Surface Sealers:
Concrete Pavement Applications

John Cunningham

representing the

National CP Tech Center

Special Thanks to Xuhao Wang

Surface Sealers

- Joint performance today
- The role of sealers
- Lab studies and field trials

Tech Center

Surface Sealers

JOINT PERFORMANCE TODAY

Moisture

- The issue revolves around moisture entering, and lingering in, the concrete matrix at the joints and random cracks

Distress

- Two causes of distress resulting from moisture penetration
  - Saturation of concrete that leads to freeze/thaw deterioration
  - Chemical reaction of certain de-icing chemicals with products of cement hydration

Tech Center

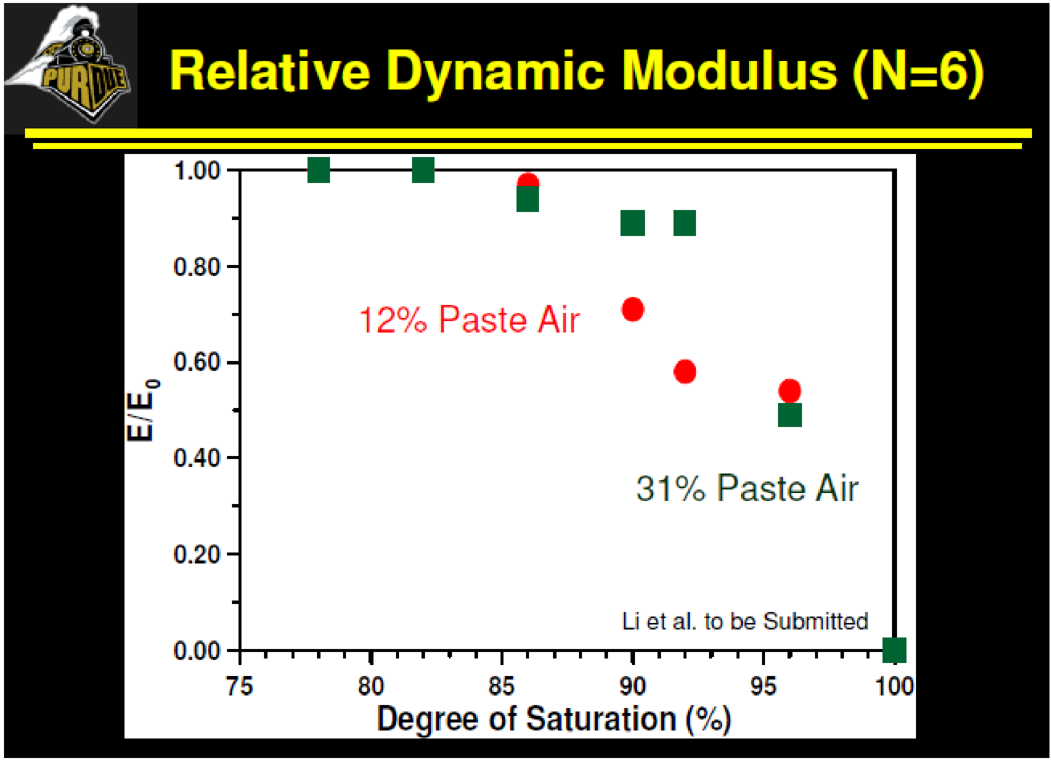
Freeze/Thaw Deterioration

- Saturation above 85%
  - Concrete will perform through decreasing number of freeze/thaw cycles
    - Regardless of having specified air content
- De-icing chemicals draw moisture to the joint
  - Moisture drains from the pavement surface
- Design plays an important role
  - Allow the joint to dry out!

