Appendix B

Bridge Material Testing Reports

Client: CH2M Hill
Project: Latah Bridge Rehabilitation Study
Report Date: November 8, 2011

CTLGroup Project No.: 150721
CTLGroup Project Mgr.: Q. Li
Technician: P. Brindise
Approved By: J. L. Jones

ASTM C 42 / C 42M - 04
Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
Section 7: Cores for Compressive Strength

Specimen Identification

Client Identification	A1	A5
CTLGroup Identification	2970403	2970404
Date Core Obtained from the Field	10/4/2011	10/4/2011
Date Core Placed in Sealed Bag after Saw Cutting	10/24/2011	10/24/2011
Date Core was Tested	10/31/2011	10/31/2011

Concrete Description

Nominal Maximum Aggregate Size, in.	1 1/2	1 1/2
Concrete Age at Test	~ 100 yrs	~ 100 yrs
Moisture Condition at Test	Note 1	Note 1
Orientation of Core Axis in Structure	Note 3	Note 3

Concrete Dimensions

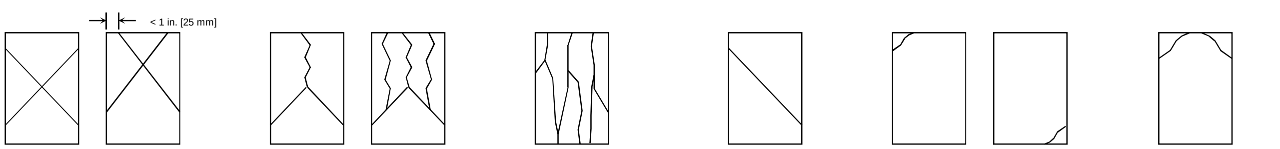
Length of Core as Drilled, in.	9	8 3/4
Diameter 1, in.	3.78	3.78
Diameter 2, in.	3.78	3.78
Average Diameter, in.	3.78	3.78
Cross-Sectional Area, in^2	11.22	11.22
Length Trimmed, in.	5.9	7.1
Length Capped, in.	5.9	7.3

Density, lb/ft^3	154	154

Compressive Strength and Fracture Pattern

Maximum Load, lb	102,400	121,500
Uncorrected Compressive Strength, psi	9,130	10,830
Ratio of Capped Length to Diameter	1.57	1.93
Correction Factor	0.97	1.00
Corrected Compressive Strength, psi	**8,860**	**10,830**
Fracture Pattern	Type 1	Type 1

Schematic of Typical Fracture Patterns



Type 1 — Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2 — Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3 — Columnar vertical cracking through both ends, no well-formed cones

Type 4 — Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5 — Side fractures at top or bottom (occur commonly with unbonded caps)

Type 6 — Similar to Type 5 but end of cylinder is pointed

Notes:
1. Per ASTM C42, test samples were wet saw-cut and then sealed in bag for at least 5 days prior to testing.
2. Per Section 7.1, the preferred minimum core diameter is three times the nominal maximum size of the coarse aggregate, but it should be at least two times the nominal maximum size of the coarse aggregate.
3. Cores were taken from the top surface of arch ribs at approximately the 1/4 points of the arches. The core axes are transverse to the axis of the arches.
4. This report represents specifically the samples submitted.
5. This report may not be reproduced except in its entirety.

Client: CH2M Hill
Project: Latah Bridge Rehabilitation Study
Report Date: November 8, 2011

CTLGroup Project No.: 150721
CTLGroup Project Mgr.: Q. Li
Technician: P. Brindise
Approved By: J. L. Jones

ASTM C 42 / C 42M - 04
Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
Section 7: Cores for Compressive Strength

Specimen Identification

Client Identification	B2	C7
CTLGroup Identification	2970405	2970406
Date Core Obtained from the Field	10/4/2011	10/4/2011
Date Core Placed in Sealed Bag after Saw Cutting	10/24/2011	10/24/2011
Date Core was Tested	10/31/2011	10/31/2011

Concrete Description

Nominal Maximum Aggregate Size, in.	2	1 1/2
Concrete Age at Test	~ 100 yrs	~ 100 yrs
Moisture Condition at Test	Note 1	Note 1
Orientation of Core Axis in Structure	Note 3	Note 3

