UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

In the Matter of NEXTERA ENERGY SEABROOK, LLC (Seabrook Station, Unit 1)	Docket No. 50-443-LA-2 ASLBP No. 17-953-02-LA-BD01

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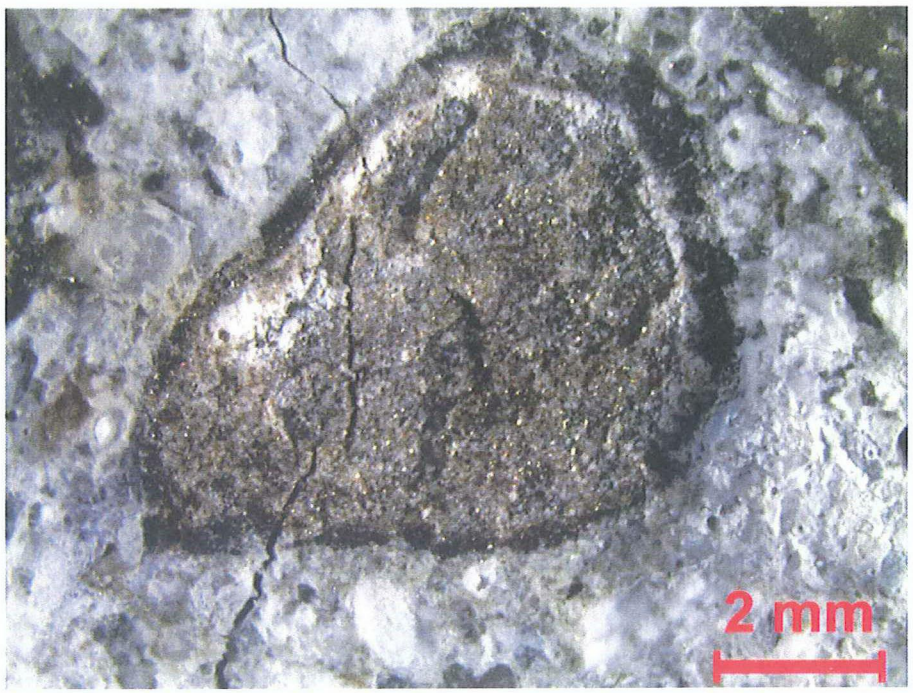
Petrographic Examination of Concrete Cores

Seabrook, New Hampshire



Final Report
May 26, 2016
WJE No. 2014.3453.2

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RHR AND CS EQUIPMENT VAULT AT NEXTERA ENERGY SEABROOK STATION
Petrographic Examination of Concrete Cores

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WJE | ENGINEERS ARCHITECTS MATERIALS SCIENTISTS

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RHR AND CS EQUIPMENT VAULT AT NEXTERA ENERGY SEABROOK STATION
Petrographic Examination of Concrete Cores

Seabrook, New Hampshire

INTRODUCTION

At the request of Mr. Brian Brown of NextEra Energy Seabrook, LLC (Seabrook), Wiss, Janney, Elstner Associates, Inc. (WJE) performed a petrographic examination of nineteen of the twenty concrete cores removed from the Residual Heat Removal (RHR) and Containment Spray (CS) Equipment Vault Structure (Equipment Vault) at Seabrook Station, located at 626 Lafayette Road, Seabrook, New Hampshire. The objective of the petrographic examination was to assess the general properties of the concrete, to identify the likely causes of cracking detected in the condition assessment previously performed by WJE, and to determine the relative extent of distress in the concrete.

Construction of Seabrook Station began in 1976 and was completed in 1986. The Equipment Vault is a mostly below-grade, rectangular structure with three intersecting interior walls. Two redundant equipment trains (designated Alpha and Bravo) are housed in the RHR "A" and RHR "B" vault, respectively. The exterior walls are reinforced concrete retaining walls 2 feet, 6 inches to 4 feet thick, and the two vaults are separated by an interior, 2-foot, 6-inch thick reinforced concrete wall. Adjacent structures of various depths are located on the north, east, and south ends of the Equipment Vault, whereas backfill concrete is immediately adjacent to the west end of the vaults. A plan view of the vault is shown in Figure 1.

Narrow gaps in the concrete and ground water leakage were reportedly first observed 15 to 20 years ago. In the last few years, cracking and degradation of the concrete has progressed, predominately at the interior walls of the structure. WJE performed an initial condition assessment and presented its findings in a report dated March 3, 2015 (Seabrook FP 100903). WJE later performed a follow-up condition assessment and presented a final report on February 4, 2016 (Seabrook 101055). Based on recommendations from these WJE reports, the current petrographic examination of drilled cores was undertaken.

Based on the information provided, the approved concrete mix designs included the following: 4-AWR-1, cement 636 pounds per cubic yard; 3-AWR-1, cement 457 pounds per cubic yard; 3-AWR-1/2 (#8), cement 516 pounds per cubic yard; 4-AWR-1-1/2, cement 564 pounds per cubic yard; 4-AWR-67 with Melment, cement 560 pounds per cubic yard; where A represents Master Builders air entraining admixture, MB-AE-10, W represents Master Builders water reducer admixture Pozzolan 300 N, and R represents Master Builders retarder, Pozzolan 300R. These concrete mix designs typically included low alkali Portland cement (i.e. < 0.6% total alkali) and were designed to produce either 3,000 psi or 4, 000 psi compressive strengths at 28 days.

SAMPLES AND TESTS

Samples

Based on Option I of WJE's *Proposal for Laboratory Evaluation of Concrete Cores*, dated January 22, 2016, WJE performed on-site petrographic examination of nineteen 4-inch diameter concrete cores removed from various locations in the Equipment Vault. The core locations were based on

recommendations provided in the WJE report dated February 4, 2016, and the cores were drilled and retrieved by Seabrook. Table 1 lists the approximate core locations and core descriptions. Core 17 was taken for the purpose of verifying rebar corrosion, and no petrography was performed for the core. Additional information regarding reinforcement corrosion and vault wall observations, which are not germane to the petrographic analysis, will be provided in a subsequent WJE letter report to be issued as a follow-up to this document.

For convenience of this report, the finished ends of the cores are termed "top" and the fractured ends of the cores are termed "bottom," although all cores were drilled horizontally. Therefore, vertical or longitudinal indicates parallel to the axis of a core and horizontal indicates perpendicular to the axis of a core. It should be pointed out, however, a "longitudinal" crack in a core only means the crack is parallel to the axis of the core. The cores were documented based on WJE SOP 1, *Logging Samples* (Seabrook FP101002).

The top surface of the cores was a formed finish; many cores contained a paint coating on the top surface. The bottom surfaces of the cores were fractured. Of the twenty cores, six cores, including Cores 3, 5, 6, 9, 13, and 14, had full-depth longitudinal macroscopical cracks (Figures 2 and 3). Cores 8, 10, 15, and 20 had partial-depth longitudinal macroscopical cracks (Figure 4). The cracks were epoxy injected using a clear, low viscosity epoxy before the drilling to maintain the integrity of the cores, and no core was separated along the crack surface. Cores 5, 11, and 16 were broken transversely at approximately 3 to 4 inches as a result of core obstruction. After the broken core was removed, drilling resumed at a new location approximately 1 inch away from the original location (Figure 5).

No reinforcement was intersected by any core.

Petrographic Examination

Petrographic examination was performed for the entire length of every core, based on the guidelines of ASTM C856, *Standard Practice for Petrographic Examination of Hardened Concrete*, and the WJE Standard Operation Procedure (SOP) X.1, *Petrographic Examinations* (Seabrook FP101001). For the petrographic examination, any cores longer than 6 inches were first cut horizontally into approximately 6-inch long sections to accommodate the maximum length the saw could cut longitudinally. Each section was then cut longitudinally using a diamond blade rock saw. When cracks were present, the longitudinal saw-cut surface was always selected to be perpendicular to the crack surface. For convenience in this report, the saw-cut sections were given an ABCDE nomenclature. If a core is cut into four sections, AB represents the top most section, BC represents the top middle section, CD represents the third section, and DE represents the bottom section. For example, Core 1AB indicates the top section of Core 1 and Core 1DE indicates the bottom section of the core and the core was cut into four sections. If the core was sufficiently short and was not cut into multiple sections, there will be no letters following the core identification, such as Core 3. Many cores were only cut into two and three sections.

One of the longitudinal sections from each core section was lapped with progressively finer grinding media to achieve a smooth surface. Freshly fractured surfaces were induced for examination from the remaining pieces of the cores. The lapped sections and fractured surfaces were examined using a stereomicroscope at magnifications up to 80X. Powder mounts of the paste and materials of interest were prepared and examined using a petrographic (polarized light) microscope at magnifications up to 630X. Examination of powder mounts using a petrographic microscope allows identification of minerals in the cement paste, aggregates, and secondary deposits based on their optical properties. Thin section fabrication and examination were outside of our scope of services for this assignment.

The depth of carbonation of the concrete was measured by applying a phenolphthalein solution to a freshly fractured concrete surface located at and perpendicular to the top surface of the core and measuring the depth of color change. The water to cement ratio (w/c) of the concrete was estimated based on the paste color, hardness, porosity, abundance of residual cement particles, and abundance and particle size of calcium hydroxide crystals. The cement content and air content of the concrete were estimated based on the experience of the petrographer.

Damage Rating Index (DRI)

DRI was measured for all core sections in order to obtain a quantified assessment of distress induced by alkali-silica reaction (ASR). Selected distress features, such as cracked aggregate particles, presence of gel, cracks in the cement paste, and reaction rims in aggregate particles, are counted in each one centimeter square superimposed on the entire lapped section of each core. The total number of each distress feature is then multiplied by a predetermined weighting factor. The sum of the above product is then divided by the total number of squares covered and multiplied by 100. The ASR distress in a core is thus represented by a single numerical index. The larger the index, the more severe the ASR-induced distress. The distress features counted and the associated weighting factors are given in Table 2. The DRI measurement was based on WJE SOP X.2, *Damage Rating Index* (Seabrook FP101000).

A detailed discussion of significance and application of DRI is beyond the scope of this report. Compared to the traditional qualitative approach of petrography, DRI measurement provides a semi-quantitative and more accurate approach to assess and compare ASR-induced distress in different locations of the same concrete structure, or to determine the progress of ASR development over time in the same structure. DRI measurement also allows for graphic presentation and comparison of different ASR-induced distress. However, there is no universal standard procedure on DRI measurement and, in particular, the assignment of weighting factors to different distress features can be subjective. For example, a crack 1 mil (0.001 inch) wide and a crack 1/16 inch wide may have the same weighting factor in DRI measurement, but they obviously represent significantly different stages in ASR development. In addition, if the concrete also contains cracks not caused by ASR, the cracks will still be counted, skewing the results. Nevertheless, DRI measurement provides a unique way to analyze and compare ASR development in large projects with multiple cores and the information obtained is significant with respect to this project.

FINDINGS

The nineteen cores examined were similar in major composition but differed slightly in mix proportions. The following general descriptions of the concrete applies to all cores, except as noted otherwise. A summary of findings is given in Tables 3 and 4 for cores from Train Alpha and Train Bravo, respectively. The separation of cores into different trains was for convenience of handling the data. The concrete in both trains was essentially the same. The description of distress and measurement of DRI are presented in separate sections. The original petrographic data sheets for each core section, a total of forty-six, are attached as an appendix to this report.

General Properties

Aggregate

The aggregates were generally sound, well graded, tightly bonded to the paste, and uniformly distributed through the thickness of all cores (Figures 6 to 24). Freshly fractured surfaces induced during the examination propagated primarily through aggregate particles.

The fine aggregate was natural siliceous sand containing a major amount of quartz and minor amounts of feldspar, mica, and granite. The fine aggregate was clear to brown, subangular to subrounded, hard, and dense. The fine aggregate did not contain potentially reactive components for ASR in concrete.

The coarse aggregate was crushed siliceous rock having a nominal maximum size of 3/4 inch. The coarse aggregate was gray to dark gray, hard to moderately hard, dense to relatively dense, and mostly angular. The coarse aggregate was composed of a major amount of fine-grained quartz and minor to trace amounts of microcrystalline quartz, feldspar, mica, pyrite, and calcite. The aggregate particles were not uniform and exhibited variability in both texture and composition. Some particles contained less and finer quartz and exhibited a weak foliation, others contained relatively larger and more abundant quartz and exhibited a massive granular texture. While a more accurate identification of the coarse aggregate will require thin section investigation and review of geological data of the quarry, the overall properties of the coarse aggregate suggest that it was a low grade metamorphic rock called quartzite (Figure 25). Due to the metamorphic nature of the quartzite, while the rock may appear massive and uniform in a quarry, it is texturally and compositionally variable on a much smaller scale, such as on a scale of a few inches. Layers, lenses, and inclusions of different composition and texture are common factors in this type of metamorphic rock. When the rock was quarried and crushed, such layers and inclusion textures would be destroyed and different particles might appear as different types of rock. Therefore, all cores contained the same coarse aggregate, but the metamorphic nature of the quartzite dictates its variability in composition and texture, from particle to particle, after crushing.

The microcrystalline quartz and possible presence of strained quartz in the quartzite indicate that the aggregate may be potentially reactive in concrete and susceptible to deleterious ASR. Evidence of ASR was detected in several cores examined and will be discussed in details in the section entitled, Distress.

Paste

The paste was essentially uniform, gray, hard, dense, and had a semiconchoidal texture. A moderately low amount of residual portland cement particles was detected, most of which were ferrite phases. No supplementary cementitious materials, such as fly ash, slag cement, or silica fume, were detected. Calcium hydroxide crystals from cement hydration were moderate in size and concentration. The hydration of the cement appeared to be normal for the age of the concrete.

The depth of carbonation of the cores varied from less than 1/32 inch up to 1/4 inch (Tables 3 and 4). The variability in the carbonation depth was not due to different quality of the concrete, but rather a result of different exposure conditions arising from the existence of surface coatings and how well the coatings were bonded to the concrete. Typically, concrete without a coating and with a poorly bonded coating tends to have a relatively deeper carbonation depth.

The compositional and textural characteristics of the paste indicated that the concrete had a moderate w/c, estimated to be in the range of 0.43 to 0.50, slightly variable from core to core (Tables 3 and 4). The portland cement content was estimated to be 6 to 6-1/2 bags (564 to 611 pounds) per cubic yard.

Air Void System

The concrete was air-entrained with a total air content estimated to be 2-1/2 to 8 percent, variable from core to core (Tables 3 and 4). Some cores had a marginally entrained air void system with air content on the lower end of the estimate (Figure 26). Others were well entrained and had air content in the higher end of

the estimate (Figure 27). Air content was not only highly variable among different cores, it also varied significantly within a given core, for some cores (Figure 28). This was likely due to poor distribution of air entraining admixtures in the fresh concrete. Cores 2, 6, 8, 13, and 16 exhibited internal variation in air content.

Voids were mostly coarse and irregular, consistent with entrapped air voids, when the total air content was low, and became fine and spherical, due to purposeful entrainment, when the air content was high. Voids were uniformly distributed for most cores except for those indicated in Tables 3 and 4. Voids in most cores were free of secondary deposits, indicating that the concrete in the sampling locations had not been exposed to significant internal moisture migration. These cores typically exhibited no evidence of ASR. For other cores, especially those with significant evidence of ASR, abundant secondary ettringite deposits were detected in air voids (Figures 29 and 30). This observation suggests that concrete represented by cores with evidence of ASR had been exposed to significant moisture movement.

Distress

The cores exhibited different types of distress and to different extents, and therefore, are described separately.

Core 1

Core 1 was taken from the south face of the north exterior wall at -61 feet. The core was 19-1/2 inches long and resulted in four lapped sections. The core contained a longitudinal crack at the surface that was up to 5 mils wide. The crack narrowed down at approximately 1/2 inch from the top surface and propagated through aggregate particles (Figure 31). No evidence of ASR was detected in the top region of the core represented by Core 1 AB; very limited but unambiguous evidence of ASR was detected in Core 1 BC, CD, and DE, including an isolated case of reaction rims in coarse aggregate and microcracks filled with alkali-silica gel extending out from aggregate into the paste (Figures 32 and 33).

No other distress was detected.

Core 2

Core 2 was taken from the east face of the west exterior wall at -31 feet. The core was 18-1/2 inches long and resulted in three lapped sections. The core contained one longitudinal crack that was 3/8 inch long, up to 6 mils wide, and propagated through aggregate particles (Figure 34). This crack was likely related to the ASR distress in the core.

Abundant evidence of severe ASR was detected in the core. The evidence was primarily manifested in the forms of very abundant reaction rims around reactive coarse aggregate particles and considerable cracking filled with gel within reactive aggregate particles or extending into the paste (Figures 35 to 40), and abundant microcracks in the paste, most of which were filled with alkali-silica gel (Figures 41 to 43). In addition, many air voids were coated or completely filled with gel (Figure 44 and 45). Many aggregate particles exhibited multiple manifestations of ASR, such as reaction rims, cracking, and cracks filled with gel (Figure 46). The cracks in the core were up to 3 inches long and 30 mils wide. While the cracks were essentially randomly oriented, many were subparallel to the top surface of the core. Given the fact that abundant microcracks were present, only limited intersections of microcracks were detected (Figure 47). Fresh (still soft and sticky) alkali-silica gel was also detected on the lapped section of the core (Figure 48).

The fresh gel was formed due to the additional exposure to moisture from cutting and lapping of the core, indicating significant potential reactivity of the concrete.

The reactive aggregate in the core was quartzite, as discussed in the General Property section.

It was also noted that secondary ettringite deposits were detected in many air voids, sometimes even co-existing with alkali-silica gel in a single void (Figure 49). However, no ettringite deposit was detected in any cracks or aggregate/paste interfaces.

It appeared that the second section of the core contained more cracks with gel than the other sections. A more quantitative comparison of ASR distress in different sections is given in the DRI Measurement section.

No other distress was detected in the core.

Core 3

Core 3 was taken from the west face of the east interior wall at -31 feet. The core was 3-1/2 inches long and contained a full-depth longitudinal crack (Figure 8). The crack was up to 100 mils wide near the top surface and branched out at approximately 1-1/4 inch from the top surface (Figure 50). The crack propagated through aggregate particles.

No evidence of ASR was detected. No evidence of other deterioration was detected.

Core 4

Core 4 was taken from the north face of the middle wall at -31 feet. The core was 4-3/4 inches long and contained an approximately 1/2-inch long longitudinal crack that propagated essentially around aggregate particles (Figure 51). The crack was less than 1 mil wide.

No evidence of ASR was detected. No evidence of other deterioration was detected.

Core 5

Core 5 was taken from the north face of the middle wall at -31 feet. The core was 12-3/8 inches long and resulted in two lapped sections. The core contained a full-depth longitudinal crack that propagated through aggregate particles (Figure 10). The crack was up to 95 mils wide and exhibited no evidence of narrowing at the bottom end of the core.

No evidence of ASR was detected. No evidence of other deterioration was detected.

Core 6

Core 6 was taken from then north face of the middle wall at -31 feet. The core was 13-1/2 inches long and resulted in two lapped sections. The core contained a full-depth longitudinal crack that propagated through aggregate particles (Figure 11). The crack was up to 95 mils wide and exhibited no evidence of narrowing down at the bottom end of the core.

No evidence of ASR was detected except a very weak reaction rim around a coarse aggregate particle. No evidence of other deterioration was detected.

Core 7

Core 7 was taken from the south face of the north exterior wall at -31 feet. The core was 18 inches long and resulted in three lapped sections. The core contained no full-depth longitudinal cracks or other macroscopical cracks.

The core exhibited evidence of ASR, including reaction rim in coarse aggregate particles (Figure 52), cracked reactive aggregate particles with some crack extending out into the paste (Figures 53 and 54), and gel-filled air voids (Figure 55). The overall extent of ASR distress appeared to be minor, and the extent of ASR was more advanced in sections BC and CD than in section AB.

Similar to Core 2, for which severe ASR was detected, most air voids were coated with secondary ettringite; however, no ettringite was detected in cracks.

No evidence of other distress was detected.

Core 8

Core 8 was taken from the south face of the north exterior wall at -11 feet. The core was 20-3/4 inches long and resulted in four lapped sections. The core contained an 11-inch long longitudinal crack that propagated though aggregate particles. The crack was up to 30 mils wide in Core 8 AB and Core 8 BC, but was narrowed and terminated at 3/4 inch from the saw-cut top surface of Core 8 CD (Figure 56). While the crack was a continuous single crack, small branches were observed from the main crack (Figure 57).

No evidence of ASR or other distress was detected.

Core 9

Core 9 was taken from the south face of the north exterior wall at -31 feet. This core was 2-1/2 inches long and contained two full-depth longitudinal cracks (Figure 14). The cracks propagated around aggregate particles and were up to 30 mils wide. The crack branched out with shifting locations, where one branch stopped and another continued (Figure 58).

No evidence of ASR was detected. No evidence of other deterioration was detected.

Core 10

Core 10 was taken from the south face of the north exterior wall at -9 feet. The core was 18-1/2 inches long and resulted in three lapped sections. The core contained one longitudinal crack that propagated through aggregate particles and was up to 30 mils wide. The crack narrowed and terminated at approximately 3-3/4 inches from the top surface of the core (Figure 15a). Prior to the termination, the crack propagated through a reactive particle with multiple cracks filled with alkali-silica gel (Figure 59).

Moderately abundant evidence of ASR was detected in the core, and became more abundant in Core 10 BC and Core 10 CD than Core 10 AB. The overall extent of ASR was assessed as moderate. Similar to other cores with ASR, the evidence of ASR was primarily manifested in the forms of abundant reaction rims around reactive aggregate particles; considerable cracking of reactive aggregate particles, some filled with gel, within the aggregate particles or extending into the paste (Figures 60 to 62); abundant microcracks in the paste, many of which were filled with alkali-silica gel (Figure 63); and gel-filled voids (Figure 64). In

addition, a ball of fresh clear gel was detected on the lapped section of the core (Figure 65). The fresh gel was formed due to the additional exposure to moisture from cutting and lapping of the core, indicating significant potential reactivity of the concrete.

While some air voids were coated or filled with alkali-silica gel, many voids were coated with secondary ettringite (Figure 66). Some voids were located next to each other but were coated with either gel or ettringite (Figure 67). In another case, it appeared that a void coated with ettringite was later covered with gel (Figure 68). It was also observed that secondary ettringite crystals precipitated sparsely in a wide crack (Figure 69).

No other distress was detected in the core.

Core 11

Core 11 was taken from the north face of the south exterior wall at -61 feet. The core was 21 inches long and resulted in four cut and lapped sections. It contained multiple surface coatings that were poorly bonded to each other and the concrete (Figure 70). A total of six individual layers could be identified, with each layer having variable thickness. The total thickness of the multiple layers was up to 21 mils.

While the concrete contained no macroscopical cracks, it contained very abundant microcracks. The microcracks were mostly randomly oriented, with a majority more or less parallel to the top surface. The cracks were up to 3-1/2 inches long and 8 mils wide. These cracks were induced by ASR.

Significant evidence of severe ASR was detected in the core, and appeared to be more or less consistent in different sections of the core. Similar to other cores with ASR, the evidence of ASR was primarily manifested in the forms of abundant reaction rims around reactive aggregate particles; considerable cracking of reactive aggregate particles, some filled with gel, within the aggregate particles or extending into the paste; abundant microcracks in the paste, many of which were filled with alkali-silica gel; and gel-filled voids (Figures 71 to 75).

Similar to other cores with ASR, many voids in the core were coated with secondary ettringite. No other distress was detected in the core.

Core 12

Core 12 was taken from the north face of the south exterior wall at -41 feet. The core was 18 inches long and resulted in three lapped sections. Abundant microcracks were detected in the core. The microcracks were up to 3-1/2 inches long and up to 9 mils wide. While most microcracks were randomly oriented, many were subparallel to the top surface of the core (Figure 17). These cracks were due to ASR.

Significant evidence of severe ASR was detected in the core, and it appeared to be more or less consistent in different sections of the core. Similar to other cores with ASR, the evidence of ASR was primarily manifested in the forms of abundant reaction rims around reactive aggregate particles; considerable cracking of reactive aggregate particles, some filled with gel, within aggregate particles or extending into the paste; abundant microcracks in the paste, many of which were filled with alkali-silica gel; and gel-filled voids (Figures 76 to 81).

Unlike other cores with ASR, significant evidence of ASR was detected for Core 12 near the surface region (Figures 82 and 83).

Similar to other cores with ASR, many voids of the core were coated with secondary ettringite. No other distress was detected in the core.

Core 13

Core 13 was taken from the south face of the middle wall at -31 feet. The core was 12-1/4 inches long and resulted in two lapped sections. The core contained a full-depth longitudinal crack that branched out at several locations (Figure 18 and Figure 84). The crack propagated through aggregate particles, did not narrow down toward the bottom of the core, and was as much as 95 mils wide in Core 13 BC.

No evidence of ASR was detected. No evidence of other deterioration was detected.

Core 14

Core 14 was taken from the south face of the middle wall at -31 feet. The core was 5 inches long and contained a full-depth longitudinal crack that propagated through aggregate particles (Figure 19). The crack was 95 mil wide and did not narrow toward the bottom of the core.

No evidence of ASR was detected. No evidence of other deterioration was detected.

Core 15

Core 15 was taken from the south face of the middle wall at -29 feet. The core was 12 inches long and resulted in two lapped sections. The core contained a longitudinal crack that propagated through aggregate particles (Figure 20). The crack was 95 mil wide and extended out of the core at approximately 5-5/8 inches from the top surface. Similar to other cores with long longitudinal cracks, the crack often branched out.

No evidence of ASR was detected. No evidence of other deterioration was detected.

Core 16

Core 16 was taken from the east face of the west exterior wall at -31 feet. The core was 18-1/2 inches long and resulted in three lapped sections. No long longitudinal cracks were detected in the core; however, a moderate amount of microcracks were detected. The cracks were up to 3 inches long and 5 mils wide.

Moderately abundant evidence of ASR was detected in the core. The evidence was weak and limited in the top section of the core (Core 16 AB) and significantly increased toward the bottom section (Core 16 CD). The overall extent of ASR was judged to be moderate. The evidence manifested itself in similar forms as other cores with ASR, including abundant reaction rims around reactive aggregate particles; considerable cracking of reactive aggregate particles, some filled with gel, within aggregate particles or extending into the paste; abundant microcracks in the paste, many of which were filled with alkali-silica gel; and gel-filled voids (Figures 85 to 87).

Similar to other cores with ASR, many voids of the core were coated with secondary ettringite. No other distress was detected in the core.

Core 18

Core 18 was taken from the north face of the middle wall at -61 feet. The core was 2-3/4 inches long with both the top and bottom surface fractured (Figure 22). The core contained no cracks and no evidence of distress.

Core 19

Core 19 was taken from the south face of the middle wall at +3 feet. The core was 11-1/2 inches long and resulted in two lapped sections (Figure 23). No cracks or other forms of distress were detected in the core. The top surface of the core contained surface paint and was intact (Figure 88).

Core 20

Core 20 was taken from the east face of the west exterior wall at ground level. The core was 18-1/2 inches long and resulted in four lapped sections. The core contained two horizontal cracks that separated the core into three portions. The central portion was then cut into two (Figure 24).

A full-depth longitudinal crack approximately 5 inches long was detected in Core 20 AB, which propagated through aggregate particles. The crack was up to 30 mils wide and contained no alkali-silica gel deposits. Similar to other long longitudinal cracks, the longitudinal crack also branched out (Figure 89). No longitudinal crack was detected in Core 20 BC.

Core 20 AB exhibited no evidence of ASR. The core was also exposed to very limited moisture movement because most air voids were essentially free of secondary ettringite.

Limited evidence of ASR was detected in the other three sections of the core, and the evidence appeared to be much more abundant in Core 20 DE than in sections BC and CD. Even so, the overall extent of ASR was judged to be minor.

Similar to other cores with ASR, the evidence of ASR included cracked reactive coarse aggregate, cracks extending out from reactive particles into the paste, cracks in the paste and air voids filled with gel (Figures 90 to 92).

Also similar to other cores with ASR, most voids in Core 20 BC, CD, and DC were coated with secondary ettringite, suggesting that the concrete was exposed to internal moisture movement. In an air void, it was observed that calcium hydroxide and ettringite deposited together (Figure 93).

DRI Measurement

The results of the DRI measurement, normalized for each individual core, are given in Table 5 and Figure 94. The results clearly identified eight cores with unambiguous evidence of ASR. Three cores, Cores 2, 11, and 12, with total DRI values greater than 350, exhibited the most severe ASR. Two cores, Cores 10 and 16, with total DRI greater than 200, exhibited moderate ASR. Two additional cores, Cores 7 and 20, with total DRI greater than 85, also exhibited noticeable ASR, albeit to a much less significant extent. These conclusions are consistent with the results of the petrographic examination. Petrographic examination also indicated that very limited but unambiguous evidence of ASR was detected in Core 1 BC, CD, and DE; the total DRI for the core, however, was only 17. Nevertheless, the total DRI had a contribution of unambiguous evidence of ASR.

The other eleven cores had DRI values between 8 and 83. Further examination of the data clearly demonstrated that these values were primarily due to cracks in the paste as well as aggregate particles. Out of the eleven cores, eight cores contained large longitudinal cracks that were either full depth or partial depth. While the cause of these longitudinal cracks in the cores will be further discussed in the Discussion section, these cores did not contain distress unambiguously attributable to ASR, such as cracks with gel in the paste or aggregate. Results of the petrographic examination also indicated that theses cores exhibited no evidence of ASR. Since the DRI measurements for these cores were primarily due to the large cracks in the cores, and not obvious ASR-induced distress, the DRI measurements for these eleven cores are not true measurements of ASR distress in these cores. Therefore, no further discussion is warranted for these cores.

For the eight cores that exhibited unambiguous evidence of ASR, the DRI data provided detailed depiction of ASR development in each core section. Such details are otherwise unresolvable by typical petrographic examination. Therefore, the DRI data for each core is discussed further below.

Core 1

The total DRI for the core was very low at 17, and distress due to ASR was very minor. The core resulted in four lapped sections, with no ASR-induced distress in the top two sections, except for reaction rims in some aggregate particles in Core 1 BC. The bottom two sections exhibited unambiguous evidence of ASR, with gel-filled cracks in the paste and reactive aggregate particles (Figure 95).

Core 2

Core 2 exhibited severe ASR with a total DRI of 400. The core resulted in three lapped sections, with the top section exhibiting significantly more severe ASR than the middle and bottom sections (Figure 96). The total DRI for the top portion was 561, while the total DRI for the middle and bottom portion was 341 and 315, respectively. The most significant contributor to the DRI measurement was gel in cracks in paste, followed by gel in cracked aggregate particles. The unique feature of ASR in the concrete was abundant gel production.

Core 7

The core resulted in three lapped sections and had a total DRI of 86, with the top section exhibiting significantly less ASR than the middle and bottom sections (Figure 97). The total DRI for the top portion was 35, while the total DRI for the middle and bottom portions was 109 and 112, respectively. The most significant contributor to the DRI measurement was gel in cracks in paste, followed by gel in cracked aggregate particles. In addition, cracks without gel in the cement paste also contributed significantly to the total DRI measurement.

Core 10

The core resulted in three lapped sections and had a total DRI of 219, with the top section exhibited significantly less ASR than the middle and bottom sections (Figure 98). The total DRI for the top portion was 102, while the total DRI for the middle and bottom portions was 261 and 267, respectively. The most significant contributor to the DRI measurement was gel in cracks in paste, followed by gel in cracked aggregate particles. In addition, cracks without gel in the cement paste also contributed significantly to the total DRI measurement.

Core 11

The core resulted in four lapped sections and had a total DRI of 358. While the top portion exhibited the lowest DRI of the four sections, the difference was insignificant (Figure 99). The total DRI for the core, from top to bottom, was 290, 416, 326, and 332, with the middle top section significantly higher than the other three sections. The most significant contributor to the DRI measurement was gel in cracks in paste, followed by gel in cracked aggregate particles. The contribution from cracks without gel in the cement paste to the total DRI measurement was negligible. It appeared that more abundant gel was produced as ASR developed further.

Core 12

The core resulted in of three lapped sections and had a total DRI of 383, with the three sections exhibiting very similar total DRI (Figure 100). The total DRI was 379, 387, and 382 for the top, middle, and bottom sections, respectively. The most significant contributor to the DRI measurement was gel in cracks in paste, followed by gel in cracked aggregate particles. Contribution to DRI from cracks without gel in the cement paste was limited. The ASR in the core was also a gel-rich process.

Core 16

The core resulted in three lapped sections and had a total DRI of 203. The DRI exhibited significant increase from the top section to the bottom section (Figure 101). The total DRI was 58, 162, and 344 for the top, middle, and bottom sections, respectively. Similar to the other cores, the most significant contributors to the DRI measurement was gel in cracks in paste and gel in cracked aggregate particles.

Core 20

The core resulted in four lapped sections and had a total DRI of 107. Similar to that of Core 16, the DRI of Core 20 also exhibited a significant increase from the top section to the bottom section (Figure 102). The total DRI for the core, from top to bottom, was 28, 71, 107, and 196. The top portion of the core contained no unambiguous evidence of ASR. The measured DRI was primarily due to a longitudinal crack in that core section. Unambiguous evidence of ASR was detected from section BC down. In the bottom section, the most significant contributor to the DRI measurement was gel in cracks in paste, followed by gel in cracked aggregate particles. The core further confirmed that more abundant gel was produced as ASR developed further.

DISCUSSION AND CONCLUSIONS

Summary

The concrete represented by the nineteen cores (forty-six sections) examined was similar and represented the same concrete mix design. The concrete was air-entrained and contained crushed quartzite coarse aggregate, natural siliceous sand fine aggregate, and portland cement. The estimated w/c was in the range of 0.43 to 0.50. The portland cement content was estimated to be 564 to 611 pounds per cubic yard. The air content varied from 2-1/2 percent to 8 percent. The variability of mix proportions from core to core was primarily due to variability that occurred in the batching, mixing, and placement of the fresh concrete, rather than different concrete mix designs. Variable air content was also detected within many individual cores, consistent with this assessment.

Due to the limited information regarding to the concrete mix design, WJE could not determine whether the mix proportions of the concrete represented by the cores were consistent with the original concrete mix design. However, the overall property of the concrete suggests that it was likely a 4,000- psi class concrete.

The concrete represented by the cores exhibited significant cracking. Of the nineteen cores examined, only two cores, Core 18 and Core 19, exhibited no detectable cracks. Eight cores, Cores 1, 2, 7, 10, 11, 12, 16, and 20, exhibited various degrees of microcracking, which was due unambiguously to ASR. The evidence of ASR manifested primarily in the forms of abundant random microcracks in the paste and/or reactive quartzite coarse aggregate particles, and the cracks were often filled with abundant alkali-silica gel. The cracks were up to 3-1/2 inches long and 30 mils wide. The extent of ASR varied significantly from core to core, or even within individual cores. Core 1 had very limited distress due to ASR with a total DRI of 17. Core 7 and Core 20 had minor ASR with a total DRI of 86 and 107, respectively. Core 10 and Core 16 had moderate ASR with a total DRI of 219 and 203, respectively. Core 2, Core 11, and Core 12 all exhibited severe ASR with a total DRI of 400, 358, and 383, respectively.

All eight cores with ASR were drilled from the exterior walls of the Equipment Vault. While some voids in theses cores were coated or filled with alkali-silica gel, due to ASR, the majority of the air voids in these cores were coated with secondary ettringite deposits, suggesting that the concrete had been exposed to internal moisture movement.

Within each core, the extent of ASR was also different depending on the locations of the cores. Of the eight cores with ASR, Core 2 was the only one that exhibited the most severe ASR in the top portion of the core. All other cores either exhibited significantly less ASR in the top portions than the deeper portions or a similar extent of ASR between the top portions and deeper portions. This observation suggests that ASR in the concrete was likely initiated and controlled by a factor from deep inside the concrete, rather than from the top surface of the concrete. The development of ASR was controlled by availability of moisture coming from the exterior end of the walls.

Nine cores exhibited cracks that did not appear to be directly related to ASR distress. Core 4 contained a 1/2-inch long longitudinal crack that was less than 1 mil wide. Six cores, Core 3, Core 5, Core 6, Core 9, Core 13, and Core 14, contained full-depth longitudinal cracks that propagated through aggregate particles and were mostly up to 95 mils wide, except for Core 9, which was 30 mils wide. Cracks in these cores did not exhibit a trend of narrowing down as the depth of the cores. Two additional cores, Core 8 and Core 15, had partial-depth longitudinal cracks that were up to 30 mils wide. All these cores also exhibited clean air voids with essentially no secondary deposits, suggesting that the concrete represented by these cores had not been exposed to significant internal moisture movement. Further examination indicates that these cores, except for Core 8 and Core 9, were all extracted from the interior or middle walls and were not exposed to external moisture.

While the possibility of shrinkage-induced or thermal-related volume change could not be completely ruled out for these cores with large cracks, a more logical explanation is that the cracks in these cores were volume change cracks as a result of ASR distress in the adjacent walls. Expansion of the exterior walls due to ASR caused overall volume change of the Equipment Vault, which resulted in the large cracks in the middle walls of the vault.

Distress Mechanism

Alkali-Silica Reaction (ASR)

A detailed discussion of the mechanism of ASR is beyond the scope of this report. Briefly, ASR is a chemical reaction occurring between reactive siliceous aggregate particles and hydroxyl ions of the pore solution in hardened concrete. The reaction product is an amorphous gelatinous material that contains silicon, alkalis, calcium, and water, which swells when moisture is absorbed and can cause expansion and cracking in concrete structures. The high concentration of hydroxyls (high pH value) typically found in the pore solution of portland cement concrete is a result of and maintained by the release of alkali ions (potassium and sodium) from the hydration of portland cement. The reactive aggregate is normally an amorphous silica material (lack of long range order at atomic level, such as chert), or a silica whose long range order was destroyed due to strain and stress, such as strained quartz. Quartz is one of the most stable minerals on earth, which had an interconnected framework of silicon oxide tetrahedra at atomic level. When quartz is exposed to stress, such as during a metamorphic process, the long range framework of tetrahedra is destroyed and replaced with broken bonds of silicon oxides and becomes susceptible to potential ASR. The quartzite coarse aggregate in the concrete contained two reactive components. One was microcrystalline quartz and the other was strained quartz.

ASR will not necessarily occur in concrete with reactive aggregate and high alkali load. Three prerequisites must be met simultaneously for ASR to occur: reactive aggregate, sufficient alkali load in the concrete, and available moisture. Moisture movement within the concrete is the driving force of ASR. ASR is typically initiated as microcracks in the reactive aggregate particles, which extend into the surrounding paste and often are filled with gel. The cracks in turn allow more and easier moisture migration, resulting in more reactive particles to participate in the reaction. The process is typically self-sustained as long as moisture is supplied.

We know low alkali Portland cement was predominately used in the concrete based on the Certified Material Test Reports (CMTRs) provided by the cement manufacturers and independent laboratory testing performed by Pittsburg Testing Laboratory (PTL) on every 1200 tons of Portland cement delivered to Seabrook during the construction phase of the plant. While we do not know the alkali content of the hardened concrete, the occurrence of ASR in the concrete suggests that it was sufficiently elevated for ASR to occur. The reactive aggregate in the concrete was the primary component of the aggregate and was abundant. Even for cores with severe ASR, such as Core 2, Core 11, and Core 12; however, there was still a significant number of quartzite particles that had not exhibited evidence of ASR. Therefore, the concrete represented by the cores should have significant potential for continued development of ASR, as long as the moisture supply is maintained.

All cores with ASR were from the exterior walls with the source of the moisture from the exterior sides of the walls, or from the bottoms of the cores toward the top surfaces of the cores. Because of the same composition and mix proportions of the concrete for different cores and across the depth of a given core, it is reasonable to assume that the different ASR development in a given core was due to limitation of available moisture. For the three cores with the most severe ASR, Core 2, Core 11, and Core 12, the top portions exhibited either more severe ASR (Core 2), or similar ASR as the interior (Core 11 and Core 12). This observation suggests that the ASR for these cores was at a steady state, unlimited by the availability of moisture. Sufficient moisture had reached to the top surface of the concrete, and ASR development was only limited by the intrinsic property of the concrete, such as available alkali and reactive aggregate, but was not restrained by the availability of moisture. While the rate of ASR might have been in a steady state

for these cores, the ASR-induced distress would be accumulative and deeper in the walls, much more significant distress is expected.

