A Study of Microbiological Induced Corrosion

2015 WWETT Conference

February 23, 2015

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Introduction

- The Process of MIC
- The Purdue Study
- Next Steps
- Current Precautions
- Summary

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About NPCA

- International trade association
- Established in 1965
- Dedicated to expanding the use of quality concrete products





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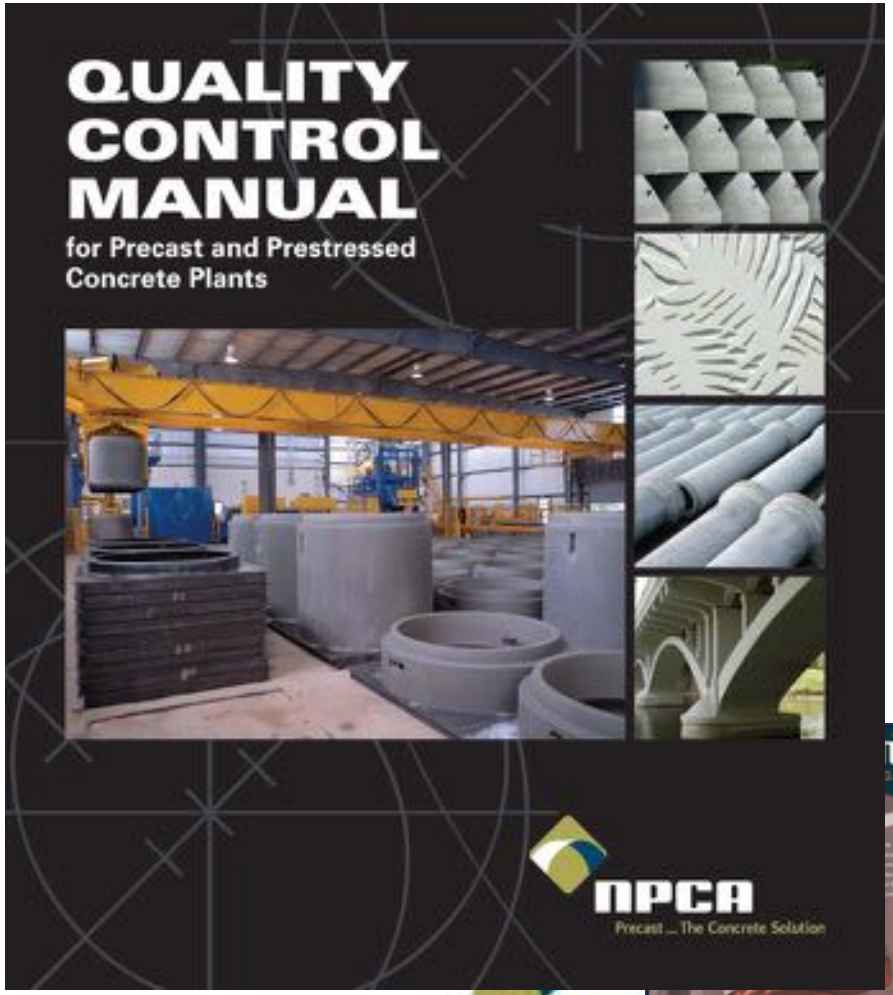
About NPCA

- The Precast Show
- Educational seminars
- Industry publications
- Technical service
- Quality Control Program
- Committees



Industry Outreach

- National
- Regional

Corrosion

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Thiobacillus

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Common Myths

- The bacteria eats concrete
- The H_2S gas corrodes the concrete
- MIC is rampant

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MIC Attributes

- Bacteria / Biofilm
- Low dissolved oxygen in wastewater
- Sulfates in the effluent
- Turbulence
- Moisture on the walls above water line
- Reactive compounds in concrete
- Low effluent flow
- Other common factors

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How Does It Appear?

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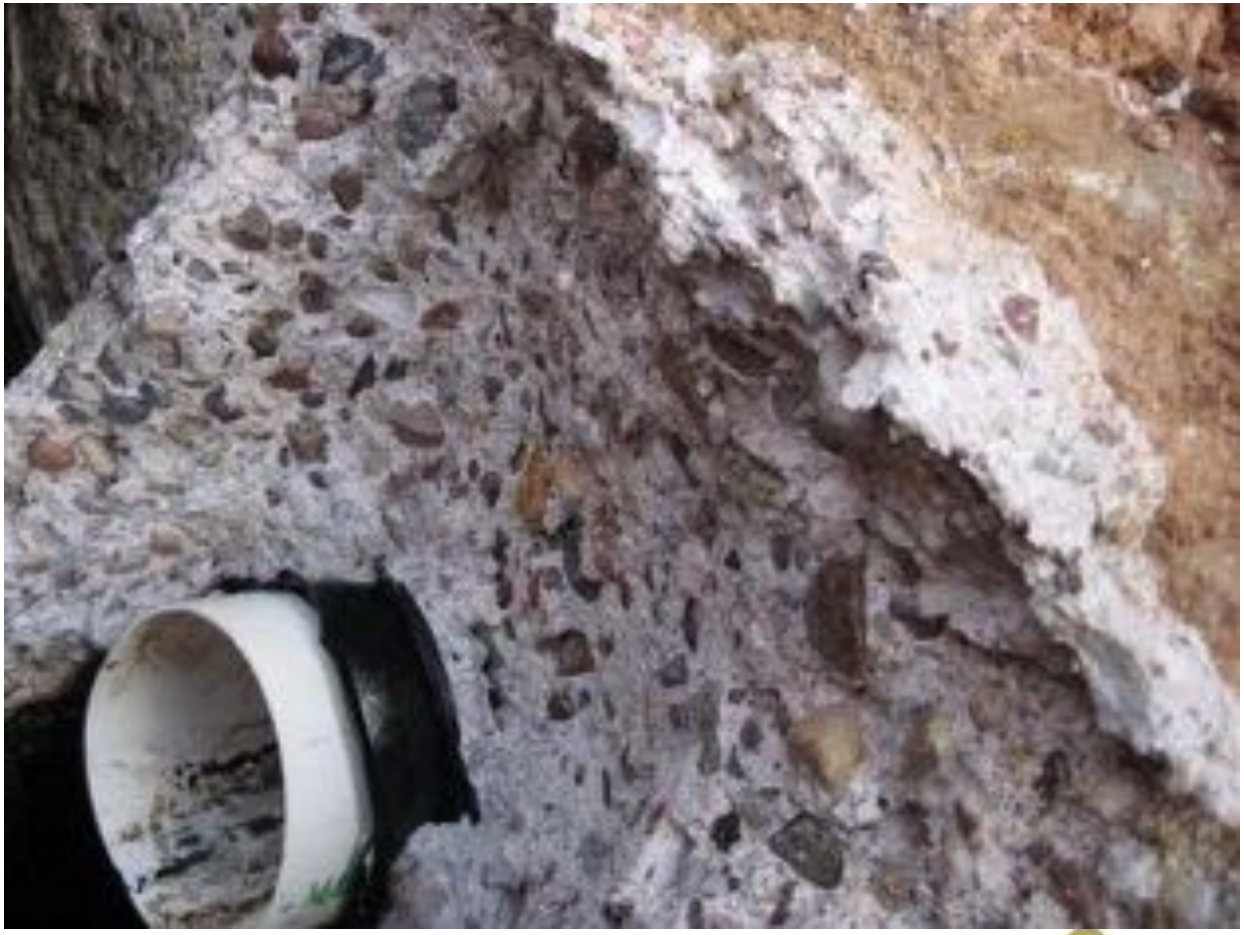
How Does It Appear?



