Hycrete

Delivering Concrete Solutions

Protecting Assets:

Water and Moisture Design Considerations in Concrete & Mortar Repair Materials

Presenter: Dave Dennsteadt

Agenda

1. **Concrete – Water-Related Challenges and Consequences**
2. Applications/Examples
3. Ongoing Testing & Development
4. Summary

What is a Waterproofing Admixture?

1.

2.

3.

4.

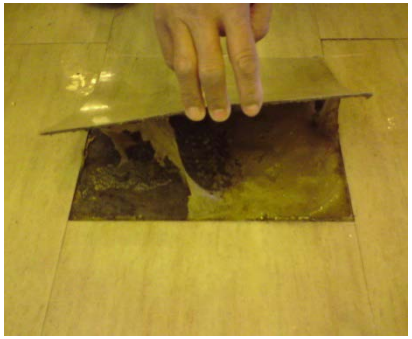
Seven Things to Think About…

…When Designing Concrete Structures

Capillary Absorption

Durability & Maintenance

Floor Failure, Moisture & Mold



Aesthetics

Leaks in Concrete

Environmental Considerations

Compatibility & Adhesion

Design Issue 1: Capillary Absorption in Concrete

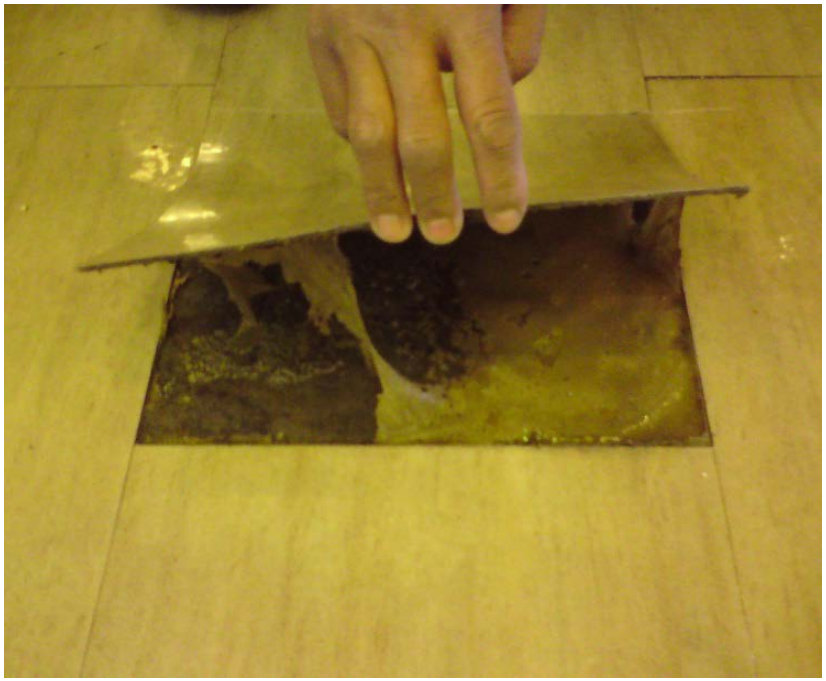
- Average water absorption (5,000 psi mix): 3-6%
- Water also brings in chlorides and other deleterious substances
- Damp interiors and humidity
- Freeze thaw damage

Design Issue 2: Durability and Maintenance

- Annual cost of corrosion to infrastructure: $22.6 billion
- Leads to concrete spalling and freeze-thaw
- Expensive and labor-intensive maintenance

Design Issue 3: Floor Failure, Moisture and Mold

- Moisture vapor transmission through concrete leads to floor failures
- Excess water in concrete affects flooring adhesion
- Trapped moisture can cause mold growth



Design Issue 4: Aesthetics

- Efflorescence
- Staining
- Surface deterioration and spalling
- Color preservation

Design Issue 5: Leaks in Concrete

- Water enters through joints, penetrations & cracks
- Leaks lead to building interior damage and expensive liability
- Expensive repairs and delays

Design Issue 6: Environmental Considerations with Concrete

- The production of Portland cement accounts for 9% of global CO_2 emissions
- Coatings and membranes, used to achieve concrete waterproofing objectives, contribute to landfill
- Environmentally, it is important to:
  - Maximize concrete durability
  - Maximize concrete recyclability
  - Minimize added materials

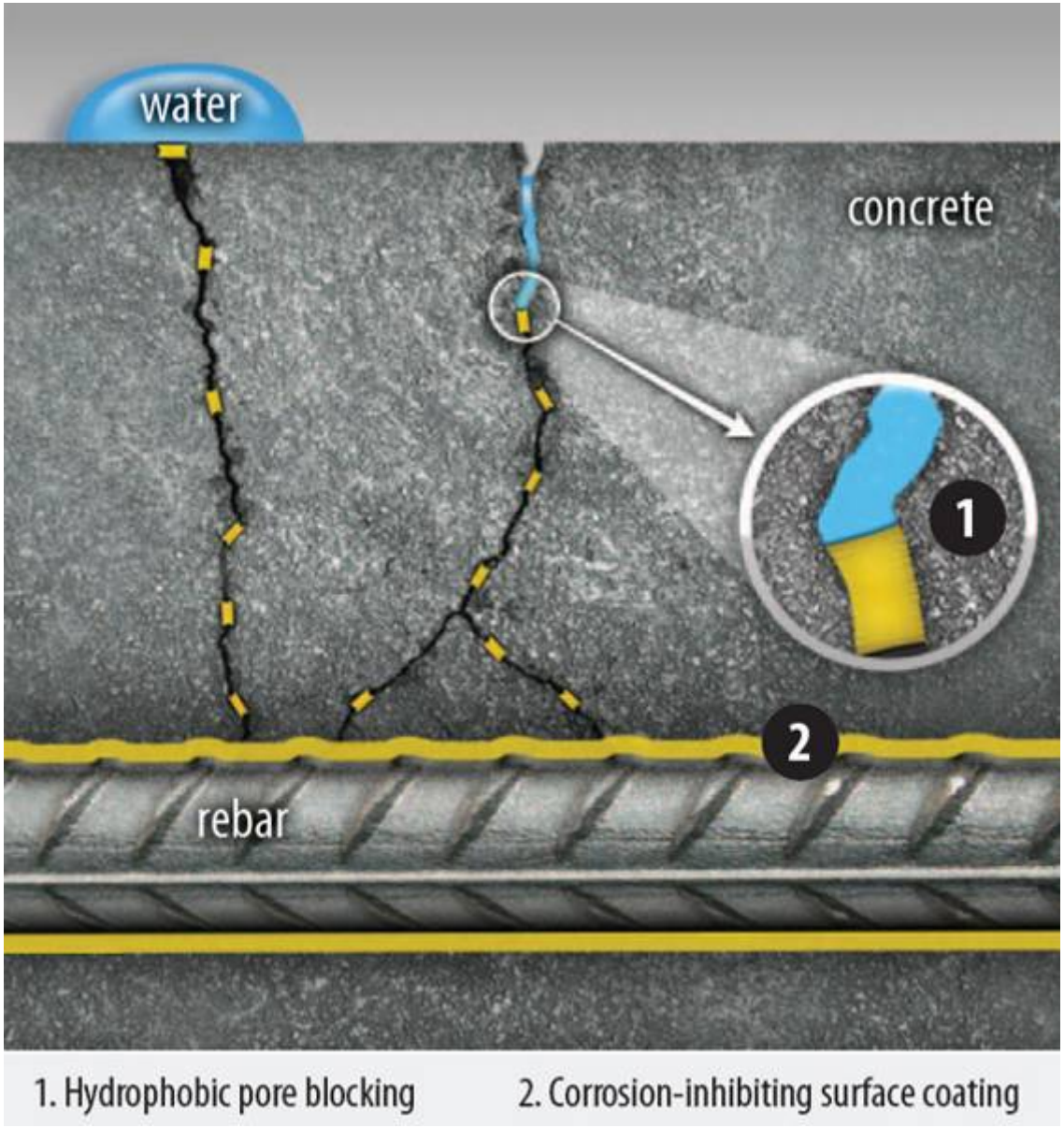
Design Issue 7: Compatibility and Adhesion

- Adhesion problems related to concrete being too wet
  - Coatings, membranes and sealers
- Compatibility between admixtures
  - Affect on set time, workability, finishing, and other properties

Admixture - Block Pores & Protect Rebar

- Water-based surfactant with hydrophobic (water-repellant) tails
- Forms a performance copolymer which is water repellant to the transport of moisture vapor and liquid
- Reacts with metallic ions including calcium in cement and rebar

+



Hydrophobic Admix's Absorption Advantage

Agenda

1. Concrete – Water-Related Challenges and Consequences
2. **Applications / Examples**
3. Ongoing Testing & Development
4. Summary

