Durable and Watertight Concrete Infrastructure

Presented by Sam Lines

Concrete Sealants, Inc.

SEAL OF SECURITY

BOND OF TRUST

ConSeal™

Concrete Sealants Inc.

Don't Just Seal It. ConSeal It!

Overview

- Manhole and Pipe connections
- Waterstops
- Watertight and Durable Concrete
- Microbially Induced Corrosion of Concrete

Pipe and Manhole Connections

Making watertight connections

Design Considerations

Infiltration / Exfiltration

Soil tight

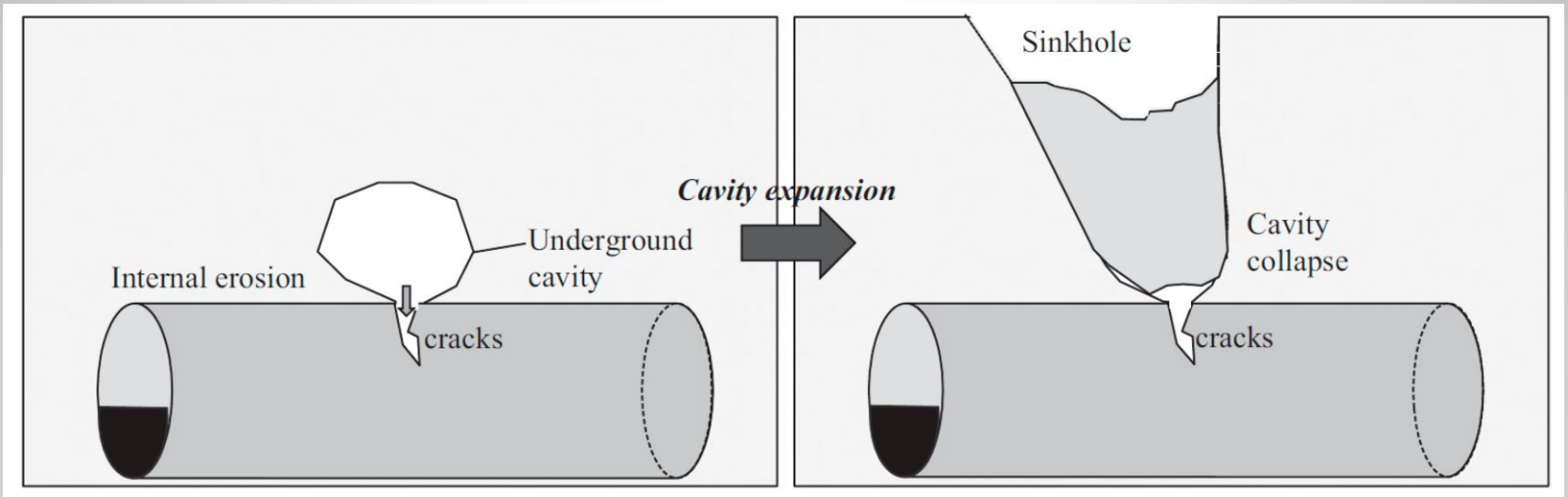
Leak resistant / Watertight

Infiltration / Exfiltration

Potential Causes:

- Voids in the concrete
- Poor concrete quality
- Improper joint sealant installation
- Rocks or debris in the joint
- Damaged joint or seal
- Damage during installation
- Cracks in the concrete

Soil Tight

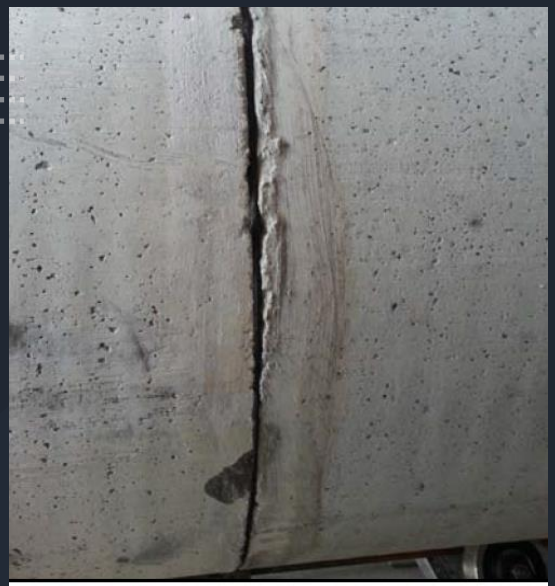


Potential Causes:

- Joint not tight
- Not enough sealant
- No external band

Potential Problems:

- Silting of soil, fines
- Erosion of soil
- Sinkhole / potholes



48" Pipe Deflected Joint
Test Complete - No Leakage

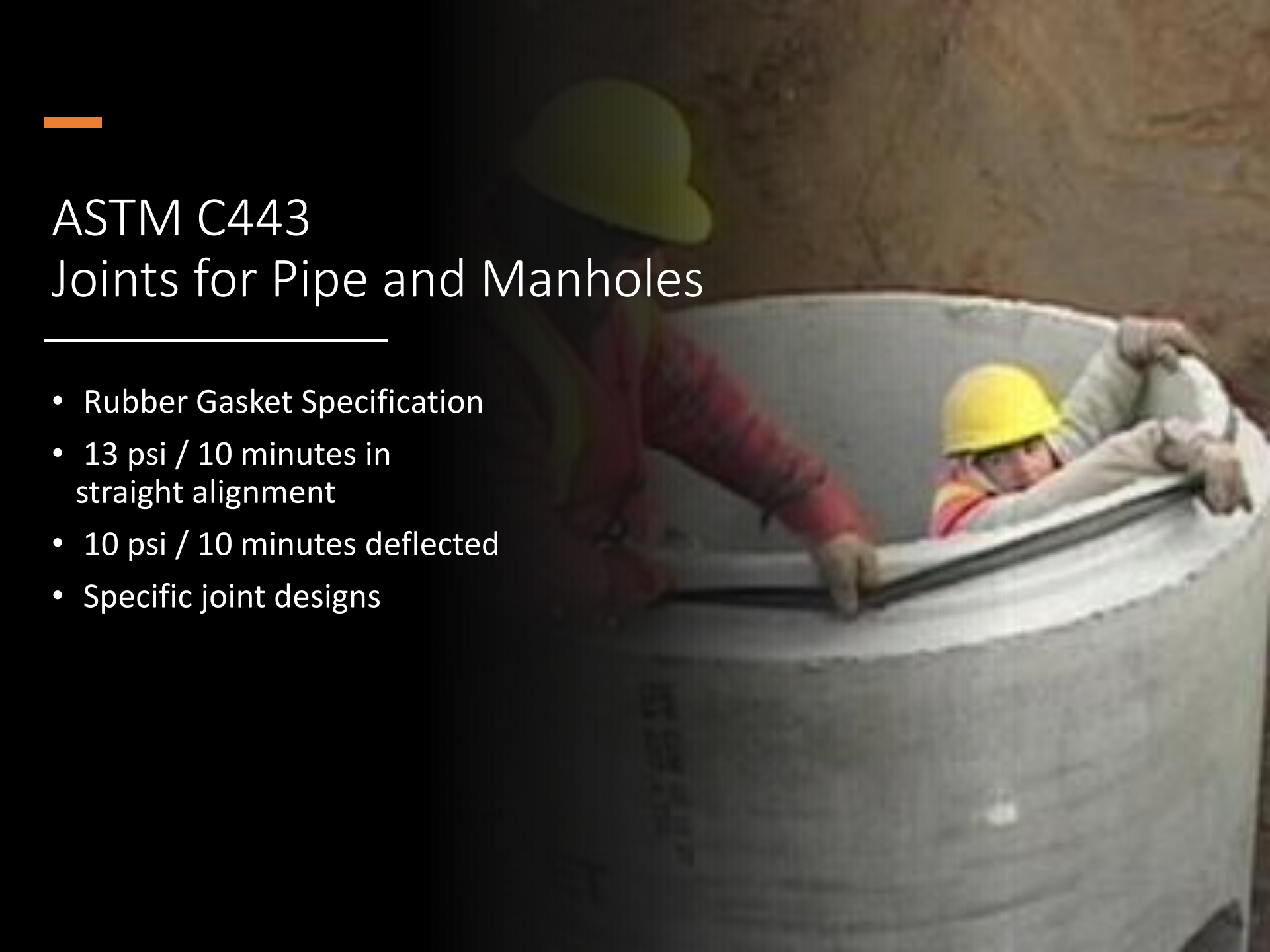
Leak Resistant

Watertight

- Holds water under pressure
  - 4 psi
  - 10 psi
  - 13 psi
  - >13 psi

ASTM C443
Joints for Pipe and Manholes

- Rubber Gasket Specification
- 13 psi / 10 minutes in straight alignment
- 10 psi / 10 minutes deflected
- Specific joint designs



ASTM C990
Preformed Butyl Tape

- 10 psi / 10 minutes
- Self-Adhesive
- Fills irregular joints
- Testing to meet the ASTM C443 requirements

NOTE 1—This specification covers only the design and material of the sealing bands. Sealing bands covered by this specification are adequate, when properly installed, for external hydrostatic pressures up to 13 psi, (30 ft) without leakage. The amount of infiltration or exfiltration flow in an installed pipeline is dependent upon many factors other than the sealing bands; allowable quantities and suitable testing of the installed pipeline and system must be covered by other specifications.

ASTM C877 External Sealing Band

- Positive side water resistance to 13 psi
- Prevents “silting” of fines in the soil
- Available in Type I, Type II, and Type III

Type I

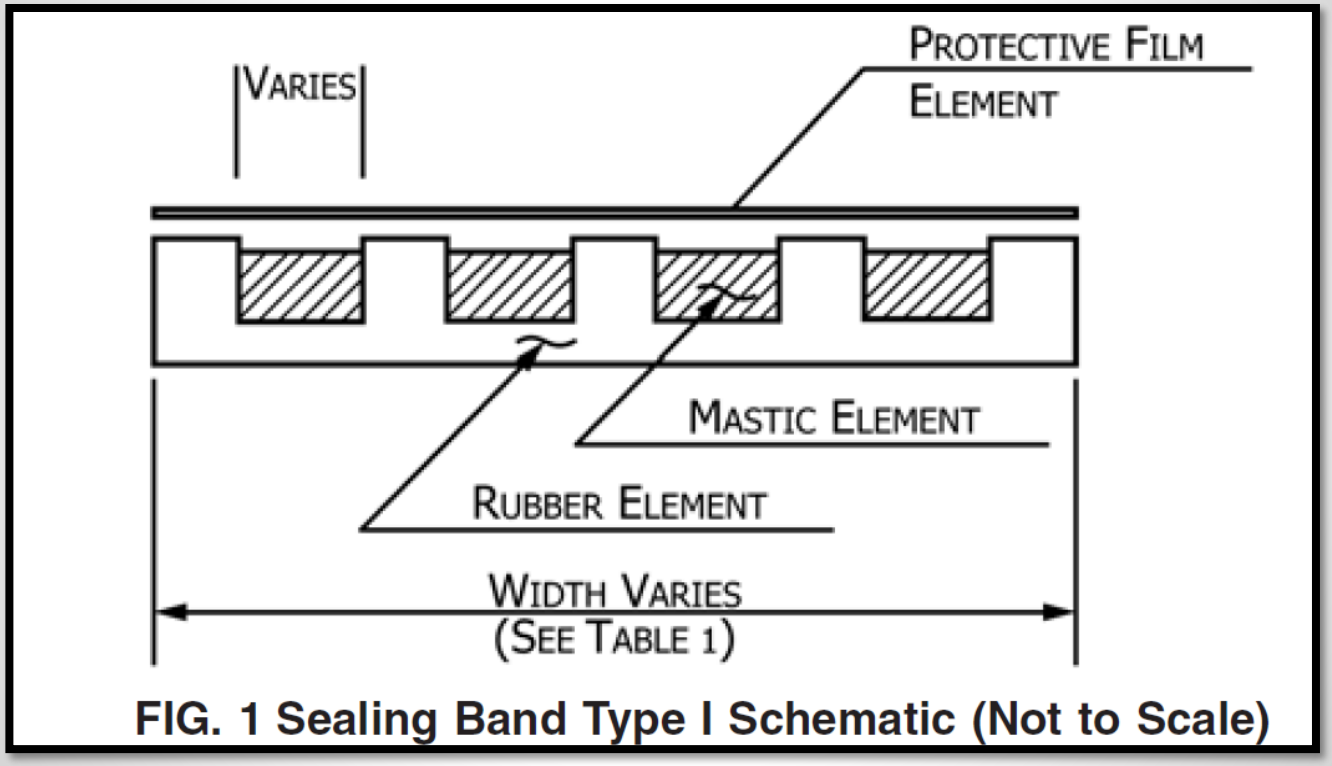


FIG. 1 Sealing Band Type I Schematic (Not to Scale)

