Commercialization of SulfCrete®: An Alternative Low-Carbon Concrete

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Advanced Energy Conference, DOE R&D Session
March 27, 2018
Background

- Sulfur is a by-product material generated from the production of oil and gas and the cleanup of coal-fired power plant emission gases.

- Millions of tons/year are produced throughout the world - supply exceeds demand and large volumes of by-product sulfur are in storage (>21 M tons).
By-products to Co-products

- Excess by-product sulfur can be recycled into beneficial concrete co-products (e.g., pipes, aggregate for road construction, paving stones, railroad ties) for improved sustainable development

- Potential for displacement of conventional hydraulic cement in many applications; large potential markets
Sulfur Polymer Concrete Products

Recycling industrial by-products to produce new commercial co-products
Sulfur: the Green Concrete

- Large amounts of CO$_2$ are generated in the production of conventional hydraulic cement as limestone is converted to calcium oxide using high temperature fossil fuel kilns:

  $$\text{CaCO}_3(s) \rightarrow \text{CaO}(s) + \text{CO}_2(g)$$

- The cement industry accounts for 5 - 7% of all the anthropogenic production of CO$_2$ annually.

- Displacement of conventional hydraulic cement with sulfur-based thermoplastic binders (SPC) can reduce concrete industry carbon footprint.
Elemental sulfur is a thermoplastic that undergoes a solid phase change on cooling which results in changes in density and mechanical instabilities.

Sulfur polymer was developed by researchers in U.S., Canada, and Europe to suppress solid phase change and improve performance for use as an alternative construction material.

Currently, production of conventional sulfur polymer is limited by the cost and availability of dicyclopentadiene (DCPD) and oligomer additives used for processing.
SulfCrete® Formulation

- Conventional SPC is not cost-competitive and has not gained a significant market share
- BNL and collaborators developed an innovative and cost-effective alternative stabilized sulfur binder known as SulfCrete®
- (5) U.S. and international patents issued
- Replaces expensive organic additives (DCPD) with inexpensive fossil energy by-products and high surface area fillers (refinery distillates and coal fired fly ash)
## SulfCrete. Mechanical Strength (MPa)

<table>
<thead>
<tr>
<th>SSBAF Mechanical Testing</th>
<th>20° C</th>
<th>50° C</th>
<th>14 day immersion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Compressive strength</td>
<td>62.3</td>
<td>59.6</td>
<td>56.7</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>3.8</td>
<td>4.5</td>
<td>1.6</td>
</tr>
<tr>
<td>Average Flexural Strength</td>
<td>8.1</td>
<td>8.0</td>
<td>10.1</td>
</tr>
<tr>
<td>Std Deviation</td>
<td>1.1</td>
<td>2.0</td>
<td>1.1</td>
</tr>
</tbody>
</table>

### Typical conventional SPC:
- **Compressive strength**: 27.6
- **Flexural strength**: 5.2

*Sulfur Polymer Cement Handbook, The Sulphur Institute*

### Typical hydraulic cement concrete:
- **Compressive strength**: 20 – 40
- **Flexural strength**: 3 – 5

*http://www.engineeringtoolbox.com/concrete-properties-d_1223.html*
SulfCrete® Technology Status

- Limited lab-scale R&D and scale-up feasibility by BNL resulted in successful formulation with favorable mechanical properties
- Formulation optimization needed to identify lowest cost and best performance
- Engineering scale-up and demonstration
- Concrete product fabrication and testing
SulfCrete® Commercial Status

- Green SulfCrete, Inc. and BNL negotiated an exclusive license agreement
- Green SulfCrete is seeking business opportunities, capitalization and industrial partnerships
- Partnership with Roman Stone Construction, Inc.
- BNL and SulfCrete team won:
  - NSF Phase I grant for scale-up feasibility (complete)
  - DOE TCF grant for scale-up engineering and demonstration (awarded, pending contracts)
  - NYSERDA grant for scale-up product (awarded, pending contracts)
Green SulfCrete Business Plan

DOE Technology Commercialization Fund
NYSERDA

SBIR

Technology R&D (Scale-up feasibility)

Technology R&D (Scale-up deployment)

High Profile Demonstration

Industrial Partnerships

Commercial Deployment and Market Penetration

Roman Stone Construction Co.
DOE Technology Commercialization Fund

**Goals:**

- Design, develop, and demonstrate a working pilot-scale SulfCrete® production facility
- Fabricate real-world SulfCrete® products and test (under leveraged support from NYSERDA)
DOE Technology Commercialization Fund

**Tasks:**

1) Engineering scale-up; process equipment selection & preliminary testing
2) Characterization of materials
3) Optimization of formulations and process parameters
4) Short-term performance and QA/QC testing
5) Demonstration of integrated processing
6) Selection of SulfCrete® pre-cast products for production
7) Fabrication/testing of SulfCrete® pre-cast products
8) Determine marketing potential and outreach
Summary and Conclusions

- SPC results in lower greenhouse gas emissions: greener alternative than OPC
- Compared with conventional SPC, SulfCrete® uses multiple FE by-products to produce cost-effective co-products for a more sustainable world
- DOE TCF and NYSERDA projects will demonstrate pilot-scale viability needed to establish commercial viability