3 WALL AND CORE SAMPLING, INSPECTION, AND DESCRIPTION

Two sections of the intermediate-scale grout monolith tank wall were removed during destructive grout–wall bond testing on April 1, 2011, as described in Section 2, enabling visual inspection of the three lifts and pours within the lifts.

Additionally, three cores were collected from pilot holes drilled on April 21, 2011 at the locations shown in Figure 3-1 for visual inspection of cracks, matrix color changes, and vugs. The three 2.5-cm [1-in]-diameter pilot holes were wet cored: one control hole was cored in a location free from surficial cracks (Corehole 7) and two holes (Coreholes 8 and 9) were cored at the intersection of surficial cracks. Corehole 7 is located in a region that only received the first and second pours of Lift 3, and not the third and final pour. Corehole 8 targets the intersection of a long radial crack with a long curvilinear crack that nearly parallels the perimeter of the monolith on the southeast side. Corehole 9 targets the *en echelon* ramp between two long, linear cracks that nearly dissect the monolith into two equally sized parts and their intersection with a long, large-aperture radial crack. The term *en echelon* refers to that characteristic of a crack family in which each crack is positioned successively to the side of its adjacent crack(s) to form a steplike series.

The three pilot holes and intersecting cracks were filled with blue-dyed epoxy during May 2011, prior to being overcored with a 7.6-cm [3-in]-diameter core barrel on May 23, 2011. This approach preserved crack distribution and aperture information previously available only for cracks intersecting the surface of the grout monolith.

3.1 Wet-Coring and Water-Flow Observations

An unmeasured quantity of water was injected into the intermediate-scale grout monolith during wet-coring operations on April 21, 2011, and within 40 minutes, water was observed weeping from the sidewalls of the monolith where the tank walls had been removed (Figure 3-2). Observers were not stationed to watch weeps develop, so the timing of breakthrough was not captured. The pilot coreholes were dried the week of April 25, 2011 using a wet/dry vacuum in preparation for initial pilot hole epoxying on May 3, 2011.

A torrential rainstorm passed over SwRI during midmorning hours of May 12, 2011, causing water to reinvade the grout monolith. On the morning of May 13, 2011, water was again observed weeping out of the monolith where the tank walls had been removed (Figure 3-2). Wet coreholes were again dried on May 13 and 16, 2011, with a wet/dry vacuum in preparation for final application of epoxy to pilot holes during May 17–18, 2011.

An unmeasured quantity of water was again injected into the grout monolith when the epoxy-filled pilot holes were overcored on May 23, 2011, removing three 7.6-cm [3-in]-diameter cores from the specimen. Staff from the coring company, D.W. Coring, indicated that less water is generally required to core a 7.6-cm [3-in]-hole than to core a 2.5-cm [1-in]-hole, and that between 4 and 8 L [1 and 2 gal] of water were probably injected per 7.6-cm [3-in] corehole. Changes to the water breakthrough pattern at each exposed sidewall were documented during this coring process [Figures 3-3(a),(b)]. Water injected to overcored Corehole 7 preferentially broke through the western (Section One) sidewall [Figure 3-3(a)], but breakthrough to the southern (Section Three) sidewall was not observed until the overcoring of Corehole 8, and continued through to the overcoring of Corehole 9 [Figure 3-3(b)]. Overcoring at location 8

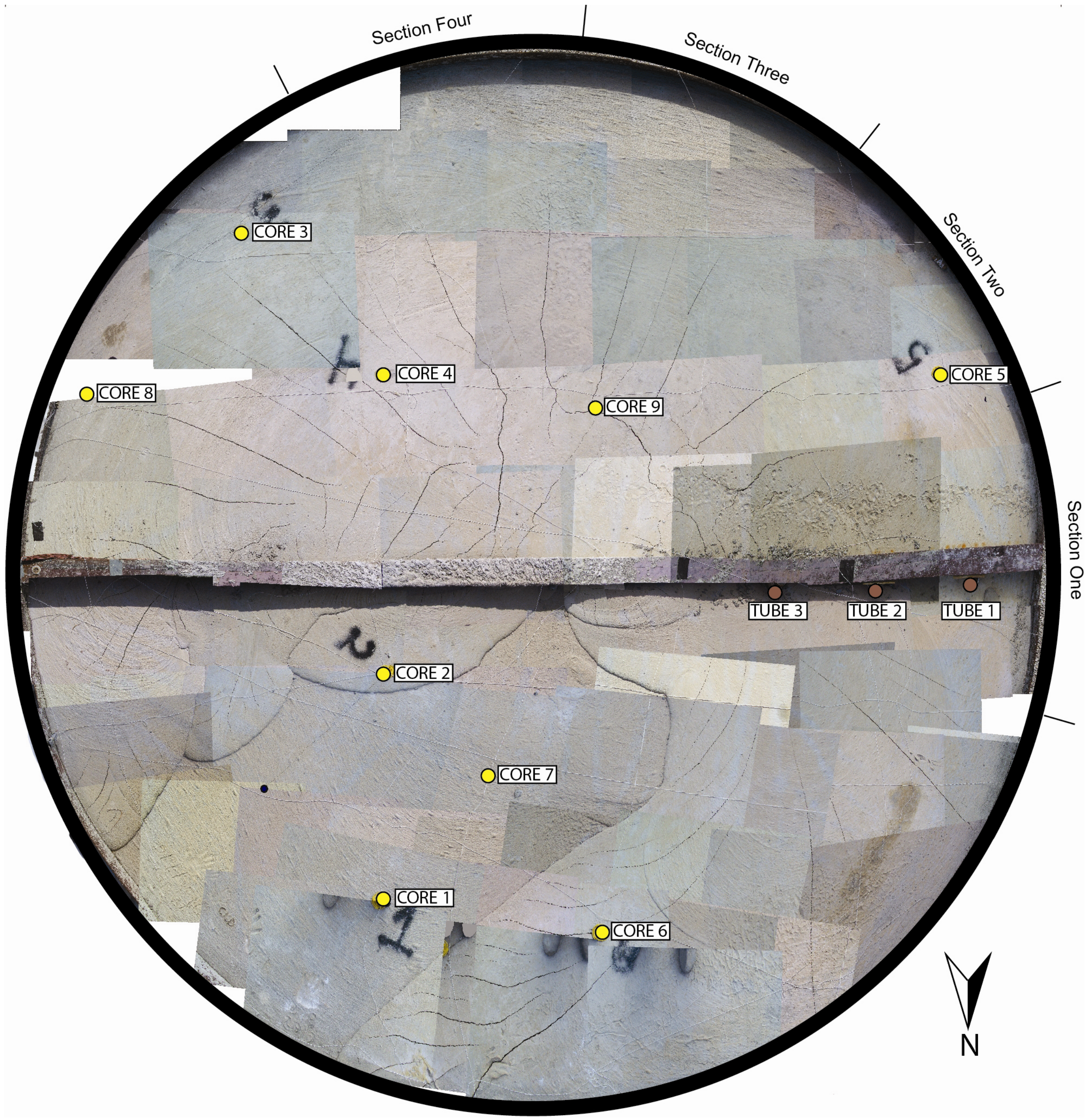


Figure 3-1. Photomosaic of Surface of the 6.1-m [20-ft]-Diameter Intermediate-Scale Grout Monolith. The Location of Nondestructive Testing Sections One Through Four Are Indicated. Coreholes 1–6 Were Dry-Cored in 2010 for Permeability Measurement [Walter, et al. (2010) Incorrectly Identified Coreholes 3 and 5 by Switching Their Numerical Identifiers in Figure 3-25], and Coreholes 7–9 Were Wet-Cored in 2011 for Core Description.