Applications / Examples of Technology

Replacing Waterproofing Membranes

Protecting Flooring from Moisture

Replacing Coatings & Sealers

Belt and Suspenders

Durable Concrete; Corrosion Protection

Architectural & Precast Concrete

Applications / Examples of Technology

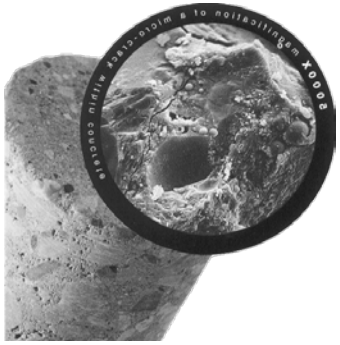
Replacing Waterproofing Membranes

Protecting Flooring from Moisture

Replacing Coatings & Sealers

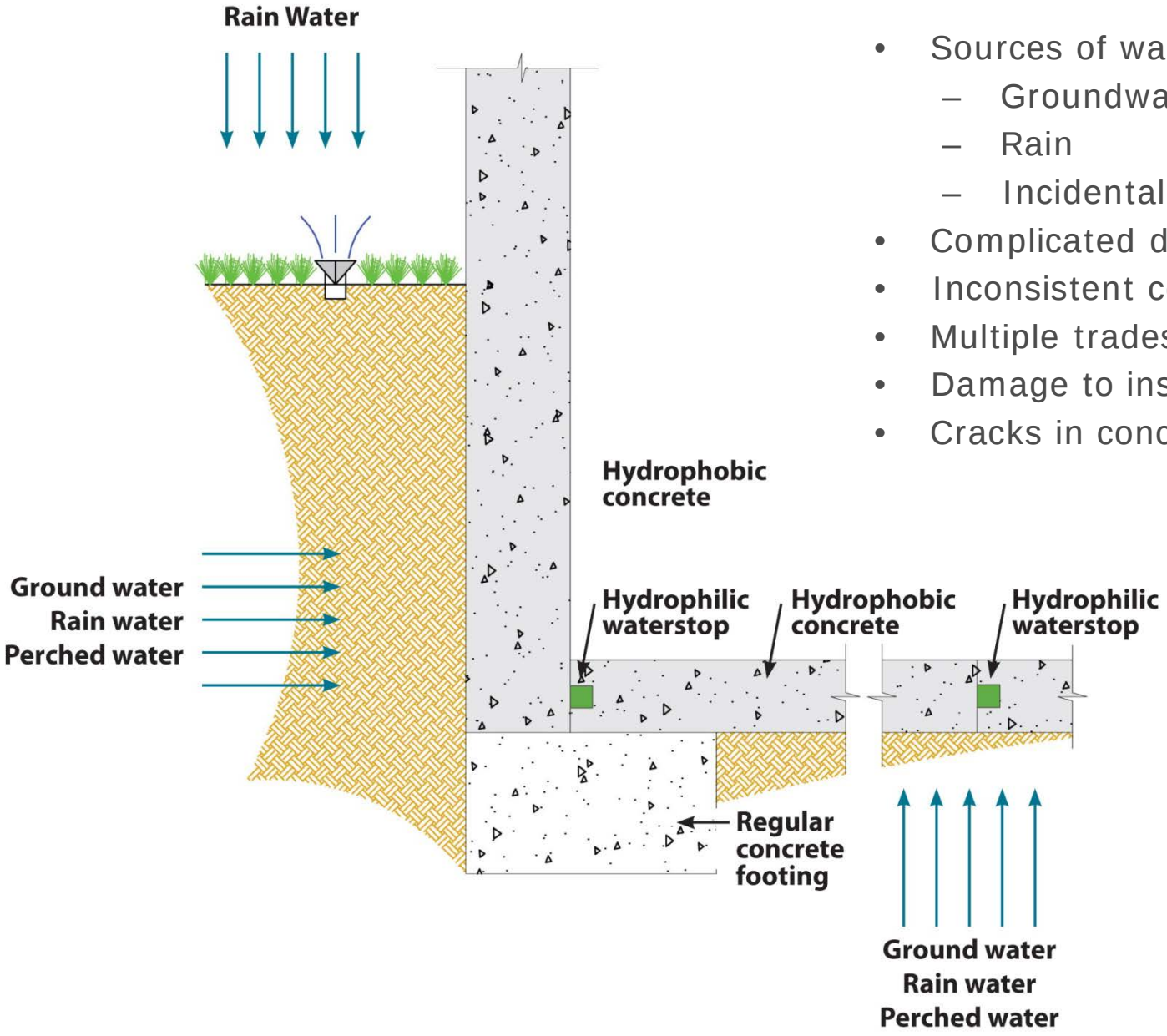
Belt and Suspenders

Durable Concrete; Corrosion Protection



Architectural & Precast Concrete

Causes of Leaks in Concrete



- Sources of water
  - Groundwater
  - Rain
  - Incidental (irrigation, snow, etc.)
- Complicated detailing
- Inconsistent concrete
- Multiple trades
- Damage to installed systems
- Cracks in concrete

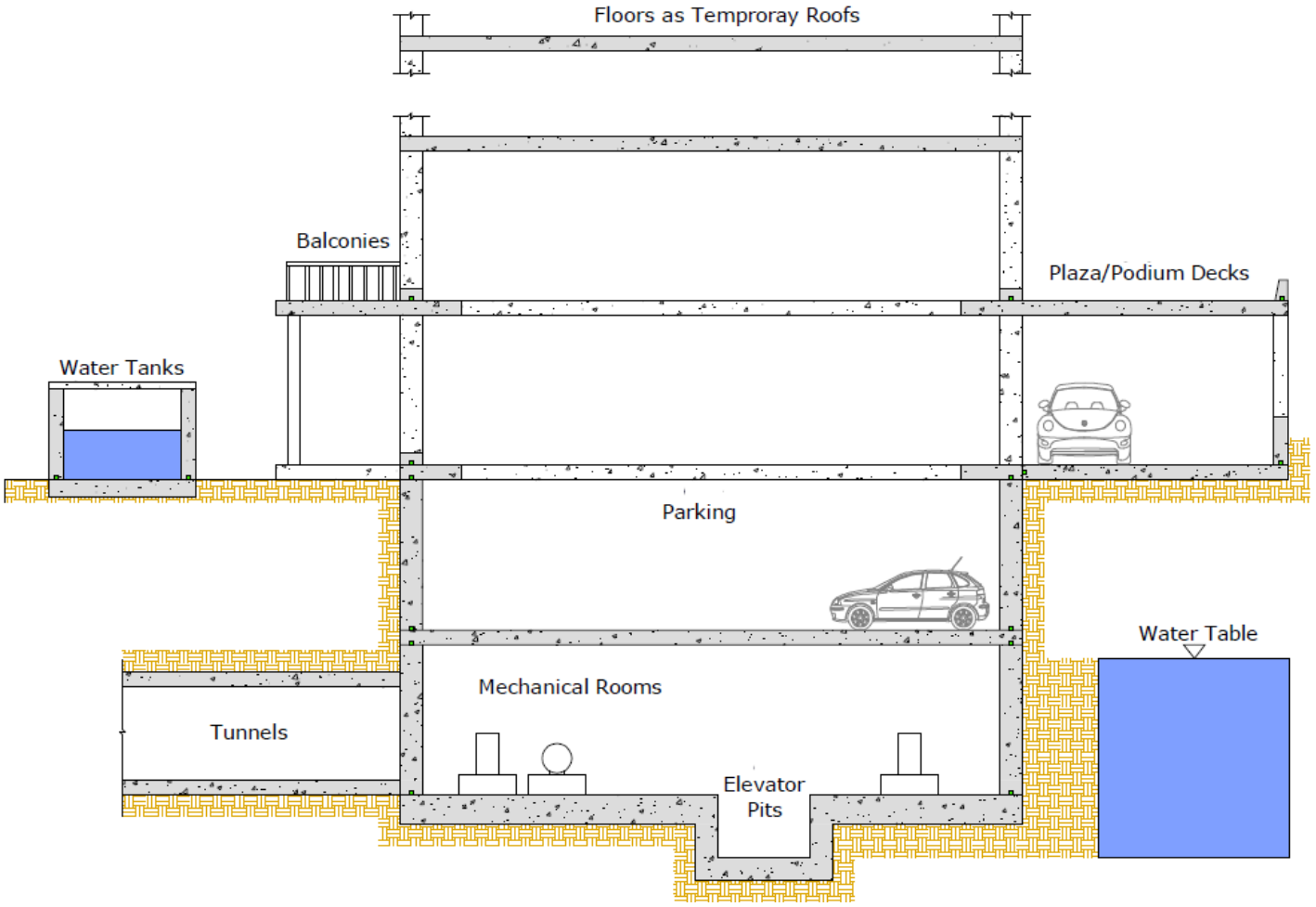
Typical Areas of Concern

Waterproofing:

- Foundations
- Elevator pits
- Podium decks
- Plazas
- Tunnels
- Water tanks

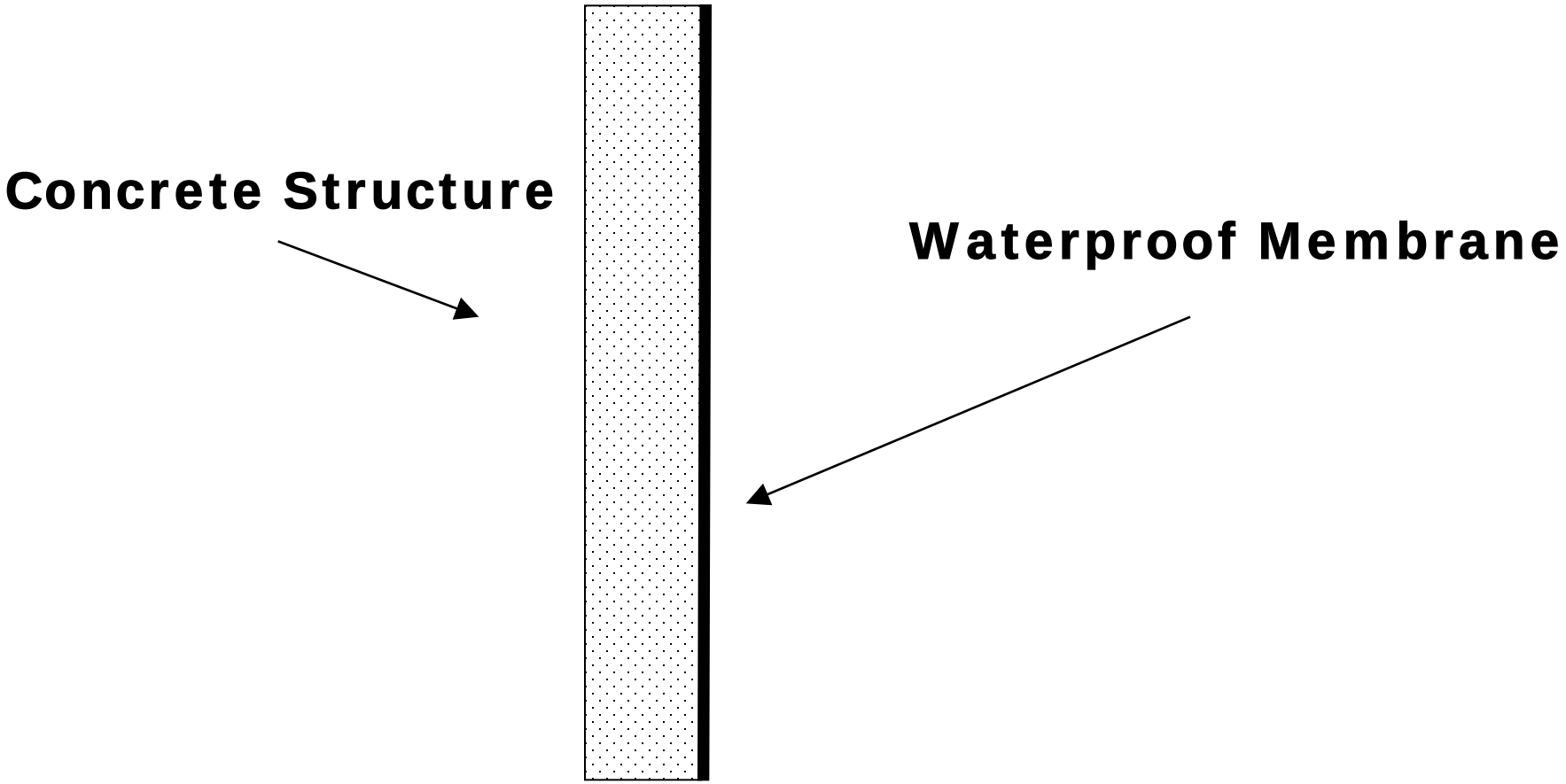
Corrosion control:

- Parking garages
- Balconies



Traditional Design Approach

The “Black Line Method” of Waterproofing Detailing



Contractors describe waterproofing details, particularly in as-built conditions, as a major source of change orders

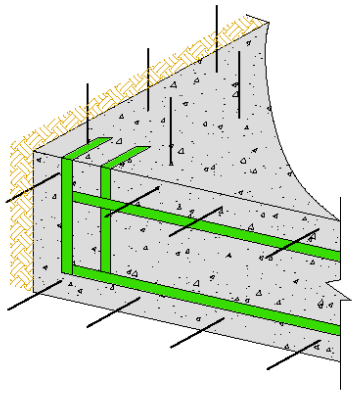
The Solution: A Systems Approach

Integral waterproofing must offer all of these

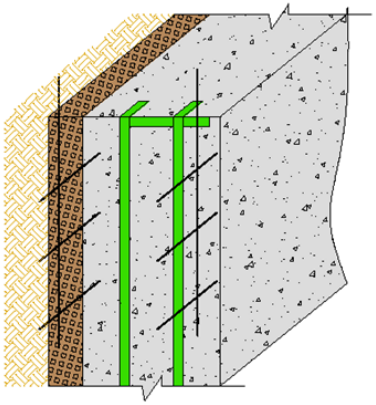
Do details right… the first time.