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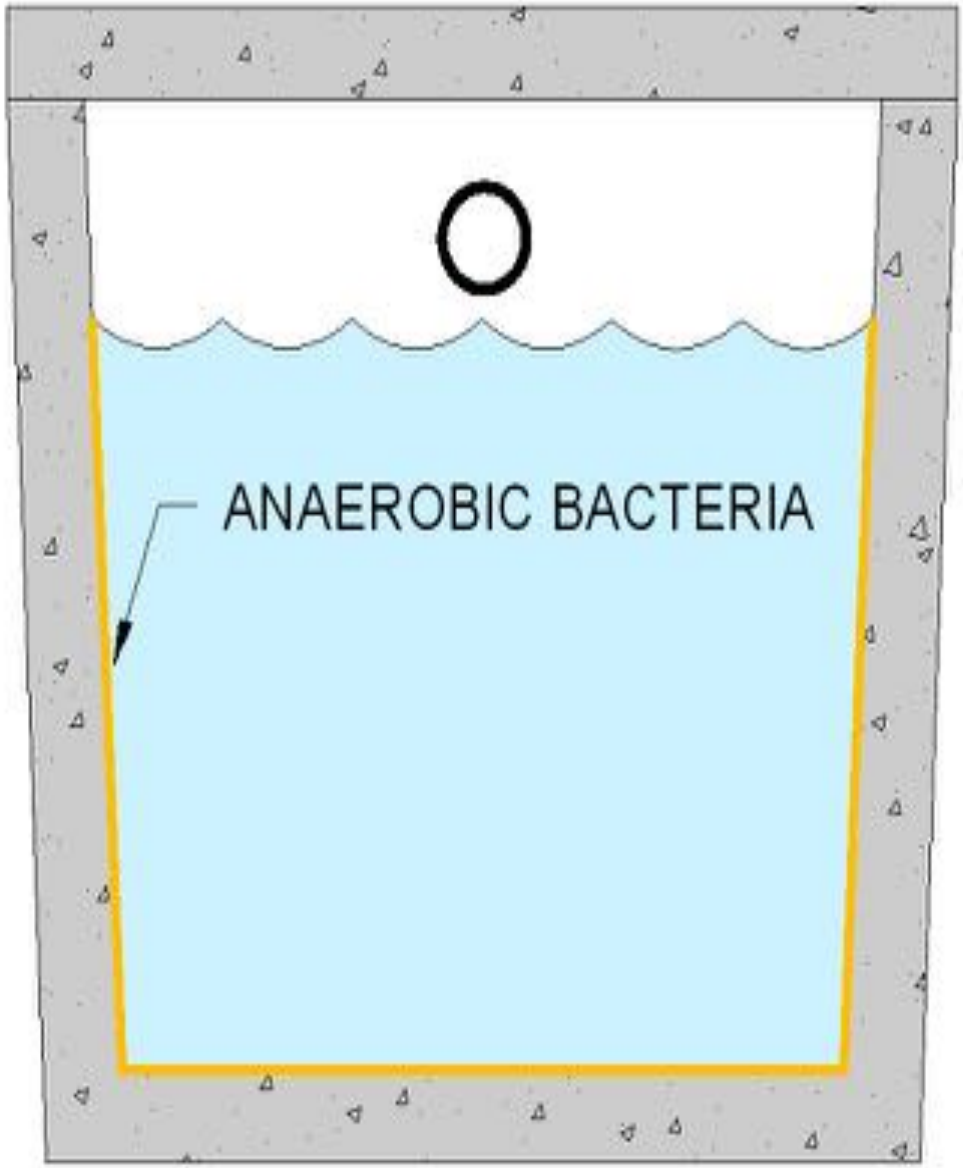
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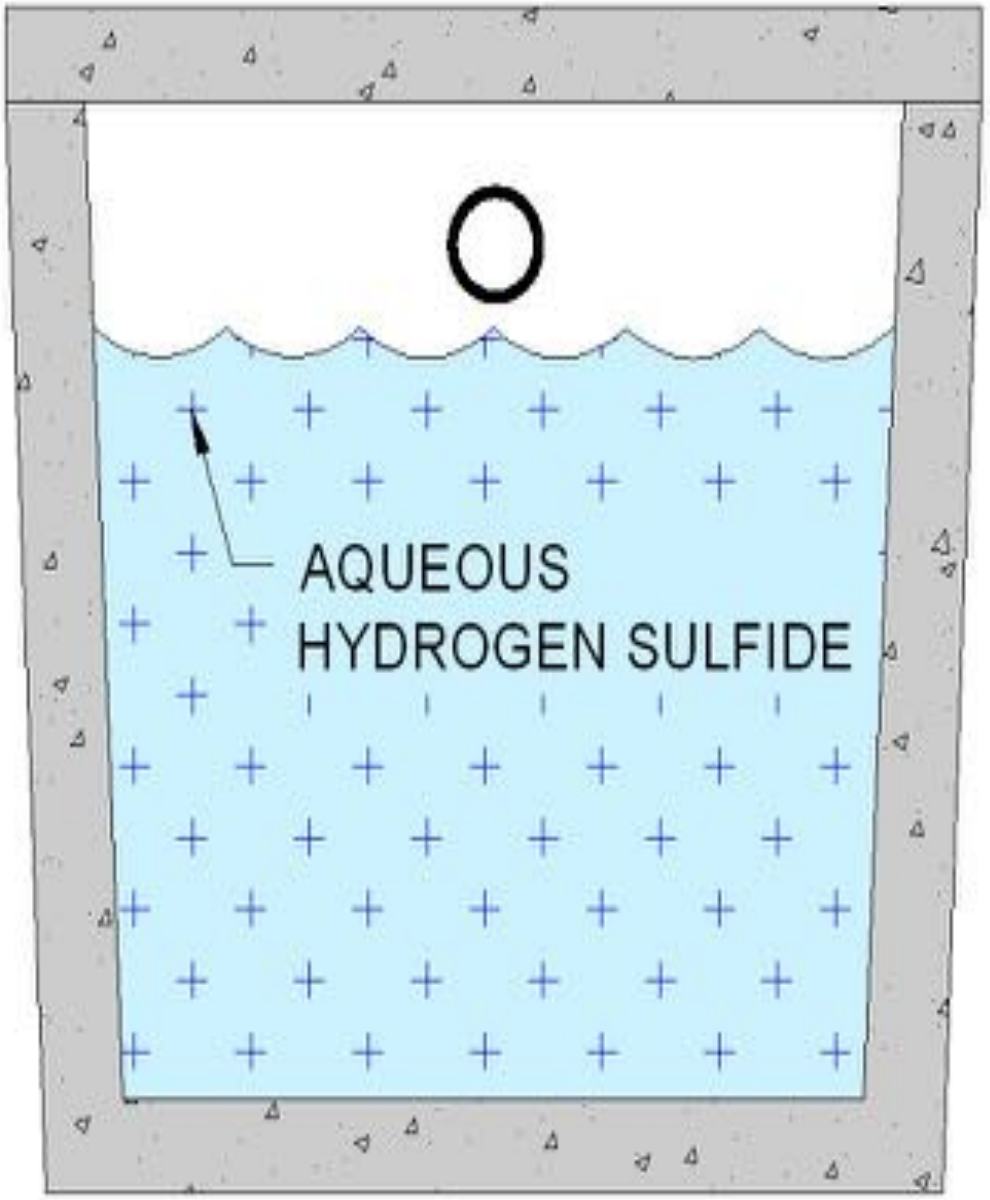
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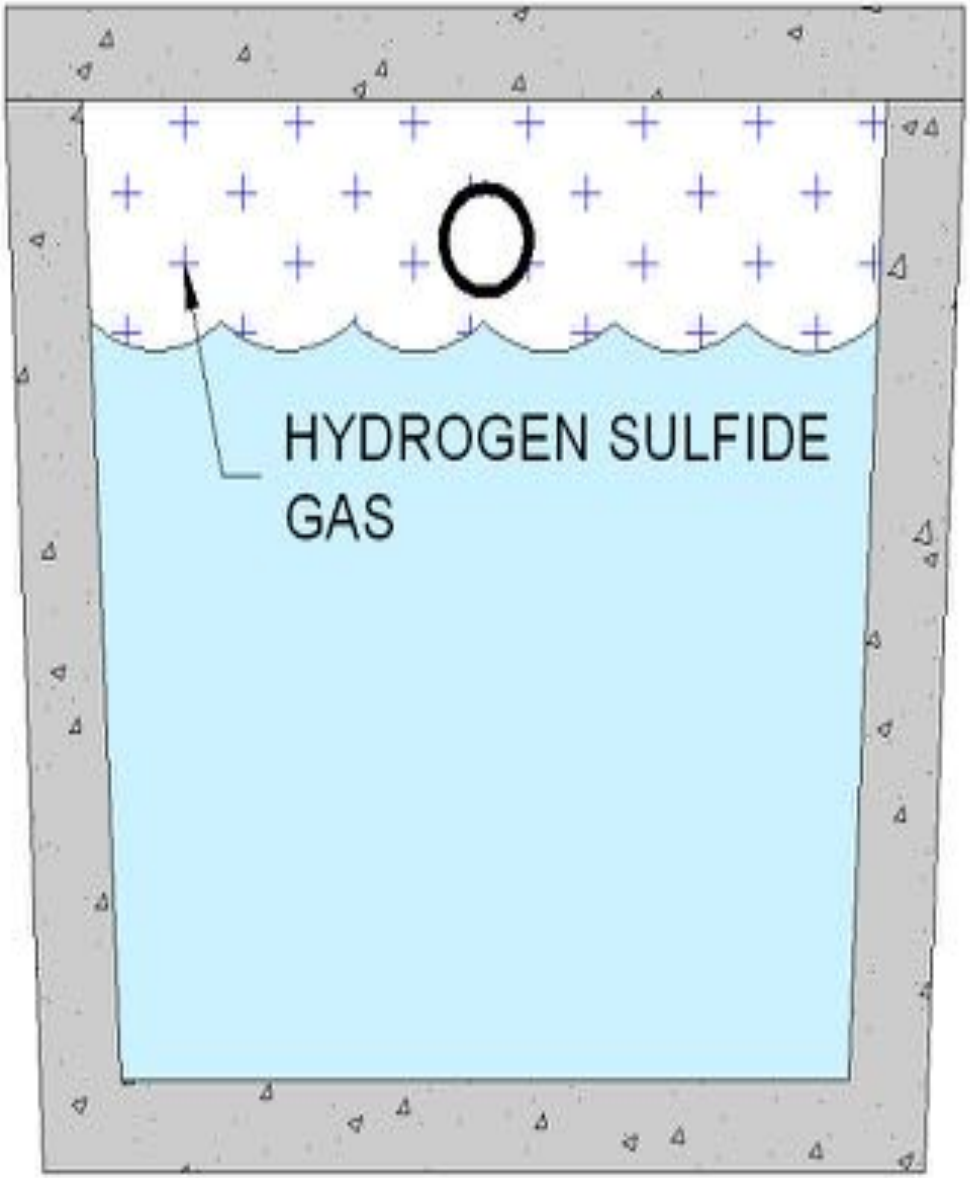
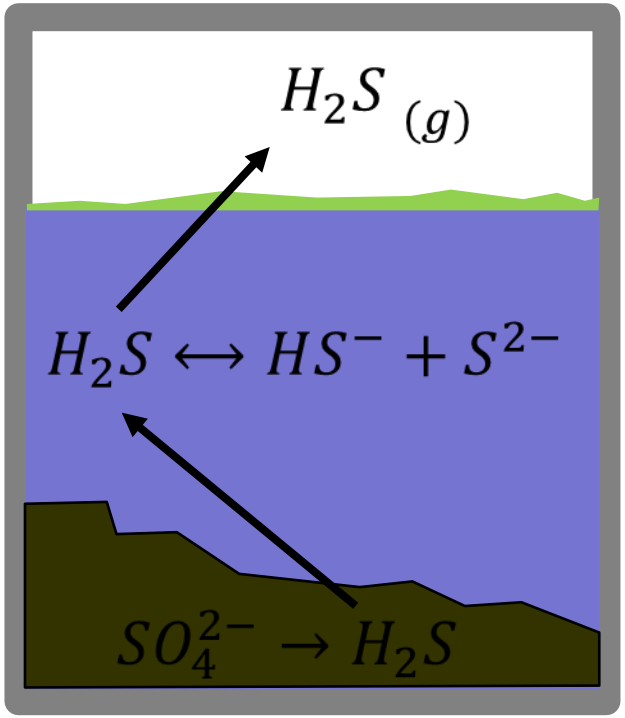
HYDROGEN SULFIDE


HYDROGEN SULFIDE
GAS

The development of H_2S Gas



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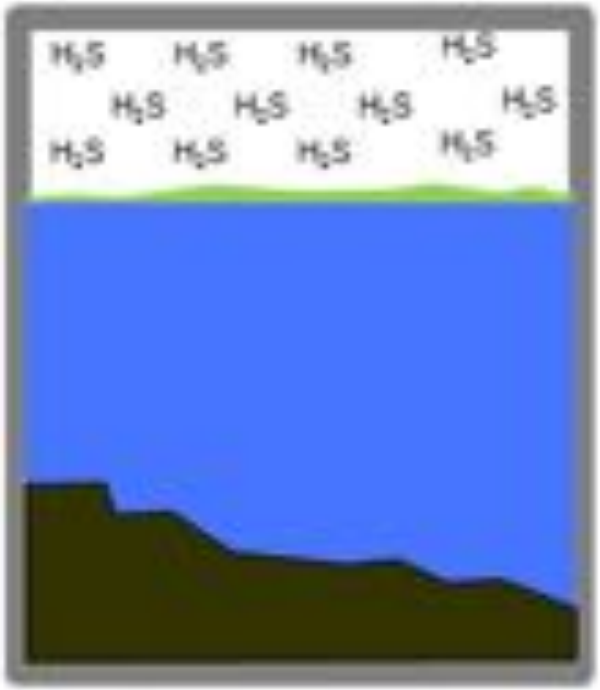
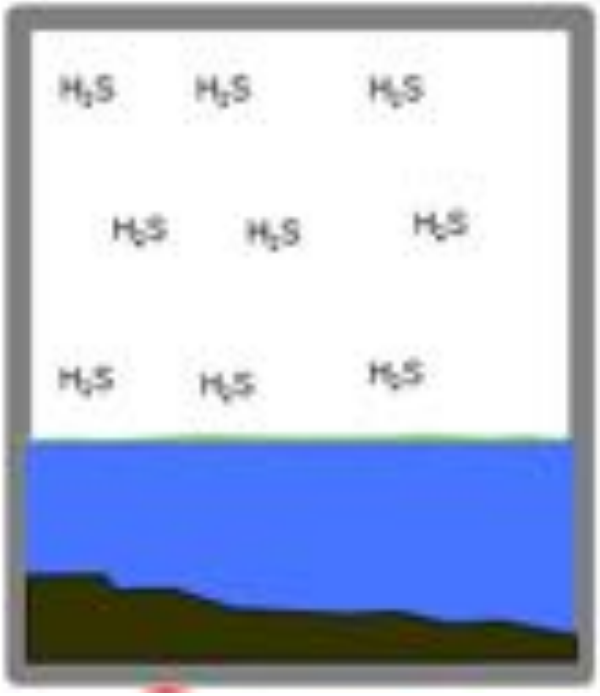
H_2S Gas Concentrations