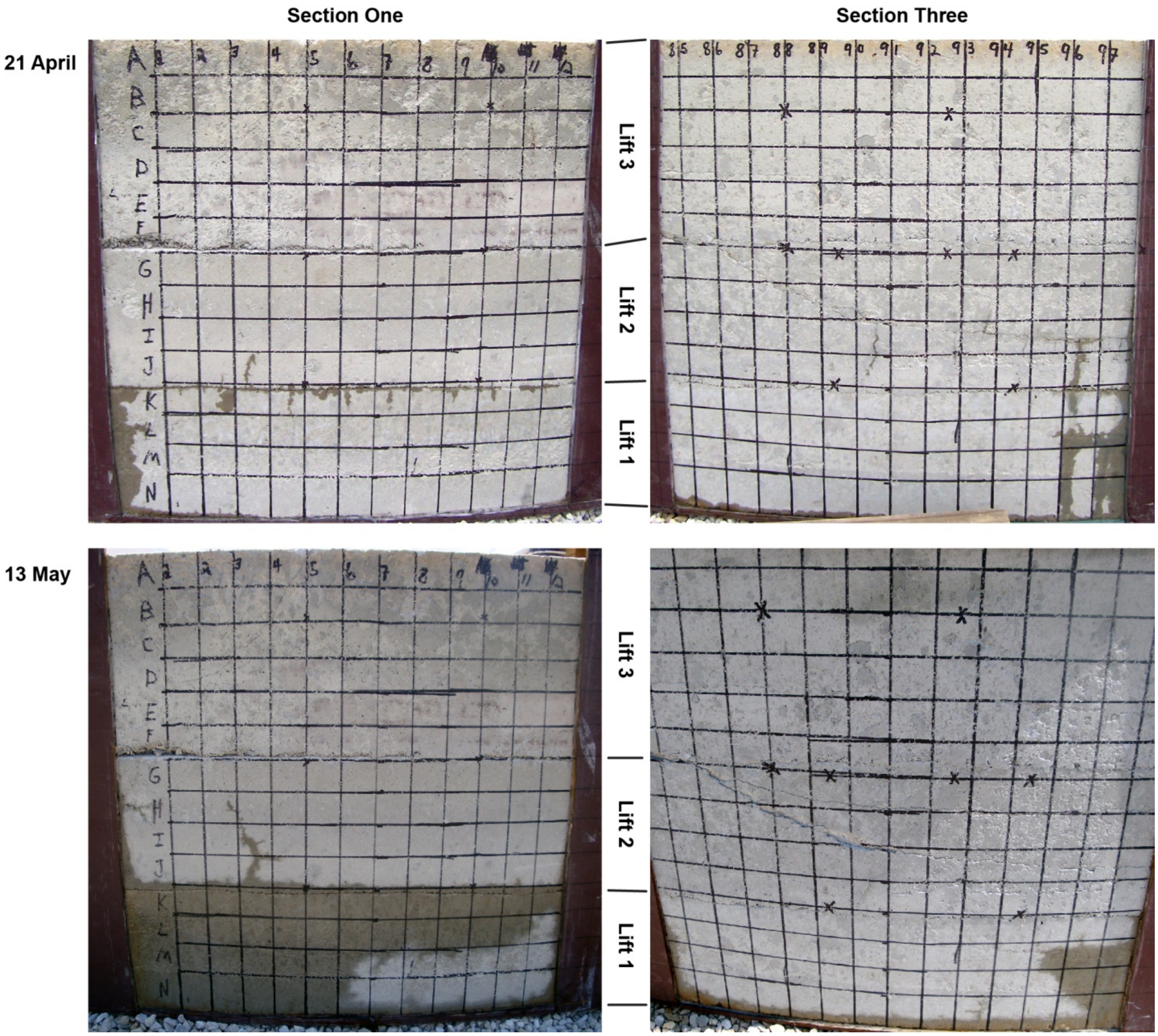


Figure 3-2. Water Breakthrough at Exposed Grout Surfaces Following Wet-Coring Operations on April 21, 2011, and Approximately 24 Hours After 2.3 cm [0.92 in] Precipitation Fell on May 12, 2011

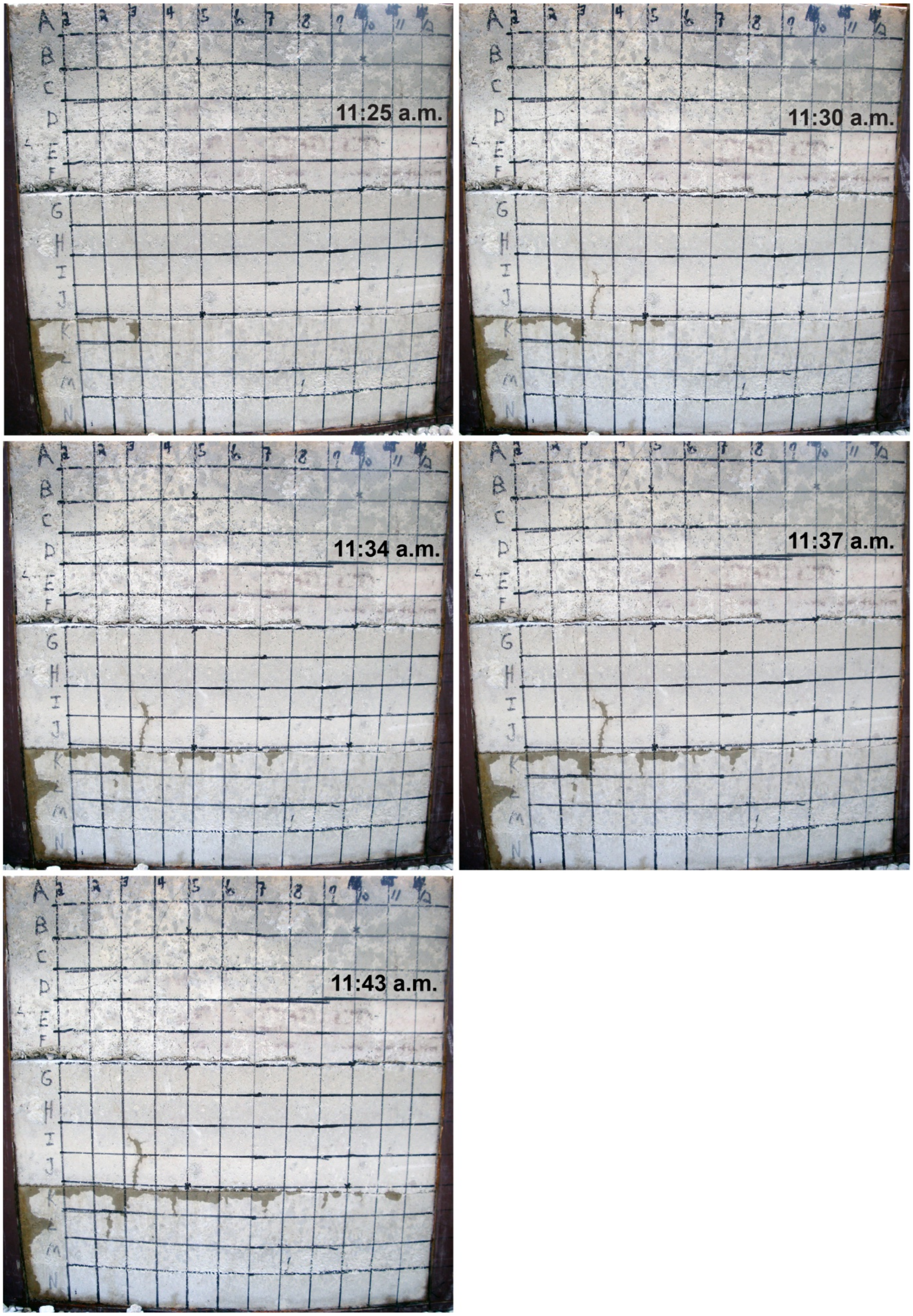


Figure 3-3(a). Section One Water Breakthrough on May 23, 2011 Following Wet-Overcoring Operations at Corehole 7. Overcoring Began at 10:55 a.m., and Water Injection Ended by 11:27 a.m. When Overcore 7 Was Removed. Water Appears to Preferentially Travel Along Lift Interfaces and Later Wicks Up and Down Open Hairline Cracks.

