# <u>Chemical Penetration of Concrete Testing</u>

## *MODIFIED ASTM C1152 – Standard Test Method for Acid-Soluble Chloride in Mortar and Concrete*
## *with Nano Computed Tomography (nCT); Penetration with Iodide*

**HYPOTHESIS –** To test the benefits of a disrupted capillary system in ordinary Portland-cement based concretes as to combating various forms of steel corrosion in concrete.

**BACKGROUND** – ASTM C1152 & ASTM C1218 – Chloride (Acid & Water Soluble) Testing for Concrete & Mortars are standard test methods for taking pulverized sections of concrete (moving your way down a ponding or injected specimen), adding nitric acid or water (respectively), boiling that mixture and measuring the chloride content. These procedures have always produced large swings in results, with chlorides pulverized from aggregate being included; which we know have little intent or purpose on the corrosion of steel. Plus, some chlorides are bound by cement hydration product and aren't a factor in steel corrosion either. Top researchers like Dr. Tyler Ley (http://www.tylerley.com), a tenured professor that runs the engineering department at Oklahoma State University, and is considered one of the top experts on structural and concrete materials engineering. Dr. Ley has significant influence in the overall direction of national codes and standards. He sits on and is at the forefront of ACI's Concrete Durability and Sustainability technical committees. As well, he serves on the executive committee of the National Concrete Consortium, a group made up of DOT engineers from 35 different states. Dr. Ley's alternative (Modification), along with other leading industry researchers, is the following protocol - "Using a Medical X-ray Machine to Determine the Service Life of Concrete" or nano/micro Computed Tomography. In effect, this protocol uses a medical X-ray scanner to track the movement of ions within concrete.

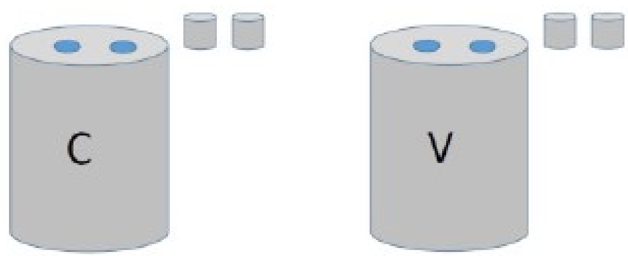
***X-ray imaging of potassium iodide in concrete is rapid, simple, and provides critical information about how hard or easy it is for outside chemical to penetrate into the concrete.***

**nCT; Nano Computed Tomography Protocol**

Step 1

Outside chemical penetration

- Two - 1" diameter cores were taken from the surface of cylinder C and V.




Step 2

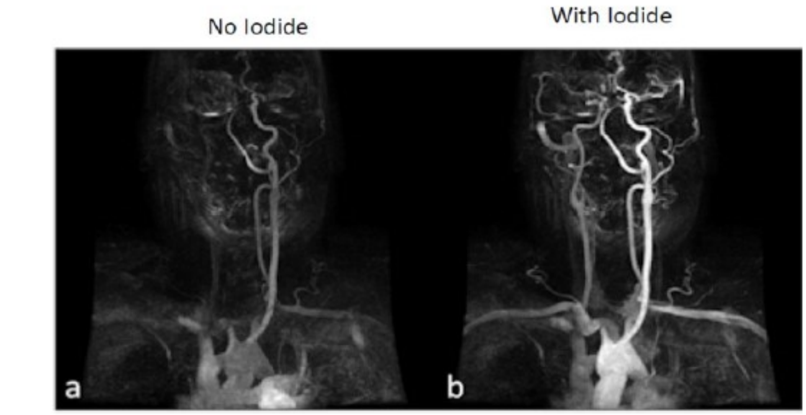
Outside chemical penetration

- Next, we coat all the surfaces but the top with wax.

## Step 3 Outside chemical penetration

- Place the material in potassium iodide solution.
- Since all sides but the surface are coated with wax then the chemicals will only penetrate from the surface.
- Take X-ray image at 0,1,5,10 days.
- Why potassium iodide?

