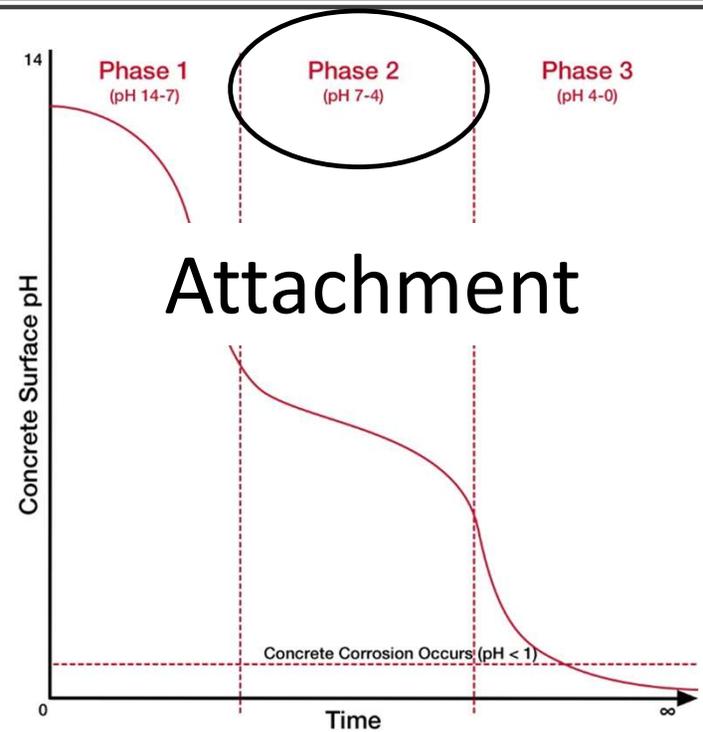




Microbially Induced Corrosion of Concrete (MICC): Efficacy of Antimicrobial and Colloidal Silica Admixtures

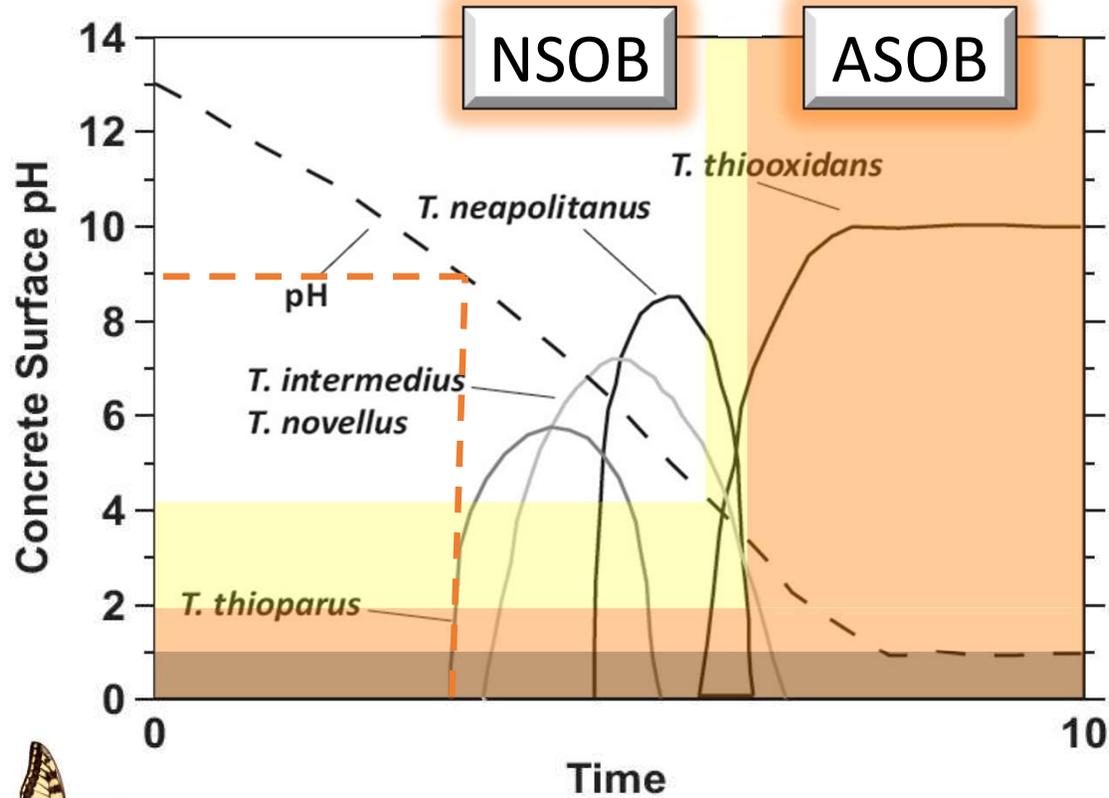
*Presented by:
Samuel Lines
Concrete Sealants, Inc.*