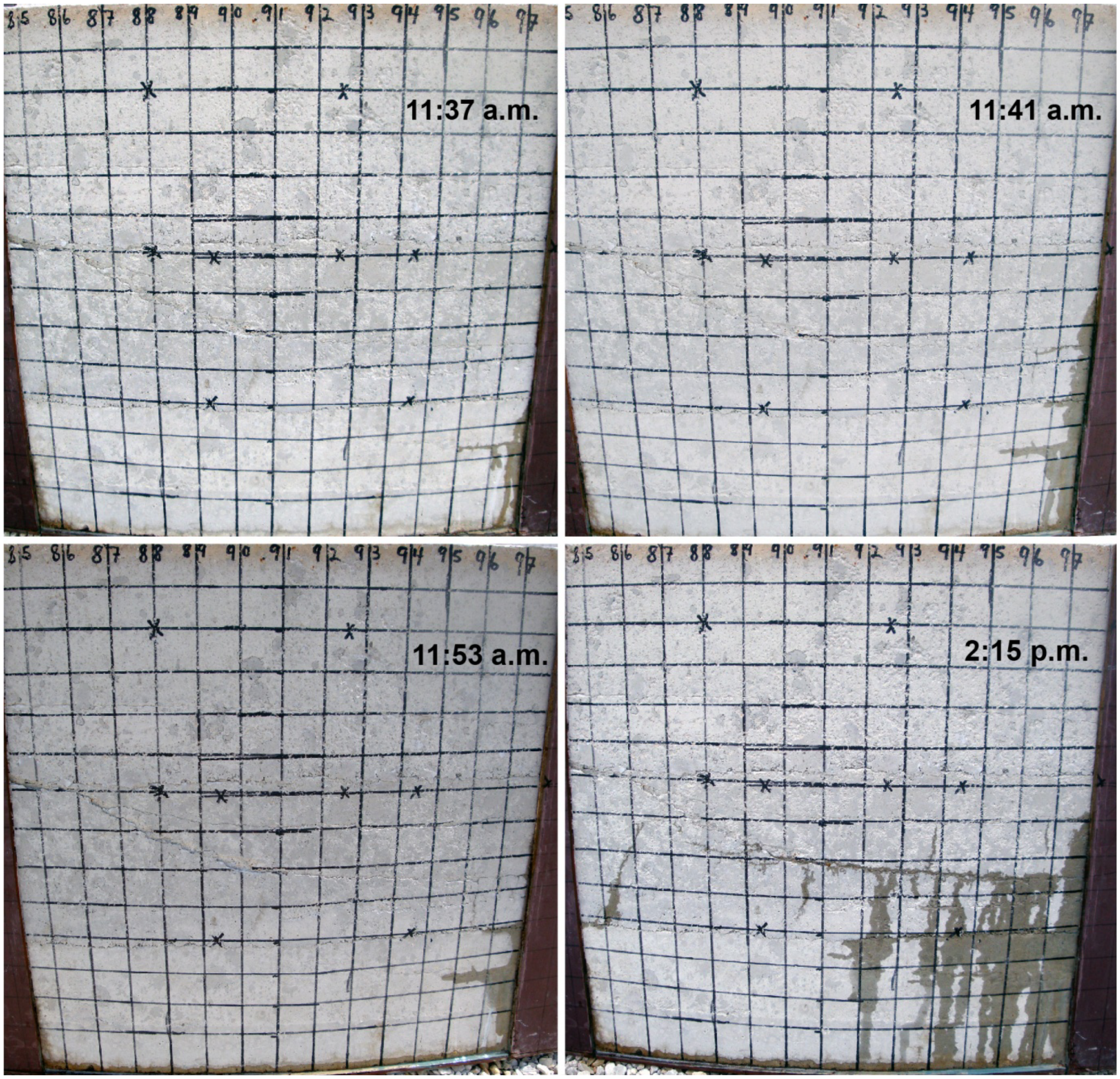


Figure 3-3(b). Section Three Water Breakthrough on May 23, 2011 Following Wet-Overcoring Operations at Coreholes 8 and 9. Overcoring at Location 8 Began at ~11:30 a.m. and Overcoring at Location 9 Began at ~2:10 p.m. Water Appears to Preferentially Travel Along Lift Interfaces and Later Wicks into Open Hairline Cracks. Surficial Rivulet Flow on the Surface Dominates at Late Time.

began at ~11:30 a.m., followed by time-intensive efforts at core extraction from 12:00 to 2:00 p.m.

Overcoring at location 9 began at ~2:10 p.m. Water appears to preferentially travel along lift interfaces and later wicks into open hairline cracks. Surficial rivulet flow dominates at late time.

The horizontal parting or interface between Lifts 1 and 2 played a major role in conducting water from cored holes to the perimeter of the monolith (Figures 3-2 through 3-4). Water introduced to the cored holes likely was ponded to at least this height, providing a direct source of water to the