Concrete Dimensions

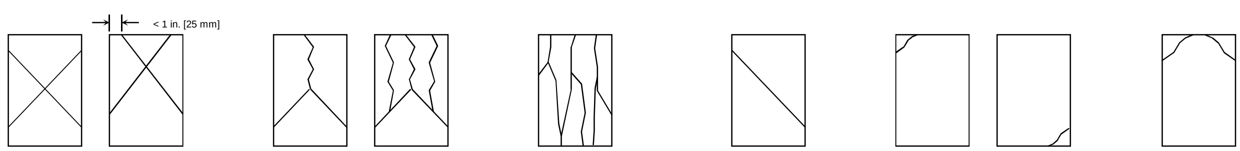
Length of Core as Drilled, in.	9	8
Diameter 1, in.	3.77	3.78
Diameter 2, in.	3.78	3.79
Average Diameter, in.	3.78	3.79
Cross-Sectional Area, in^2	11.22	11.28
Length Trimmed, in.	6.3	6.6
Length Capped, in.	6.4	6.8

Density, lb/ft^3	152	151

Compressive Strength and Fracture Pattern

Maximum Load, lb	82,800	105,000
Uncorrected Compressive Strength, psi	7,380	9,310
Ratio of Capped Length to Diameter	1.70	1.79
Correction Factor	0.98	1.00
Corrected Compressive Strength, psi	**7,230**	**9,310**
Fracture Pattern	Type 2	Type 1

Schematic of Typical Fracture Patterns



Type 1 Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2 Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3 Columnar vertical cracking through both ends, no well-formed cones

Type 4 Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5 Side fractures at top or bottom (occur commonly with unbonded caps)

Type 6 Similar to Type 5 but end of cylinder is pointed

Notes:
1. Per ASTM C42, test samples were wet saw-cut and then sealed in bag for at least 5 days prior to testing.
2. Per Section 7.1, the preferred minimum core diameter is three times the nominal maximum size of the coarse aggregate, but it should be at least two times the nominal maximum size of the coarse aggregate.
3. Cores were taken from the top surface of arch ribs at approximately the 1/4 points of the arches. The core axes are transverse to the axis of the arches.
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Client: CH2M Hill
Project: Latah Bridge Rehabilitation Study
Report Date: November 8, 2011

CTLGroup Project No.: 150721
CTLGroup Project Mgr.: Q. Li
Technician: P. Brindise
Approved By: J. L. Jones

ASTM C 42 / C 42M - 04
Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
Section 7: Cores for Compressive Strength

Specimen Identification

Client Identification	D	D4	D8
CTLGroup Identification	2970402	2970407	2970408
Date Core Obtained from the Field	10/4/2011	10/4/2011	10/4/2011
Date Core Placed in Sealed Bag after Saw Cutting	10/24/2011	10/24/2011	10/24/2011
Date Core was Tested	10/31/2011	10/31/2011	10/31/2011

Concrete Description

Nominal Maximum Aggregate Size, in.	1 1/2	1 1/2	1 1/2
Concrete Age at Test	~ 100 yrs	~ 100 yrs	~ 100 yrs
Moisture Condition at Test	Note 1	Note 1	Note 1
Orientation of Core Axis in Structure	Vertical	Vertical	Vertical

Concrete Dimensions

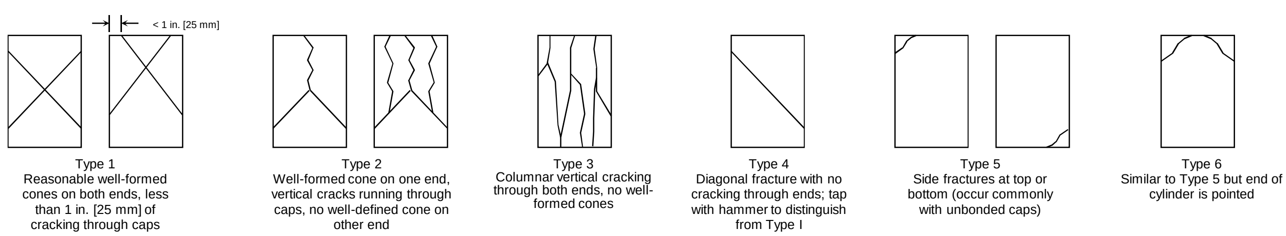
Length of Core as Drilled, in.	9 1/2	8 1/4	7 1/4
Diameter 1, in.	3.77	3.78	3.78
Diameter 2, in.	3.78	3.78	3.77
Average Diameter, in.	3.78	3.78	3.78
Cross-Sectional Area, in^2	11.22	11.22	11.22
Length Trimmed, in.	6.2	4.4	5.7
Length Capped, in.	6.4	4.6	5.9