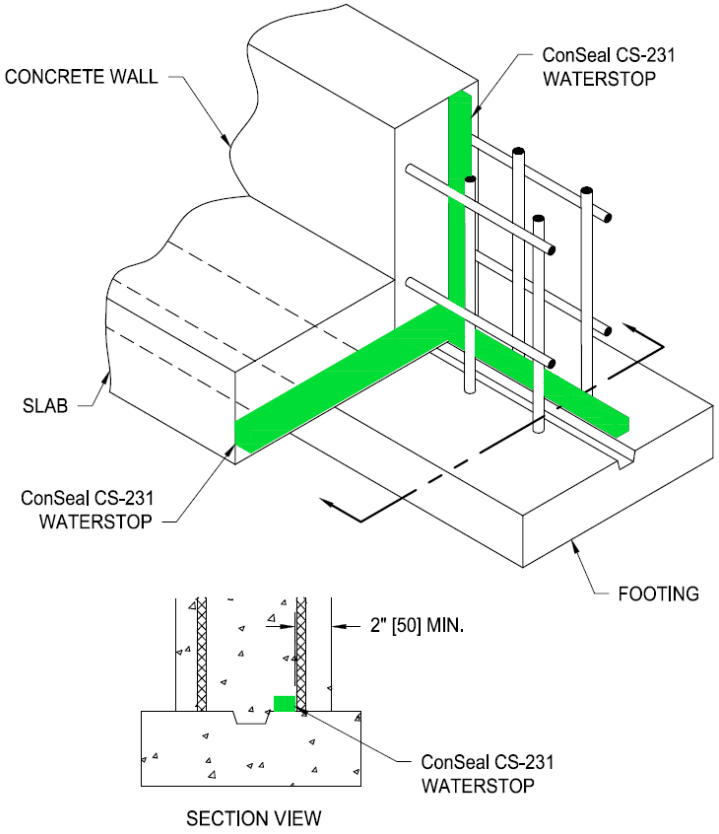
Type II

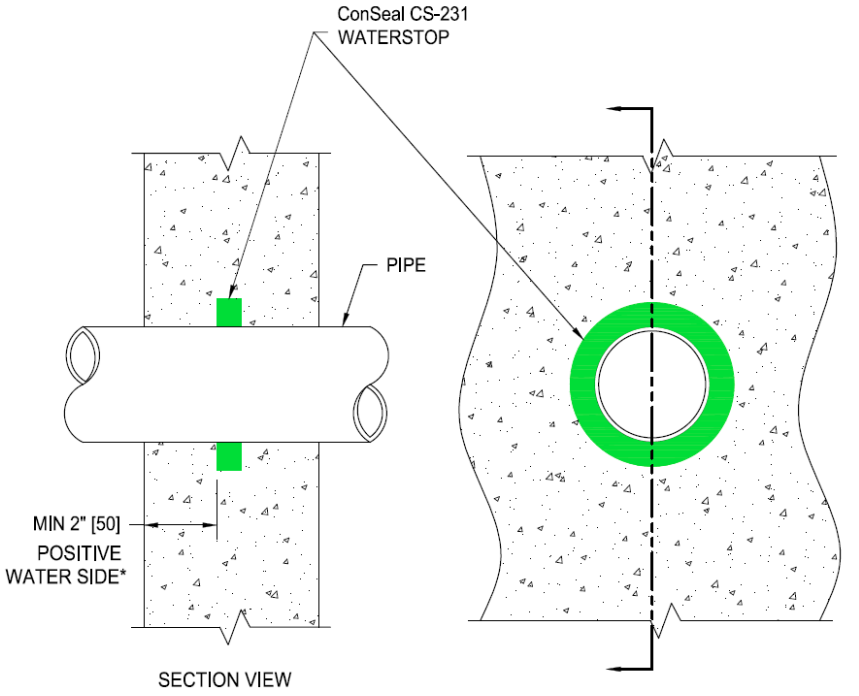
Type III

ASTM C920
Elastomeric Joint Sealants

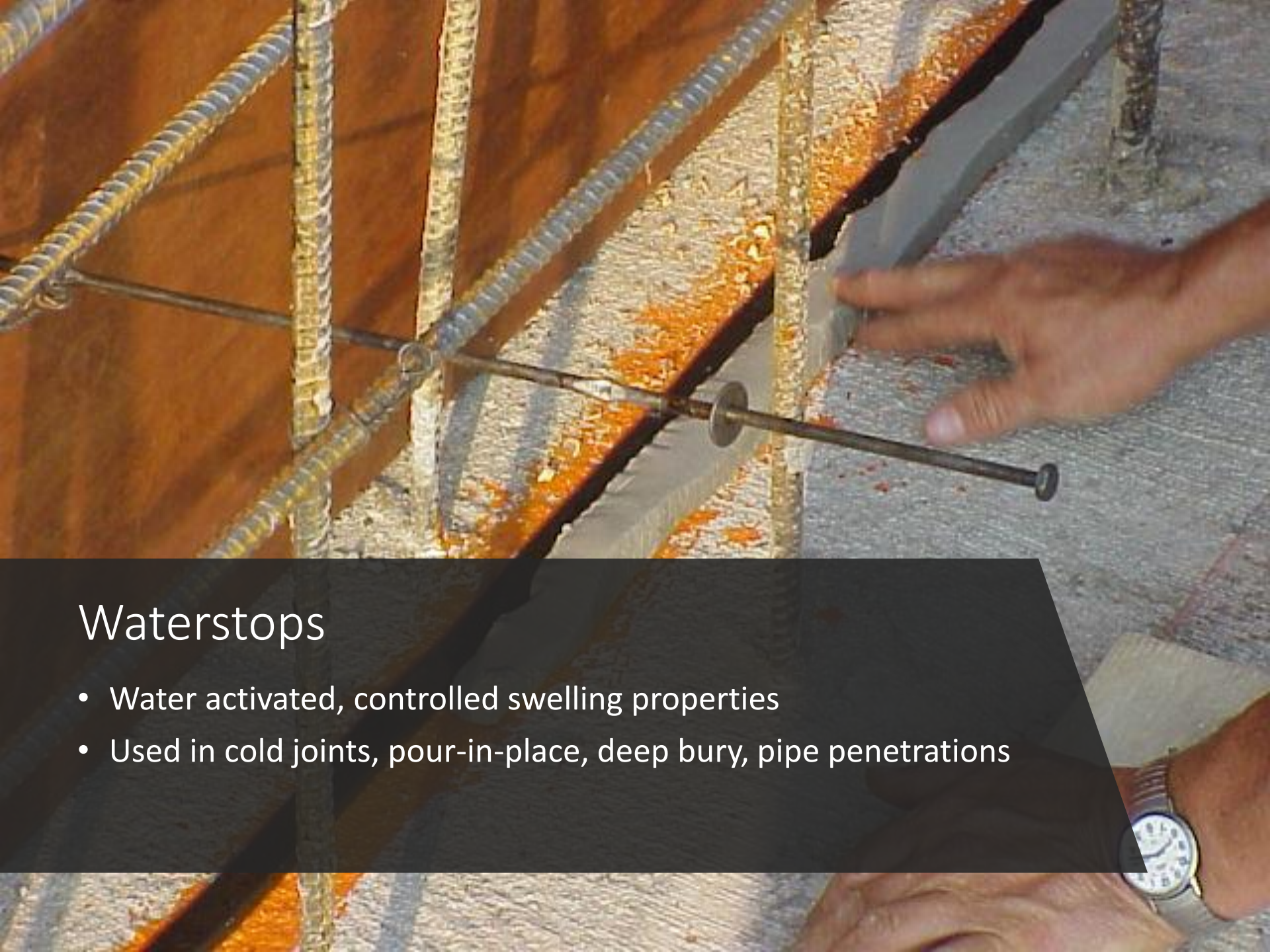
- Expansion capabilities based on class of material
- Bonds to concrete, glass, aluminum, and more depending on type of material
- Can have high tensile strength
- Can hold high water pressure
- Types:
  - Silicone
  - Polyurethane
  - Modified Silicone (hybrid of polyurethane & silicone)

Waterstops





* The sealant will expand toward the infiltrating water to cut-of the flow. The minimum cover on the negative (dry) side can be reduced to 1" in some applications.



Waterstops

- Water activated, controlled swelling properties
- Used in cold joints, pour-in-place, deep bury, pipe penetrations

