

RESISTANCE TO DEGRADATION OF LARGE-SIZE AGGREGATE BY ABRASION AND IMPACT IN LOS ANGELES MACHINE (ASTM C535)

Job Number: 093-81042-00011

Golder Associates Inc.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	**M-2010-2450-BULK (Bucket Number 105,106,107)**

Date Received: April, 2010
Date Tested: April 22, 2010

Sampled by: N/A
Golder Lab Number: G-10-051

Grading	2
Sieve Sizes	50.0mm – 25.0mm
Mass – Before test (g)	10010.3
Number of revolutions	1000
Number of spheres (g)	12
Mass of spheres (g)	5016.2
Mass after 1000 revolutions (g)	8157.4
Loss after 1000 revolutions (%)	**18.5**

Remarks: **1.** The maximum allowable loss of 35% for granite is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: May 4, 2010

MS 82+000

RESISTANCE TO DEGRADATION OF LARGE-SIZE AGGREGATE BY ABRASION AND IMPACT IN LOS ANGELES MACHINE (ASTM C535)

Job Number: 093-81042-00011

Golder Associates Inc.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	**M-2010-2470-BULK (Bucket Number 108)**

Date Received: April, 2010
Date Tested: May 10, 2010

Sampled by: N/A
Golder Lab Number: G-10-054

Grading	2
Sieve Sizes	50.0mm – 25.0mm
Mass – Before test (g)	10022.5
Number of revolutions	1000
Number of spheres (g)	12
Mass of spheres (g)	5012.7
Mass after 1000 revolutions (g)	6294.5
Loss after 1000 revolutions (%)	**37.2**

Remarks: **1.** The maximum allowable loss of 35% for granite is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: May 14, 2010

SOUNDNESS OF COARSE AGGREGATE USE OF SODIUM SULFATE (ASTM C88)

Job Number: 093-81042-00011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	M-2010-2450-BULK (Bucket Number 105,106,107)

Date Received: April, 2010
Date Tested: May 11 – May 18, 2010

Sampled by: N/A
Golder Lab No.: G-10-051

Sieve Fraction (mm)	Original Grading	Mass per fraction before test (g)	Loss (%)	Weighted Loss (%)	Acceptance Requirement [1]
50.0 – 37.5	0.054	2010.3	0.1	0.0	5.0 Max.
37.5 – 25.0	0.620	1021.7	0.2	0.1	
25.0 – 19.0	0.326	503.5	0.1	0.0	
	1.000		**TOTAL**	**0.1**	

Remarks: 1.The acceptance requirement is taken from Table 1-2-1of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: May 27, 2010

SOUNDNESS OF COARSE AGGREGATE USE OF SODIUM SULFATE (ASTM C88)

Job Number: 093-81042-011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	M2010-2470-Bulk (Bucket Number 108)

Date Received: April, 2010
Date Tested: June 10 – June 18, 2010

Sampled by: N/A
Golder Lab No.: G-10-054

Sieve Fraction (mm)	Original Grading	Mass per fraction before test (g)	Loss (%)	Weighted Loss (%)	Acceptance Requirement [1]
50.0 – 37.5	0.054	2013.2	0.06	0.0	5.0 Max.
37.5 – 25.0	0.620	1026.5	0.09	0.1	
25.0 – 19.0	0.326	509.9	0.25	0.1	
	1.000		**TOTAL**	**0.2**	

Remarks: 1.The acceptance requirement is taken from Table 1-2-1of the AREMA Manual for Railway Engineering.

Reviewed by: _____ Date: July 15, 2010
John A. Watkins, Laboratory Services Manager

EVALUATION OF DURABILITY OF ROCK FOR EROSION CONTROL UNDER FREEZING AND THAWING CONDITIONS (ASTM D5312-04)

Job Number: 093-81042-00011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	M-2010-2450-BULK (Bucket Number 105,106,107)

Date Received: May, 2010
Date Started: June 23, 2010 for 30 cycles

Sampled by: N/A
Golder Lab No.: G-10-051

Sample No.	Mass of rock before test (g)	Mass of rock after test (g)	Loss (%)
51A	1549.1	1547.6	0.1
51B	1284.4	1283.7	0.1
51C	1281.6	1279.6	0.2
51D	1512.5	1509.8	0.2

Remarks:

Reviewed by: _____
Jeremy Rose, Laboratory Manager

Date: August 16, 2010

EVALUATION OF DURABILITY OF ROCK FOR EROSION CONTROL UNDER FREEZING AND THAWING CONDITIONS (ASTM D5312-04)

Job Number: 093-81042-00011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	M-2010-2470-BULK (Bucket Number 108)

Date Received: May, 2010
Date Started: June 23, 2010 for 30 cycles

Sampled by: N/A
Golder Lab No.: G-10-054

Sample No.	Mass of rock before test (g)	Mass of rock after test (g)	Loss (%)
54A	2051.1	2046.4	0.2
54B	1589.9	1588.5	0.1
54C	1167.4	1165.8	0.1
54D	1898.7	1897.0	0.1
54E	1533.6	1532.3	0.1

Remarks:

Reviewed by: _____
Jeremy Rose, Laboratory Manager

Date: August 16, 2010

PETROGRAPHIC EXAMINATION OF COARSE AGGREGATE

CSA A23.2-15A / ASTM C 295

August 23, 2010
Project number: 093-81042-00011

GOLDER ASSOCIATES INC.
4438 Haines Road,
Duluth, MN
USA 55811

ATTENTION: Amy Thorson, P.E.