For the other five cores with moderate and/or minor ASR, Core 1, Core 7, Core 10, Core 16, and Core 20, the top portions of the cores always exhibited significantly less development of ASR than the corresponding deeper portions of the cores. This observation suggests that the ASR development near the top surface of the cores was limited by the availability of moisture. Deeper in the walls where these cores were taken and moisture availability was not an issue, ASR development might have been significantly more advanced than the cores suggest. Therefore, more significant distress induced by ASR is expected for the deeper portions of the walls represented by these cores, due to increased rate of reaction and accumulative effect of distress.

Delayed Ettringite Formation (DEF)

All cores with ASR also contained abundant secondary ettringite deposits in air voids; therefore, it is necessary to discuss the possibility of another internal expansion mechanism that involves secondary ettringite, which is known as delayed ettringite formation (DEF). Ettringite is a normal hydration product of portland cement and is typically innocuous in hardened concrete. The amount of ettringite produced during cement hydration depends on the composition of the cement and curing conditions of fresh concrete. When the internal temperature of concrete is 70 degrees Celsius (approximately 160 degrees Fahrenheit) or above, whether due to external high temperature curing or internal heat of hydration, the normal formation of ettringite is interrupted, and no ettringite will form in concrete. After concrete is in service and exposed to moisture, components of ettringite will migrate to convenient locations, such as aggregate/paste interfaces, and precipitate out. This will cause a uniform paste expansion, resulting in peripheral cracking around aggregate particles and network cracking in the paste. The unique characteristics of DEF is peripheral cracking and abundant ettringite deposits in cracks. We did not detect any peripheral cracking in the concrete. The paste/aggregate bond was typically tight and strong. The microcracks were primarily filled with alkali-silica gel, and not ettringite.

Since ettringite was a typical hydration product of portland cement and has a relatively high solubility, it was often observed as secondary deposits in air voids of concrete, as a result of moisture migration within the concrete. As in the cores examined herein, the ettringite coating of many air voids in the concrete only occurred in cores with evidence of ASR, which was clearly involved with moisture movement. Therefore, the ettringite coating of voids in the concrete was an indication of internal moisture movement, rather than an indication of internal expansion involving ettringite. The concrete represented by the cores exhibited no evidence of DEF, and no DEF is expected in the future.

Conclusions and Recommendations

Based on the petrographic examination of nineteen concrete cores retrieved from different locations of the walls of the Equipment Vault, eight cores, all from exterior walls, exhibited variable extent of ASR-induced distress, from minor to severe. ASR-induced expansion may also be responsible for large longitudinal cracks in many cores taken from interior walls. While the extent of ASR distress in the examined cores was variable, more significant ASR-induced distress is expected in the deeper portions of the exterior walls, which have greater access to moisture. Further, ASR is expected to continue to develop unless the moisture supply is interrupted.

To further evaluate the ASR development rate and associated distress in the Equipment Vault, additional testing is recommended. In light of the information obtained from the petrographic examination, WJE recommend the following tests:

- Accelerated Expansion Tests should be performed to assess the potential for additional ASR in the RHR vaults.
  - Accordingly, we recommend the following sampling plan:
    - Six 12-inch long and 3-inch diameter cores should be taken for Alpha and Bravo Train separately. All cores should be taken from the exterior walls in the vicinity of the cores that have exhibited severe, moderate, and minor ASR. Cores should be taken at two severe, two moderate, and two minor ASR locations.
    - Two additional cores from the middle wall between the trains should be taken and tested in the same way. As the concrete for the middle wall is likely the same as that used for the exterior walls, we expect these cores to undergo ASR expansion once they are provided sufficient moisture.

Once the Invar wire extensometer instrumentation and the core expansion testing have completed a twelve month cycle, we will have data that will provide a greater understanding regarding the rate of ASR expansion and the potential for additional future expansion. DRI could be used to further quantify the results learned from the referenced instrumentation and expansion testing by selecting companion cores to some of the cores examined in this study. Accordingly, we recommend the following:

- DRI Comparative Study. Take three cores per train at the vicinity of the cores exhibiting severe, moderate, and minor ASR after twelve months of extensometer and expansion data acquisition and perform DRI measurement to assess the development of ASR in the concrete under in-service conditions.

TABLES

Table 1. Core Locations and Descriptions

ID	Train	Wall	Elevation	Field Comments	Length (in.)	Description
1	Alpha	North Exterior Wall (South Face)	-61'-0"	8'-8" west of wall, 16'-7" above -61' level	19-1/2	Cut into four sections
2		West Exterior Wall (East Face)	-31'-0"	3'-10" from north ext. wall 3'-8" above -31' grate	18-1/2	Cut into three sections
3		East Interior Wall (West Face)	-31'-0"	7'-0" from middle, 1'-0" above -31' grate	3-1/2	Full-depth longitudinal crack
4		Middle Wall (North Face)	-31'-0"	6'-6" from west interior wall; 3'-6" above concrete floor (-31' level)	4-3/4	
5		Middle Wall (North Face)	-31'-0"	5'-3" from west interior wall; 3'-7" above concrete floor (-31' level)	12-3/8	Full-depth longitudinal crack, top 4-1/2 inch shafted
6		Middle Wall (North Face)	-31'-0"	6'-0" from west interior wall; 5'-10" above grate floor (-31' level)	13-1/2	Full-depth longitudinal crack, broken horizontally into two sections
7		North Exterior Wall (South Face)	-31'-0"	1'-6" off west int. wall 2'-6" above -31' grating	18	Cut into three sections
8		North Exterior Wall (South Face)	-11'-0"	7'-0" west of west ext. wall 5'-0" above grating.	20-3/4	Partial-depth longitudinal crack
9		North Exterior Wall (South Face)	-31'-0"	7'-6" from west interior wall; 5'-3" above concrete floor (-31' level)	2-1/4	Full-depth longitudinal crack, rebar imprint at bottom
10		North Exterior Wall (South Face)	-9'-0"	7'-8" from west interior wall; 3'-4" above grate floor (-9' level)	18-1/2	Longitudinal crack approximately 3 inches
17		Middle Wall (North Face)	-61'-0"	1'-6" from west exterior wall; 2'-9" above concrete floor	2	Not for petrography, for verifying rebar corrosion
18		Middle Wall (North Face)	-61'-0"	2'-0" from west exterior wall; 2'-4" above concrete floor	2-3/4	
11	Bravo	South Exterior Wall (North Face)	-61'-0"	4'-4" from west exterior wall; 0'-10" above concrete floor (-61' level)	21	Top 2-3/4-inch shafted. Broken into two at 8' from bottom
12		South Exterior Wall (North Face)	-41'-0"	6'-0" west of west exterior wall and 6" above construction joint.	18	Cut into three sections
13		Middle Wall (South Face)	-31'-0"	6'-2" from east interior wall; 2'-4" above grate floor (-31' level)	12-1/4	Full-depth longitudinal crack
14		Middle Wall (South Face)	-31'-0"	4'-3" from east interior wall; 3'-1" above grate floor (-31' level)	5	Full-depth longitudinal crack
15		Middle Wall (South Face)	-29'-0"	Through delaminated area and 30-mil crack. 8' east of west exterior wall and 4' above grating.	12	6-inch long longitudinal crack
16		West Exterior Wall (East Face)	-31'-0"	4'-1" from south exterior wall; 0'-9" above grate floor (-31' level)	18-1/2	Top 3-1/2-inch shafted. Broken horizontally into two sections at 11-1/2 inches.
19		Middle Wall (South Face)	+3'-2"	5'-8" east of east int. wall 2'-4" above 3'-2" grating	11-1/2	Cut into two sections
20		West Exterior Wall (East Face)	-0'-1/2"	5'-2" south of middle wall 2'-2" above 0'-0" grating	18-1/2	5-1/2-inch deep longitudinal crack, broken horizontally into three sections

Table 2. Distress Features in DRI Measurement and Associated Weighting Factors

Distress Code	Distress Feature	Weighting Factor
CCA	Cracks in coarse aggregate	**0.25**
CGCA	Cracks and gel in coarse aggregate	**2.0**
CAD	Coarse aggregate debonding	**3.0**
RCA	Reaction rim around coarse aggregate	**0.5**
CCP	Crack in cement paste	**2.0**
CGCP	Crack and gel in cement paste	**4.0**
GAV	Air void with gel	**0.5**

Table 3. Summary of Findings of the Petrographic Examination for the Cores from Train Alpha

Core ID	1	2	3	4	5	6	7	8	9	10	18
Coarse aggregate	Crushed quartzite with a nominal maximum size of 3/4 inch, dark gray, angular, mostly hard and dense, and uniformly distributed.										
Fine aggregate	Natural siliceous sand consisting of major amount of quartz and minor amount of feldspar, granite, and mica.										
Paste feature	Gray, uniform, hard, dense, and had a semiconchoidal texture.										
Residual cement	Minor amount, mostly ferrite phases, no supplementary cementitious materials										
Estimated w/c	0.45 to 0.50	0.43 to 0.48	043 to 0.48	0.45 to 0.50	0.45 to 0.50	0.45 to 0.50	0.45 to 0.50	0.45 to 0.50	0.45 to 0.50	0.45 to 0.50	0.43 to 0.48
Estimated cement content	6 to 6-1/2 bags (564 to 611 pounds) per cubic yard										
Air void system	Entrained	Entrained	Entrained	Marginal	Marginal	Marginal	Entrained	Entrained	Entrained	Entrained	Marginal
Estimated air content (%)	4-1/2 to 5-1/2	3 to 6, highly variable	6 to 7	3 to 4	3-1/2 to 4-1/2	3 to 4, variable with clusters	6 to 8	4 to 6-1/2 Non-uniform	6-1/2 to 7-1/2	5 to 6	3 to 4
Depth of carbonation (in.)	1/32	1/32 to 1/4	1/32 to 1/4	1/4	1/8	<1/32	1/32	1/16 to 5/16	1/16 to 1/8	1/32	None, fractured
Surface coating thickness	10 mils, partially debonded	10 mils, tightly bonded	None	None	None	None	None	None	None	None	None, fractured
Cracking	One micro-	Abundant micro-	One micro-	One micro-	One macro-	One macro-	Micro-	Macro-	Macro-	Both	None
Crack feature	Through aggregate	Through aggregate	Through aggregate	Around aggregate	Through aggregate	Around aggregate	Through aggregate	Through aggregate	Through aggregate	Through aggregate	--
Crack orientation	Longitudinal at surface	Random	Longitudinal	Longitudinal at surface	Longitudinal	Longitudinal	Random	Longitudinal	Longitudinal	Longitudinal to random	--
Crack length	1/2 in.	Up to 3 inches	Full depth	1/2 inch	Full depth	Full depth	Up to 1-1/2 inches	11 inches	Full depth	Up to 3-3/4 inches	--
Crack width	Up to 5 mil	Up to 30 mils	Up to 100 mils	< 1 mil	Up to 95 mils	Up to 95 mils	Up to 6 mils	Up to 30 mils	Up to 30 mils	Up to 30 mils	--
ASR	Limited	Severe	None	None	None	None	Minor	None	None	Moderate	None
Comment	Voids clean	Voids with ettringite	Voids clean	Voids clean	Voids clean	Most voids clean	Voids with ettringite	Voids clean except for bottom portion	Voids clean	Voids with ettringite	Voids clean

Table 4. Summary of Findings of the Petrographic Examination for the Cores from Train Bravo

Core ID	11	12	13	14	15	16	19	20
Coarse aggregate	Crushed quartzite with a nominal maximum size of 3/4 inch, dark gray, angular, mostly hard and dense, and uniformly distributed.							
Fine aggregate	Natural siliceous sand consisting of major amount of quartz and minor amount of feldspar, granite, and mica.							
Paste feature	Gray, uniform, hard, dense, and had a semiconchoidal texture.							
Residual cement	Minor amount, mostly ferrite phases, no supplementary cementitious materials							
Estimated w/c	0.43 to 0.48	0.43 to 0.48	0.45 to 0.50	0.45 to 0.50	0.45 to 0.50	0.45 to 0.50	0.43 to 0.48	0.43 to 0.48
Estimated cement content	6 to 6-1/2 bags (564 to 611 pounds) per cubic yard							
Air void system	Marginal	Marginal	Entrained	Marginal	Entrained	Entrained	Entrained	Entrained
Estimated air content (%)	3 to 4	2-1/2 to 4	3 to 5-1/2, variable	3 to 4	3-1/2 to 4-1/2	3-1/2 to 4-1/2 slightly variable	4-1/2 to 5-1/2	4-1/2 to 5-1/2
Depth of carbonation (in.)	1/32	1/8, partially	<1/32	3/32	<1/32	Up to 1/4 partial	1/8 to 1/4	1/8
Surface coating thickness	Multiple layers totaling 21 mils	10 mils, poorly bonded	10 mils, tightly bonded	10 mils, poorly bonded	7 mils, tightly bonded	10 mils, tightly bonded	10 mils, tightly bonded	10 mils, tightly bonded
Cracking	Abundant micro-	Abundant micro-	One macro-	One micro-	One Macro-	One macro- And abundant micro-	None	Both type of cracks
Crack feature	Through aggregate	Through aggregate	Through aggregate	Through aggregate	Through aggregate	Through aggregate	--	Through aggregate
Crack orientation	Random	Random	Longitudinal	Longitudinal	Longitudinal	Longitudinal Random	--	Longitudinal to random --
Crack length	3-1/2 inches	Up to 3-1/2 inches	Full depth	Full depth	Up to 5-5/8 inches	Up to 3 inches	--	Up to 5 inches for the V-crack, 1/2 for random cracks.
Crack width	Up to 8 mils	Up to 9 mils	Up to 95 mils	Up to 95 mils	Up to 30 mils	Up to 5 mils	--	Up to 30 mils for the V-crack, 1 mil for the others
ASR	Severe	Severe	None	None	None	Moderate	None	Minor
Comment	Voids with ettringite	Voids with ettringite	Voids clean	Voids clean	Voids clean	Voids with ettringite	Voids mostly clean	Voids with ettringite

Table 5. Summary Results of DRI Measurement for Each Core

Core ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	19	20
Cracked CA	3	5	1	4	2	2	4	2	3	4	4	3	5	0	2	4	3	3	7
Cracked CA w/gel	2	82	0	0	0	0	14	0	0	39	78	69	0	0	0	36	0	0	25
Reaction Rim in CA	2	7	0	0	1	1	9	3	1	9	3	9	1	1	0	10	5	1	9
Cracks in paste	1	33	54	4	42	25	14	20	78	46	7	20	55	29	16	21	11	0	18
Cracks w/gel in paste	9	265	0	0	0	0	43	0	0	115	260	277	0	0	0	126	0	0	47
Gel in void	0	8	0	0	0	0	3	0	0	4	6	5	0	0	0	8	0	0	1
Total	17	400	55	8	44	27	86	25	83	219	358	383	60	30	19	203	18	4	107

FIGURES

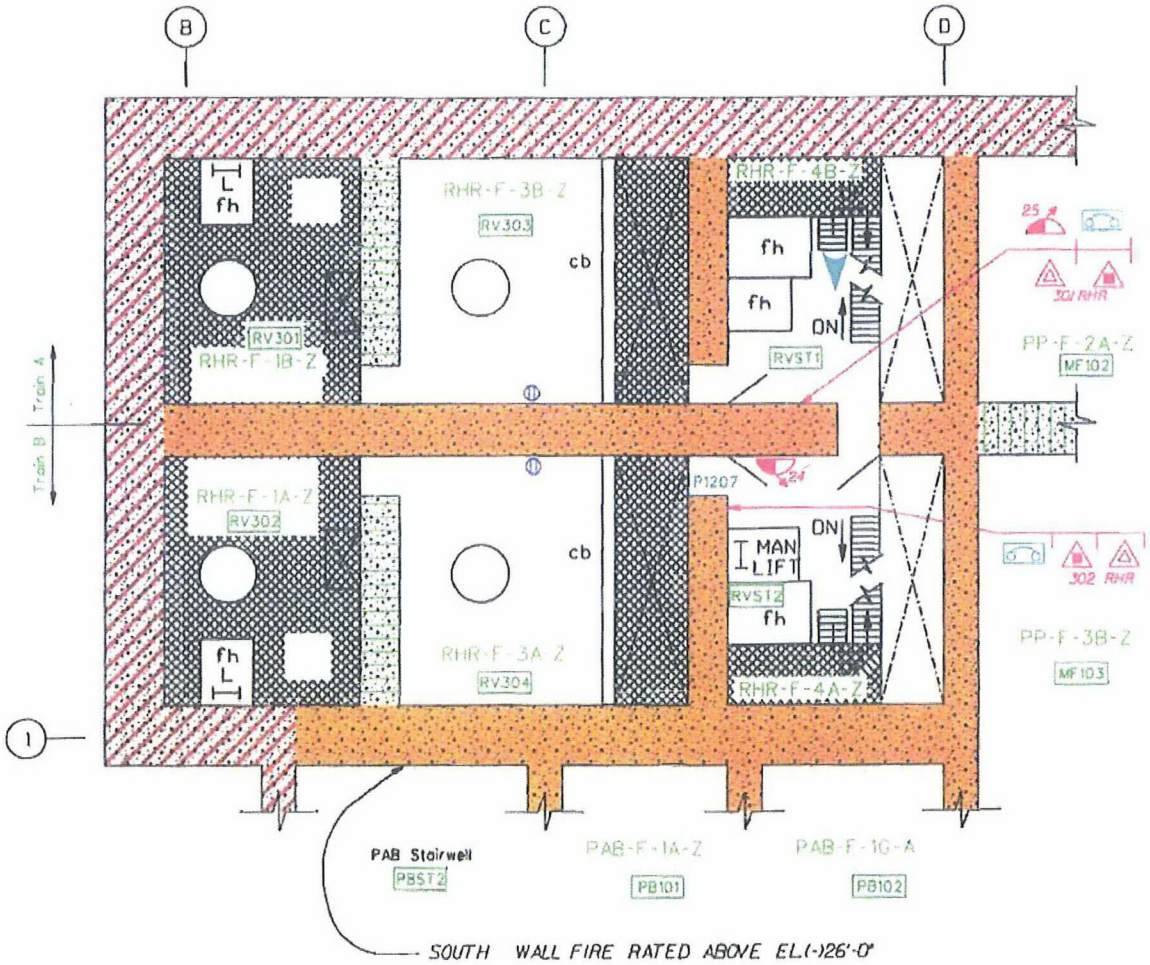

Figure 1. Plan view of Equipment Vault at Elevation -31'-10". Plan view taken from Fire Protection Drawings.

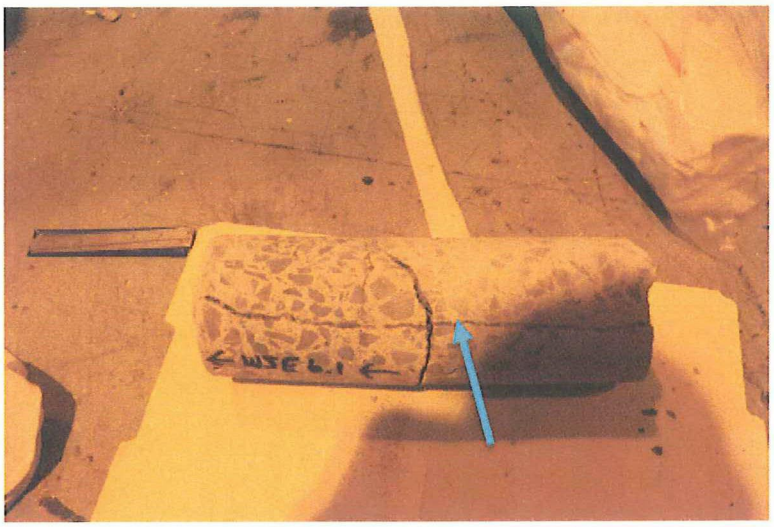

Figure 2. As-received Core 6 showing the full-depth longitudinal crack (arrow).

Figure 3. As-received Core 13 showing the full-depth longitudinal crack (arrow).

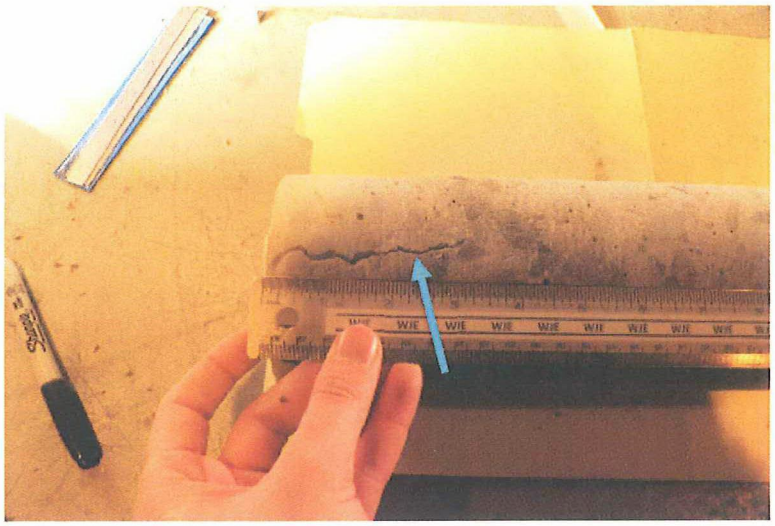

Figure 4. As-received Core 10 showing a partial-depth crack (arrow).

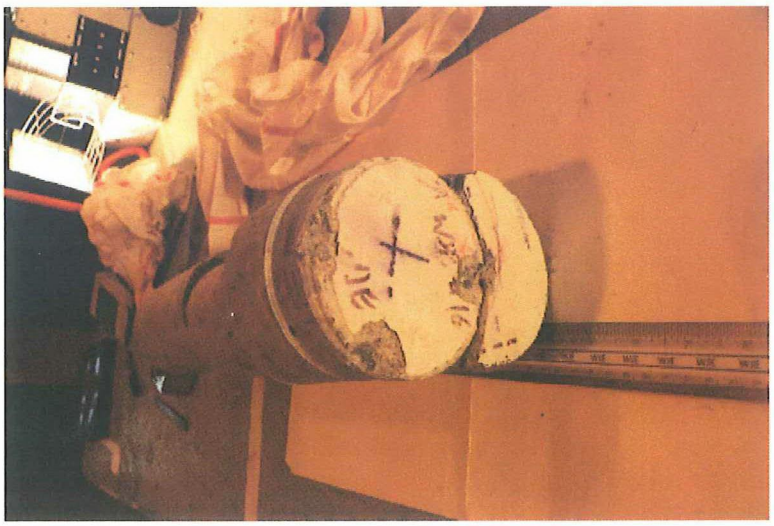

Figure 5. As-received Core 16 showing the shifting of the core.

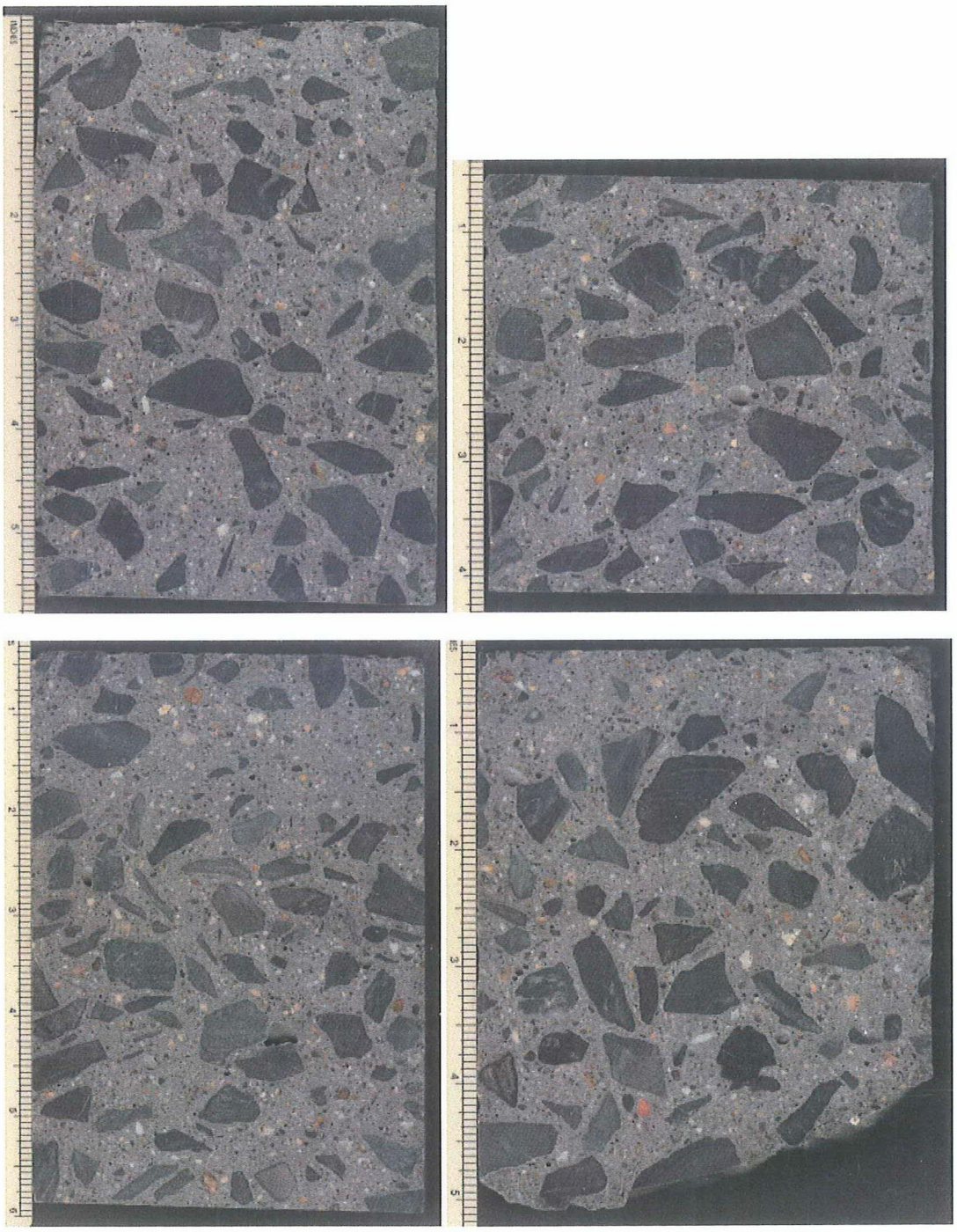

Figure 6. The four lapped sections of Core 1 with the top section at the top left and bottom section on the lower right, showing uniform distribution of aggregate particles.

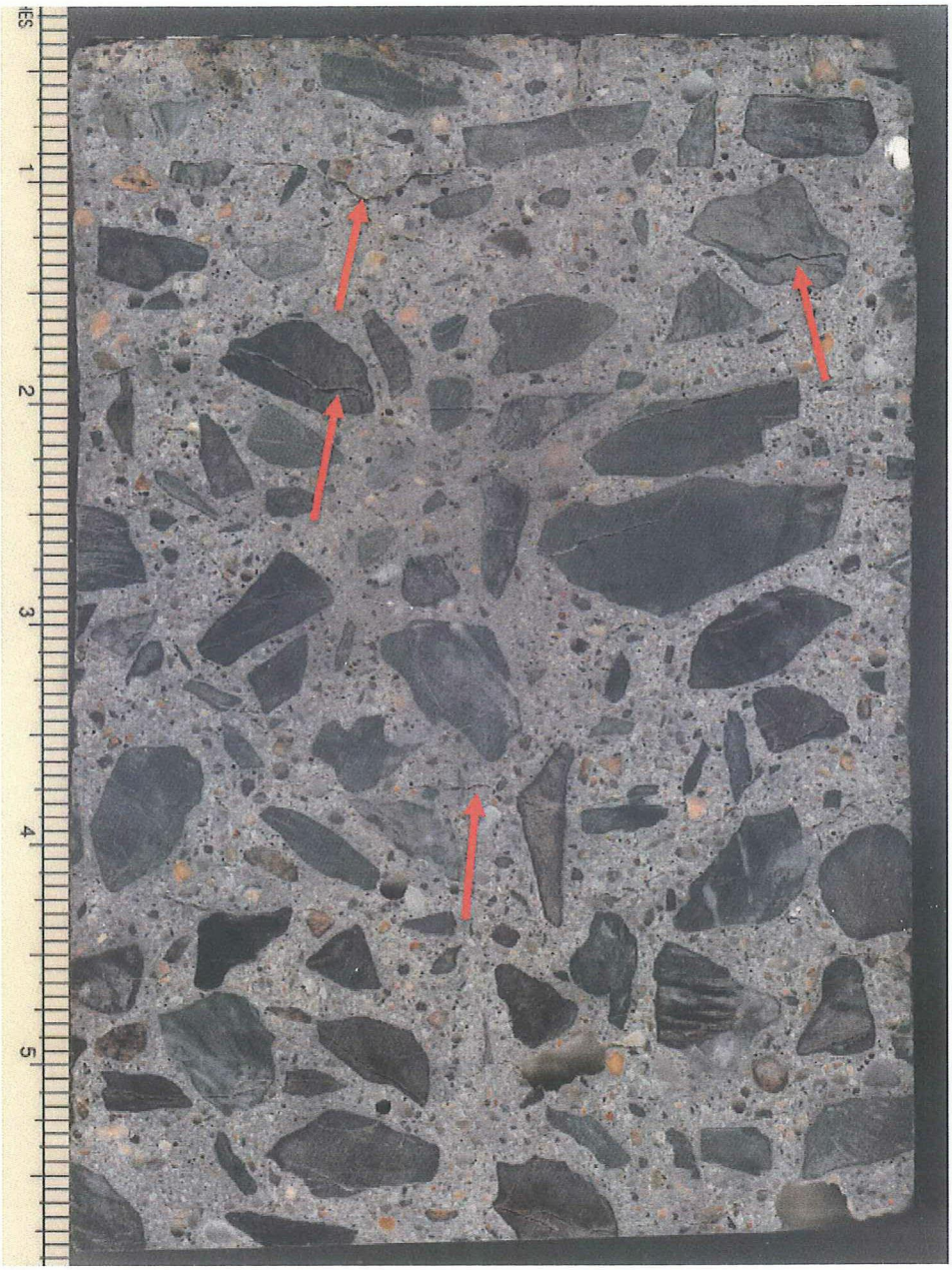

Figure 7a. Lapped section of Core 2 top portion showing the uniform distribution of aggregate particles and abundant microcracks due to ASR (arrows).

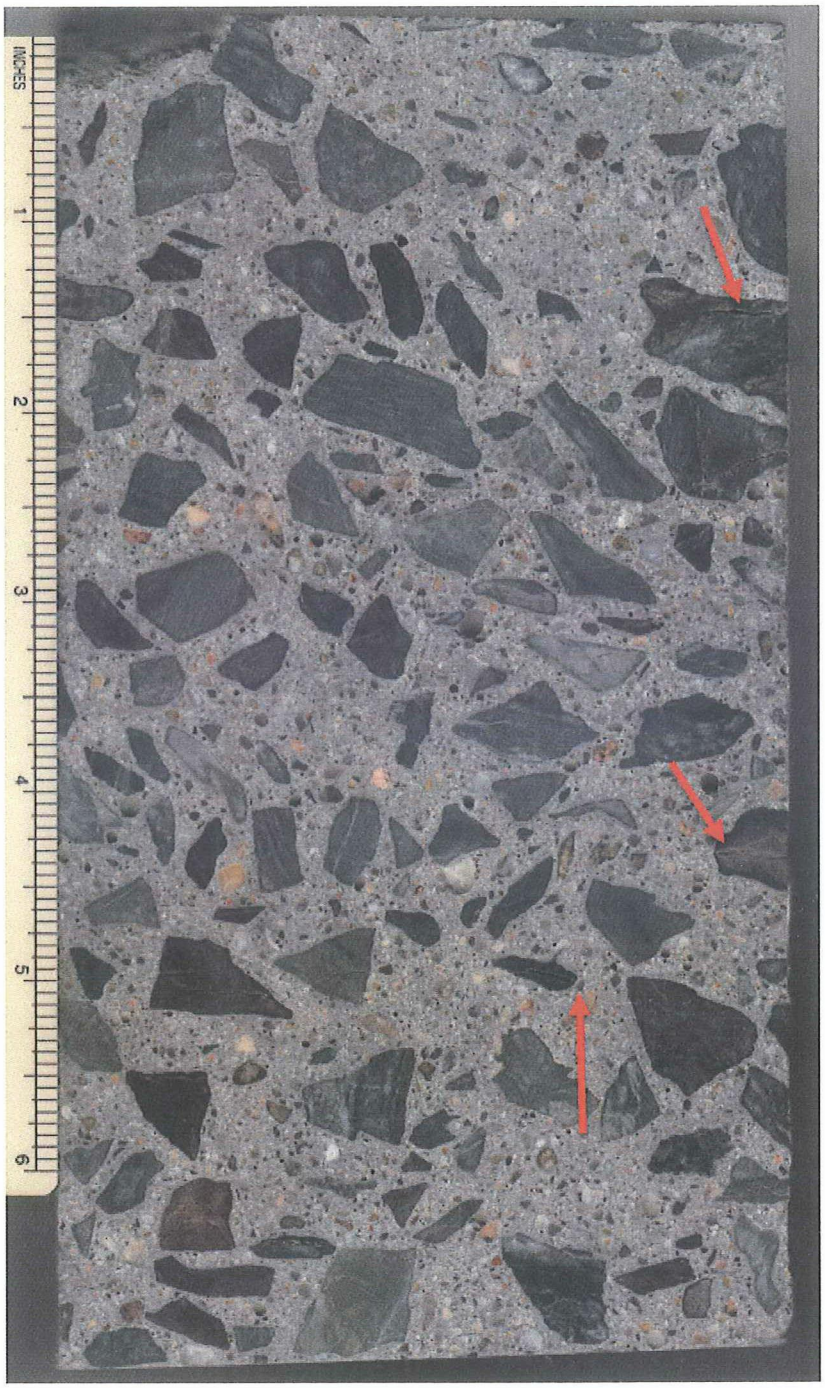

Figure 7b.. Lapped section of Core 2 middle portion showing the uniform distribution of aggregate particles and abundant microcracks due to ASR (arrows).

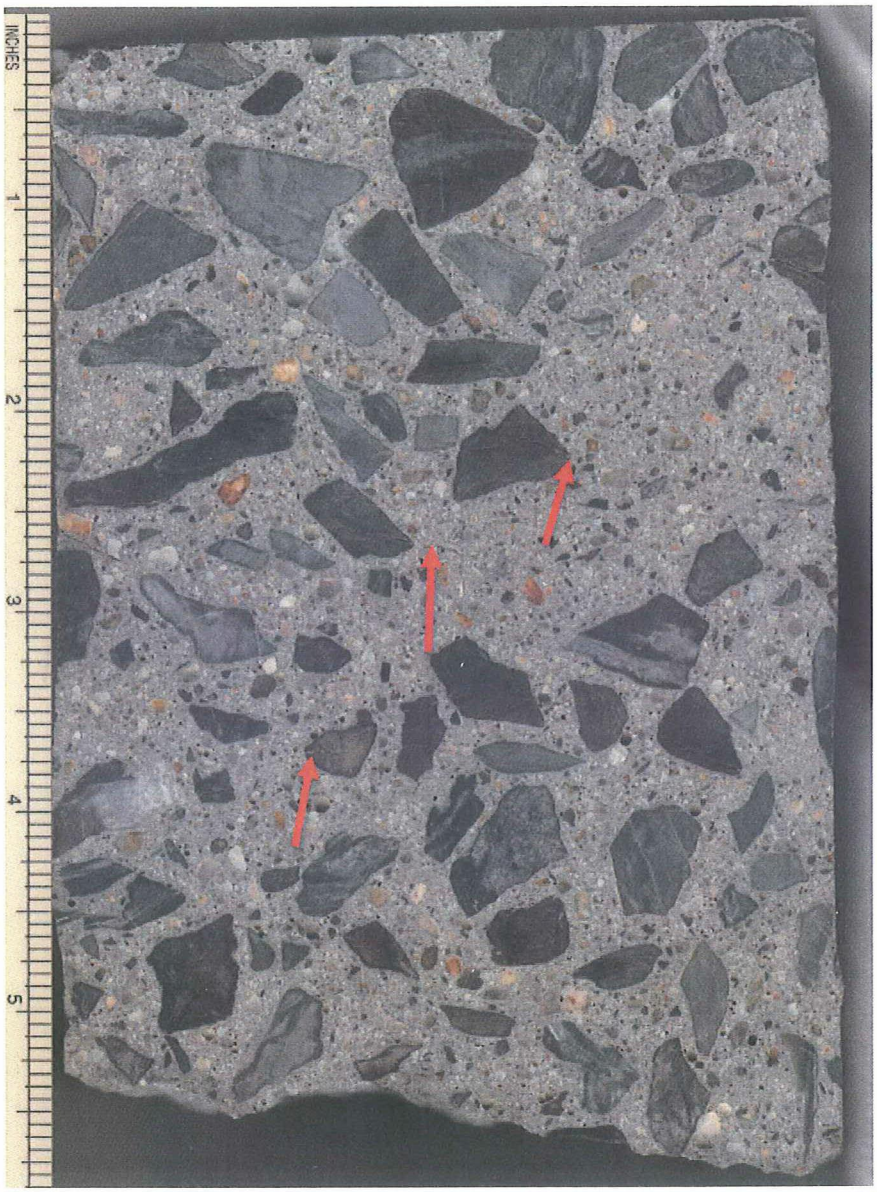

Figure 7c.. Lapped section of Core 2 bottom portion showing the uniform distribution of aggregate particles and abundant microcracks due to ASR (arrows).

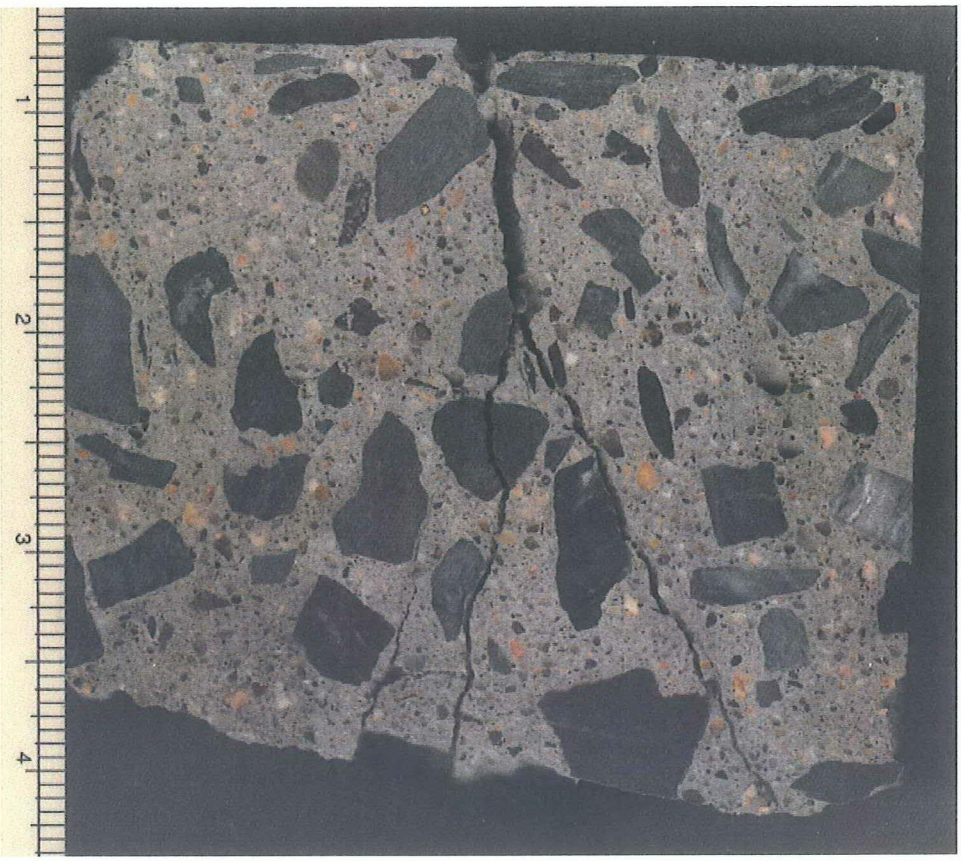

Figure 8. Lapped section of Core 3 showing the uniform distribution of aggregate particles and the full-depth cracks.