Density, lb/ft^3	151	149	153

Compressive Strength and Fracture Pattern

Maximum Load, lb	96,400	115,400	113,400
Uncorrected Compressive Strength, psi	8,590	10,290	10,110
Ratio of Capped Length to Diameter	1.69	1.22	1.57
Correction Factor	0.98	0.92	0.97
Corrected Compressive Strength, psi	**8,420**	**9,470**	**9,810**
Fracture Pattern	Type 2	Type 1	Type 2

Schematic of Typical Fracture Patterns



Notes:
1. Per ASTM C42, test samples were wet saw-cut and then sealed in bag for at least 5 days prior to testing.
2. Per Section 7.1, the preferred minimum core diameter is three times the nominal maximum size of the coarse aggregate, but it should be at least two times the nominal maximum size of the coarse aggregate.
3. This report represents specifically the samples submitted.
4. This report may not be reproduced except in its entirety.

CTL GROUP

Client:	**CH2M HILL**	CTL Project No:	**150721**
Project:	**Chemical Analysis**	CTL Project Mgr.:	**Qiang Li**
		Analyst:	**C. Wedzicha**
Contact:	**John Hinman**	Approved:	*R W Stevenson*
Submitter:	**John Hinman**	Date Analyzed:	**November 2, 2011**
Date Received:	**October 24, 2011**	Date Reported:	**November 2, 2011**

REPORT of ACID-SOLUBLE CHLORIDE

Sample Identification			Determined Chloride	
CTL ID	Client ID	Description	(wt% sample)	(ppm Cl)
2970409	Core A, 0.5"depth	Concrete	0.034	340
2970410	Core A, 1.5"depth	Concrete	0.036	360
2970411	Core A, 3.0"depth	Concrete	0.004	40
2970412	Core B, 0.5"depth	Concrete	0.004	40
2970413	Core B, 1.5"depth	Concrete	0.003	30
2970414	Core B, 3.0"depth	Concrete	0.002	20
2970415	Core C, 0.5"depth	Concrete	0.020	200
2970416	Core C, 1.5"depth	Concrete	0.011	110
2970417	Core C, 3.0"depth	Concrete	0.001	10

Notes:

1. This analysis represents specifically the samples submitted on a dry (45°C) basis.
2. Analysis by potentiometric titration with silver nitrate. (ASTM C 1152-04ε1)
3. This report may not be reproduced except in its entirety.

CTLGROUP

Client:	**CH2M HILL**	CTL Project No:	**150721**
Project:	**Chemical Analysis**	CTL Project Mgr.:	**Qiang Li**
		Analyst:	**C.Wedzicha**
Contact:	**John Hinman**	Approved:	*R W Stevenson*
Submitter:	**John Hinman**	Date Analyzed:	**October 31, 2011**
Date Received:	**October 24, 2011**	Date Reported:	**November 1, 2011**

REPORT of ACID-SOLUBLE CHLORIDE

Sample Identification			Determined Chloride	
CTL ID	Client ID	Description	(wt% sample)	(ppm Cl)
2970418	Powder 1A	Concrete Powder	0.280	2800
2970419	Powder 1B	Concrete Powder	0.091	910
2970420	Powder 1C	Concrete Powder	0.011	110
2970421	Powder 2A	Concrete Powder	0.010	100
2970422	Powder 2B	Concrete Powder	0.001	10
2970423	Powder 2C	Concrete Powder	<0.001	<10
2970424	Powder 3A	Concrete Powder	<0.001	<10
2970425	Powder 3B	Concrete Powder	0.001	10
2970426	Powder 3C	Concrete Powder	0.001	10
2970427	Powder 4A	Concrete Powder	0.175	1750
2970428	Powder 4B	Concrete Powder	0.135	1350
2970429	Powder 4C	Concrete Powder	0.010	100
2970430	Powder 5A	Concrete Powder	0.001	10
2970431	Powder 5B	Concrete Powder	<0.001	<10
2970432	Powder 5C	Concrete Powder	<0.001	<10
2970433	Powder 6A	Concrete Powder	<0.001	<10
2970434	Powder 6B	Concrete Powder	<0.001	<10
2970435	Powder 6C	Concrete Powder	0.001	10
2970436	Powder 7A	Concrete Powder	0.221	2210
2970437	Powder 7B	Concrete Powder	0.028	280
2970438	Powder 7C	Concrete Powder	0.006	60
2970439	Powder 8A	Concrete Powder	0.037	370
2970440	Powder 8B	Concrete Powder	0.005	50
2070441	Powder 8C	Concrete Powder	<0.001	<10