PROJECT: Aggregate Testing - Canada Chrome

Sample	**G-10-055 (M-2010-2590-BULK)**

Date Received: June 21, 2010 **Sampled by:** Client

	PETROGRAPHIC DESCRIPTION/ PHYSICAL QUALITY	PERCENT BY MASS	MULTI-PLIER	PN CONTRI-BUTION
GOOD	**Gneiss** – granitic, quartz, feldspar, biotite. Pink-white-black, medium grained, except occasional coarse-grained zones, banded appearance common, typical salt-pepper appearance, dense, strong.	97.6	1	97.6
	Subtotal	**97.6**		**97.6**
FAIR	**Gneiss** – granitic, quartz-feldspar-biotite, iron-oxide, moderately weathered, feldspar alteration to clay (sericite) common, medium strength.	2.4	3	**7.2**
	Subtotal	**2.4**		**7.2**
TOTALS		**100.0**	**PN**	**104.8**

Note: 1. The PN is not related to potential for Alkali-Aggregate Reaction. AAR must be assessed separately.

PETROGRAPHER: _____
F. Shrimer, P. Geo.

Notice: The data given in this report pertain to the sample provided, and may not be applicable to samples from earlier or subsequent production. This report comprises a testing service only. Interpretation may be provided upon written request.

G-10-054 (M-2010-2590-BULK)

General

The sample consisted of crushed stone. The material was split, quartered and washed to remove surficial dust, in preparation for the examination.

The particle geometry was primarily cubical with some flat particles, and had an angular to subangular shape. The particle surface textures were generally moderately rough.

Lithologic Composition

Identification of rock types and minerals was done using a stereomicroscope with magnifications from 8x to about 60x, supplemented by basic geologic diagnostic methods. Thin sections were prepared from selected samples and examined, but no chemical analyses were undertaken to assist in the identification of the rock types.

The sample consisted of granitic gneiss, generally consisting of quartz, feldspar, and biotite. The overall grain size was medium with euhedral to subhedral crystals. 97.6% of the sample was composed of gneiss that was dense, strong and with little significant weathering/alteration.

The remaining material (2.4%) was gneiss that exhibited some degree of alteration, such as feldspar alteration to sericite. These gneisses were less dense and of medium strength.

Engineering Characteristics

In addition to the geologic classification of the aggregate, the sample was also examined for characteristics relevant to engineering uses. Aspects such as porosity, strength, tenacity, presence or absence of vugs, voids, fissures, cracks, coatings and impurities in the particles were considered in the assignment of individual particles into various quality classifications.

Most of the particles examined were found to be of good engineering quality, being dense, strong and unweathered.

On the basis of this sorting of the sample, the relative amounts of "Good" and "Fair" quality material were determined. This enabled the determination of a Petrographic Number (or "PN"), in accordance with the method given in CSA A23.2-15A. The PN is an index of a coarse aggregate's overall physical-mechanical quality. The PN for this sample was "105".

For reference, the PN scale referenced in CSA A23.2-15A, Attachment A2, is as follows:

PN LIMITS	PRODUCT TYPE
125	Concrete Class C1, C2, F1
140 max	Other concrete classes
125	Shotcrete
125	Railroad ballast
150	Granular base

PN LIMITS	PRODUCT TYPE
160	Select Granular sub-base

The G-10-055 crushed stone sample would therefore be considered of suitable quality for all the uses noted above, subject to demonstrated compliance with applicable specification requirements.

Alkali-Aggregate Reaction (AAR) Potential

Most of the rock material comprising the sample could have a potential to be alkali-aggregate reactive in concrete, due to the presence of quartz exhibiting undulatory extinction as seen in thin-section.

Should the material was considered for use as Portland cement concrete aggregate, it is recommended that its potential for AAR be evaluated using the procedures given in CSA as A23.2-14A (or ASTM as C 1293) ("Concrete Prism") and A23.2-25A (ASTM C1260) ("Accelerated Mortar Bar").

Summary

The G-10-055 crushed stone sample consisted of granitic gneiss and had a PN of 105.

On the basis of the Petrographic Examination, the aggregate is judged to be suitable for use as railroad ballast, concrete aggregate or asphalt aggregate, as well as for other construction applications.

F. Shrimer, P. Geo.

Reviewed by:

A. Briggs, M. Sc., GIT

RESISTANCE TO DEGRADATION OF LARGE-SIZE AGGREGATE BY ABRASION AND IMPACT IN LOS ANGELES MACHINE (ASTM C535)

Job Number: 093-81042-00011

Golder Associates Inc.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	**M-2010-2590-BULK (Bucket Number 110)**

Date Received: April, 2010
Date Tested: April 22, 2010

Sampled by: N/A
Golder Lab Number: G-10-055

Grading	2
Sieve Sizes	50.0mm – 25.0mm
Mass – Before test (g)	10023.2
Number of revolutions	1000
Number of spheres (g)	12
Mass of spheres (g)	5016.2
Mass after 1000 revolutions (g)	7665.3
Loss after 1000 revolutions (%)	**23.5**

Remarks: **1.** The maximum allowable loss of 35% for granite is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: May 4, 2010

SOUNDNESS OF COARSE AGGREGATE USE OF SODIUM SULFATE (ASTM C88)

Job Number: 093-81042-00011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	M-2010-2590-BULK (Bucket Number 110)