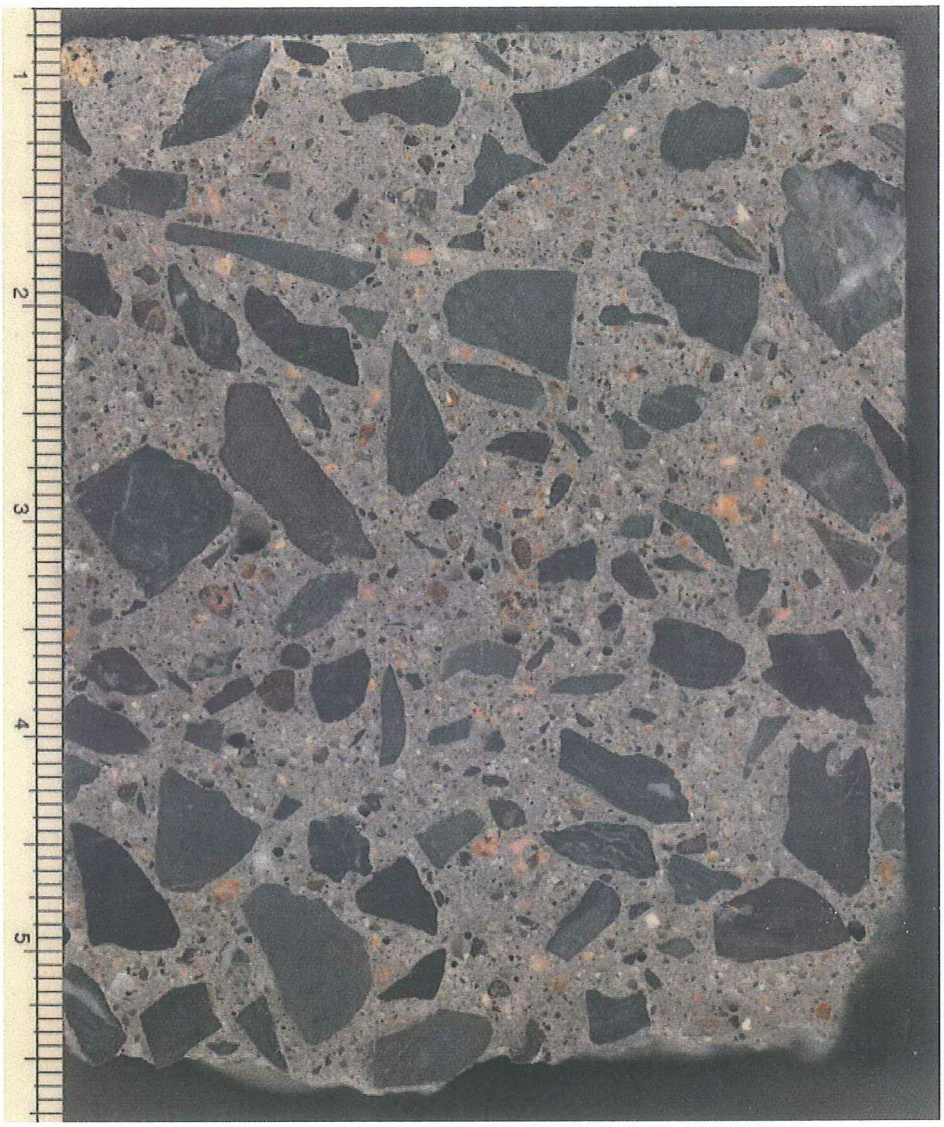

Figure 9. Lapped section of Core 4 showing the uniform distribution of aggregate particles.

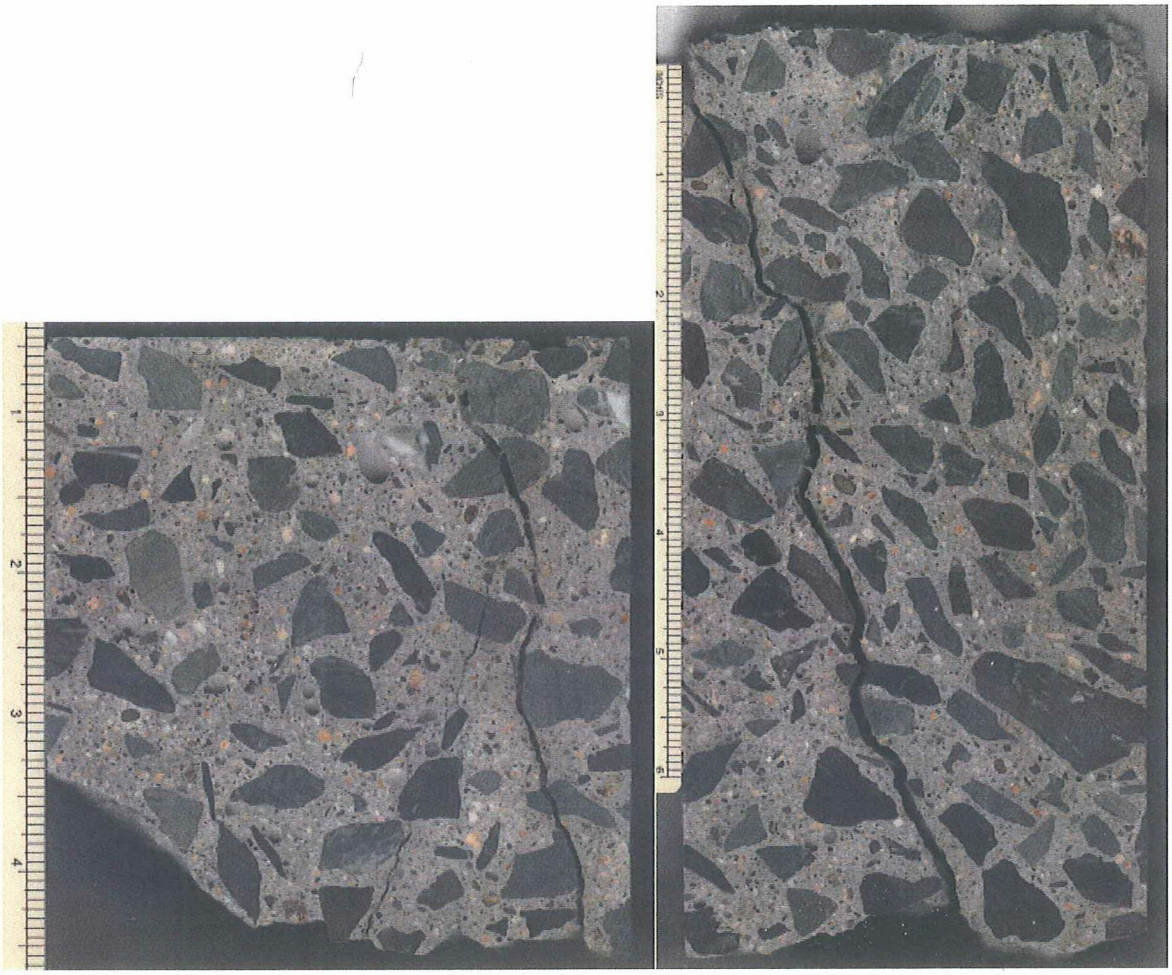

Figure 10. Lapped sections of Core 5 showing the uniform distribution of aggregate particles and a full-depth longitudinal crack. The top portion is on the left.

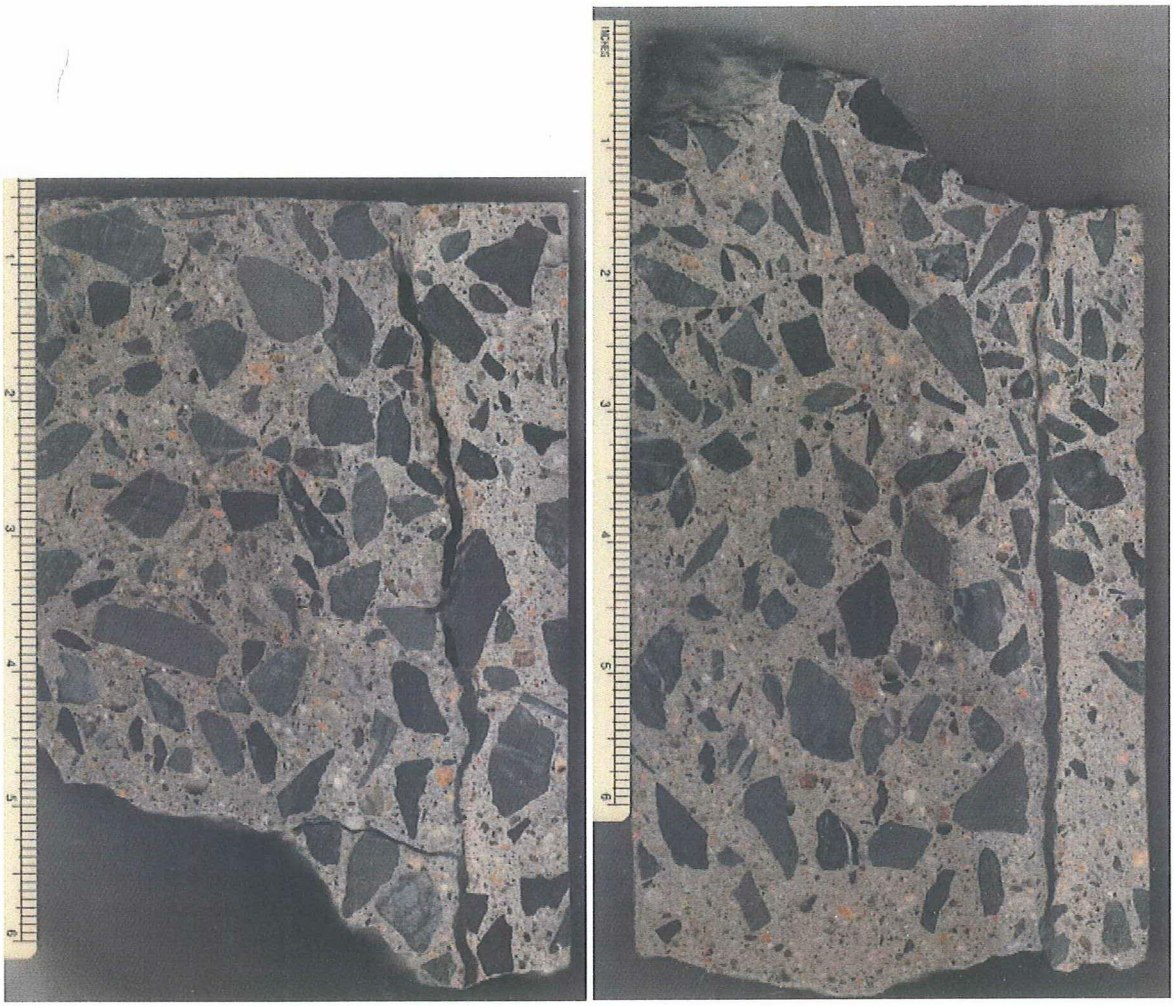

Figure 11. Lapped sections of Core 6 showing the uniform distribution of aggregate particles and the full-depth longitudinal crack. Top portion is on the left.

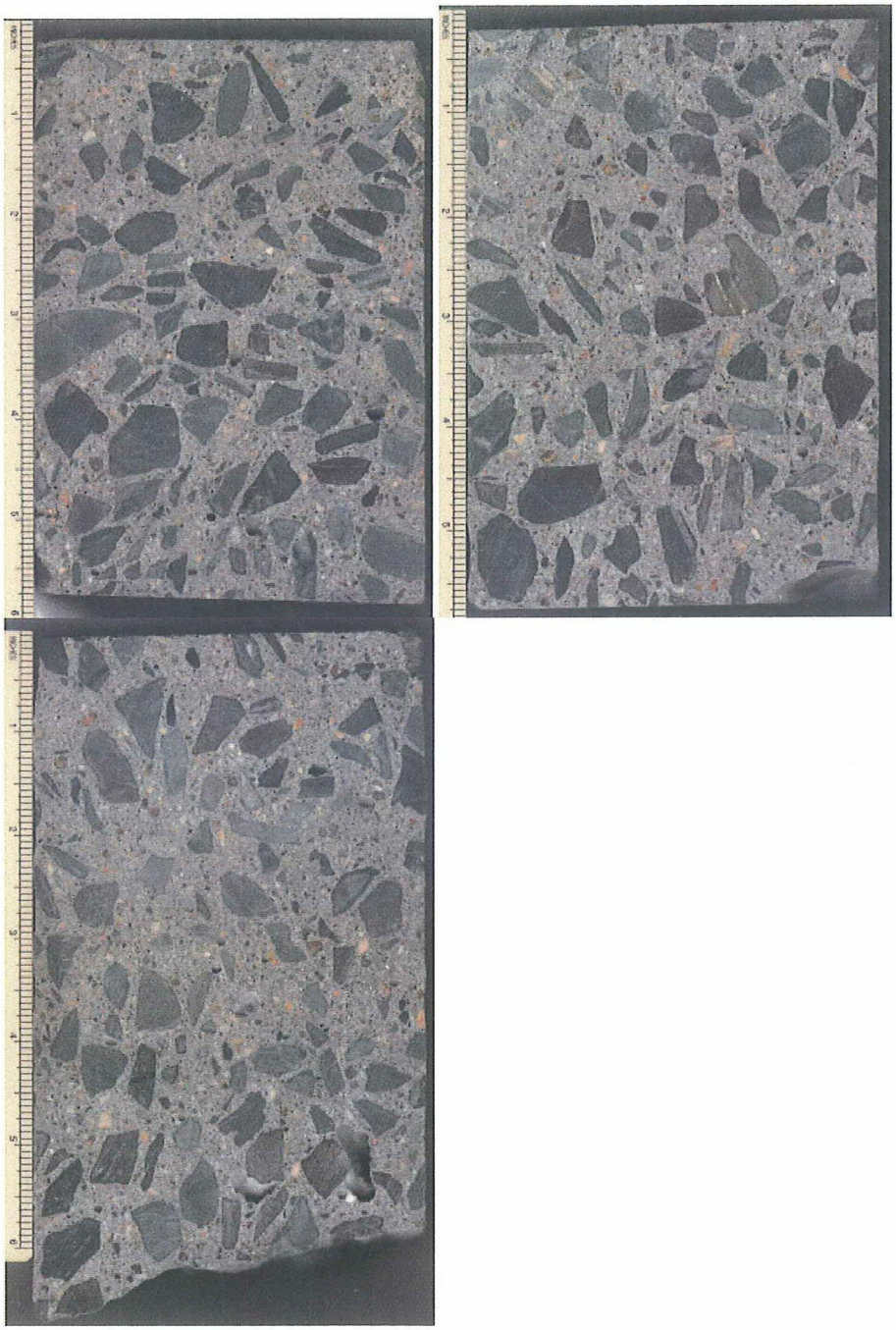

Figure 12. Lapped sections of Core 7 showing the uniform distribution of aggregate particles. The top portion is at the top left and the bottom portion is at the bottom left.

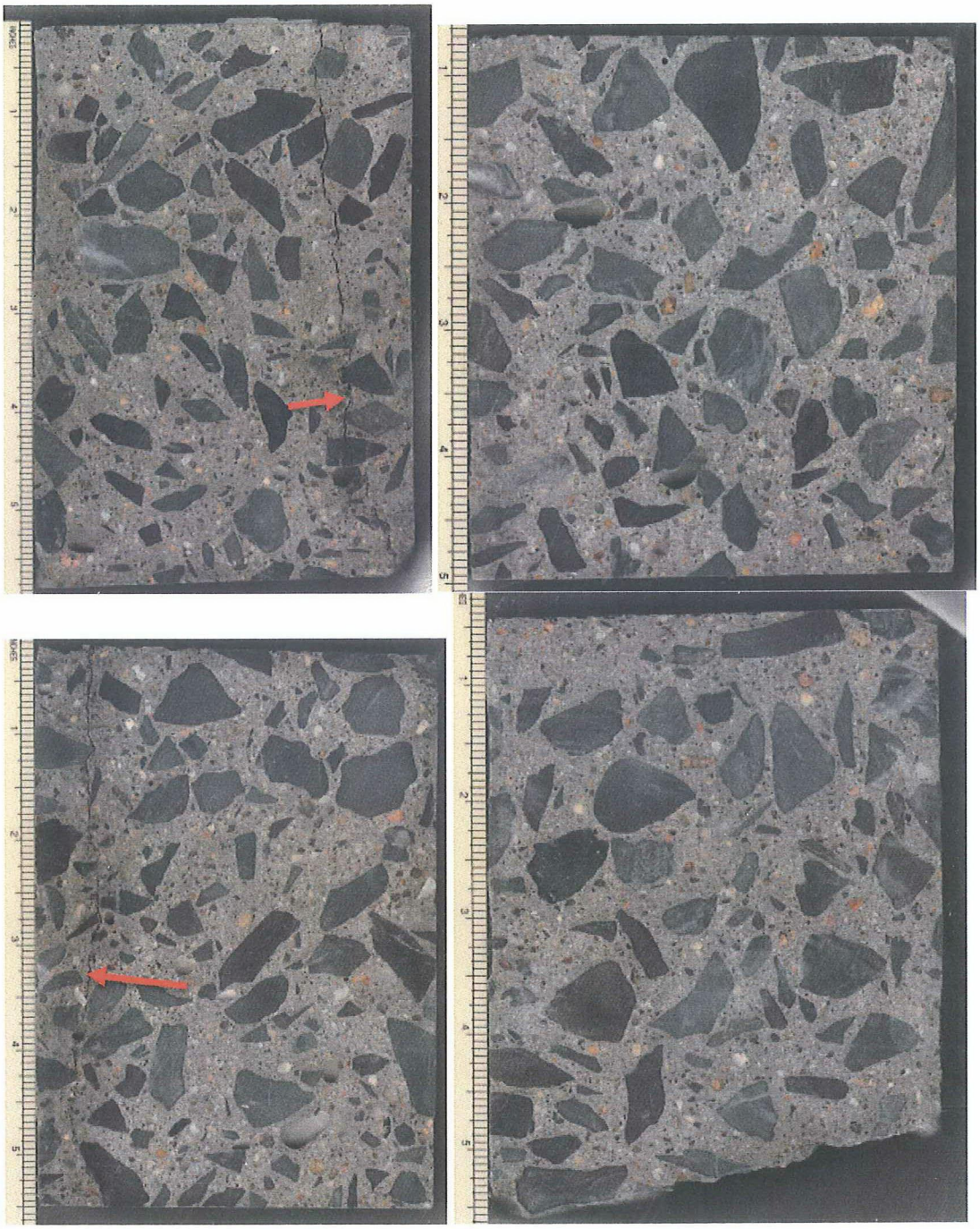

Figure 13. Lapped Section of Core 8 showing the uniform distribution of aggregate particles. Also note the longitudinal cracks in the two top portions (arrows).

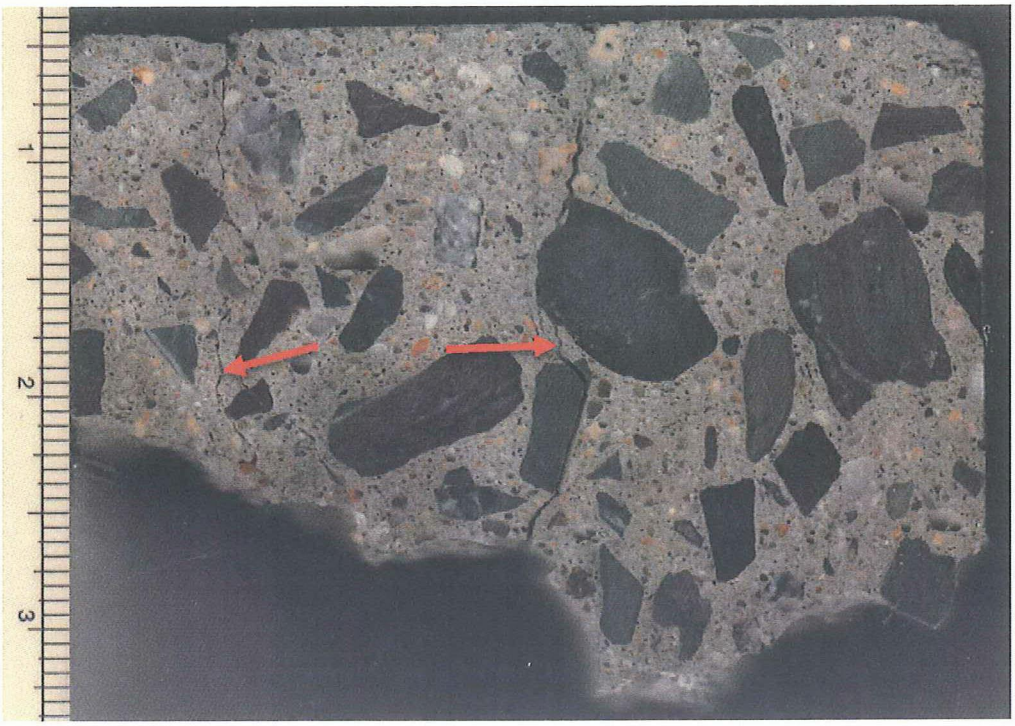

Figure 14. Lapped section of Core 9 showing the uniform distribution of aggregate particles and the longitudinal cracks (arrow).

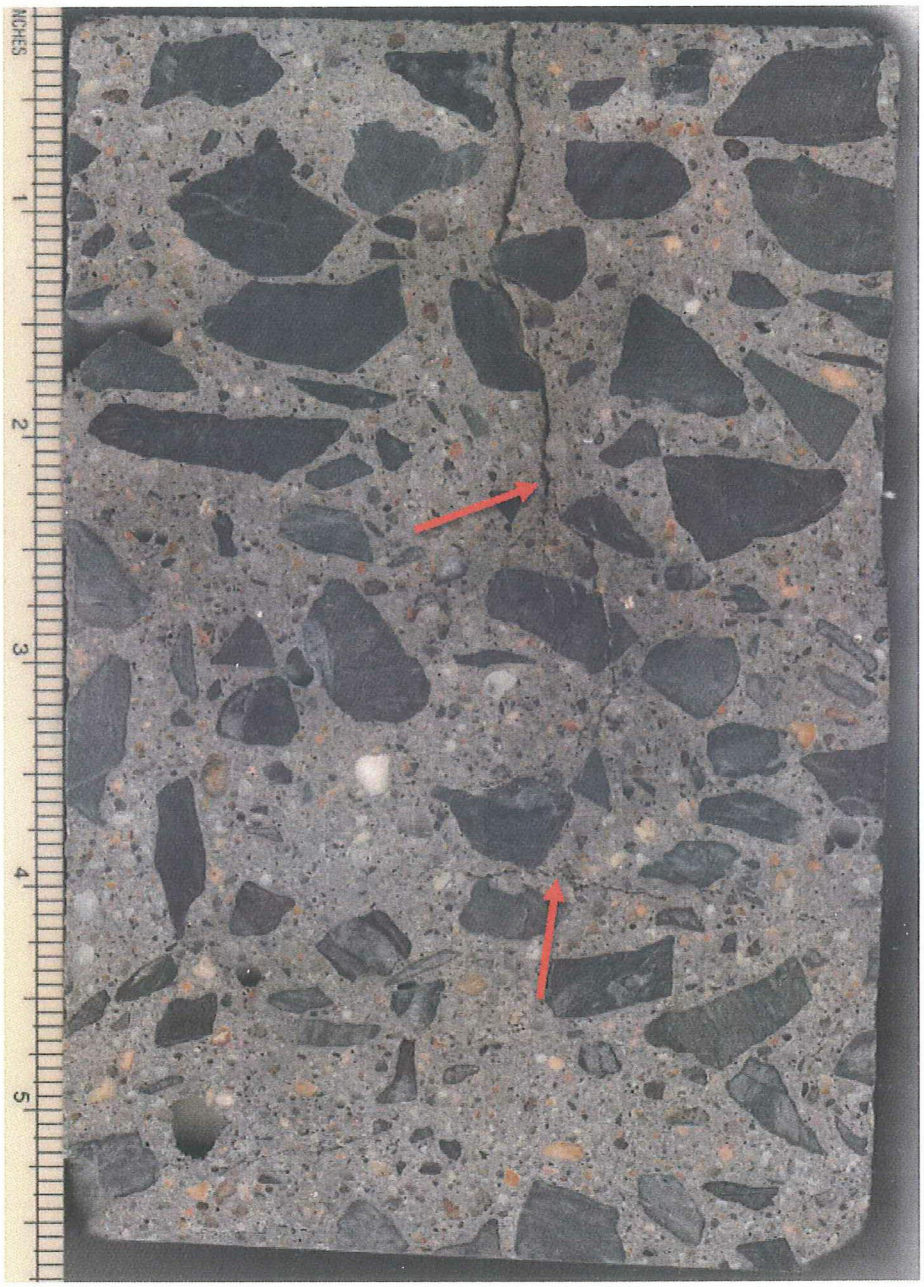

Figure 15a. Lapped section of the top portion of Core 10 showing the uniform distribution of aggregate and cracks due to ASR (arrow).

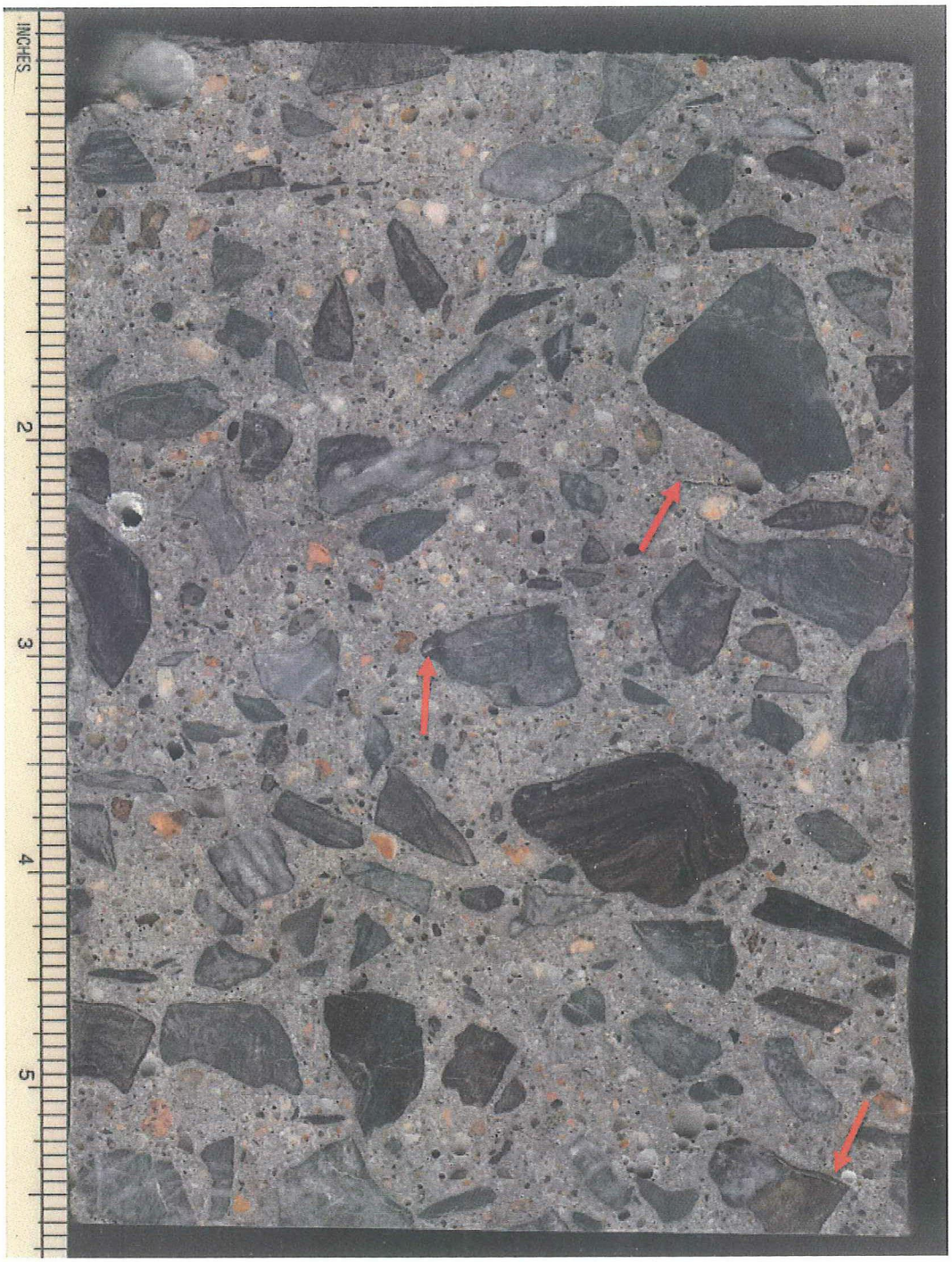

Figure 15b. Lapped section of the middle portion of Core 10 showing the uniform distribution of aggregate and cracks due to ASR (arrow).

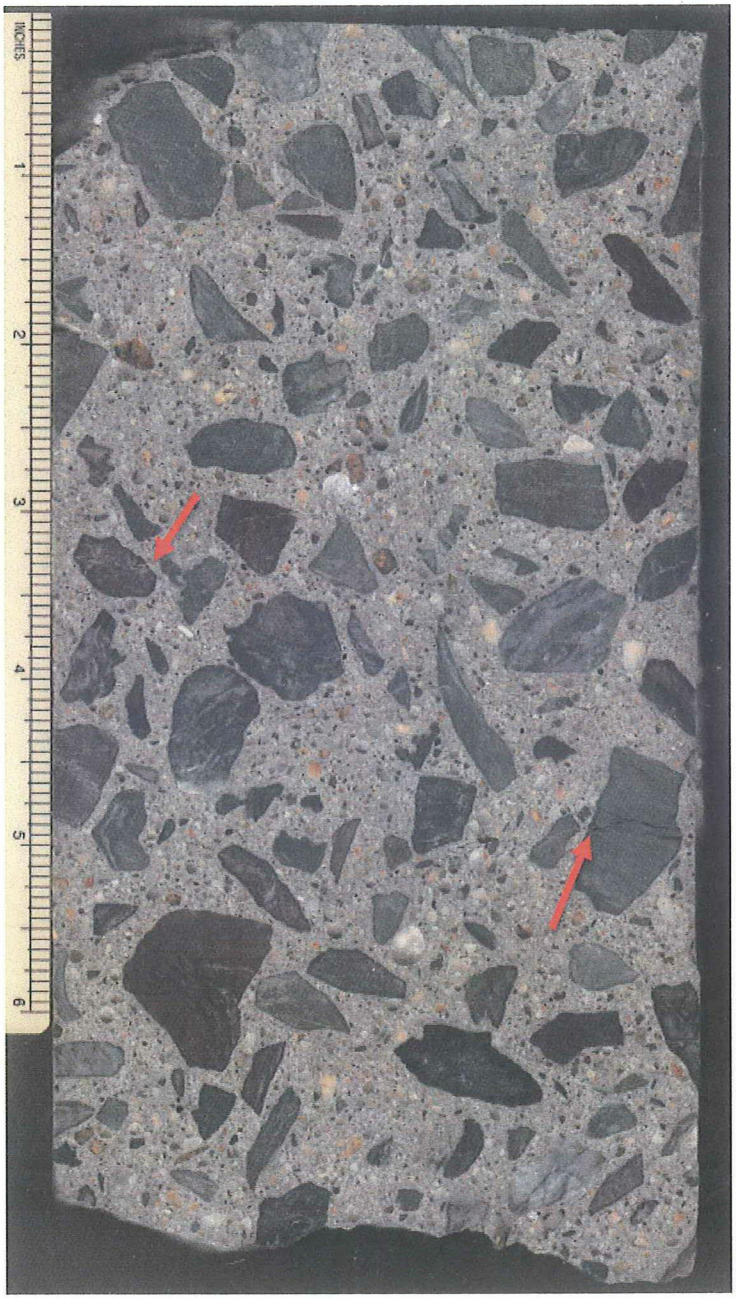

Figure 15c. Lapped section of the bottom portion of Core 10 showing the uniform distribution of aggregate and cracks due to ASR (arrow).

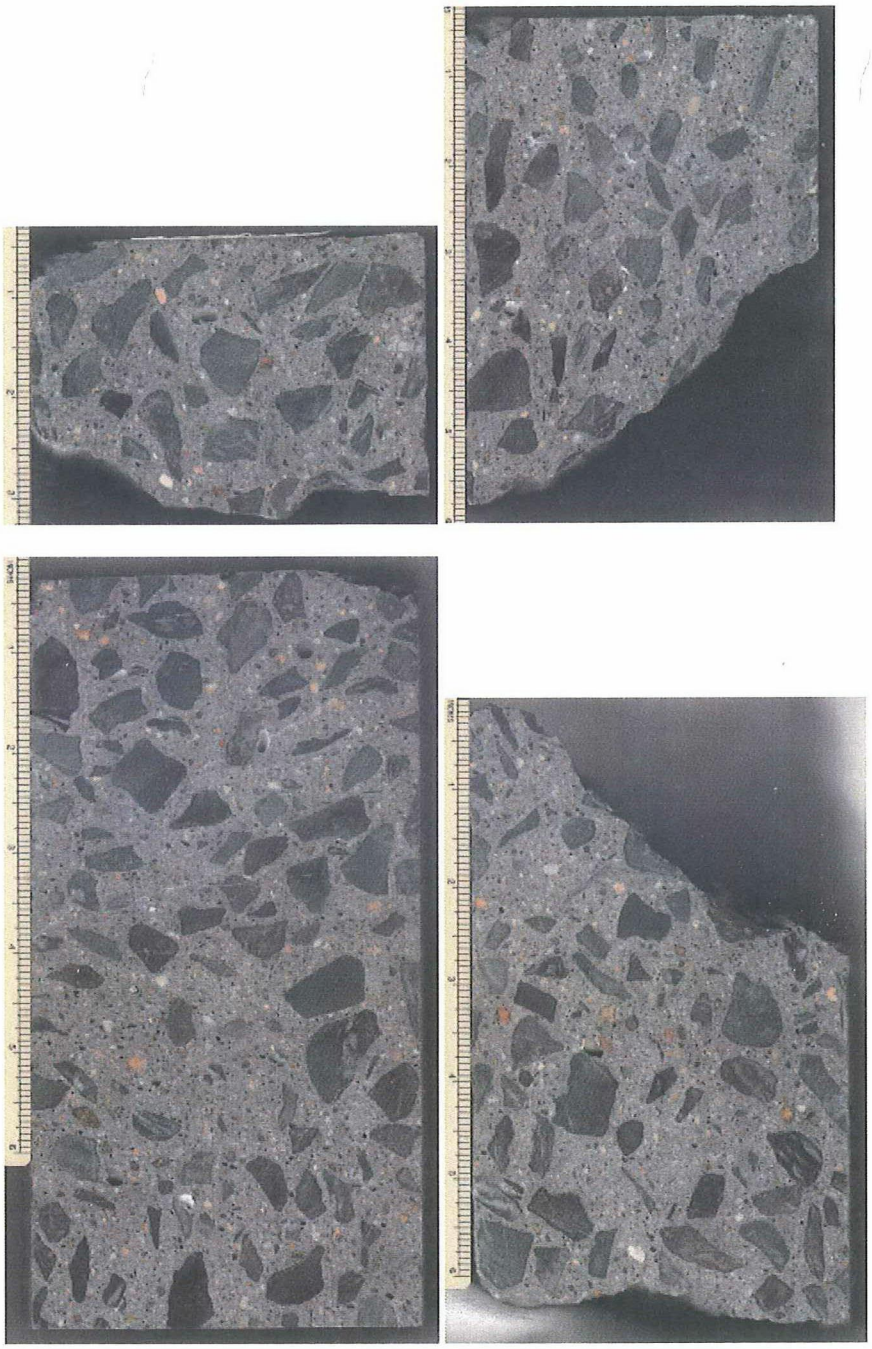

Figure 16. Lapped sections of Core 11 showing the uniform distribution of aggregate particles. The top portion is at the top left and the bottom portion at bottom right.

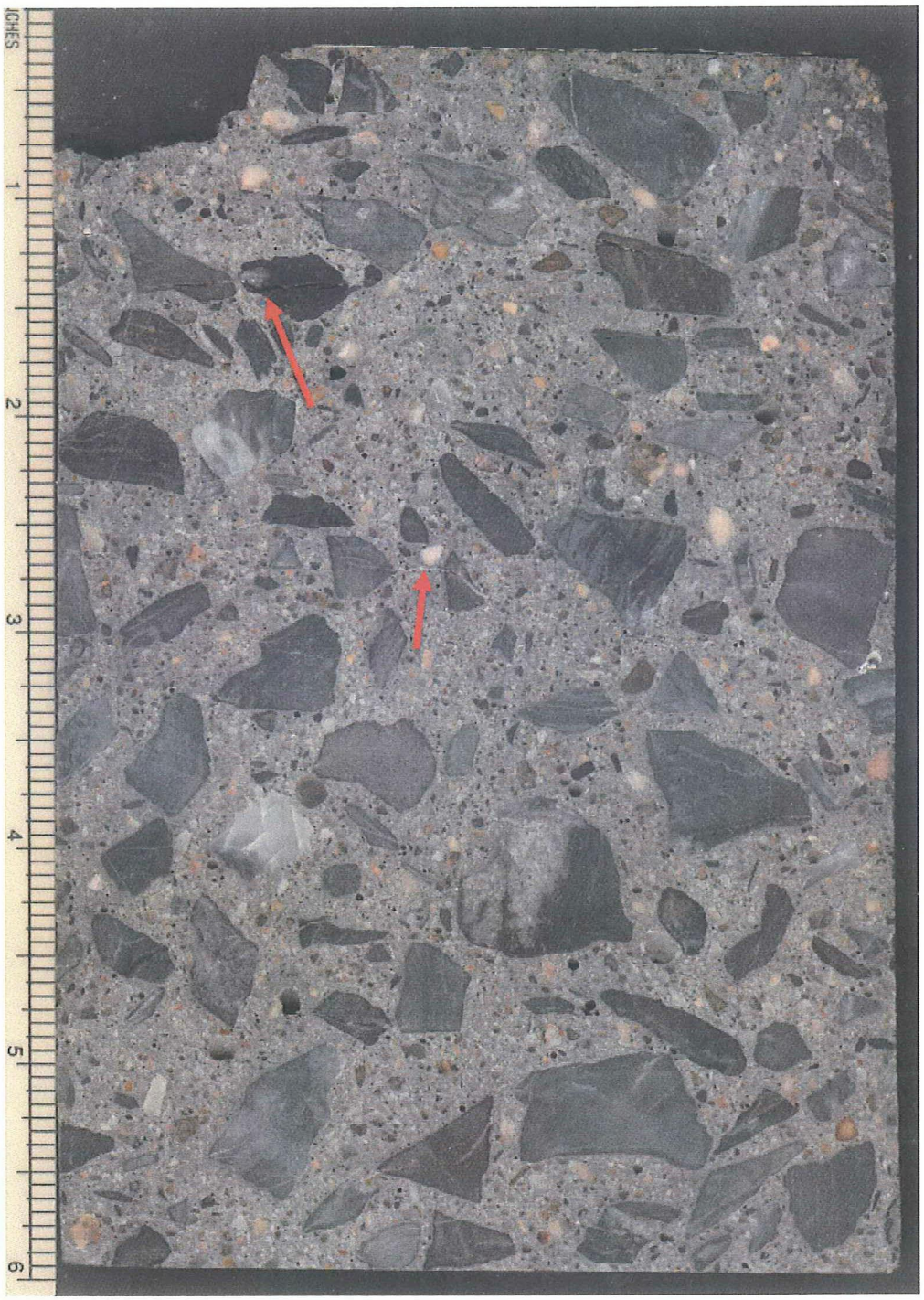

Figure 17a. Lapped section of the top portion of Core 12 showing the uniform distribution of aggregate and cracks due to ASR (arrows).