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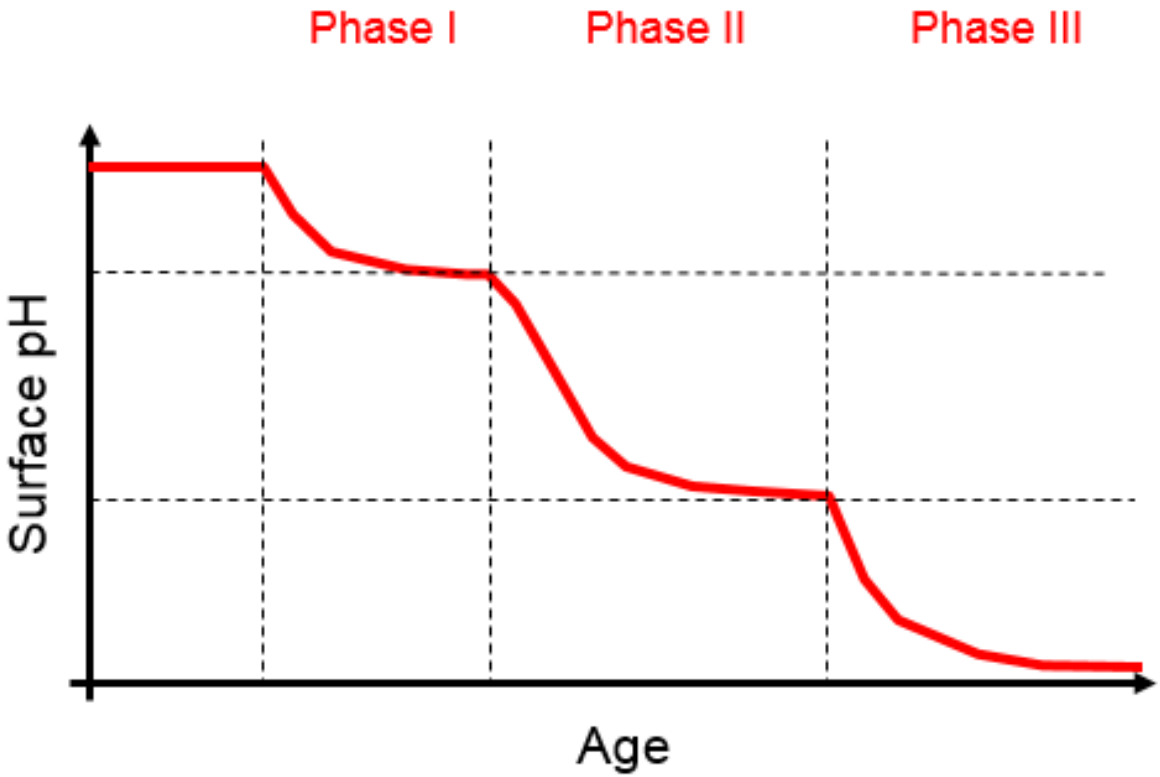
A 3 Stage Process



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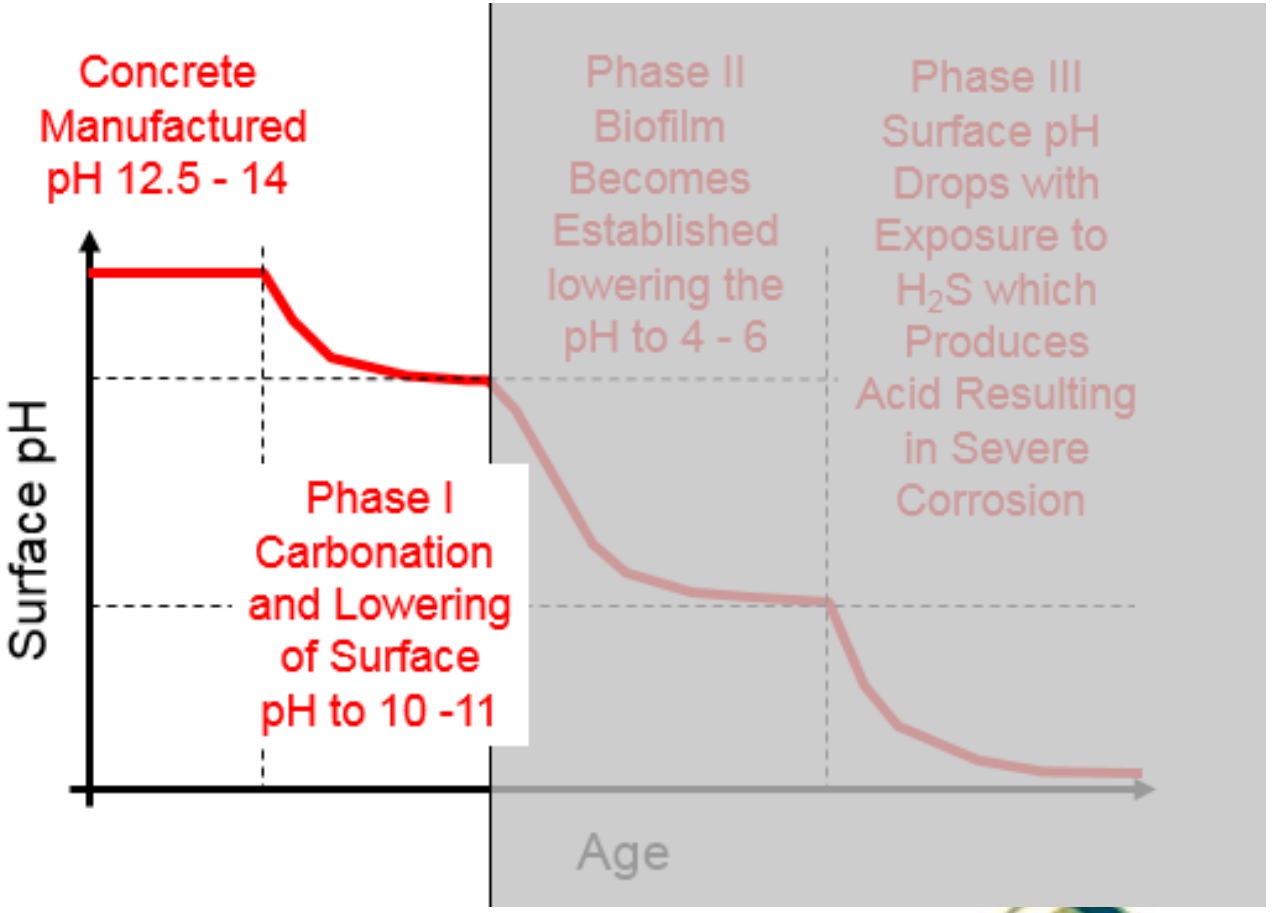

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Carbonation

Phase I – Carbonation and Lowering of pH

- Carbonation : dissolution of CO_2, movement through pore solution and reaction with Calcium Hydroxide (CH) to form $CaCO_3$
- CH helps to keep the pH in concrete high
- pH can be lowered by fluids in contact with the surface that dissolves CH

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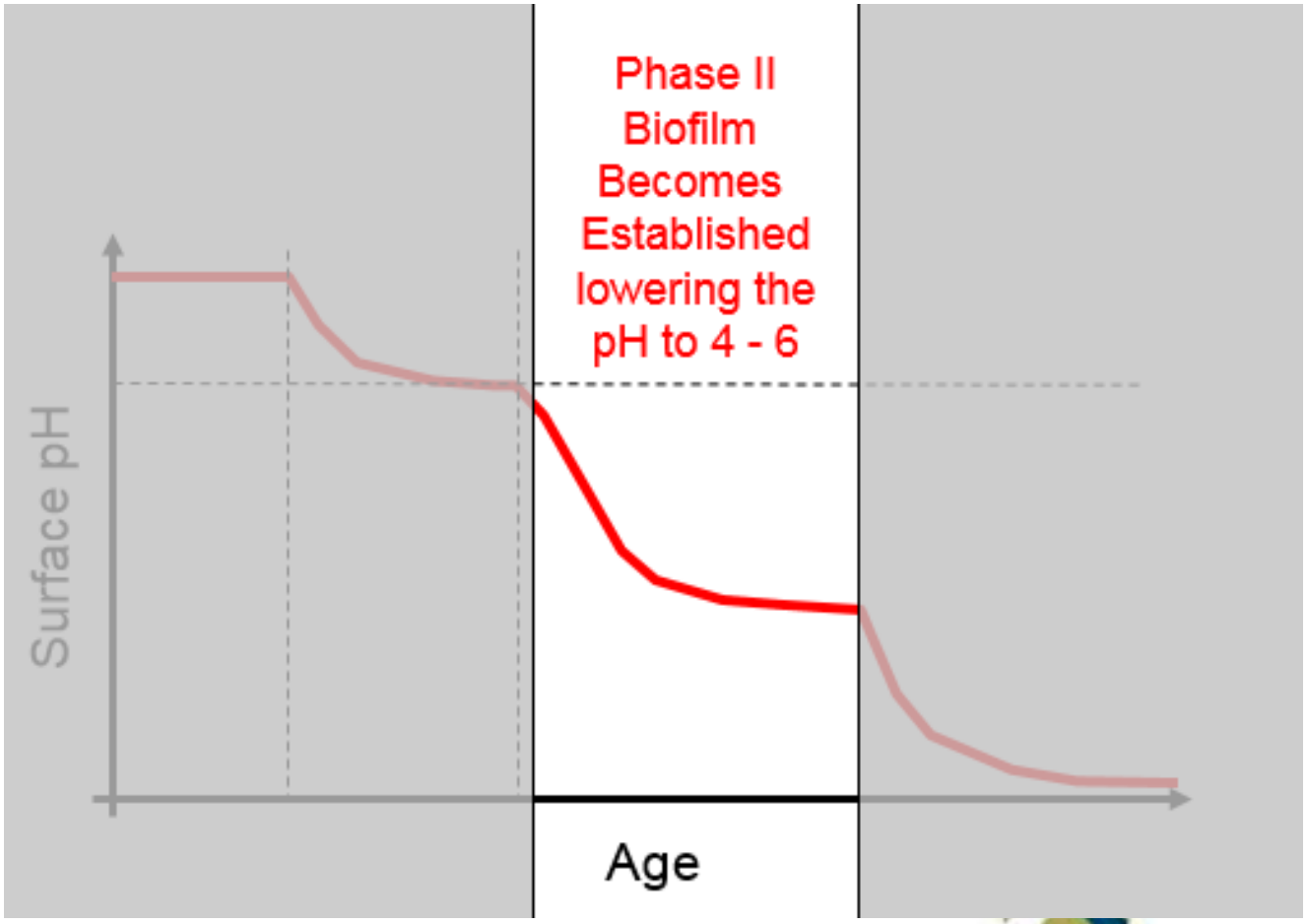
A 3 Stage Process



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Phase II - Attachment

Phase II - What can be done?