Date Received: April, 2010
Date Tested: May 11 – May 18, 2010

Sampled by: N/A
Golder Lab No.: G-10-055

Sieve Fraction (mm)	Original Grading	Mass per fraction before test (g)	Loss (%)	Weighted Loss (%)	Acceptance Requirement [1]
50.0 – 37.5	0.054	2011.9	0.1	0.0	5.0 Max.
37.5 – 25.0	0.620	1002.9	0.2	0.1	
25.0 – 19.0	0.326	509.2	0.2	0.1	
	1.000		**TOTAL**	**0.2**	

Remarks: 1.The acceptance requirement is taken from Table 1-2-1of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: May 27, 2010

EVALUATION OF DURABILITY OF ROCK FOR EROSION CONTROL UNDER FREEZING AND THAWING CONDITIONS (ASTM D5312-04)

Job Number: 093-81042-00011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	M-2010-2590-BULK (Bucket Number 110)

Date Received: May, 2010
Date Started: June 23, 2010 for 30 cycles

Sampled by: N/A
Golder Lab No.: G-10-055

Sample No.	Mass of rock before test (g)	Mass of rock after test (g)	Loss (%)
55A	1944.3	1942.1	0.1
55B	922.2	921.0	0.1
55C	2187.2	2184.2	0.1
55D	758.4	757.9	0.1
55E	972.1	970.6	0.2

Remarks:

Reviewed by: _____
Jeremy Rose, Laboratory Manager

Date: August 16, 2010

PETROGRAPHIC EXAMINATION OF COARSE AGGREGATE

CSA A23.2-15A / ASTM C 295

July 23, 2010
Project number: 093-81042-00011

GOLDER ASSOCIATES INC
4438 Haines Road,
Duluth, MN
USA 55811

ATTENTION: Amy Thorson, P.E.

Sample	G-10-056

Date Received: June 21, 2010 **Sampled by:** Client

	PETROGRAPHIC DESCRIPTION/ PHYSICAL QUALITY	PERCENT BY MASS	MULTI-PLIER	PN CONTRIBUTION
GOOD	**Gneiss –** Quartz, feldspar, biotite. Pink-white-black, medium grained, oxidation common, some sericite alteration of the feldspar.	45.5	1	45.5
GOOD	**Gneiss –** Quartz, feldspar, biotite. Grey to black/white, fresh, minor oxidation. Generally moderate to high biotite content, with biotite often concentrated in some zones.	26.3	1	26.3
GOOD	***Subtotal***	**71.8**		**71.8**
FAIR	**Gneiss –** Pink and grey, brittle, frequently banded, medium strength	16.9	3	**50.7**
FAIR	***Subtotal***	**16.9**		**50.7**
POOR	**Gneiss –** weathered, alteration common to pronounced, low strength, brittle	5.0	6	**30.0**
POOR	***Subtotal***	**5.0**		**30.0**
	TOTALS	**100.0**	**PN**	**158.8**

Note: 1. The PN is not related to potential for Alkali-Aggregate Reaction. AAR must be assessed separately.

PETROGRAPHER: _____

J. Taylor, M.Sc./ F. Shrimer, P. Geo.

G-10-056

General

The sample consisted of crushed stone

The particle geometry was primarily cubical with some particles trending towards elongated morphology, with angular to subangular shape. The particle surface textures were moderately rough to rough.

Lithologic Composition

Identification of rock types and minerals was done using a stereomicroscope with magnifications from 8x to about 40x, supplemented by basic geologic diagnostic methods. Thin sections were examined but no chemical analyses were undertaken to aid in the identification of the rock types.

The sample was composed entirely of gneiss, which was divided into sub-categories based on the mineralogic composition, strength and physical attributes, and dominant colour.

In thin-section, the gneisses were composed of quartz, feldspar, biotite in varying proportions. Feldspars occasionally exhibited sericite rims; iron oxide alteration was observed after biotite. Rare garnets were observed in occasional biotite gneiss specimens. Crystallinity ranged from subhedral to euhedral, and texture for the rocks was generally medium to coarse-grained, with some finer-grained zones.

Rocks exhibiting zonation and concentrations of minerals were common.

Stronger gneisses tended to be those which exhibited low alteration, while the more altered and weathered gneisses were of moderate to low strength.

Engineering Characteristics

In addition to the geologic classification of the aggregate, the sample was also examined for characteristics relevant to engineering uses. Aspects such as porosity, strength, tenacity, presence or absence of vugs, voids, fissures, cracks, coatings and impurities in the particles were considered in the assignment of individual particles into various quality classifications.

On the basis of this sorting of the sample, the relative amounts of “Good”, “Fair” and “Poor” quality material were determined. This enabled the determination of a Petrographic Number (or “PN”), in accordance with the method given in CSA A23.2-15A. The PN is an index of a coarse aggregate’s overall physical-mechanical quality. The PN for this sample was “159”.

For reference, the PN scale referenced in CSA A23.2-15A, Attachment A2, is as follows:

PN LIMITS	PRODUCT TYPE
125	Concrete Class C1, C2, F1
140 max	Other concrete classes
125	Shotcrete

PN LIMITS	PRODUCT TYPE
125	Railroad ballast
150	Granular base
160	Select Granular sub-base

The G-10-056 crushed stone sample would be considered to be of unsuitable quality for uses as noted above, and is judged to be of suitable physical-mechanical engineering quality only for use as granular subbase and similar structural fill aggregates, subject to compliance with applicable specification requirements.

It is understood that the sample is under consideration for use as railroad ballast. Comparison with the suggested PN limits given in CSA, per the table above, indicates that the sample exceeds the suggested limit of 125. Thereby, the material would be anticipated to provide unacceptable performance with respect to durability due to excessive "fair/poor" quality rock, as identified in this sample.

