

WHITE PAPER

Chemical Penetration of Concrete Testing

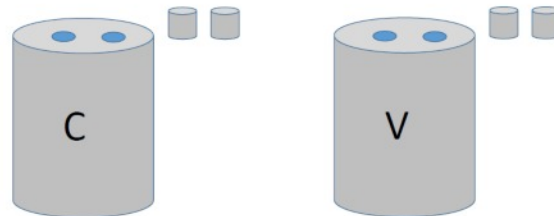
ABSTRACT - The drying, curing, and hydrating of portland-based concrete has to do with water/moisture leaving the matrix. This process allows for deleterious elements to enter the matrix through the same mechanism and migrate towards encased steel and over time trigger steel corrosion. Steel corrosion is one of the few drawbacks of Structural/Reinforced concrete and thought to be one of the top three expenses that our country faces. Testing and evaluating products and systems that alleviate and/or slow the corrosion process in concrete has been difficult and subjective to date.

BACKGROUND - Dr. Tyler Ley (<http://www.tylerley.com>) is a tenured professor and runs the engineering department at Oklahoma State University. He is considered one of the top experts on structural and concrete materials engineering and has significant influence over changes/modification in national codes and standards. Tyler 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, among other focuses, has put forth the following protocol - "Using a Medical X-ray Machine to Determine the Service Life of Concrete". In effect, he uses a medical X-ray scanner to track the movement of ions within concrete.

Step 1

Outside chemical penetration

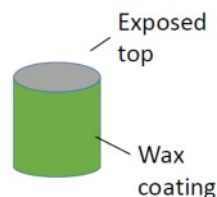
- Two - 1" diameter cores were taken from the surface of cylinder C and V.



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?

Tyler's protocol is listed above. Potassium iodide is used over water or other chemicals for three reasons;

1. Iodide will absorb and reflect X-rays in greater (increased positive, double & two-dimensional) contrast (exhibit I),
2. Iodide will absorb and reflect X-rays far better than water (exhibit II),
3. Potassium iodide ions closely mimic the penetration through concrete to that of chloride ions (exhibit III).

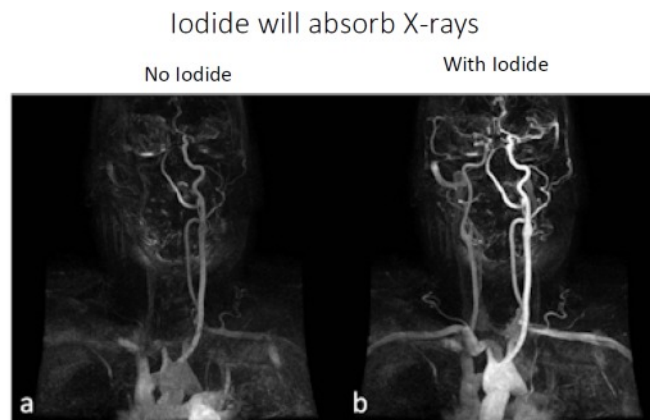


Exhibit I

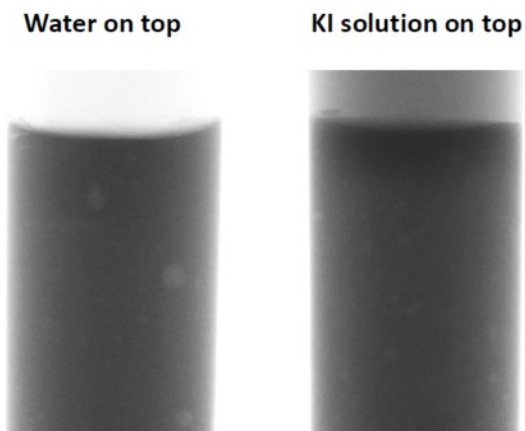


Exhibit II

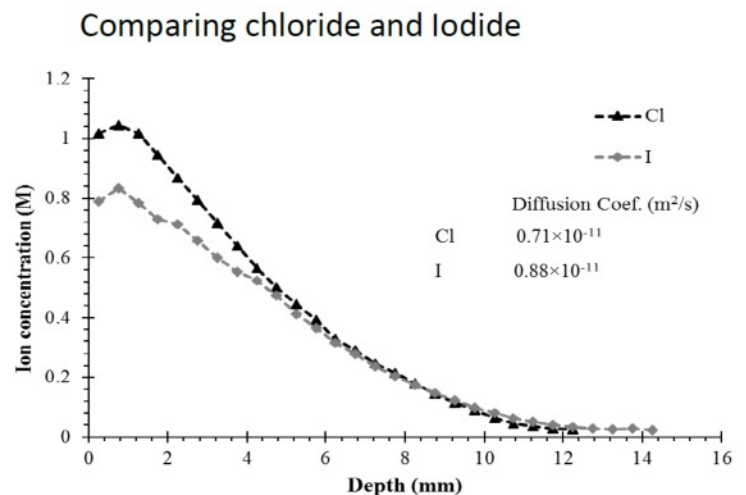
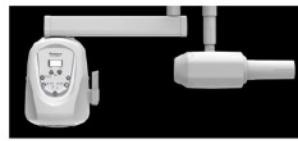