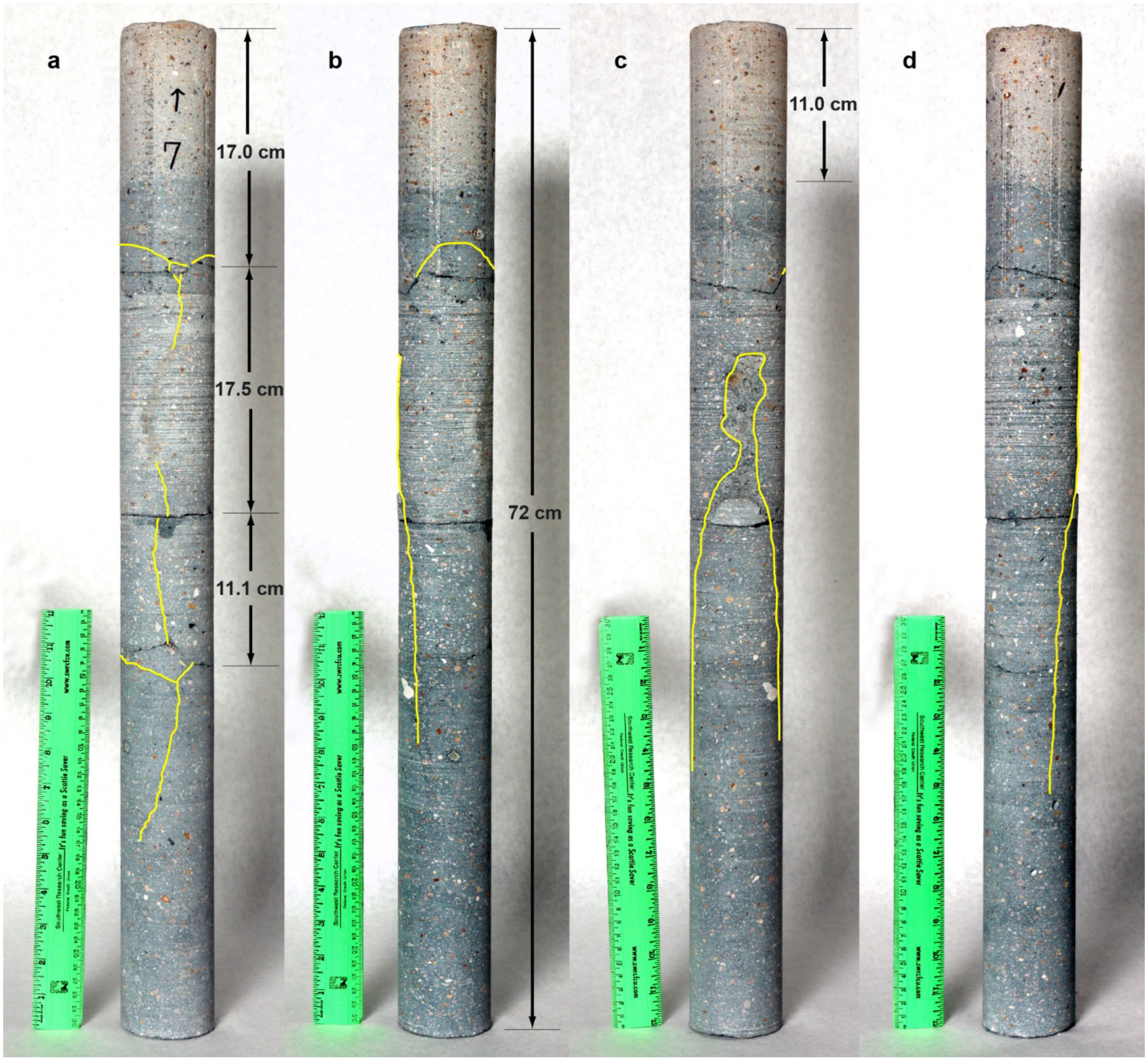


Figure 3-4. Overcore 7 Shown Dry. Core Was Turned Counterclockwise in ~90° Increments for Each Photograph. Orthogonal Subvertical Hairline Cracks are Traced in (a) and (c). Crack Family in (a) is ~50 cm [19.7 in] Long and Tips Out Inside the Core. Crack in (c) is 30.5 cm [12.0 in] Long with an 80° Dip.

lift interface. Controlled-volume tracer experiments are recommended for future work, with rapid time-lapse photography or videography used to record breakthrough times and styles.

3.2 Epoxy Application and Observations

Based on a design volume of the three cored pilot holes plus a contingency for crack fill, 2.3 kg [5 lbs] of EPO-TEK 301–2FL epoxy was acquired from Epoxy Technology along with 113 g [4 oz] of EPO-TEK #11 blue color concentrate. The epoxy components Parts A, B, and color concentrate were freshly manufactured to order. Staff mixed the epoxy components with 85 g [3 oz] of color concentrate and began to fill the three pilot holes on May 3, 2011. The three coreholes took different volumes of epoxy from greatest to least in the order of Corehole 9, Corehole 8, and Corehole 7; however, the specific volumes of epoxy applied to each corehole were not measured. Coreholes 8 and 9 required significantly more epoxy than Corehole 7 due to the filling of connected crack porosity. The following morning (May 4, 2011), the epoxy level in Corehole 7 had only declined approximately 2.5 cm [1 in] from the surface, presumably due to loss of epoxy to vug porosity, but epoxy levels in Coreholes 8 and 9 had dropped considerably due to flow into adjacent cracks.

The epoxy proved so flowable that more volume was lost to surrounding cracks than had been originally anticipated, so an additional 0.9 kg [2 lb] of less flowable (approximately twice as viscous) EPO-TEK 301-2 epoxy was acquired for use with the remaining 28 g [1 oz] of color concentrate. Staff mixed a 0.45-kg [1-lb] kit of epoxy components Parts A, B, and color concentrate to fill the remaining headspace of the three pilot holes on May 17, 2011. Corehole 7 had 4 cm [1.5 in] of headspace, Corehole 8 had 21 cm [8.3 in] of headspace, and Corehole 9 had 19.5 cm [7.7 in] of headspace remaining to be filled. Again, Corehole 9 rapidly lost epoxy to the surrounding crack systems and required the largest volume of epoxy of the three coreholes. Corehole 8, which intersects narrower cracks, required less volume to maintain a filled condition. It quickly became clear that time was needed to let the first 0.45-kg [1-lb] kit set up and flow out before mixing and applying the final 0.45-kg [1-lb] kit.

On 18 May 2011, Corehole 7 had 5 mm [0.2 in] of headspace, Corehole 8 had 4 cm [1.6 in] of headspace, and Corehole 9 had 9 cm [3.5 in] of headspace remaining to be filled. Staff mixed the final 0.45-kg [1-lb] kit of epoxy components Parts A, B, and color concentrate to fill the remaining headspace of the three pilot holes. Fresh epoxy was immediately poured into Coreholes 7 and 8, but 1 hour and 45 minutes were allowed to elapse prior to pouring the epoxy into Corehole 9, with the thought that it would begin to thicken and less epoxy would be lost to the crack system. At this time, the epoxy was still very fluid, and Corehole 9 continued to lose epoxy to the surrounding crack system. Another hour was allowed to elapse, but by this time, the epoxy had undergone exothermic reactions within the mixing container and had largely solidified, probably due to the heat of the day and because the container was resting on the surface of the warm grout monolith. As a result, Corehole 9 was not fully filled with epoxy, but the coring company successfully extracted a fully intact overcore at this location.

Epoxy kits from Epoxy Technology are very easy to use. If similar work is conducted in the future, it would be useful to measure the volumes of epoxy applied to/accepted by each individual corehole.

3.3 Core Observations

Features revealed through extraction of cores ranged from matrix color variations to vug sizes, crack distributions, apertures, and trace lengths.

There is a matrix color change from light tan near the monolith surface to gray at depth consistently across the three 2.5-cm [1-in]-diameter cores. This color change occurs rapidly over a short distance. This type of color change may also have been observed within drum grout specimens via borescope (cf. Walter, et al., 2009, p. 29).

Vesicles were also observed consistently within each core. Based upon visual inspection alone, it is suggested that vesicles are skewed to smaller sizes {2–4 mm [0.08–0.16 in]}, but several were observed to be as large as 1 cm [0.39 in] in an elongate dimension within the 2.5-cm [1-in]-diameter cores. Larger vesicles and vugs were observed within the 7.6-cm [3-in]-diameter cores, as described next.

3.3.1 Corehole 7

Recoverable core from control pilot Corehole 7 was 69.7 cm [27.44 in] in length. The upper 10.7 cm [4.2 in] of the pilot core matrix is light tan, and the lower 59 cm [23.2 in] is gray. The pilot core presents with vesicles and vugs {up to 1 cm [0.39 in]} and large particles {up to 5 mm [0.2 in]} in very fine grained matrix.

A 72-cm [28.3-in]-long intact core was recovered from overcored Corehole 7 [Figure 3-4(b)]. The upper 11 cm [4.3 in] of the overcore matrix was light tan, and the lower 61.5 cm [24.2 in] was gray [Figure 3-4(c)]. The overcore presents with vesicles and vugs {up to 1.4 cm [0.55 in]} and large particles {up to 2 cm [0.79 in] across} in very fine grained matrix. Horizontal partings are present [Figure 3-4(a)]. The horizontal partings connect to vertical hairline cracks on the periphery of the overcore [e.g., Figure 3-4(a),(c)]. A subvertical crack with 80° dip intersects the periphery of the overcore, and a small piece of grout with the opposing crack surface spalled off the main overcore [e.g., Figure 3-4(c)]. Cracks are sometimes observed to penetrate relatively soft clasts instead of forming around clast edges. Horizontal crack intensity is estimated in the range from 4 to 7 m^{-1} [1 to 2 ft^{-1}]. Near-vertical cracks are undersampled by vertical core.