Alkali-Aggregate Reaction Potential

The rocks comprising this sample are considered to be as "potentially alkali-reactive", meaning that they may contribute under certain circumstances to a deleterious expansive reaction in concrete termed *"Alkali-Aggregate Reaction"* (AAR).

Should the material be considered for use as concrete aggregate, periodic assessment of the aggregate's AAR characteristics is recommended utilizing the procedures given in CSA A23.2-14A (or ASTM as C 1293) ("Concrete Prism") and CSA A23.2-25A (ASTM C 1260) ("Accelerated Mortar Bar").

Summary

The G-10-056 crushed stone sample consisted of gneiss, and had a PN of 159.

On the basis of the Petrographic Examination, the aggregate is judged unsuitable for use in a variety of applications, including railroad ballast, concrete, asphalt and road base materials.

Reviewed by:

J. Taylor, M. Sc.

F. Shrimer, P. Geo.

PETROGRAPHIC EXAMINATION OF COARSE AGGREGATE

CSA A23.2-15A / ASTM C 295

August 23, 2010
Project number: 093-81042-00011

GOLDER ASSOCIATES INC.
4438 Haines Road,
Duluth, MN
USA 55811

ATTENTION: Amy Thorson, P.E.

PROJECT: Aggregate Testing - Canada Chrome

Sample	**G-10-057 (M-2010-2650-BULK)**

Date Received: June 21, 2010 **Sampled by:** Client

	PETROGRAPHIC DESCRIPTION/ PHYSICAL QUALITY	PERCENT BY MASS	MULTI-PLIER	PN CONTRI-BUTION
GOOD	**Gneiss** – granitic, quartz, feldspar, biotite. Pink-white-black, medium grained, except occasional coarse-grained zones, banded appearance common, typical salt-pepper appearance, dense, strong.	94.8	1	94.8
	Subtotal	**94.8**		**94.8**
FAIR	**Gneiss –** granitic, quartz-feldspar-biotite, iron-oxide moderately weathered, feldspar alteration to clay. (sericite) common, medium strength.	5.2	3	**15.6**
	Subtotal	**5.2**		**15.6**
TOTALS		**100.0**	**PN**	**110.4**

Note: 1. The PN is not related to potential for Alkali-Aggregate Reaction. AAR must be assessed separately.

PETROGRAPHER: _____
F. Shrimer, P. Geo.

G-10-055 (M-2010-2650-BULK)

General

The sample consisted of crushed stone. The material was split, quartered and washed to remove surficial dust, in preparation for the examination.

The particle geometry was primarily cubical with some flat particles, and particles had an angular to subangular shape. The particle surface textures were generally moderately rough.

Lithologic Composition

Identification of rock types and minerals was done using a stereomicroscope with magnifications from 8x to about 60x, supplemented by basic geologic diagnostic methods. Thin sections were prepared from selected samples and examined, but no chemical analyses were undertaken to assist in the identification of the rock types.

The sample consisted of granitic gneiss, generally consisting of quartz, feldspar, and biotite. The overall grain size was medium with euhedral to subhedral crystals. 94.8% of the sample was composed of gneiss that was dense, strong and with little significant weathering/alteration.

The remaining material (5.2%) was gneiss that exhibited some degree of alteration, such as feldspar alteration to sericite. These gneisses were less dense and of medium strength.

Engineering Characteristics

In addition to the geologic classification of the aggregate, the sample was also examined for characteristics relevant to engineering uses. Aspects such as porosity, strength, tenacity, presence or absence of vugs, voids, fissures, cracks, coatings and impurities in the particles were considered in the assignment of individual particles into various quality classifications.

Most of the particles examined were found to be of good engineering quality, being dense, strong and unweathered.

On the basis of this sorting of the sample, the relative amounts of "Good" and "Fair" quality material were determined. This enabled the determination of a Petrographic Number (or "PN"), in accordance with the method given in CSA A23.2-15A. The PN is an index of a coarse aggregate's overall physical-mechanical quality. The PN for this sample was "110".

For reference, the PN scale referenced in CSA A23.2-15A, Attachment A2, is as follows:

PN LIMITS	PRODUCT TYPE
125	Concrete Class C1, C2, F1
140 max	Other concrete classes
125	Shotcrete
125	Railroad ballast
150	Granular base

PN LIMITS	PRODUCT TYPE
160	Select Granular sub-base

The G-10-057 crushed stone sample would therefore be considered of suitable quality for all the uses noted above, subject to demonstrated compliance with applicable specification requirements.

Alkali-Aggregate Reaction (AAR) Potential

Most of the rock material comprising the sample could have a potential to be alkali-aggregate reactive in concrete, due to the presence of quartz exhibiting undulatory extinction as seen in thin-section.

Should the material was considered for use as Portland cement concrete aggregate, it is recommended that its potential for AAR be evaluated using the procedures given in CSA as A23.2-14A (or as ASTM C 1293) ("Concrete Prism") and A23.2-25A (ASTM C 1260) ("Accelerated Mortar Bar").

Summary

The G-10-057 crushed stone sample consisted of granitic gneiss and had a PN of 110.

On the basis of the Petrographic Examination, the aggregate is judged to be suitable for use as railroad ballast, concrete aggregate or asphalt aggregate, as well as for other construction applications.