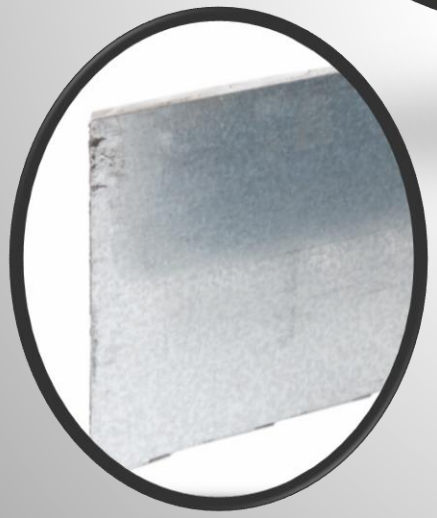
Waterstop Types

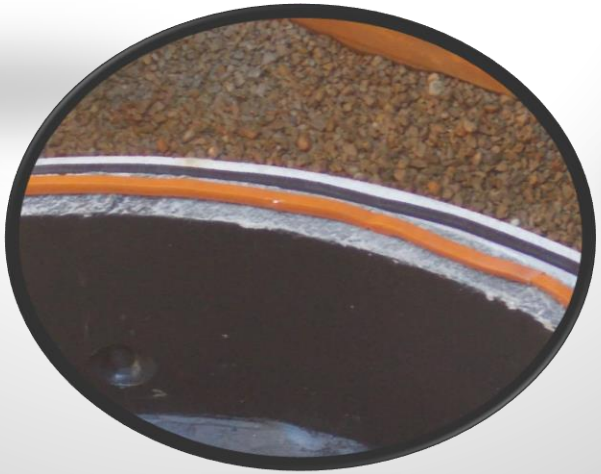
Cast-in concrete

- PVC
- Metal

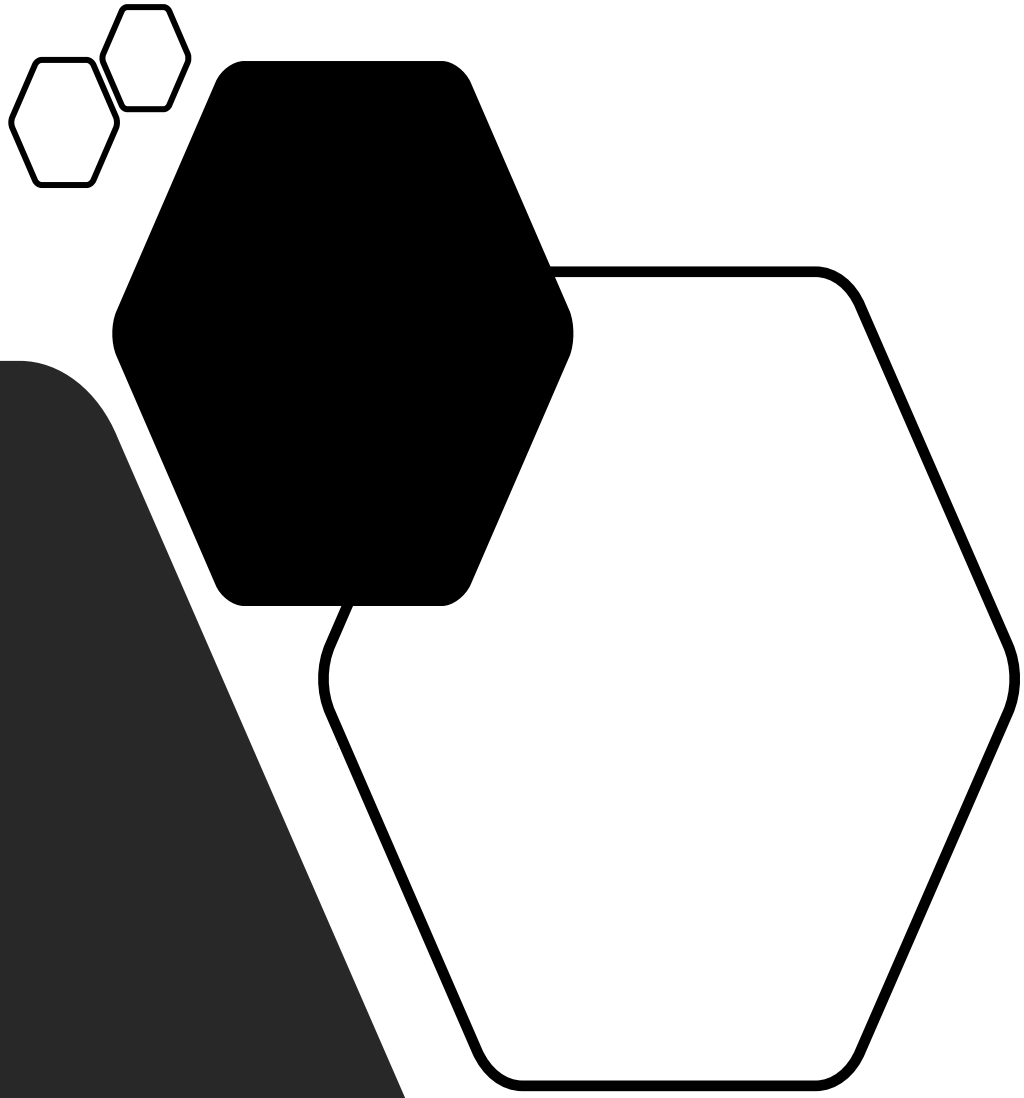
Placed on concrete

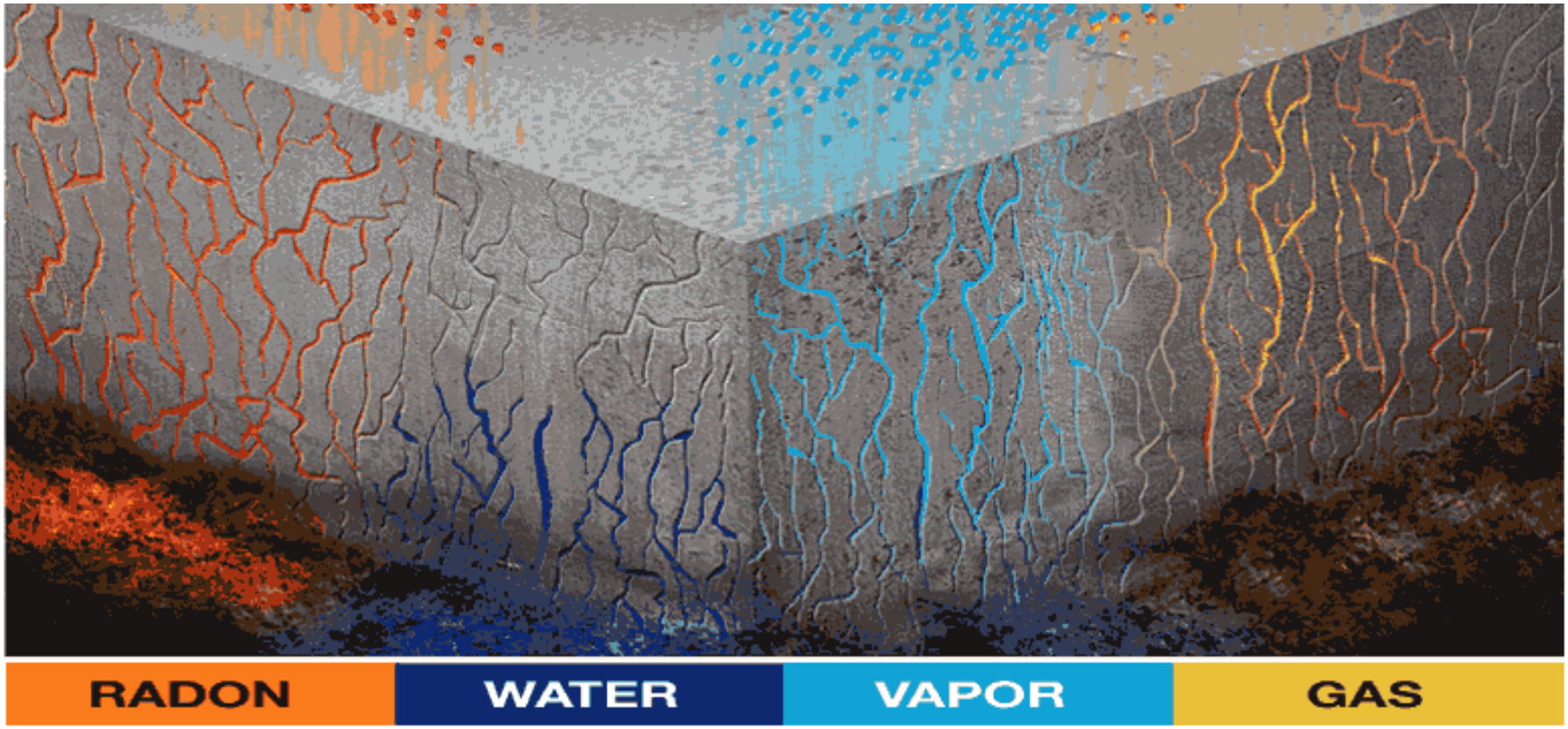
- Extruded Mailable Strip
- Extruded Cured Rubber Strip
- Gun Grade



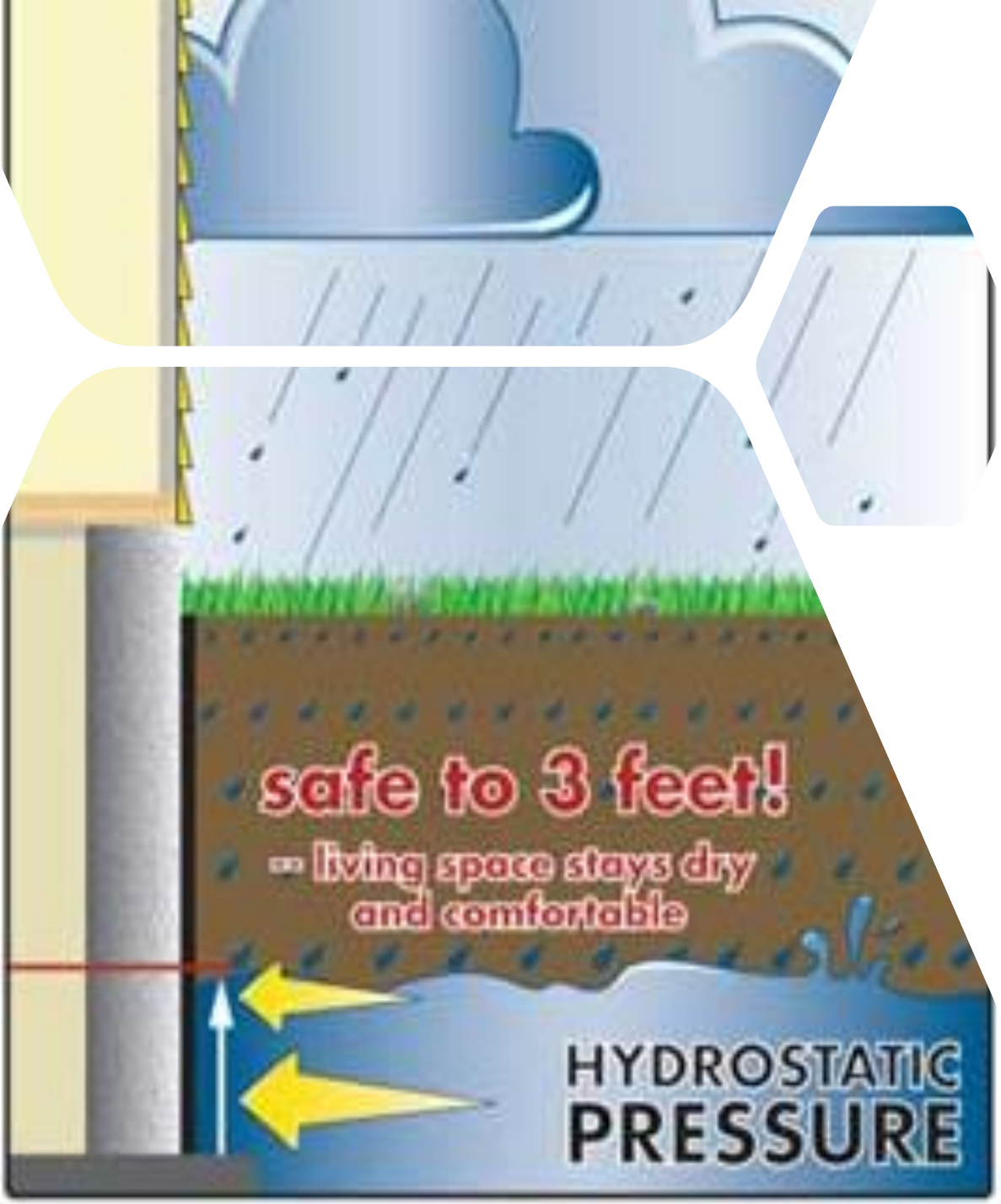


Concrete Porosity





Concrete is Porous



Waterproof or Dampproof

- Hydrostatic condition
- Below/Above grade
- Coating thickness

Waterproof Definitions

- “Building codes typically require that basement walls be dampproofed for conditions where hydrostatic pressure will not occur, and waterproofed where hydrostatic pressures may exist.”

