INTRODUCTION

Nature is inspiring biologists, chemists, and engineers to research together and create bioinspired materials that could advance various fields. Bioinspired materials are found in nature, can be used, modified, or modeled for a man-made application. These new materials can already be seen in industry.

To bring bioinspired materials to civil engineering, proteins are being considered as a baseline to creating a new admixture. This research considers three common proteins (albumin, hemoglobin, and lysozyme), their morphology in an alkaline environment and effects on the mechanical properties of cement.

OBJECTIVES

1. Determine changes in mechanical properties of cement with natural protein additives.
2. Observe changes to proteins’ physical and chemical structure when in alkaline solution.
3. Connect properties in proteins that cause certain changes in cement properties.

METHODS

Common mechanical tests were done on cement samples with protein concentrations of 0%, 0.05%, 0.25%, 0.5%, and 1.0%.
- Compressive strength
- Air content and distribution
- EIS
- TGA

Foaming properties of proteins in alkaline solution
- Foam stability
- Foam capacity
- Surface tension
- Bubble size

RESULTS

Cement Properties

Figure 1 (above): a) shark skin, b) Sharklet® material to reduce algae settlement and bacteria growth.

Figure 2 (left): protein structures of a.) albumin, b.) hemoglobin, and c.) lysozyme.

Figure 3: Optical images of cement cross sections used to determine the air void size distribution of a.) control b.) albumin, c.) hemoglobin, and d.) lysozyme.

RESULTS: Cement Properties

<table>
<thead>
<tr>
<th>Protein</th>
<th>Foam Stability</th>
<th>Foam Capacity</th>
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<tbody>
<tr>
<td>Albumin</td>
<td>H0 min/H10 min</td>
<td>H0 min/H10 min</td>
</tr>
<tr>
<td>DI</td>
<td>0.84</td>
<td>0.96</td>
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<tr>
<td>AR</td>
<td>0.98</td>
<td>0.97</td>
</tr>
<tr>
<td>DI</td>
<td>0.87</td>
<td>0.96</td>
</tr>
<tr>
<td>AR</td>
<td>0.94</td>
<td>0.97</td>
</tr>
<tr>
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<td>0.00</td>
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<tr>
<td>AR</td>
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<td>0.32</td>
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<tr>
<td>DI</td>
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<tr>
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<td>25.3</td>
</tr>
<tr>
<td>AR</td>
<td>9.3</td>
<td>16.5</td>
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</table>

Alginates
- Has a high (6.5%) uniform air void content
- Long setting time (25 hrs) but reduced flow caused air voids to stay trapped
- Significant reduction in compressive strength
- Slight rise in CH content at low concentrations

Hemoglobin
- Has the lowest air content (1%) of all protein concentrations
- High flow and long set time (34 hrs) allows most of the air voids to rise and escape, leaving small and uniform voids behind
- Slightly reduced compressive strength
- Linearly reducing CH content relative to protein concentration
- Has a high (6.5%), uniform air void surface

Lysozyme
- Has the highest air content (10.9%)
- Due to high flow, air voids were able to rise and combine but were trapped due to a smaller setting time (16 hrs.).
- Lower compressive strength by nearly half and a lower CH content
- Creates a crystalline air void surface

REFERENCES


RCSB, Protein Data Bank, (2018).

CONCLUSIONS

Data is currently being analyzed to identify the structural and chemical properties of the proteins and relate results to changes seen in cement so that someday, a synthetic admixture based on these natural proteins can be designed.

CONCLUSIONS

A Bio-Inspired Approach for Sustainable Concrete Infrastructure

Katelyn Kosar, Ali Ghahremaninezhad

DEFINITIONS

CH: Capillary height

Table: Concentration

<table>
<thead>
<tr>
<th>Solution</th>
<th>Concentration</th>
<th>Foam Stability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albumin</td>
<td>0.00</td>
<td>0.84</td>
</tr>
<tr>
<td>Hemoglobin</td>
<td>0.00</td>
<td>0.87</td>
</tr>
<tr>
<td>Lysozyme</td>
<td>0.00</td>
<td>0.96</td>
</tr>
</tbody>
</table>

Figure 4: SEM images of air void surfaces a.) control b.) albumin, c.) hemoglobin, and d.) lysozyme.

Figure 5: Optical images of foam used to determine the bubble size distribution of a.) control b.) albumin, c.) hemoglobin, and d.) lysozyme.

CONCLUSIONS