Three Reasons…. 1st reason - Iodide will absorb X-rays

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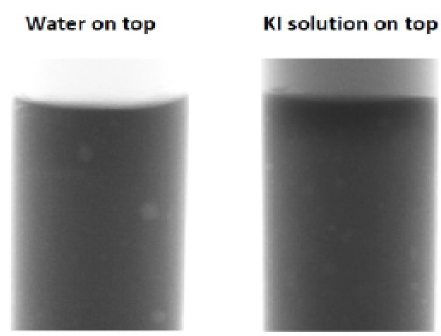
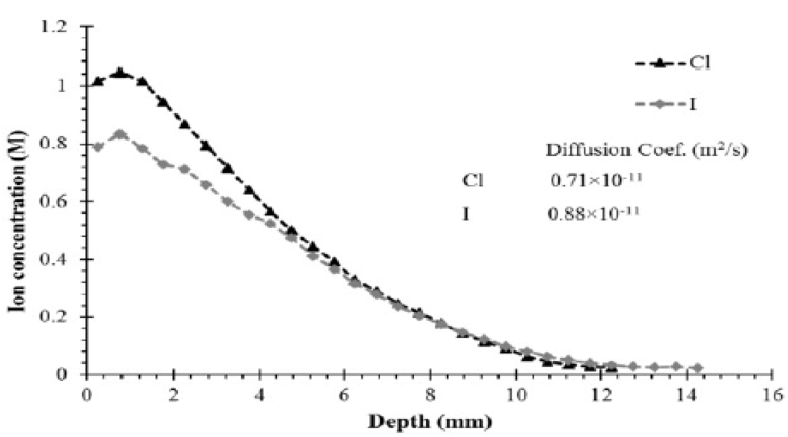
2nd reason - Iodide shows up in X-rays vs. water….




Comparing chloride and Iodide

3rd reason - Iodide and chlorides act very similar in penetration of mortar/paste.

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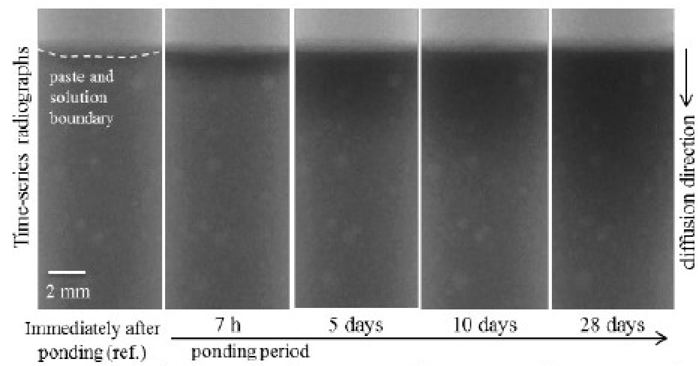
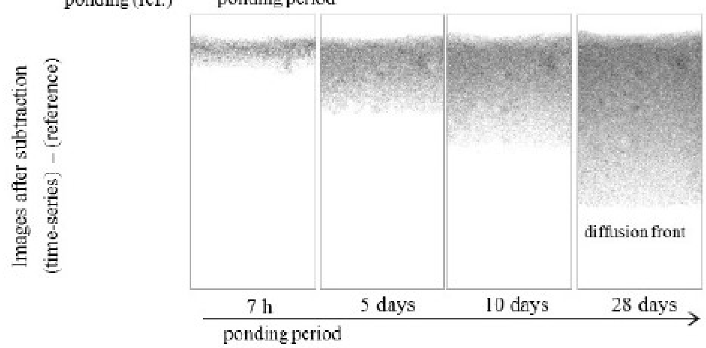
## Outside chemical penetration

- Take an X-ray image of the sample from two different angles.