- **Rate of attachment and succession will depend on bacteria's "happiness"**
  - Temperature – The cooler the better
  - Surface texture – Application of sealers to reduce surface roughness
  - Moisture – Dry walls will have few bacteria
  - Availability of nutrients – Likely provided by other microorganisms

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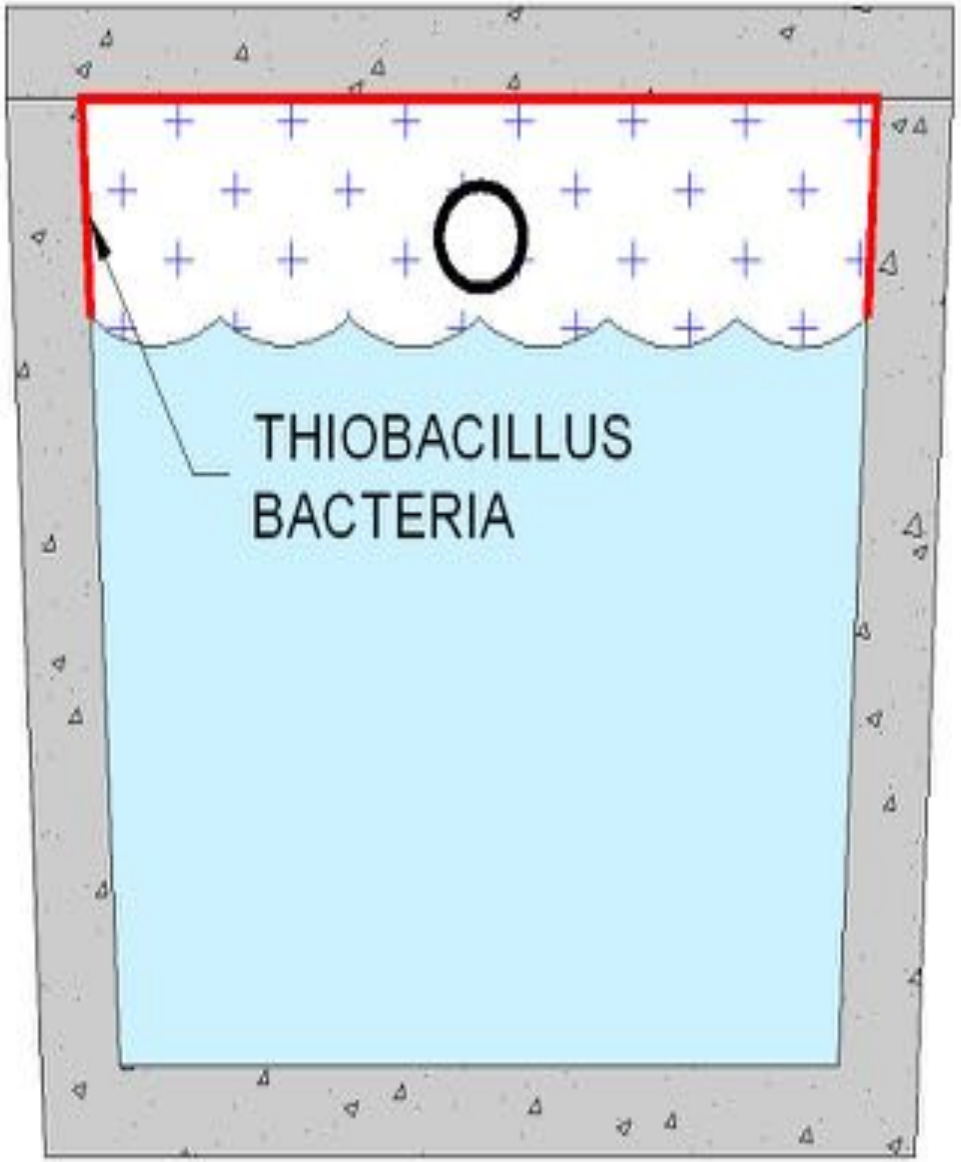
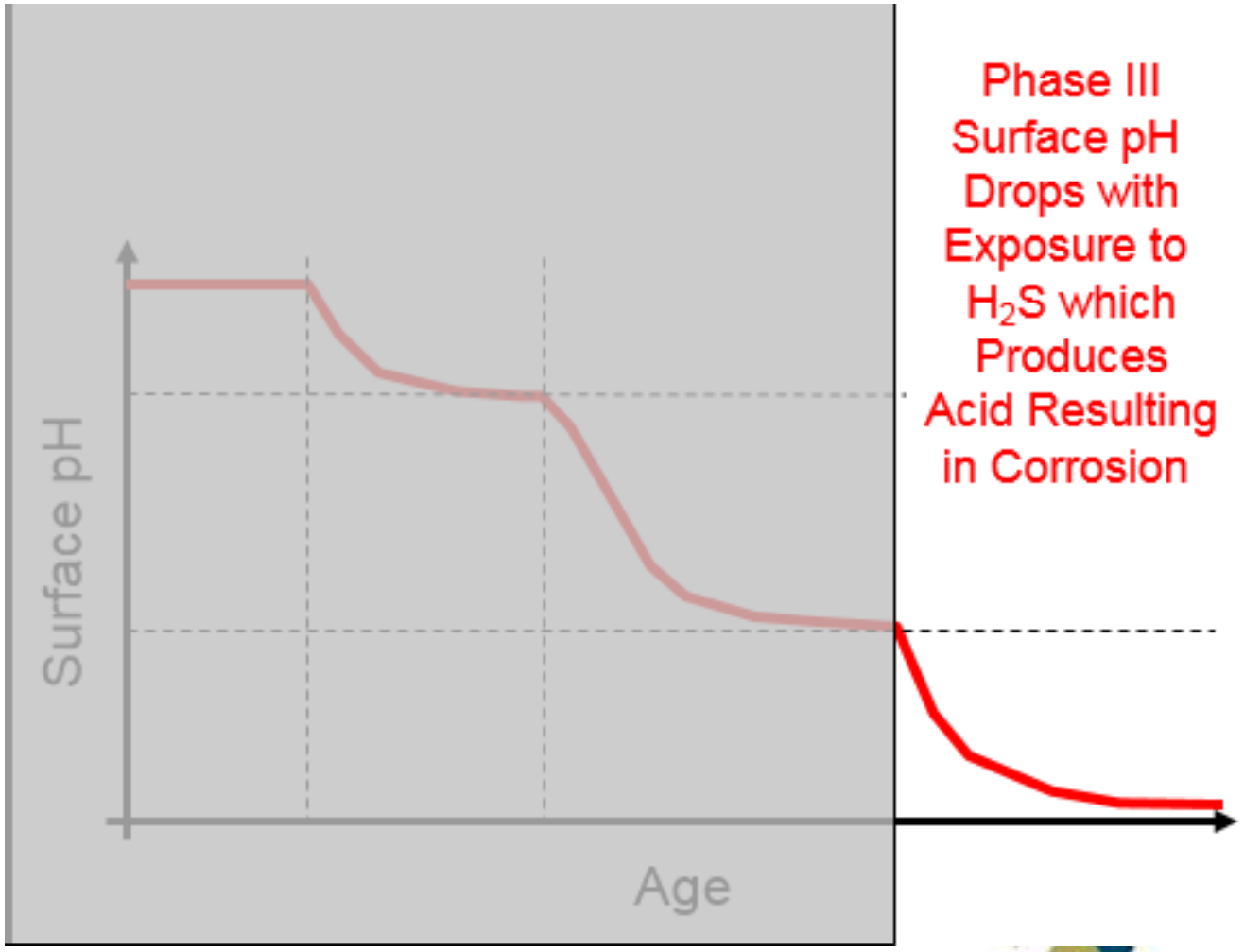

O
THIOBACILLUS
BACTERIA

A 3 Stage Process



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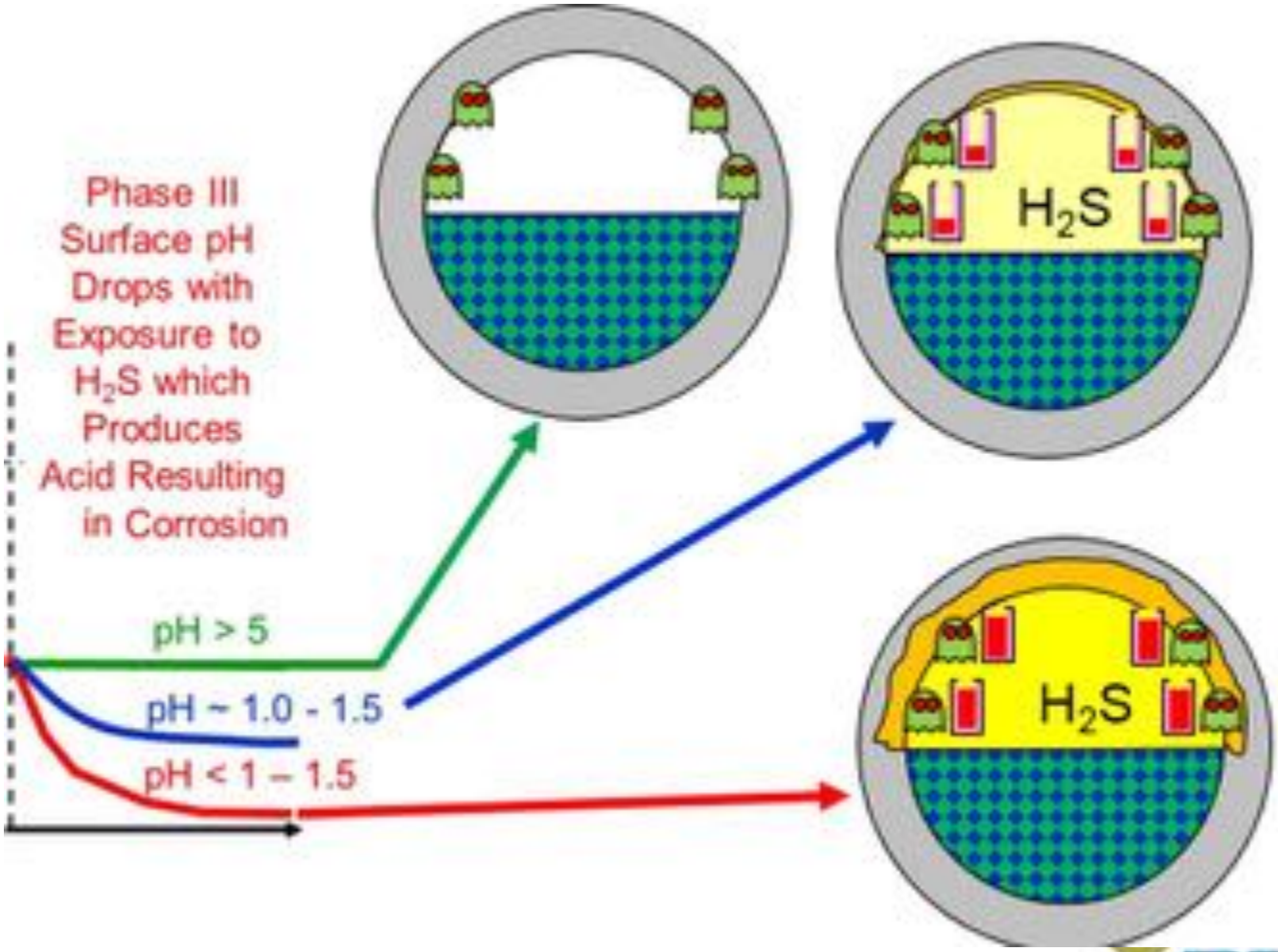
Phase III - Corrosion