CP Tech Center

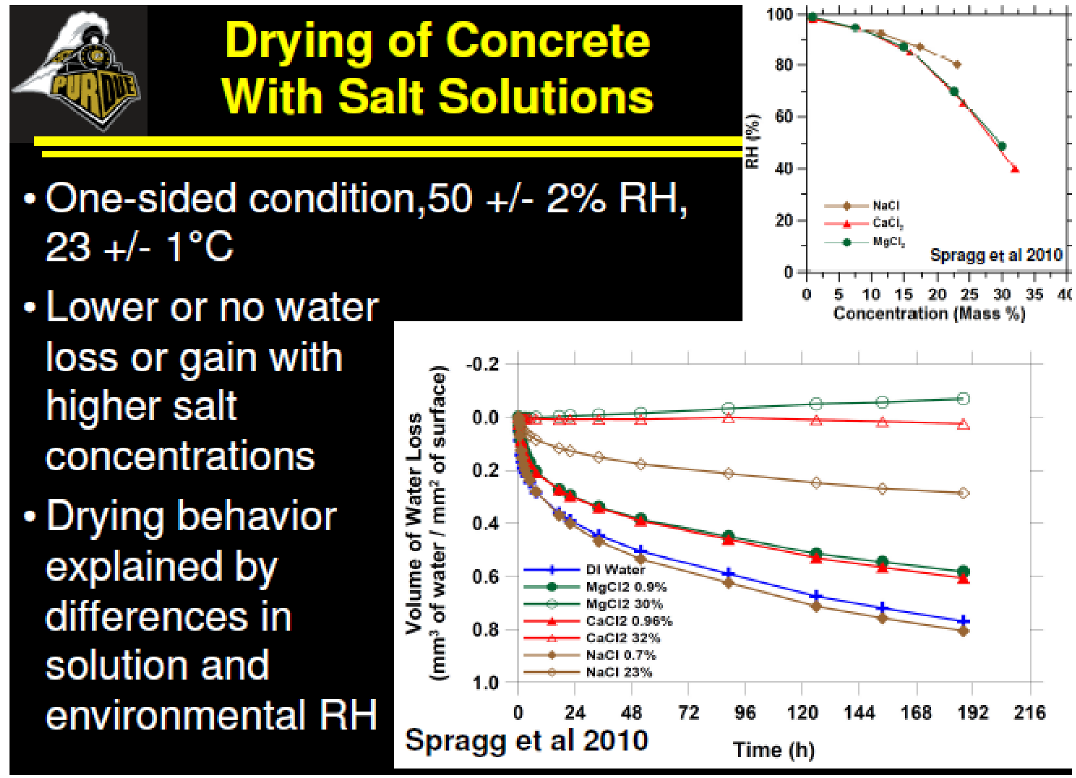
Saturation

- Dr. Jason Weiss
  - Now at Oregon State University
- At 100% saturation
  - Air voids are full!
  - Moisture has no room for expansion
- >85% saturation
  - Diminishing ability to withstand F/T