Notes:
1. This analysis represents specifically the samples submitted as received.
2. Analysis by potentiometric titration with silver nitrate. (ASTM C 1152-04ε1)
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Client:	**CH2M HILL**	CTL Project No:	**150721**
Project:	**Chemical Analysis**	CTL Project Mgr.:	**Qiang Li**
		Analyst:	**C.Wedzicha**
Contact:	**John Hinman**	Approved:	*R W Stevenson*
Submitter:	**John Hinman**	Date Analyzed:	**October 31, 2011**
Date Received:	**October 24, 2011**	Date Reported:	**November 1, 2011**

REPORT of ACID-SOLUBLE CHLORIDE

Sample Identification			Determined Chloride	
CTL ID	Client ID	Description	(wt% sample)	(ppm Cl)
2970442	Powder 9A	Concrete Powder	0.022	220
2970443	Powder 9B	Concrete Powder	0.018	180
2970444	Powder 9C	Concrete Powder	0.010	100
2970445	Powder 10A	Concrete Powder	0.002	20
2970446	Powder 10B	Concrete Powder	<0.001	<10
2970447	Powder 10C	Concrete Powder	<0.001	<10
2970448	Powder 11A	Concrete Powder	0.001	10
2970449	Powder 11B	Concrete Powder	0.002	20
2970450	Powder 11C	Concrete Powder	<0.001	<10
2970451	Powder 12A	Concrete Powder	0.101	1010
2970452	Powder 12B	Concrete Powder	0.057	570
2970453	Powder 12C	Concrete Powder	0.001	10

Notes:

1. This analysis represents specifically the samples submitted as received.
2. Analysis by potentiometric titration with silver nitrate. (ASTM C 1152-04ε1)
3. This report may not be reproduced except in its entirety.

Copy No. 1

Report for
CH2M HILL

CTLGroup Project No. 150721

Petrographic Examination of a Concrete Core Sample from Latah Bridge, Spokane, Washington

November 16, 2011

Submitted by:
Qiang Li
Victoria A. Jennings

COA # 1869

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REPORT OF PETROGRAPHIC EXAMINATION

Date: November 16, 2011

CTLGroup Project No.: 150721

Petrographic Examination of a Concrete Core Sample from Latah Bridge, Spokane, Washington

Eleven concrete cores and thirty-six powder samples, listed in Table 1, were received on October 19, 2011, from Mr. John Hinman of CH2M HILL, Boise, Idaho. The concrete samples were reportedly taken from a concrete arch bridge, Latah Bridge in Spokane, Washington. Various testing was requested (see Table 1) to evaluate the condition of the 98-year old bridge. Mr. Hinman indicated that nearly all cores were taken from the top surface of arch ribs at approximately the ¼ points of the arch (the core axes are transverse to the axis of the arch). Core D was taken from the concrete deck; the axis of the core is vertical to the deck surface (through the thickness of the deck).

Petrographic examination (ASTM C856) was requested on Core B6 (Figs. 1 and 2) to evaluate the quality and condition of the concrete and determine the following concrete characteristics:

- color of the mortar just inside of the original exterior surface, and within the body of the core, using the Munsell color system,
- depth of paste carbonation,
- aggregate composition and approximate grading,
- occurrence of alkali-silica reaction,
- air content,
- cement properties, and
- water-cement ratio.

Table 1 Requested Testing for Submitted Concrete Cores and Powder Samples

Sample ID	ASTM C856	ASTM C42	ASTM C1152
Core B6	X	-	-
Core A	-	-	X (0.5", 1.5" and 3" depths)
Core B	-	-	X (0.5", 1.5" and 3" depths)
Core C	-	-	X (0.5", 1.5" and 3" depths)
Core D	-	X	-
Core A1	-	X	-
Core A5	-	X	-
Core B2	-	X	-
Core C7	-	X	-
Core D4	-	X	-
Core D8	-	X	-
Powder 1	-	-	X (1A, 1B, and 1C)
Powder 2	-	-	X (2A, 2B, and 2C)
Powder 3	-	-	X (3A, 3B, and 3C)
Powder 4	-	-	X (4A, 4B, and 4C)
Powder 5	-	-	X (5A, 5B, and 5C)
Powder 6	-	-	X (6A, 6B, and 6C)
Powder 7	-	-	X (7A, 7B, and 7C)
Powder 8	-	-	X (8A, 8B, and 8C)
Powder 9	-	-	X (9A, 9B, and 9C)
Powder 10	-	-	X (10A, 10B, and 10C)
Powder 11	-	-	X (11A, 11B, and 11C)
Powder 12	-	-	X (12A, 12B, and 12C)

Reports of compressive strength testing (ASTM C42) and acid-soluble chloride content (ASTM C1152) were submitted to Mr. Hinman on November 9, 2011, under separate covers.