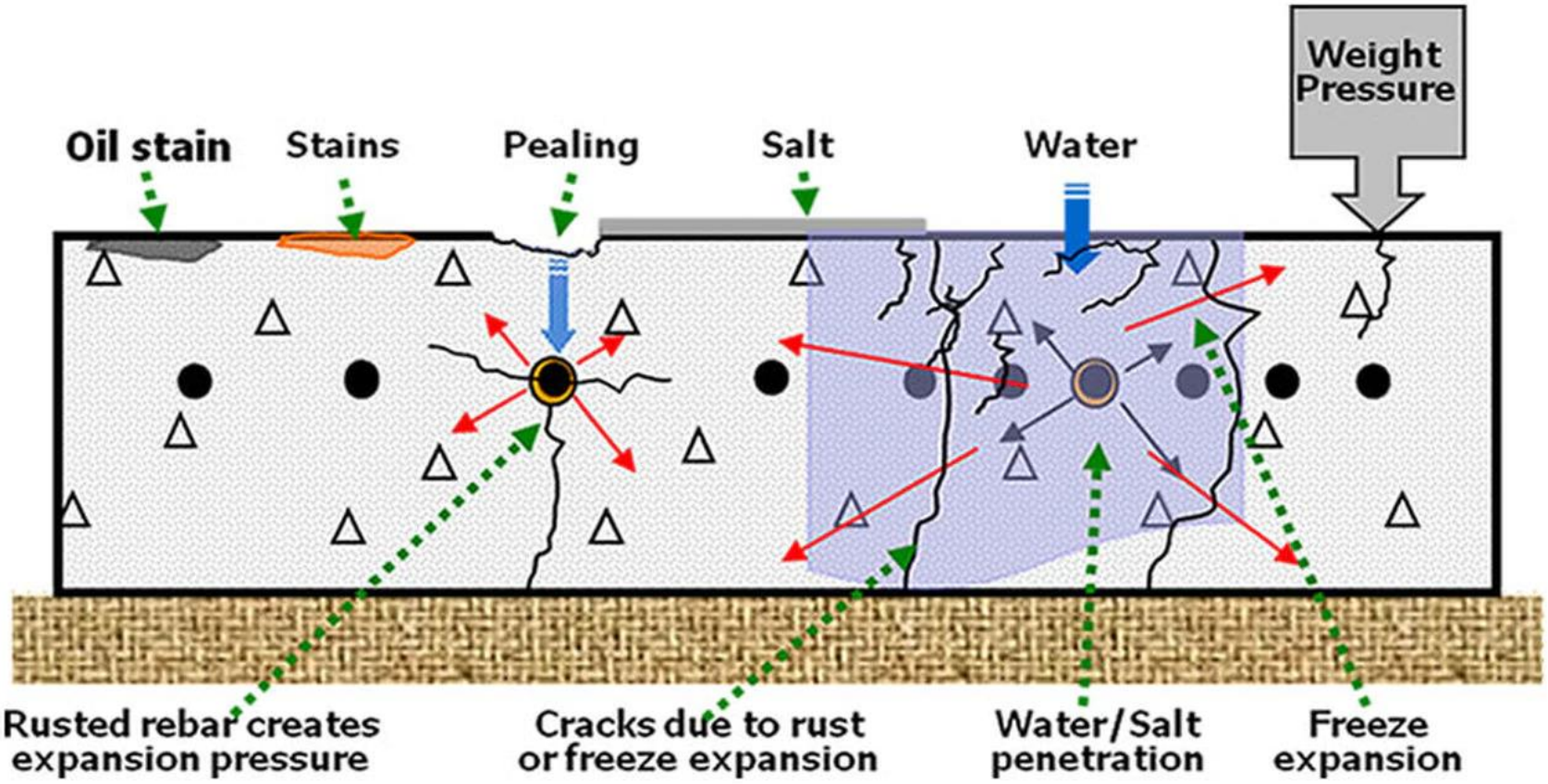
  - National Concrete Masonry Association

Waterproof Definitions

- Waterproofing coatings are typically 40 mils or greater in thickness.
- Dampproofing coatings are generally thin: around 12 mils or less.
- Resistant to hydrostatic pressure.

Can anything truly be waterproof?

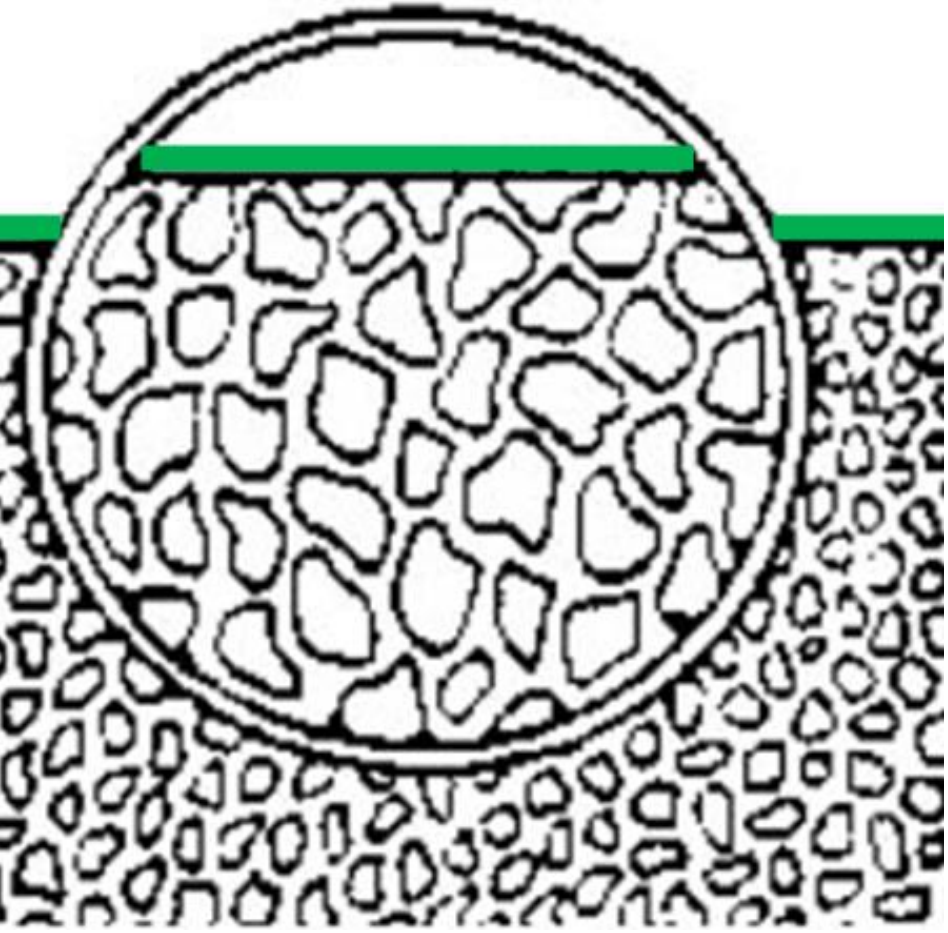
Why Seal Concrete?



A Variety of Technologies

- Coatings/paints
  - Acrylics
  - Epoxies
  - Urethanes
  - Asphalt
- Cementitious coatings
  - Portland based
  - Special materials

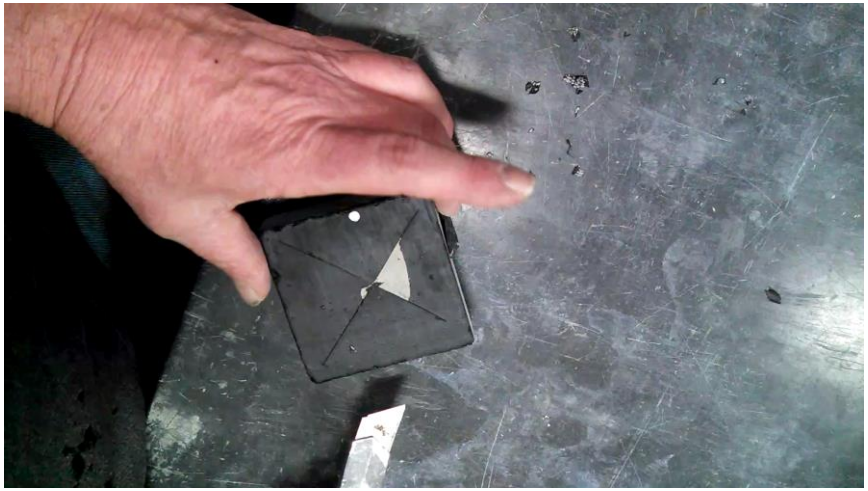
- Sealers
  - Silane
  - Siloxane
  - Silicas
  - Combinations
- Admixtures
  - Waterproofing
  - Antimicrobial
  - Strength enhancing



Coatings vs. Sealers

Coatings Challenges

- Delamination
- Excessive Concrete moisture
- Concrete dirty or dusty
- Form release agent on the concrete
- Forming surface



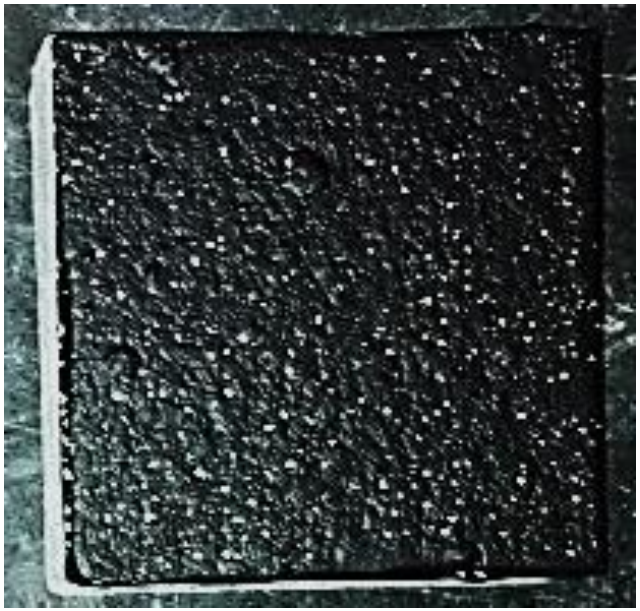
Bad Adhesion

Good Adhesion

The “X” Adhesion Test

Coating Problems

- Outgassing
  - Air escapes from concrete
  - Pinholes, typically in thin coatings