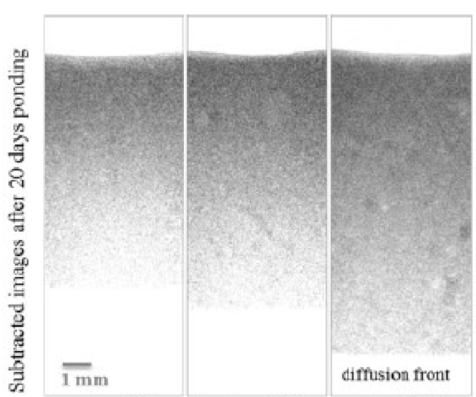

As intuition dictates, the more time elapsed, the greater the penetration -




And tone mapping, helps too…




0.35, 0.40, & 0.45 w/c mixes; X-Ray & Plotted.




| | w/c = 0.35 | w/c = 0.40 | w/c = 0.45 |
|---|---|---|---|
| Diffusion coefficient ($m^2/s$) | $1.09\times 10^{-11}$ | $1.62\times 10^{-11}$ | $2.11\times 10^{-11}$ |
| Penetration depth (mm) | 10 | 11.8 | 13.9 |

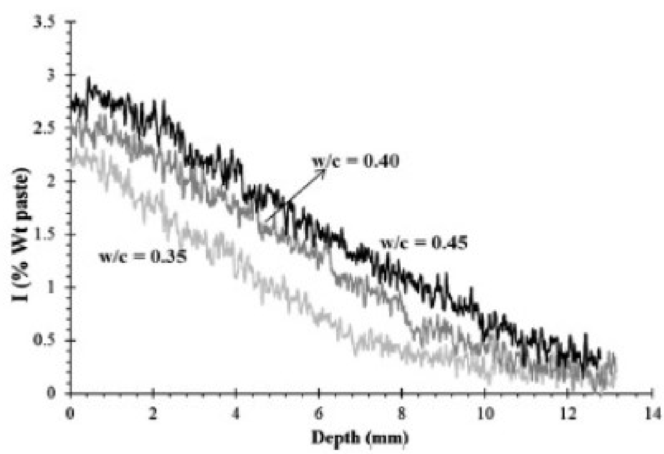



**Fig. 11.** Comparison of different paste mixtures performance against I diffusion after 20 d ponding.

## **Mix Design**

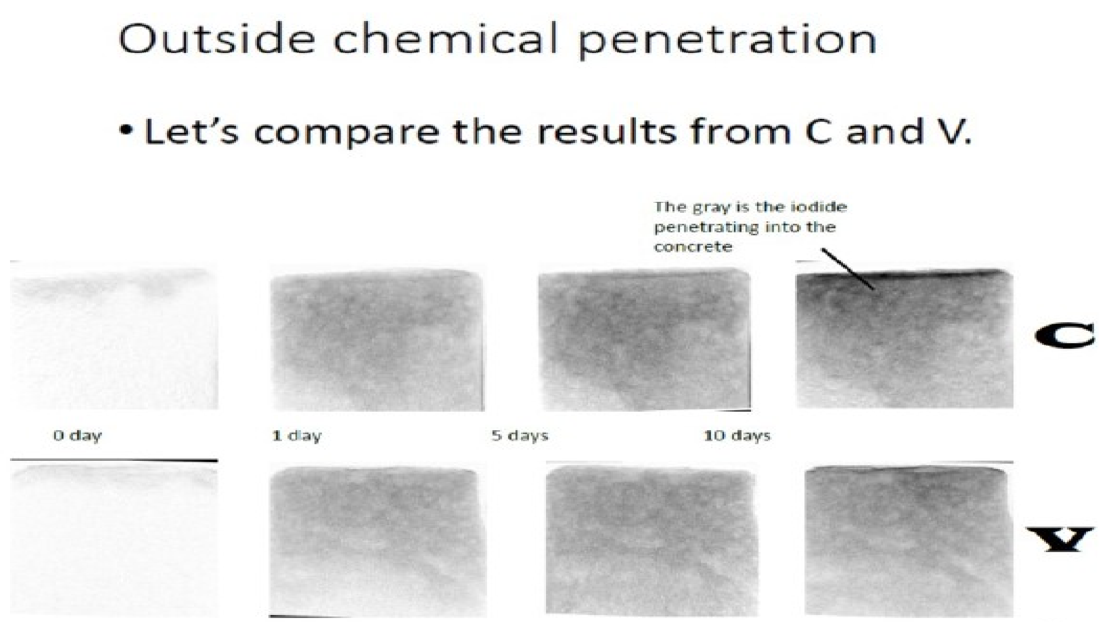
0.45 w/c ratio, pump mix with 1” top size agg. 28-Day comp. strengths were 6,320 psi.