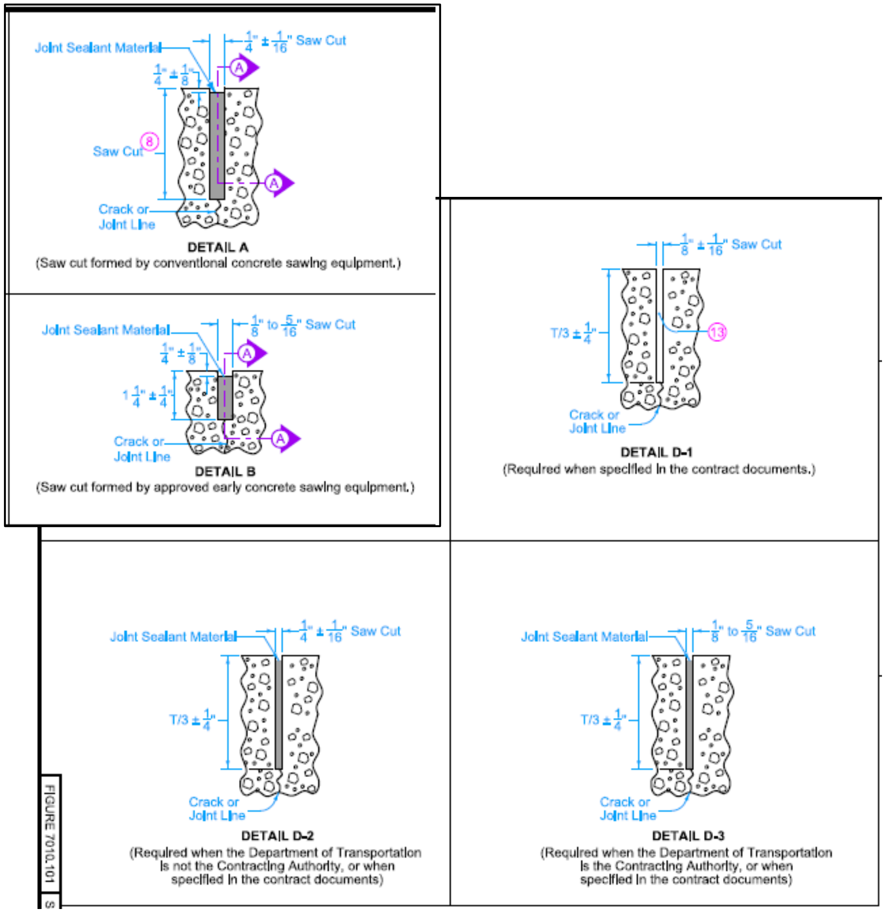
Chemical De-icers & Saturation

- Dr. Jason Weiss
- Some de-icers pull moisture from the air
  - Causing greater saturation of the matrix
    - Especially around joints and cracks



Design for Drying of Joints

- Design the joints to allow some period of drying to occur
- No backer rod
  - Fill all joints with hot pour sealant
  - Do not fill joints
    - Must then design the entire pavement system to drain
- Consider drainage beneath the slab
  - In either of the case



Oxychloride Formation

- Calcium Hydroxide (CH) is a product of the cement hydration process
  - The less important of the two products
- CH can react with de-icers to form Oxychloride
  - Magnesium Chloride
  - Calcium Chloride

Oxychloride Expansion

- Oxychloride formation is accompanied by 30%
  - Expansion of the oxychloride
  - At temps above freezing
- Water expands by 9%
  - When freezing
- Worst joint deterioration is a result of both

How Do We Limit Oxychloride Formation?

- Limit the amount of CH exposed
  - Moisture transports the $MgCl_2$ & $CaCl_2$
    - Minimize permeability
  - SCMs react with CH
    - Tie up the CH
    - Create more CSH
- Cement hydration produces CH and CSH
  - Causes Stuff to Harden

Prevention is the Best Solution

- Design and build pavement >5% air behind the paver
- Design and build pavement with a system that allows drying of the joints
  - Drainage
  - No backer rod
- Design and build with less permeable concrete
  - Low w/c ratio (<0.42)
  - Use of SCMs for less permeability
- Design and build for less oxychloride formation
  - Use SCMs to tie up Calcium Hydroxide (CH)

CP Tech Center

Nothing Wrong Here!

What if?

- Existing concrete is showing issues…
- Greater protection of new concrete is desired…

CP Tech Center

Surface Sealers

THE ROLE OF SEALERS

Decreasing Permeability

- Minimize the transport of chlorides to proximity of the CH
  - Less internal expansion due to oxychloride formation
  - Keep the two apart
- Minimize the transport of moisture into the concrete matrix
  - Less internal expansion due to freezing of moisture
  - Keep the water out

Tech Center

Decreasing Permeability

Remove the bad actors

Let it freeze outside

Jerod’s Driveway

Surface Sealers

LAB STUDIES & FIELD TRIALS

Are Sealers the Answer?

- Is moisture penetrating the pore structure within the joint after applying a surface sealer?
- Is moisture prevented from freezing within the pore structure?
- Are the “bad actors” kept out?
- Is the deterioration stopped, slowed, or altered in any way?

How can we tell?

CP Tech Center

Challenges

- Joint deterioration is a slow process
  - About ten years in the field
- Freeze/thaw deterioration is not typically tested on the faces of joints
- Testing for oxychloride formation is a relatively new process
- Much of the moisture entering a slab is from the bottom

Challenges

- Costs are very difficult to estimate
  - The adequate application rates are difficult to know for each product
- Frequency of application is difficult to know
  - Accelerated testing or long-term field trials would need to be done to develop for each product
- An application process did not exist for each product for this particular issue
  - One product supplier actually developed equipment specific to this application

Tech Center

Tests and Trials

- Conducted specifically for this issue
  - Iowa *Field* Trials
    - Photo log
      - Attempting to monitor visible deterioration
    - Drop test
      - Attempting to measure moisture penetration
  - Paste Expansion Test (ISU)
    - Attempting to measure expansion due to oxychloride formation

Tech Center

Types of Penetrating Sealers

- Linseed oil
  - Decades of use in Iowa on pavements & bridges
- Silane/siloxane based sealers
  - Very widely used outside of the pavement world
- Soy-methyl Esters
  - Soy bean oil
- Lithium or Sodium Silicate
  - Densifiers
- Crystalline
  - Both hydrophylic and hygroscopic