A Review of MICC: Three Stages





Succession of Bacteria



T. Thiooxidans begins to colonize

T. Thiooxidans is the only species

Severe Corrosion

House, M. Wiess, J. (2014). Review of Microbially Induced Corrosion and Comments on Needs Related to Testing Procedures. *4th International Conference on the Durability of Concrete Structures*.





What if the baton...

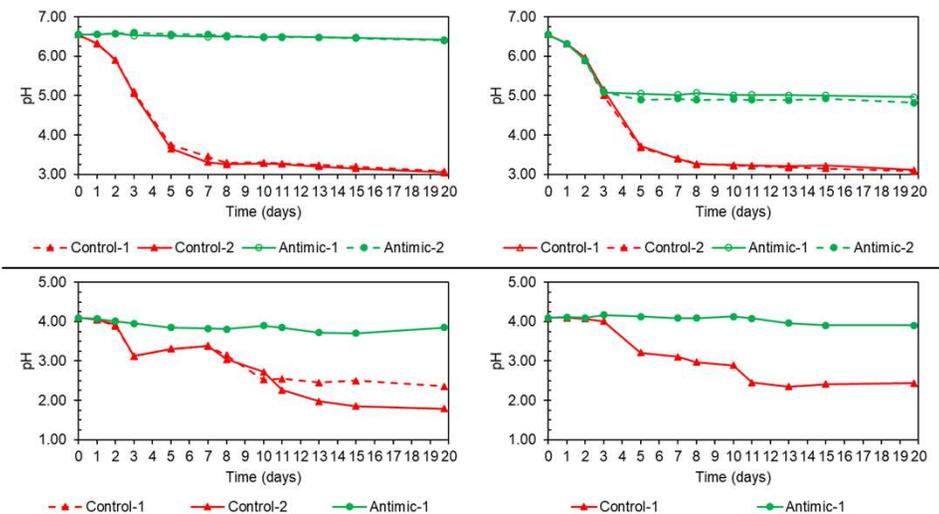


...never gets passed?

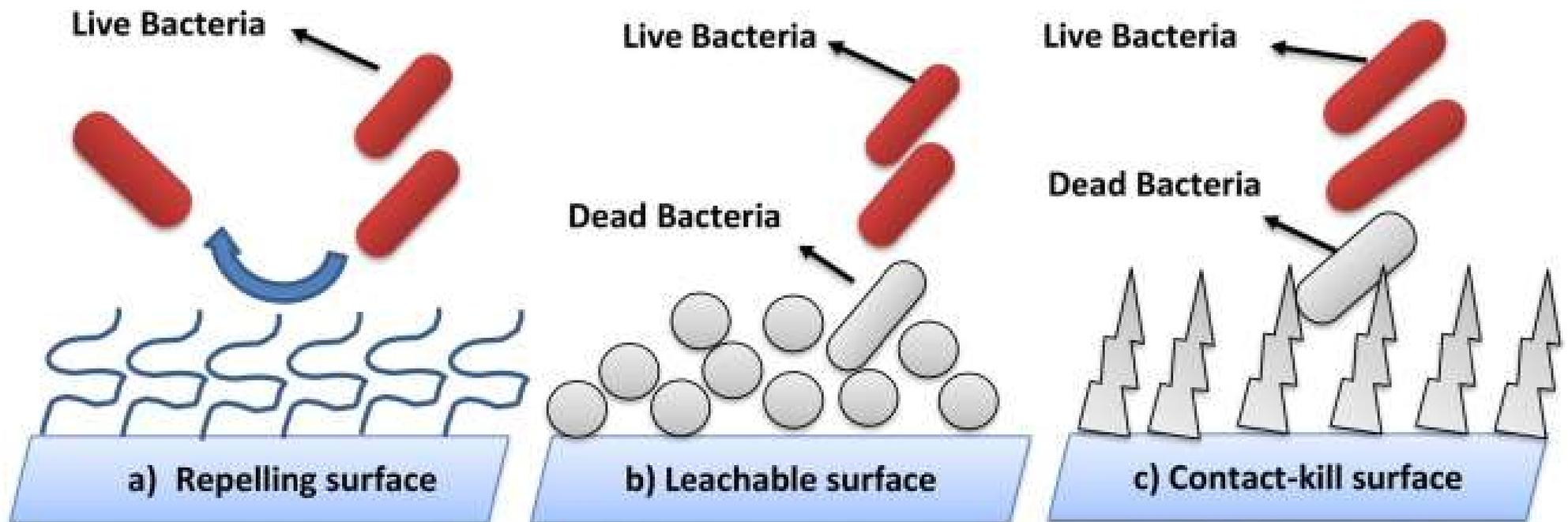
ASTM C1904-20 - Test Method A Antimicrobial Admixture

