Pro Perma Engineered Coatings

Partnership Research with the ERDC, MS&T and PPEC

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**Partnership Research with the ERDC, MS&T and PPEC**

**DISTRIBUTION/AVAILABILITY STATEMENT**
Approved for public release; distribution unlimited

**ABSTRACT**


**SECURITY CLASSIFICATION OF:**

<table>
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<tr>
<th>a. REPORT</th>
<th>b. ABSTRACT</th>
<th>c. THIS PAGE</th>
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**LIMITATION OF ABSTRACT**

Same as Report (SAR)

**NUMBER OF PAGES**

18
Financial support to complete this presentation is provided in part by the U.S. National Science Foundation under Award No. CMMI0900159 and by the Missouri Department of Transportation under Award No. 00022940.
What is the issue?

Ingress of corrosive species (into porous concrete)

Cracking and spalling of the concrete cover

Build up of voluminous corrosion products

Corroding reinforcing steel

Porous concrete

Corrosive species may already be present in concrete from “contaminated” mix ingredients

Volume Relative to Iron

<table>
<thead>
<tr>
<th>Compound</th>
<th>Volume Relative to Iron</th>
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<tbody>
<tr>
<td>Fe(OH)₃ · 3H₂O</td>
<td>6.5</td>
</tr>
<tr>
<td>Fe(OH)₃</td>
<td>4.5</td>
</tr>
<tr>
<td>Fe(OH)₂</td>
<td>3.5</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>2.5</td>
</tr>
<tr>
<td>Fe₃O₄</td>
<td>1.5</td>
</tr>
<tr>
<td>FeO</td>
<td>0.5</td>
</tr>
<tr>
<td>Fe</td>
<td>0.1</td>
</tr>
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0 1 2 3 4 5 6 7
Why Enamel?

- The glass layer limits the intrusion of chlorides into the reinforcement by making a protective layer.
- Enamel bonds directly with the steel.
- Concrete shrinkage is limited or non-existent.
- It is a known product, around for centuries.
- Can be applied to virtually any kind of metal substrate.
ERDC began looking into enameling as a way to increase strength and limit corrosion.

ERDC did preliminary data.

Partnered with outside sources to bring the technology forward.

PPEC was an early proponent of this technology providing samples.
Data From ERDC

Result of Pullout Composite Coatings

<table>
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<th>Treatments</th>
<th>Force (lbf)</th>
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<tr>
<td>Control</td>
<td>588.6</td>
</tr>
<tr>
<td>Enamel/Silica Fume</td>
<td>798.1</td>
</tr>
<tr>
<td>Enamel/Mica</td>
<td>1327.5</td>
</tr>
<tr>
<td>Enamel/Portland Cement</td>
<td>1767.2</td>
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Why Joint Research?

• Gain access to brighter minds.
• Participate in the discovery of new or novel ideas.
• Gain a different perspective of the technology
• Make sure that the idea was a good one.
Why MS&T and Missouri

Total Combined Truck Flows (1998)

MISSOURI

Network Flows (Tons)
- 6 - 200,000
- 200,000 - 1,000,000
- 1,000,000 - 5,000,000
- 5,000,000 - 50,000,000
- More Than 50,000,000

State to State Flows (Tons)
- 0 - 1,000,000
- 1,000,000 - 5,000,000
- 5,000,000 - 10,000,000
- More Than 10,000,000

U.S. Department of Transportation
Federal Highway Administration
Office of Freight Management and Operations
Freight Analysis Framework
Bond between concrete and coated rebar keeps increasing
Our material will promote bond strength with the concrete interface (an improvement of at least 3 times greater than regular rebar) while also inhibiting corrosion.

We use processes that have been around forever. Equipment needed (but not optimized) can be bought today.
Increase in Strength

Testing done at Missouri S&T
Bond between concrete and coated rebar keeps increasing

Some interesting behaviors from the coating
Before After

24 hours submerged in Distilled Water
Enameled Rebar (sample 4)

Before immersion in Distilled water

24h in Distilled water
Pictures of the Coating
Research has shown that we must make a more consistent glass layer on the part. We need to modify our production to allow some different methods of application. Manufacturing items:

1. Trying to get a certain % of active component
2. How to get the material into the matrix efficiently
3. Optimizing the glass layer
PPEC has placed rebar at Corpus Christi
We have other projects through the Corps
Missouri has committed to doing a bridge at the conclusion of our research
Conclusion

- We are not a new technology, but rather a hybrid.
- We have a technology that has been transitioned, is going through applied research, and in the demonstration phase.
- The technology can be sold commercially and needs to be optimized.