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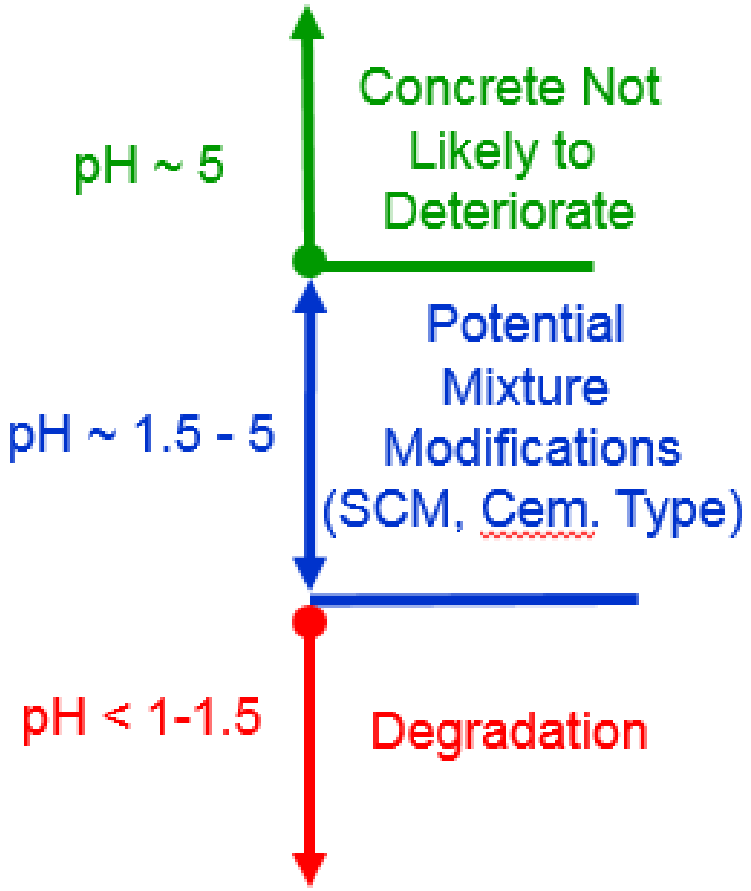
Phase III - Corrosion



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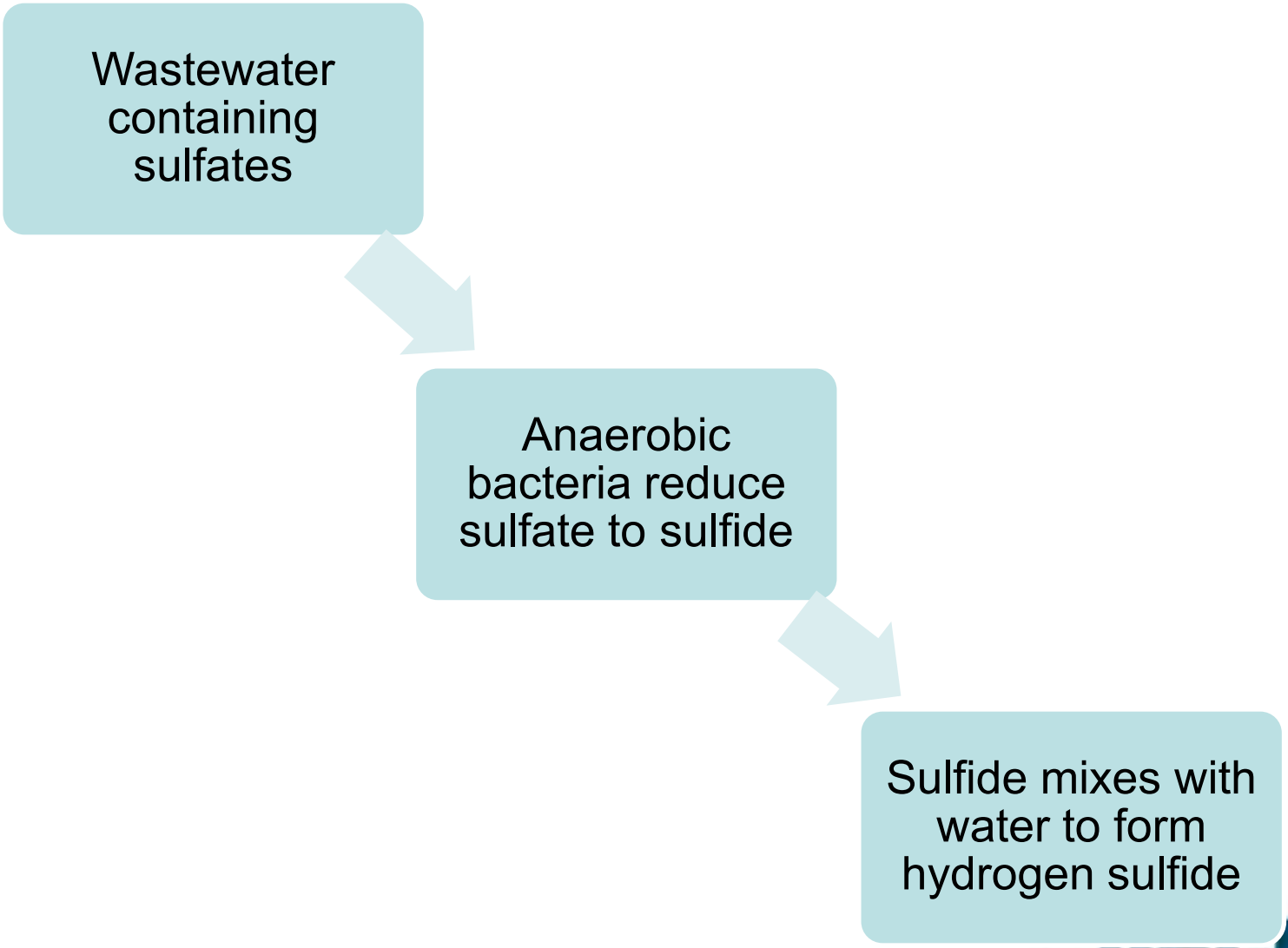
Hydrogen Sulfide



Phase I – Carbonation and pH Reduction

Carbon Dioxide and water form carbonic acid

Carbonic Acid reacts with concrete above water level

pH of Concrete is reduced to about 10-11

Phase II - Attachment

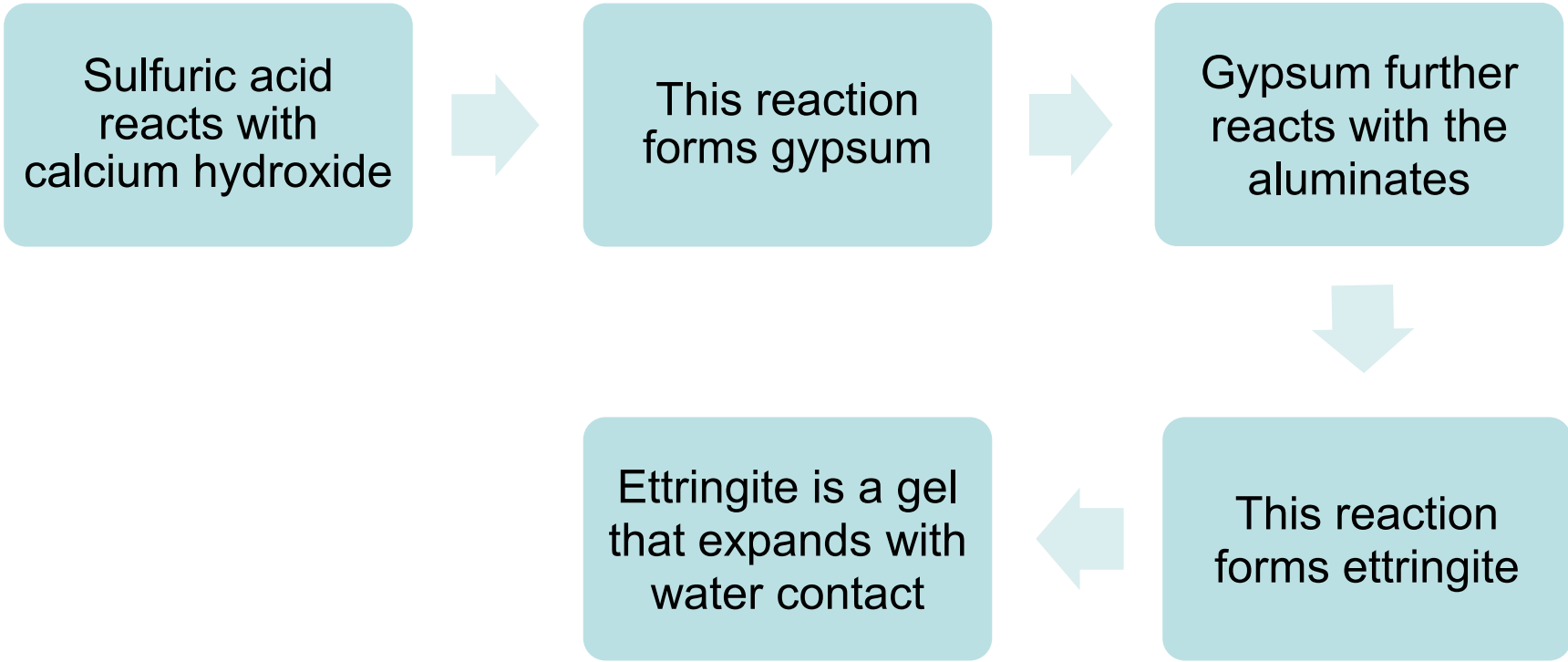
At ~ pH 9 and less, thiobacillus bacteria colonize

H2S provides nutrients for aerobic bacteria

Different strains of Thiobacillus live and die off

Thiobacillus consume H2S and excrete sulfuric acid

Phase III - Corrosion



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The Purdue Study

- We made 12 samples of varying mix designs
- A Biological Growth Chamber was constructed