4.1 Bacterial enumeration

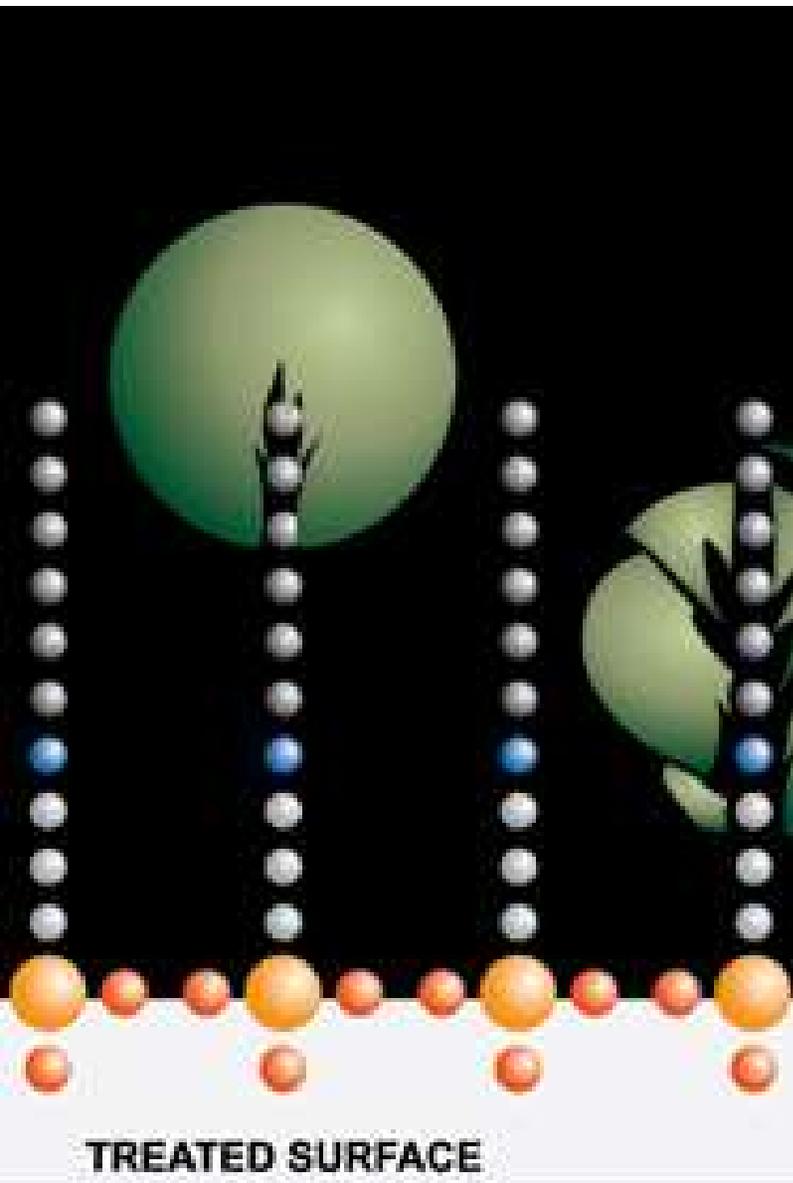
The bacteria present in the environments created (SL1, SL2, and SL3) were quantitatively assessed. Both NSOB and ASOB were enumerated in this study. However, it should be noted that NSOB are the dominant bacteria in the Stage II of MICC, which is the initiation of bacterial succession stage. The MICC process begins with the activity of NSOB, and if the antimicrobial is not effective during the early stages where NSOB is predominant, it would not be effective when conditions become more aggressive with lowered pH and high ASOB activity. Also, in order for ASOB to be active in deterioration, the environmental conditions must be suitable for their growth. Therefore, the activity of NSOB is essential for making the environment suitable for ASOB. Given that the antimicrobial additives are expected to prevent bacterial succession, they first need to combat with NSOB species.



