CHLORIDE CONTENT AND CARBONATION OF KU MEMORIAL STADIUM CORES

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ABSTRACT:

Three cores were taken from KU Memorial Stadium on 08/17/22 by personnel from Wiss, Janney, Elstner Associates and analyzed for water-soluble chloride content and depth of carbonation. Cores A4 and B4 were taken from original construction dating to the 1920s, and Core C4 was taken from construction dating to the 1960s. All three cores exhibited low chloride contents, approximately 0.01% by mass of concrete at the depth of reinforcement. Core A4 exhibited carbonation to the deepest depth, 3.5 in., while Cores B4 and C4 exhibited carbonation to depths of 1.25 in. and less than 0.25 in., respectively.

INTRODUCTION:

This report details the analysis of three cores taken from Memorial Stadium on 08/17/22. Coring was performed by personnel from Wiss, Janney, Elstner Associates (WJE), and the cores were delivered to the KU Concrete Lab on the afternoon of 08/17. The cores were analyzed for chloride content and depth of carbonation, described later in this report. Core A4 (Figure 1) was taken from the east columns of the stadium, originally constructed in the 1920s. The core has an average length of approximately 7.5 in. Core B4 (Figure 2) was taken from the north stadium wall, also built in the 1920's, and has an average length of 8.5 in. Core C4 (Figure 3) was taken from the west columns of the stadium, built in the 1960s, and has an average length of 9.25 in. All three cores had an average diameter of 3.6 in.

Figure 1: Core A4

Figure 2: Core B4

Figure 3: Core C4

EXPERIMENTAL WORK:

Each core was analyzed for chloride contend and depth of carbonation. Details of each analysis are provided below.

Chloride Content

Based on the recommendations of WJE personnel, cores were sampled for chlorides at depths of 0.5 in., 1.5 in., 2.5 in., and 3.5 in. Samples were taken using a 0.25-in. diameter masonry drill bit and a drill press. After securing the core on its side in the press, the bit was aligned with the center of the bit at the prescribed depth. The core was drilled to a depth of 0.25 in.; the powder collected from this region was discarded to avoid any contamination from the water used during drilling. The bit was then cleaned, and drilling continued for an additional 3-in. depth into the core. The powder from this region was saved for analysis. This procedure was repeated a second time at the same depth, with the holes drilled parallel and approximately 1 in. apart; the two drill holes yielded approximately 10g of powdered concrete at a given depth. Samples were then analyzed for water-soluble chloride content in accordance with ASTM C1218.

Carbonation Depth

Carbonation depth was determined using a 0.5% phenolphthalein spray. The spray was applied after chloride samples were taken to avoid possible contamination. Carbonation was checked twice-once on the surface of the core after chloride sampling was completed, and again after splitting the core in half longitudinally by applying a diametral compressive force along the length of the core using a hydraulic press. No difference in carbonation depth was observed between the two surfaces.

RESULTS:

Chloride Content

The chloride content at each depth, expressed as a percent by weight of concrete, are shown in Table 1 and Figure 4. As shown in the table and figure, Cores B4 and C4 exhibited low chloride

levels-approximately 0.01% by mass of concrete-at all depths. Core A4, the oldest of the three cores, exhibited chloride levels of 0.033% at a depth of 0.5 in., dropping to 0.01% at a depth of 1.5 in. It should be noted that the sample taken from 3.5 in. exhibited a much higher chloride content than any other sample, 0.0816%. This reading is possibly due to an isolated bit of contamination and, based on the readings at shallower depths, is unlikely to be representative of the concrete at this depth. At the depth of reinforcement, chloride contents were around or less than 0.01% by mass of concrete in all cases.

ACI Committee 222 recommends a maximum water-soluble chloride content of 0.15% by mass of cementitious material (not concrete) for new construction (ACI-PRC-222R-19). Assuming a cementitious materials mass of 20%, the chloride contents obtained in this analysis are below this limit, with the exception of the chloride content at 0.5 in. from Core A4 (0.165%) and aforementioned outlier reading from A4 at 3.5 in.