Exhibit III

Step 4

Outside chemical penetration

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



X-ray Source



Sample

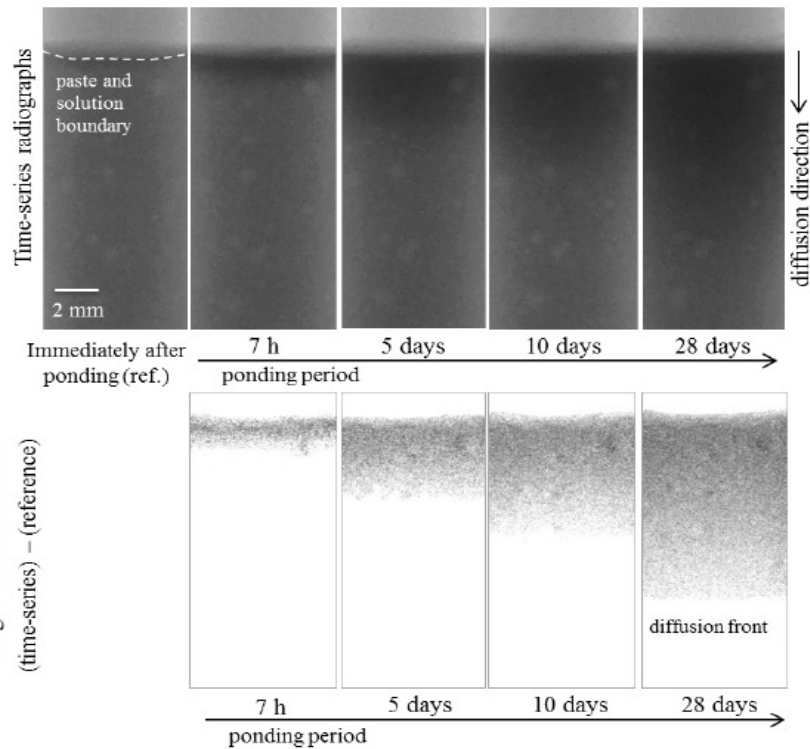


Detector



Result

As intuition dictates, the more time elapsed, the greater the penetration (darker areas) -



And tone mapping (negative), helps too...

The lower the number (less penetration), the superior, greater the Durability is assumed. Intuition and experience shows that a lower water/cement ratio mix has less penetration vs. higher w/c ratio mixes.

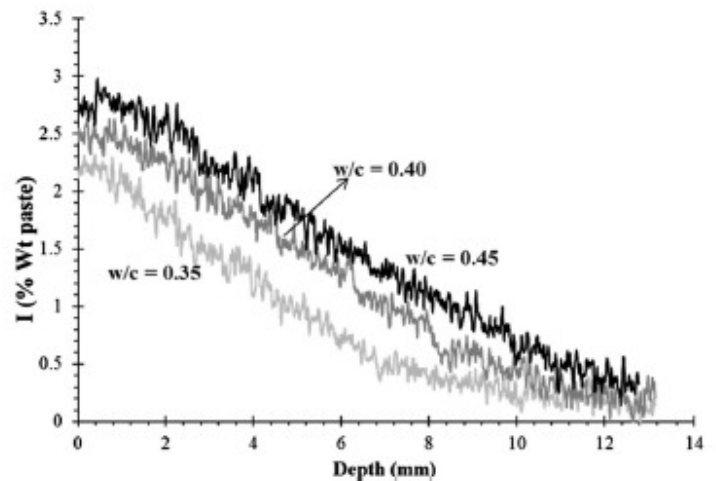
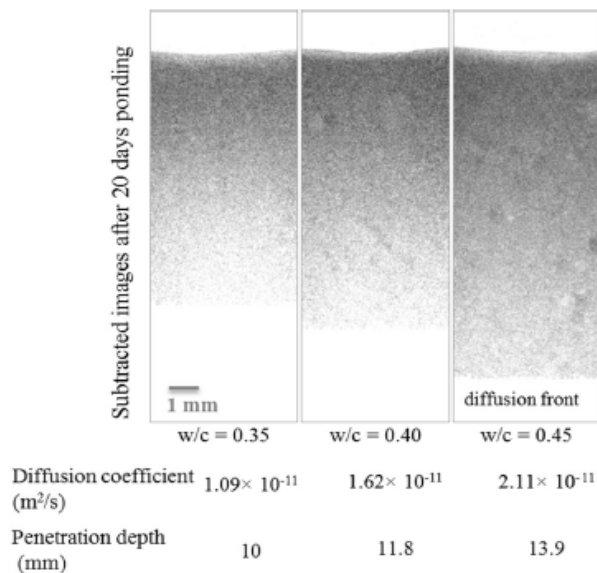