Overview of Antimicrobial Technologies



Quaternary Ammonium Compounds (QACs)



- Cationic Surface-Active Agents
- Silane base structure
- Used in textiles in the medical 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.



PERSONAL CARE PRODUCTS



HAND SOAPS



PAINTS



EXERCISE MATS



FLOORING



APPAREL



FOOD STORAGE CONTAINERS



HOME TEXTILES



KEY PADS/BOARDS



KITCHENWARE



SCHOOL SUPPLIES



COUNTERTOPS

ASTM Standards C1898 and C1904

ASTM C1898-20

ASTM C1904-20

Stage 3 Test

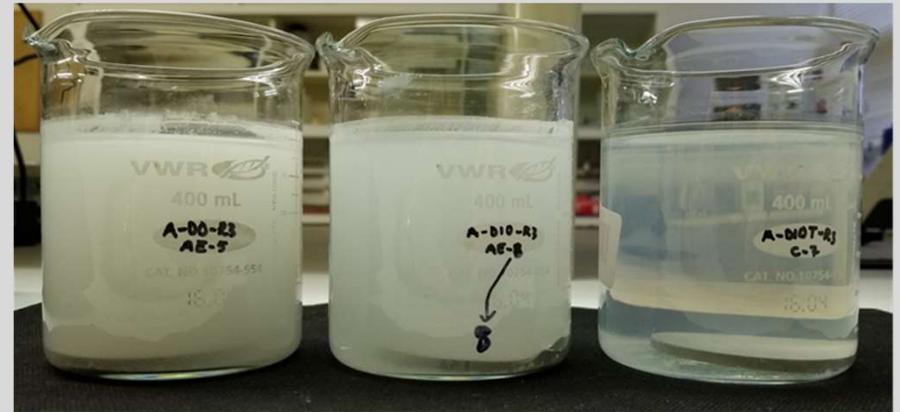


Coated

Control

After 90 days of immersion
0.5 pH sulfuric acid

Stage 2 Test



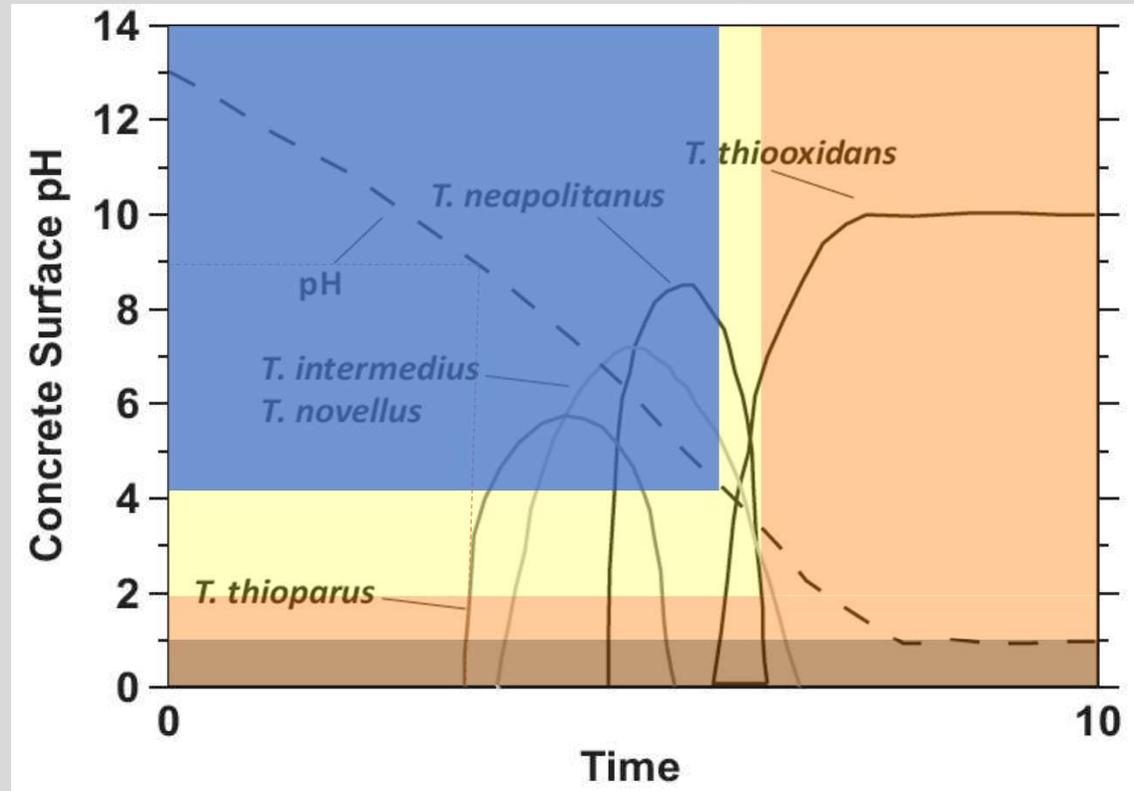
Control

Admixture

Admixture + Sealer

Succession of Bacteria

Where antimicrobials are most effective

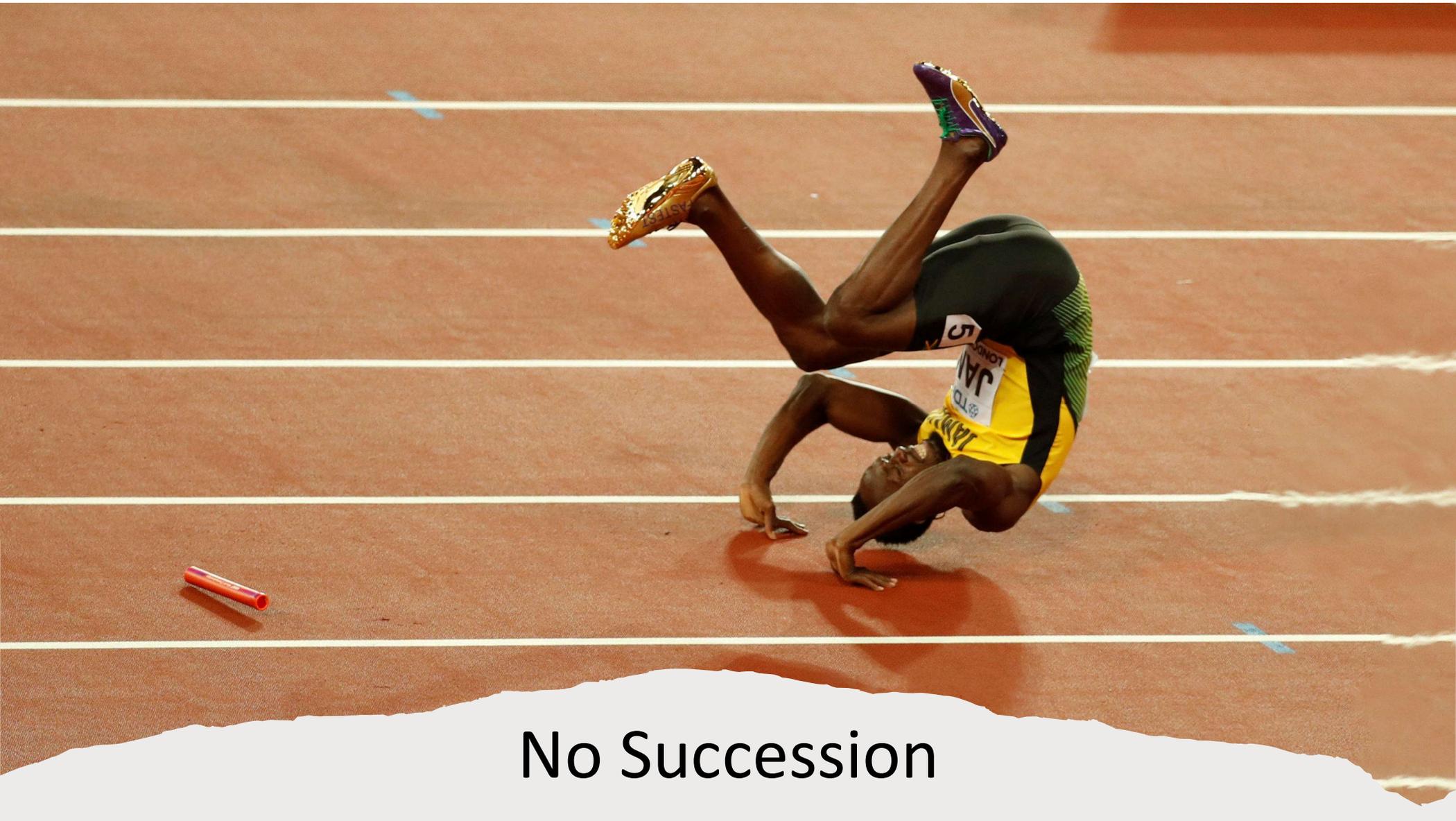


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No Succession

Surface Applied Sealers

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

Calcium Leaching (ASTM C1904-20)