Table 1: Water-Soluble Chloride Contents, Percent by Mass of Concrete

Core	**Water-Soluble Chloride Content, %**			
	0.5 in.	**1.5 in.**	**2.5 in**	**2.5 in.**
A4	0.0330%	0.0112%	0.0082%	0.0816%
B4	0.0127%	0.0108%	0.0061%	0.0084%
C4	0.0100%	0.0046%	0.0100%	0.0058%

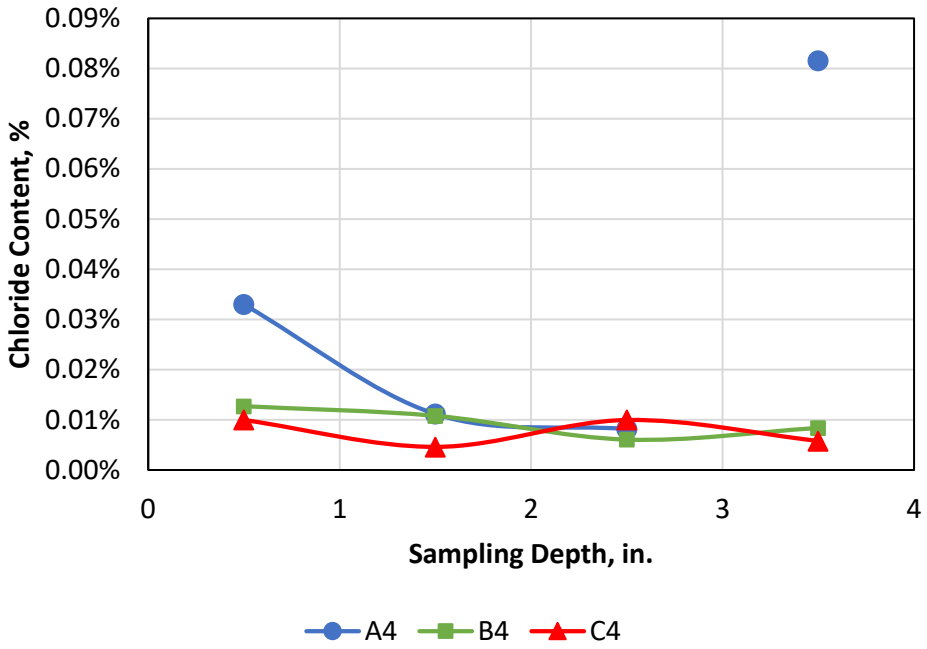

Figure 4: Water-soluble chloride content by mass of concrete vs. sampling depth.

Carbonation Depth

Table 2 shows the average depth of carbonation for the cores; photos of the split cores after carbonation testing are shown in Figures 5, 6, and 7 for Cores A4, B4, and C4 respectively. Core A4 exhibited the greatest depth of carbonation, 3.5 in (Figure 5). Cores B4 and C4, from newer construction, exhibited carbonation at much lower depths; Core B4 exhibited carbonation to a depth of 1.25 in. (Figure 6), and Core C4 exhibited no significant carbonation (Figure 7).

Table 2: Carbonation depth

Core	Carbonation Depth (in.)
A4	3.5
B4	1.25
C4	<0.25

Figure 5: Carbonation depth for Core A4

Figure 6: Carbonation depth for Core B4

Figure 7: Carbonation depth for Core C4

SUMMARY AND CONCLUSIONS:

Three cores were taken from KU Memorial Stadium on 08/17/22 and analyzed for water-soluble chloride content and depth of carbonation. Cores A4 and B4 were taken from original construction dating to the 1920s, and Core C4 was taken from construction dating to the 1960s.

The following conclusions are based on the analyses presented in this report:

1) Water-soluble chloride contents were generally low in all cores, averaging around 0.01% by mass of concrete.
2) Cores A4 and B4, sampled from original construction, exhibited carbonation to a depth of 3.5 in. and 1.25 in., respectively. Core C4, sampled from newer construction, exhibited much less carbonation, extending to a depth of less than 0.25 in.

REFERENCES:

ACI PRC-222R-19. “Guide to Protection of Reinforcing Steel in Concrete Against Corrosion,” American Concrete Institute, Farmington Hills, MI, 60 pp.

ASTM C1218, 2017, “Standard Specification for Water-Soluble Chloride in Mortar and Concrete (ASTM C1218/C1218M-17),” ASTM International, West Conshohocken, PA, 3 pp.