Horizontal

– Slab-to-Slab & Slab-to-Wall



SLAB TO SLAB JOINT



WALL TO WALL JOINT

Do details right… the first time.

Penetrations

Do details right… the first time.

Horizontal

– Slab-to-Slab & Slab-to-Wall

The Solution: A Systems Approach

Design & Pre-Construction

Pre-Inspection

Concrete Batch Plant Monitoring

Placement Monitoring

Ensure things are *designed* right

- Solid specs
- Comprehensive detail drawings
  - Waterstops for joints, etc.
- Review of drawings
- Concrete mix design guidance
- Site inspection of waterstops, etc.

Ensure things are *done* right

- Audit concrete batch plants
- Monitor trucks
- Assist during pours to ensure no piece gets displaced or overlooked
- Ensure proper concrete curing

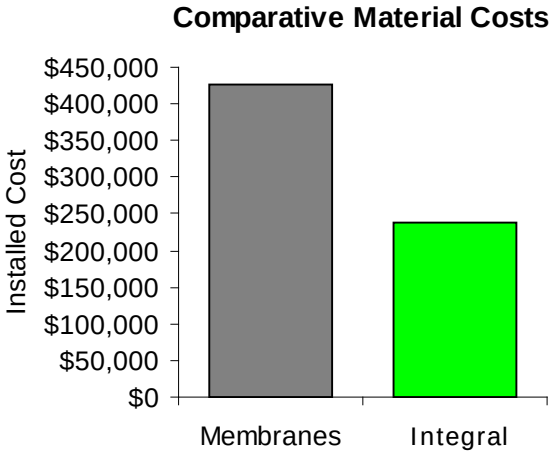
Case Study: LEED ID Credit Earned for Membrane Elimination

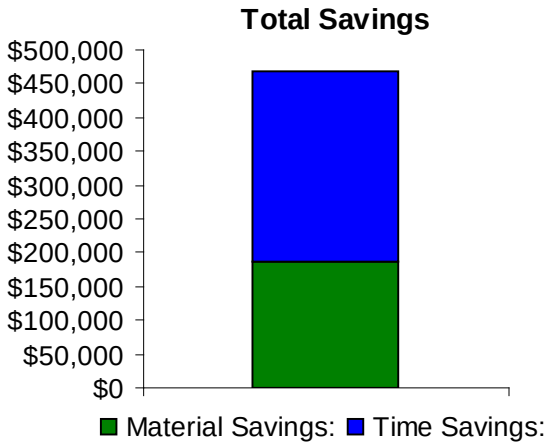
THOMAS JEFFERSON SCHOOL OF LAW
SAN DIEGO, CALIFORNIA

University classroom building located in downtown San Diego, CA. Shotcrete below grade construction.

Team

Owner:	TJ Law School
General Contractor:	Bovis Lend Lease
Architect:	Carrier Johnson
Engineer:	Hope Engineering
Ready Mix Provider:	Hanson
Concrete Contractor:	JT Wimsatt
Waterpr. Consultant:	Deihl Group





USGBC LEED Credit Delivered

- Environmental impact quantified
- Innovation in Design Credit "anticipated" at design review stage for "Membrane-Free Construction"

U.S. GREEN BUILDING COUNCIL MEMBER

All This Leads to Big Sustainability Impact

"Membrane-Free Construction Through Integral Concrete Waterproofing"

Example impact:

Reduced environmentally negative materials and construction waste

- *Elimination of **36 tons of landfill debris**.*
- *Elimination of an estimated **53,844 pounds of non-renewable materials**.*
- *Elimination of an estimated **18,567 pounds of polymers**.*
- *Reduction in required onsite equipment – concrete waterproofing is added at ready-mix, not site.*
- *Elimination of excavation / backfill required for membrane installation reduces construction footprint*
- *Improved concrete recyclability, as future membrane removal is eliminated.*
- *Et cetera ….*

NOTE: Full Thomas Jefferson School of Law Case Study follows …

The USGBC Has Previously Granted an Innovation in Design (ID) Credit for Membrane-Free Waterproofing

Applications / Examples of Technology

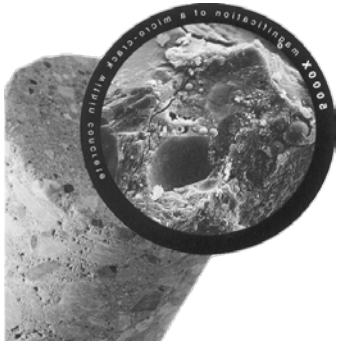
Replacing Waterproofing Membranes

Protecting Flooring from Moisture

Replacing Coatings & Sealers

Belt and Suspenders

Durable Concrete; Corrosion Protection



Architectural & Precast Concrete

Moisture Problems in Flooring

Common Problems:

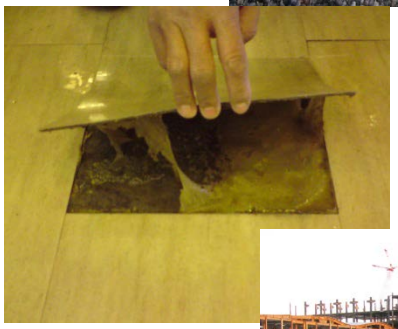
- Delamination
- Discoloration and staining
- Odors
- Mold growth
- Blistering, cupping, warping

Expensive delays & repairs and liability

Flooring Manufacturers Do Not Warranty Against Moisture-Related Flooring Failures

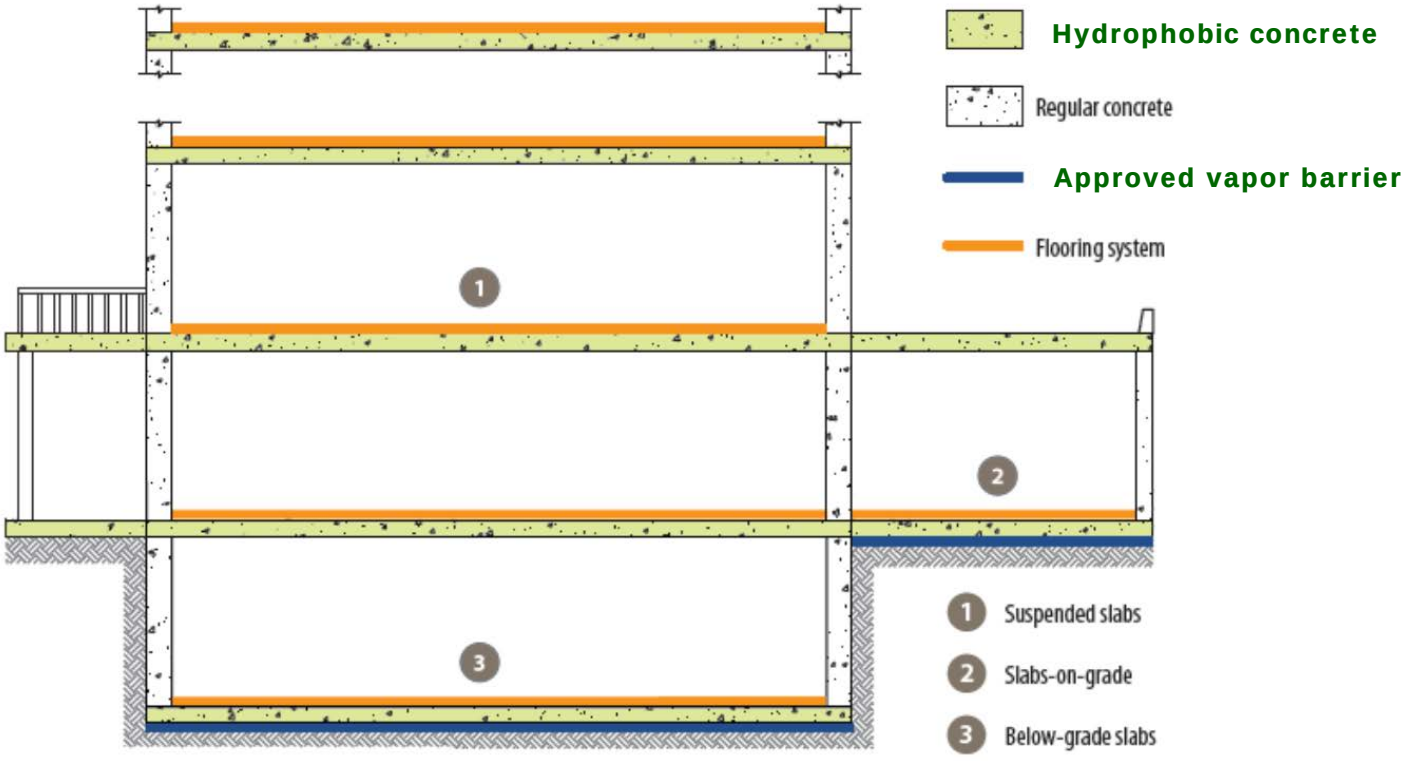
Causes of Flooring Failures – What Has Changed?