*Sand was a blend of local and Polaris’s Orca sand from the Pacific Northwest.

*Cement was imported from the Pacific Northwest.

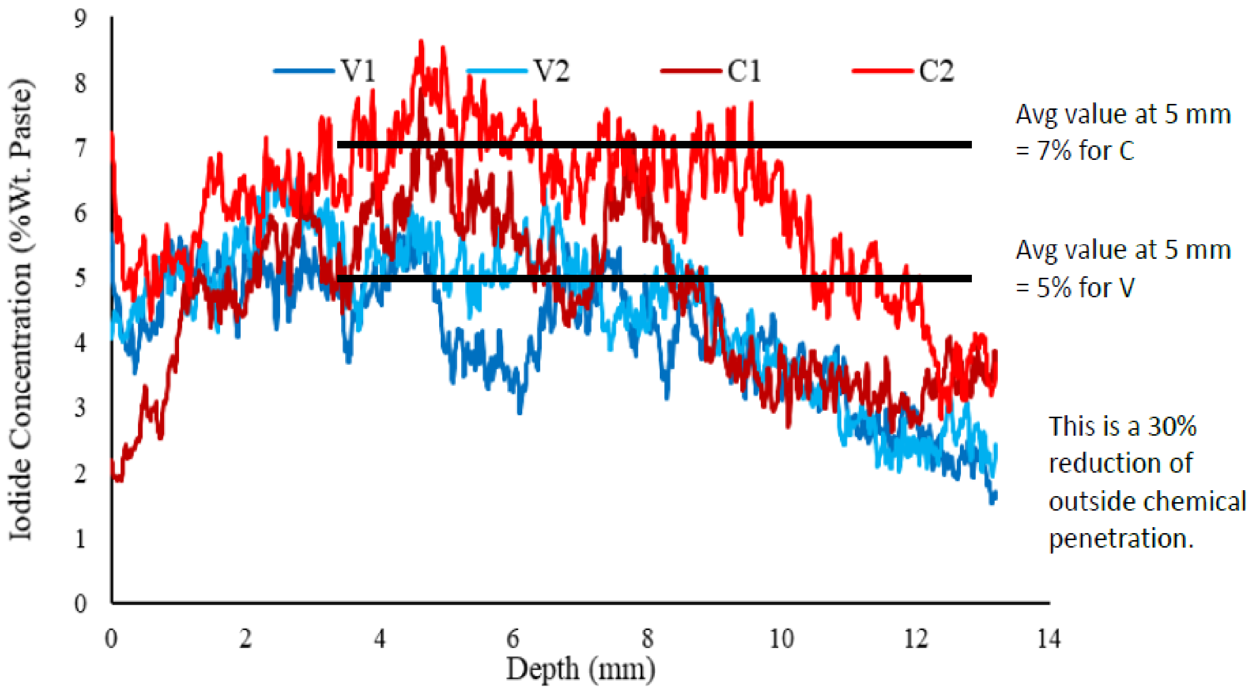
*4 ounces per hundred weight of low range water reducer was added.

| **Materials** | **Weights** |
|---|---|
| 1” Aggregate | 1,053 lbs. |
| 3/8” Aggregate | 708 lbs. |
| Sand | 1,393 lbs. |
| Cement | 630 lbs. |
| Water | 283 lbs./34.0 gallons |
| Control C Mix - amine salts/carboxylic acids admixture | 24 ounces |
| Control V Mix - Vapor Lock 40/40 admixture | 63 ounces |



# Overall Comparison

Concentration profiles of all the samples after 10 days of ponding.




## Summary

- Two cores were tested from each cylinder.
- Both cores showed good agreement with each other for sample C and V.
- There is a 30% reduction at 10 days of exposure for sample V when compared to C. Similar results were found at 5 days of exposure.

Performed by Oklahoma State University, 2019.

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