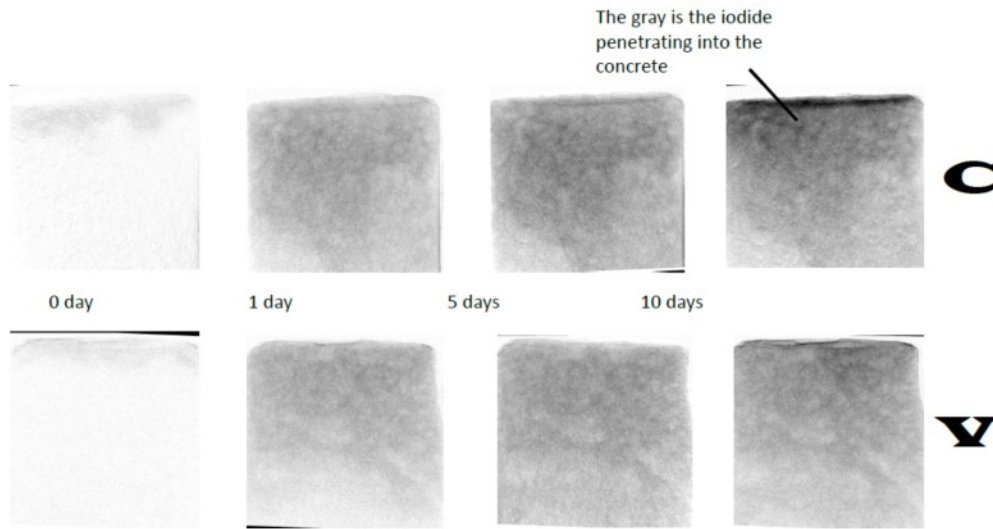
Fig. 11. Comparison of different paste mixtures performance against I diffusion after 20 d ponding.

Summary

- 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.

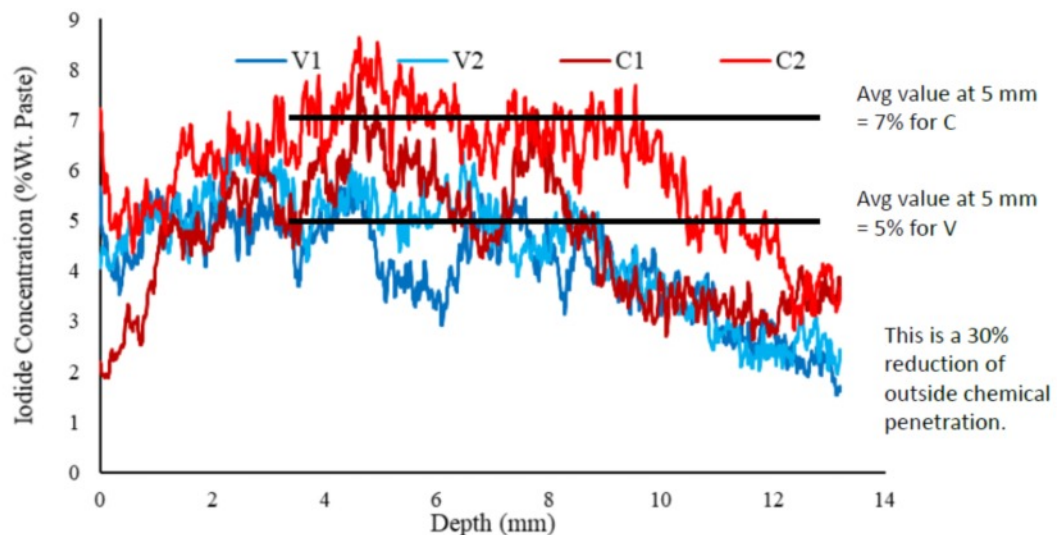
Outside chemical penetration

- Let's compare the results from C and V.



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.

Mix Designs

4500 psi, Pump Mix

1" top size agg., w/c = 0.45

*Sand is a blend of local and Orca (Vancouver/Polaris Materials) sand.

**This was pre-project testing for Kaneohe-Kailua Wastewater Conveyance and Treatment Facilities Project; Oahu, Hawaii.

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
MasterPozz 322 - 4 ounces per hundred weight	25.2 ounces
Control C Mix - amine salts/carboxylic acids admixture	24 ounces
Control V Mix - Vapor Lock 40/40 admixture	63 ounces

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