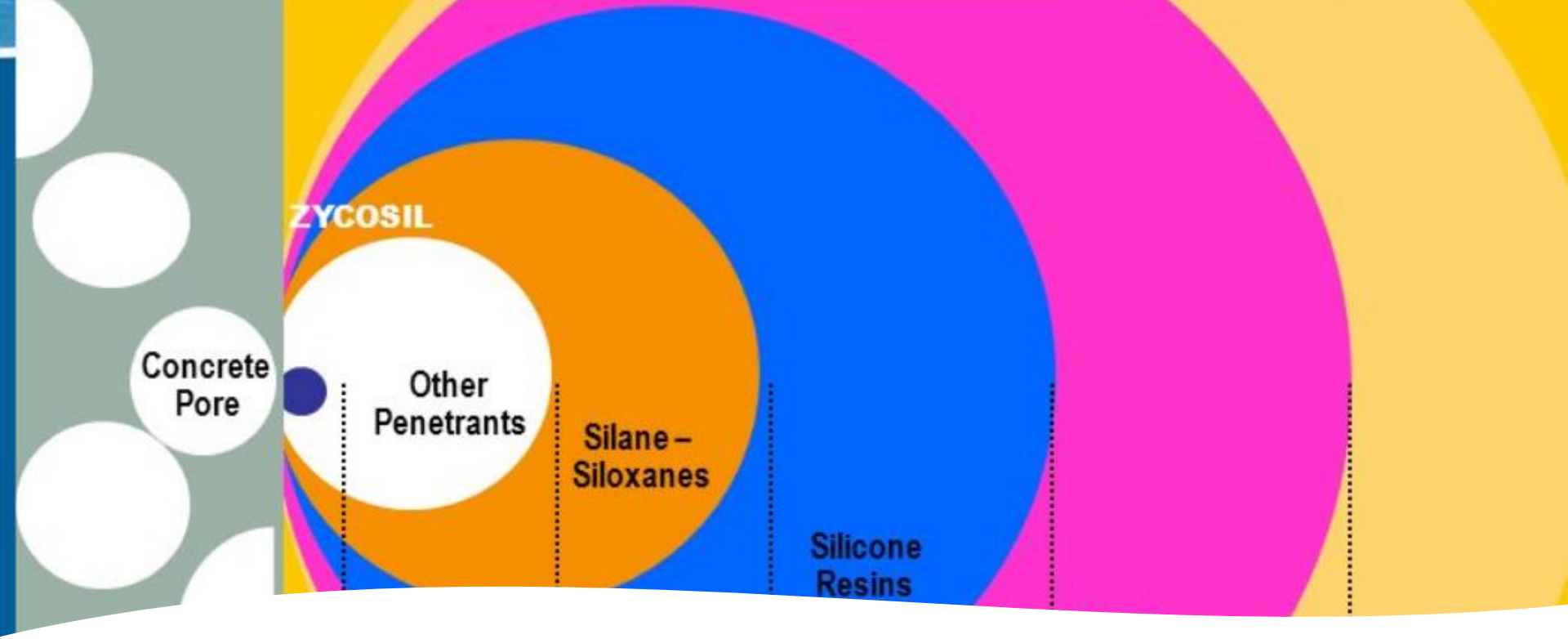


Cementitious Coatings

Cement based coatings bond well to concrete. They often fill the small voids in the concrete. They offer a thicker coating than some paints.

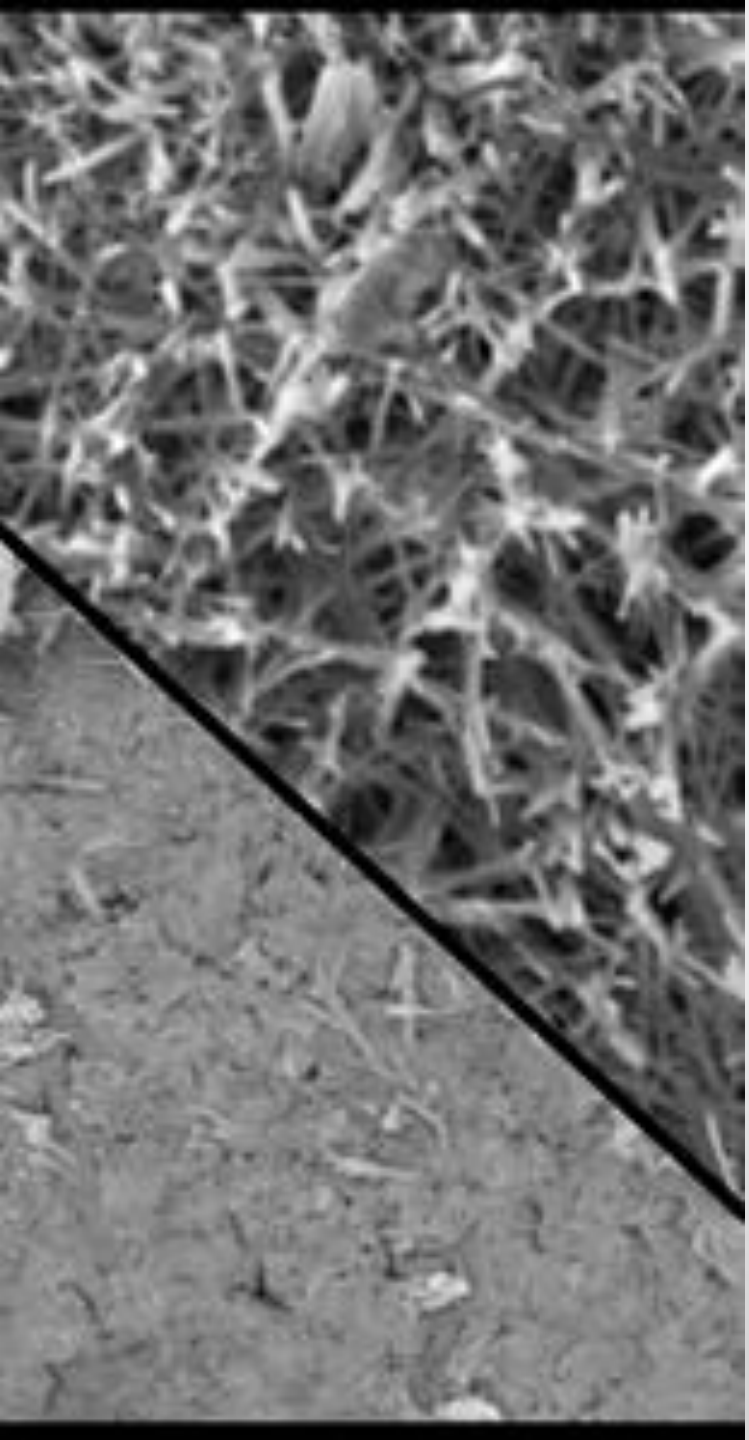
Cold Applied Waterproofing Membrane

- ASTM C836
- Elastomeric (flexible)
- Resists Hydrostatic Pressure
- 40 – 60 Mils Typical
- Single and Two Component Systems



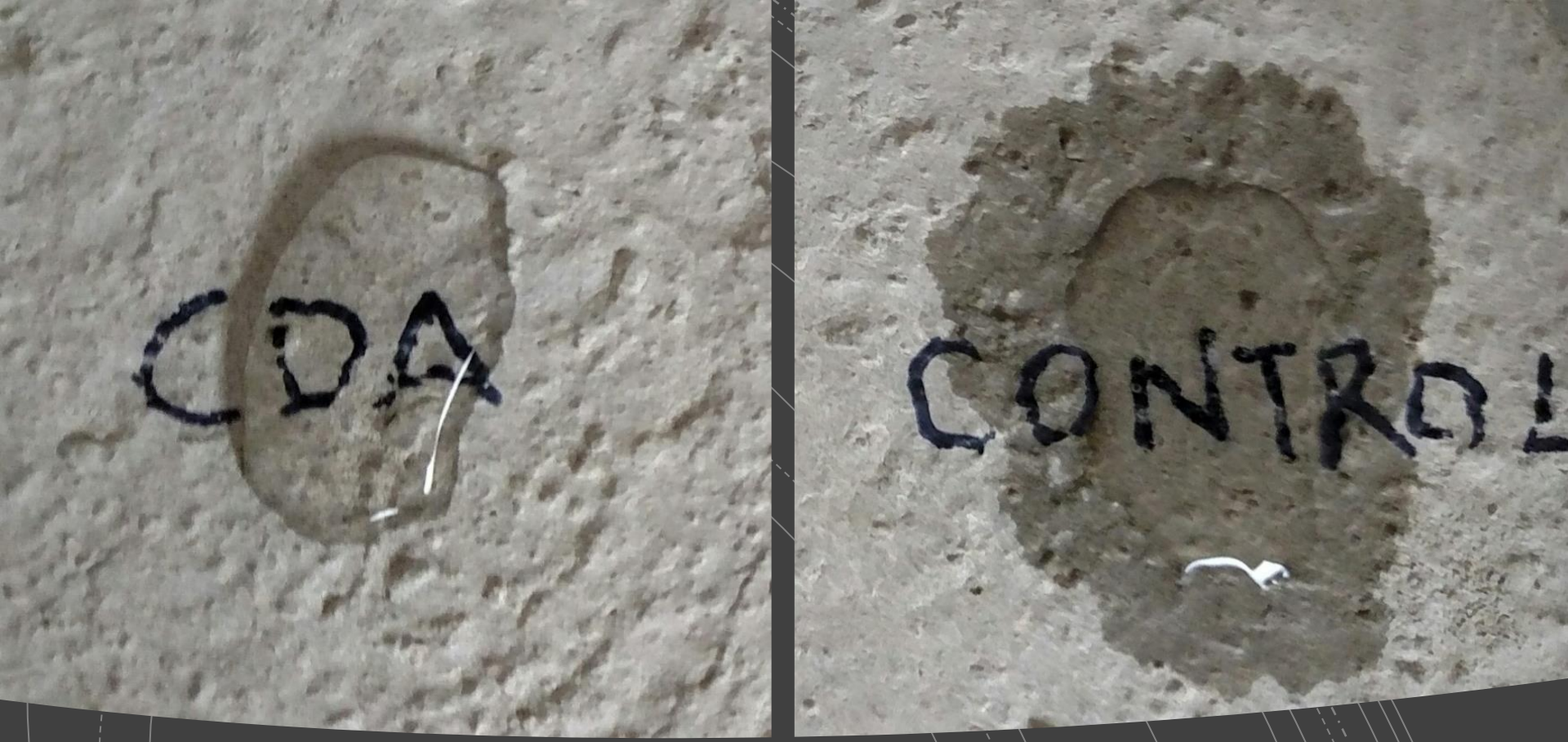
Sealers for Concrete

Penetrating sealers come in different sizes. Smaller molecules penetrate deeper, some are reactive, and some create hydrophobicity.



Integral Waterproofing

- Concrete admixture (powder/liquid)
- Works internally, reacts chemically
- Crystals created to block the pores
- Waterproof [CRD C48]
- Low Permeability [ASTM C1585]



Waterproofing from the inside

Microbially Induced Corrosion of Concrete (MICC): Causes, Research, Testing, and Solutions

What is it?

What causes it?

Where is it most common?

Cast-in-place - 1958
(62 years old)
8.5 feet tall
30 inches thick

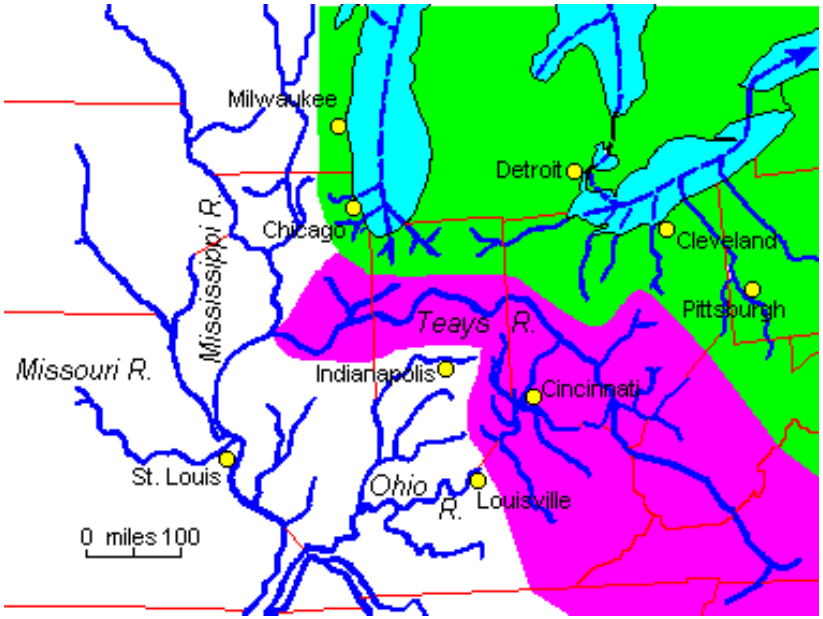
CSO turbulence
(hydraulic jump)
released H2S gas

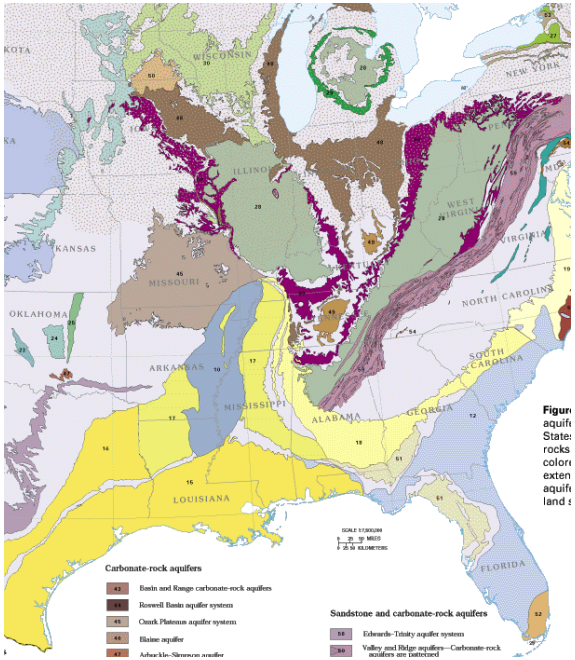
10 inches / 250 mm
of concrete was
lost due to MICC
(4 mm per year)

Inside the MSD Ohio River Interceptor —
Concrete and rebar pipe wearing away, rebar should not be visible

Old Water = Low Oxygen

- Artesian Wells
- Shale Deposits





Low Oxygen, H2S, and Shale Gas Resources

Pressurized Formations

Sometimes in drilling programs there are formations that are encountered that are not expected. They may be flowing artesian formations or formations containing natural gasses such as carbon dioxide, methane, or hydrogen sulphide (H2S).