FINDINGS AND CONCLUSIONS

Based on petrographic examination, the concrete represented by Core B6 is judged to be of fairly good quality and is in good condition. No evidence of deleterious reactions was observed.

The concrete is well consolidated and exhibits no aggregate segregation (Fig. 3). Additional findings and descriptions of the core are provided in the attached petrographic examination data sheets.

The determined Munsell color of the mortar within the core sample and depth of carbonation are presented in Table 2.

Table 2 Mortar Color and Depth of Paste Carbonation in Core B6

	Core B6	
Location Within Core	**Munsell Notation**	**Descriptive Name**
Subsurface	2.5Y 7/1	Light gray
Near-surface	2.5Y 8/2	Pale yellow
Body	5Y 8/1 overall; locally 5Y 7/1 or N9 around some agg. particles	Yellowish gray overall; locally light gray or white around some agg. particles
Depth of carbonation	Approximately 1 mm (0.04 in.) along much of the exterior surface, locally as deep as 13 mm (0.5 in.) near sub-surface voids and microcracks (Fig. 4)	

The aggregate in the core is comprised of siliceous gravel coarse aggregate and natural sand fine aggregate. The coarse aggregates are hard and dense, comprised of sandstone, quartzite, basalt, and other igneous and sedimentary rocks. The fine aggregates are also hard and dense, comprised of similar rock types as the coarse aggregate. The coarse aggregate in the core appears somewhat unevenly graded to an observed top size of 30 mm (1.2 in.); the volume of intermediate-sized aggregate appears relatively low.

No evidence of alkali-silica reaction (ASR), such as reaction rims, ASR gel, or internal aggregate microcracking, is observed in the core. Although some quartzite particles (which are potentially ASR reactive) are observed in the concrete, there is no evidence indicating the rock is experiencing deleterious reactions.

The concrete is not air-entrained, based on the scarcity of small, spherical voids in the hardened cement paste. Air content is estimated at 1 to 2% (Fig. 5).

A small amount of unhydrated and partially hydrated portland cement clinker particles, estimated 2 to 4% by volume, is observed in the cement paste. The particles are very coarse, measured up to 0.2 mm (0.008 in.) across (Fig. 6). Belite nests (clusters of rounded belite crystals in an aluminoferrite matrix) are also observed in the paste. Relics of in-situ hydrated cement clinker particles are common. The coarse-ground nature of the cement and presence of belite nests are consistent with portland cement commonly used prior to the 1940s. The observed scarcity of medium-sized unhydrated clinker particles, frequency of relic cement grains, and paste properties that are better than thin-section observations would suggest, indicate that the cement likely continued to hydrate with exposure to moisture through life the of the concrete structure. Estimated water-cement ratio (w/c) is moderate to moderately high (0.50 to 0.60), based on the microscopical and physical paste properties of the hardened cement paste. However, the estimation is speculative due to the advanced hydration of cement in the concrete. Paste in the core is hard overall, and locally soft around some aggregate particles, with subvitreous luster and moderately low to low water absorbency overall. Paste-aggregate bond is moderately tight.

METHODS OF TEST

Petrographic Examination

Petrographic examination of the provided sample was performed in accordance with ASTM C 856, "Standard Practice for Petrographic Examination of Hardened Concrete." The core was visually inspected and photographed as received. A slice was cut longitudinally from the core and one of the resulting sides of the slice was ground (lapped) to produce a smooth, flat, semi-polished surface. Lapped and freshly broken surfaces of the concrete were examined using a stereomicroscope at magnifications up to 90X.

For thin-section study, a small rectangular block was cut from the middle portion of the core, and one side of the block was lapped to produce a smooth, flat surface. The block was cleaned and dried, and the prepared surface was mounted on a ground glass microscope slide with epoxy resin. After the epoxy hardened, the thickness of the mounted block was reduced to approximately 20 μm (0.0008 in.). The resulting thin section was examined using a polarized-light (petrographic) microscope at magnifications up to 400X to study aggregate and paste mineralogy and microstructure.

Estimated water-cement ratio (w/c), when reported, is based on observed concrete and paste properties including, but not limited to: 1) relative amounts of residual (unhydrated and partially hydrated) portland cement clinker particles, 2) amount and size of calcium hydroxide crystals, 3) paste hardness, color, and luster, 4) paste-aggregate bond, and 5) relative absorbency of paste as indicated by the readiness of a freshly fractured surface to absorb applied water droplets. These techniques have been widely used by industry professionals to estimate w/c.