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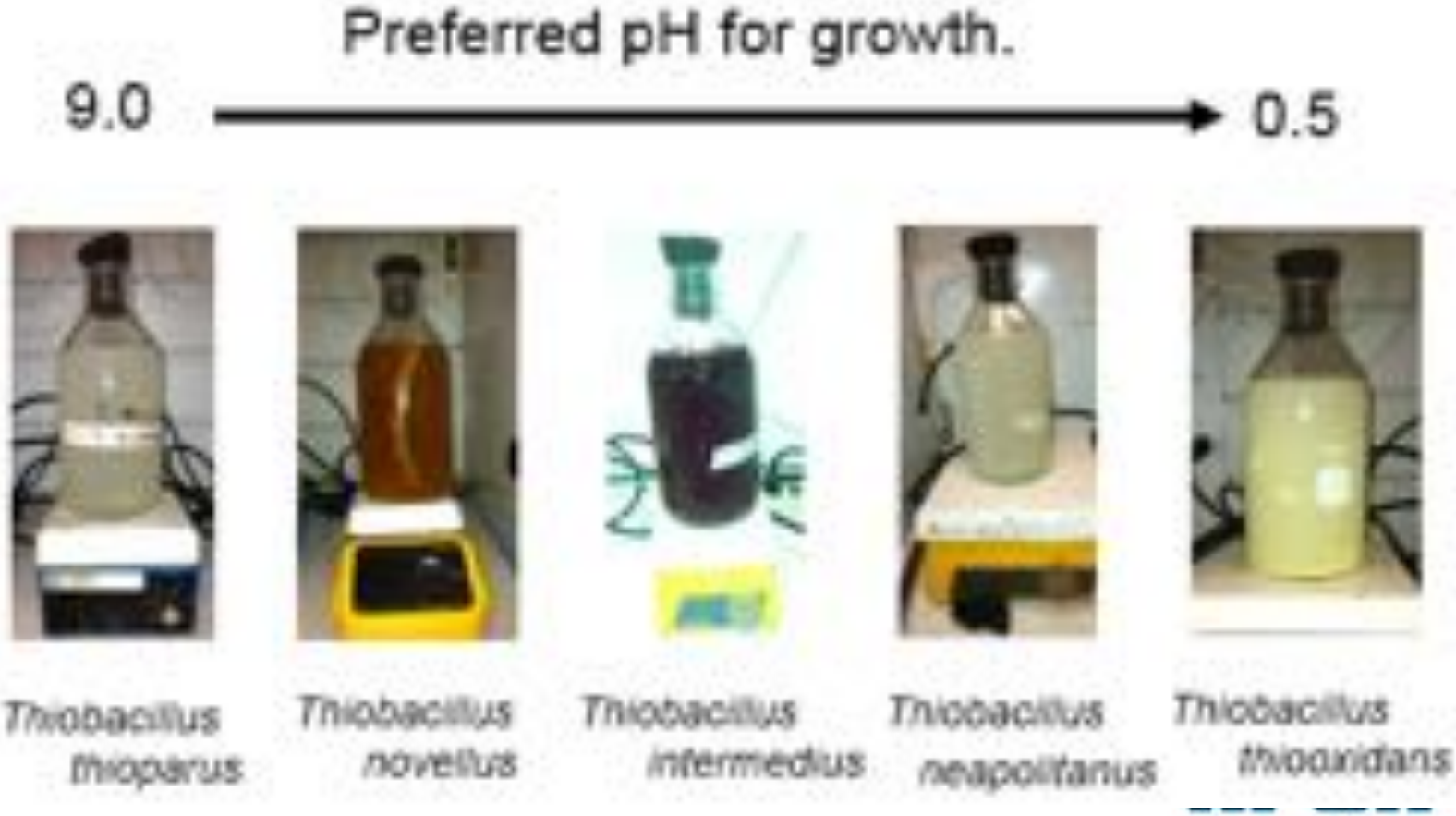
The Purdue Study

- **Bacteria was obtained**



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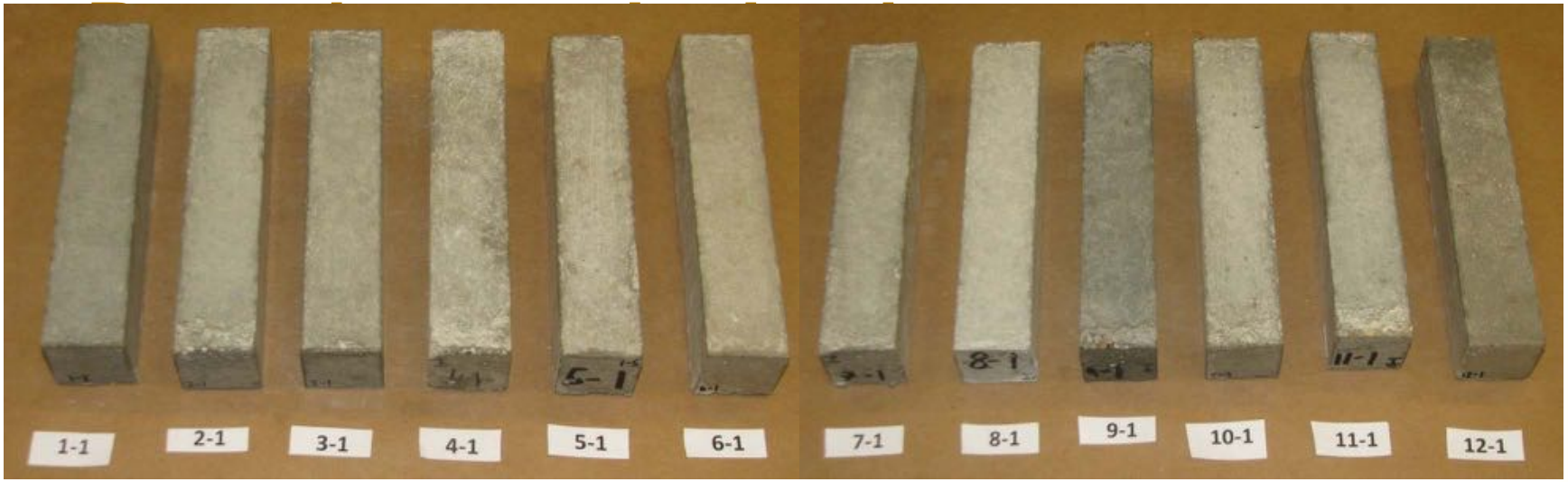
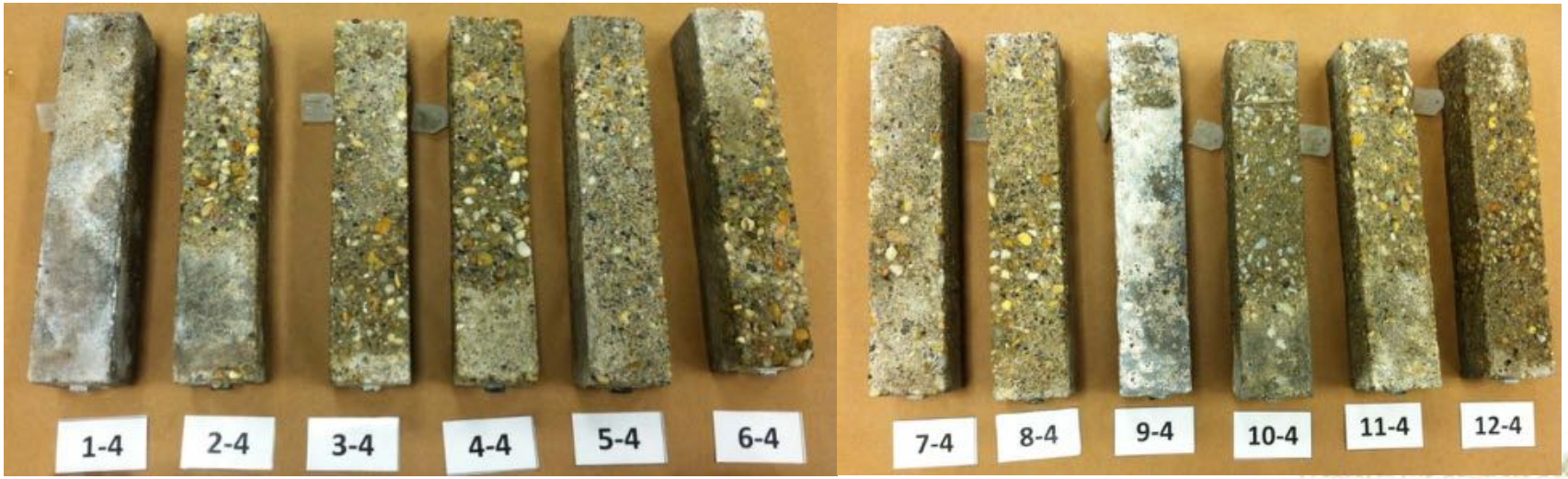
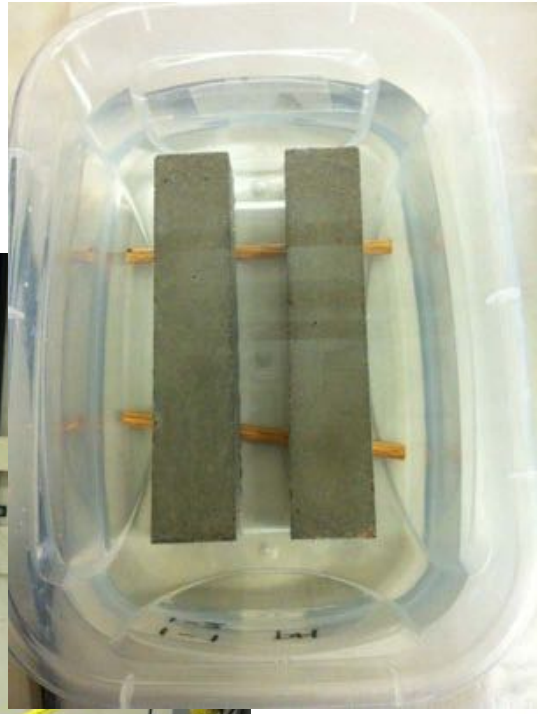
The Purdue Study