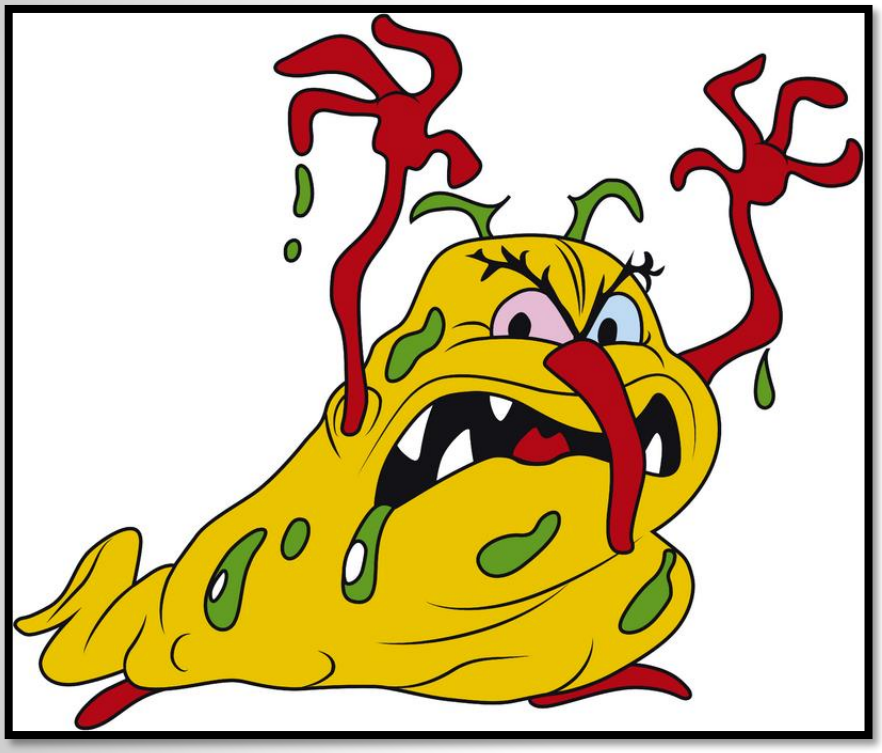
Encountering these gasses creates some very unique problems. Carbon dioxide gasses, in sufficient quantities, can create a low oxygen atmosphere and create a safety hazard. Methane gasses, in quantities, can create an explosive atmosphere as well a fire hazard. H2S in very low percentages can cause suffocation and possibly death. The possibility of encountering these formations increases when working on the east side of the Rockies (e.g. the Peace River area) in northern B.C. where shale gas resources are known to exist.

www.bcgwa.org/flowing-artesian-water-well-control-methods/

The Goal:
>100 Year
Life Cycle

Concrete Corrosion

Mr. “T” Thiobacillus



Sulfur Oxidizing Bacteria

THIOPARUS

INTERMEDIUS

NOVELLUS

NEAPOLITANUS

THIOOXIDANS

What is the cause?

- **Microbially Induced Corrosion** (C.D. Parker 1947)

  1947 Mar 29;159(4039):439. Species of sulphur bacteria associated with the corrosion of concrete.

  PARKER CD. PMID: 20340258

- H_2S, Hydrogen Sulfide gas, converted to

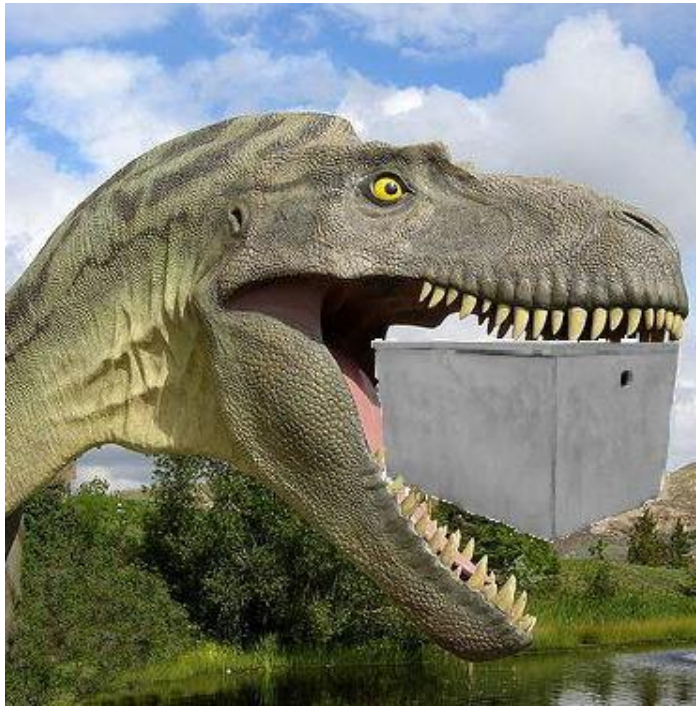
  H_2SO_4, Sulfuric Acid by **S**ulfur **O**xidizing **B**acteria

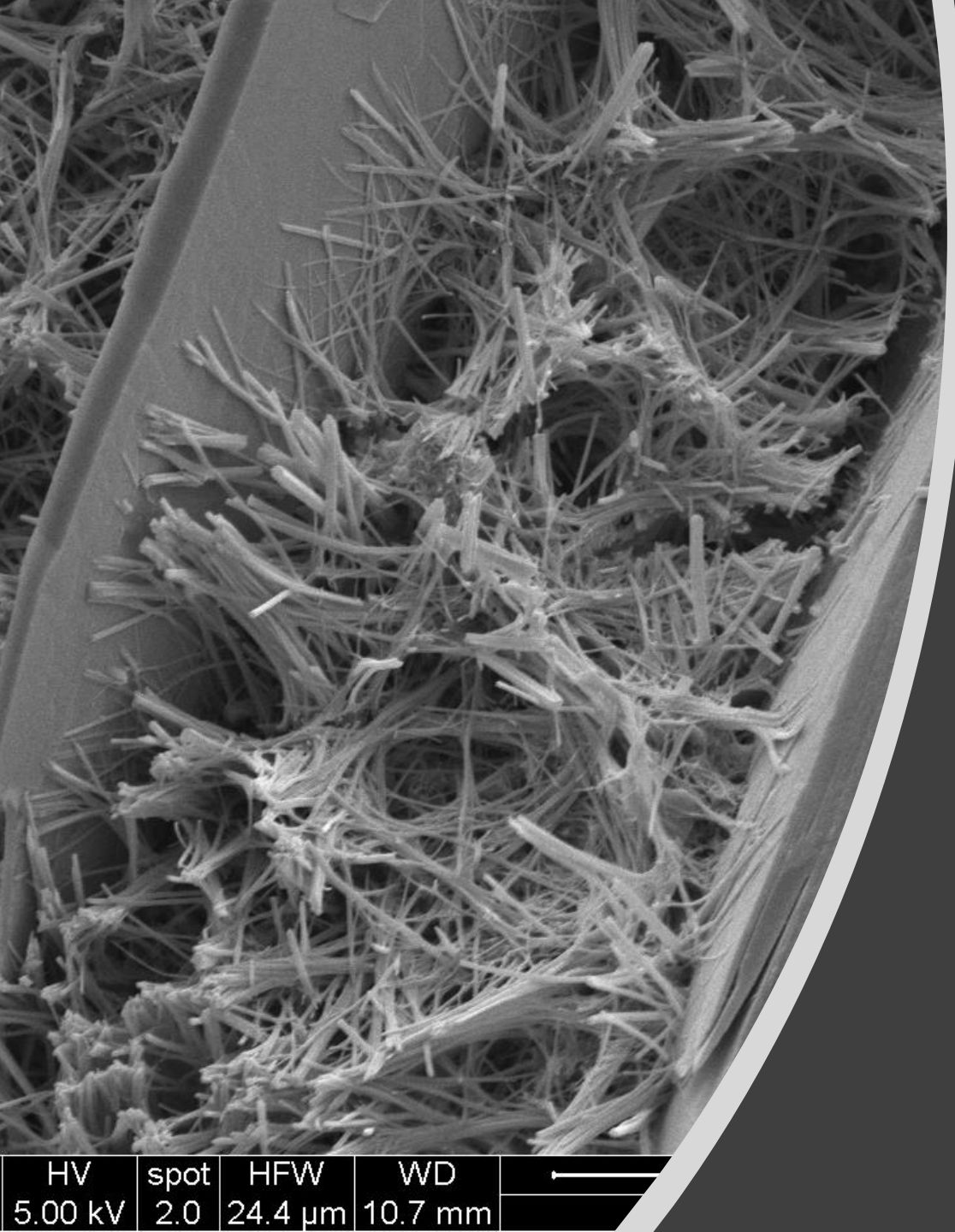
"…it cannot proceed under sterile conditions and can only be carried to the acid stage through the activity of this organism."