Reviewed by:

F. Shrimer, P. Geo.

A. Briggs, M. Sc., GIT

RESISTANCE TO DEGRADATION OF LARGE-SIZE AGGREGATE BY ABRASION AND IMPACT IN LOS ANGELES MACHINE (ASTM C535)

Job Number: 093-81042-00011

Golder Associates Inc.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	**M-2010-2630-BULK (Bucket Number 113)**

Date Received: April, 2010
Date Tested: April 22, 2010

Sampled by: N/A
Golder Lab Number: G-10-056

Grading	2
Sieve Sizes	50.0mm – 25.0mm
Mass – Before test (g)	10053.7
Number of revolutions	1000
Number of spheres (g)	12
Mass of spheres (g)	5016.2
Mass after 1000 revolutions (g)	7410.3
Loss after 1000 revolutions (%)	**26.3**

Remarks: **1.** The maximum allowable loss of 35% for granite is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: May 4, 2010

RESISTANCE TO DEGRADATION OF LARGE-SIZE AGGREGATE BY ABRASION AND IMPACT IN LOS ANGELES MACHINE (ASTM C535)

Job Number: 093-81042-00011

Golder Associates Inc.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	M-2010-2650-BULK (Bucket Number 114)

Date Received: April, 2010
Date Tested: April 22, 2010

Sampled by: N/A
Golder Lab Number: G-10-057

Grading	2
Sieve Sizes	50.0mm – 25.0mm
Mass – Before test (g)	10009.7
Number of revolutions	1000
Number of spheres (g)	12
Mass of spheres (g)	5016.2
Mass after 1000 revolutions (g)	7535.5
Loss after 1000 revolutions (%)	**24.7**

Remarks: **1.** The maximum allowable loss of 35% for granite is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: May 4, 2010

EVALUATION OF DURABILITY OF ROCK FOR EROSION CONTROL UNDER FREEZING AND THAWING CONDITIONS (ASTM D5312-04)

Job Number: 093-81042-00011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	M-2010-2630-BULK (Bucket Number 113)

Date Received: May, 2010
Date Started: June 23, 2010 for 30 cycles

Sampled by: N/A
Golder Lab No.: G-10-056

Sample No.	Mass of rock before test (g)	Mass of rock after test (g)	Loss (%)
56A	1653.8	1650.7	0.2
56B	1314.6	1313.5	0.1
56C	1110.2	1108.4	0.2
56D	1347.2	1344.1	0.2

Remarks:

Reviewed by: _____
Jeremy Rose, Laboratory Manager

Date: Auguat 16, 2010

MS 86+800

EVALUATION OF DURABILITY OF ROCK FOR EROSION CONTROL UNDER FREEZING AND THAWING CONDITIONS (ASTM D5312-04)

Job Number: 093-81042-00011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	M-2010-2650-BULK (Bucket Number 114)

Date Received: May, 2010
Date Started: June 23 for 30 cycles

Sampled by: N/A
Golder Lab No.: G-10-057

Sample No.	Mass of rock before test (g)	Mass of rock after test (g)	Loss (%)
57A	1969.5	1966.4	0.2
57B	1973.3	1970.7	0.1
57C	2072.1	2069.9	0.1
57D	1099.1	1097.7	0.1
57E	893.8	892.7	0.1

Remarks:

Reviewed by: _____
Jeremy Rose, Laboratory Manager

Date: August 16, 2010

EVALUATION OF DURABILITY OF ROCK FOR EROSION CONTROL UNDER FREEZING AND THAWING CONDITIONS (ASTM C5312)

Job Number: 093-81042-00011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-003-N249-01

Date Received: February, 2010
Date Started: March 01, 2010 for 30 cycles

Sampled by: N/A
Golder Lab No.: G-10-039

Sample No.	Mass of rock before test (g)	Mass of rock after test (g)	Loss (%)
39A	1358.3	1358.2	0.0
39B	1911.3	1910.8	0.0
39C	1848.9	1848.7	0.0
39D	1639.1	1639.0	0.0
39E	2123.3	2123.0	0.0

Remarks:

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: May 27, 2010

PETROGRAPHIC EXAMINATION OF COARSE AGGREGATE

CSA A23.2-15A / ASTM C 295

July 23, 2010
Project number: 093-81042-00011

GOLDER ASSOCIATES INC
4438 Haines Road,
Duluth, MN
USA 55811

ATTENTION: Amy Thorson, P.E.

PROJECT: Aggregate Testing – Canada Chrome

Sample	**G-10-039 (RS-003-N249-01)**

Date Received: June 21, 2010 **Sampled by:** Client

	PETROGRAPHIC DESCRIPTION/ PHYSICAL QUALITY	PERCENT BY MASS	MULTI-PLIER	PN CONTRIBUTION
GOOD	**Diorite** – Plagioclase, amphibole, some sulphides, minor epidote, occasional thin quartz veins. Medium to coarse grained, with concentrations of fine grained amphibole. Contains very thin weathering rims.	100.0	1	**100.0**
	Subtotal	**100.0**		**100.0**
FAIR	**Diorite** – Weathering rims and fine grained concentrations of amphibole	Trace	3	**Trace**
	Subtotal	**Trace**		**Trace**
	TOTALS	**100.0**	**PN**	**100.0**

Note: 1. The PN is not related to potential for Alkali-Aggregate Reaction. AAR must be assessed separately.

PETROGRAPHER: _____
A. Briggs, M.Sc., GIT

G-10-039 (RS-003-N249-01)

General

The sample consisted of crushed stone.