Iowa Program

- Funded by ICPA
- 4 Sites
  - Site 1: Des Moines (Siloxane)
  - Site 2: Davenport (Crystalline)
  - Site 3: West Des Moines (a) (Crystalline)
  - Site 4: West Des Moines (b) (Silane-Siloxane)

Iowa Program

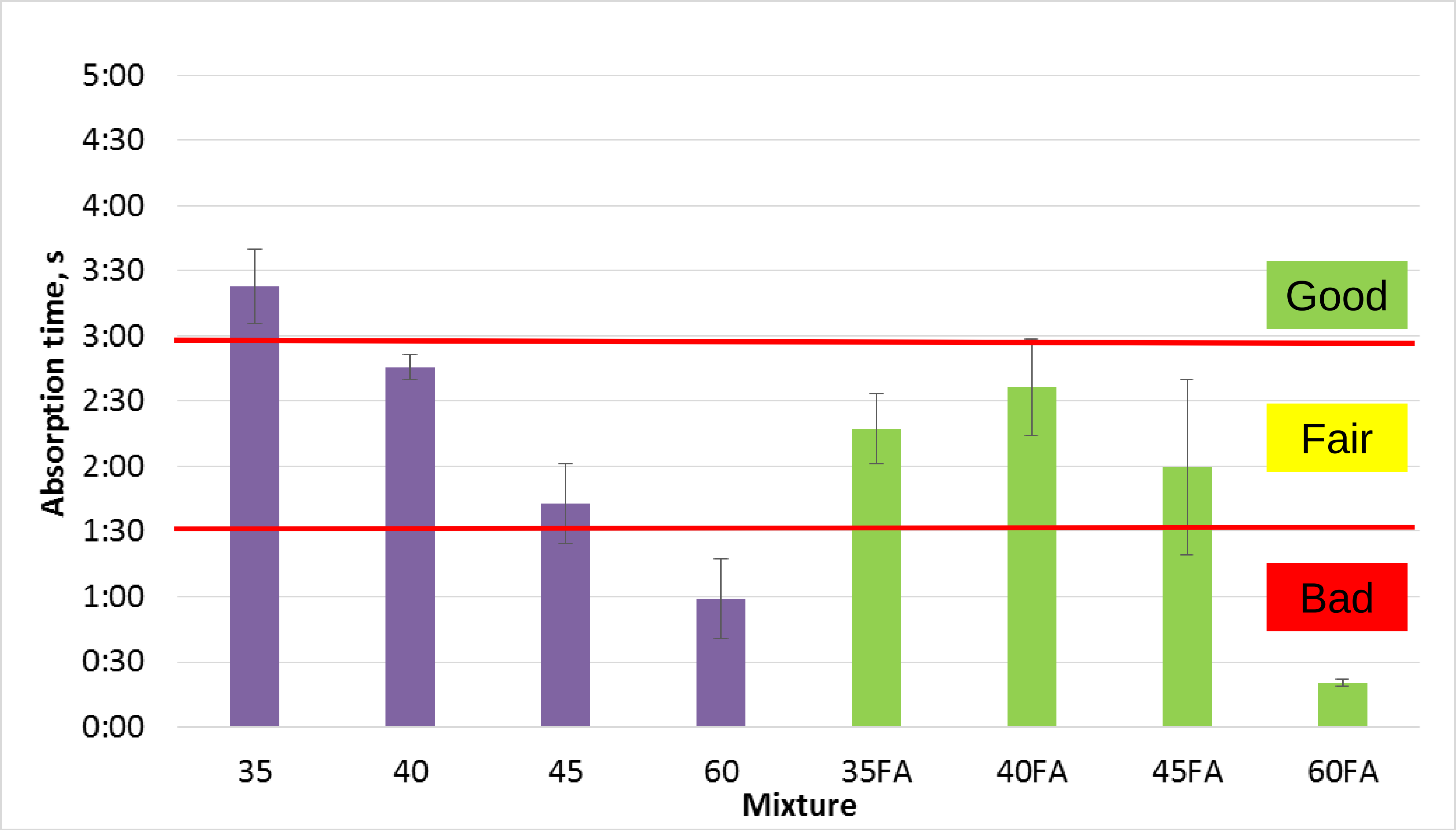
- Approach
  - Pre-application evaluation
  - Application by the manufacturer
  - Re-evaluation periodically
- Detailed Photo-log
- Extract cores – two over good joints, two over bad joints, two off joints
  - Drop-absorption test on sawn face and on top surface