C.D. Parker

from Latin - “concrete eating”

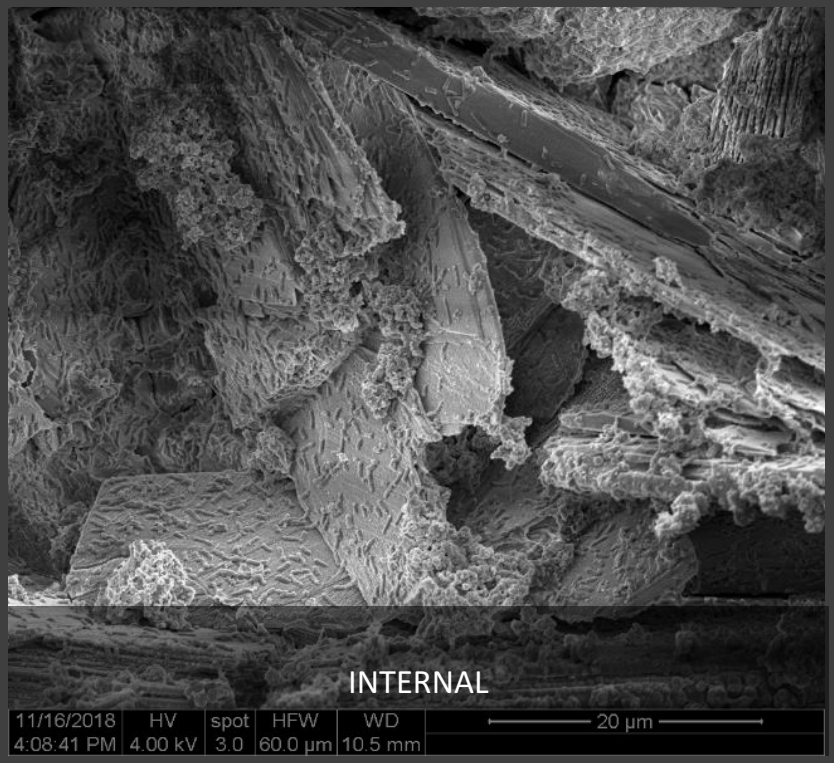
Concretivorous

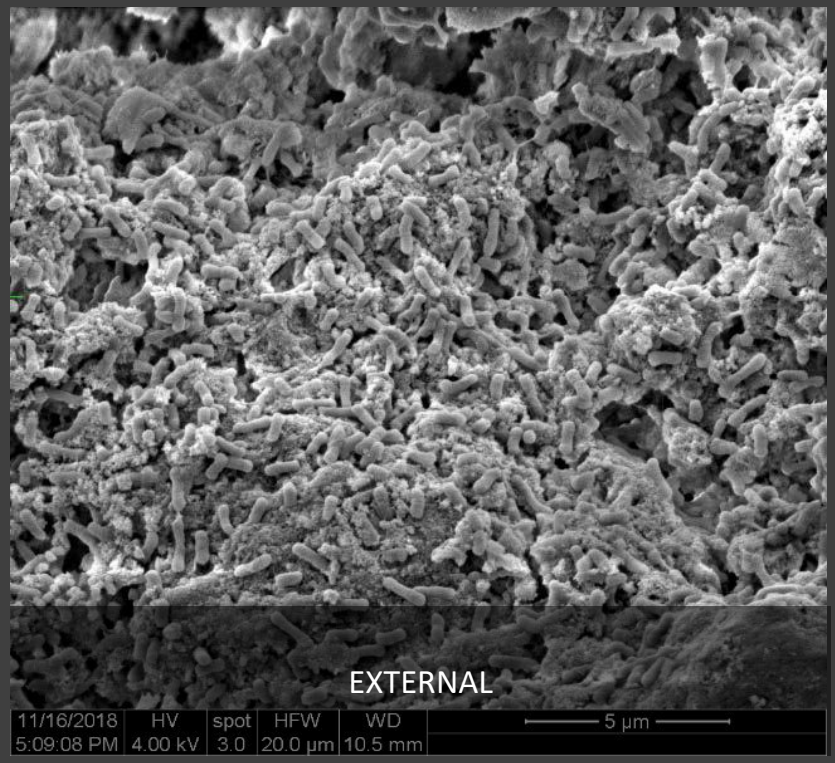


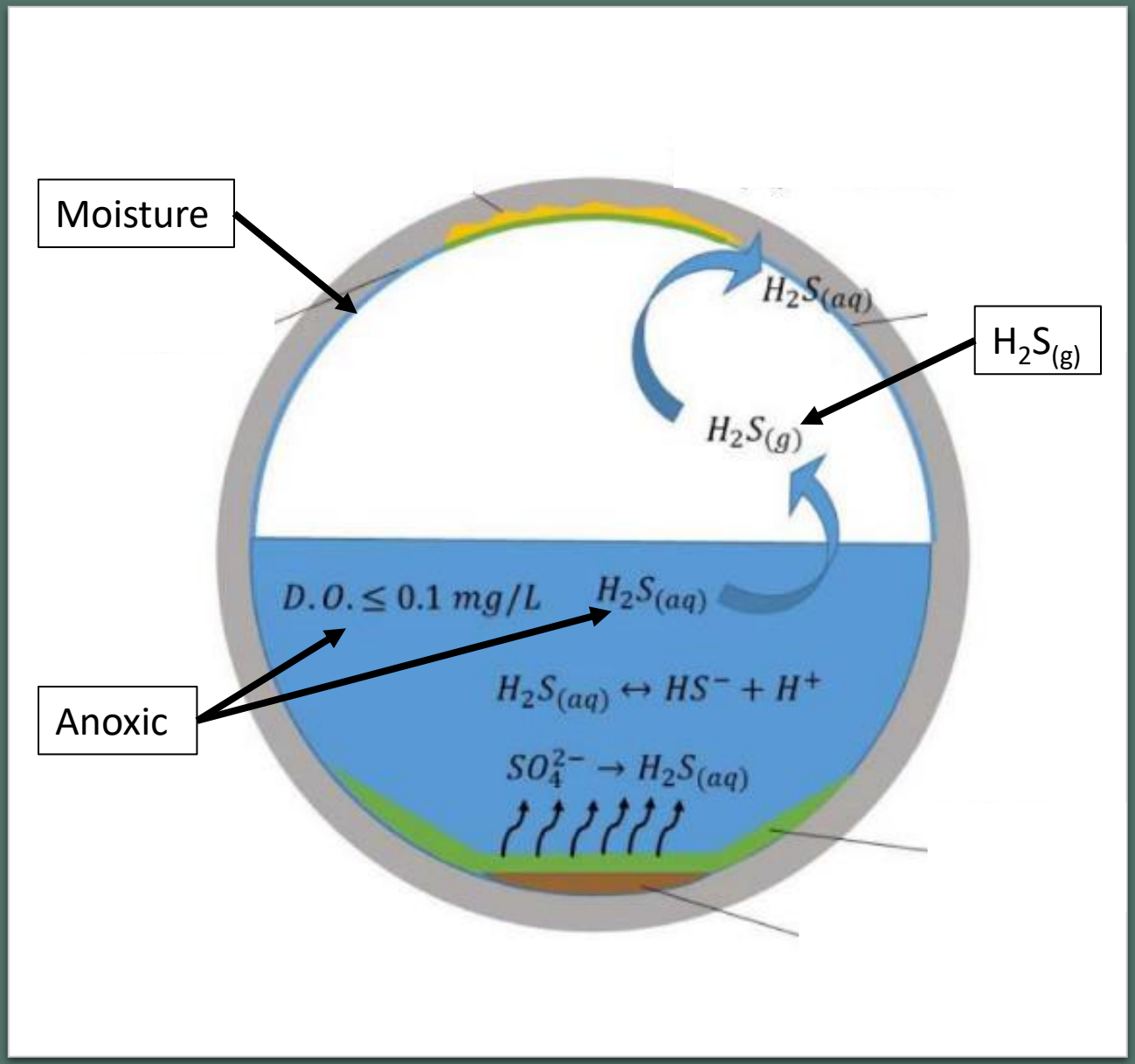


Microscopic Photo of New Concrete

Microscopic Photos of Concrete with MICC







MICC in a Sewer Pipe

University Research
2014-2020

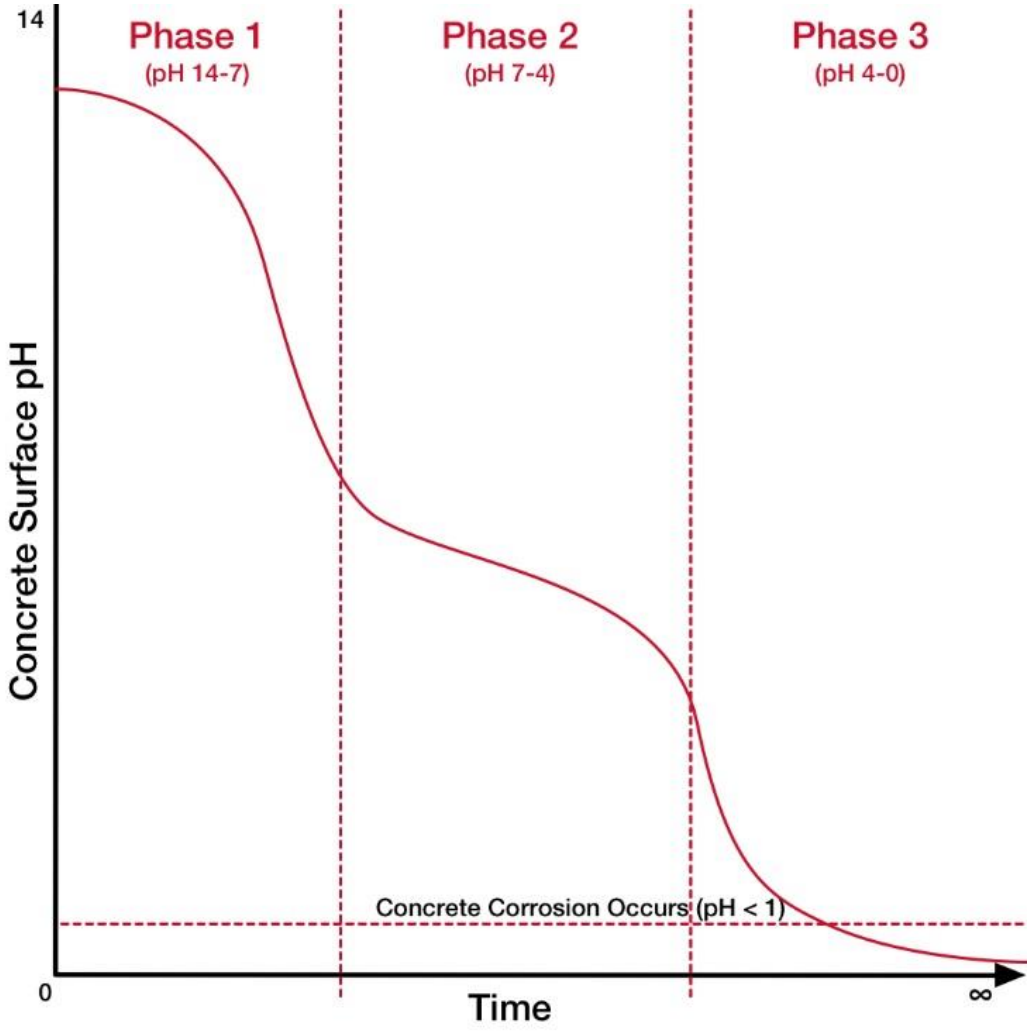
Purdue University
Pankow Materials Laboratory