The Purdue Study

- Acid Immersion Test



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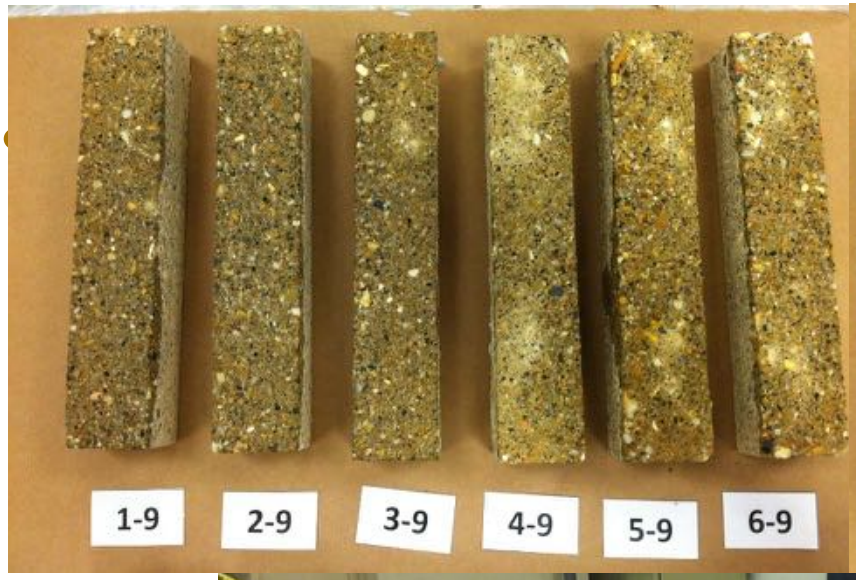
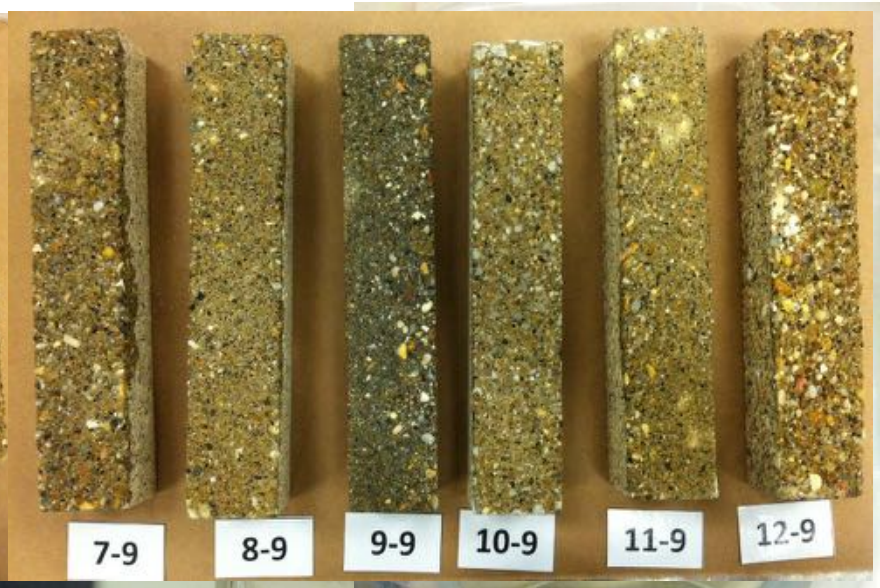
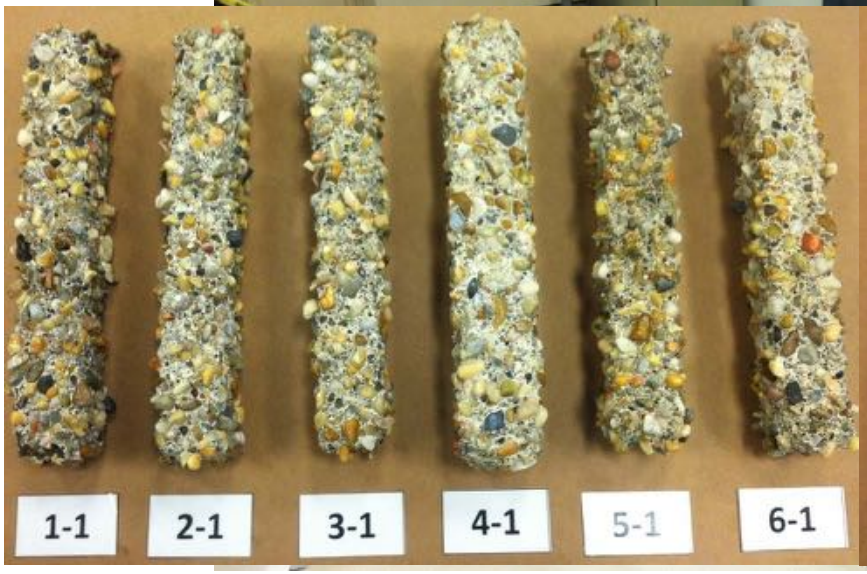
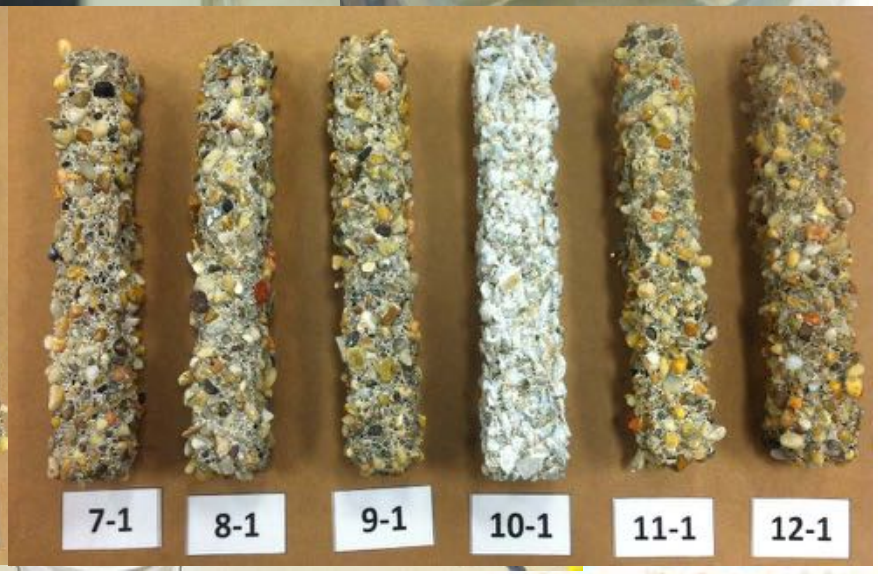
The Purdue Study









Purdue Study Conclusions

- MIC is a three-stage process that relates to bacterial growth and the surface pH inside the tank above the liquid level.
- Devising a testing protocol that mimics an environment in which MIC could thrive is very dangerous, difficult to maintain and difficult to control.
- The development of a single comprehensive test method to evaluate concrete resistance to MIC is inherently complex. It may be more useful to investigate each of the three stages separately.
- Use of SCMs, Limestone show benefits

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Next Steps

- Developing testing protocol for field studies, testing of proprietary products, ASTM test methods and the effects of other variables such as venting.
- Developing information for our members and industry.

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Testing Protocals

- **Stage I**
  - Not much to do. Carbonation will occur. Not detrimental
- **Stage II**
  - Studies attachment and growth potential
  - Important for admixtures and sealers
- **Stage III**
  - Acid immersion studies
  - Fix test gray areas

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Field Study

- Field data will be useful to have to determine how the field corrosion rate matches environment

Temp/RH Probe

H_2S Meter

Surface pH Meter

Three Ways to Improve Concrete's Resistance to Acid Attack

1. Employing the right concrete composition to make it as impermeable as possible

2. Isolating it from the environment by using a suitable coating or

3. Modifying the environment to make it less aggressive to the concrete

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Three Ways to Improve Concrete's Resistance to Acid Attack

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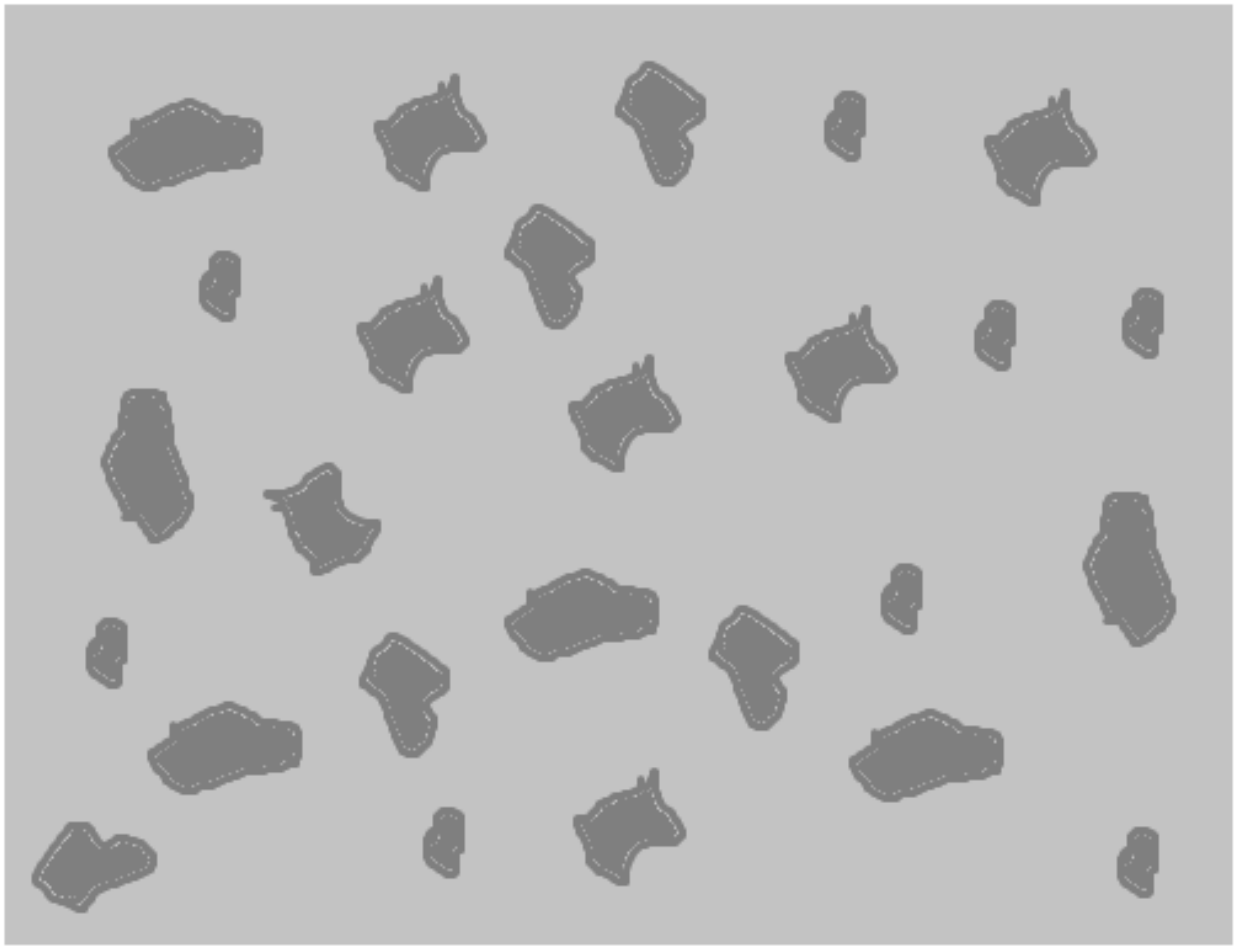