Evaluation

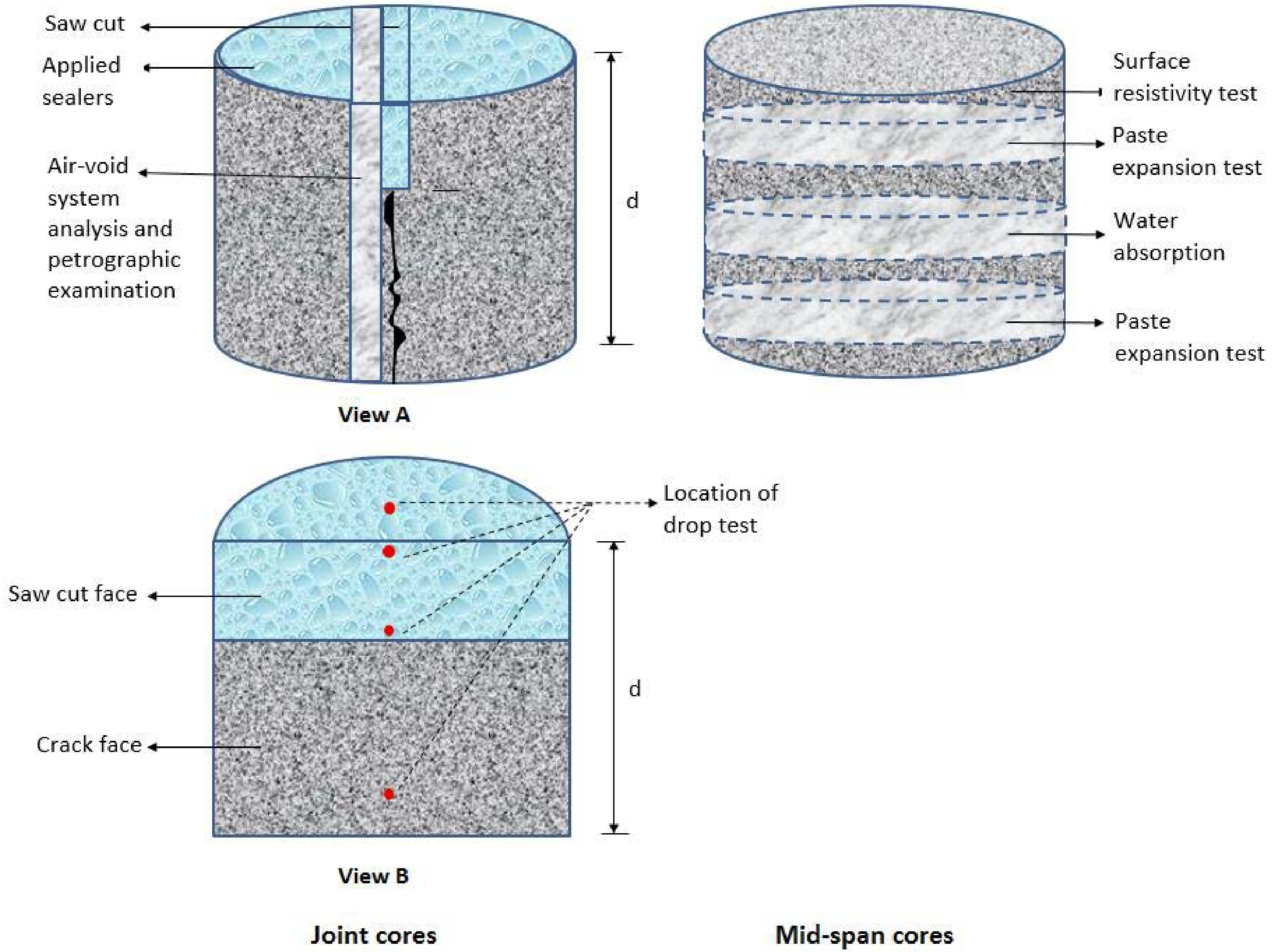
- Test
  - Drop test (ISU) - assess the quality of paste in an exposed surface at a local scale of less than 0.5 in^2

Evaluation

– Drop test calibration (56 days)