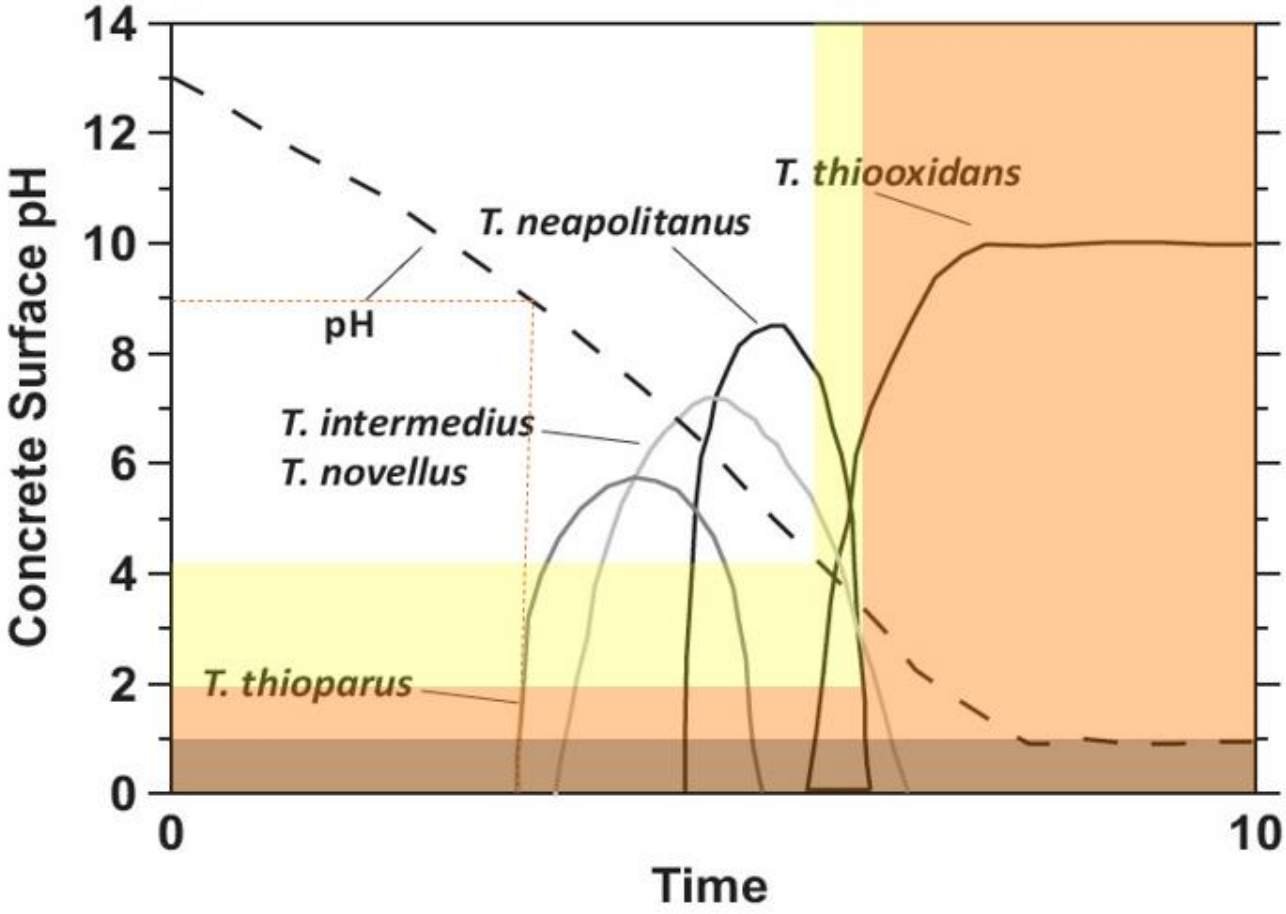
Dr. O. Burkan Isgor
Professor
John and Jean Loosley Faculty Fellow
Oregon State University
e-mail: **burkan.isgor@oregonstate.edu**

Oregon State University
College of Engineering

Dr. W. Jason Weiss
Head of Civil and Construction Engineering
Edwards Distinguished Professor of Engineering
Oregon State University
Head of the Kiewit Transportation Institute
e-mail: **jason.weiss@oregonstate.edu**

MIC Phases: Carbonation phase Attachment phase, Acid Generation phase



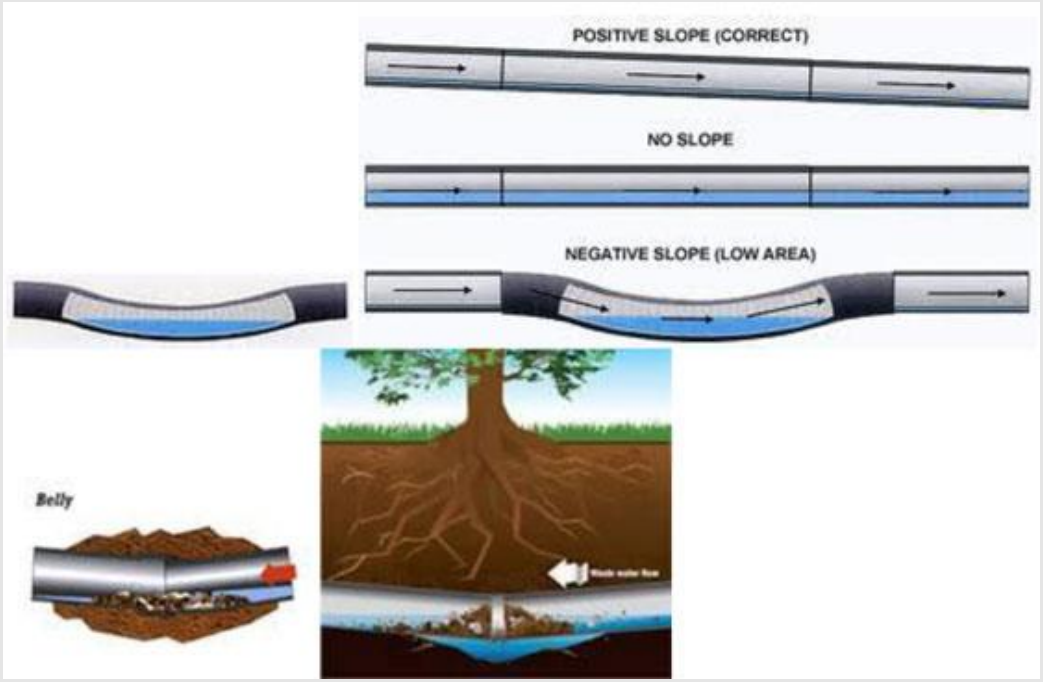


T. Thiooxidans begins to colonize

T. Thiooxidans is the only species

Severe Corrosion

Succession of Bacteria



MICC Environment Attributes

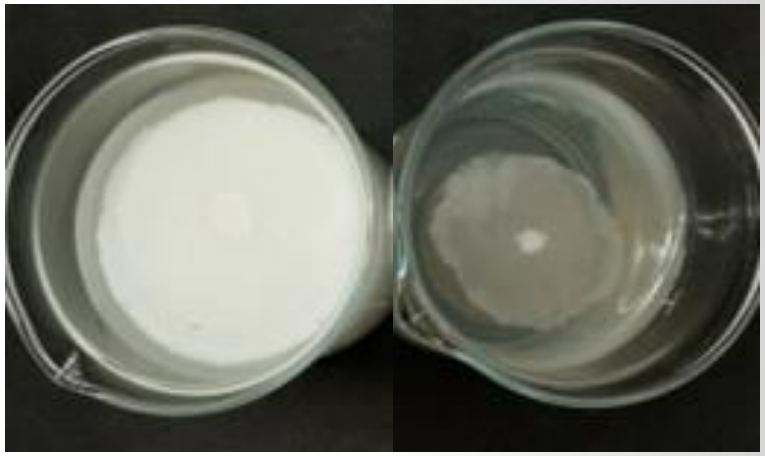
- High Biological Oxygen Demand
- High Sulfates in the sewage
- Warm effluent temperatures
- Turbulence in the flow
- Slow sewage flow
- Long retention time
- High relative humidity

Uncontrolled drop creates turbulence and release of H2S gas

Surface Applied Sealers

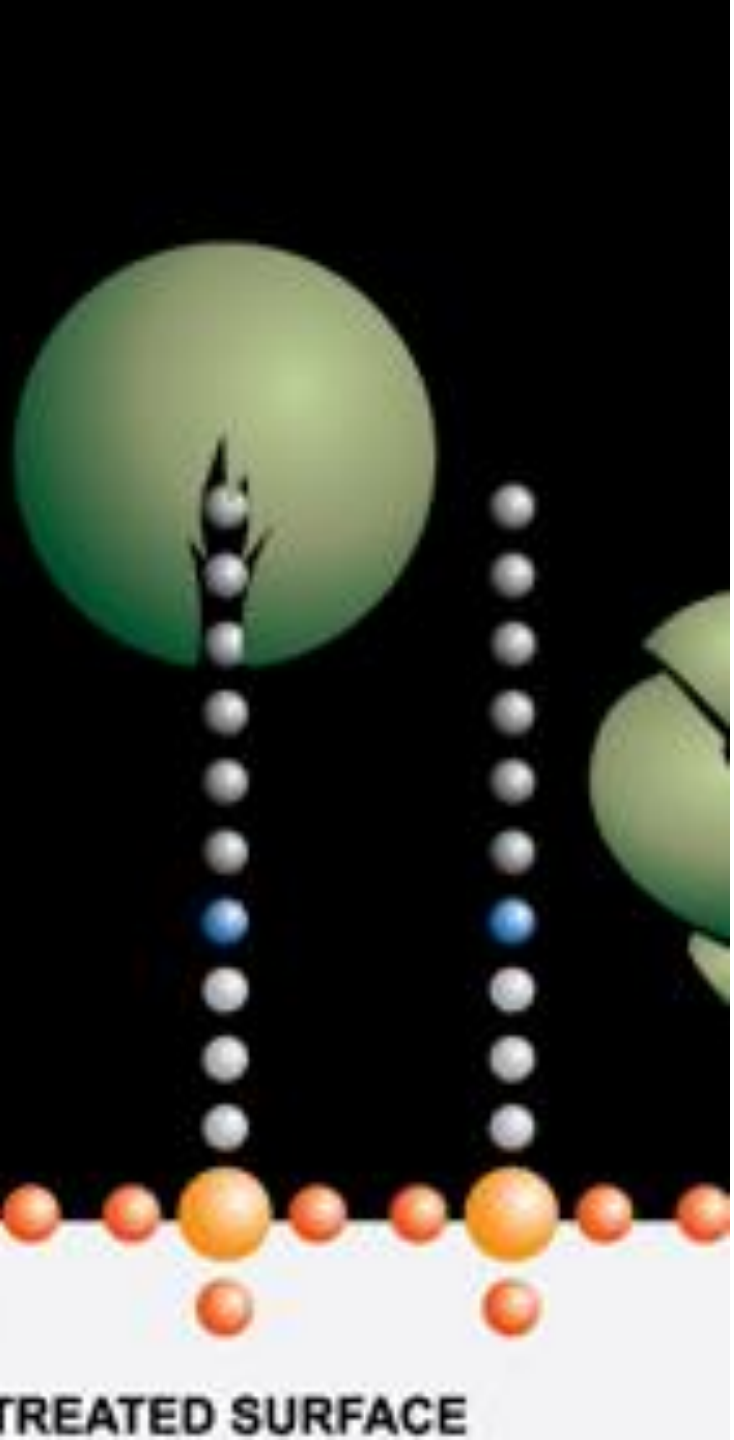
- Water repellants
- Biocidal / antimicrobial
- Surface densification
- Molecular layer
- First line of defense for MICC

Calcium Leaching (ASTM C1904-20)



Control Concrete Treated Concrete*

*Treated contains a US EPA registered antimicrobial concrete admixture with a topical water repelling concrete sealer containing a US EPA registered antimicrobial.



Quaternary Ammonium Compounds (QACs)

- Cationic Surface-Active Agents
- Silane base structure
- Used in textiles in the medial field to minimize germ transfer
- 1995 – Used as a concrete additive
- Kills greater than 99% of bacteria* that leads to Microbially Induced Corrosion

*In testing conducted by Situ Biosciences for Concrete Sealants, 99.4% of T. novella was mitigated in testing using ISO 22196 on concrete with a 6.5-6.8 pH.

Samuel Lines, MBA, LSSMBB
Engineering Manager
Concrete Sealants, Inc.
slines@conseal.com
1-800-332-7325

SEAL OF SECURITY
BOND OF TRUST
ConSeal™
Concrete Sealants Inc.
Don't Just Seal It. ConSeal It!