The particle geometry was primarily cubical with angular to subangular shape. The particle surface textures were primarily moderately rough.

Lithologic Composition

Identification of rock types and minerals was done using a stereomicroscope with magnifications from 8x to about 60x, supplemented by basic geologic diagnostic methods. Thin sections were examined but no chemical analyses were undertaken to aid in the identification of the rock types.

The sample consisted entirely of diorite with very thin weathering rims. All of the material was dense and hard to very hard.

The grain size of the diorite was 1-3 mm and the rock consisted of plagioclase, amphibole and some sulphide minerals. Fine grained epidote was scattered throughout the tin section and some quartz veining was also observed.

Engineering Characteristics

In addition to the geologic classification of the aggregate, the sample was also examined for characteristics relevant to engineering uses. Aspects such as porosity, strength, tenacity, presence or absence of vugs, voids, fissures, cracks, coatings and impurities in the particles were considered in the assignment of individual particles into various quality classifications.

Most of the particles examined were found to be of good engineering quality, being dense, strong and unweathered.

On the basis of this sorting of the sample, the relative amounts of "Good", and "Fair" quality material were determined. This enabled the determination of a Petrographic Number (or "PN"), in accordance with the method given in CSA A23.2-15A. The PN is an index of a coarse aggregate's overall physical-mechanical quality. The PN for this sample was "100".

For reference, the PN scale referenced in CSA A23.2-15A, Attachment A2, is as follows:

PN LIMITS	PRODUCT TYPE
125	Concrete Class C1, C2, F1
140 max	Other concrete classes
125	Shotcrete
125	Railroad ballast
150	Granular base
160	Select Granular sub-base

Comparison of the PN with the suggested limits given above indicates that the G-10-039 crushed stone sample would be considered to be of suitable quality for all uses noted above, including railroad ballast and is judged to be of suitable physical-mechanical engineering quality for use in a variety of applications, including concrete, asphalt and road base materials, subject to compliance with applicable specification requirements.

The aggregate would be anticipated to provide durability and strength commensurate with these ratings, when used as construction-grade aggregate.

Alkali-Aggregate Reaction (AAR) Potential

The rock type that comprised this sample was classified as diorite. This rock type contains no or very small amounts of quartz. Quartz is the primary mineral that reacts with the alkalis in the Portland cement in the alkali-aggregate reaction and thereby causing expansion and cracking of Portland cement concrete. Although no quartz was observed as a mineral constituent in the diorite, some quartz veining was observed. However, the quartz veining would not be expected to be significant enough to render the sample reactive with respect to AAR, should the material be considered for use as concrete aggregate.

Summary

The G-10-039 crushed stone sample consisted of diorite, and had a PN of 100.

On the basis of the Petrographic Examination, the aggregate is judged suitable for use in a variety of applications, subject to satisfactory compliance with applicable specifications.

Reviewed by:

A. Briggs, M. Sc., GIT

F. Shrimer, P. Geo.

MS 279+400

RELATIVE DENSITY AND ABSORPTION OF COARSE AGGREGATE (ASTM C127)

Job Number: 093-81042-011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-003-N249-01

Date Received: February, 2010
Date Tested: February 26, 2010

Sampled by: N/A
Golder Lab No.: G-10-039

Sieve Fraction (mm)	Relative Density (dry basis)	Relative Density (SSD basis)	Apparent Relative Density	Absorption (%)
50.0 – 19.0	2.95	2.96	2.98	0.3

Remarks: 1. The minimum allowable bulk specific gravity of 2.60 is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.
2. The maximum allowable absorption of 1.0% is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: March 29, 2010

MS 279+400

CLAY LUMPS AND FRIABLE PARTICLES (ASTM C142)

Job Number: 093-81042-011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-003-N249-01

Date Received: February, 2010
Date Tested: February 26, 2010

Sampled by: N/A
Golder Lab No.: G-10-039

Sieve Fraction (mm)	Mass of Sample (g)	Clay Lumps (%)	Acceptance Requirement [1]
50.0 – 19.0	5008.4	0.0	0.5 Max.

Remarks: 1.The acceptance requirement is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: March 29, 2010

MS 279+400

RESISTANCE TO DEGRADATION OF LARGE-SIZE AGGREGATE BY ABRASION AND IMPACT IN LOS ANGELES MACHINE (ASTM C535)

Job Number: 093-81042-011

Golder Associates Inc.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	**RS-003-N249-01**

Date Received: February, 2010
Date Tested: March 18, 2010

Sampled by: N/A
Golder Lab Number: G-10-039

Grading	3
Sieve Sizes	37.5mm – 19.0mm
Mass – Before test (g)	10046.8
Number of revolutions	1000
Number of spheres (g)	12
Mass of spheres (g)	4996.9
Mass after 1000 revolutions (g)	8732.1
Loss after 1000 revolutions (%)	**13.1**

Remarks: 1. The maximum allowable loss of 25% for traprock is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: March 29, 2010

MS 279+400

SOUNDNESS OF COARSE AGGREGATE USE OF SODIUM SULFATE (ASTM C88)

Job Number: 093-81042-011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-003-N249-01

Date Received: February, 2010
Date Tested: March 11 – March 18, 2010

Sampled by: N/A
Golder Lab No.: G-10-039

Sieve Fraction (mm)	Original Grading	Mass per fraction before test (g)	Loss (%)	Weighted Loss (%)	Acceptance Requirement [1]
50.0 – 37.5	0.054	2003.6	0.2	0.1	5.0 Max.
37.5 – 25.0	0.620	1023.3	1.3	0.8	
25.0 – 19.0	0.326	518.8	0.1	0.0	
	1.000		**TOTAL**	**0.9**	

Remarks: 1.The acceptance requirement is taken from Table 1-2-1of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: April 19, 2010

PETROGRAPHIC EXAMINATION OF COARSE AGGREGATE

CSA A23.2-15A / ASTM C 295

July 23, 2010

Project number: 093-81042-00011

GOLDER ASSOCIATES INC
4438 Haines Road,
Duluth, MN
USA 55811

ATTENTION: Amy Thorson, P.E.