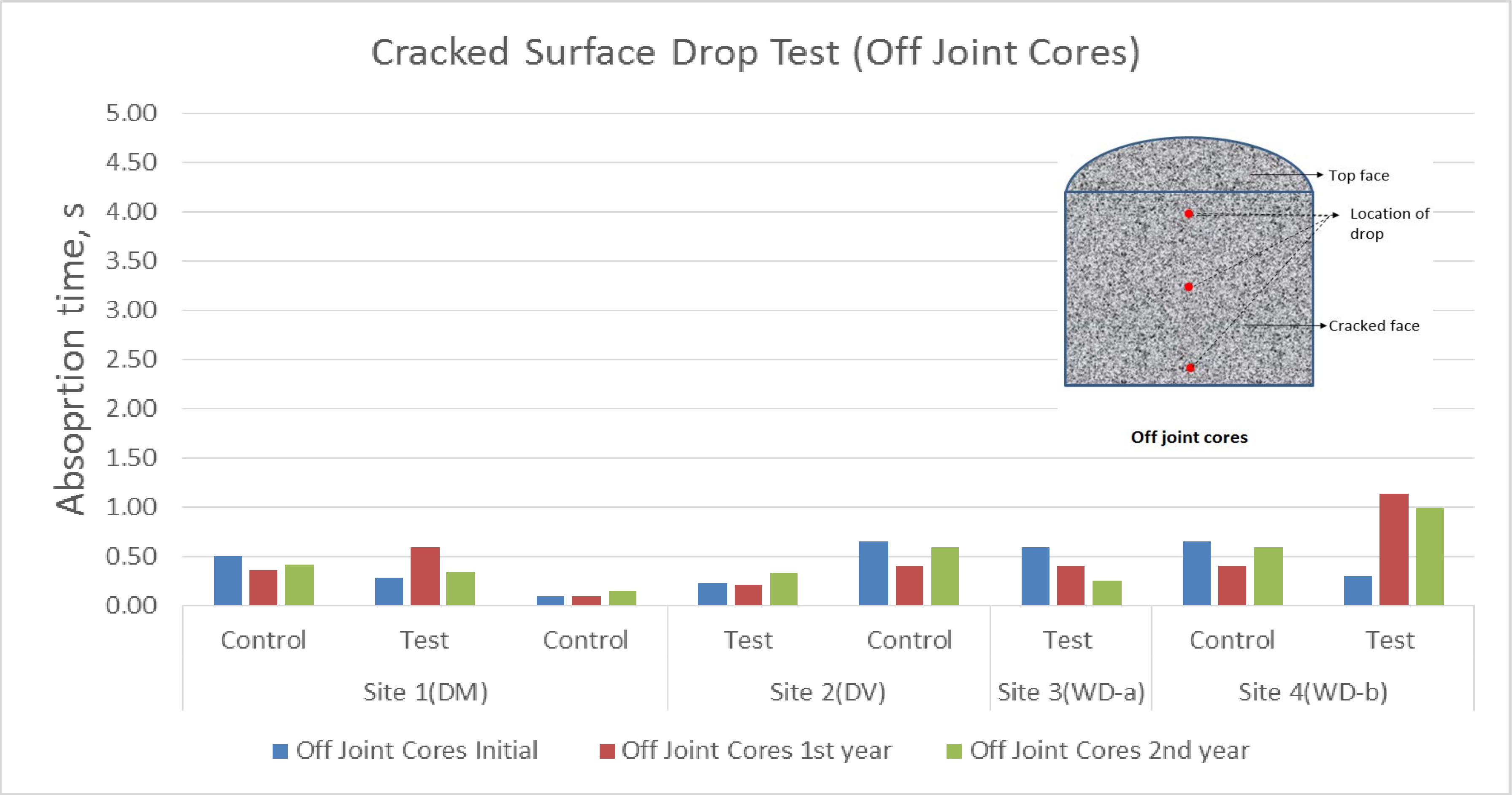
Proposed Field Investigation



Credit: Xuhao Wang, National CP Tech Center

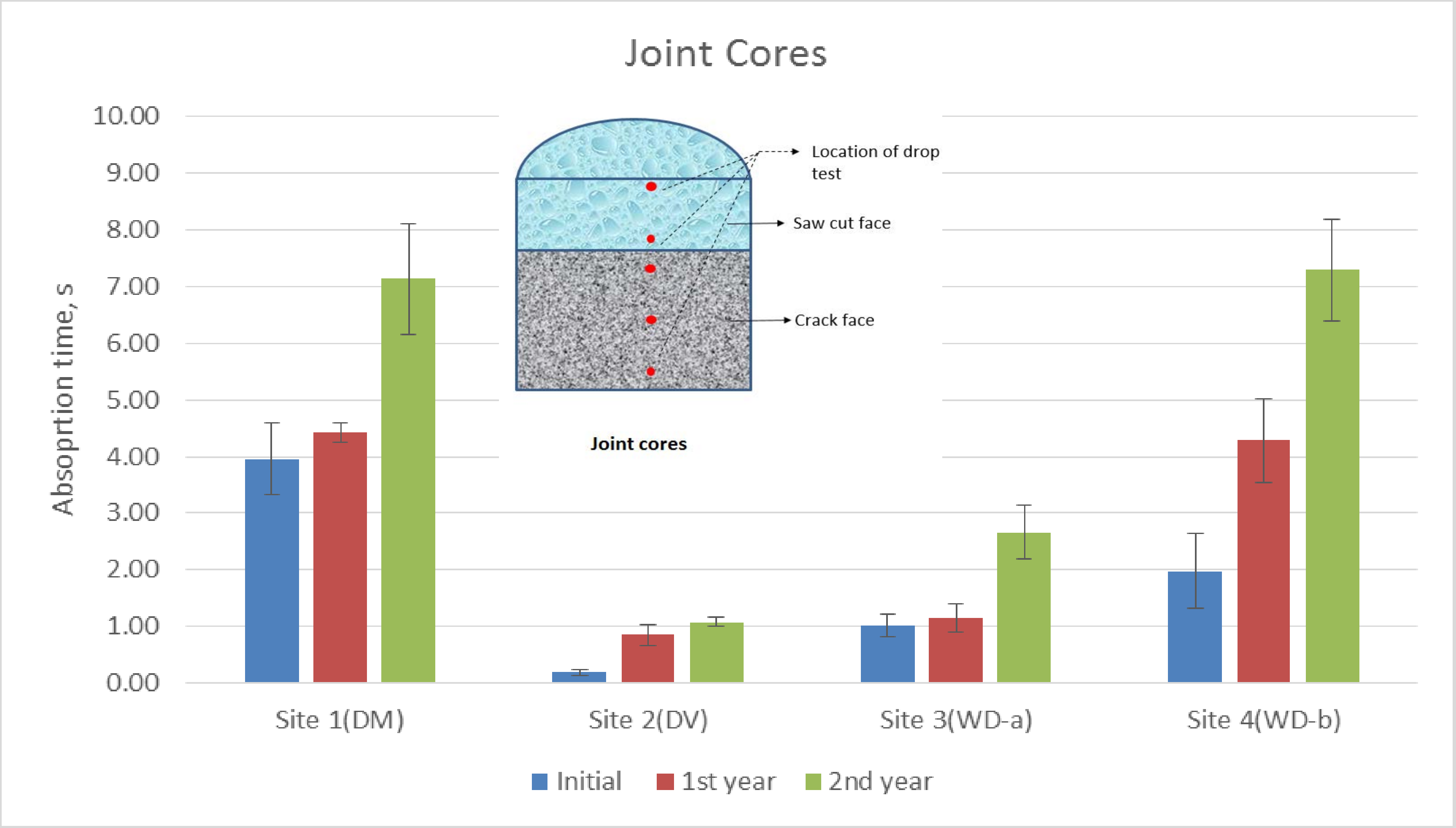
Iowa Program – Off Joint

- Drop-absorption test



Iowa Program – On Joint

- Drop-absorption test



Credit: Xuhao Wang, National CP Tech Center

Iowa Program

- Site 3 photo-log (control)

Initial Year (2014)

Second Year (2016)

Iowa Program

- Site 3 photo-log (test)

Initial Year (2014)

Second Year (2016)

Sealer Evaluation

- Test
  - Chemical reaction assessment
    - Paste expansion test (ISU) – assess the ability to resist oxychloride formation
      - Topically treated slices
      - Immerse in 4%, 20% $MgCl_2$ and $CaCl_2$ solution at 40˚F for 8 weeks

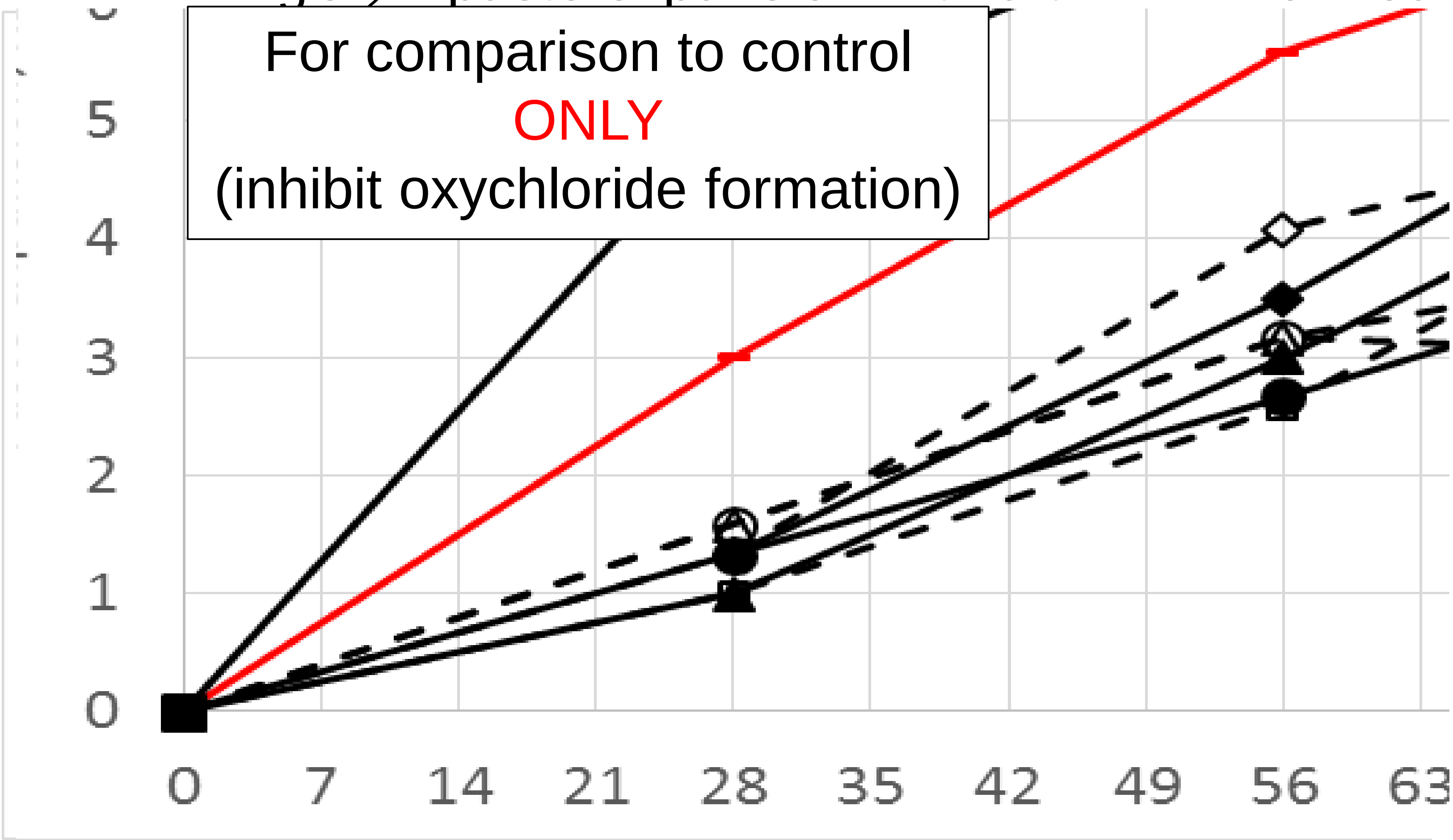
Credit: Xuhao Wang, National CP Tech Center

4% $MgCl_2$ @ 40°F for 28 days

20% $CaCl_2$ @ 40°F for 28 days

Sealer Evaluation

- Paste Expansion
  - 4% $MgCl_2$ – paste expansion with a thin film formed



Answers

- Drop test indicates less permeability
- Paste expansion test (ISU) indicates less expansion

Questions?

Credit: Christmas Vacation