Depth and pattern of paste carbonation was determined by application of a pH indicator solution (phenolphthalein) to freshly cut concrete surfaces. The solution imparts a deep magenta stain to high pH, non-carbonated paste. Carbonated paste does not change color.

Mortar color determination

Mortar color was evaluated by comparison to Munsell color charts; the Munsell numerical notation was determined by matching the mortar to the closest colored paint chip on the Munsell chart. Descriptive color names were assigned to the Munsell numerical designations in accordance with the Geological Society of America Rock-Color Chart.

Qiang Li
Petrography Group

Victoria A. Jennings
Victoria A. Jennings
Petrography Group

QL/VAJ/hma

Notes:
1. Results refer specifically to the sample submitted.
2. This report may not be reproduced except in its entirety.
3. The sample will be retained for 30 days, after which it will be discarded unless we hear otherwise from you.

1a. Exterior surface.

1b. Interior surface.

Fig. 1 End surfaces of Core B6, as received.

Fig. 2 Side view of Core B6 as received. Exterior surface at left.

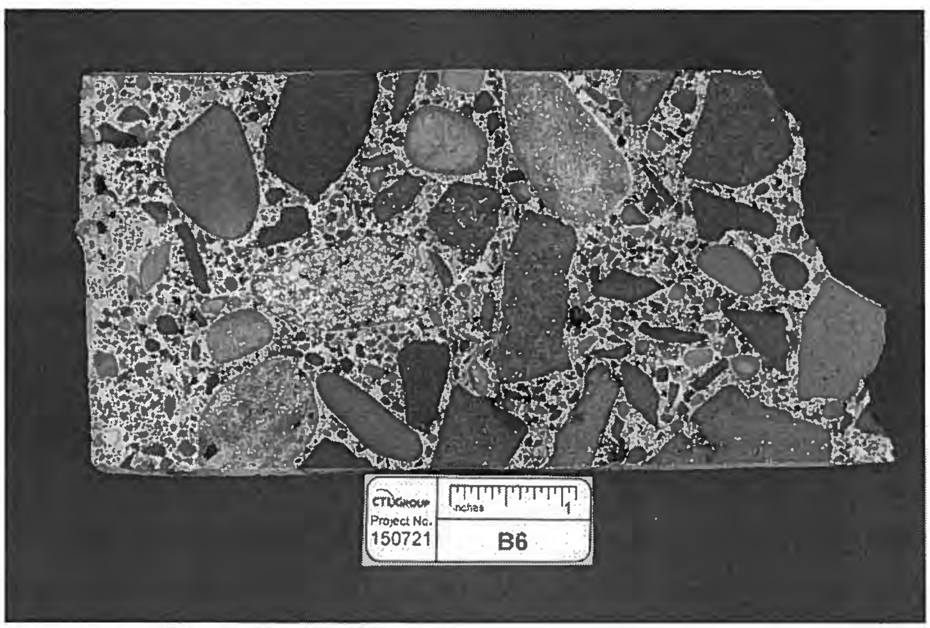

Fig. 3 Cut and lapped section of Core B6. Exterior surface at left.

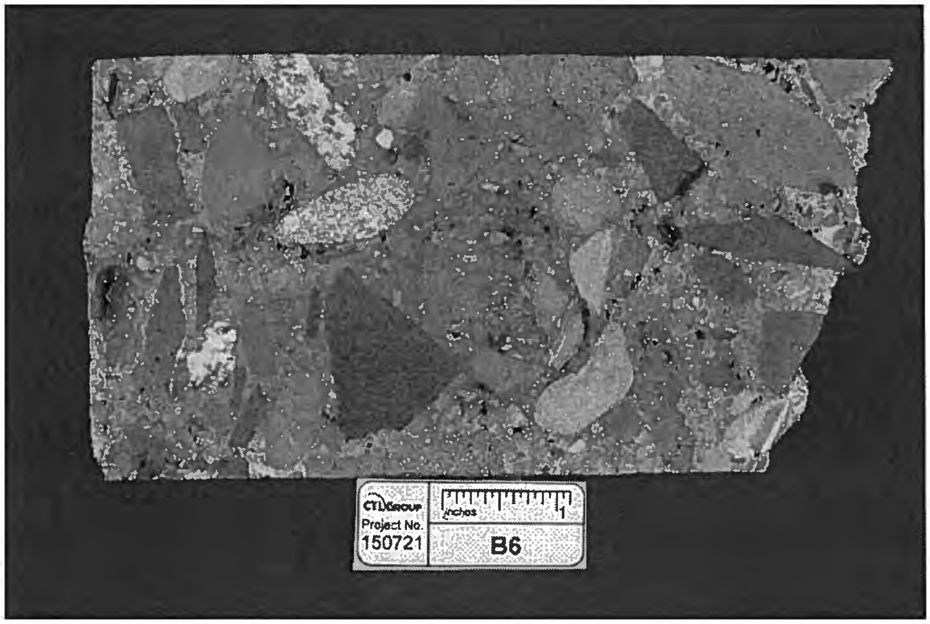

Fig. 4 **Saw-cut cross-section of Core B6, exterior surface at left, stained with pH indicator (phenolphthalein) solution. The solution imparts a deep magenta stain to high pH, non-carbonated paste. Carbonated paste does not change color.**

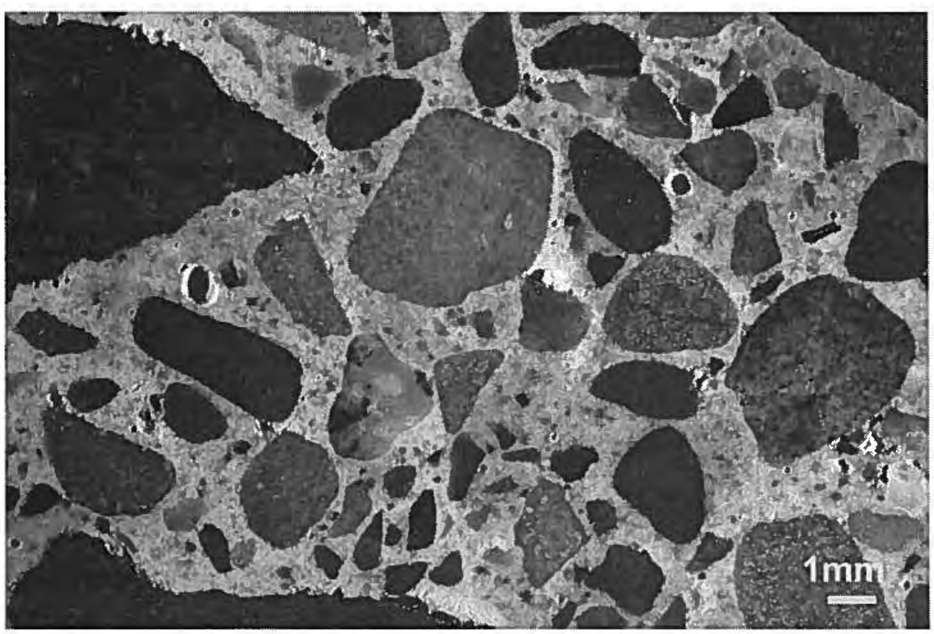

Fig. 5 **Close-up view of lapped section of Core B6, showing non-air entrained concrete.**

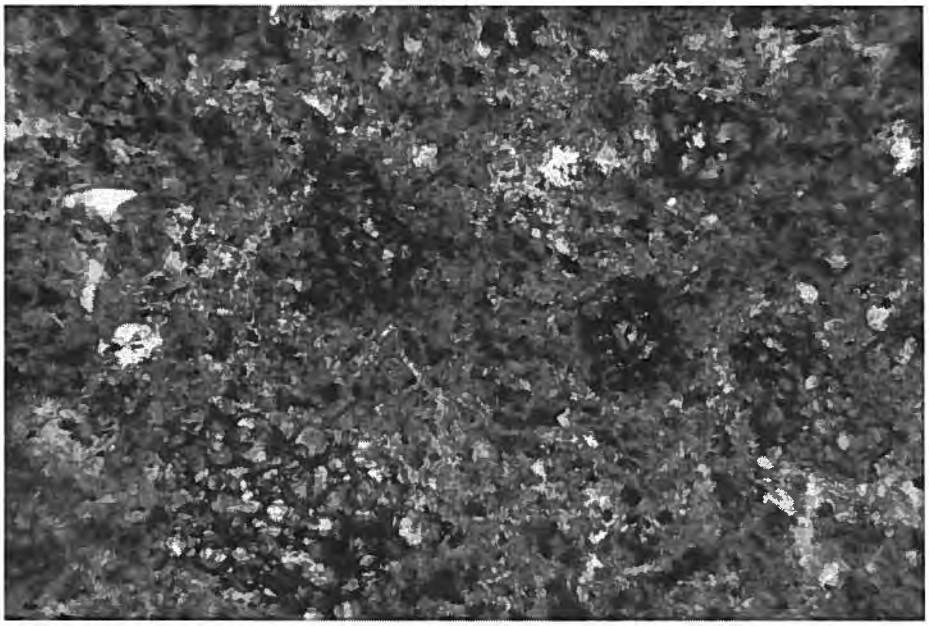

Fig. 6 Transmitted light photomicrograph of Core B6, showing paste microstructure. Red arrows indicate coarse unhydrated and partially hydrated portland cement clinker particles. Field of view is approximately 0.7 mm (0.03 in.). Plane-polarized light.

PETROGRAPHIC EXAMINATION OF HARDENED CONCRETE, ASTM C 856

STRUCTURE: Concrete Arch Bridge — *DATE RECEIVED*: October 19, 2011

LOCATION: Spokane, Washington — *EXAMINED BY*: Q. Li

SAMPLE

Client Identification: B6.

CTLGroup Identification: 2970401.

Dimensions: Core diameter = 96 mm (3.8 in.). Core length = 155 to 183 mm (6.1 to 7.2 in.); partial rib thickness.

Exterior End: Relatively flat and slightly rough surface, covered with white paint.

Interior End: Rough and uneven, fractured surface. Paste is light to medium beige and hard.

Cracks, Joints, Large Voids: Several irregularly-shaped voids are noted, measuring up to 17 mm (0.7 in.) long and 4 mm (0.2 in.) wide. No major cracks or joints are observed.

Reinforcement: None observed.

AGGREGATES

Coarse: Partially crushed natural gravel composed mainly of sandstone, quartzite, basalt, and other igneous and sedimentary rocks.

Fine: Natural sand composed mainly of sandstone, quartzite, quartz, basalt, and other minerals and rocks.

Gradation & Top Size: Visually appears to be unevenly graded to an observed top size of 30 mm (1.2 in.). The volume of intermediate-sized aggregate appears relatively low.

Shape, Texture, Distribution: Coarse- sub-angular to rounded, and equant to slightly elongated, with smooth surfaces; distribution is uniform. Fine- sub-angular to rounded, and mostly equant, with smooth to slightly rough surfaces; distribution is uniform.

PASTE

Color: In the outer 1 to 2 mm (0.04 to 0.08 in.) region, Munsell color designation is 2.5Y 7/1 (light gray). In the region between 2 to 10 mm (0.08 to 0.4 in.), color is locally Munsell 2.5Y 8/2 (pale yellow). In body of core, overall color is Munsell 5Y 8/1 (yellowish gray), and locally 5Y 7/1 (light gray) or N9 (white) around some aggregate particles.

Hardness: Hard overall; locally soft in white paste around some aggregate particles.

Luster: Subvitreous.

Paste-Aggregate Bond: Moderately tight.

Air Content: Estimated 1 to 2%. Concrete is not air-entrained, based on the scarcity of small, spherical voids in the hardened cement paste.

Depth of Carbonation: Approximately 1 mm (0.04 in.) along much of the exterior surface; locally as deep as 13 mm (0.5 in.) near sub-surface voids and microcracks.

Calcium Hydroxide*: Overall estimated 10 to 20%, generally comprised of medium to large sized crystals and patches distributed throughout cement paste and along periphery of aggregate particles. Distribution is somewhat non-uniform, and volume is locally lower due to leaching.

Residual Portland Cement Clinker Particles*: Estimated 2 to 4% unhydrated and partially hydrated portland cement clinker particles. The size of the particles is somewhat coarse, measured up to 0.2 mm (0.008 in.) across. Relics of in-situ hydrated clinker particles are common.

Supplementary Cementitious Materials*: None observed.

Secondary Deposits: Ettringite crystals line or completely fill some voids.

MICROCRACKING: A few vertical microcracks extend from the exterior surface to depths of up to 30 mm (1.2 in.), passing through aggregate particles. A 10 mm (0.04 in.) long, surface-parallel microcrack extends around aggregate particles at a depth of 3 mm (0.1 in.) from the exterior surface. Short, discontinuous, randomly-oriented microcracks are common in cement paste; these microcracks are not related to any deleterious mechanisms.

ESTIMATED WATER-CEMENT RATIO: Moderate to moderately high (0.50 to 0.60), based on the microscopical and physical properties of the hardened cement paste. However, the estimation is speculative due to the advanced hydration of cement in the 98-year old concrete.

MISCELLANEOUS: Cement paste exhibits moderately low to low water absorbency overall; locally high in the regions of white paste.

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*percent by volume of paste