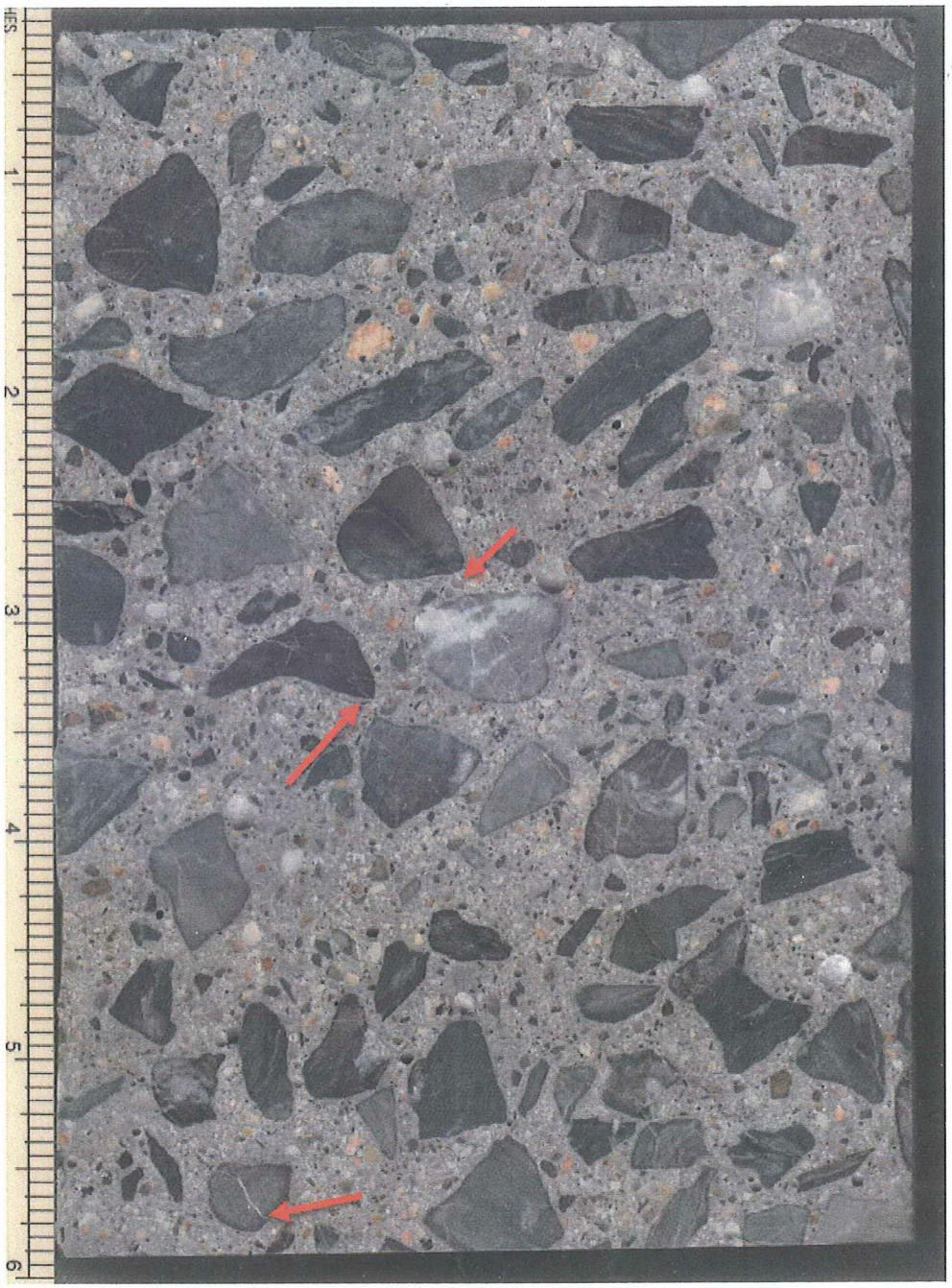

Figure 17b. Lapped section of the middle portion of Core 12 showing the uniform distribution of aggregate and cracks due to ASR (arrows).

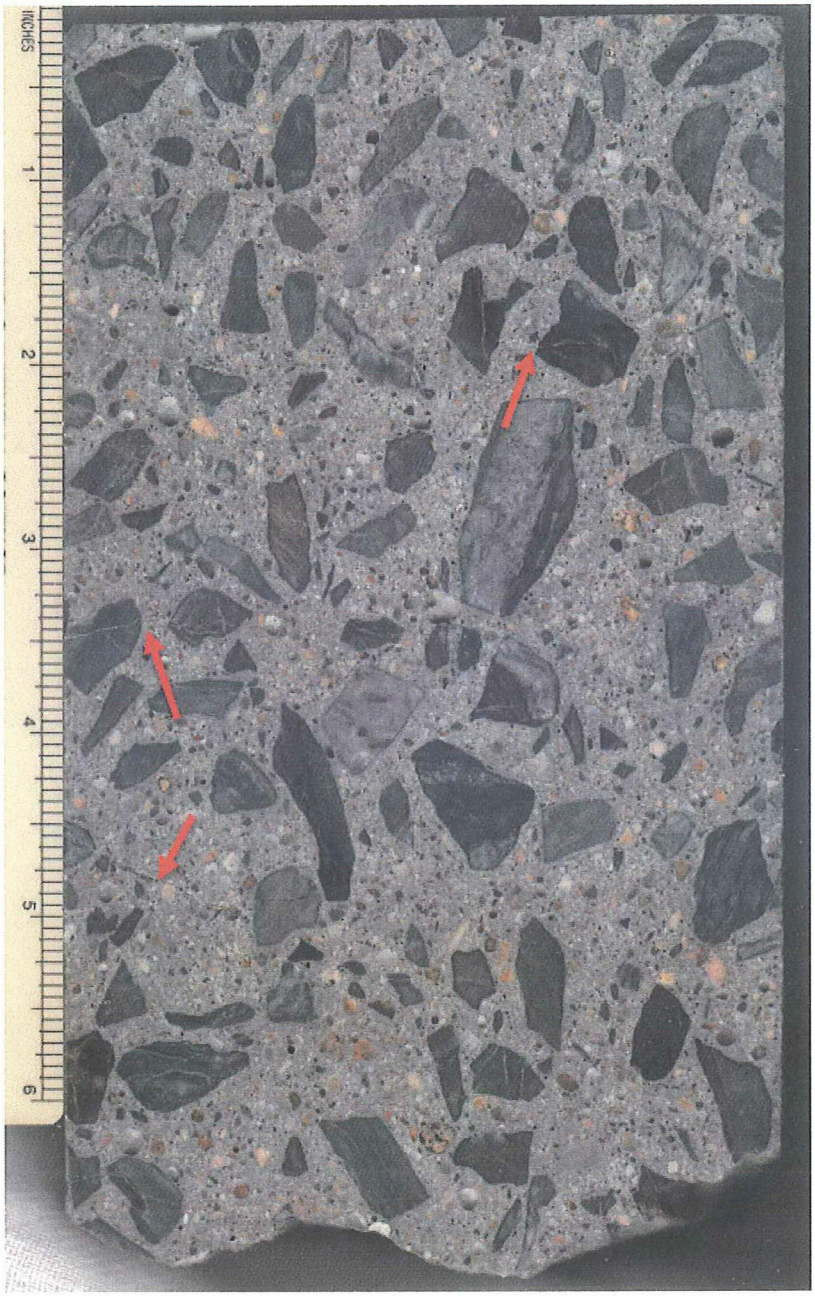

Figure 17c. Lapped section of the bottom portion of Core 12 showing the uniform distribution of aggregate and cracks due to ASR (arrows).

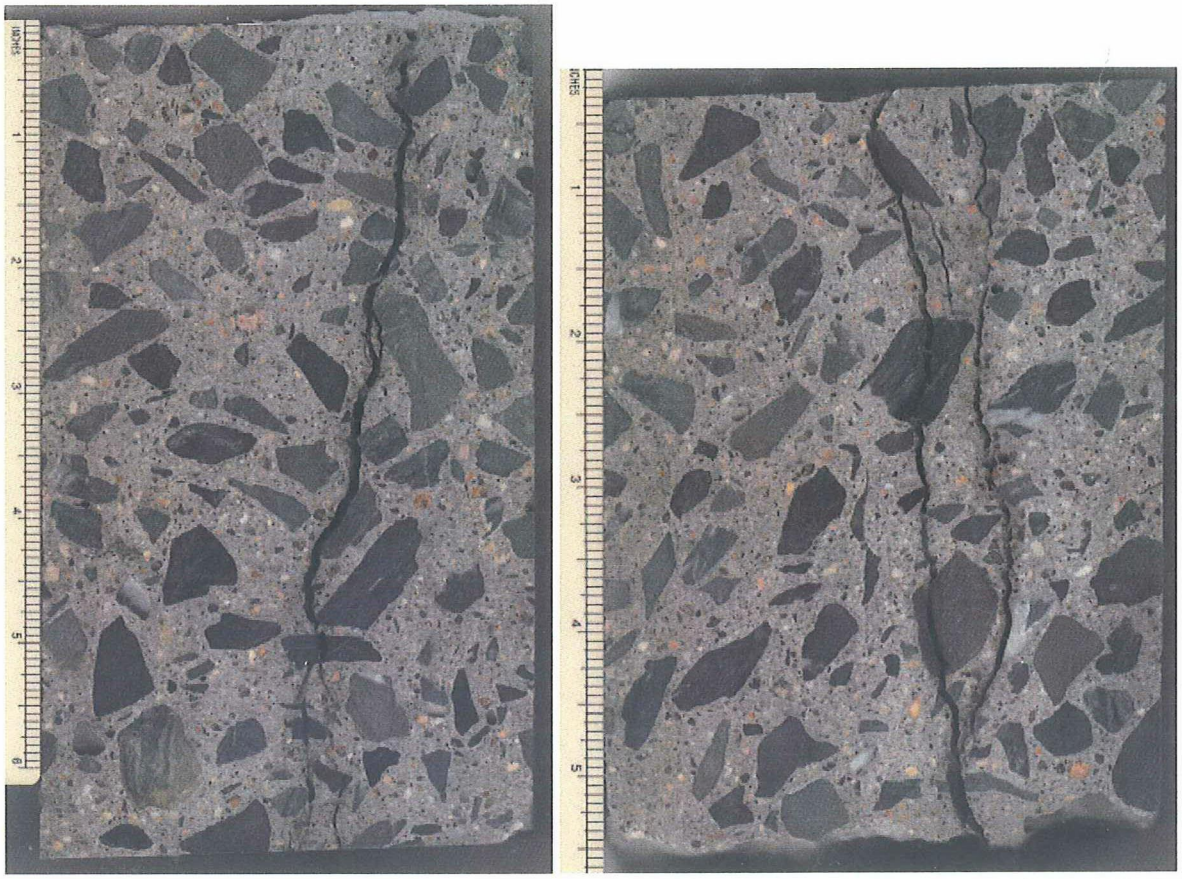

Figure 18. Lapped sections of Core 13 showing the uniform distribution of aggregate particles and the full-depth longitudinal cracks. Top portion is on the left.

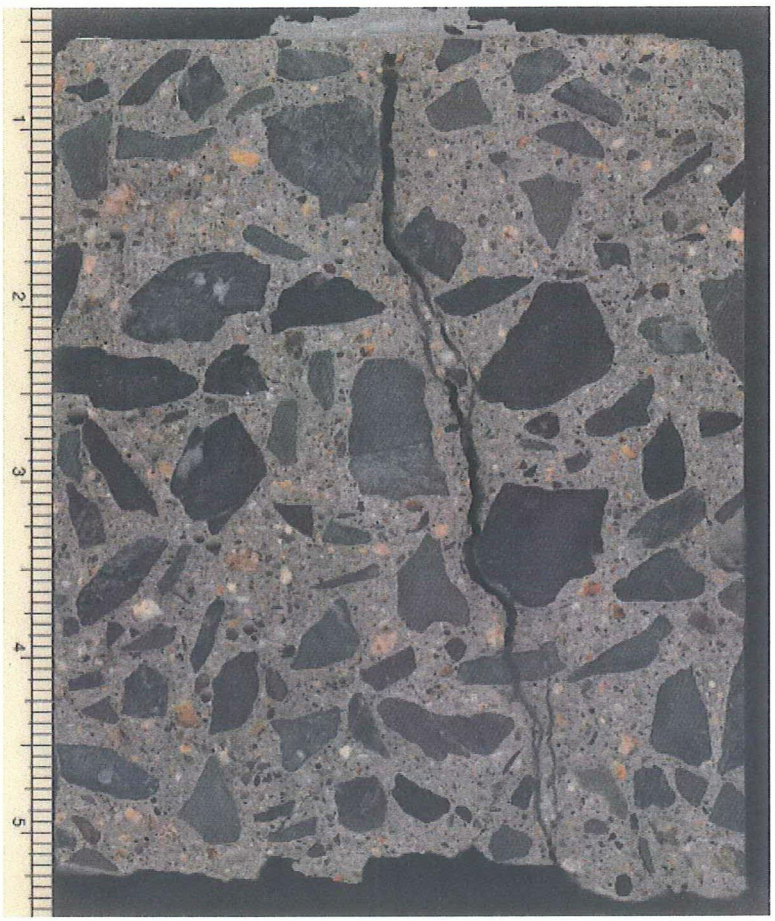

Figure 19. Lapped section of Core 14 showing the uniform distribution of aggregate particles and the full-depth longitudinal crack.

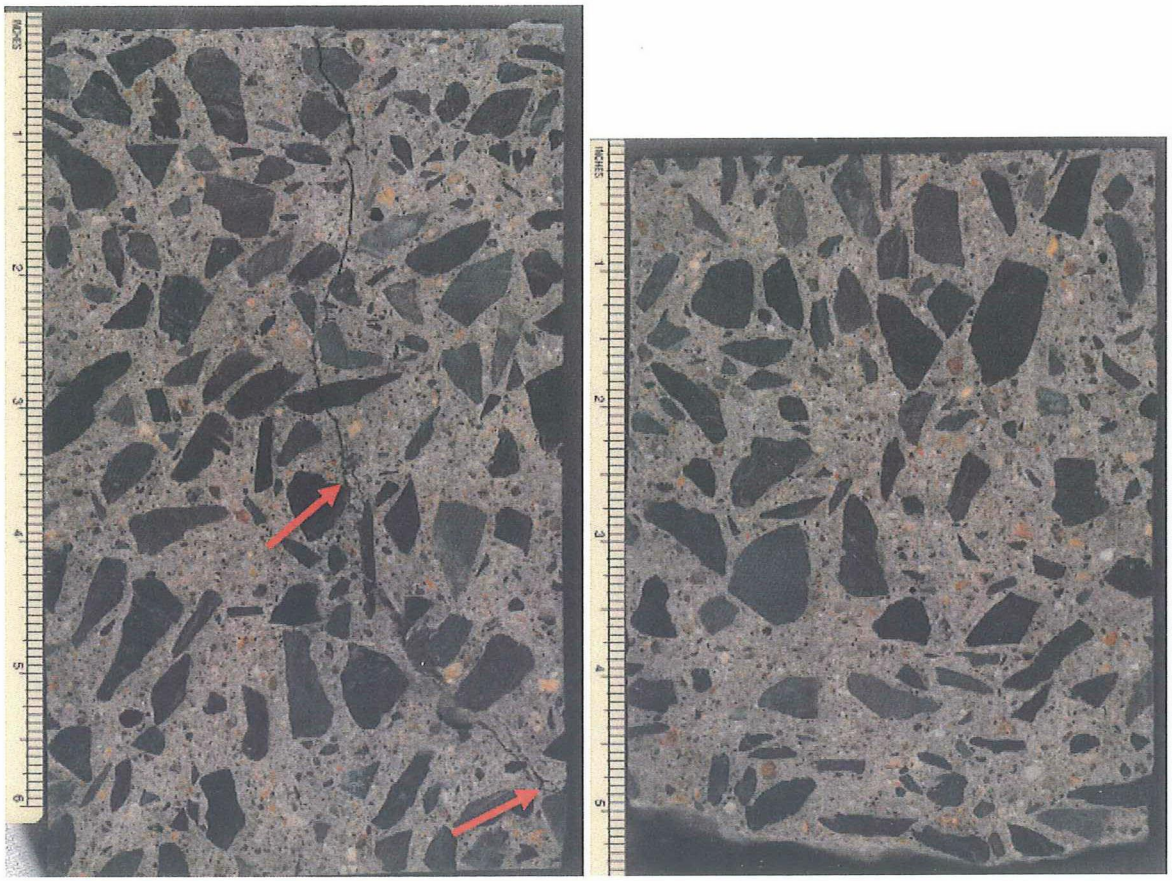

Figure 20. Lapped sections of Core 15 showing the uniform distribution of aggregate particles and a longitudinal crack in the top portion of the core (arrows).

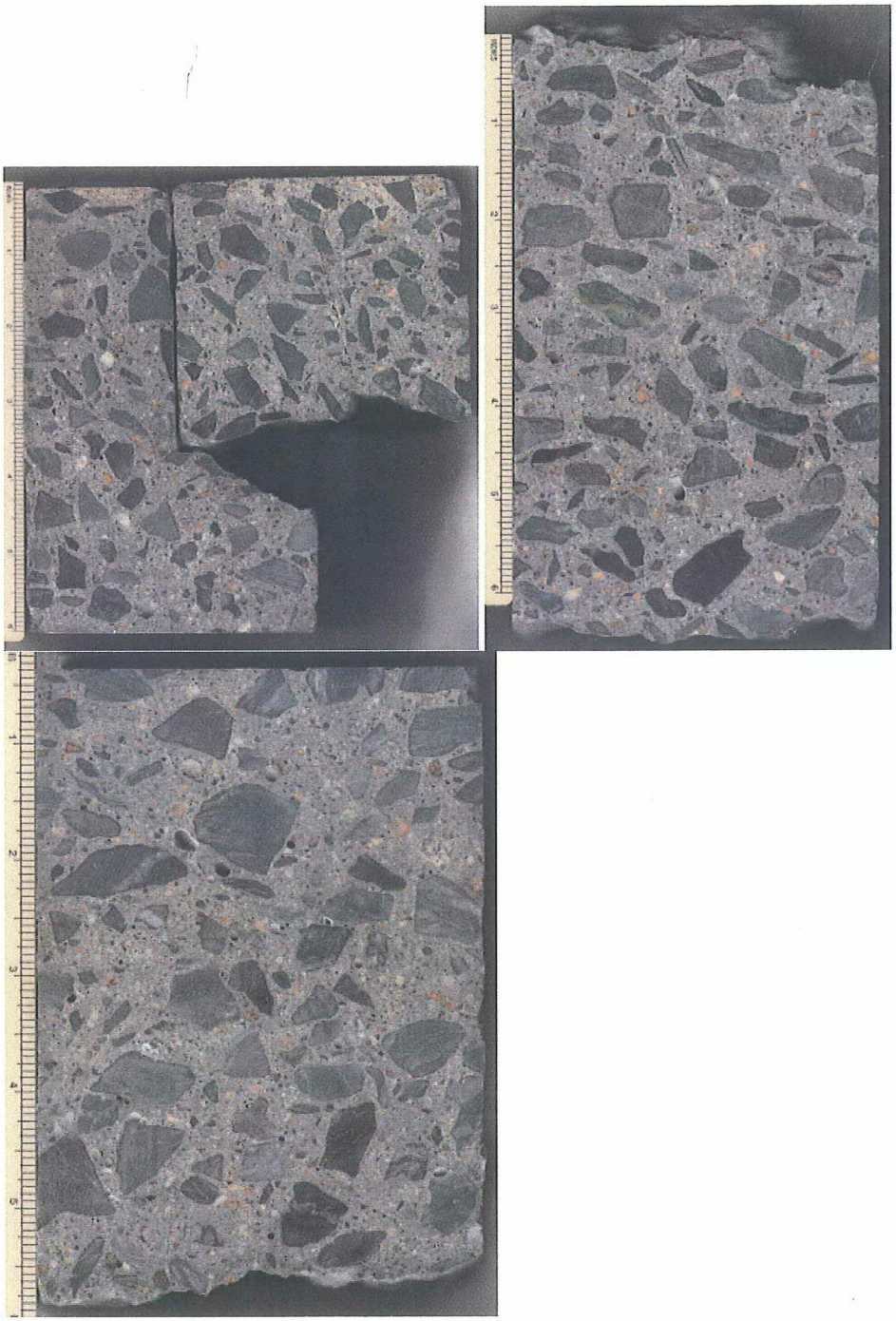

Figure 21. Lapped sections of Core 16 showing the uniform distribution of aggregate particles. Note the top portion of the core location was shafted.

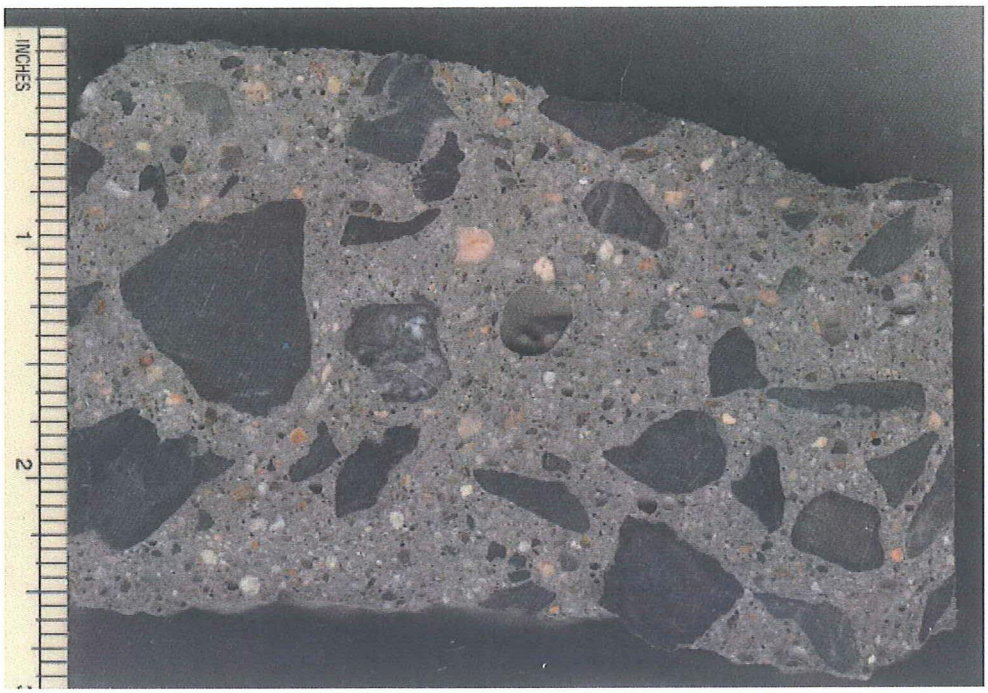

Figure 22. Lapped section of Core 18 showing the uniform distribution of aggregate particles. The top surface of the core was fractured.

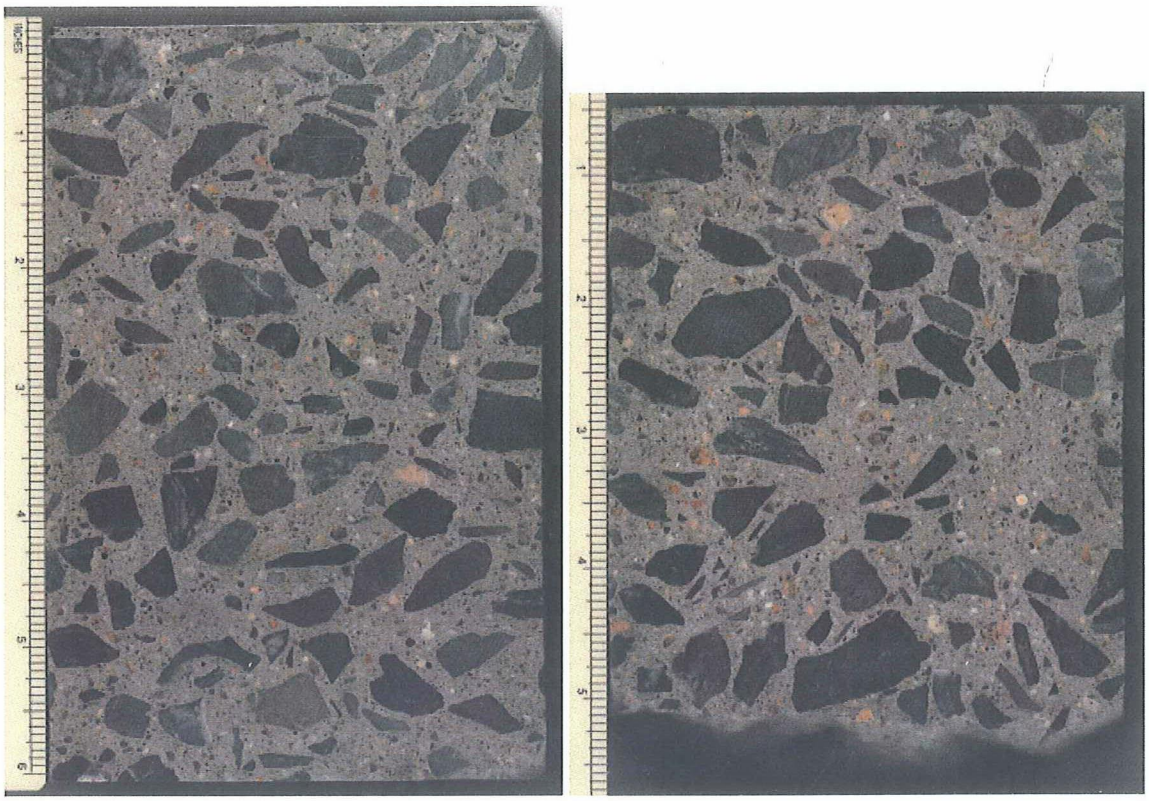

Figure 23. Lapped sections of Core 19 showing the uniform distribution of aggregate particles.

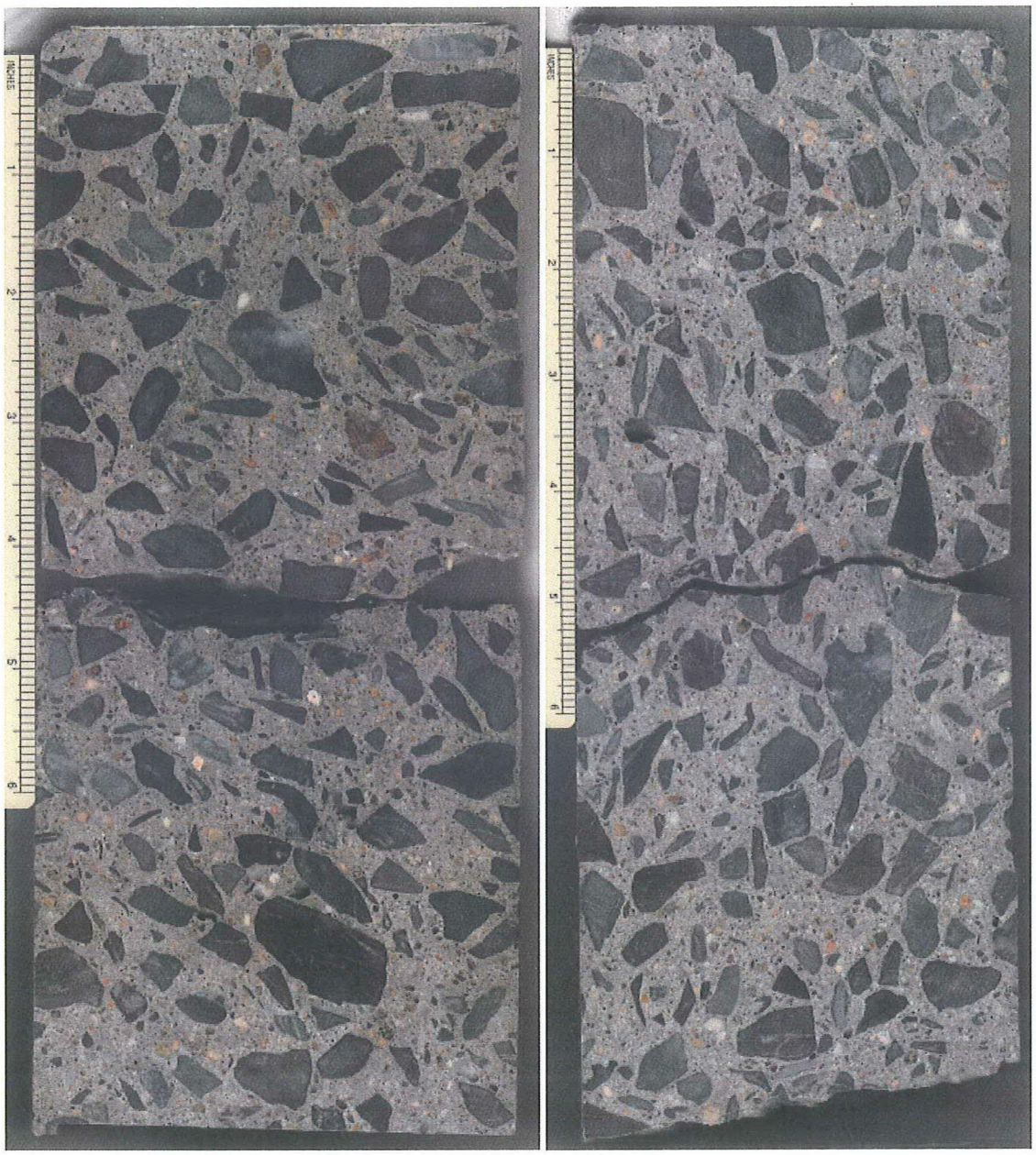

Figure 24. Lapped sections of Core 20 showing the uniform distribution of aggregate particles.

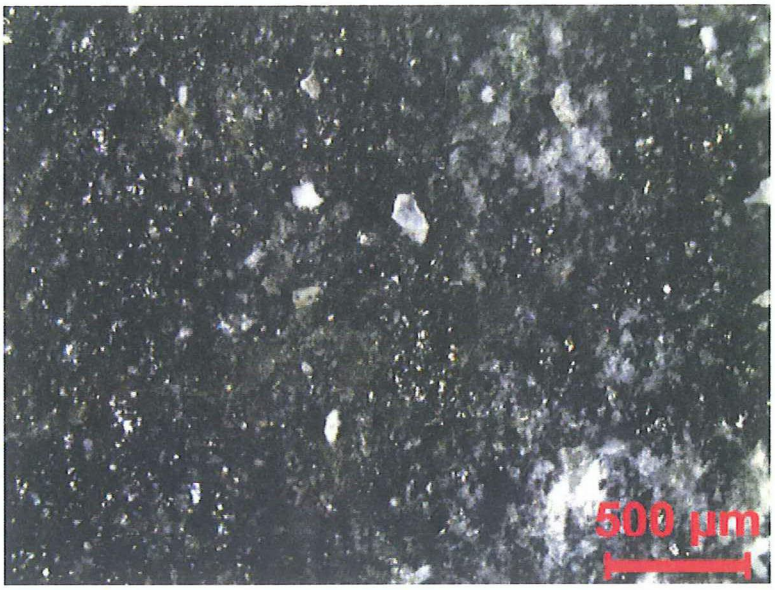

Figure 25. A fractured surface of a quartzite in Core 12 BC, showing the granular texture.

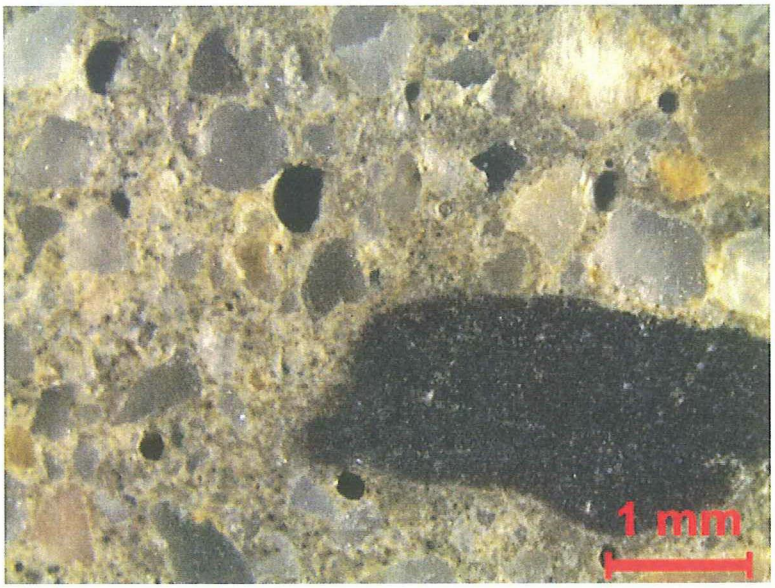

Figure 26. Lapped section of Core 4 showing low air content.

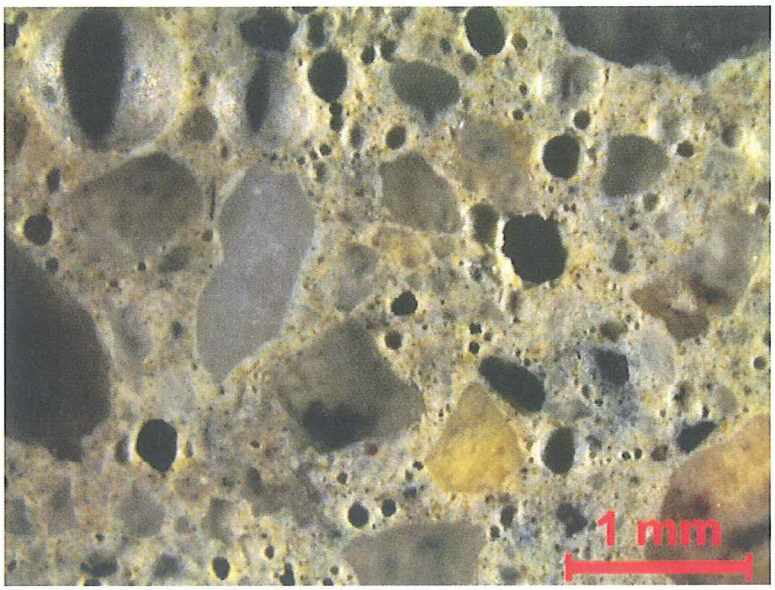

Figure 27. Lapped section of Core 3 showing relatively high air content. Note that most voids were free of secondary deposits.

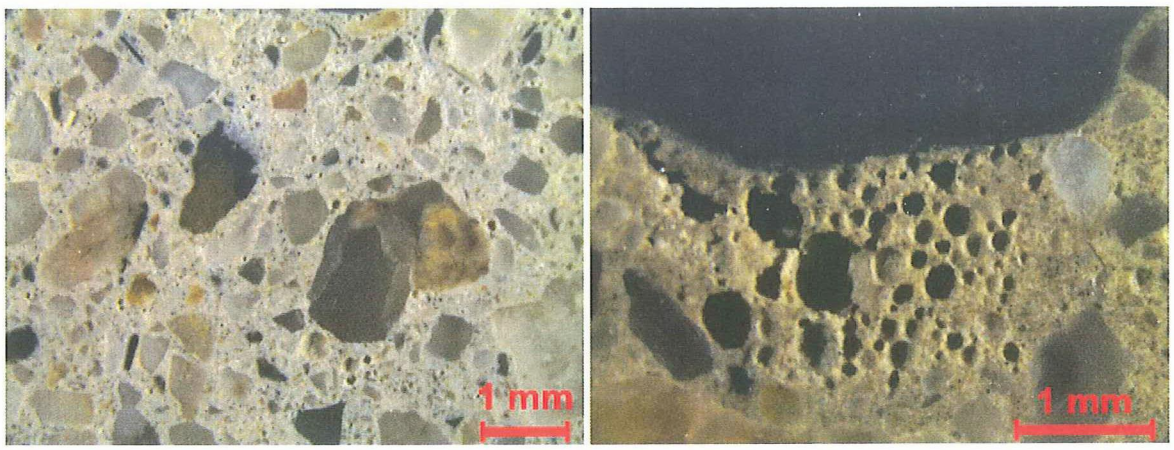

Figure 28. Lapped section of Core 6 AB (left) and Core 6 BC (right) showing significantly different air content of the two sections of the core.

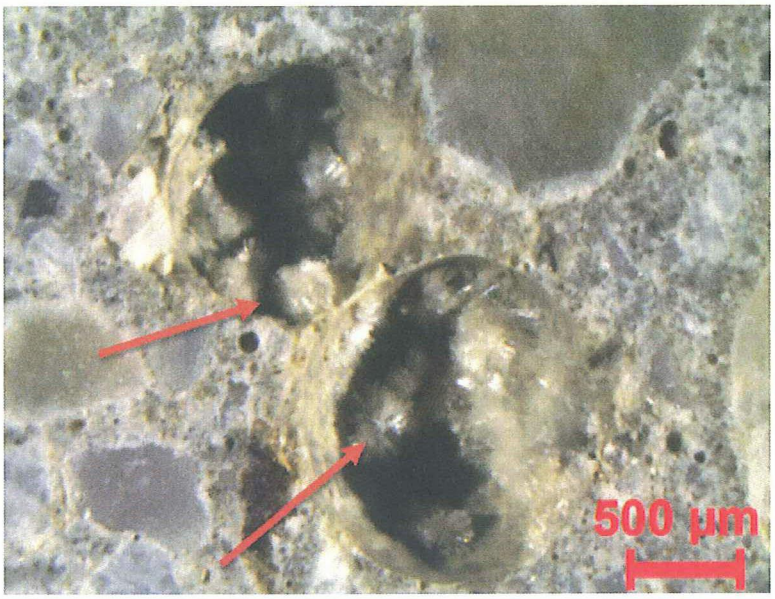

Figure 29. Lapped section of Core 2 BC showing ettringite deposits in air voids (arrows).

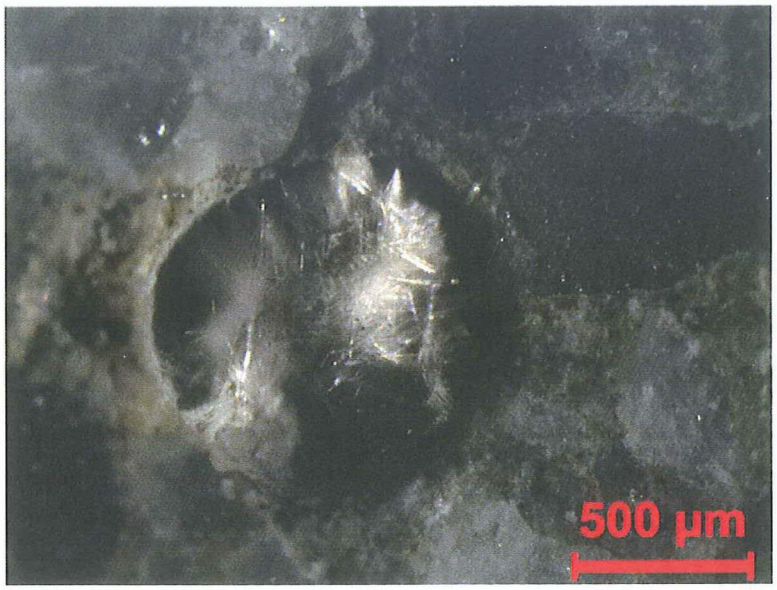

Figure 30. Lapped section of Core 11DE showing secondary ettringite in an air void

Figure 31. Lapped section of Core 1 AB showing a longitudinal crack terminating at approximately 1/2 inch from the top surface (arrow).

Figure 32. Reaction rim in a coarse aggregate in Core 1 BC.

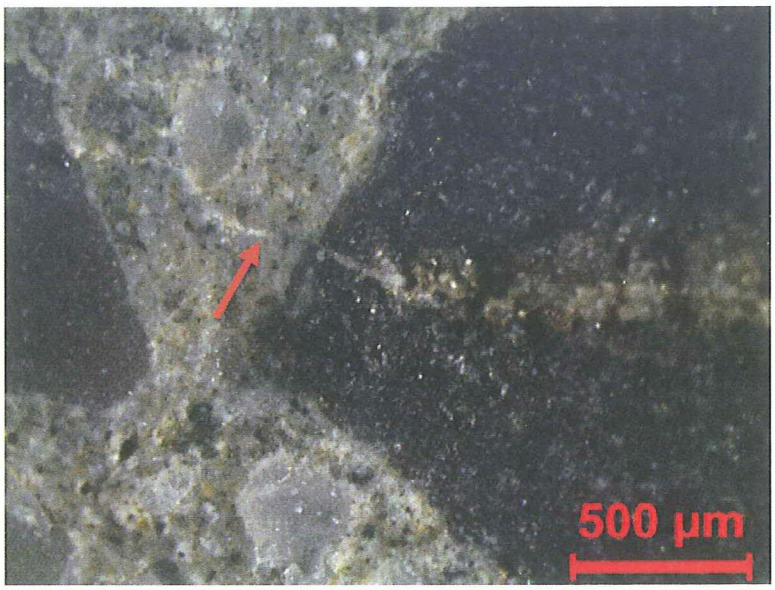

Figure 33. Lapped section of Core 1 CD showing a crack with gel extending from aggregate to paste (arrow).