PROJECT: Aggregate Testing – Canada Chrome

Sample	**G-10-038 (RS-002-N0310-01)**

Date Received: June 21, 2010 **Sampled by:** Client

	PETROGRAPHIC DESCRIPTION/ PHYSICAL QUALITY	PERCENT BY MASS	MULTI-PLIER	PN CONTRIBUTION
GOOD	**Gneiss** – Quartz, feldspar, biotite. Pink, medium grained, oxidation common, some sericite alteration of the feldspar.	50.7	1	**50.7**
GOOD	**Gneiss** – Quartz, feldspar, biotite. Grey, fresh, minor oxidation.	38.8	1	**38.8**
GOOD	***Subtotal***	**89.5**		**89.5**
FAIR	**Gneiss** – Pink, brittle	10.3	3	**30.9**
FAIR	***Subtotal***	**10.3**		**30.9**
POOR	**Gneiss** – Pink, brittle and weathered	0.2	6	**1.2**
POOR	***Subtotal***	**0.2**		**1.2**
	TOTALS	**100.0**	**PN**	**121.6**

Note: 1. The PN is not related to potential for Alkali-Aggregate Reaction. AAR must be assessed separately.

PETROGRAPHER: A. Briggs, M.Sc., GIT

G-10-038 (RS-002-N0310-01)

General

The sample consisted of crushed stone

The particle geometry was primarily cubical with some particles trending towards elongated morphology and angular to subangular shape. The particle surface textures were moderately rough to rough.

Lithologic Composition

Identification of rock types and minerals was done using a stereomicroscope with magnifications from 8x to about 60x, supplemented by basic geologic diagnostic methods. Thin sections were examined but no chemical analyses were undertaken to aid in the identification of the rock types.

The sample was composed entirely of gneiss, which was divided into sub-categories based on the dominating colour. Grey gneiss was composed of alternating mafic bands and grey quartzo-feldspathic bands. All of this rock type was hard, dense and competent; minor concentrations of oxidation staining within these rocks were not observed to affect the strength.

Pink gneiss consisted of dark bands alternating with primarily pink quartzo-feldspathic bands which exhibited varying degrees of sericite alteration and oxidation. Most of this rock type was strong; however, some more prominently oxidized particles were more brittle and were only of moderate to poor strength.

Engineering Characteristics

In addition to the geologic classification of the aggregate, the sample was also examined for characteristics relevant to engineering uses. Aspects such as porosity, strength, tenacity, presence or absence of vugs, voids, fissures, cracks, coatings and impurities in the particles were considered in the assignment of individual particles into various quality classifications.

Most of the particles examined were found to be of good engineering quality, being dense, strong and unweathered.

On the basis of this sorting of the sample, the relative amounts of "Good", and "Fair" quality material were determined. This enabled the determination of a Petrographic Number (or "PN"), in accordance with the method given in CSA A23.2-15A. The PN is an index of a coarse aggregate's overall physical-mechanical quality. The PN for this sample was "122".

For reference, the PN scale referenced in CSA A23.2-15A, Attachment A2, is as follows:

PN LIMITS	PRODUCT TYPE
125	Concrete Class C1, C2, F1
140 max	Other concrete classes
125	Shotcrete
125	Railroad ballast

PN LIMITS	PRODUCT TYPE
150	Granular base
160	Select Granular sub-base

The G-10-038 crushed stone sample would be considered to be of suitable quality for all uses noted above, and is judged to be of suitable physical-mechanical engineering quality for use in a variety of applications, including as railroad ballast, concrete, asphalt and road base materials, subject to compliance with applicable specification requirements.

The aggregate would be anticipated to provide durability and strength commensurate with these ratings, when used as construction-grade aggregate.

Alkali-Aggregate Reaction Potential

All of the rocks comprising this sample have been identified as "potentially alkali-reactive", meaning that they may contribute under certain circumstances to a deleterious expansive reaction in concrete termed *"Alkali-Aggregate Reaction"* (AAR).

Should the material be considered for use as concrete aggregate, periodic assessment of the aggregate's AAR characteristics is recommended utilizing the procedures given in CSA A23.2-14A (or ASTM as C 1293) ("Concrete Prism") and CSA A23.2-25A (ASTM C 1260) ("Accelerated Mortar Bar").

Summary

The G-10-038 crushed stone sample consisted of gneiss, and had a PN of 122.

On the basis of the Petrographic Examination, the aggregate is judged suitable for use in a variety of applications, including railroad ballast, subject to satisfactory compliance with applicable specifications.