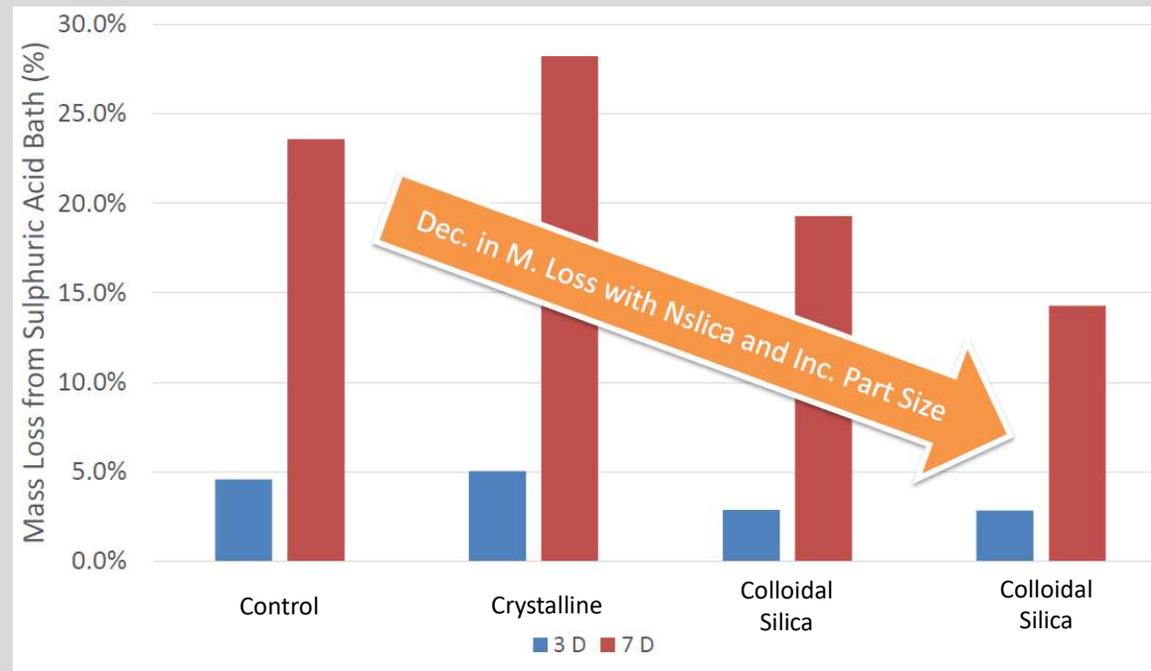
Control Concrete

Treated Concrete*

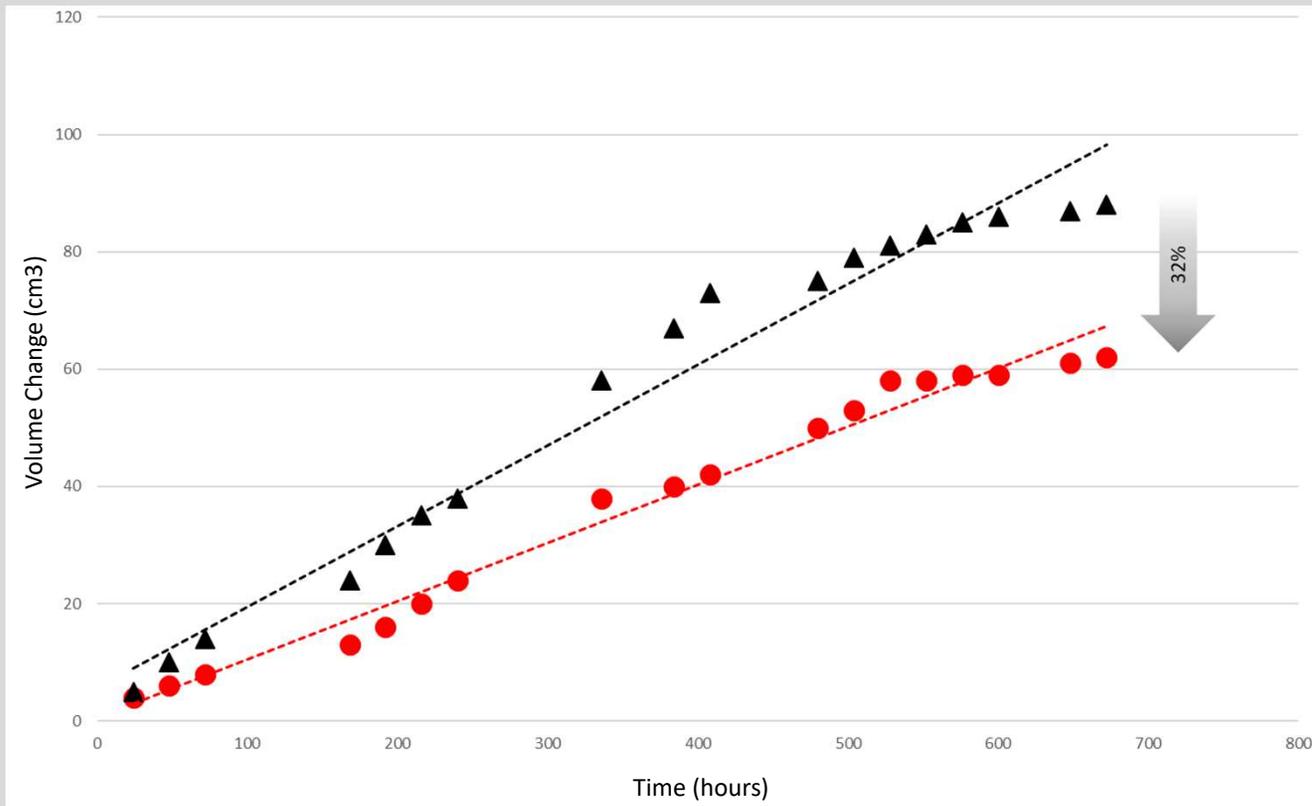
*Treated contains a US EPA registered antimicrobial concrete admixture with a topical water repelling concrete sealer containing a US EPA registered antimicrobial.

Colloidal Silica

- An amorphous dispersion of pure silicon dioxide of 1 to 100 nanometers in size
- Nanotechnology (ACI 241)
- Strength and durability enhancement in concrete
- Improves concrete's resistance to degradation in acid.