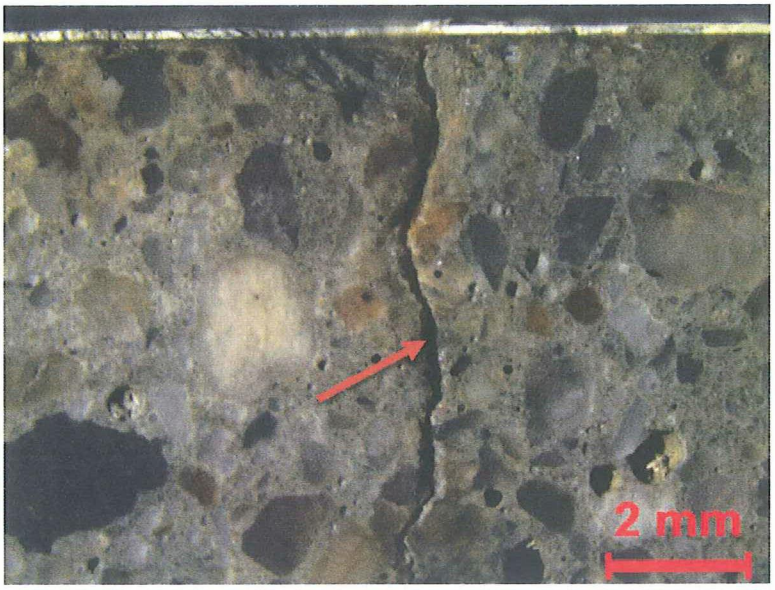

Figure 34. Lapped section of Core 2AB showing a longitudinal crack without secondary deposits.

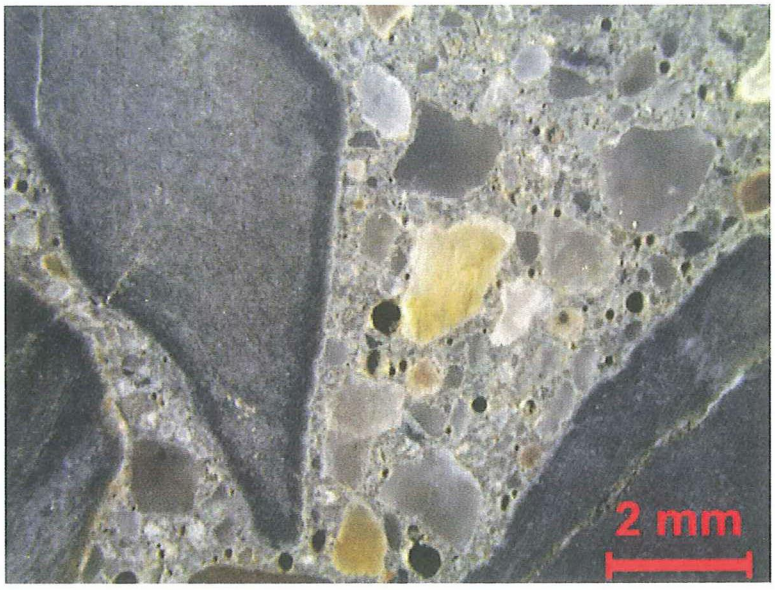

Figure 35. Lapped section of Core 2 AB showing a coarse aggregate particle with reaction rim.

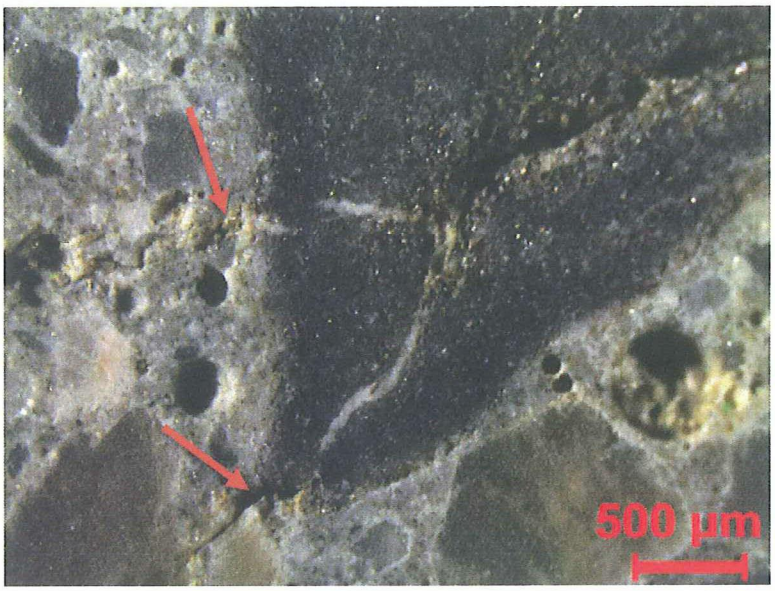

Figure 36. Lapped section of Core 2 BC showing cracks partially filled with gel extending into the paste (arrows).

Figure 37. Lapped section of Core 2 BC showing a cracked coarse aggregate with no gel filling the cracks.

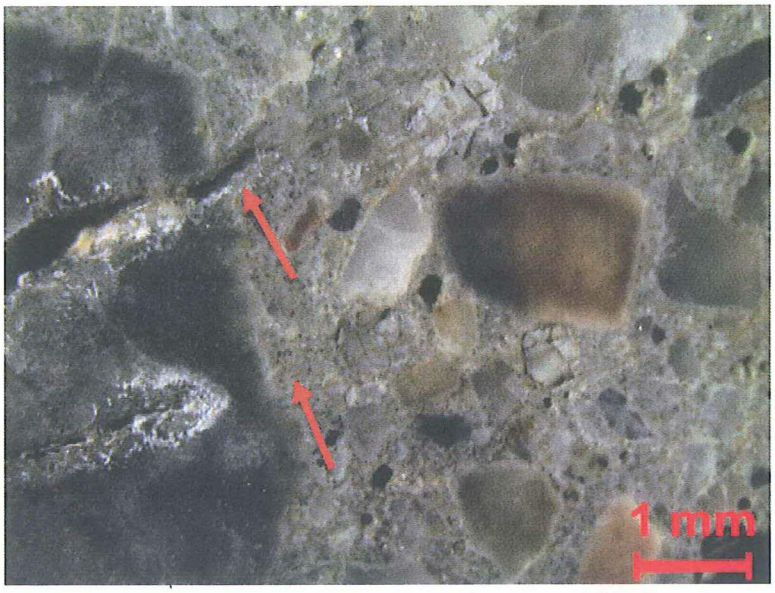

Figure 38. Lapped section of Core 2 AB showing gel filled cracks extending from aggregate particle on the left into the paste (arrows).

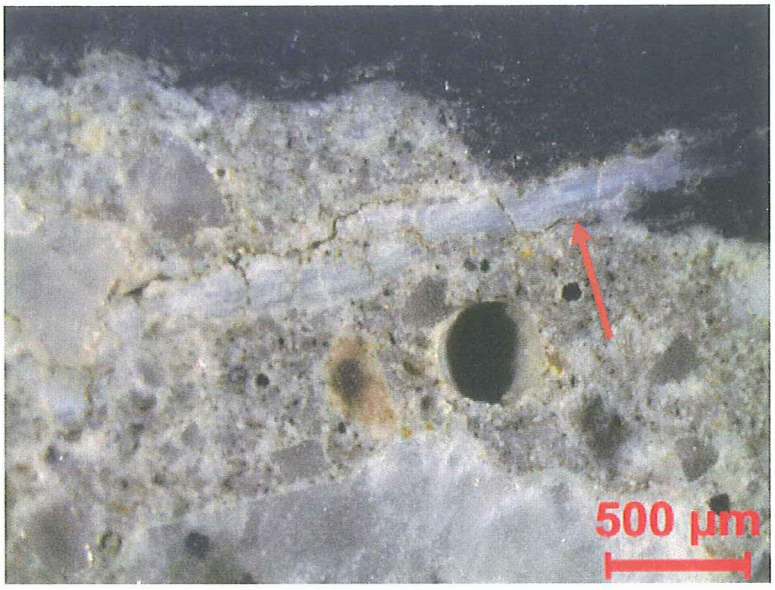

Figure 39. Lapped section of Core 2 BC showing a gel-filled crack extending from a coarse aggregate particle on the right into the paste (arrow).

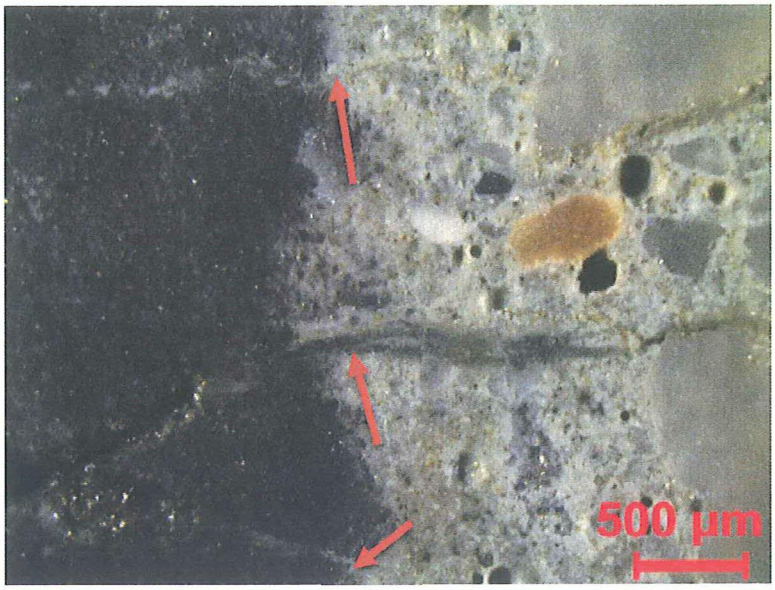

Figure 40. Lapped section of Core 2 CD showing multiple cracks filled with gel extending from a coarse aggregate particle on the left into the paste (arrows).

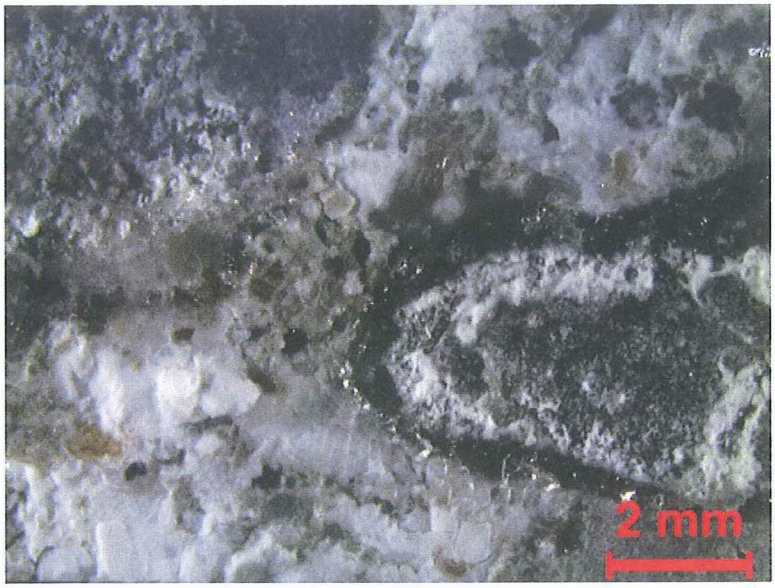

Figure 41. A fractured surface along a crack in Core 2 AB showing abundant white gel deposit.

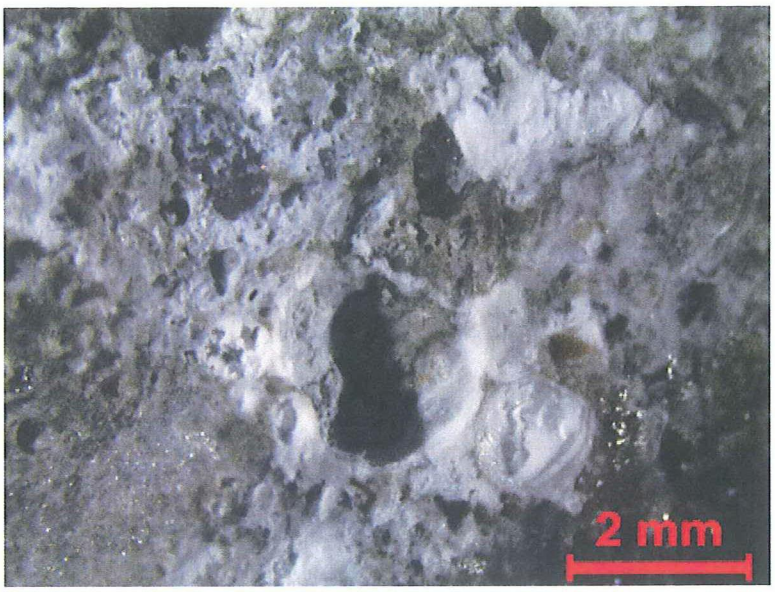

Figure 42. A fractured surface along a crack in Core 2 BC showing abundant white gel deposit.

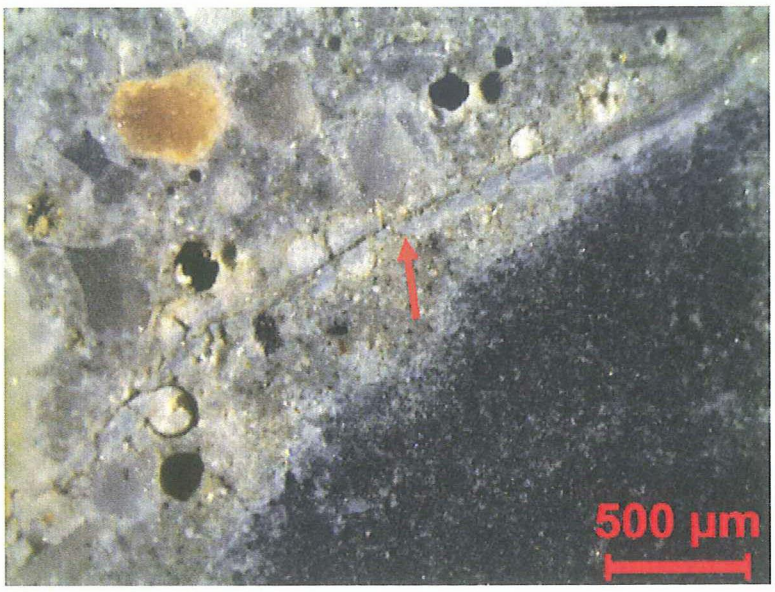

Figure 43. Lapped section of Core 2 CD showing a crack filled with gel in the paste (arrow).

Figure 44. Lapped section of Core 2 AB showing an entrapped air void filled with white gel.

Figure 45. Lapped section of Core 2 CD showing an entrapped void filled with clear gel.

Figure 46. Lapped section of Core 2 AB showing a reactive aggregate particle with both reaction rim and cracking.

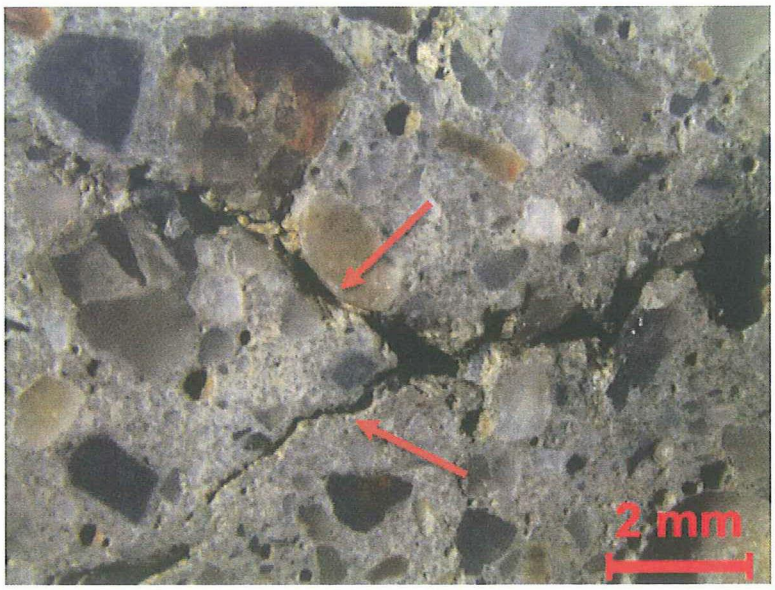

Figure 47. Lapped section of Core 2 AB showing branched crack in the paste (arrows).

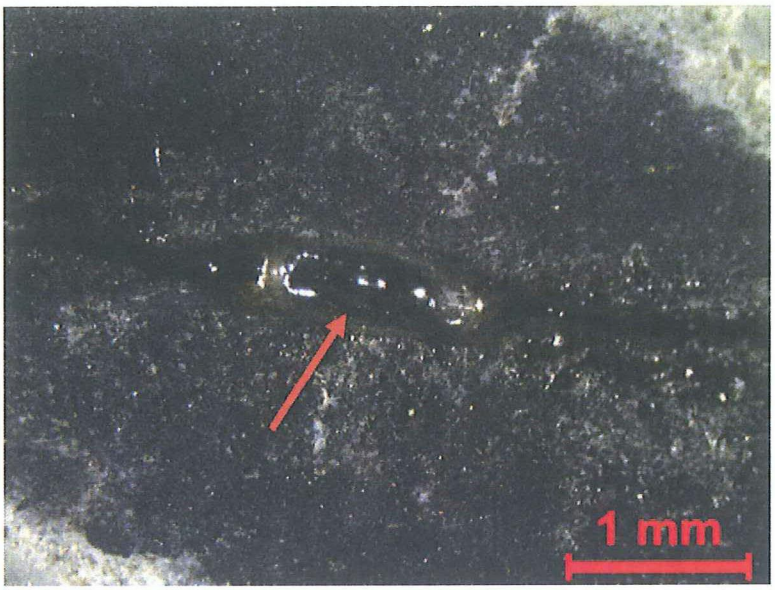

Figure 48. Lapped section of Core 2 AB showing fresh and clear gel forms in a crack with an aggregate particle (arrow).

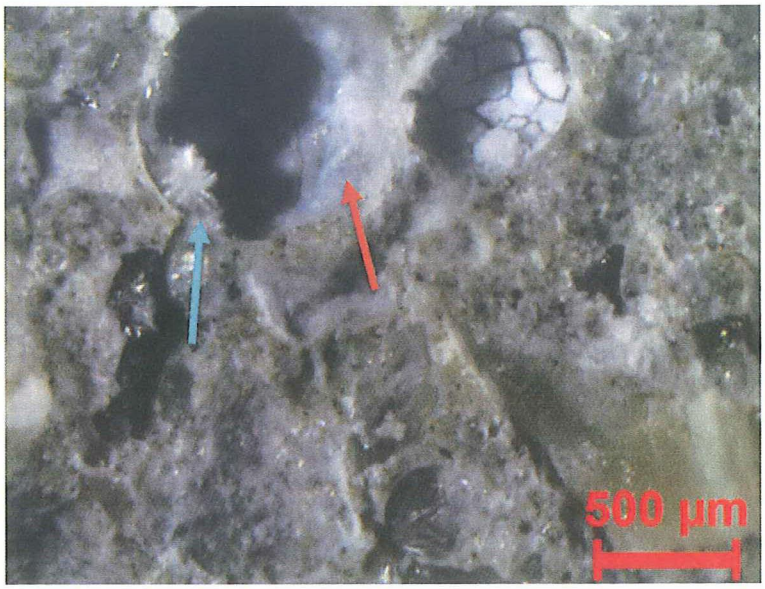

Figure 49. A fractured surface of Core 2 CD showing an air void coated with ettringite (blue arrow) and ASR gel (red arrow) next to another void coated with gel.

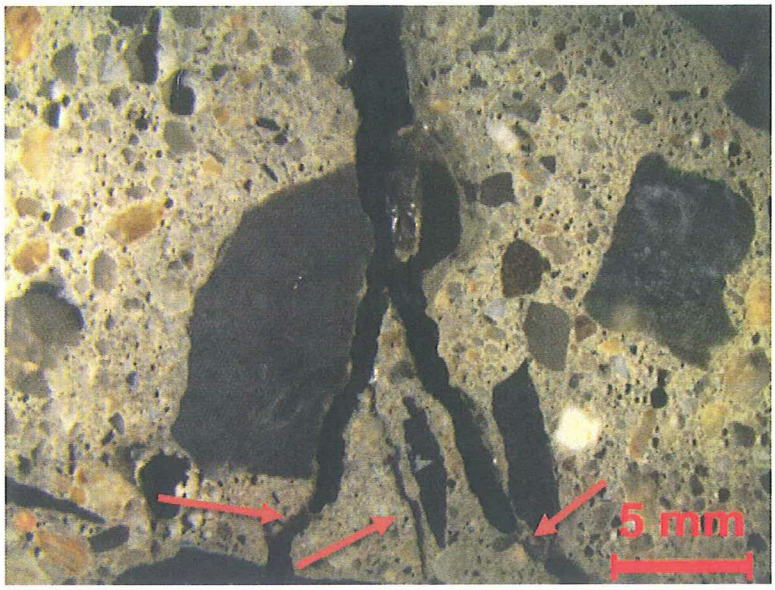

Figure 50. Lapped section of Core 3 showing the branch out of the longitudinal crack. Some areas of the crack are filled with clear epoxy (arrows).

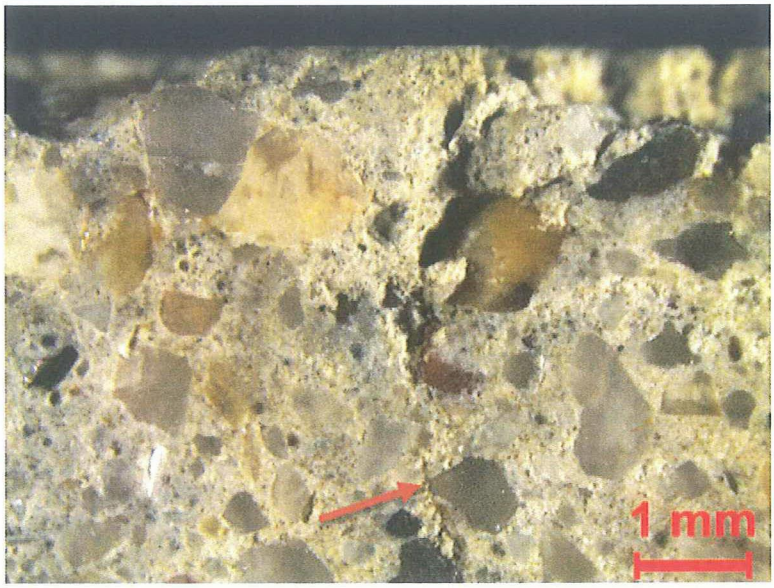

Figure 51. Lapped section of Core 4 showing the longitudinal crack (arrow).

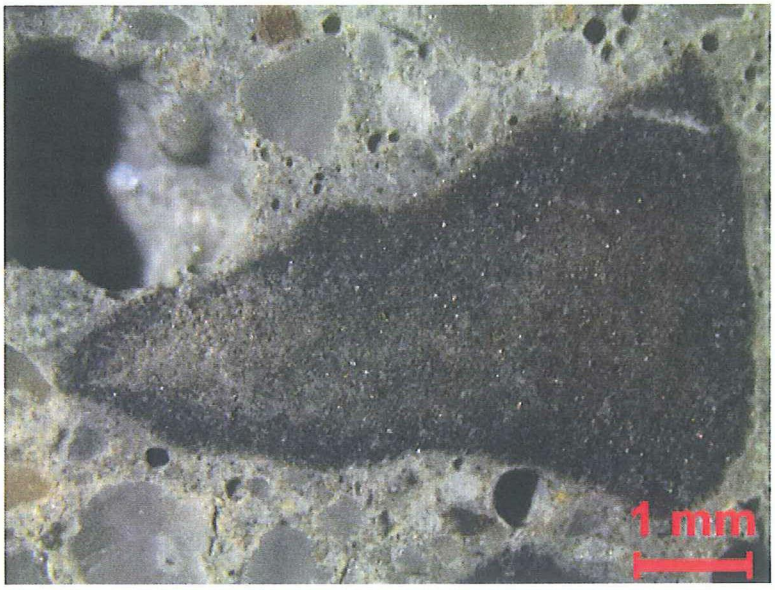

Figure 52. Lapped section of Core 7 AB showing a reactive aggregate particle with reaction rim.

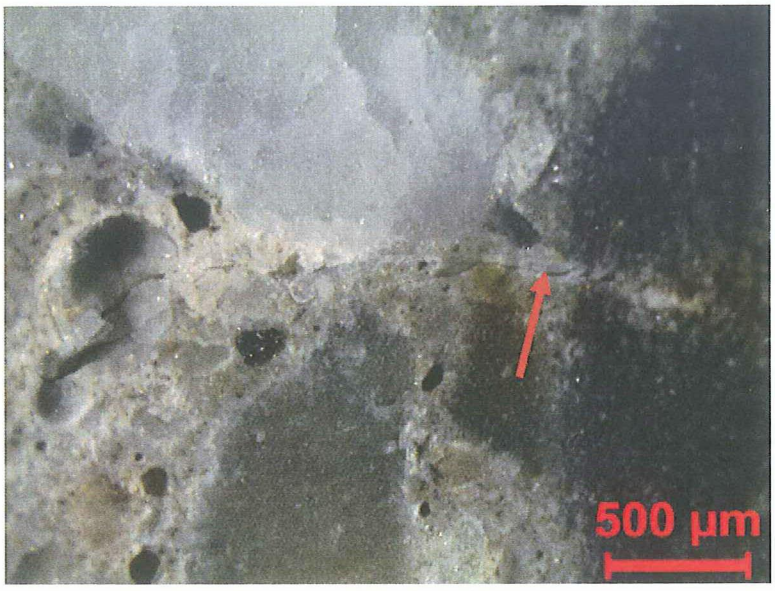

Figure 53. Lapped section of Core 7 BC showing a gel-filled crack extending out from a reactive aggregate particle on the right (arrow).

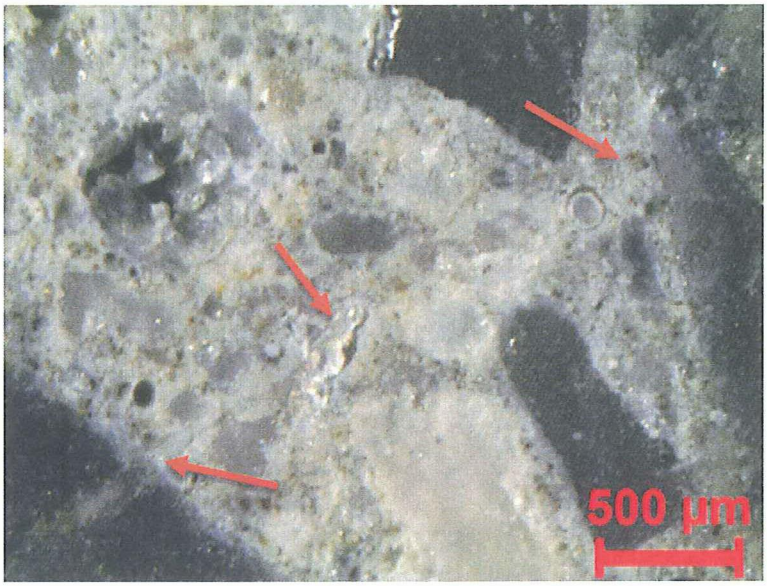

Figure 54. Lapped section of Core 7 BC showing a gel-filled crack linking two reactive particles (arrows).

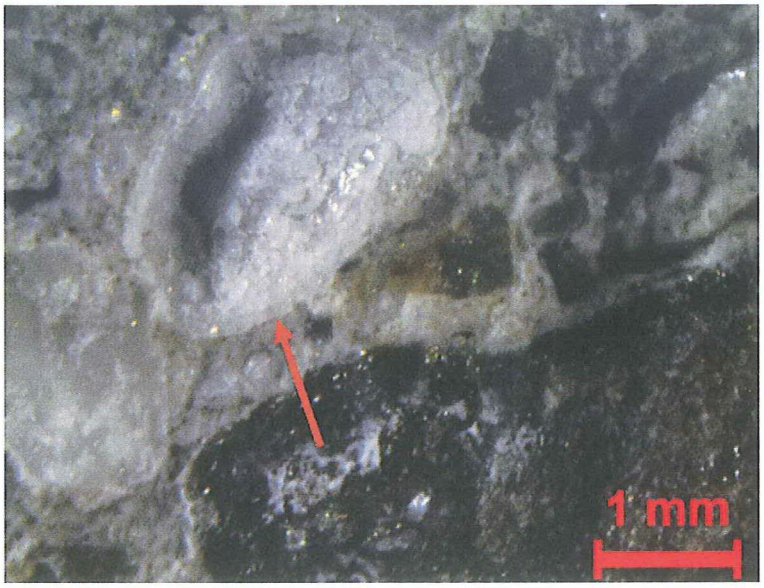

Figure 55. A fractured surface of Core 7 BC showing a white gel-filled air void (arrow).

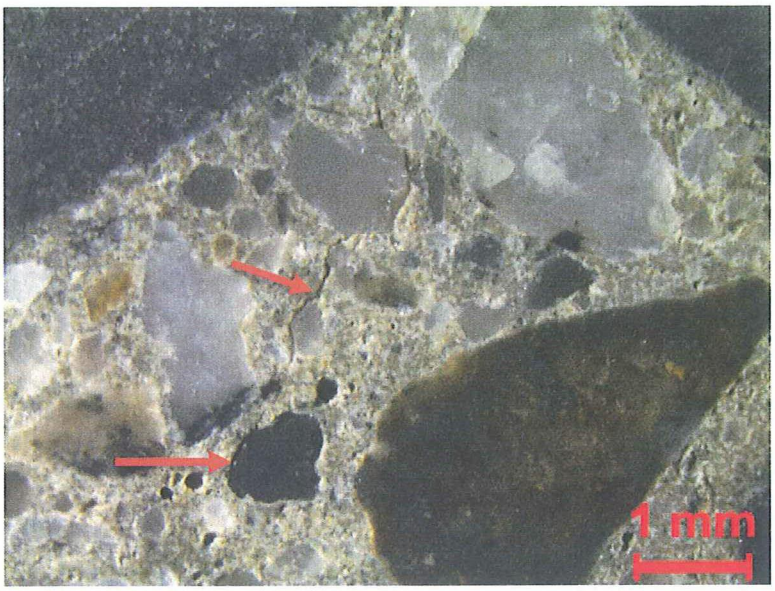

Figure 56. Lapped section of Core 8 CD showing the termination of the longitudinal crack (arrows).

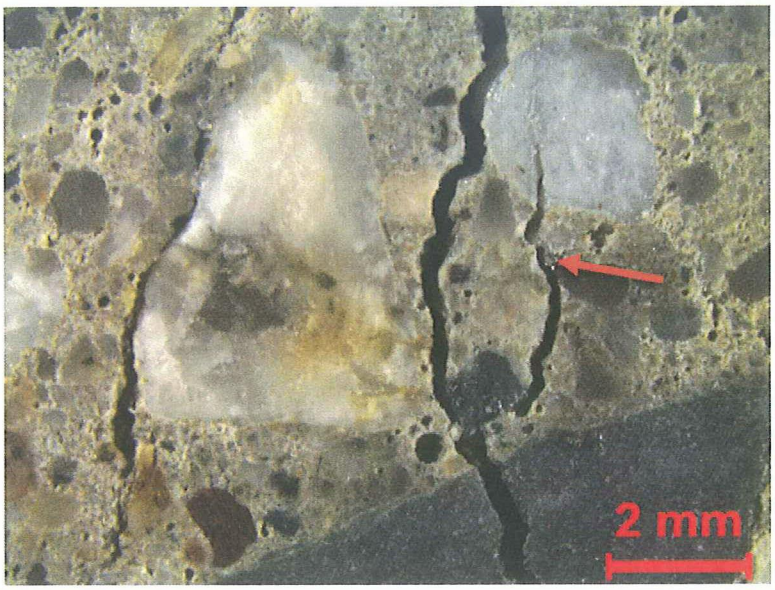

Figure 57. Lapped section of Core 8 AB showing branch out of the longitudinal crack (arrow).

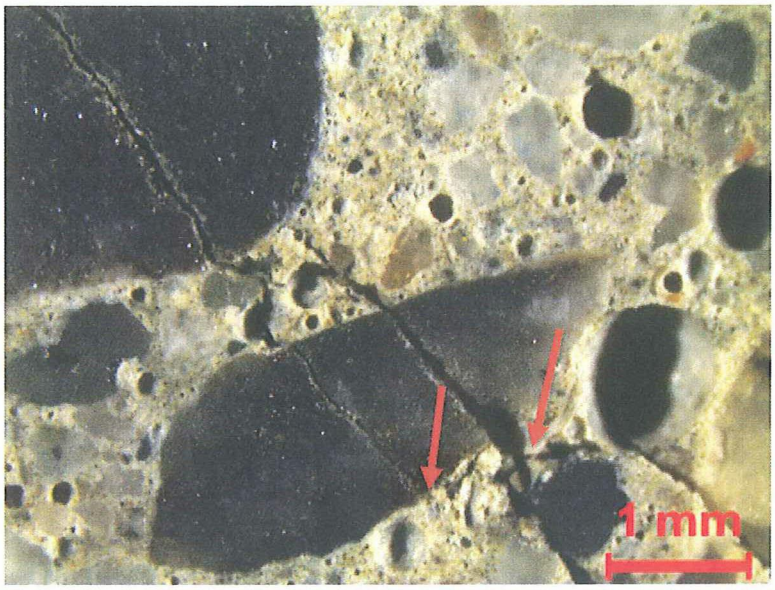

Figure 58. Lapped section of Core 9 showing branch out of the longitudinal crack (arrows).

Figure 59. Lapped section of Core 10 AB showing the interaction of the longitudinal crack and a cracked reactive aggregate particle with multiple cracks (arrow).

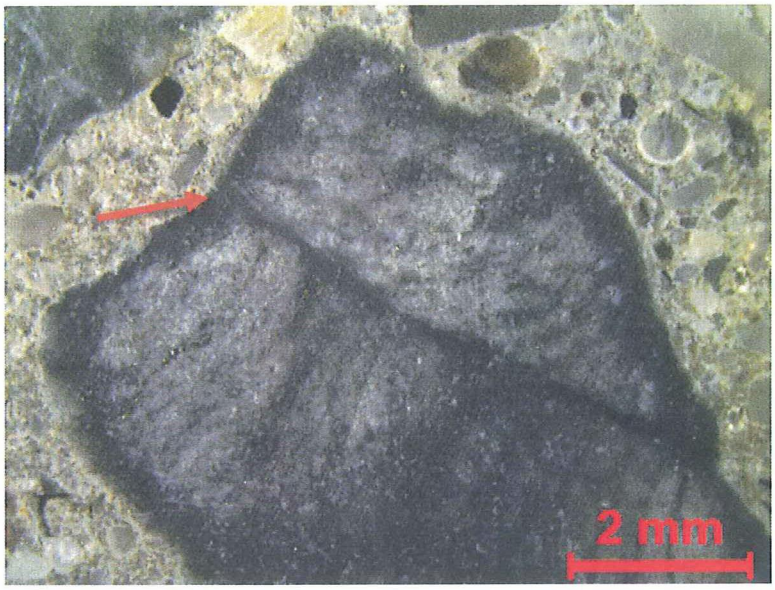

Figure 60. Lapped section of Core 10 AB showing a coarse aggregate particle with reaction rim and cracking into paste (arrow).

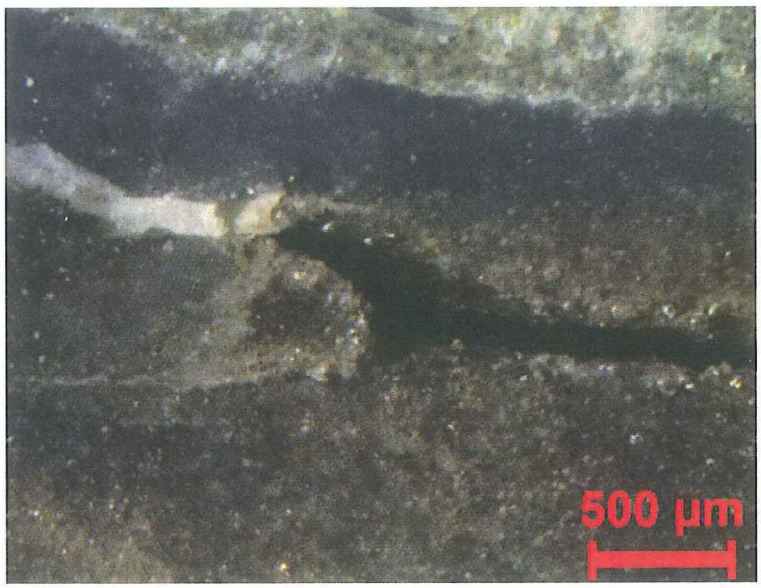

Figure 61. Lapped section of Core 10 BC showing an internal crack in a reactive aggregate partially filled with white gel.

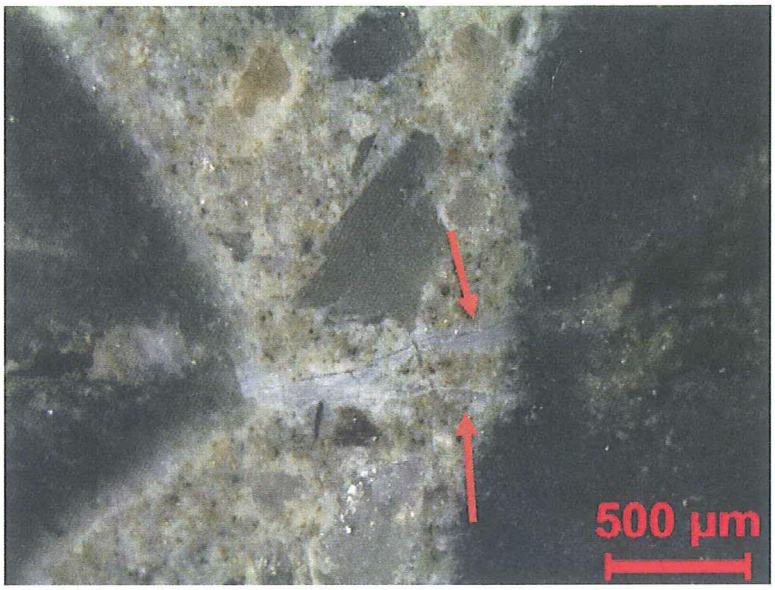

Figure 62. Lapped of Core 10 CD showing two gel-filled cracks linking two reparative aggregate particles (arrow).

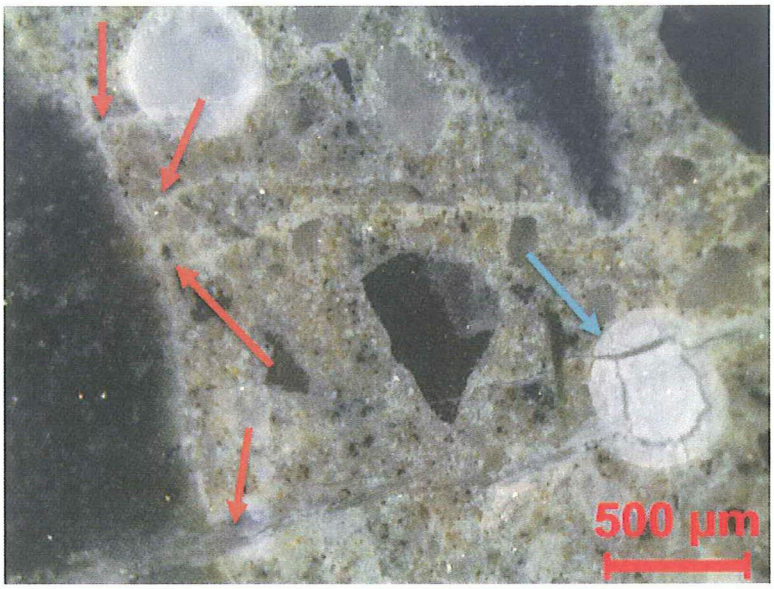

Figure 63. Lapped section of Core 10 CD showing multiple crack filled with gel extending out from an aggregate particle in to the paste (arrows). Also note a gel-filled air void (blue arrow).