Reviewed by:

A. Briggs, M. Sc., GIT

F. Shrimer, P. Geo.

Golder Associates

MS 312+000

CELEBRATING 50 YEARS in 2010

RESISTANCE TO DEGRADATION OF LARGE-SIZE AGGREGATE BY ABRASION AND IMPACT IN LOS ANGELES MACHINE (ASTM C535)

Job Number: 093-81042-011

Golder Associates Inc.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-002-N0310-01

Date Received: February, 2010
Date Tested: March 18, 2010

Sampled by: N/A
Golder Lab Number: G-10-038

Grading	3
Sieve Sizes	37.5mm – 19.0mm
Mass – Before test (g)	10021.2
Number of revolutions	1000
Number of spheres (g)	12
Mass of spheres (g)	4996.9
Mass after 1000 revolutions (g)	7712.4
Loss after 1000 revolutions (%)	**23.0**

Remarks: **1.** The maximum allowable loss of 35% for granite is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: March 29, 2010

50 BEST EMPLOYERS IN CANADA 2009 REPORT ON BUSINESS

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MS 312+000

CELEBRATING 50 YEARS in 2010

SOUNDNESS OF COARSE AGGREGATE USE OF SODIUM SULFATE (ASTM C88)

Job Number: 093-81042-011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-002-N0310-01

Date Received: February, 2010
Date Tested: March 11 – March 18, 2010

Sampled by: N/A
Golder Lab No.: G-10-038

Sieve Fraction (mm)	Original Grading	Mass per fraction before test (g)	Loss (%)	Weighted Loss (%)	Acceptance Requirement [1]
50.0 – 37.5	0.054	2007.1	0.3	0.1	5.0 Max.
37.5 – 25.0	0.620	1022.2	0.0	0.0	
25.0 – 19.0	0.326	519.1	0.3	0.0	
	1.000		**TOTAL**	**0.1**	

Remarks: 1.The acceptance requirement is taken from Table 1-2-1of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: April 19, 2010

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MS-312+000 Rejected as material site

MS 312+000

EVALUATION OF DURABILITY OF ROCK FOR EROSION CONTROL UNDER FREEZING AND THAWING CONDITIONS (ASTM C5312)

Job Number: 093-81042-00011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-002-N0310-01

Date Received: February, 2010
Date Started: March 01, 2010 for 30 cycles

Sampled by: N/A
Golder Lab No.: G-10-038

Sample No.	Mass of rock before test (g)	Mass of rock after test (g)	Loss (%)
38A	1783.1	1782.8	0.0
38B	1429.6	1429.1	0.0
38C	1974.8	1973.9	0.1
38D	2232.3	2231.4	0.0
38E	2067.7	2066.9	0.0

Remarks:

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: May 27, 2010

Golder Associates

CELEBRATING 50 YEARS in 2010

CLAY LUMPS AND FRIABLE PARTICLES (ASTM C142)

Job Number: 093-81042-011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-002-N0310-01

Date Received: February, 2010
Date Tested: February 26, 2010

Sampled by: N/A
Golder Lab No.: G-10-038

Sieve Fraction (mm)	Mass of Sample (g)	Clay Lumps (%)	Acceptance Requirement [1]
50.0 – 19.0	4999.7	0.0	0.5 Max.

Remarks: 1.The acceptance requirement is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: March 29, 2010

50 BEST EMPLOYERS IN CANADA 2009 REPORT ON BUSINESS

50 BEST MANAGED COMPANIES

Golder Associates

CELEBRATING 50 YEARS in 2010

RELATIVE DENSITY AND ABSORPTION OF COARSE AGGREGATE (ASTM C127)

Job Number: 093-81042-011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-002-N0310-01

Date Received: February, 2010
Date Tested: February 26, 2010

Sampled by: N/A
Golder Lab No.: G-10-038

Sieve Fraction (mm)	Relative Density (dry basis)	Relative Density (SSD basis)	Apparent Relative Density	Absorption (%)
50.0 – 19.0	2.65	2.66	2.68	0.5

Remarks:
1. The minimum allowable bulk specific gravity of 2.60 is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.
2. The maximum allowable absorption of 1.0% is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: March 29, 2010

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CLAY LUMPS AND FRIABLE PARTICLES (ASTM C142)

Job Number: 093-81042-011

Golder Associates Ltd.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	RS-002-N0310-01

Date Received: February, 2010
Date Tested: February 26, 2010

Sampled by: N/A
Golder Lab No.: G-10-038

Sieve Fraction (mm)	Mass of Sample (g)	Clay Lumps (%)	Acceptance Requirement [1]
50.0 – 19.0	4999.7	0.0	0.5 Max.

Remarks: 1.The acceptance requirement is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: March 29, 2010

Golder Associates

CELEBRATING 50 YEARS in 2010

RESISTANCE TO DEGRADATION OF LARGE-SIZE AGGREGATE BY ABRASION AND IMPACT IN LOS ANGELES MACHINE (ASTM C535)

Job Number: 093-81042-011

Golder Associates Inc.
4438 Haines Road
Duluth, Minnesota
USA 55811

ATTENTION: Ms. Amy Thorson

PROJECT: Aggregate Testing – Canada Chrome

Sample ID	**RS-002-N0310-01**

Date Received: February, 2010
Date Tested: March 18, 2010

Sampled by: N/A
Golder Lab Number: G-10-038

Grading	3
Sieve Sizes	37.5mm – 19.0mm
Mass – Before test (g)	10021.2
Number of revolutions	1000
Number of spheres (g)	12
Mass of spheres (g)	4996.9
Mass after 1000 revolutions (g)	7712.4
Loss after 1000 revolutions (%)	**23.0**

Remarks: **1.** The maximum allowable loss of 35% for granite is taken from Table 1-2-1 of the AREMA Manual for Railway Engineering.

Reviewed by: _____
John A. Watkins, Laboratory Services Manager

Date: March 29, 2010

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