3.3.2 Corehole 8

Recoverable core from cracked pilot Corehole 8 was 66.9 cm [26.34 in] in length. The upper 11.2 cm [4.4 in] of the pilot core matrix is light tan, and the lower 55.7 cm [21.9 in] is gray. The pilot core presents with vesicles and vugs {up to 1 cm [0.39 in]} and large particles in very fine grained matrix. Two intersecting cracks were observed in the near surface, which is why this location was selected for coring. Of the recoverable length, 49.6 percent was not cracked.

Recoverable core from cracked overcored Corehole 8 is difficult to estimate from the overcore alone, because more than half of the overcore was very difficult to remove from the core barrel and ultimately was extracted in bits and pieces (Figure 3-5). The depth of the corehole, however, was measured at 73.5 cm [28.9 in]. Only the base of the overcore was removed intact (Figures 3-5 and 3-6). The intact section of overcore presents with vesicles and vugs {up to 1.5 cm [0.59 in]} and large particles in very fine grained gray matrix. Five preexisting cracks are observed: (i) a 46-cm [18-in]-long vertical crack observed at the surface tips out [Figures 3-6(b), 3-6(d)] above, (ii) an older, >10-cm [>3.9-in]-long oblique crack with 55° dip [Figures 3-6(b),(c),(d)], which tips out above, and (iii) a horizontal parting. Intersecting the large oblique crack is (iv) a smaller oblique crack surface with 40° dip showing traces of epoxy [Figure 3-6(b)]. A fifth (v) horizontal parting at the top of the intact core section is suspected. A sixth (vi) shallow crack at the top of the specimen that is observed inside Corehole 8 (Figure 3-5) is counted. Other cracks in this core (unfilled with epoxy) were likely induced by coring and are not counted. The horizontal parting at a height of 17.5 cm [6.9 in] above base is likely an interface between Lifts 1 and 2. A suspected horizontal parting at the top of the intact section of core is likely an interface between Lifts 2 and 3. The vertical crack penetrates no deeper than the large oblique crack with 55° dip. A large, orange and spongy-organic-filled circular vug observed adjacent a large oblique crack may be a clump of poorly mixed ingredients. Horizontal crack intensity is estimated at 6 m^{-1} [2 ft^{-1}]. Near-vertical cracks are undersampled by vertical core.

When water is sponged onto the grout matrix, it either instantaneously (i) evaporates or (ii) is imbibed into the matrix—only cracks, partings, and vugs remain visibly wetted [Figures 3-5(b) and 3-6).

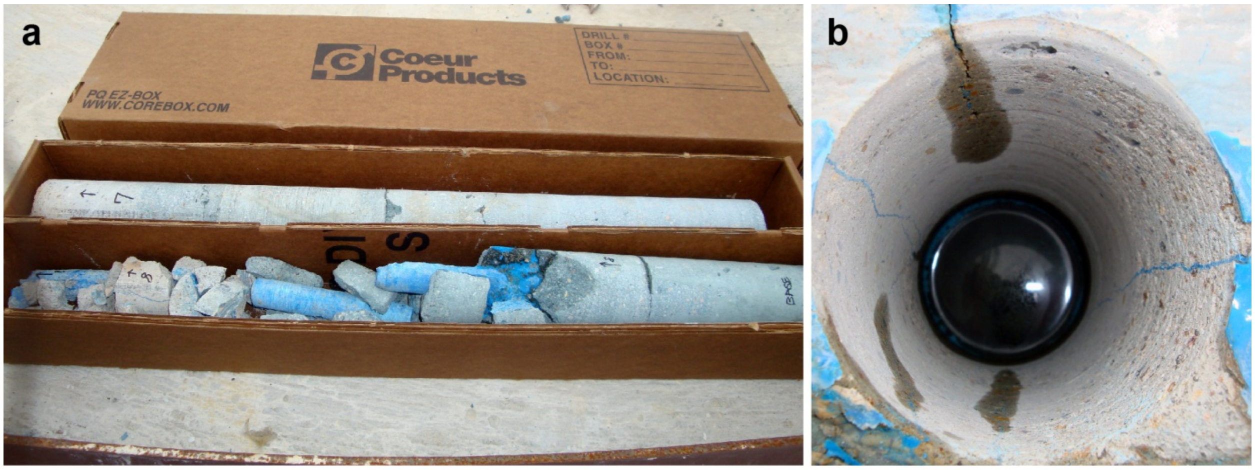


Figure 3-5. (a) Photograph of Overcores 7 and 8 Illustrates the Rubblized Zone of Grout and Blue Epoxy that Comprise the Top of Overcore 8. (b) View Into Corehole 8 Supports Staff Recommendation To Conduct Future Borescopic Observations in Coreholes 1–9.

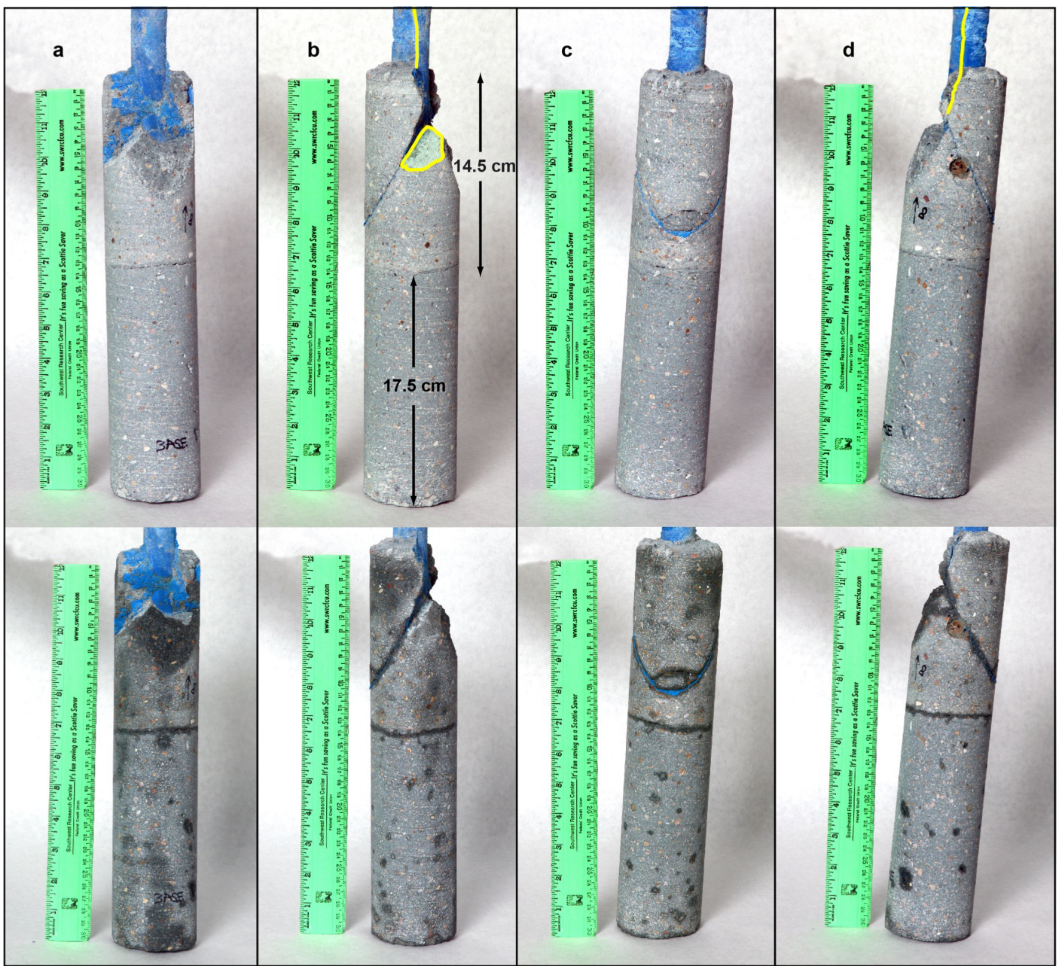


Figure 3-6. Intact Section From Overcore 8 From Base to Height of 32 cm [12.6 in] Shown Dry (Top) and Wet (Bottom). Core Was Turned Counterclockwise in ~90° Increments for Each Photograph.