- Inadequate vapor barrier design, detailing, and installation
- Excess water in concrete mix designs and improper concrete placement
- Water-based adhesives; VOC compliance
- Multiple trades and change orders (which typically are not in the budget)



Applicable Anywhere There is Flooring

- Slabs on grade
- Elevated slabs



The Solution – Multi-Pronged Approach

- Project review

1. Underslab vapor barrier
   - Selection and installation
2. Mix design
   - Better quality concrete
   - Blocking capillaries
3. Quality control and inspections

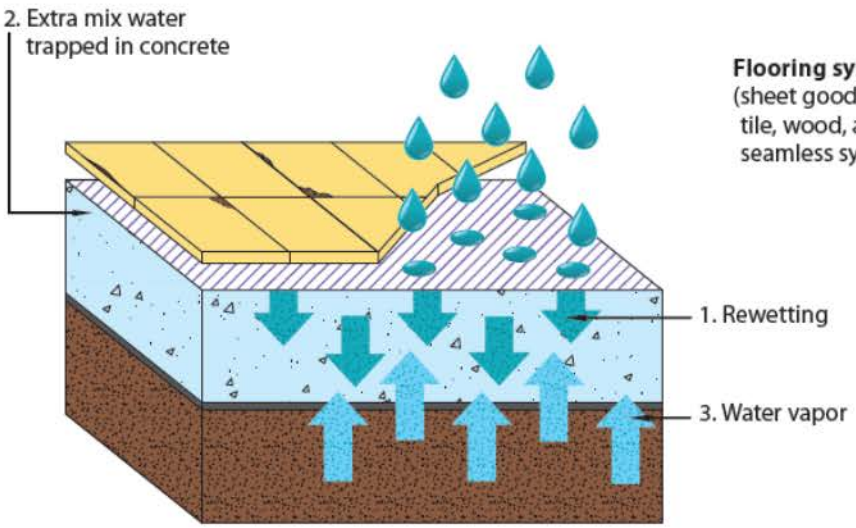
- Performance warranty

Three Slab Water Sources – New Construction

- Floor finish problems result from 3 water sources:
  - Mix Design Water
  - Ground Water / Moisture Vapor
  - Environmental (Rain, Snow, Site Conditions, etc.)

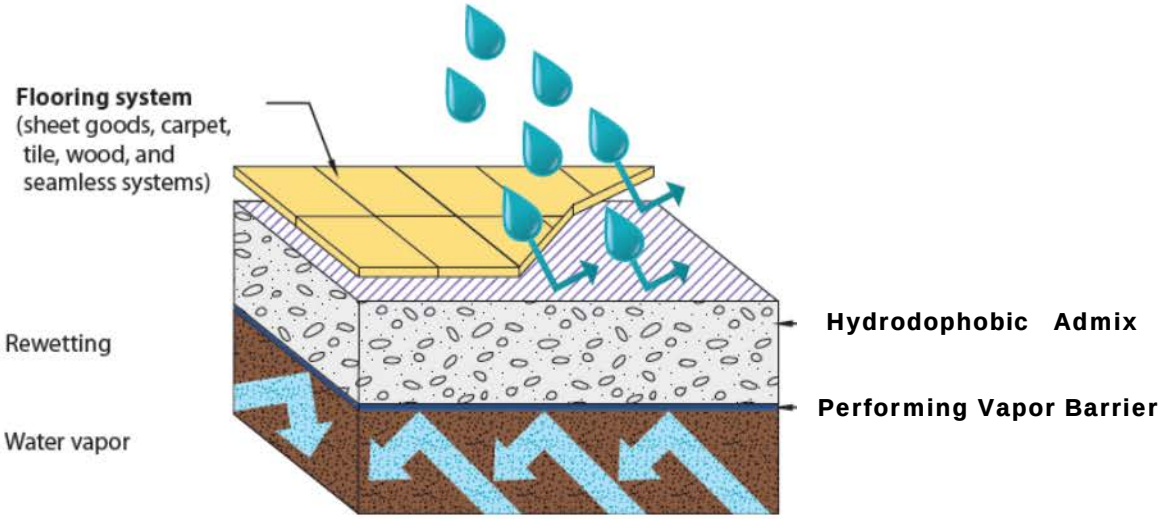
THE PROBLEM:

The Three Moisture Sources Leading to Flooring Failure



THE SOLUTION:

A Better System Backed by a Formidable Warranty



USACE Testing Program
Hydrophobic Admixture and RH and Vapor Considerations

- Hydrophobic Admixture, Vapor Transmission and Flooring Failure
  - Concretes made at CTLGroup
  - Slabs for exposed drying studies using RH probes

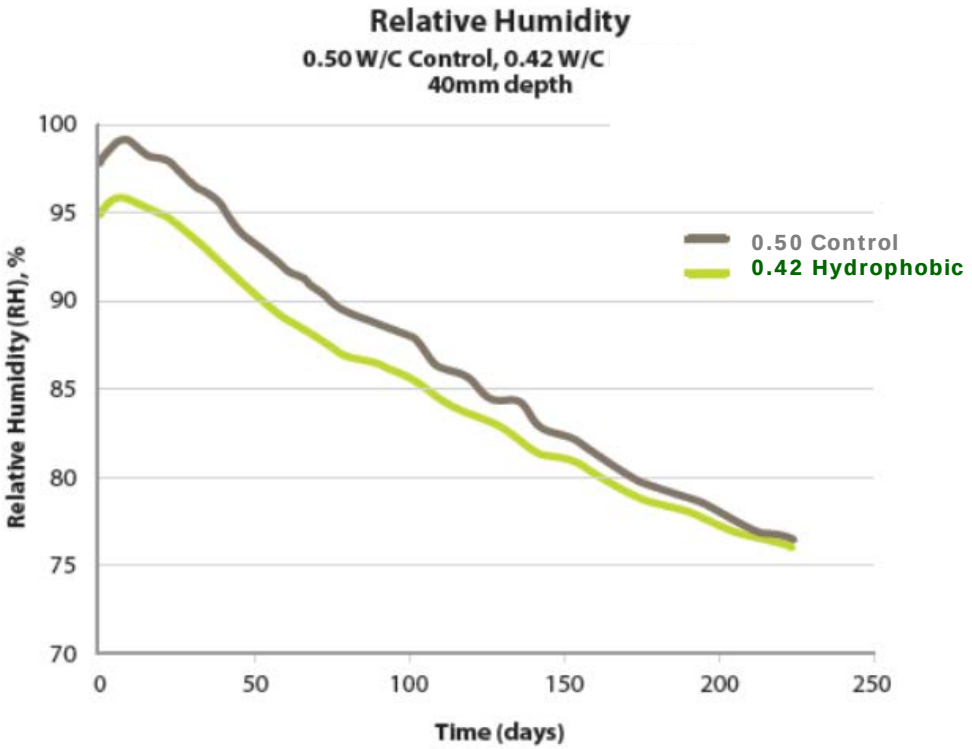
Step 1: Keep the unneeded water out of mix design

Relative Humidity (RH)

ASTM F2170 – Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in situ Probes

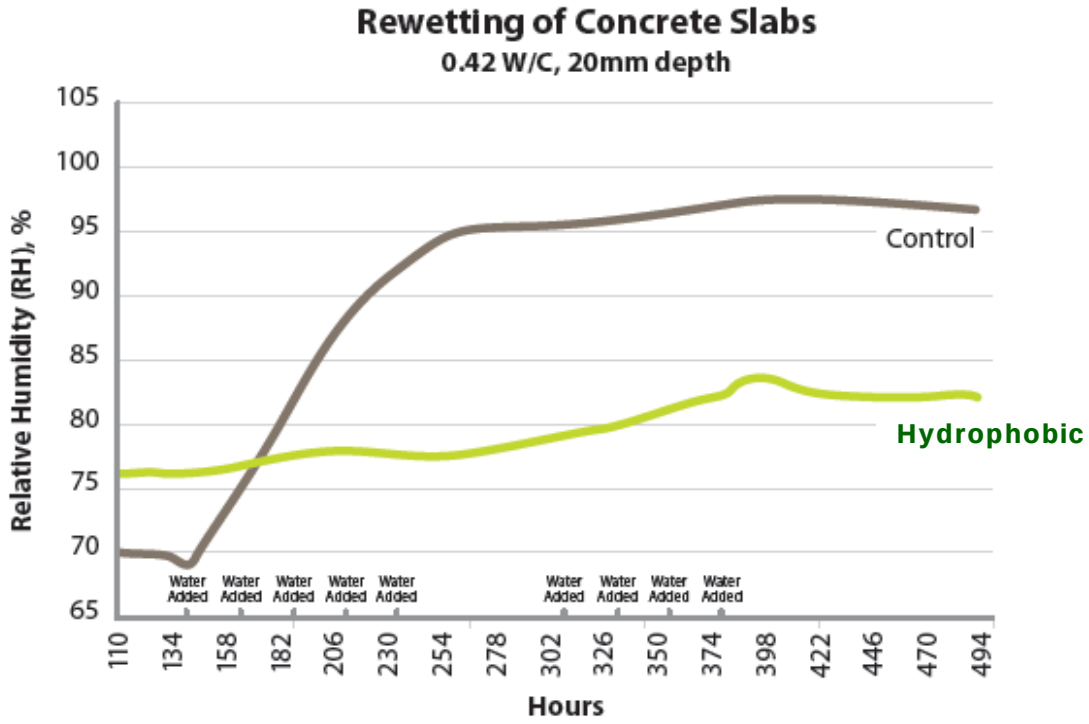
Concrete slabs are cast and instrumented with relative humidity (RH) probes to measure internal relative humidity over time. A probe is suspended in air close to the slabs to record ambient temperature and relative humidity. The slabs are exposed to ambient temperature and relative humidity, which is meant to mimic typical field construction exposure conditions.

CTLGroup, Skokie, IL



Step 2: Prevent rewetting with Hydrophobic Admix

Stop Rewetting



ASTM F2170 – Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in situ Probes

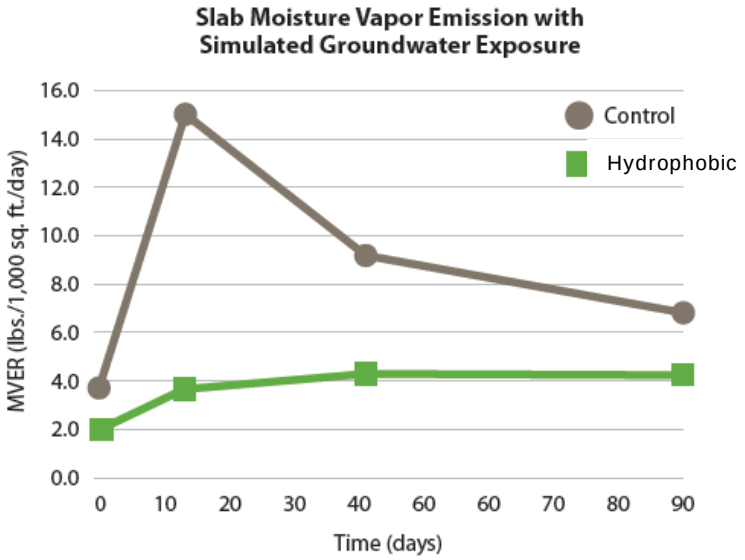
Samples are soaked in ½ inch of water for one hour each day and then dried to simulate real-world conditions. Relative humidity is measured at a depth of 20mm using in situ probes.