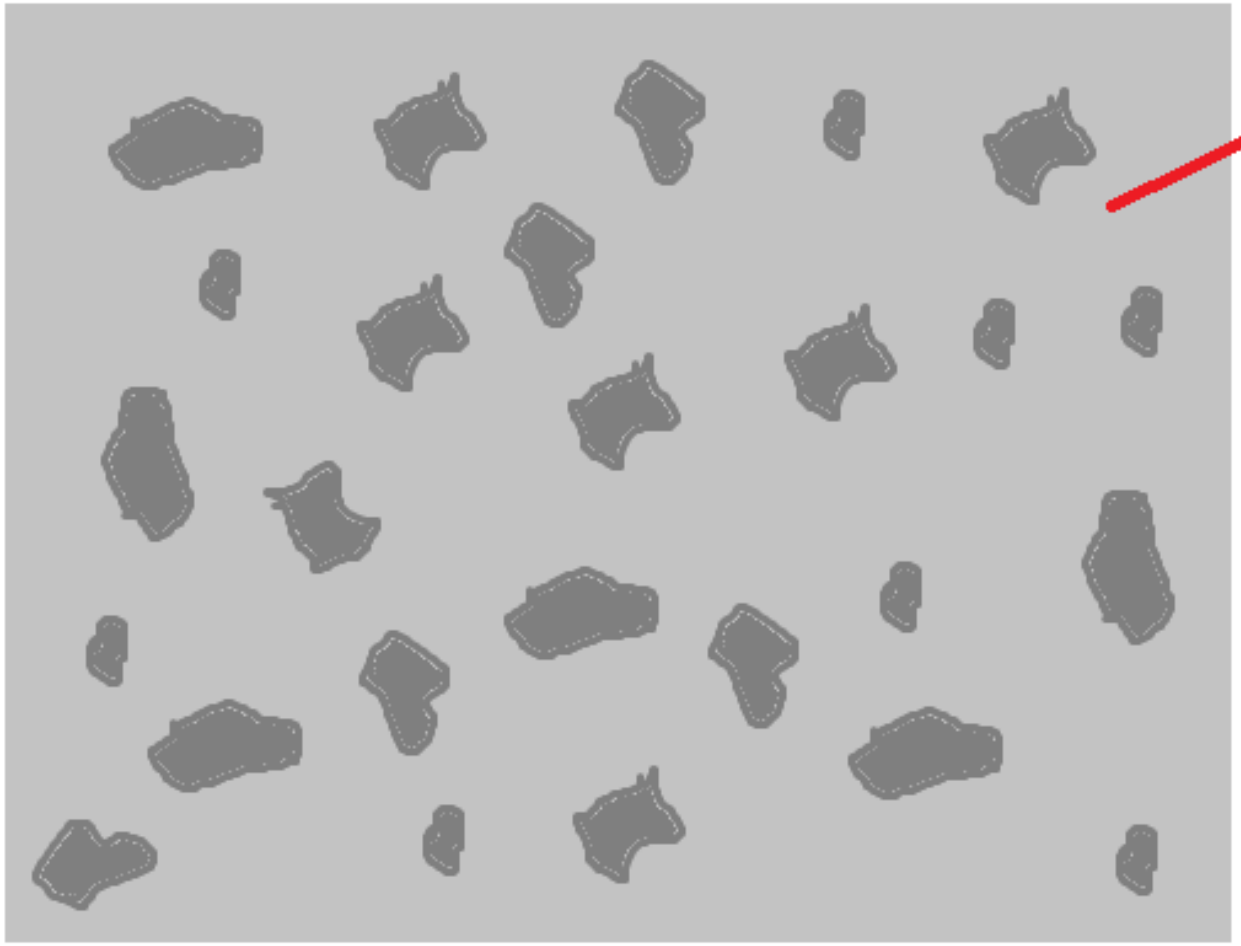
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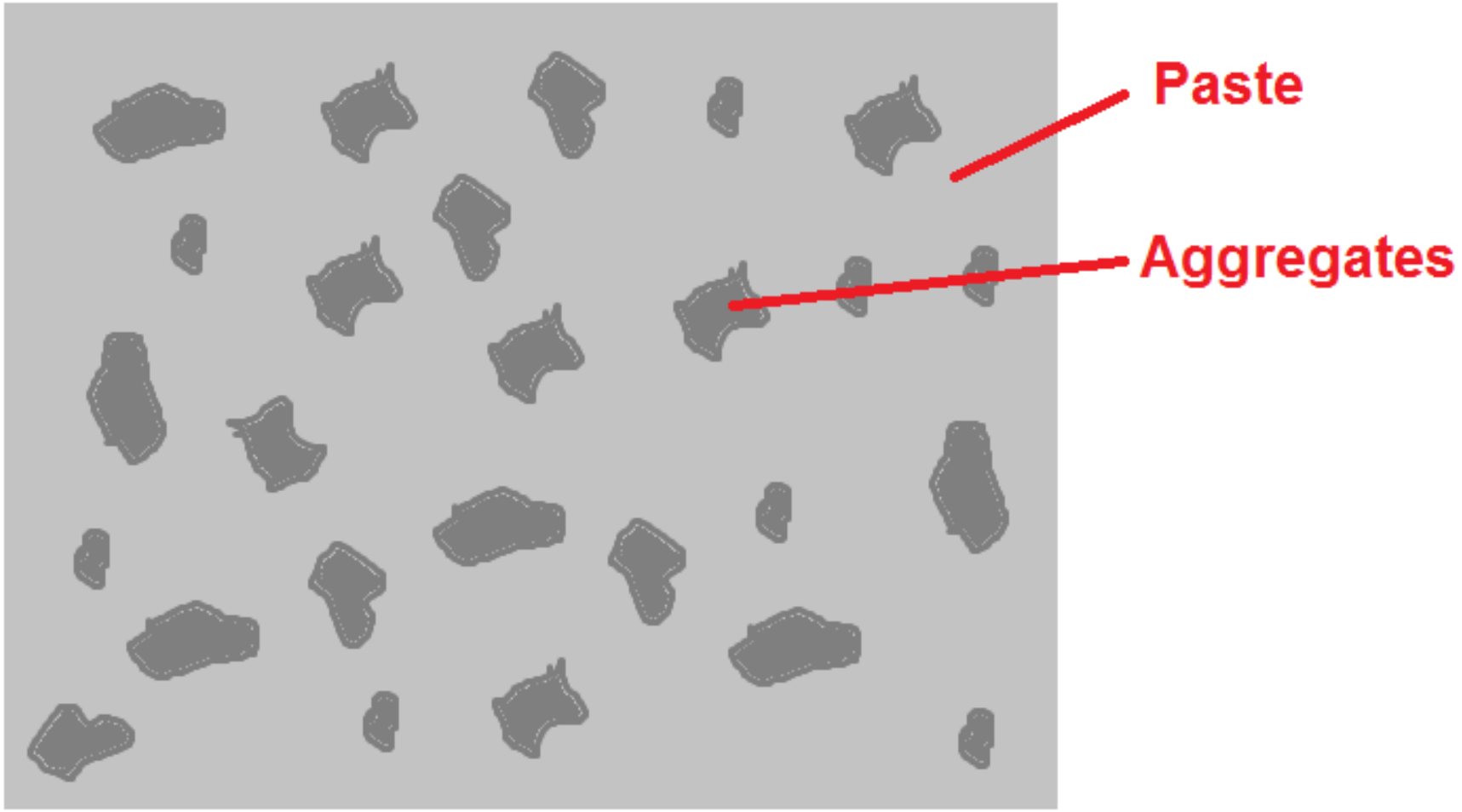
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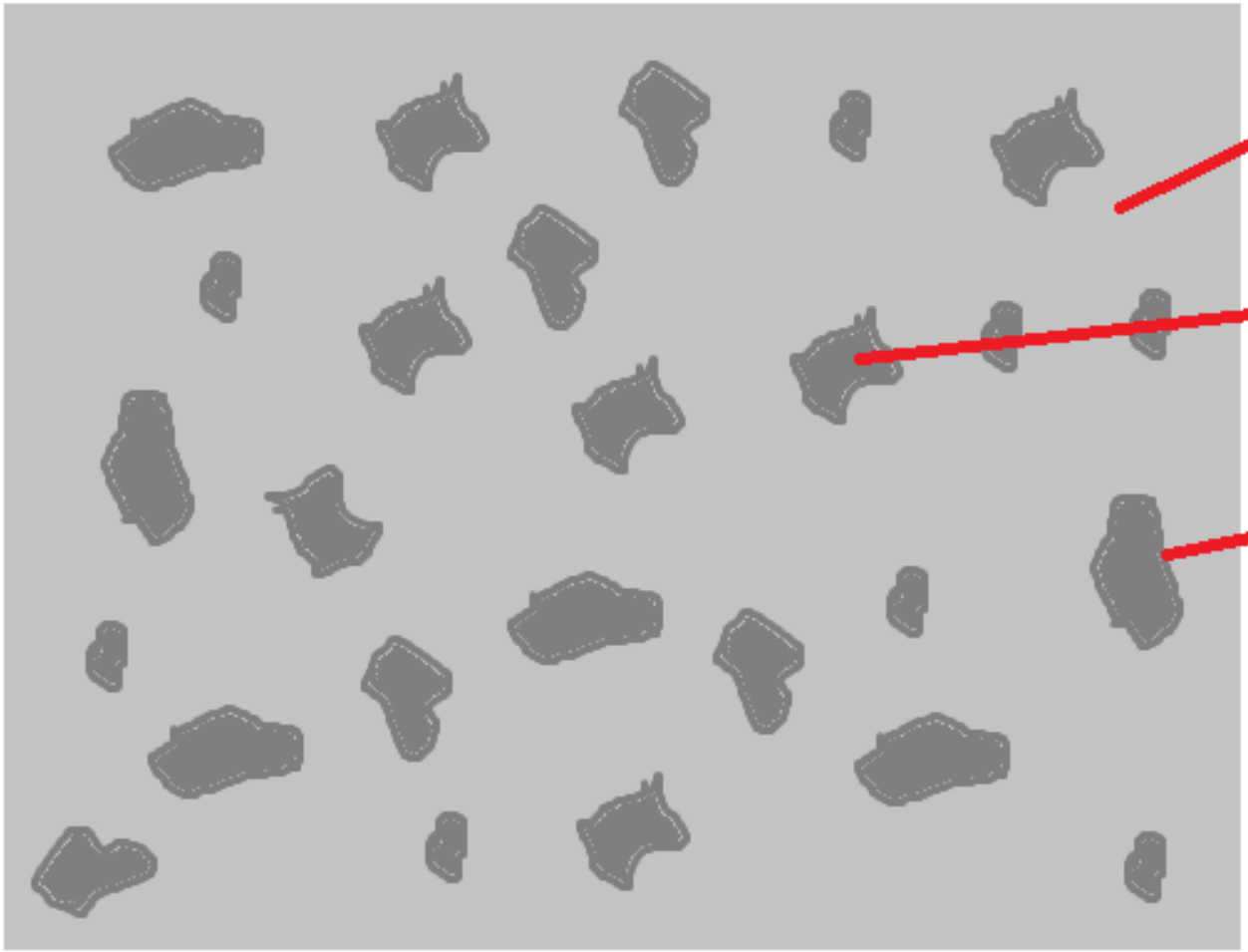
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Aggregates
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Aggregate
Interface

Three Ways to Improve Concrete's Resistance to Acid Attack

1. Employing the right concrete composition to make it as impermeable as possible

W/C Ratio

Cement Content & Type

Suitable Aggregates

Aggregate Gradation

Water Quality

Admixtures / Additives

SCM's

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Three Ways to Improve Concrete's Resistance to Acid Attack

1. Employing the right concrete composition to make it as impermeable as possible

Mix workability

Consolidation

Batching & Placing Process

Curing

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Three Ways to Improve Concrete's Resistance to Acid Attack

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2. Isolating it from the environment by using a suitable coating

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Summary

- MIC is not everywhere.
- Sulfates to Sulfides to Aqueous H_2S to H_2S Gas
- 3 Stage Process
- Test Protocols and Field Studies next
- Producer need to focus on low w/c ratio, high strength, dense concrete
- Use us as a resource!!!

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Additional Information & Resources

NPCA website

http://precast.org/

Visit us at booth 5462

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Questions?

- **If you have any questions about this presentation please contact:**

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THANK YOU!

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