Effect of C-S-H Coated CNFs on the Performance of Cement Paste

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I. Motivation
- Carbon nanofibers (CNFs) have a tensile strength greater than that of steel
- CNFs and carbon nanotubes (CNTs) have the potential to enhance the mechanical performance of cement-based composites
- Unfortunately, dispersion of CNFs within the cement matrix remains a major challenge

II. Objectives
- Synthesize C-S-H (Calcium Silicate Hydrate) in the presence of CNFs to make CNFs more receptive to the cement matrix
- Characterize the coating of CNFs with C-S-H and dispersion effect by examining the microstructure and testing the macroscale mechanical properties

III. C-S-H synthesis with CNFs
- CNF dispersion
  - Sonicated with water and superplasticizer using a probe sonicator
  - Total sonication time: 15 mins
- C-S-H synthesis
  - Calcium nitrate tetrahydrate + Sodium metasilicate pentahydrate added to CNF solution
  - Total sonication time: 20 mins
- Sonication settings
  - 50% amplitude
  - 20 second on/ 20 second off pulses
  - 3/4" solid probe used

IV. Composites
- Portland Cement Pastes
  - Water to cement ratio = 0.28
  - CNF loading: 0.2% by wt. cement
  - CNF incorporation: polycarboxylate-based superplasticizer with sonication; CNFs with and without synthesized C-S-H
  - Solutions made were added to cement and then poured into three beams from which samples were cut

<table>
<thead>
<tr>
<th>Mix</th>
<th>Cement (g)</th>
<th>H2O (g)</th>
<th>SP (g)</th>
<th>CNFs (g)</th>
<th>Ca(NO3)2 · 4H2O (g)</th>
<th>Na2SiO3 · 5H2O (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC-M8</td>
<td>2700</td>
<td>756</td>
<td>27</td>
<td>5.4</td>
<td>16.2</td>
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V. Microstructure
- CNFs synthesized with C-S-H led to CNF microscale agglomerates in cement pastes that were less dense and more infiltrated by the cement phases

VI. Macroscale Mechanical Properties
- Mechanical Testing Methods
  - 3 point bending flexural test
  - Compression beam testing

- Flexural Strength
  - CNFs with synthesized C-S-H (PC-M8) improved the flexural strength at all ages

- Compressive Strength
  - No significant effect of CNFs (PC-CNFM) or CNFs with synthesized C-S-H (PC-M8) on the compressive strength at all ages

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Mix Cement (g) H2O (g) SP (g) CNFs (g) Ca(NO3)2 · 4H2O (g) Na2SiO3 · 5H2O (g)
PC-M8 2700 756 27 5.4 16.2 16.2
PC-CNFM 2700 756 27 0.4 0 0
PC 2700 756 27 0 0 0