3.3.3 Corehole 9

Recoverable core from cracked pilot Corehole 9 was 64.8 cm [25.5 in] in length. The upper 7.2 cm [2.8 in] of the pilot core matrix is light tan, and the lower 57.6 cm [22.7 in] is gray. The pilot core presents with unremarkable vugs and large particles in very fine grained matrix. Two intersecting cracks were observed in the near surface, which is why this location was selected for coring, but these cracks did not extend to great depth within the 2.5-cm [1-in]-diameter core. Of the recoverable pilot core length, 47.5 percent was not cracked.

A 77-cm [30.3-in]-long intact core was recovered from overcored Corehole 9 [Figure 3-6(b)]. Nine preexisting cracks are observed in the overcore. The color of the matrix changes at variable depths around the periphery, in relation to the location of a relatively shallow oblique crack that tips out 11 cm [4.3 in] below the surface [Figures 3-7(a),(c)]. There is an early transition from light tan to gray above the tip of the oblique crack, at approximately 6 to 7 cm [2.4 to 2.8 in] below the top of the overcore [Figure 3-7(a)]. Below the oblique crack tip, the matrix color returns to light tan for another 2.5 to 3.0 cm [1.0 to 1.2 in] along the overcore axis, and then switches back to gray again at 15 cm [5.9 in] below the surface. Elsewhere around the periphery of the overcore, the color transitions from light tan to gray at approximately 9 cm [3.5 in] below the surface [Figure 3-7(c)]. The oblique crack [Figures 3-7(a),(b),d)] has a relatively large aperture ranging from 3 to 5 mm [0.12 to 0.20 in]. The oblique crack is 12.5-cm [4.9-in]-long with an 80° dip, and it formed early. Two *en echelon* vertical cracks formed later [Figures 3-7(b),(c)]. One of the *en echelon* vertical cracks is as long as the core [Figure 3-7(c); this crack is off to the side of the smaller pilot core where the pilot core was observed to be noncracked] and has an aperture from 1–3 mm [0.04–0.12 in]; the other *en echelon* vertical crack, located at the top of the core inside the trace of the oblique crack [Figure 3-7(b)], is 7.5 cm [3 in] long. On the other side of the oblique crack is another 5.5-cm [2-in]-long vertical crack [Figure 3-7(d)]. The longest vertical crack has several small linking branches along its main trend [traced in Figures 3-7(b),(c)], but these are counted as one crack. A 4-cm [1.6-in]-long, subhorizontal hairline crack is observed on both sides of the long vertical crack and is associated with a light tan matrix color, as at the near surface [Figures 3-7(a),(b)]. A 9.5-cm [3.7-in]-long orthogonal vertical crack is observed tangent to the core near its base [Figure 3-7(a)]. Three horizontal partings formed—two as shown [Figure 3-7(a)], with the third at the base of the core. The middle horizontal parting consists of two cracks [Figure 3-7(c)] that formed subsequent to formation of the long-tracelength vertical crack. Horizontal crack intensity is estimated at 4 to 5 m^{-1} [1 to 1.5 ft^{-1}]. Near-vertical cracks are undersampled by vertical core.

The overcore presents with vesicles and vugs {up to 1.5 cm [0.59 in]} and large particles {up to 2 cm [0.79 in] across} in very fine-grained matrix. A large vug at the periphery of the core is filled with epoxy [Figure 3-6(c)].

All cores are archived for future reference and testing.

3.4 Wall Observations

On 1 April 2011, two sections of the intermediate-scale grout monolith tank wall were removed (Figure 3-7), exposing three emplaced lifts in cross section and existing cracks that evolved further and bifurcated with the passage of time (Figure 3-8).