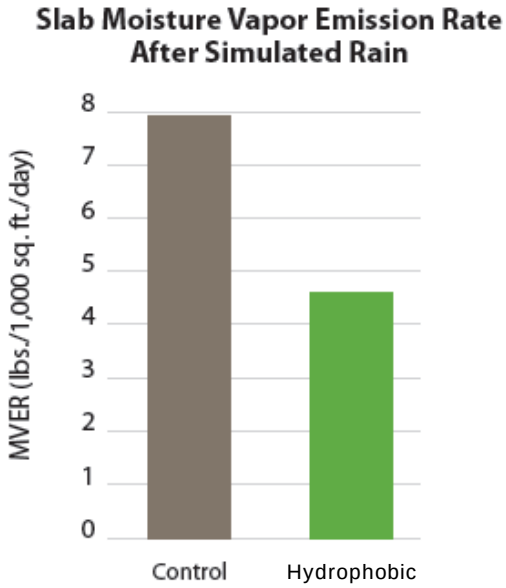
CTLGroup, Skokie, IL

ydrophobic

Step 3: Slow Moisture Vapor Transfer w/Admix

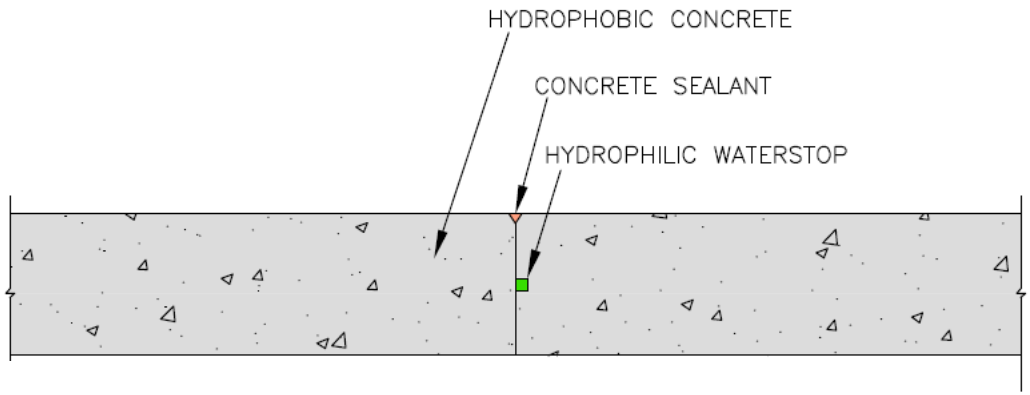
- Mix design
  - 0.42 water/cement and lower
  - Blocking capillaries with admixture technologies
  - Good concrete designs dry faster
- By blocking capillaries:
  - Reduce moisture vapor transmission (MVER)
  - Concrete remains dry



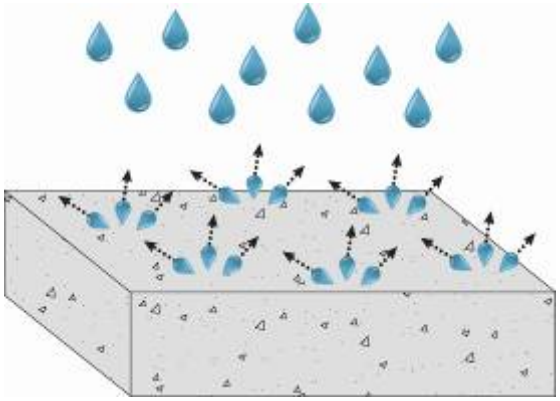


Step 4: On Site Inspection!

- Get details right the first time
- No excess water added to concrete
- Use and install vapor barriers as required
- Install concrete to ACI standards
- Take no shortcuts!



What Once Re-Soaked a Floor … Now Does Not



Hydrophobic Concrete

Months Delay (or Future Floor Failures) Are Avoided

Summary: You need a Systems Approach

Flooring Protection must offer all of these

Protecting Your Assets with a Warranty

- 10 year performance warranty
- Guaranteed adhesion of specified floor system
- No change to construction critical path
- No delays
- An "**in**-concrete" solution vs. an "**on**-concrete" solution

Warranted protection for less than $1/ft² - Includes:

- **Project review**
- **Architectural detailing**
- **Mix design adjustments**
- **Concrete admixture**
- **Inspections**
- **Performance guarantee against floor failures**

Applications / Examples of Technology

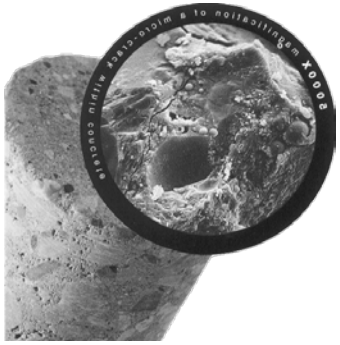
Replacing Waterproofing Membranes

Protecting Flooring from Moisture

Replacing Coatings & Sealers

Belt and Suspenders

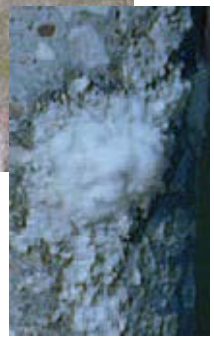
Durable Concrete; Corrosion Protection



Architectural & Precast Concrete

Durability Problems in Concrete Decks

- Concrete decks are susceptible to water and **chloride attack**, resulting from:
  - Heavy traffic and surface abrasion
  - Severe weather
  - Road salts



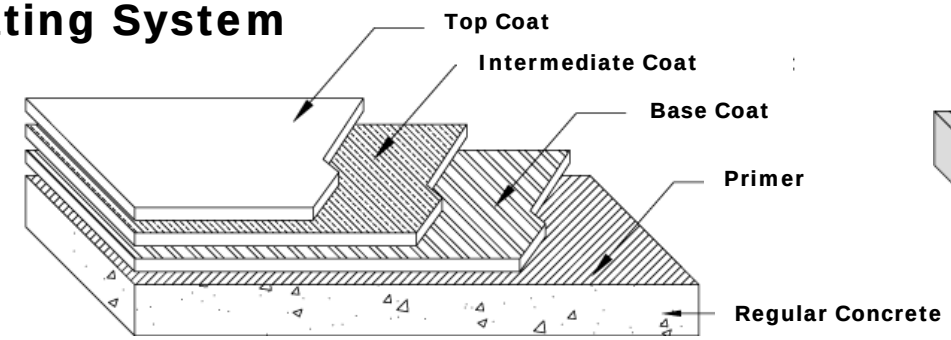
Problem Areas in Parking Structures

- Driving lanes
  - High levels of traffic
- Turning radii
  - High stress on concrete surface
- Top deck
  - Snow plows
  - Exposed to weather

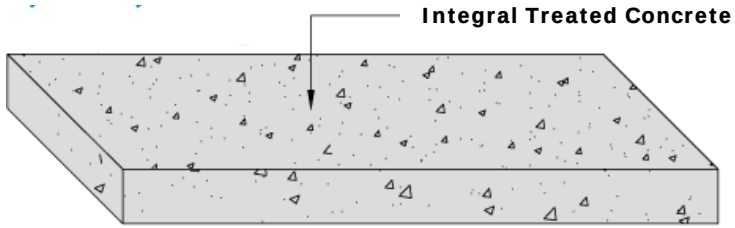
The Solution – Integral Decks

- Using integral admixture technology to shut down capillary absorption in concrete and protect steel
- Benefits include:
  - **One-time application; admixture is mixed throughout concrete and doesn't wear out**
  - Dual-mechanism corrosion protection
  - Significant up-front and life cycle cost savings
  - Significantly reduced maintenance and down-time
  - Simplified detailing

Coating System



Integral System



Applications / Examples of Technology

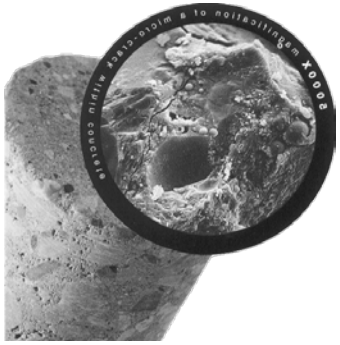
Replacing Waterproofing Membranes

Protecting Flooring from Moisture

Replacing Coatings & Sealers

Belt and Suspenders

Durable Concrete; Corrosion Protection



Architectural & Precast Concrete

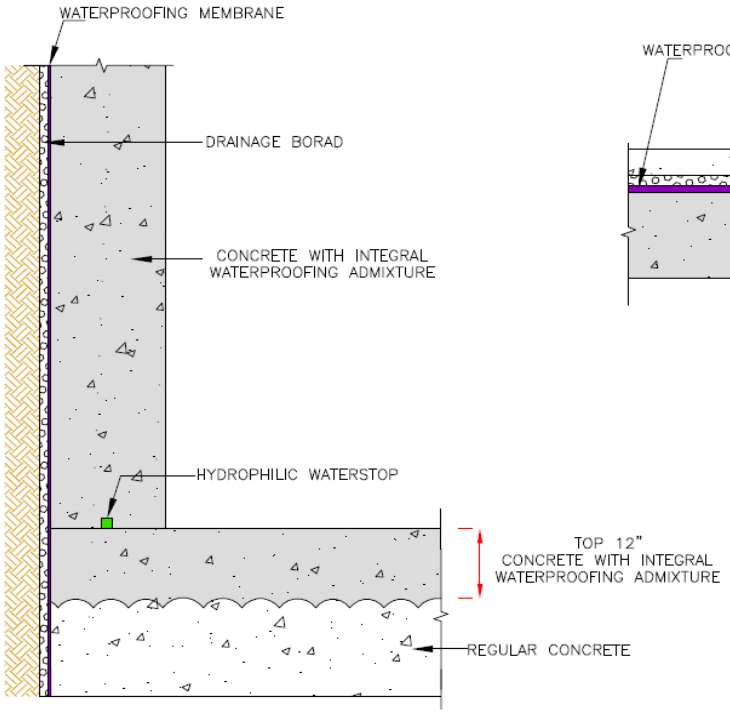
Backup Systems – Belt and Suspenders

- Critical applications
  - (i.e., green roofs, sensitive indoor environments)
- Failure would be catastrophic
- Large potential liability
  - (i.e., finished space with limited access to concrete)
- Concern of water coming through concrete