Water Absorption at 200 PSI CRD-C 48-92



Improved Water Repellency

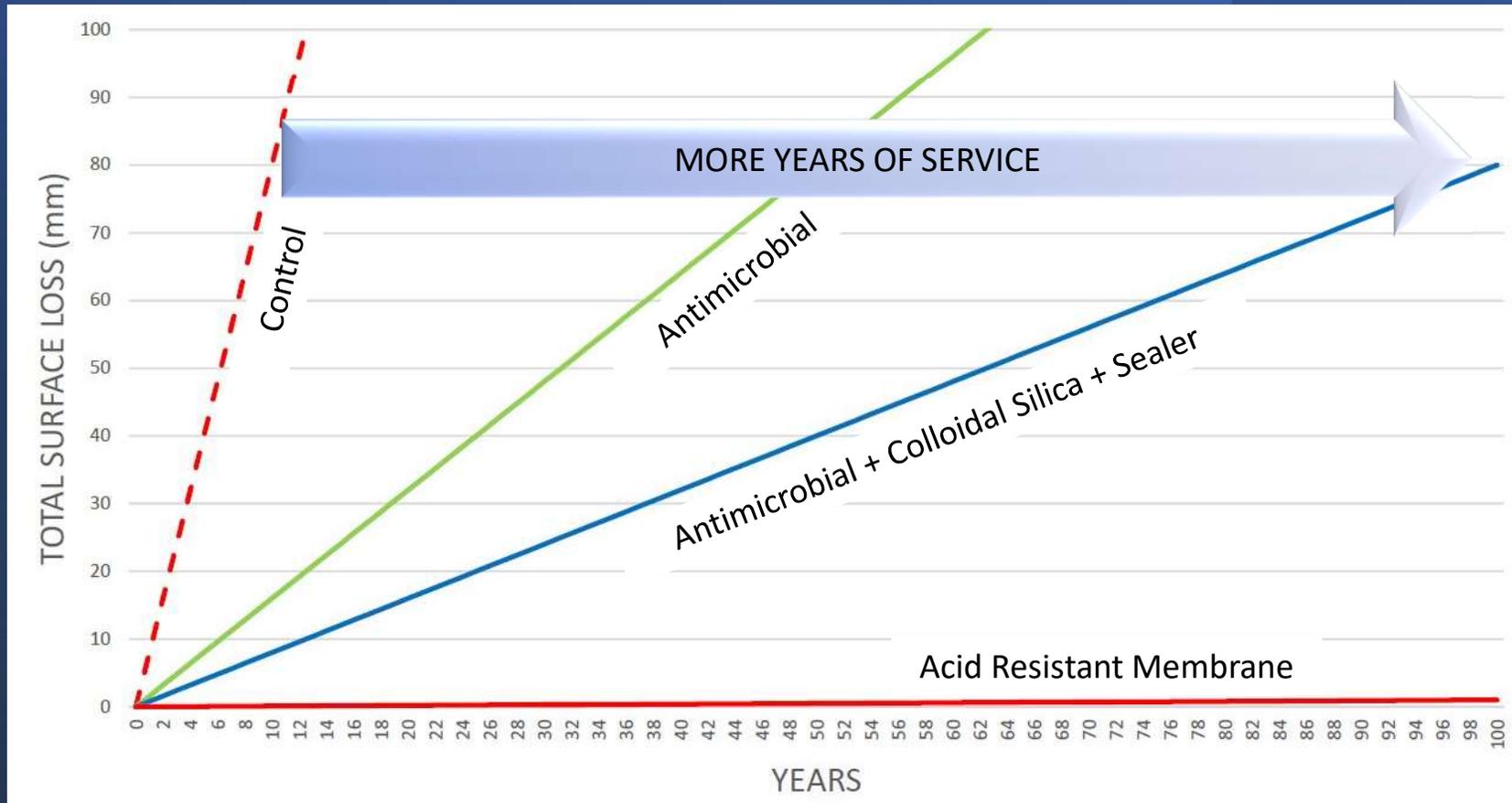


Reference Concrete



Concrete with Colloidal Silica

Combined Effectiveness of Antimicrobials and Colloidal Silica



Consider Severity Level

- **Severity Level 1**
 - Low bacterial population
 - Low bacterial activity
- **Severity Level 3**
 - High bacterial population
 - High bacterial activity
- **Severity Level 2**
 - Some combination of the above

Fit the
Solution to
the Condition



Cost Comparisons of Solutions

Option A – **Antimicrobials Alone**

Option B – **Antimicrobials and Colloidal Silica**

Option C – **Acid Resistant Membrane Coating**

Option D – HDPE liners, Epoxy coatings, etc.

Option E – Non-Cement-Based Materials



Option A



Option B



Option C



Option D



Option E





Samuel Lines, MBA, LSSMBB
Engineering Manager

Concrete Sealants, Inc.

slines@conseal.com

1-800-332-7325