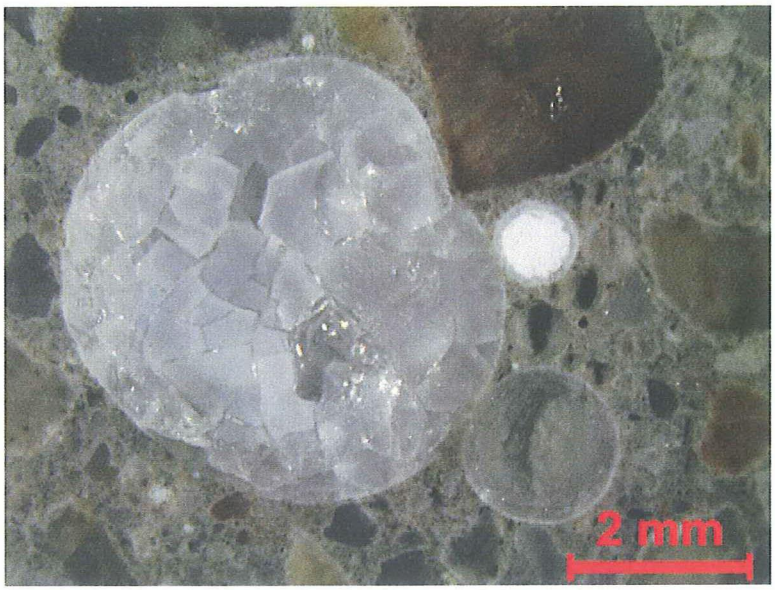

Figure 64. Lapped section of Core 10 CD showing gel-filled air voids.

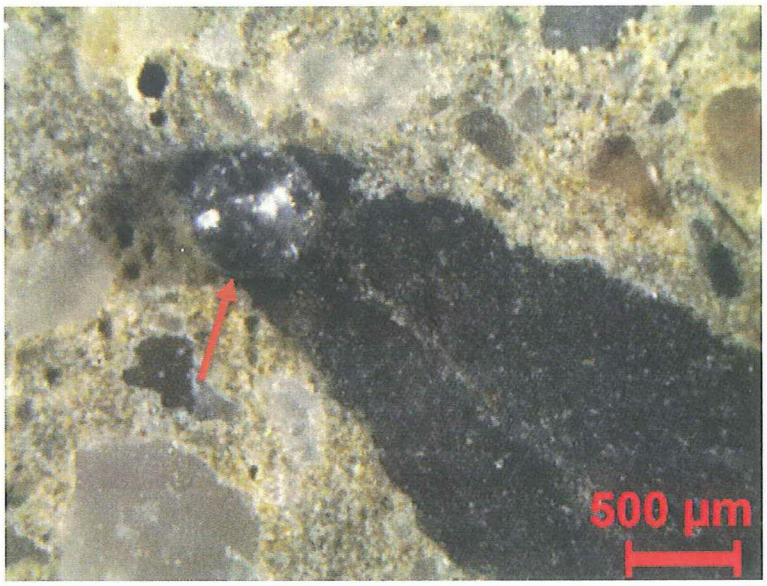

Figure 65. A lapped section of Core 10 AB showing a ball of clear gel formed on the lapped surface of the core (arrow).

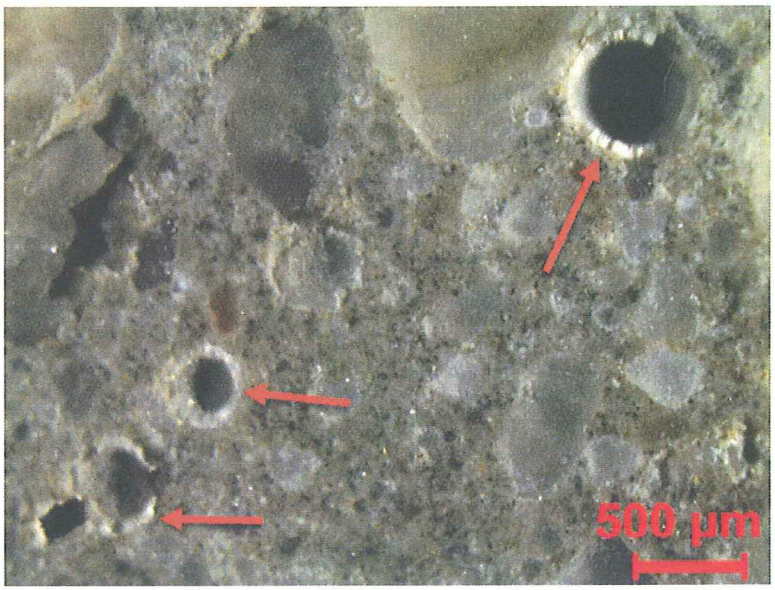

Figure 66. Lapped section of Core 10 AB showing ettringite-coated air voids (arrows).

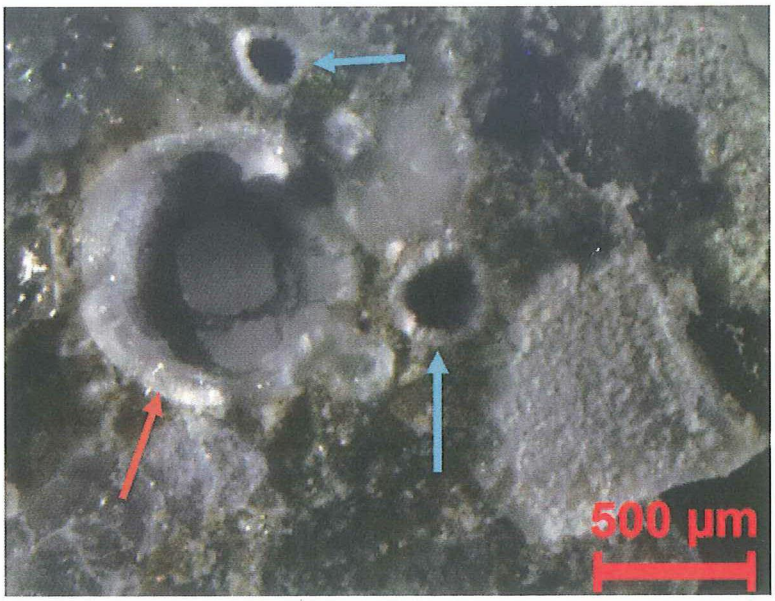

Figure 67. A fractured surface of Core 10 BC showing air voids coated with ettringite (blue arrows) and alkali-silica gel (red arrow).

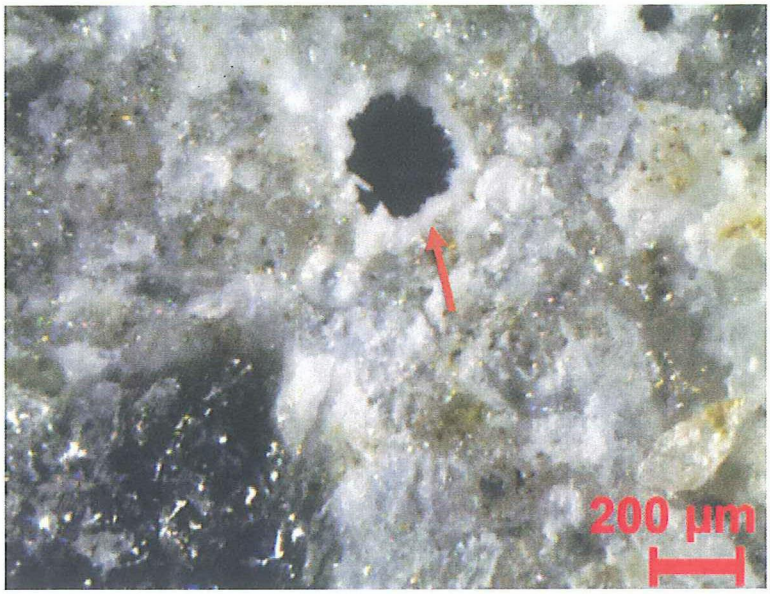

Figure 68. A fractured surface of Core 10 BC showing a gel-covered void that was likely coated with ettringite previously (arrow).

Figure 69. Lapped section of Core 10 BC showing ettringite deposit in a crack (arrow).

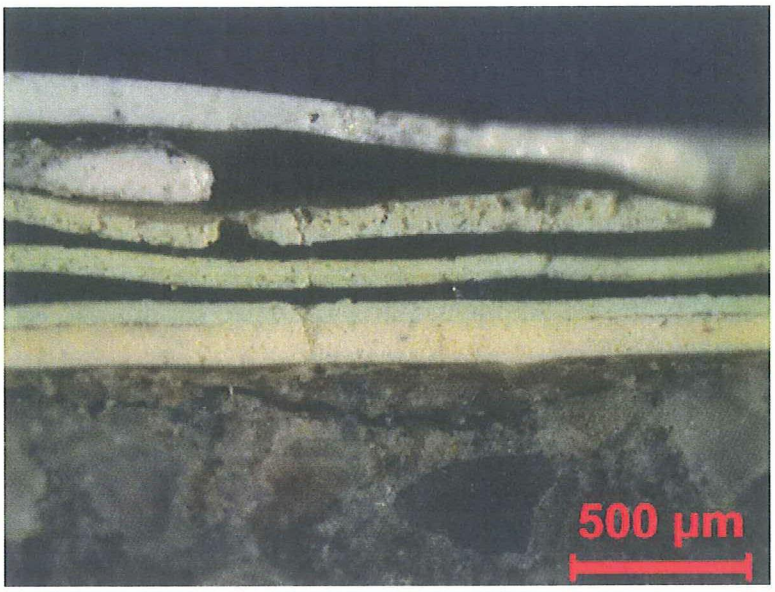

Figure 70. Lapped section of Core 11 AB showing the poorly bonded multiple layers of paint coats. Six individual layers could be identified.

Figure 71. A fractured surface of Core 11 BC showing a reactive coarse aggregate with reaction rim and white gel deposit.

Figure 72. A fractured surface of Core 11 BC showing abundant gel deposit between two reactive aggregate particles.

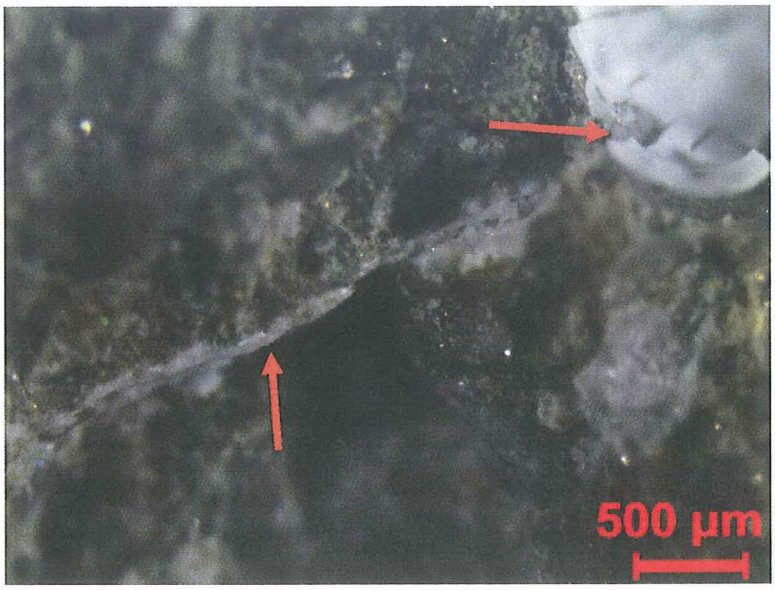

Figure 73. A fractured surface of Core 11 AB showing a crack filled with gel leading into a void coated with gel (arrows).

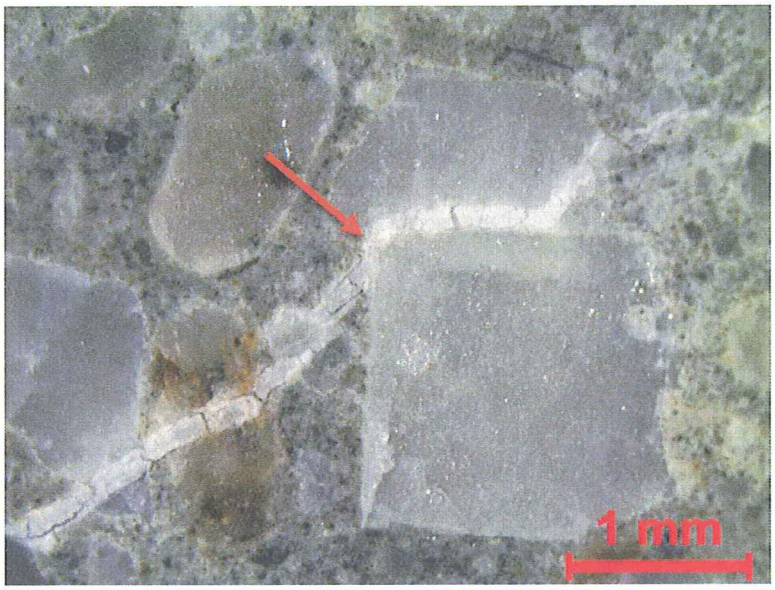

Figure 74. A lapped section of Core 11 BC showing a gel-filled crack through a non-reactive quartz particle (arrow).

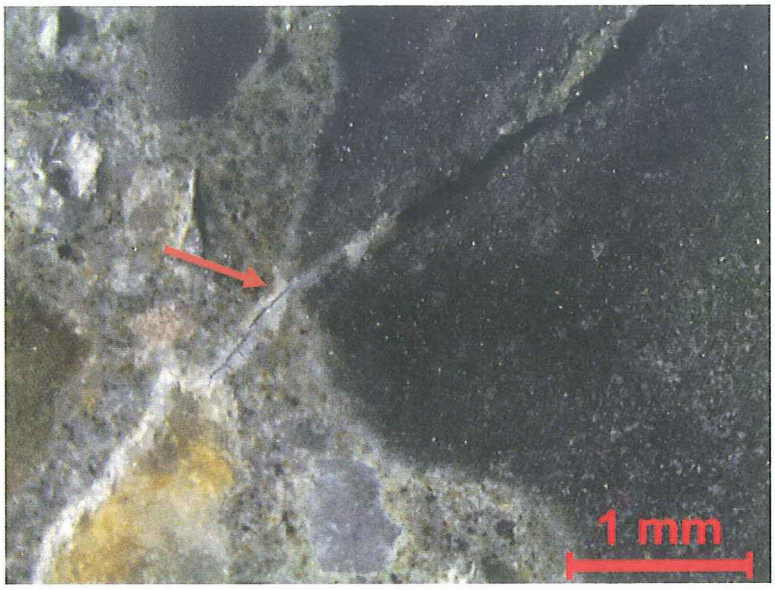

Figure 75. A lapped section of Core 11 CD showing a gel-filled crack extending from a reactive aggregate on the right into the paste (arrow).

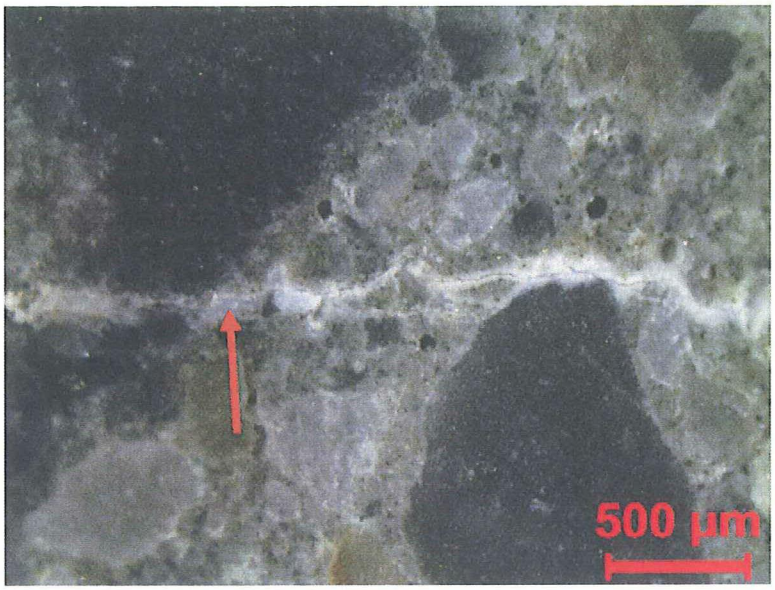

Figure 76. Lapped section of Core 12 CD showing a crack filled with gel extending from a reactive aggregate on the left into the paste (arrow).

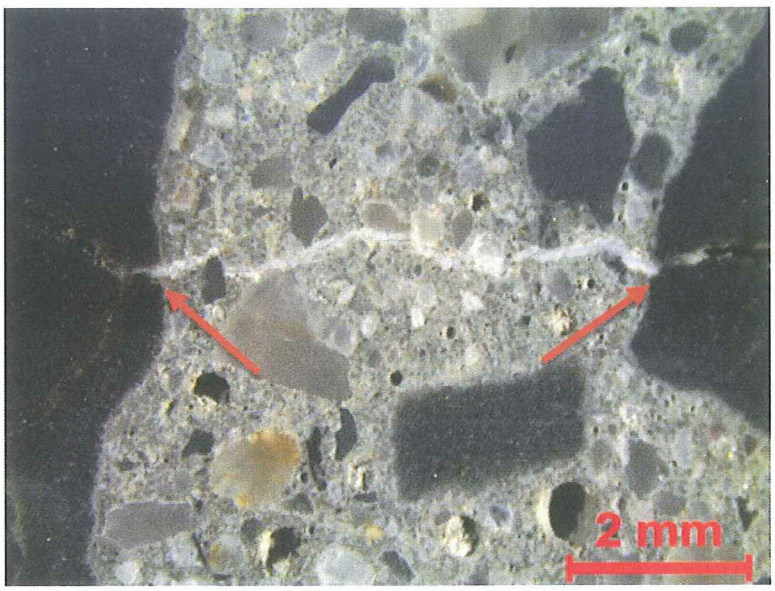

Figure 77. Lapped section of Core 12 CD showing a gel-filled crack linking to two reactive aggregate particles (arrows).

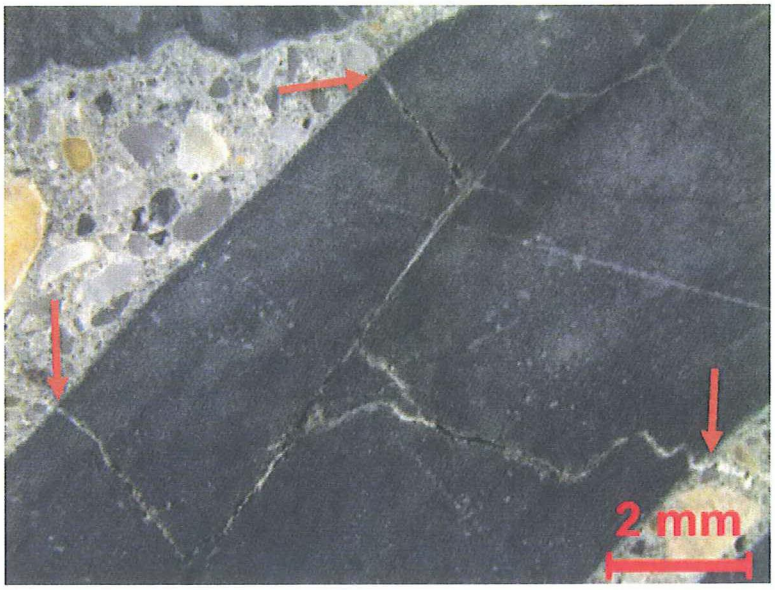

Figure 78. Lapped section of Core 12 BC showing a reactive aggregate particle with narrow reaction rim and abundant internal cracks, some of which extended into the paste (arrows).

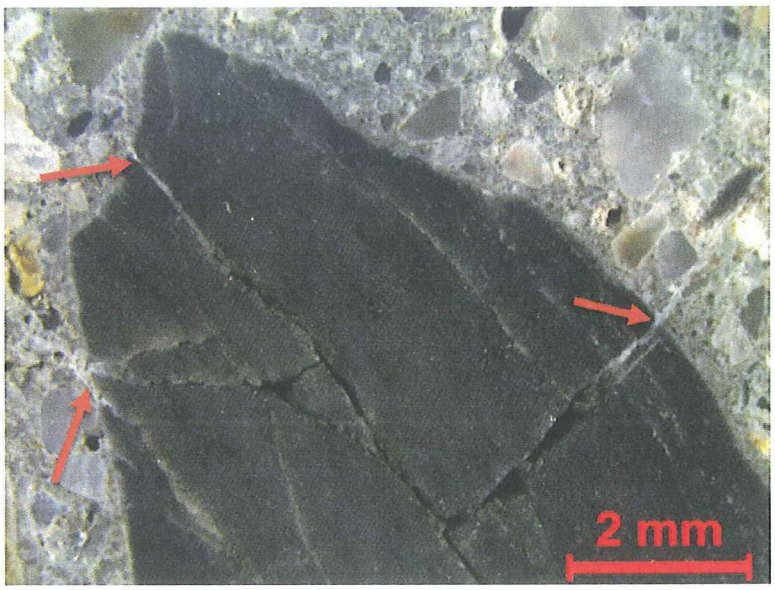

Figure 79. Lapped section of Core 12 CD showing a cracked reactive aggregate particle with cracks extending into the paste (arrows).

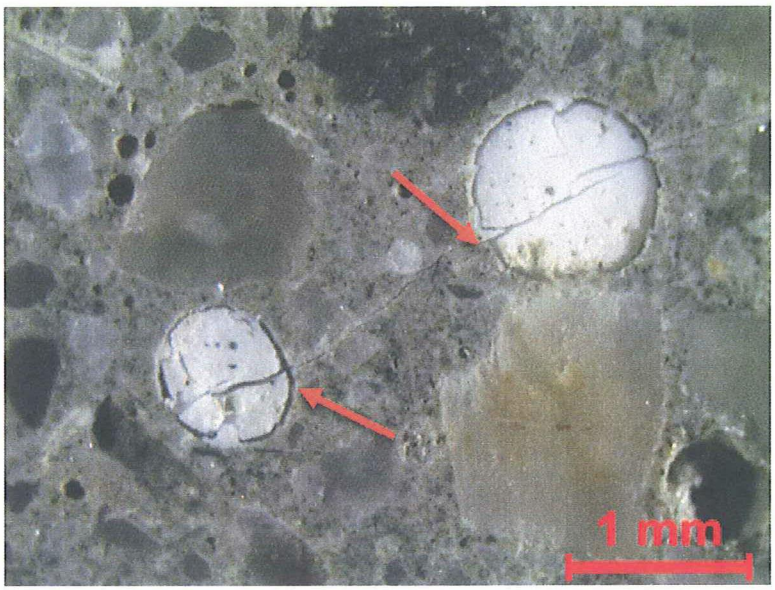

Figure 80. Lapped section of Core 12 CD showing two air voids filled with white gel and connected with a crack (arrows).

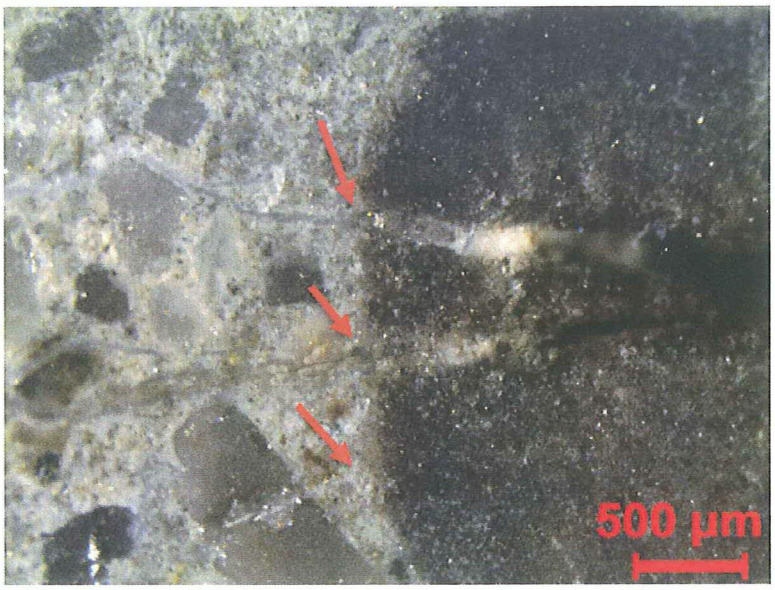

Figure 81. Lapped section of Core 12 AB showing multiple cracks extending out from a reactive aggregate on the right (arrows).

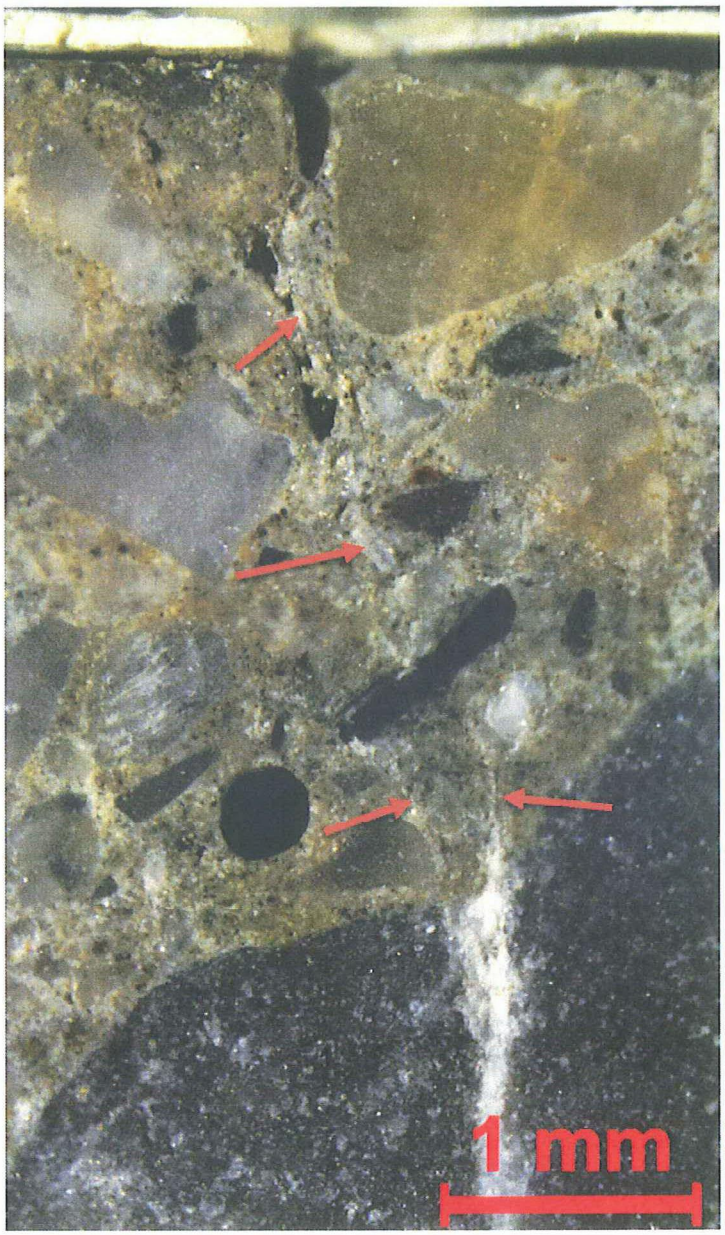

Figure 82. Lapped section of Core 12 AB showing a gel-filled crack extending from a reactive aggregate particle on the bottom to the top surface of the core (arrows).

Figure 83. A fractured surface along a longitudinal crack at 1/4 inch from the top surface of Core 12 AB showing abundant white gel deposits.

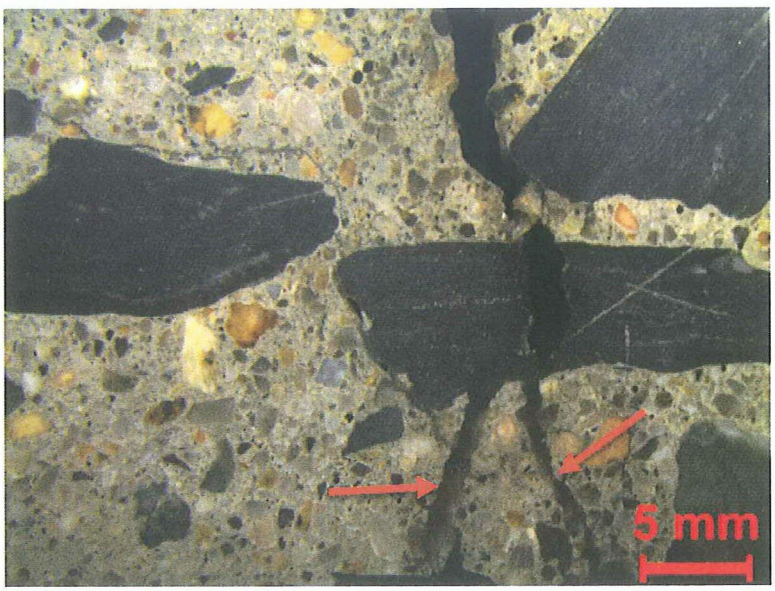

Figure 84. Lapped section of Core 13AB showing branching out of the longitudinal crack. Note the epoxy in the cracks (arrows).

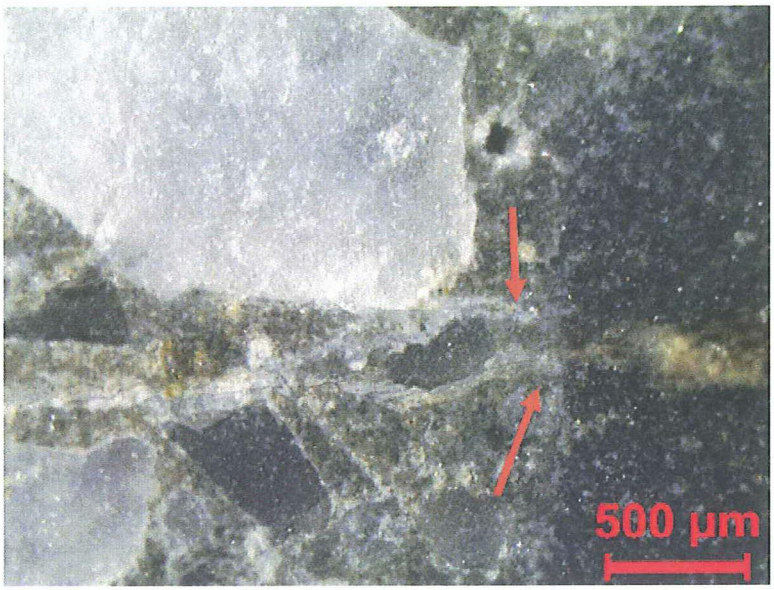

Figure 85. Lapped section of Core 16 BC showing cracks filled with gel extending from a reactive aggregate on the right into the paste (arrows).

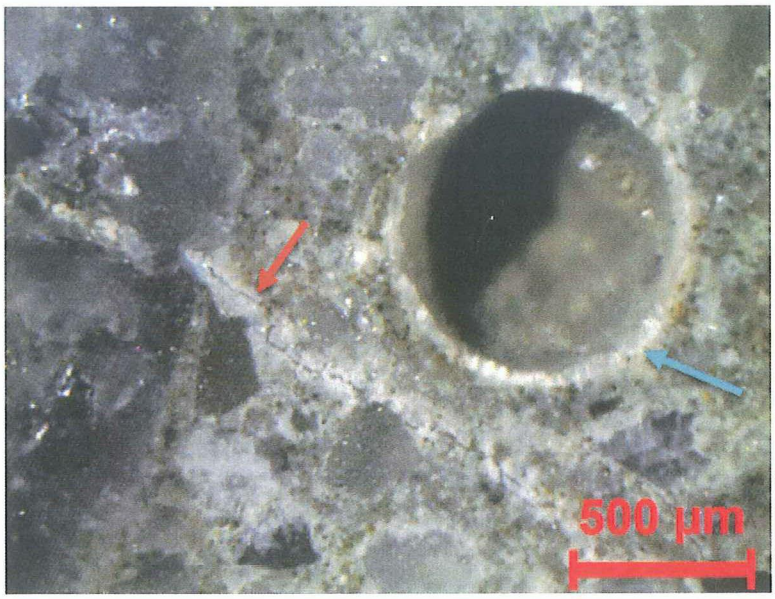

Figure 86. Lapped section of Core 16 CD showing a gel-filled crack extending from a reactive aggregate particle on the left into the paste (red arrow). Also note an air void coated with ettringite (blue arrow).

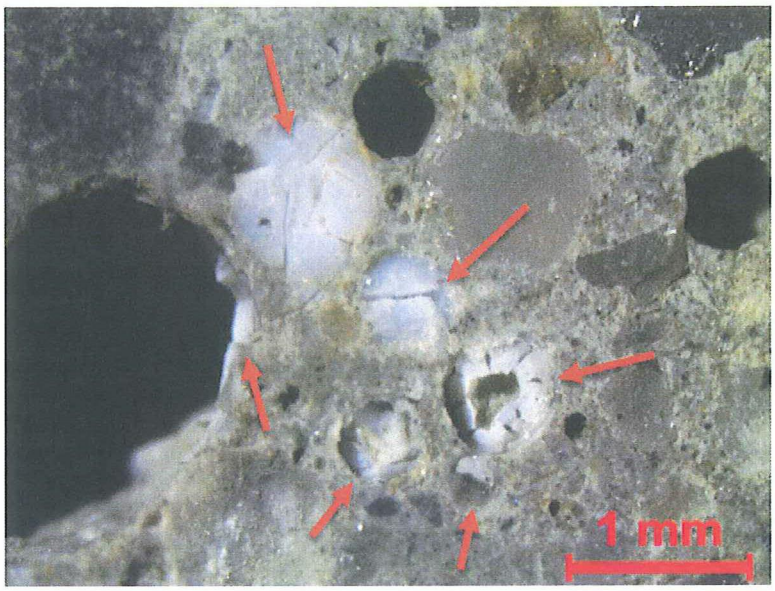

Figure 87. Lapped section of Core 16 BC showing multiple voids filled or coated with alkali-silica gel (arrows).

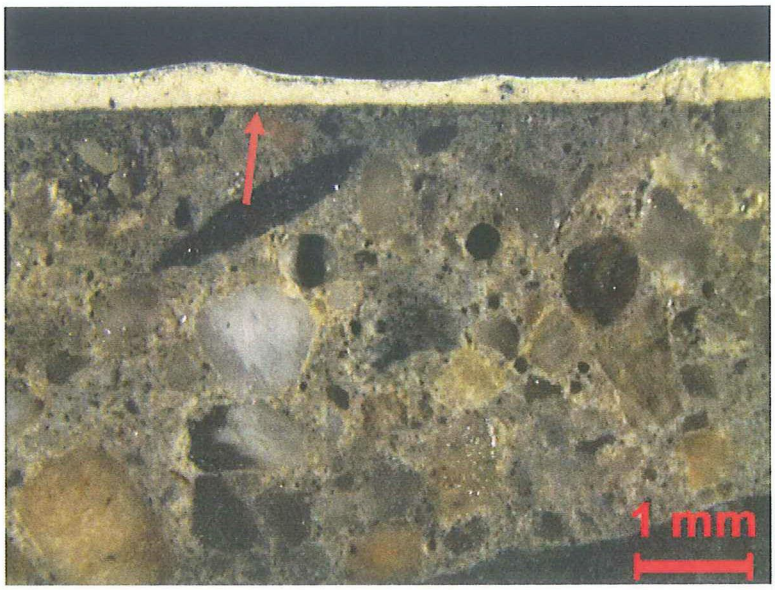

Figure 88. Lapped section of Core 19 AB showing the intact surface coating (arrow).

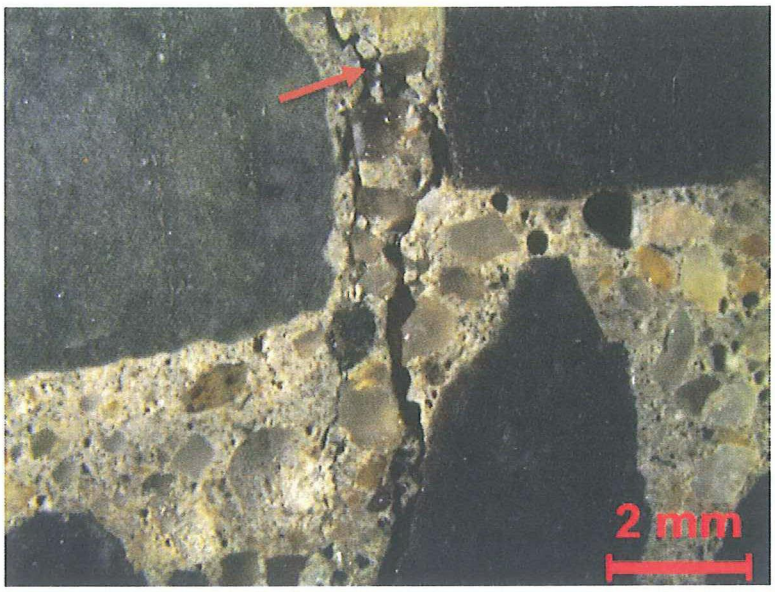

Figure 89. Lapped section of Core 20 AB showing branching out of the longitudinal crack (arrow).

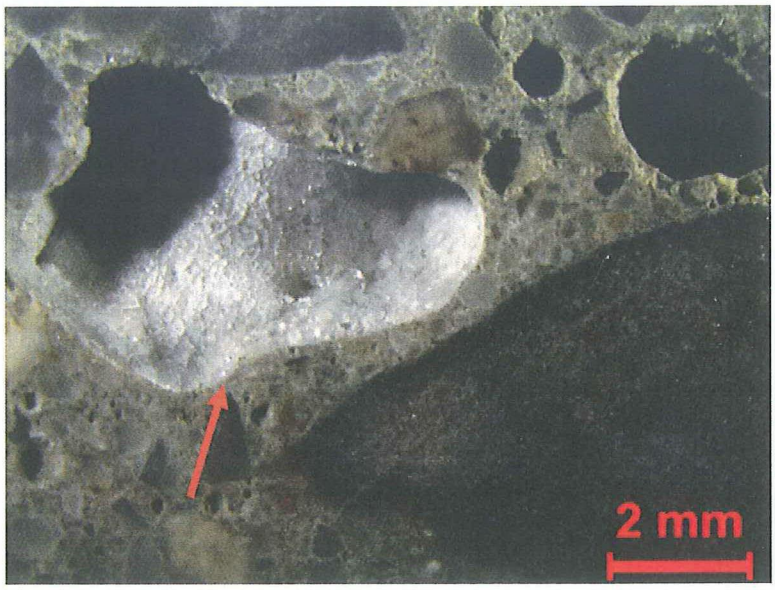

Figure 90. Lapped section of Core 20 BC showing a gel-coated air void next to a reactive aggregate with reaction rim (arrow).

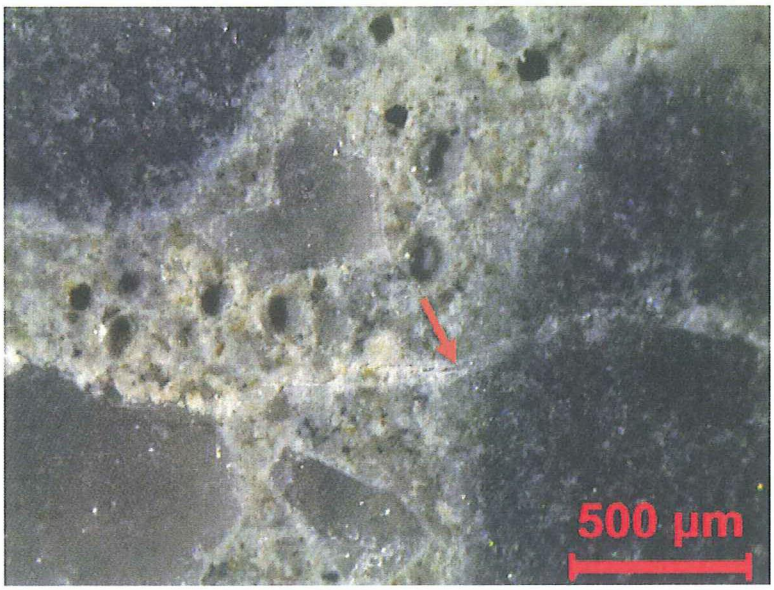

Figure 91. Lapped section of Core 20 DE showing a gel-filled crack extending out from a reactive aggregate on the right into the paste (arrow).