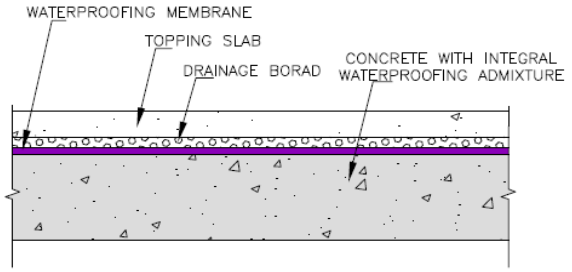
The Solution – Dual Approach

...Stopping Water From Coming Through Concrete

- Water that finds its way through a membrane/coating system and to concrete does **not pass through** concrete
- Protection **in** and **around** concrete



MAT SLAB – WALL JOINT
(NTS)



DECK SLAB
(NTS)

Back-up Protection for about $0.50-$1.50/ft²

Applications / Examples of Technology

Replacing Waterproofing Membranes

Protecting Flooring from Moisture

Replacing Coatings & Sealers

Belt and Suspenders

Durable Concrete; Corrosion Protection

Architectural & Precast Concrete

Protect Your Concrete for the Sake of Your Structure

- Concrete readily absorbs water and elements dissolved in the water
- Results
  - Damp interiors
  - Paint and coating failure
  - Interior asset damage
  - Concrete failure

All Leading to Increased LIABILITY

Causes of Aesthetic & Durability Problems

- Secondary efflorescence
  - Water wicks salts to concrete surface, which is difficult to remove

- Freeze-thaw
  - Expansion and contraction degrade concrete surface
  - Jeopardizes aesthetics

- Corrosion
  - Corroding rebar expands and cracks and spalls concrete
  - Leads to expensive repairs

Corrosion in Concrete – Expensive Repairs & Liability

- The annual cost of corrosion-related repairs in the US exceeds $22 billion

How and Why Corrosion Starts in Concrete

- What is needed for corrosion to start in concrete?
  - Chlorides + water + oxygen
- Where do chlorides comes from?
  - Road salts
  - Marine environments
  - Soil
- How do chlorides get to steel?
  - Capillary transport through concrete
- Results
  - Rebar expands
  - Concrete then cracks
  - Structural performance is jeopardized

Chlorides + H_2O + O_2

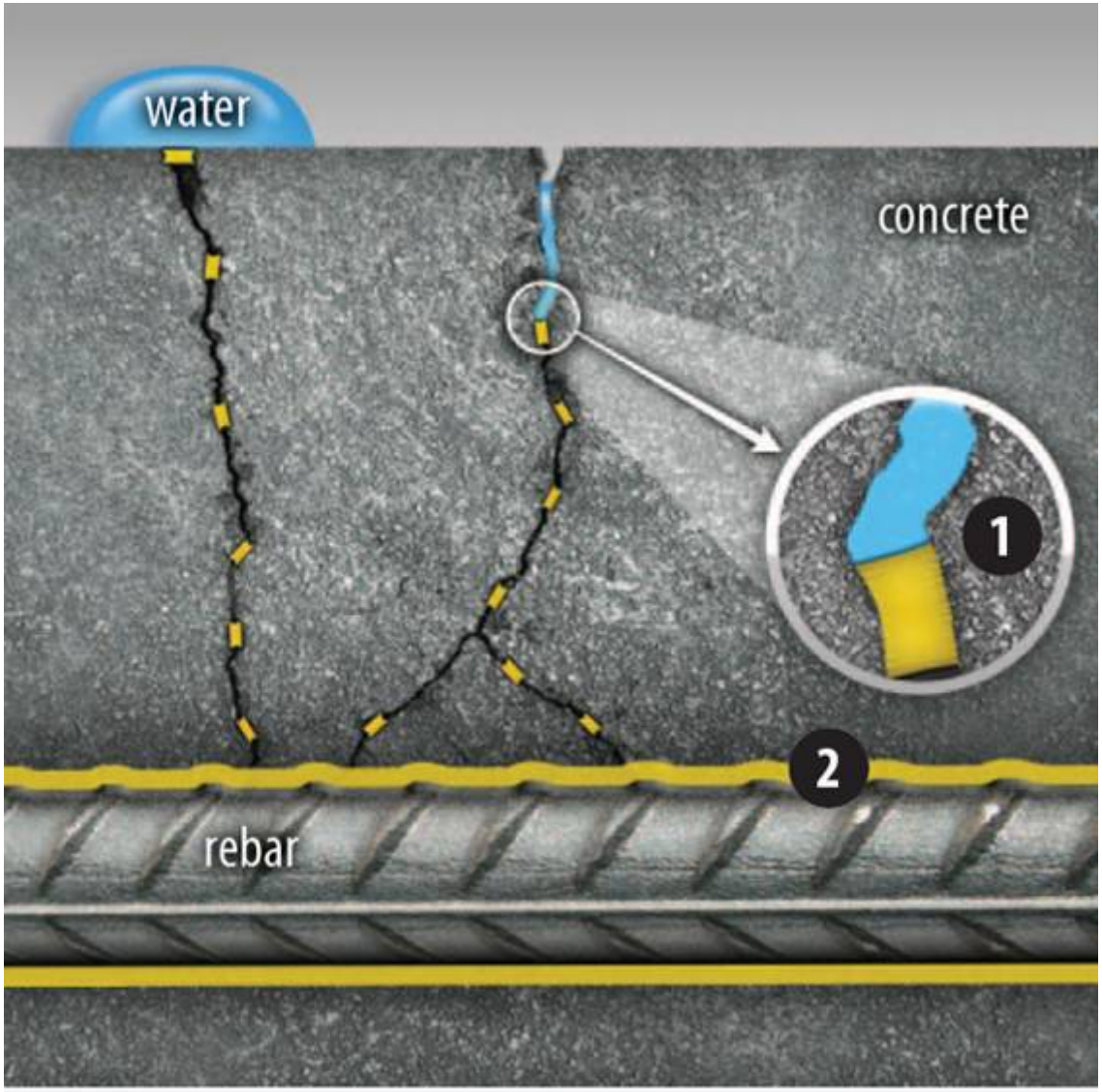
The Solution: Hydrophobic Admixtures Last

- One-time, durable solution
- Don’t wear or wash out
- Reduces maintenance requirements
- Reduces efflorescence and other staining
- Enhances concrete durability and protects surface

Hydrophobic Admixture Blocks Pores & Protects Rebar

- Water-based surfactant with hydrophobic (water-repellant) tails
- Forms a performance copolymer which is water repellant to the transport of moisture vapor and liquid
- Reacts with metallic ions including calcium in cement and rebar

+

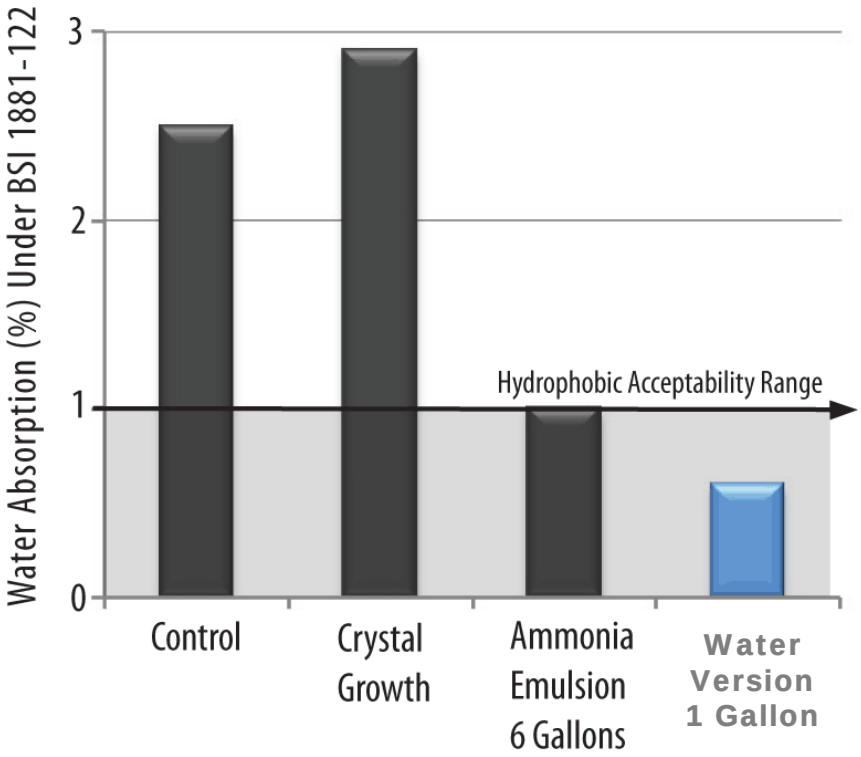


Agenda

1. Concrete – Water-Related Challenges and Consequences
2. Applications/Examples
3. **Ongoing Testing & Development**
4. Summary

Corrosion: Hydrophobics Keep Water Out

High dosage for visual emphasis



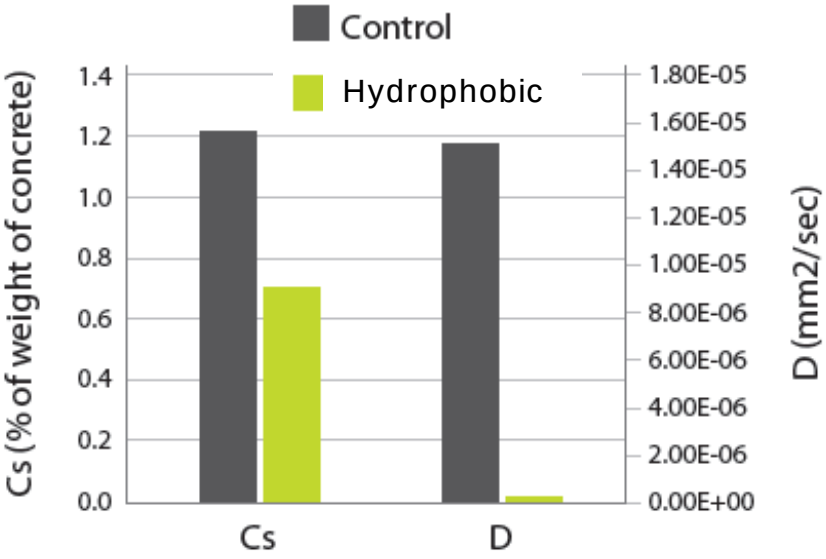
South Carolina Independent Lab Testing: 40/60 Structural Mix, 0.40 W/C - 611 Type I-II Cement Polycarboxylate Superplasticizer

"Hydrophobic" performance defined as <1% Absorption per BSI 1881.122

The Solution: Corrosion Protection Performance

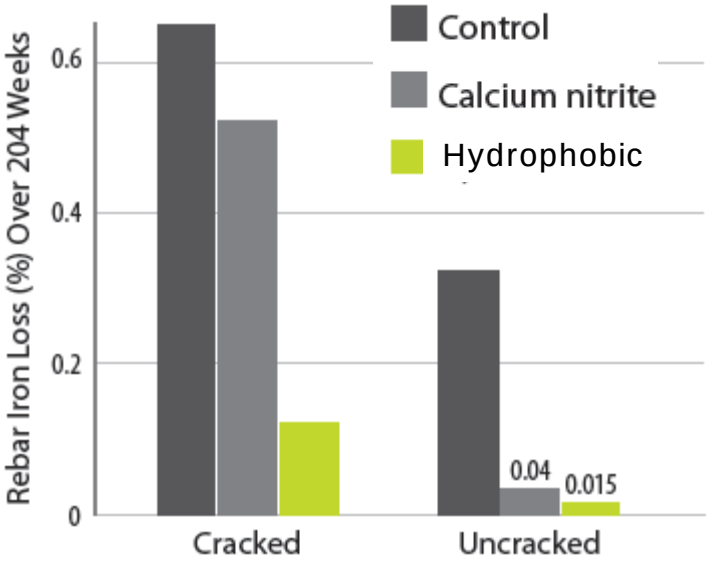
Surface Concentration of Chlorides and Diffusion Coefficient

ASTM C1556

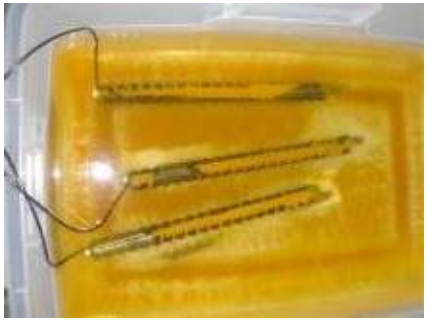


Protection of Steel in Concrete

ASTM G109

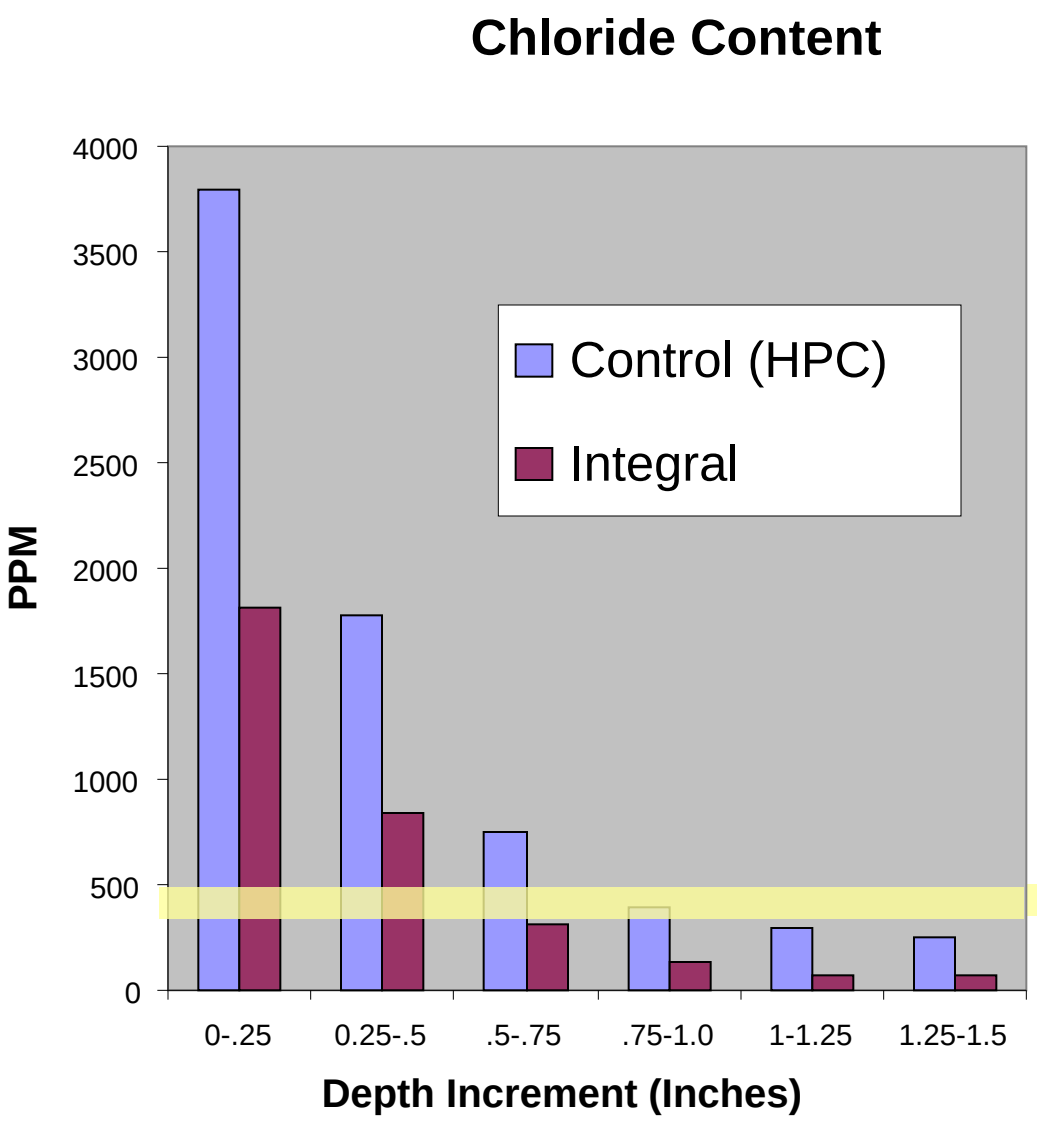


Control



Hydrophobic

Case Study: NJ DOT US Route 130 Bridge

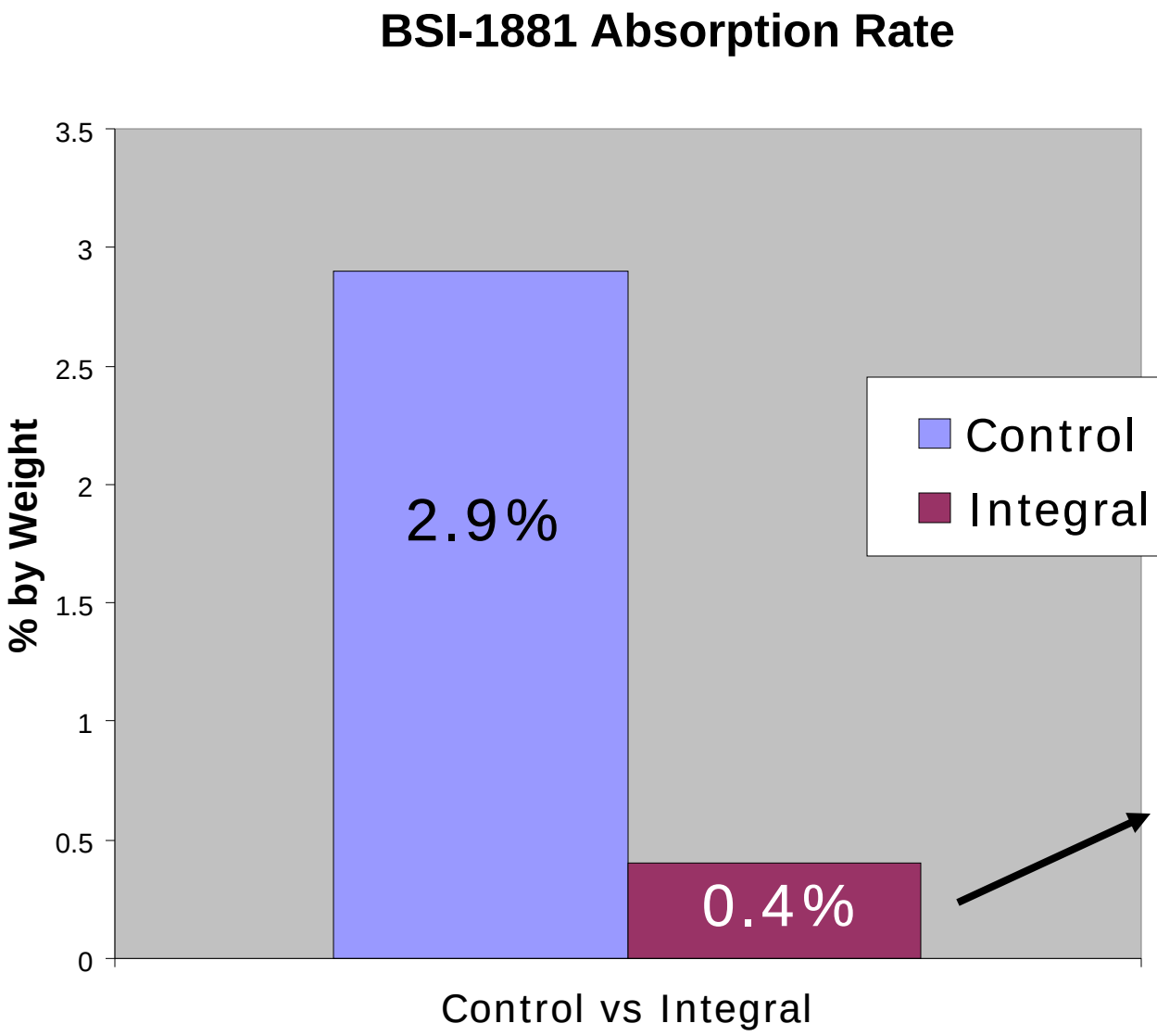


In-situ DOT Testing

- New Jersey Rte 130 Bridge
- Installed Spring, '06
- Control span employed NJ's high-performance (HPC) mix

Critical Chloride Content for Corrosion Initiation (Integral: **2-3.5X** more effective than control)

Route 130 Absorption Results (3.5 years service)



Integral: More than **7X** better than control; full performance consistent with dosage.

Case Study – CT DOT Highway Barriers

- Concrete jersey barriers
- 8 years in service
- Freeze-thaw environment

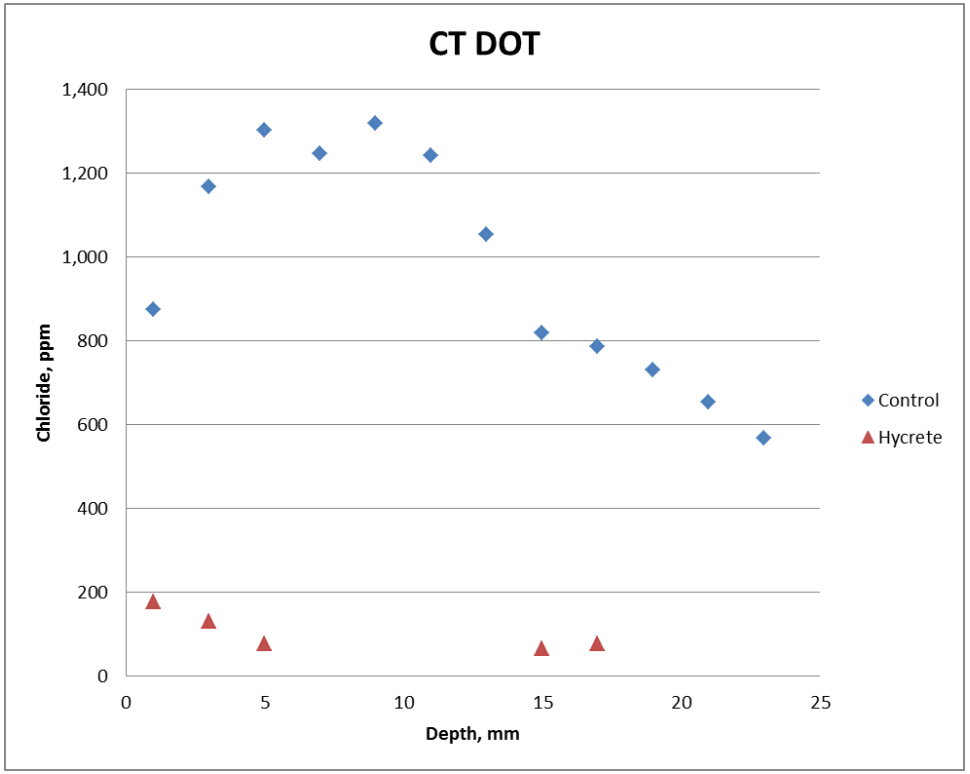
Control

With Hydrophobic Protection

Case Study – CT DOT Highway Barriers

- CT DOT I-84 Median Barriers – 2003
- Use Profile Grinder and Titrator to get chloride levels in field structures

Hydrophobic Admixture



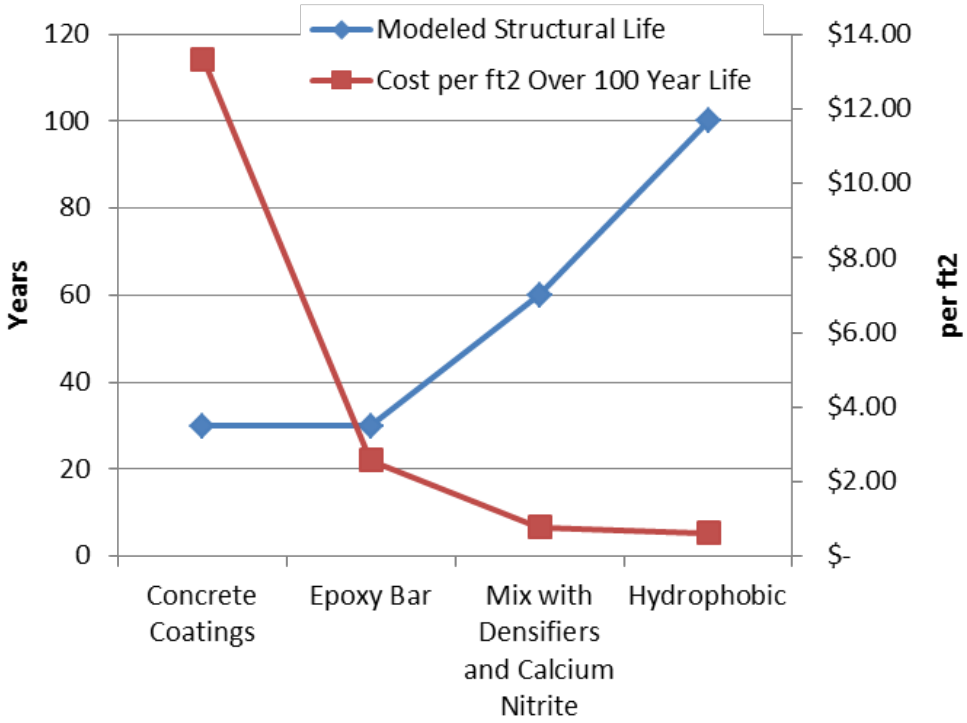
Validating the Solution: Life Cycle Modeling

- Software to **estimate service life** and **life-cycle costs** of alternative concrete mixes and surface treatments
- Tool for design consultants
- Estimates effects of mix design, chloride exposure, and concrete barriers (i.e., coatings) on life

Modeling Example:

Parameters:

- Parking deck
- 5” thick
- Exposed to water and chlorides



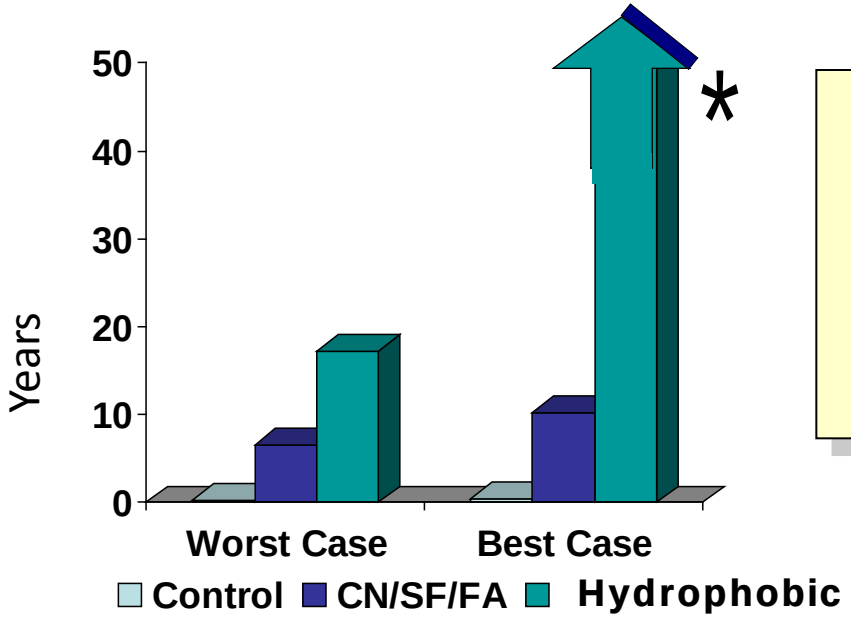
American Concrete Institute®
Advancing concrete knowledge

Life 365™

Hydrophobic Admixture Delivers $$ Savings

Life 365™

Time to Corrosion Initiation



* Note: Examples did not corrode implying a theoretical "best case" of **150 years**

VTRC Virginia Transportation Research Council

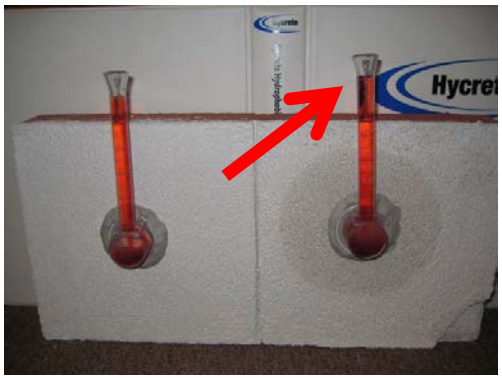
"The use of Hydrophobic Admixture is expected to lead to extended service life and to aid in minimizing maintenance costs…VDOT would save $1.5 million dollars each year through the use of Hydrophobic Admixture." - VTRC

Department of Transportation Class A4 concrete mix designs - 2007 VTRC Report by H. Celik Ozyildirim and Stephen R. Sharp

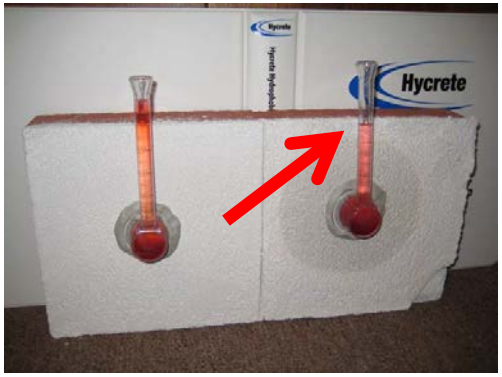
The Solution: Hydrophobic Admixtures Last

- Mortar Applications
- Enhanced water protection
- Reduce potential corrosion
- Decrease Moisture Vapor Transfer

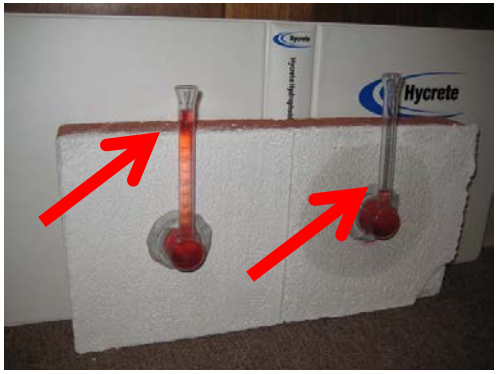
9:30am
100%



11:00am
50%



1:00pm
0%



Agenda

1. Concrete – Water-Related Challenges and Consequences
2. Applications/Examples
3. **Ongoing Testing & Development – USACE Research**
4. Summary

Sulfate Exposure Results – UTexas (Hydrophobic Admixture – USACE)

Figure 3: Mixture 9 Set 2 Prisms after 6 months of Exposure

Figure 4: Mixture 10 Set 2 Prisms after 6 months of Exposure

Hydrophobic Admixture – USACE Construction Project

- Hawaii Seawall
- Hydrophobic Admixture technicians installed the Hydrophobic Admixture in the precast panels
- Some panels have sensors in them to monitor corrosion. Test panels will be cored for chloride penetration measurements.

Agenda

1. Concrete – Water-Related Challenges and Consequences
2. Applications/Examples
3. Ongoing Testing & Development
4. **Summary**

Summary – Customized Solutions

- Hydrophobic additives can…
  - Enhance the life of structures
  - Reduce moisture/water related issues.
  - Reduce potential for floor finish failures.
- Hydrophobic additives perform best with…
  - Clear performance based specifications
  - Field Support
  - Customize solutions for specific applications.





Performance Specs – Ensuring Quality

Property	Standard	Performance Level
Water absorption	BSI 1881-122	<1%
Capillary absorption	ASTM C1585	>25% reduction
Corrosion protection – diffusion	ASTM C1556	Protection versus control
Corrosion protection – rebar loss	ASTM G109	Protection versus control
Permeability	DIN 1048	Pass
Crack healing	ASTM C597	Benefit versus control
Set time	ASTM C403	Neutral
Approval for potable water	NSF/ANSI 61	Approved

Integral Waterproofing – Benefits in 6 Critical Areas of Construction & Repair

Replacing Waterproofing Membranes

Protecting Flooring from Moisture

Replacing Coatings & Sealers

Belt and Suspenders

Durable Concrete; Corrosion Protection

Architectural & Precast Concrete

www.hycrete.com

(866) HYCRETE

Dave Dennsteadt