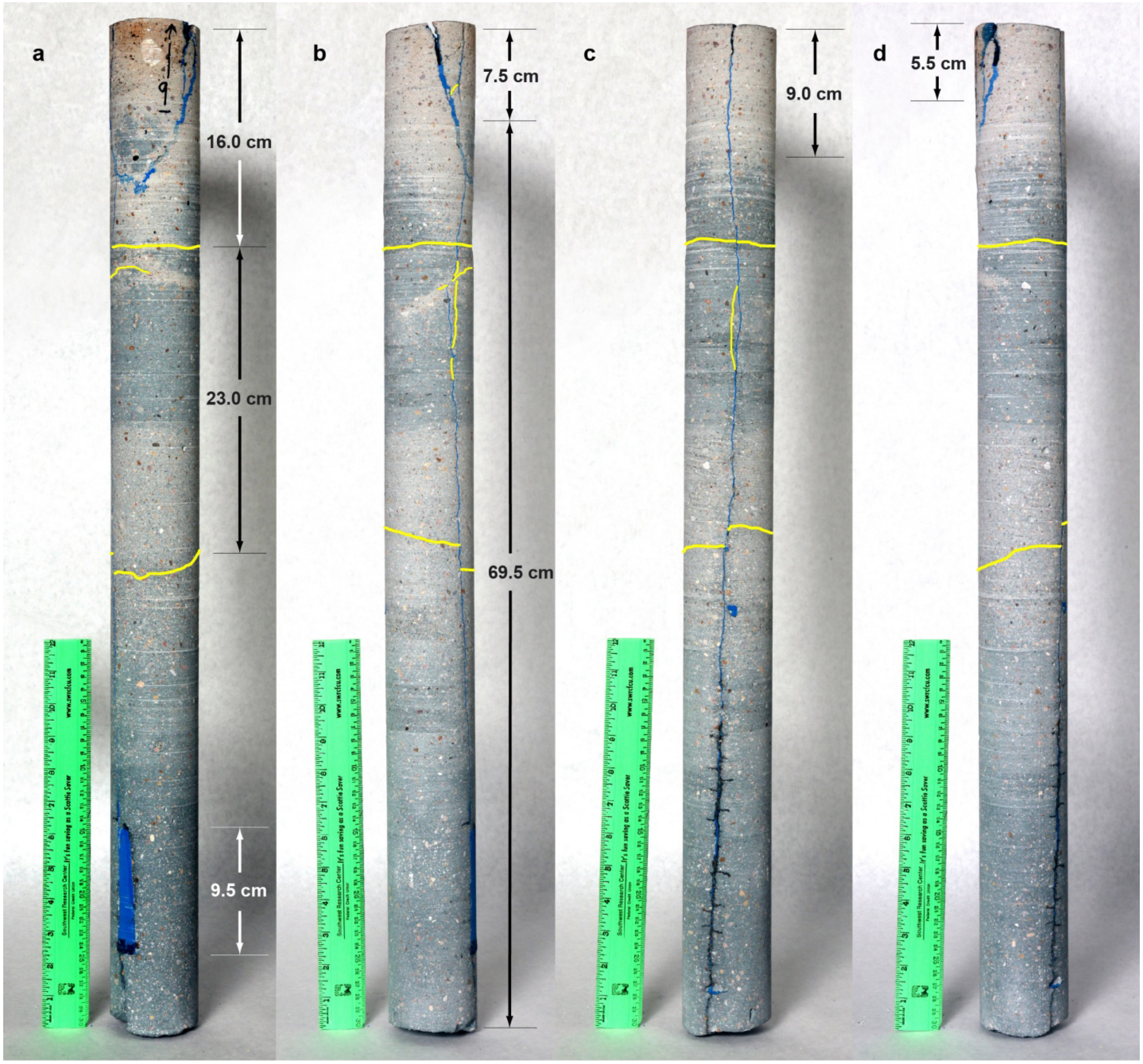
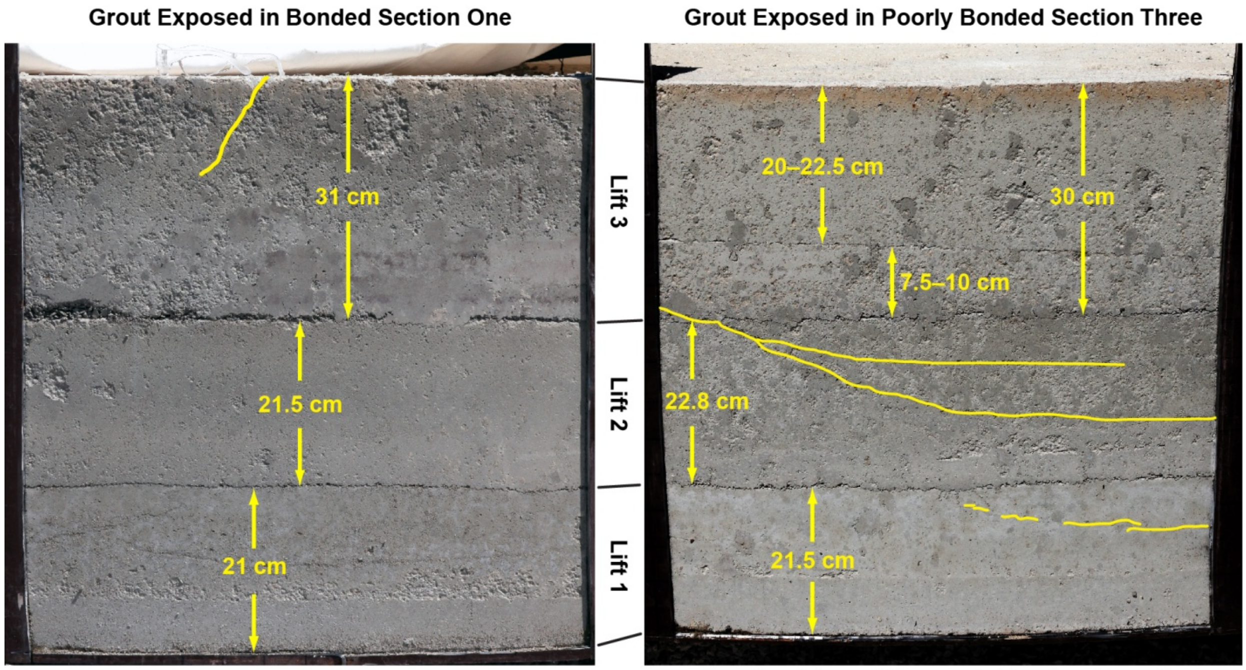


Figure 3-7. Overcore 9 Shown Dry. Core Was Turned Counterclockwise in ~90° Increments for Each Photograph. Thin Horizontal Partings Are Traced, as Are Epoxy-Filled Hairline Cracks. See Text for Detailed Description.

Grout within lower lifts in each section tends to be smoother than grout within Lift 3 (Figures 3-8 and 3 -9), which is attributed to the overburden pressure that tends to compress voids, vesicles, vugs, and bubbles in the grout. Smoother grout may correspond to more favorable permeabilities: the results of gas injection testing (Walter, et al., 2010) indicated a decrease in permeability with depth.The initial pour of Lift 1 in both sections is typically devoid of grout spatters, but above this level, early-curing grout spatters are evident (Figures 3-8 and 3-9).



Section One Ultrasonic Testing Results

D = possible delamination

Lift		1	2	3	4	5	6	7	8	9	10	11	12
Lift 3	A												
	B												
	C												
	D					D							
	E					D	D	D	D	D			
	F												
Lift 2	G												
	H									D			
	I												
	J												
Lift 1	K												
	L												
	M												
	N												

Section Three Ultrasonic Testing Results

D = possible delamination

Lift		85	86	87	88	89	90	91	92	93	94	95	96	97
Lift 3	A	D	D	D	D	D	D	D	D	D	D	D	D	D
	B		D	D	D	D	D	D	D	D	D	D	D	D
	C	D	D	D	D	D	D							
	D	D	D	D	D	D	D	D	D		D	D	D	D
	E		D	D	D	D	D	D	D	D	D	D	D	D
	F		D	D	D	D	D	D	D	D	D	D	D	D
Lift 2	G	D	D	D	D	D	D	D	D	D	D	D	D	D
	H	D	D	D	D	D	D	D	D	D	D	D	D	D
	I	D	D	D	D	D	D	D	D	D	D	D	D	D
	J	D	D	D	D	D	D	D	D	D	D	D	D	D
Lift 1	K	D	D	D	D	D	D	D	D	D	D	D	D	D
	L	D	D	D	D	D	D	D	D	D	D	D	D	D
	M	D	D	D	D	D	D	D	D	D	D	D	D	D
	N					D	D	D	D	D	D	D	D	D

Figure 3-8. Intermediate-Scale Grout Monolith as Photographed in Cross Section (Several Hours After Tank Wall Removal on April 1, 2011) and Corresponding Air-Gap Maps Predicted From Nondestructive Testing (Green Outline Encloses Tap-Test Forecast). Preexisting Cracks Are Traced for Comparison Against the Crack Systems in an Evolved Future State (cf. Figure 3-9).

3.4.1 Section One

Lifts 1 and 2 have considerably smoother faces than Lift 3 (Figures 3-7 and 3-8). Grout above the initial pour of Lift 1, however, is uncharacteristically rough compared to the rest of the grout in this lowest lift (Figure 3-6). With some uncertainty, the hypothesis is that this roughness is related to grout spatters that were particularly well adhered to the removed tank wall.

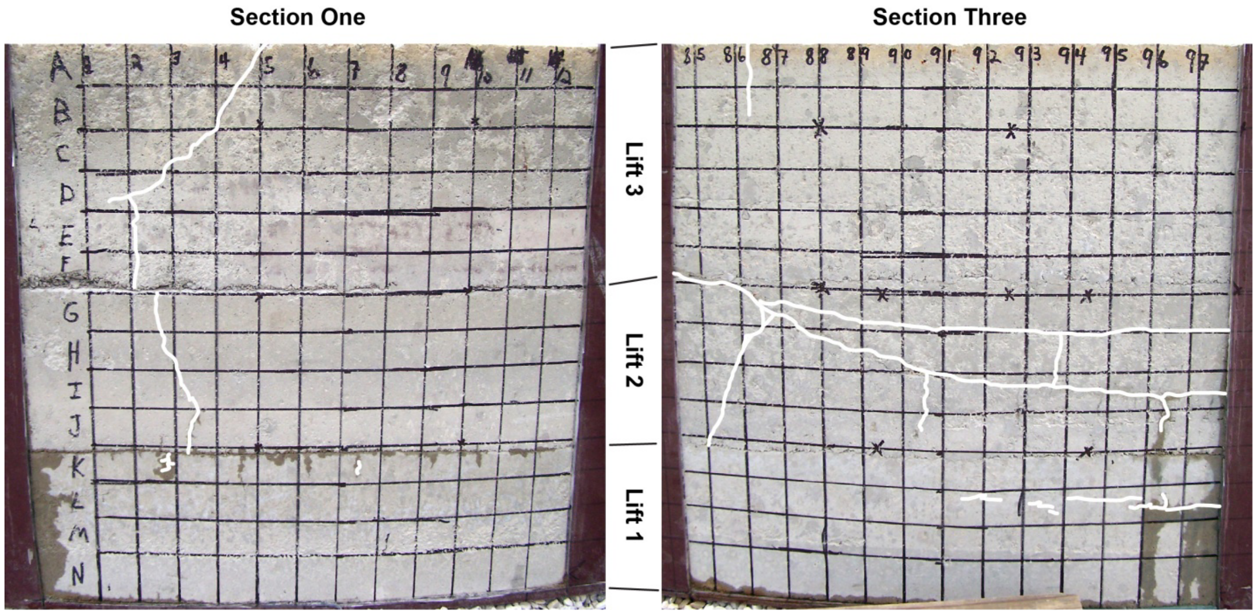


Figure 3-9. Crack Systems Developed at Intermediate-Scale Grout Monolith's Wall Exposures as of 19 May 2011

A curvilinear crack exposed on the surface of the grout monolith that intersects Corehole 5 is also exposed in cross section and extends at 57° to 37° angles into Lift 3 (Figure 3-8). This crack continued to grow at its tip more than halfway into Lift 3 and was observed as early as April 7, 2010 to have bifurcated another crack growing vertically downward (Figure 3-9).

Late-developed subvertical cracks within Lift 2 and possibly within Lift 1 (Figure 3-9, Section One) were observed transmitting water during coring operations on April 21, 2010 and on May 13, 2010 following a rainstorm (Figure 3-3). The affinity for water to flow along lift interfaces and through cracks is notable.

The interface between Lifts 1 and 2 is higher quality than the interface between Lifts 2 and 3 (Figure 3-8). The interface between Lifts 2 and 3 on the left side of the exposure is particularly poor, but improves toward the center (much of the grout material was well adhered to the removed tank wall, Figure 2-17b, Row F), is near seamless within columns 8 and 9 (Figures 2-17b, 3-8, and 3-9), and slightly decreases in quality toward the right side of the exposure. The interface between Lifts 1 and 2 is of near uniform quality throughout the exposure (Figure 3-8).

3.4.2 Section Three

Lift 1 is considerably smoother than Lifts 2 and 3 (Figure 3-8). Some grout spatters are observed to have remained with the grout mass, while other grout spatters that were well adhered to the tank wall separated from the grout mass. The presence of early-cured grout spatters, which had adhered during emplacement of lower lifts, is associated with significant void space surrounding the grout spatter at the tank wall. That is, the grout mass tends to not flow into all available void space surrounding early-cured grout spatters on the tank wall.

Two curvilinear cracks within Lift 2 are not subhorizontal as they appear in two dimensions (Figure 3-8); rather, they are high-angle subvertical cracks, easily peeled from the massive grout behind them like two layers of an onion. Coin-tap test results (Figure 3-8) correlate well with the position of these two cracks, and directly tap testing the grout in the absence of the steel wall produces a similar audible change between solid massive grout outside this area and the thin cracked grout layers overlying this area.

Late-developed subvertical cracks within Lifts 1 and 2 were observed transmitting water during coring operations on April 21, 2010, and on May 13, 2010, following a rainshower (Figure 3-3). The affinity for water to flow along lift interfaces and through cracks is notable.

The interfaces between Lifts 1 and 2 and between Lifts 2 and 3 are of approximately equal quality with nothing remarkable to discuss (Figure 3-8). The subhorizontal parting 7.5 to 10 cm [3 to 4 in] above the base of Lift 3 is evidence, however, of a temporal hiatus between the first and second pours within Lift 3 (Figure 3-8). A temporal hiatus (such as that caused by the need to add more water to increase the slump flow of the grout) may cause a horizontal parting similar to a lift interface. This temporal hiatus is not observed in Lift 3 of Section One (Figure 3-8).

3.4.3 Conclusions and Recommendations

The method of overcoring epoxy-filled pilot holes provided good results in terms of preserving crack apertures for analysis within intact cores. If similar work is conducted in the future, it would be useful to measure the volumes of epoxy applied to/accepted by each individual corehole as a proxy for local crack porosity. The overcores revealed the presence of through-going cracks that could be observed by inspection of the surface of the intermediate-scale grout monolith, as well as the presence of vugs and vesicles.

To improve understanding of the three-dimensional crack systems within the intermediate-scale grout monolith, staff recommend borescopic observations and descriptions of cracks exposed in sidewalls of Coreholes 1–6 and 8. Coreholes 1–6 were dry-cored in fiscal year 2010 to enable gas injection testing for estimating grout permeability. Dry-coring did not yield high-quality cores for analysis of crack systems. Borescopic observations are a simple and effective means of observing macroscopic cracks that may have influenced the magnitudes of existing permeability data. Coreholes 3 and 5, in particular, are known to have developed macroscopic cracks after core removal and permeability measurement, but pre-existing unseen microscopic cracks may have influenced the permeability field at these locations. Finally, the upper half of Corehole 8 has large cracks filled with epoxy from which additional information can be gleaned that was not easily discernable from its broken overcore. A more time-consuming alternative to borescopic observations of Corehole 8 would be reconstruction of its upper half from the materials shown in Figure 3-5(a).

To improve understanding of the sizes of vugs and the compositions of unmixed grout-ingredient inclusions, staff recommend description and documentation of core slabs made from Overcores 7, 8, and 9. To best understand the size and composition of important grout features, standard whole-core analysis and color/ultraviolet photography is performed of the flat surfaces of slabbed cores, rather than of the curved surfaces of unslabbed cores.

To improve understanding of grout matrix porosity and color variations, microcrack porosity and connectivity, and any detrimental, long-term impacts that should be expected from clumps of poorly mixed ingredients and weak aggregate particles (i.e., those which cracks penetrate through rather than traverse around), staff recommend thin section preparation and analysis.

The serendipitous observation of water seeping from the exposed sides of the intermediate-scale grout monolith during and after coring indicates the presence of an extensive network of interconnected permeable pathways in the grout. Permeable pathways like these were not observed in smaller scale specimens (Walter, et al., 2009, 2010), perhaps indicating samples of sufficient size are needed to generate such features. Controlled-volume tracer experiments are recommended as future work, with rapid time-lapse photography or videography used to record breakthrough times and styles. Consideration should be given to removal of the entire steel tank wall prior to tracer testing.

Staff considered estimating intermediate-scale grout monolith crack permeability using discrete-fracture network software such as FracMan® Reservoir Edition (FRED) by Golder Associates. FRED is a probabilistic code that develops estimates based on crack statistics and uncertainties for parameters such as crack set orientation, trace length, intensity and aperture. Staff concluded that the characteristics of the crack sets observed on the surface of the intermediate-scale grout monolith (Section 4) are not sufficiently consistent with crack set assumptions (e.g., crack set shapes and orientations) employed by the software.

Thus, staff recommend whole-monolith crack permeability testing as future work. Gas injection testing could be performed serially from multiple coreholes and from multiple packed-off intervals. New coreholes targeting intensely cracked zones within the upper sections of Lifts 2 and 3 may be needed, and borescopic observation of existing Coreholes 1–6 will support such an assessment. Staff envision the monolith perimeter and coreholes would be left open to the atmosphere, but the intensely cracked surface of the monolith could be sealed-off from above (using gas impermeable insulation in the form of a spray foam) if needed.