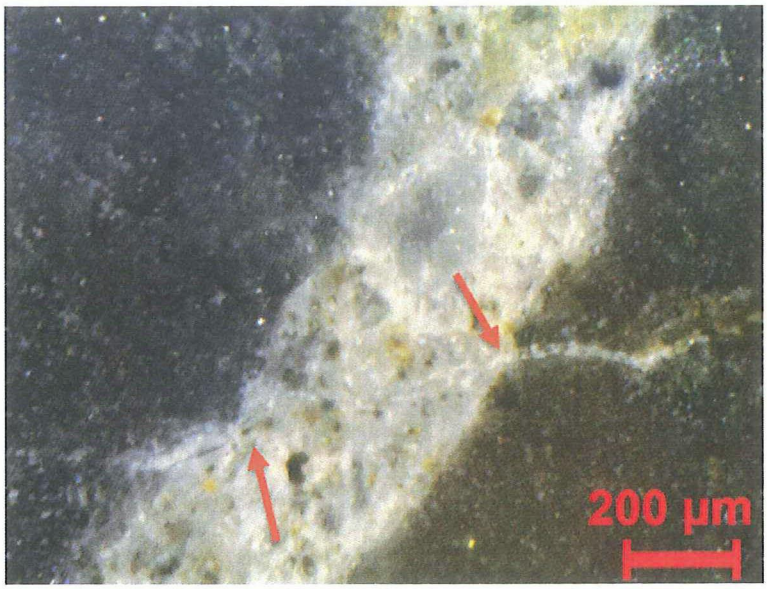

Figure 92. Lapped section of Core 20 DE showing a gel-filled crack extending out from one reactive aggregate to another (arrows

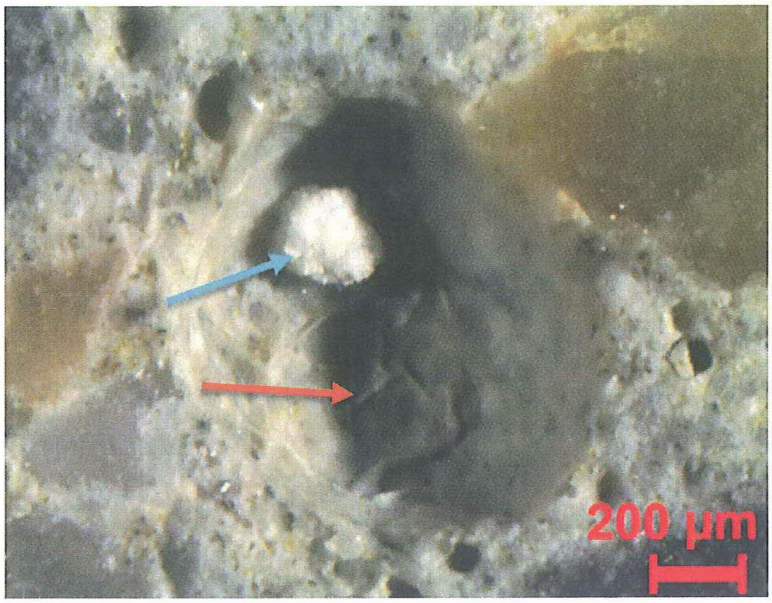

Figure 93. Lapped section of Core 20 DE showing a void with calcium hydroxide deposit (red arrow) on the bottom and ettringite on top (blue arrow).

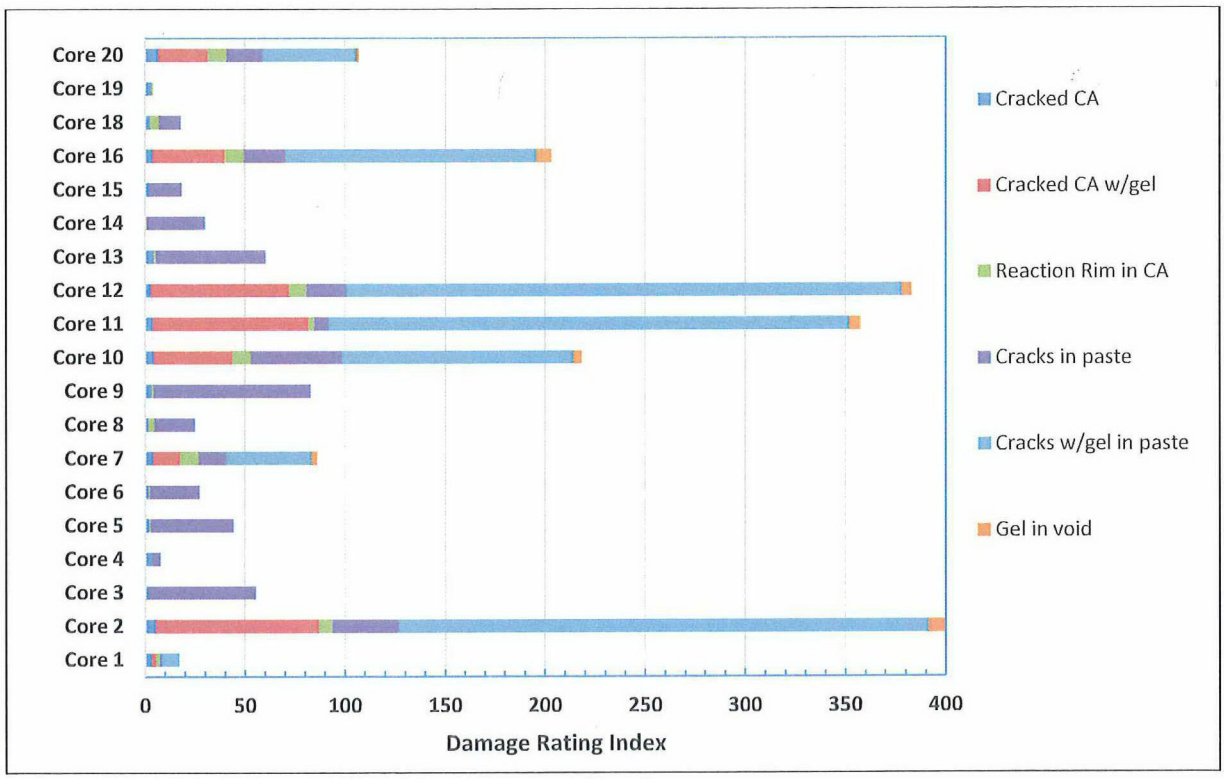

Figure 94. Diagram showing the DRI measurement for all cores.

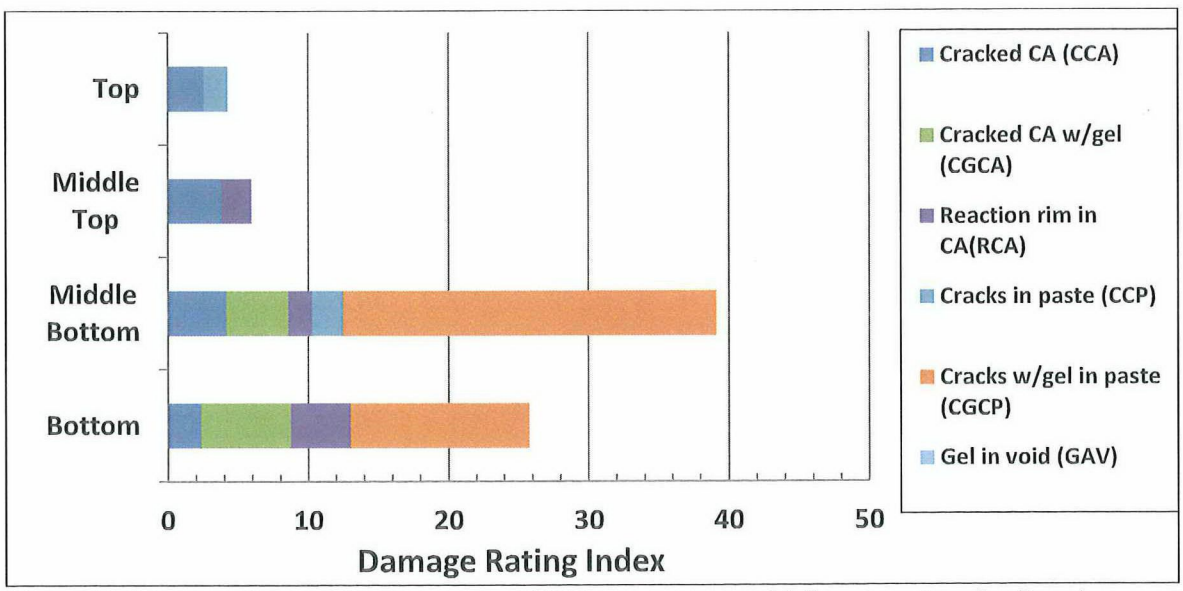

Figure 95. Diagram showing the comparison of DRI measurement of different sections for Core 1.

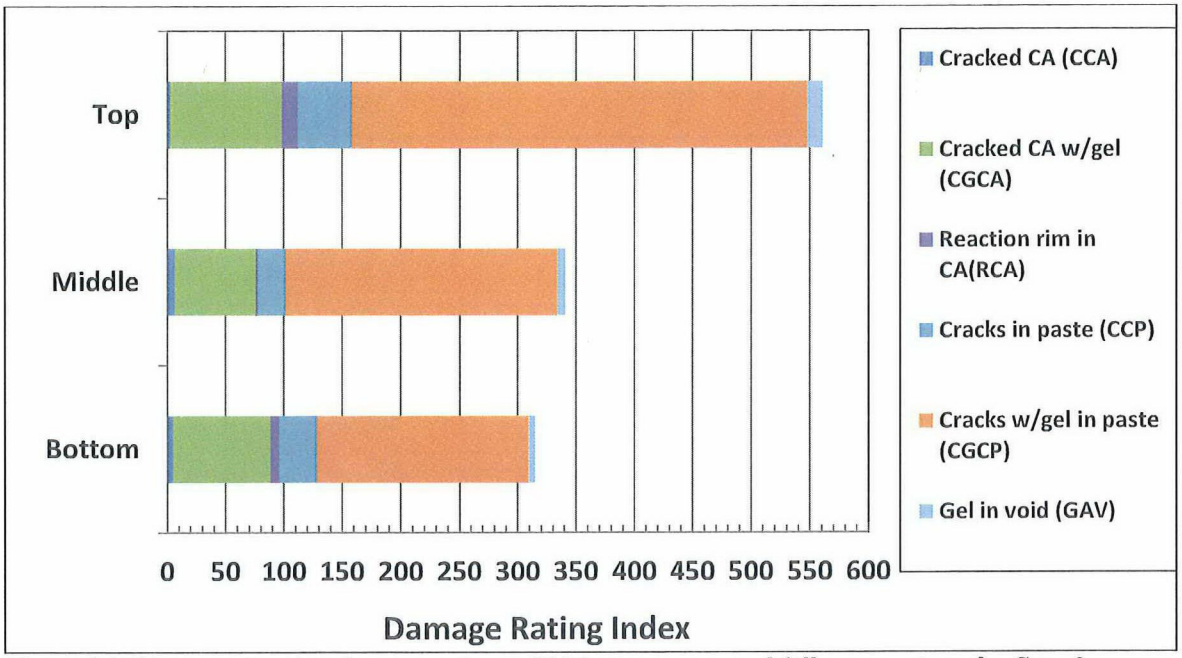

Figure 96. Diagram showing the comparison of DRI measurement of different sections for Core 2.

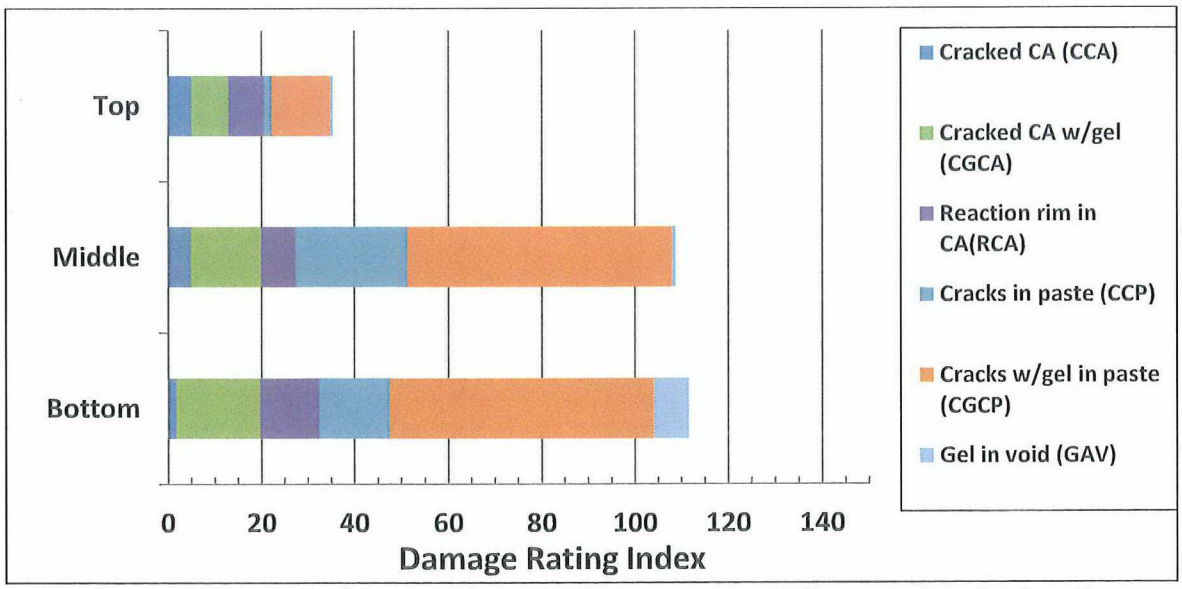

Figure 97. Diagram showing the comparison of DRI measurement of different sections for Core 7.

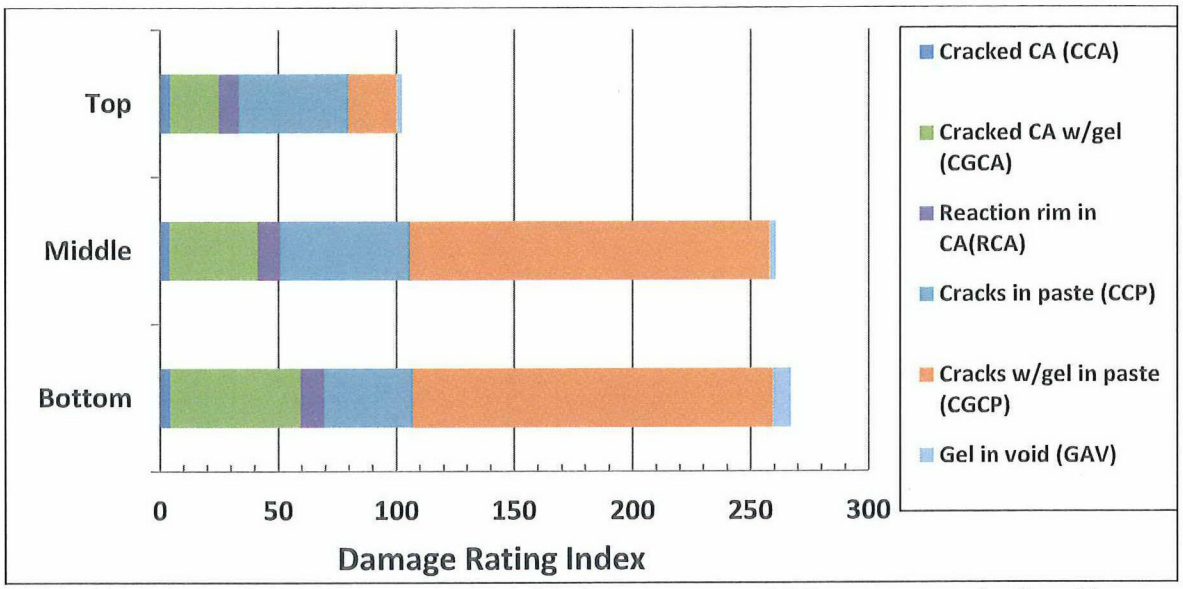

Figure 98. Diagram showing the comparison of DRI measurement of different sections for Core 10.

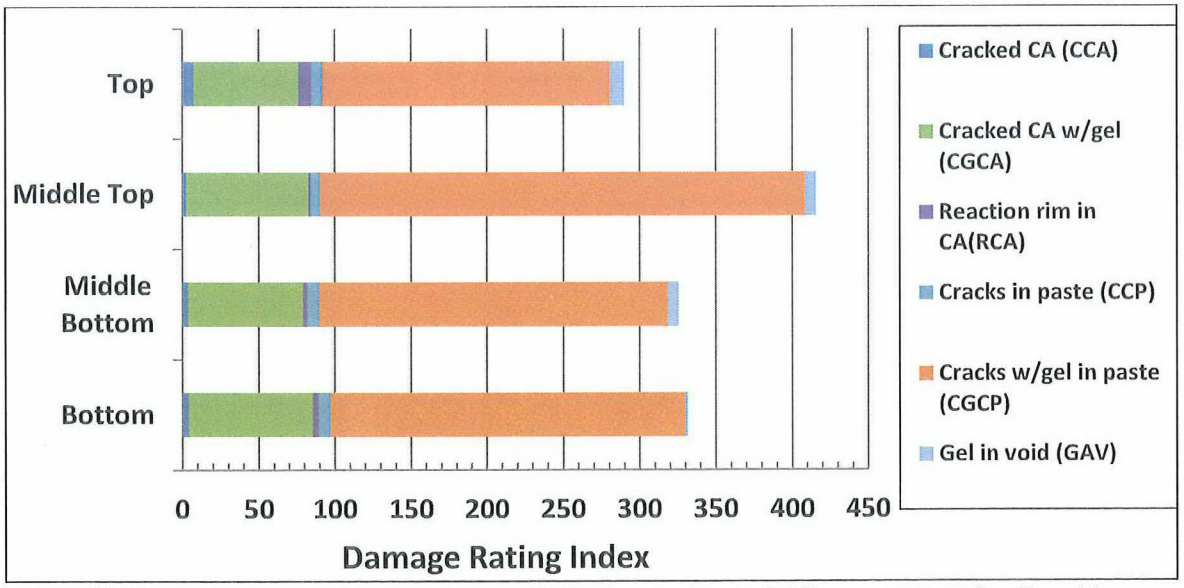

Figure 99. Diagram showing the comparison of DRI measurement of different sections for Core 11.

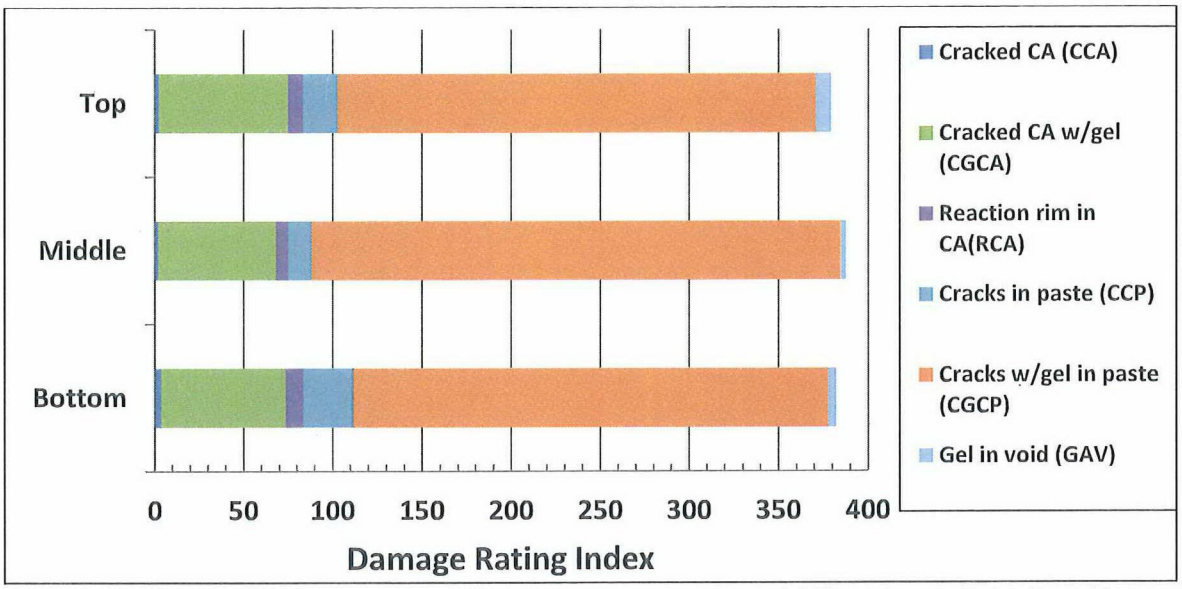

Figure 100. Diagram showing the comparison of DRI measurement of different sections for Core 12.

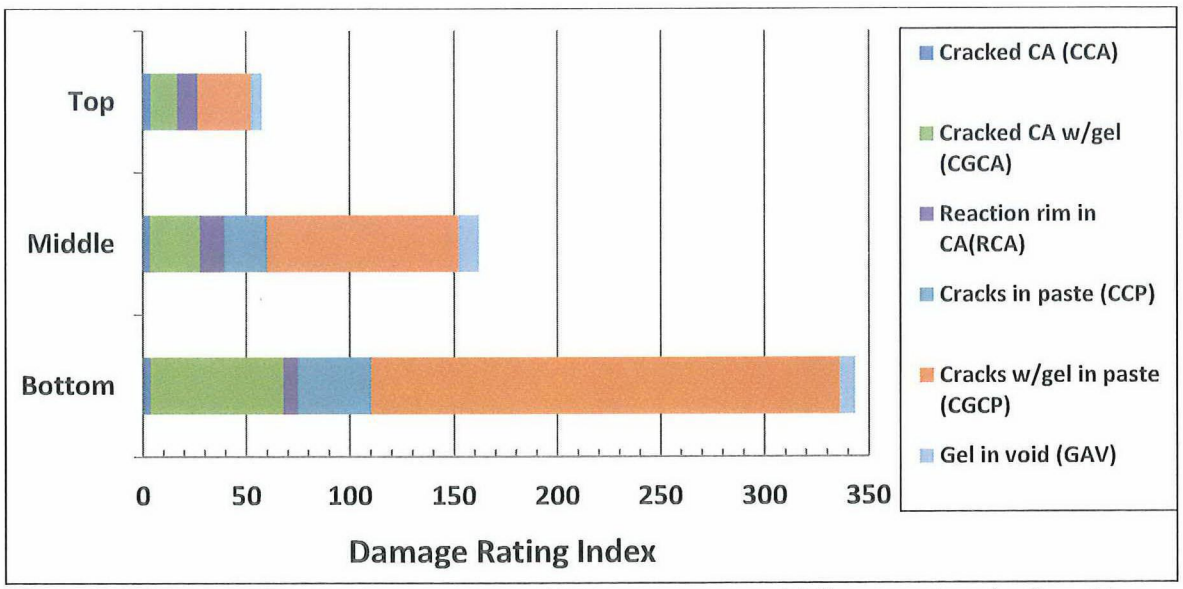

Figure 101. Diagram showing the comparison of DRI measurement of different sections for Core 16.

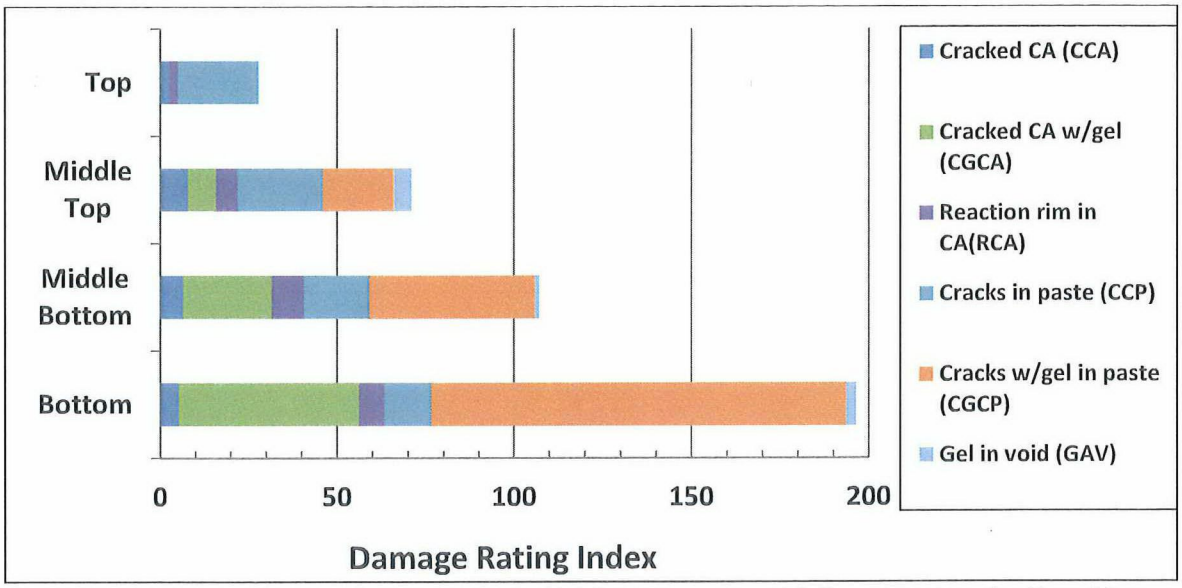

Figure 102. Diagram showing the comparison of DRI measurement of different sections for Core 20.

APPENDIX - ORIGINAL PETROGRAPHIC DATA SHEETS

PAGES 91 THROUGH 137 TPV 6/20/16

Date 03/29/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 1 AB **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 5-1/2

Finishing: broom ☐ trowel ☐ tine ☐ formed ☒ cut ☐ coating ☒ other: Paint

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☒ flat ☐ fractured ☐ barrier ☐ other:

Steel: No **Cover depth:** **Corrosion:** no ☐ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☐ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☒ Through agg ☒ Partial depth ☒ Length: 1/2 in. Width: 1 mil
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☒ thermal ☐ Crazing ☐ Other: possible ASR

Other defect

Aggregate

Coarse % — NMS: 3/4" — Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine %
manufactured ☐ combined ☐ natural Sand ☒
Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: mica
Shape: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: up to 10 % of paste
angular ☐ subangular ☒ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☒
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: 1/32" bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 to 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 4-1/2 — 5-1/2%

Coarse ☐ fine ☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☒ 2nd deposits ☐ ettringite ☐ $Ca(OH)_2$ ☐ Other ☐ thin coat ☐ thick coat ☐ full ☐ some ☐ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☐ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

No ASR detected, voids clean

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☒ thin section ☐ Other ☐ caption:

Date 03/29/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 1 BC **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 5-1/2

Finishing: broom ☐ trowel ☐ tine ☐ formed ☐ cut ☒ coating ☐ other: Paint

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☒ formed ☐ cut ☒ flat ☐ fractured ☐ barrier ☐ other:

Steel: No **Cover depth:** **Corrosion:** no ☐ moderate ☐ severe ☐

Cracking: None ☒ Micro ☐ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☐ Peripheral ☐
Yes ☐ Macro ☐ Vertical ☐ Through agg ☐ Partial depth ☐ Length: 1/2 in. Width: 1 mil
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % — NMS: 3/4" — Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine %
manufactured ☐ combined ☐ natural Sand ☒
Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: mica
Shape: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter:** mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: up to 10 % of paste
angular ☐ subangular ☒ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☒
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 to 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 4 — 5%

Coarse ☐ fine ☐ spherical ☐ irregular ☐ bleed channels ☐ water gains ☐ uniform ☐ clusters ☐ around CA ☐

voids: clean ☒ 2nd deposits ☐ ettringite ☐ $Ca(OH)_2$ ☐ Other ☐ thin coat ☐ thick coat ☐ full ☐ some ☐ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☐ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

No ASR detected, voids clean

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☒ thin section ☐ Other ☐ caption:

Date 03/29/2016 **Project No: 2014.3453.2** **Made by: DXC**

Sample I.D. # 1 BC | **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 5-1/2

Finishing: broom ☐ trowel ☐ tine ☐ formed ☐ cut ☒ coating ☐ other: Paint

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☒ formed ☐ cut ☒ flat ☐ fractured ☐ barrier ☐ other:

Steel: No | **Cover depth:** | **Corrosion:** no ☐ moderate ☐ severe ☐

Cracking: None ☒ Micro ☐ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☐ Peripheral ☐
Yes ☐ Macro ☐ Vertical ☐ Through agg ☐ Partial depth ☐ Length: 1/2 in. Width: 1 mil
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % — NMS: 3/4" — Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine %
manufactured ☐ combined ☐ natural Sand ☒
Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: mica
Shape: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ | **Grading:** well ☒ poor ☐ gap ☐ | **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter:** mils **width:** in. | **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ | **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ | uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ | **thickness:** | harder ☐ softer ☐ | darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: up to 10 % of paste
angular ☐ subangular ☒ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☒
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 | retempering: yes ☐ no ☒ | **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: | Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 to 27 % | **Cementitious Materials** 6 — 6-1/2 bags/cy | **SCM:** no ☒ yes ☐

Fly ash: ☐ — % | GGBFS: ☐ — % | Silica fume: ☐ — % | Other: ☐

Air Void System

entrained ☒ | **marginal** ☐ | **non-entrained** ☐ | **air content:** 4 — 5%

Coarse ☐ fine ☐ spherical ☐ irregular ☐ bleed channels ☐ water gains ☐ uniform ☐ clusters ☐ around CA ☐

voids: clean ☒ | 2nd deposits ☐ ettringite ☐ $Ca(OH)_2$ ☐ Other ☐ | thin coat ☐ thick coat ☐ full ☐ some ☐ most ☐

Additional Information

Thin section ☐ Point count ☐ | ASR ☐ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

No ASR detected, voids clean

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☒ thin section ☐ Other ☐ caption:

Date 03/29/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 1 CD **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 3-5/8

Finishing: broom ☐ trowel ☐ tine ☐ formed ☐ cut ☒ coating ☐ other: Paint

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☒ flat ☐ fractured ☐ barrier ☐ other:

Steel: No **Cover depth:** **Corrosion:** no ☐ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☒ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☐ Through agg ☒ Partial depth ☐ Length: 1/2 in. Width: 1 mil
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other: possible ASR

Other defect

Aggregate

Coarse % — NMS: 3/4" — Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine %
manufactured ☐ combined ☐ natural Sand ☒
Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: mica
Shape: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: up to 10 % of paste
angular ☐ subangular ☒ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☒
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 to 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 4 — 5%

Coarse ☐ fine ☐ spherical ☐ irregular ☐ bleed channels ☐ water gains ☐ uniform ☐ clusters ☐ around CA ☐

voids: clean ☒ 2nd deposits ☐ ettringite ☐ $Ca(OH)_2$ ☐ Other ☐ thin coat ☐ thick coat ☐ full ☐ some ☐ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☒ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Isolated ASR.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☒ thin section ☐ Other ☐ caption:

Date 03/29/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 1 DE **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 5-1/2

Finishing: broom ☐ trowel ☐ tine ☐ formed ☒ cut ☐ coating ☒ other: Paint

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☒ flat ☐ fractured ☐ barrier ☐ other:

Steel: No **Cover depth:** **Corrosion:** no ☐ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☐ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☒ Through agg ☒ Partial depth ☒ Length: 1/2 in. Width: 1 mil
Plastic shrinkage☐ Early drying shrinkage ☐ Later drying shrinkage ☒ thermal ☐ Crazing ☐ Other: possible ASR

Other defect

Aggregate

Coarse % — NMS: 3/4" — Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown☐ gray☒ buff☐ **Shape**: angular☒ subangular ☐ subrounded☐ rounded ☐

Fine %
manufactured ☐ Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
combined ☐ Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: mica
natural Sand ☒ **Shape**: angular ☐ subangular ☒ subrounded☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard☒ moderately hard☐ moderately soft☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: up to 10 % of paste
angular ☐ subangular ☒ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☒
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 to 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 4 — 5%

Coarse ☐ fine☐ spherical ☐ irregular ☐ bleed channels ☐ water gains ☐ uniform ☐ clusters ☐ around CA ☐

voids: clean ☒ 2nd deposits ☐ ettringite ☐ $Ca(OH)_2$ ☐ Other ☐ thin coat ☐ thick coat ☐ full ☐ some☐ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☐ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Isolated ASR

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☒ thin section ☐ Other ☐ caption:

Date 03/25/2016 **Project No: 2014.3453.2** **Made by: DXC**

Sample I.D. # 2 AB | **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 5-3/8"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☒ cut ☐ coating ☒ other: Paint | **Top:** intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other: | **Bottom:** rough ☐ formed ☐ cut ☒ flat ☐ fractured ☐ barrier ☐ other:

Steel: No | **Cover depth:** | **Corrosion:** no ☐ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☒ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☐ Through agg ☒ Partial depth ☐ Length: 3 in. Width: up to 1/32"
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other: possible ASR

Other defect

Aggregate

Coarse %	NMS: 3/4"	Gravel ☐	Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
			Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
		Crushed ☒	**Color**: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐
Fine %	manufactured ☐		Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
	combined ☐		Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: mica
	natural Sand ☒		**Shape**: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ | **Grading:** well ☒ poor ☐ gap ☐ | **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. | **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ | **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ | uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ | **thickness:** | harder ☐ softer ☐ | darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: up to 10 % of paste
angular ☐ subangular ☒ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☒ | **Content**: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 43 — 0.48 | retempering: yes ☐ no ☒ | **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: 1/32-1/4" bottom: | Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 to 27 % | **Cementitious Materials** 6 — 6-1/2 bags/cy | **SCM:** no ☒ yes ☐

Fly ash: ☐ — % | GGBFS: ☐ — % | Silica fume: ☐ — % | Other: ☐

Air Void System

entrained ☒ | **marginal** ☐ | **non-entrained** ☐ | **air content:** 3-1/2-4-1/2%

Coarse ☐ fine ☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☐ clusters ☐ around CA ☐

voids: clean ☐ | 2nd deposits ☒ ettringite ☒ $Ca(OH)_2$ ☐ Other ☒ | thin coat ☒ thick coat ☐ full ☐ some ☐ most ☒

Additional Information

Thin section ☐ Point count ☐ | ASR ☒ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Severe ASR. Air not uniform.

Surface shrinkage crack 3/8" deep, vertical.

White paint 10 mils thick.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☒ thin section ☐ Other ☐ caption:

Date 03/24/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 2 BC **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 6-7/8"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☐ cut ☒ coating ☐ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☒ flat ☐ fractured ☐ barrier ☐ other:

Steel: No **Cover depth:** **Corrosion:** no ☐ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☒ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☐ Through agg ☒ Partial depth ☐ Length: 3 in. Width: 0.152mm
Plastic shrinkage☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other: ASR

Other defect

Aggregate

Coarse % — NMS: 3/4" — Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown☐ gray☒ buff☐ **Shape**: angular☐ subangular ☐ subrounded☐ rounded ☐

Fine %
manufactured ☐ combined ☐ natural Sand ☒
Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: mica
Shape: angular ☐ subangular ☒ subrounded☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard☒ moderately hard☐ moderately soft☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☒ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☒
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 43 — 0.48 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 to 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 5-6%

Coarse ☐ fine☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☐ clusters ☒ around CA ☐

voids: clean ☐ 2nd deposits ☒ ettringite ☒ $Ca(OH)_2$ ☐ Other ☒ thin coat ☒ thick coat ☐ full ☒ some☒ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☒ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Moderate to severe ASR.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/24/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 2 CD **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 5-1/4"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☐ cut ☒ coating ☐ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☒ flat ☐ fractured ☐ barrier ☐ other:

Steel: No **Cover depth:** **Corrosion:** no ☐ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☒ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☐ Through agg ☒ Partial depth ☒ Length: 2-1/2 in. Width: 0.13mm
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other: ASR

Other defect

Aggregate

Coarse % — NMS: 3/4" — Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☐ subangular ☐ subrounded ☐ rounded ☐

Fine %
manufactured ☐ combined ☐ natural Sand ☒
Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: mica
Shape: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~5% of paste
angular ☐ subangular ☒ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☒
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 43 — 0.48 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 to 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 5-6 %

Coarse ☒ fine ☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☐ clusters ☐ around CA ☐

voids: clean ☐ 2nd deposits ☒ ettringite ☒ $Ca(OH)_2$ ☐ Other ☒ thin coat ☐ thick coat ☒ full ☐ some ☒ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☒ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Severe ASR. Gel in cracks in CA, in paste, and voids

Ettringite also in some voids. No DEF.

Photograph: yes ☐ no ☐

Photo: Lapped ☐ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/24/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 3 **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 3-3/4"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☒ cut ☐ coating ☐ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☐ flat ☐ fractured ☒ barrier ☐ other:

Steel: No **Cover depth:** **Corrosion:** no ☐ moderate ☐ severe ☐

Cracking: None ☐ Micro ☐ Horizontal ☐ Around agg ☐ Full depth ☒ Random ☐ Peripheral ☐
Yes ☒ Macro ☒ Vertical ☒ Through agg ☒ Partial depth ☐ Length: in. Width: 2.5mm
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % — NMS: 3/4" — Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine %
manufactured ☐ combined ☐ natural Sand ☒
Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
Shape: angular ☐ subangular ☒ subrounded ☐ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~5% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 43 — 0.48 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: 1/32-1/4" bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 to 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 6-7 %

Coarse ☐ fine ☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☐ clusters ☐ around CA ☐

voids: clean ☒ 2nd deposits ☐ ettringite ☐ $Ca(OH)_2$ ☐ Other ☐ thin coat ☐ thick coat ☐ full ☐ some ☐ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☐ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Cracks branch out at 1-1/4" from top surface. No ASR

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/28/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 4 **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 4-3/4"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☒ cut ☐ coating ☐ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☐ flat ☐ fractured ☒ barrier ☐ other:

Steel: No **Cover depth:** **Corrosion:** no ☐ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☒ Full depth ☐ Random ☒ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☒ Through agg ☐ Partial depth ☒ Length: 1/2 in. Width: <1mils
Plastic shrinkage☐ Early drying shrinkage ☒ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % — NMS: 3/4" — Gravel ☐ Crushed ☒

Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown☐ gray☒ buff☐ **Shape**: angular☒ subangular ☐ subrounded☐ rounded ☐

Fine %
manufactured ☐ combined ☐ natural Sand ☒

Major: limestone ☐ quartz ☒ feldspar ☒ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☐ chert ☐ granite ☒ Other: Mica
Shape: angular ☐ subangular ☒ subrounded☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard☒ moderately hard☐ moderately soft☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~5% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☒
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: 1/4" bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 to 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☐ **marginal** ☒ **non-entrained** ☐ **air content:** 3-4 %

Coarse ☒ fine☒ spherical ☒ irregular ☒ bleed channels ☐ water gains ☐ uniform ☐ clusters ☐ around CA ☐

voids: clean ☒ 2nd deposits ☐ ettringite ☐ $Ca(OH)_2$ ☐ Other ☐ thin coat ☐ thick coat ☐ full ☐ some☐ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☐ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

No ASR. Voids clean.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/25/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 5 AB **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 4"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☒ cut ☐ coating ☐ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☐ flat ☐ fractured ☒ barrier ☐ other:

Steel: No **Cover depth:** **Corrosion:** no ☐ moderate ☐ severe ☐

Cracking: None ☐ Micro ☐ Horizontal ☐ Around agg ☐ Full depth ☒ Random ☐ Peripheral ☐
Yes ☒ Macro ☒ Vertical ☒ Through agg ☒ Partial depth ☐ Length: Width: 1/16"
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % — NMS: 3/4" — Gravel ☐ Crushed ☒

Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine % — manufactured ☐ combined ☐ natural Sand ☒

Major: limestone ☐ quartz ☒ feldspar ☒ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☐ chert ☐ granite ☒ Other: Mica
Shape: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter:** mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~15% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☐ Type II/V ☒ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: 1/8" bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 to 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 3-1/2-4-1/2 %

Coarse ☒ fine ☒ spherical ☒ irregular ☒ bleed channels ☐ water gains ☐ uniform ☐ clusters ☐ around CA ☐

voids: clean ☒ 2nd deposits ☐ ettringite ☐ $Ca(OH)_2$ ☐ Other ☐ thin coat ☐ thick coat ☐ full ☐ some ☐ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☐ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

No ASR. Voids very clean. Full-depth crack shrinkage or ASR in other places.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/25/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 5 BC **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 7-3/4

Finishing: broom ☐ trowel ☐ tine ☐ formed ☐ cut ☐ coating ☐ other: Fractured

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☐ flat ☐ fractured ☒ barrier ☐ other:

Steel: No **Cover depth:** **Corrosion:** no ☐ moderate ☐ severe ☐

Cracking: None ☐ Micro ☐ Horizontal ☐ Around agg ☐ Full depth ☒ Random ☐ Peripheral ☐
Yes ☒ Macro ☒ Vertical ☒ Through agg ☒ Partial depth ☐ Length: Width: 3/32"
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % — NMS: 3/4" — Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine %
manufactured ☐ — Major: limestone ☐ quartz ☒ feldspar ☒ chert ☐ granite ☐ Other:
combined ☐ — Minor: limestone ☐ quartz ☐ feldspar ☐ chert ☐ granite ☒ Other: Mica
natural Sand ☒ — **Shape**: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter:** mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~15% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☐ Type II/V ☒ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 to 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 3-1/2-4-1/2 %

Coarse ☒ fine ☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☐ clusters ☐ around CA ☐

voids: clean ☒ 2nd deposits ☐ ettringite ☐ $Ca(OH)_2$ ☐ Other ☐ thin coat ☐ thick coat ☐ full ☐ some ☐ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☐ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

No ASR. Full-depth crack due to ASR in other places or shrinkage.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/28/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 6 AB **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 7-3/4

Finishing: broom ☐ trowel ☐ tine ☐ formed ☒ cut ☐ coating ☐ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☐ flat ☐ fractured ☒ barrier ☐ other:

Steel: No **Cover depth:** **Corrosion:** no ☐ moderate ☐ severe ☐

Cracking: None ☐ Micro ☐ Horizontal ☐ Around agg ☒ Full depth ☒ Random ☐ Peripheral ☐
Yes ☒ Macro ☒ Vertical ☒ Through agg ☐ Partial depth ☐ Length: Width: 3/32"
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % — NMS: 3/4" — Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine %
manufactured ☐ combined ☐ natural Sand ☒
Major: limestone ☐ quartz ☒ feldspar ☒ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☐ chert ☐ granite ☒ Other: Mica
Shape: angular ☐ subangular ☒ subrounded ☐ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☒ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: <1/32" bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 to 27 % **Cementitious Materials** 5-1/2 — 6 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 3-4 %

Coarse ☒ fine ☒ spherical ☒ irregular ☒ bleed channels ☐ water gains ☐ uniform ☐ clusters ☒ around CA ☐

voids: clean ☐ 2nd deposits ☒ ettringite ☒ $Ca(OH)_2$ ☐ Other ☐ thin coat ☒ thick coat ☐ full ☐ some ☒ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☐ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Most voids clean. No ASR detected.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/28/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 6 BC **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 6

Finishing: broom ☐ trowel ☐ tine ☐ formed ☐ cut ☐ coating ☐ other: Fractured

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☐ flat ☐ fractured ☒ barrier ☐ other:

Steel: No **Cover depth:** **Corrosion:** no ☐ moderate ☐ severe ☐

Cracking: None ☐ Micro ☐ Horizontal ☐ Around agg ☒ Full depth ☒ Random ☐ Peripheral ☐
Yes ☒ Macro ☒ Vertical ☒ Through agg ☐ Partial depth ☐ Length: Width: 3/32"
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % — NMS: 3/4" — Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine %
manufactured ☐ combined ☐ natural Sand ☒
Major: limestone ☐ quartz ☒ feldspar ☒ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☐ chert ☐ granite ☒ Other: Mica
Shape: angular ☐ subangular ☒ subrounded ☐ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter:** mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☒ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 to 27 % **Cementitious Materials** 5-1/2 — 6 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 3-4 %

Coarse ☒ fine ☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☐ clusters ☒ around CA ☐

voids: clean ☒ 2nd deposits ☐ ettringite ☐ $Ca(OH)_2$ ☐ Other ☐ thin coat ☐ thick coat ☐ full ☐ some ☐ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☐ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

No ASR detected. Weak rim detected in one CA.

Crack full depth, not narrowing with depth.

Poorly mixed due to air clusters.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/30/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 7AB **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 5-1/2

Finishing: broom ☐ trowel ☒ tine ☐ formed ☐ cut ☐ coating ☐ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☒ flat ☐ fractured ☐ barrier ☐ other:

Steel: No **Cover depth:** **Corrosion:** no ☐ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☒ Around agg ☐ Full depth ☐ Random ☒ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☐ Through agg ☒ Partial depth ☒ Length: 1/2 in Width: 1 mil
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other: ASR

Other defect

Aggregate

Coarse % — NMS: 3/4" — Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine % — manufactured ☐ combined ☐ natural Sand ☒
Major: limestone ☐ quartz ☒ feldspar ☒ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☐ chert ☐ granite ☒ Other: Mica
Shape: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: 1/32" bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 to 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 6-7 %

Coarse ☐ fine ☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☐ 2nd deposits ☒ ettringite ☒ $Ca(OH)_2$ ☐ Other ☒ thin coat ☒ thick coat ☐ full ☐ some ☒ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☒ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Limited ASR. Isolated.

One void filled with gel. Most void coated with very thin layer of ettringite.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/30/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 7 BC **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 5-1/2

Finishing: broom ☐ trowel ☐ tine ☐ formed ☐ cut ☒ coating ☐ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☒ flat ☐ fractured ☐ barrier ☐ other:

Steel: No **Cover depth:** **Corrosion:** no ☐ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☒ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☐ Through agg ☒ Partial depth ☒ Length: 1-1/2 in Width: 0.147mm
Plastic shrinkage☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other: ASR

Other defect

Aggregate

Coarse % — NMS: 3/4" — Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown☐ gray☒ buff☐ **Shape**: angular☒ subangular ☐ subrounded☐ rounded ☐

Fine %
manufactured ☐ Major: limestone ☐ quartz ☒ feldspar ☒ chert ☐ granite ☐ Other:
combined ☐ Minor: limestone ☐ quartz ☐ feldspar ☐ chert ☐ granite ☒ Other: Mica
natural Sand ☒ **Shape**: angular ☐ subangular ☒ subrounded☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard☒ moderately hard☐ moderately soft☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 to 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 7-8 %

Coarse ☐ fine☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☐ 2nd deposits ☒ ettringite ☒ $Ca(OH)_2$ ☐ Other ☒ thin coat ☒ thick coat ☐ full ☐ some☒ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☒ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Some ASR. Not severe.

Some voids contain ettringite.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/30/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 7CD **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 6

Finishing: broom ☐ trowel ☐ tine ☐ formed ☐ cut ☒ coating ☐ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☒ flat ☐ fractured ☒ barrier ☐ other:

Steel: No **Cover depth:** **Corrosion:** no ☐ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☐ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☐ Through agg ☒ Partial depth ☒ Length: 1-1/2 Width: 0.147mm
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other: ASR

Other defect

Aggregate

Coarse % — NMS: 3/4" — Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine % — manufactured ☐ combined ☐ natural Sand ☒
Major: limestone ☐ quartz ☒ feldspar ☒ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☐ chert ☐ granite ☒ Other: Mica
Shape: angular ☐ subangular ☒ subrounded ☐ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter:** mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☐ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 to 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 7-8 %

Coarse ☐ fine ☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☐ 2nd deposits ☒ ettringite ☐ $Ca(OH)_2$ ☐ Other ☐ thin coat ☒ thick coat ☐ full ☐ some ☒ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☒ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

No photos due to poor lapping.

Photograph: yes ☐ no ☒

Photo: Lapped ☐ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/29/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 8AB **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 6

Finishing: broom ☐ trowel ☐ tine ☐ formed ☒ cut ☐ coating ☐ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☒ flat ☐ fractured ☒ barrier ☐ other:

Steel: No **Cover depth:** **Corrosion:** no ☐ moderate ☐ severe ☐

Cracking: None ☐ Micro ☐ Horizontal ☐ Around agg ☐ Full depth ☒ Random ☐ Peripheral ☐
Yes ☒ Macro ☒ Vertical ☒ Through agg ☒ Partial depth ☐ Length: Width: 1/64"
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % — NMS: 3/4" — Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine %
manufactured ☐ combined ☐ natural Sand ☒
Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
Shape: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter:** mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: 1/16 - 5/16" bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27% % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 5-1/2-6-1/2 %

Coarse ☐ fine ☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☒ 2nd deposits ☐ ettringite ☐ $Ca(OH)_2$ ☐ Other ☐ thin coat ☐ thick coat ☐ full ☐ some ☒ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☐ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

No ASR. Crack due to other causes.

Crack branch out, shifted.

Photograph: yes ☐ no ☐

Photo: Lapped ☐ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/29/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 8CD **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 4-1/4

Finishing: broom ☐ trowel ☐ tine ☐ formed ☐ cut ☒ coating ☐ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☒ flat ☐ fractured ☒ barrier ☐ other:

Steel: No **Cover depth:** **Corrosion:** no ☐ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☒ Full depth ☐ Random ☐ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☒ Through agg ☐ Partial depth ☒ Length: 3/4in. Width: 1 mil
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % — NMS: 3/4" — Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine %
manufactured ☐ combined ☐ natural Sand ☒
Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
Shape: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 4-5 %

Coarse ☒ fine ☒ spherical ☒ irregular ☒ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☐ 2nd deposits ☒ ettringite ☒ $Ca(OH)_2$ ☒ Other ☐ thin coat ☒ thick coat ☐ full ☐ some ☒ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☐ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Crack branch out and stops.

No ASR. Air more uniform than BC.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/29/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 8DC **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 5

Finishing: broom ☐ trowel ☐ tine ☐ formed ☐ cut ☒ coating ☐ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☐ flat ☐ fractured ☒ barrier ☐ other:

Steel: No **Cover depth:** **Corrosion:** no ☐ moderate ☐ severe ☐

Cracking: None ☒ Micro ☐ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☐ Peripheral ☐
Yes ☐ Macro ☐ Vertical ☐ Through agg ☐ Partial depth ☐ Length: in. Width: mil
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % — NMS: 3/4" — Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine %
manufactured ☐ combined ☐ natural Sand ☒
Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
Shape: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter:** mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☐ **marginal** ☐ **non-entrained** ☐ **air content:** 4-5 %

Coarse ☐ fine ☐ spherical ☐ irregular ☐ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☐ 2nd deposits ☒ ettringite ☒ $Ca(OH)_2$ ☒ Other ☐ thin coat ☒ thick coat ☐ full ☐ some ☐ most ☒

Additional Information

Thin section ☐ Point count ☐ ASR ☐ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

No ASR. More secondary deposits in voids.

Photograph: yes ☐ no ☐

Photo: Lapped ☐ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/29/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 9 **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 2-1/4

Finishing: broom ☐ trowel ☐ tine ☐ formed ☒ cut ☐ coating ☐ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☐ flat ☐ fractured ☒ barrier ☐ other:

Steel: imprint **Cover depth:** 2-1/4 **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☐ Micro ☐ Horizontal ☐ Around agg ☒ Full depth ☐ Random ☐ Peripheral ☐
Yes ☒ Macro ☒ Vertical ☒ Through agg ☒ Partial depth ☐ Length: in. Width: 32 mils
Plastic shrinkage☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % — NMS: 3/4" — Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown☐ gray☒ buff☐ **Shape**: angular☒ subangular ☐ subrounded☐ rounded ☐

Fine %
manufactured ☐ combined ☐ natural Sand ☒
Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
Shape: angular ☐ subangular ☒ subrounded☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard☒ moderately hard☐ moderately soft☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: 1/8 - 1/16" bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 6-1/2 - 7-1/2 %

Coarse ☐ fine☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☐ clusters ☒ around CA ☐

voids: clean ☒ 2nd deposits ☐ ettringite ☐ $Ca(OH)_2$ ☐ Other ☐ thin coat ☐ thick coat ☐ full ☐ some☐ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☐ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

No ASR. Voids clean

Photograph: yes ☐ no ☒

Photo: Lapped ☐ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/28/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 10 AB | **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 5-1/2"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☒ cut ☐ coating ☐ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☒ flat ☐ fractured ☐ barrier ☐ other:

Steel: imprint | **Cover depth:** | **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☐ Peripheral ☐
Yes ☒ Macro ☒ Vertical ☒ Through agg ☒ Partial depth ☐ Length: 3-3/4 in. Width: 1/32"
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect | **Many random fine cracks**

Aggregate

Coarse % | NMS: 3/4" | Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine % | manufactured ☐ combined ☐ natural Sand ☒
Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
Shape: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ | **Grading:** well ☒ poor ☐ gap ☐ | **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. | **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ | **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ | uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ | **thickness:** | harder ☐ softer ☐ | darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 | retempering: yes ☐ no ☒ | **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: 1/32" bottom: | Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27 % | **Cementitious Materials** 6 — 6-1/2 bags/cy | **SCM:** no ☒ yes ☐

Fly ash: ☐ — % | GGBFS: ☐ — % | Silica fume: ☐ — % | Other: ☐

Air Void System

entrained ☒ | **marginal** ☐ | **non-entrained** ☐ | **air content:** 5-6 %

Coarse ☐ fine ☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☒ clusters ☒ around CA ☐

voids: clean ☒ | 2nd deposits ☒ ettringite ☒ $Ca(OH)_2$ ☒ Other ☒ | thin coat ☒ thick coat ☐ full ☐ some ☐ most ☒

Additional Information

Thin section ☐ Point count ☐ | ASR ☐ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Moderate ASR. Vertical cracks (3-3/4/" long)

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/30/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 10 BC **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 5-1/2"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☐ cut ☒ coating ☐ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☒ flat ☐ fractured ☐ barrier ☐ other:

Steel: imprint **Cover depth:** **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☒ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☐ Through agg ☐ Partial depth ☒ Length: 3 ins. Width: 0.25mm
Plastic shrinkage☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse 1% — NMS: 3/4" — Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown☐ gray☒ buff☐ **Shape**: angular☒ subangular ☐ subrounded☐ rounded ☐

Fine 1%
manufactured ☐ — Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
combined ☐ — Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
natural Sand ☒ — **Shape**: angular ☐ subangular ☒ subrounded☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard☒ moderately hard☐ moderately soft☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 5-6 %

Coarse ☐ fine☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☒ 2nd deposits ☒ ettringite ☒ $Ca(OH)_2$ ☒ Other ☒ thin coat ☒ thick coat ☐ full ☐ some☐ most ☒

Additional Information

Thin section ☐ Point count ☐ ASR ☐ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Moderate severe ASR.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/28/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 10 CD **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 7"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☐ cut ☒ coating ☐ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☐ flat ☐ fractured ☒ barrier ☐ other:

Steel: imprint **Cover depth:** **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☒ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☐ Through agg ☒ Partial depth ☒ Length: 1-1/2 in. Width: 0.14mm
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % NMS: 3/4" Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine %
manufactured ☐ Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
combined ☐ Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
natural Sand ☒ **Shape**: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter:** mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 5-6 %

Coarse ☐ fine ☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☐ 2nd deposits ☒ ettringite ☒ $Ca(OH)_2$ ☒ Other ☒ thin coat ☒ thick coat ☐ full ☐ some ☐ most ☒

Additional Information

Thin section ☐ Point count ☐ ASR ☒ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

More severe ASR than #10 AB. Most voids are coated with ettringite or $Ca(OH)_2$. A few with gel.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/28/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 11 AB **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 2-1/2"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☒ cut ☐ coating ☒ other:
Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:
Bottom: rough ☐ formed ☐ cut ☐ flat ☐ fractured ☒ barrier ☐ other:

Steel: imprint **Cover depth:** **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☒ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☐ Through agg ☒ Partial depth ☒ Length: 1 in. Width: 1 mils
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % NMS: 3/4" Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine %
manufactured ☐ Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
combined ☐ Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
natural Sand ☒ **Shape**: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 43 — 0.48 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: 1/32" bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☐ **marginal** ☒ **non-entrained** ☐ **air content:** 3-4%

Coarse ☒ fine ☒ spherical ☒ irregular ☒ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☐ 2nd deposits ☒ ettringite ☒ $Ca(OH)_2$ ☐ Other ☒ thin coat ☒ thick coat ☐ full ☐ some ☐ most ☒

Additional Information

Thin section ☐ Point count ☐ ASR ☒ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Multiple paint layer total 0.521mm. 4-5 layer. Voids coated with gel. Few ettringite. Severe ASR.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/28/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 11 BC **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 2-1/2"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☐ cut ☒ coating ☐ other:
Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:
Bottom: rough ☐ formed ☐ cut ☒ flat ☐ fractured ☐ barrier ☐ other:

Steel: imprint **Cover depth:** **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☒ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☐ Through agg ☒ Partial depth ☒ Length: 3-1/2 in. Width: 0.2 mm
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % NMS: 3/4" Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine %
manufactured ☐ Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
combined ☐ Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
natural Sand ☒ **Shape**: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 43 — 0.48 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: Crusher fines: No ☒ Yes ☐ : . %

Estimated Paste: 25 - 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☐ **marginal** ☒ **non-entrained** ☐ **air content:** 3-4%

Coarse ☒ fine ☒ spherical ☒ irregular ☒ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☐ 2nd deposits ☒ ettringite ☒ $Ca(OH)_2$ ☒ Other ☒ thin coat ☒ thick coat ☒ full ☐ some ☐ most ☒

Additional Information

Thin section ☐ Point count ☐ ASR ☒ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Severe ASR. Wide cracks with gel. All reaction CA is quartzite..

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/29/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 11 CD **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 2-3/4-5"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☐ cut ☒ coating ☐ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☐ flat ☐ fractured ☒ barrier ☐ other:

Steel: imprint **Cover depth:** **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☒ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☐ Through agg ☒ Partial depth ☒ Length: 3-1/2 in. Width: 0.15 mm
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % NMS: 3/4" Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine % manufactured ☐ combined ☐ natural Sand ☒
Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
Shape: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter:** mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 43 — 0.48 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☐ **marginal** ☒ **non-entrained** ☐ **air content:** 3-4%

Coarse ☒ fine ☒ spherical ☒ irregular ☒ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☐ 2nd deposits ☒ ettringite ☒ $Ca(OH)_2$ ☒ Other ☒ thin coat ☒ thick coat ☒ full ☐ some ☐ most ☒

Additional Information

Thin section ☐ Point count ☐ ASR ☒ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Severe ASR.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/29/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 11 DE **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 2-5"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☐ cut ☒ coating ☐ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☒ formed ☐ cut ☐ flat ☐ fractured ☒ barrier ☐ other:

Steel: imprint **Cover depth:** **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☒ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☐ Through agg ☒ Partial depth ☒ Length: 3-1/2 in. Width: 0.1 mm
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % NMS: 3/4" Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine %
manufactured ☐ Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
combined ☐ Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
natural Sand ☒ **Shape**: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 43 — 0.48 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☐ **marginal** ☒ **non-entrained** ☐ **air content:** 3-4%

Coarse ☒ fine ☒ spherical ☒ irregular ☒ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☐ 2nd deposits ☒ ettringite ☒ $Ca(OH)_2$ ☒ Other ☒ thin coat ☒ thick coat ☒ full ☐ some ☐ most ☒

Additional Information

Thin section ☐ Point count ☐ ASR ☒ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Severe ASR.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/30/2016 **Project No: 2014.3453.2** **Made by: DXC**

Sample I.D. # 12 AB | **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 5-3/4"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☒ cut ☐ coating ☒ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☒ flat ☐ fractured ☐ barrier ☐ other:

Steel: imprint | **Cover depth:** | **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☒ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☐ Through agg ☒ Partial depth ☒ Length: 3-1/2 in. Width: 0.204 mm
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % NMS: 3/4" Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine %
manufactured ☐ Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
combined ☐ Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
natural Sand ☒ **Shape**: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ | **Grading:** well ☒ poor ☐ gap ☐ | **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. | **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ | **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ | uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 43 — 0.48 | retempering: yes ☐ no ☒ | **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: partial 1/8" bottom: | Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27 % | **Cementitious Materials** 6 — 6-1/2 bags/cy | **SCM:** no ☒ yes ☐

Fly ash: ☐ — % | GGBFS: ☐ — % | Silica fume: ☐ — % | Other: ☐

Air Void System

entrained ☐ | **marginal** ☒ | **non-entrained** ☐ | **air content:** 3-1/2 - 4-1/2%

Coarse ☒ fine ☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☐ | 2nd deposits ☒ ettringite ☒ $Ca(OH)_2$ ☒ Other ☒ | thin coat ☒ thick coat ☒ full ☐ some ☒ most ☐

Additional Information

Thin section ☐ Point count ☐ | ASR ☒ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Relatively severe ASR

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/31/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 12 BC **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 5-1/2"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☒ cut ☐ coating ☒ other:
Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:
Bottom: rough ☒ formed ☐ cut ☒ flat ☐ fractured ☐ barrier ☐ other:

Steel: imprint **Cover depth:** **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☒ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☐ Through agg ☐ Partial depth ☒ Length: 3-1/2 in. Width: 0.146 mm
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % NMS: 3/4" Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine %
manufactured ☐ Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
combined ☐ Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
natural Sand ☒ **Shape**: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter:** mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 43 — 0.48 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☐ **marginal** ☒ **non-entrained** ☐ **air content:** 2-1/2 - 3-1/2%

Coarse ☒ fine ☒ spherical ☒ irregular ☒ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☐ 2nd deposits ☒ ettringite ☒ $Ca(OH)_2$ ☐ Other ☒ thin coat ☒ thick coat ☐ full ☐ some ☒ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☒ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Relatively severe ASR

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/31/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 12 CD **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 5-1/2"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☐ cut ☒ coating ☐ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☐ flat ☐ fractured ☒ barrier ☐ other:

Steel: imprint **Cover depth:** **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☒ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☐ Through agg ☒ Partial depth ☒ Length: 4 in. Width: 0.236 mm
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other: ASR

Other defect

Aggregate

Coarse % NMS: 3/4" Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine % manufactured ☐ combined ☐ natural Sand ☒
Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
Shape: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter:** mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 43 — 0.48 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☐ **marginal** ☒ **non-entrained** ☐ **air content:** 2-1/2 - 3-1/2%

Coarse ☒ fine ☒ spherical ☒ irregular ☒ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☐ 2nd deposits ☒ ettringite ☒ $Ca(OH)_2$ ☐ Other ☒ thin coat ☐ thick coat ☒ full ☐ some ☐ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☒ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Relatively severe ASR

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/28/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 13 AB **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 6-1/2"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☒ cut ☐ coating ☒ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☒ flat ☐ fractured ☐ barrier ☐ other:

Steel: imprint **Cover depth:** **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☐ Micro ☐ Horizontal ☒ Around agg ☐ Full depth ☒ Random ☒ Peripheral ☐
Yes ☒ Macro ☒ Vertical ☒ Through agg ☒ Partial depth ☐ Length: 4 in. Width: 1/16"
Plastic shrinkage☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % NMS: 3/4" Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown☐ gray☒ buff☐ **Shape**: angular☒ subangular ☐ subrounded☐ rounded ☐

Fine %
manufactured ☐ Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
combined ☐ Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
natural Sand ☒ **Shape**: angular ☐ subangular ☒ subrounded☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter:** mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard☒ moderately hard☐ moderately soft☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~15% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: <1/32 bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 4-1/2 - 5-1/2%

Coarse ☐ fine☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☐ clusters ☒ around CA ☐

voids: clean ☒ 2nd deposits ☐ ettringite ☐ $Ca(OH)_2$ ☐ Other ☒ thin coat ☐ thick coat ☐ full ☐ some☐ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☐ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Surface paint greenish to white. 0264mm thick.

Voids clean. Non-uniform with some clusters.

Cracks branch out at 5" from top surface.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/28/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 13 BC **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 5-1/8"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☐ cut ☒ coating ☐ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☒ flat ☐ fractured ☐ barrier ☐ other:

Steel: imprint **Cover depth:** **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☐ Micro ☐ Horizontal ☐ Around agg ☐ Full depth ☒ Random ☐ Peripheral ☐
Yes ☒ Macro ☒ Vertical ☒ Through agg ☒ Partial depth ☐ Length: in. Width: 3/32"
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % NMS: 3/4" Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine %
manufactured ☐ Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
combined ☐ Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
natural Sand ☒ **Shape**: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~15% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☐ **marginal** ☒ **non-entrained** ☐ **air content:** 3-4%

Coarse ☐ fine ☐ spherical ☐ irregular ☐ bleed channels ☐ water gains ☐ uniform ☐ clusters ☒ around CA ☐

voids: clean ☒ 2nd deposits ☐ ettringite ☐ $Ca(OH)_2$ ☐ Other ☐ thin coat ☐ thick coat ☐ full ☐ some ☐ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☐ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Cracks getting wider through CA. Cracks branch out.
No evidence of ASR except for some rims.
Less air. Also clean.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/25/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 14 **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 4-3/4"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☒ cut ☐ coating ☒ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☐ flat ☐ fractured ☒ barrier ☐ other:

Steel: imprint **Cover depth:** **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☐ Micro ☐ Horizontal ☐ Around agg ☒ Full depth ☒ Random ☐ Peripheral ☐
Yes ☒ Macro ☒ Vertical ☒ Through agg ☒ Partial depth ☐ Length: in. Width: 3/32"
Plastic shrinkage☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % NMS: 3/4" Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown☐ gray☒ buff☐ **Shape**: angular☒ subangular ☐ subrounded☐ rounded ☐

Fine % manufactured ☐ combined ☐ natural Sand ☒
Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
Shape: angular ☐ subangular ☒ subrounded☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard☒ moderately hard☐ moderately soft☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: 3/32" bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27 % **Cementitious Materials** 6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☐ **marginal** ☒ **non-entrained** ☐ **air content:** 3-4%

Coarse ☒ fine☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☒ 2nd deposits ☐ ettringite ☐ $Ca(OH)_2$ ☐ Other ☐ thin coat ☐ thick coat ☐ full ☐ some☐ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☐ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

No ASR.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/28/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 15 AB **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 6-3/8"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☒ cut ☐ coating ☒ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☒ flat ☐ fractured ☐ barrier ☐ other:

Steel: imprint **Cover depth:** **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☐ Micro ☐ Horizontal ☐ Around agg ☐ Full depth ☒ Random ☐ Peripheral ☐
Yes ☒ Macro ☒ Vertical ☒ Through agg ☒ Partial depth ☒ Length: 5-3/8 in. Width: 1/32"
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % NMS: 3/4" Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine % manufactured ☐ combined ☐ natural Sand ☒
Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
Shape: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: <1/32" bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27 % **Cementitious Materials** -5-1/2 — 6 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 3-1/2-4-1/2%

Coarse ☒ fine ☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☒ 2nd deposits ☐ ettringite ☐ $Ca(OH)_2$ ☐ Other ☐ thin coat ☐ thick coat ☐ full ☐ some ☐ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☐ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

No ASR. Surface paint 0.17mm.

Air void clean.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/28/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 15 BC **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 5-1/4"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☒ cut ☐ coating ☒ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☒ flat ☐ fractured ☐ barrier ☐ other:

Steel: imprint **Cover depth:** **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☐ Micro ☐ Horizontal ☐ Around agg ☐ Full depth ☒ Random ☐ Peripheral ☐
Yes ☒ Macro ☒ Vertical ☒ Through agg ☒ Partial depth ☒ Length: 5-3/8 in. Width: 1/32"
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % NMS: 3/4" Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine %
manufactured ☐ Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
combined ☐ Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
natural Sand ☒ **Shape**: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27 % **Cementitious Materials** -5-1/2 — 6 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 4-5%

Coarse ☐ fine ☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☒ 2nd deposits ☐ ettringite ☐ $Ca(OH)_2$ ☐ Other ☐ thin coat ☐ thick coat ☐ full ☐ some ☐ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☐ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

No ASR.

Some CA had internal cracking, not extending into paste.

Void clean.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/29/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 16 AB **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 6"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☒ cut ☐ coating ☒ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☒ flat ☐ fractured ☐ barrier ☐ other:

Steel: imprint **Cover depth:** **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☐ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☐ Through agg ☒ Partial depth ☒ Length: 1/4 in. Width: 1 mil
Plastic shrinkage☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % NMS: 3/4" Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown☐ gray☒ buff☐ **Shape**: angular☒ subangular ☐ subrounded☐ rounded ☐

Fine % manufactured ☐ combined ☐ natural Sand ☒
Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
Shape: angular ☐ subangular ☒ subrounded☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard☒ moderately hard☐ moderately soft☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: 1/4 (partial) bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27 % **Cementitious Materials** -6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 3-1/2 - 4-1/2%

Coarse ☐ fine☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☐ clusters ☒ around CA ☐

voids: clean ☐ 2nd deposits ☒ ettringite ☒ $Ca(OH)_2$ ☒ Other ☒ thin coat ☒ thick coat ☐ full ☐ some☒ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☒ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Mild ASR.

Voids had small clusters.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/29/2016 **Project No: 2014.3453.2** **Made by: DXC**

Sample I.D. # 16 BC | **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 5"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☐ cut ☒ coating ☐ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☐ flat ☐ fractured ☒ barrier ☐ other:

Steel: imprint | **Cover depth:** | **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☐ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☐ Through agg ☒ Partial depth ☒ Length: 2 in. Width: 0.1mm
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % | NMS: 3/4" | Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine %
manufactured ☐ | Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
combined ☐ | Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
natural Sand ☒ | **Shape**: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ | **Grading:** well ☒ poor ☐ gap ☐ | **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter:** mils **width:** in. | **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ | **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ | uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ | **thickness:** | harder ☐ softer ☐ | darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 | retempering: yes ☐ no ☒ | **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: | Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27 % | **Cementitious Materials** -6 — 6-1/2 bags/cy | **SCM:** no ☒ yes ☐

Fly ash: ☐ — % | GGBFS: ☐ — % | Silica fume: ☐ — % | Other: ☐

Air Void System

entrained ☒ | **marginal** ☐ | **non-entrained** ☐ | **air content:** 3-1/2 - 4-1/2%

Coarse ☐ fine ☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☐ | 2nd deposits ☒ ettringite ☒ $Ca(OH)_2$ ☒ Other ☒ | thin coat ☒ thick coat ☐ full ☐ some ☒ most ☐

Additional Information

Thin section ☐ Point count ☐ | ASR ☒ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Mild ASR.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/29/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 16 CD **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 6"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☐ cut ☐ coating ☐ other: Fractured

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☐ flat ☐ fractured ☒ barrier ☐ other:

Steel: imprint **Cover depth:** **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☒ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☐ Through agg ☒ Partial depth ☒ Length: 3 in. Width: 0.107mm
Plastic shrinkage☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % NMS: 3/4" Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown☐ gray☒ buff☐ **Shape**: angular☒ subangular ☐ subrounded☐ rounded ☐

Fine % manufactured ☐ combined ☐ natural Sand ☒
Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
Shape: angular ☐ subangular ☒ subrounded☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter:** mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard☒ moderately hard☐ moderately soft☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 45 — 0.50 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27 % **Cementitious Materials** -6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 3-1/2 - 4-1/2%

Coarse ☐ fine☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☐ 2nd deposits ☒ ettringite ☒ $Ca(OH)_2$ ☐ Other ☐ thin coat ☒ thick coat ☐ full ☐ some☒ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☒ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Moderate ASR.

Air void contains secondary deposit.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/30/2016 **Project No: 2014.3453.2** **Made by: DXC**

Sample I.D. # 18 | **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 2-1/2"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☐ cut ☒ coating ☐ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☐ flat ☐ fractured ☒ barrier ☐ other:

Steel: imprint | **Cover depth:** | **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☒ Micro ☐ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☐ Peripheral ☐
Yes ☐ Macro ☐ Vertical ☐ Through agg ☐ Partial depth ☐ Length: in. Width: mm
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % | NMS: 3/4" | Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine %
manufactured ☐ | Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
combined ☐ | Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
natural Sand ☒ | **Shape**: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ | **Grading:** well ☒ poor ☐ gap ☐ | **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. | **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ | **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ | uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ | **thickness:** | harder ☐ softer ☐ | darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 43 — 0.48 | retempering: yes ☐ no ☒ | **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: | Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27 % | **Cementitious Materials** -6 — 6-1/2 bags/cy | **SCM:** no ☒ yes ☐

Fly ash: ☐ — % | GGBFS: ☐ — % | Silica fume: ☐ — % | Other: ☐

Air Void System

entrained ☒ | **marginal** ☐ | **non-entrained** ☐ | **air content:** 3 - 4%

Coarse ☒ fine ☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☒ | 2nd deposits ☐ ettringite ☐ $Ca(OH)_2$ ☐ Other ☐ | thin coat ☐ thick coat ☐ full ☐ some ☒ most ☐

Additional Information

Thin section ☐ Point count ☐ | ASR ☐ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

No ASR.

Voids clean.

Photograph: yes ☐ no ☒

Photo: Lapped ☐ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/30/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 19 AB **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 6"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☒ cut ☐ coating ☒ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☒ flat ☐ fractured ☐ barrier ☐ other:

Steel: imprint **Cover depth:** **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☒ Micro ☐ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☐ Peripheral ☐
Yes ☐ Macro ☐ Vertical ☐ Through agg ☐ Partial depth ☐ Length: in. Width: mm
Plastic shrinkage☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % — NMS: 3/4" — Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown☐ gray☒ buff☐ **Shape**: angular☒ subangular ☐ subrounded☐ rounded ☐

Fine %
manufactured ☐ — Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
combined ☐ — Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
natural Sand ☒ — **Shape**: angular ☐ subangular ☒ subrounded☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard☒ moderately hard☐ moderately soft☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 43 — 0.48 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: 1/8 - 1/4" bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27 % **Cementitious Materials** -6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 4-1/2 - 5-1/2%

Coarse ☐ fine☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☒ 2nd deposits ☐ ettringite ☐ $Ca(OH)_2$ ☐ Other ☐ thin coat ☐ thick coat ☐ full ☐ some☒ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☐ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

No ASR.

Clean voids. Only one void with $Ca(OH)_2$.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/30/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 19 BC **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 4-1/2"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☐ cut ☒ coating ☐ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☐ flat ☐ fractured ☒ barrier ☐ other:

Steel: imprint **Cover depth:** **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☒ Micro ☐ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☐ Peripheral ☐
Yes ☐ Macro ☐ Vertical ☐ Through agg ☐ Partial depth ☐ Length: in. Width: mm
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % NMS: 3/4" Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine % manufactured ☐ combined ☐ natural Sand ☒
Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
Shape: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter:** mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 43 — 0.48 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27 % **Cementitious Materials** -6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 4-1/2 - 5-1/2%

Coarse ☐ fine ☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☒ 2nd deposits ☐ ettringite ☐ $Ca(OH)_2$ ☐ Other ☐ thin coat ☐ thick coat ☐ full ☐ some ☒ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☐ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

No ASR.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/25/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 20 AB **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 4-1/2"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☒ cut ☐ coating ☒ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☐ flat ☐ fractured ☒ barrier ☐ other:

Steel: imprint **Cover depth:** **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☐ Micro ☐ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☐ Peripheral ☐
Yes ☒ Macro ☒ Vertical ☒ Through agg ☒ Partial depth ☐ Length: in. Width: 1/32:
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other:

Other defect

Aggregate

Coarse % — NMS: 3/4" — Gravel ☐ Crushed ☒

Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine %
- manufactured ☐ — Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
- combined ☐ — Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
- natural Sand ☒ — **Shape**: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 43 — 0.48 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: 1/8" bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27 % **Cementitious Materials** -6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 4-1/2 - 5-1/2%

Coarse ☐ fine ☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☒ 2nd deposits ☐ ettringite ☐ $Ca(OH)_2$ ☐ Other ☐ thin coat ☐ thick coat ☐ full ☐ some ☒ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☐ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

No ASR.

Crack discontinuous and shifted.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/25/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 20 BC **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 4"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☐ cut ☐ coating ☐ other: Fractured

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☒ flat ☐ fractured ☐ barrier ☐ other:

Steel: imprint **Cover depth:** **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☐ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☒ Through agg ☒ Partial depth ☒ Length: <1 in. Width: <1 mil
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other: ASR

Other defect

Aggregate

Coarse % NMS: 3/4" Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine %
manufactured ☐ Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
combined ☐ Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
natural Sand ☒ **Shape**: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter:** mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 43 — 0.48 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27 % **Cementitious Materials** -6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 4-1/2 - 5-1/2%

Coarse ☐ fine ☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☐ 2nd deposits ☒ ettringite ☒ $Ca(OH)_2$ ☒ Other ☒ thin coat ☒ thick coat ☐ full ☐ some ☒ most ☐

Additional Information

Thin section ☐ Point count ☐ ASR ☒ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Very minor ASR detected.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/25/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 20 CD **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 5"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☐ cut ☒ coating ☐ other:

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☐ flat ☐ fractured ☒ barrier ☐ other:

Steel: imprint **Cover depth:** **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☒ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☐ Through agg ☒ Partial depth ☒ Length: <1/2 in. Width: <1 mil
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other: ASR

Other defect

Aggregate

Coarse % NMS: 3/4" Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine %
manufactured ☐ Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
combined ☐ Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
natural Sand ☒ **Shape**: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. **Other components:**

Paste

Luster: vitreous ☐ semi vitreous ☒ dull ☐ **Color:** dark gray ☐ gray ☒ light gray ☐ buff ☐ other:

Hardness: hard ☒ moderately hard ☐ moderately soft ☐ soft ☐ uniform ☒ gradual change ☐ variable on a microscale ☐

Texture of fresh fracture surfaces: subconchoidal ☐ semiconchoidal ☒ finely granular ☐

Different Surface layer: no ☒ yes ☐ **thickness:** harder ☐ softer ☐ darker ☐ lighter ☐

Unhydrated cement particles: Alite ☐ belite ☐ ferrite ☒ Estimated volume: ~10% of paste
angular ☐ subangular ☐ subrounded ☐ hydration rims ☐
Type I ☒ Type II/V ☐ Type III ☐ White ☐ Other ☐

Calcium Hydroxide: Size: µm
Shape: tabular ☐ patchy ☒ stringy ☐
Content: abundant ☒ moderate ☐ rare ☐
Estimated volume: — % of paste

Hydration: advanced ☐ normal ☒ poor ☐

Bulk w/cm: 0. 43 — 0.48 retempering: yes ☐ no ☒ **w/cm** near top ☐ or bottom ☐ : 0. — 0. same ☒

Carbonation depth: Top: N/A bottom: Crusher fines: No ☒ Yes ☐ : %

Estimated Paste: 25 - 27 % **Cementitious Materials** -6 — 6-1/2 bags/cy **SCM:** no ☒ yes ☐

Fly ash: ☐ — % GGBFS: ☐ — % Silica fume: ☐ — % Other: ☐

Air Void System

entrained ☒ **marginal** ☐ **non-entrained** ☐ **air content:** 4-1/2 - 5-1/2%

Coarse ☐ fine ☒ spherical ☒ irregular ☐ bleed channels ☐ water gains ☐ uniform ☒ clusters ☐ around CA ☐

voids: clean ☐ 2nd deposits ☒ ettringite ☒ $Ca(OH)_2$ ☒ Other ☒ thin coat ☒ thick coat ☐ full ☐ some ☐ most ☒

Additional Information

Thin section ☐ Point count ☐ ASR ☒ DEF ☐ Sulfate attack ☐ F/T ☐ Other:

Very mild ASR.

Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption:

Date 03/25/2016 **Project No:** 2014.3453.2 **Made by:** DXC

Sample I.D. # 20 DE **Description:** Core ☒ Cylinder ☐ Chunk ☐ Size: DXL 4 X 4-1/2"

Finishing: broom ☐ trowel ☐ tine ☐ formed ☐ cut ☐ coating ☐ other: fractured

Top: intact ☒ delaminated ☐ scaled ☐ eroded severely ☐ eroded slightly ☐ popout ☐ other:

Bottom: rough ☐ formed ☐ cut ☐ flat ☐ fractured ☒ barrier ☐ other:

Steel: imprint **Cover depth:** **Corrosion:** no ☒ moderate ☐ severe ☐

Cracking: None ☐ Micro ☒ Horizontal ☐ Around agg ☐ Full depth ☐ Random ☒ Peripheral ☐
Yes ☒ Macro ☐ Vertical ☐ Through agg ☒ Partial depth ☒ Length: 1/2 in. Width: 1 mil
Plastic shrinkage ☐ Early drying shrinkage ☐ Later drying shrinkage ☐ thermal ☐ Crazing ☐ Other: ASR

Other defect

Aggregate

Coarse % NMS: 3/4" Gravel ☐ Crushed ☒
Major: limestone ☐ quartzite ☒ granite ☐ chert ☐ sandstone ☐ Other:
Composition: Fine and microcrystalline quartz, mica, feldspar, pyrite, and calcite
Color: brown ☐ gray ☒ buff ☐ **Shape**: angular ☒ subangular ☐ subrounded ☐ rounded ☐

Fine % manufactured ☐ combined ☐ natural Sand ☒
Major: limestone ☐ quartz ☒ feldspar ☐ chert ☐ granite ☐ Other:
Minor: limestone ☐ quartz ☐ feldspar ☒ chert ☐ granite ☒ Other: Mica
Shape: angular ☐ subangular ☒ subrounded ☒ rounded ☐

Distribution: uniform ☒ segregated ☐ **Grading:** well ☒ poor ☐ gap ☐ **Bonding:** tight ☒ fair ☐ poor ☐

Fractured surface around agg. ☐ **Through agg.** ☒

Fibers: no ☒ yes ☐ **diameter**: mils **width:** in. **Other components:**

Paste

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Photograph: yes ☒ no ☐

Photo: Lapped ☒ fractured ☐ thin section ☐ Other ☐ caption: