Combustion Ash Research Activities (Year 2003) at Temple University

by
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TU Research on Combustion Ash

- Zeolites production from MSWC ash
  - Synthesis of new MSWC ash-based zeolites
  - Exchange properties of zeolites

- Combustion by-products grout injection and weathering
  - Kempton Mine Complex/Siege of Acre
  - Weathering CCBs and method’s development
Zeolites Production from MSWC Ash

– Method developed

– Zeolites generation re-confirmed

– Ion exchange processes by MSWC Ash-based zeolites

– Presentation at International Conference
Zeolites Production from MSWC Ash

- Method developed
- Zeolites generation re-confirmed

X-ray diffraction patterns for untreated (A) and treated (B) MSWC ash.
M=Mullite; Q=Quartz; P=Zeolite Na-PI; F=Faugasite; S=Sodalite Octahydrate
Scanning electron microscope images of MSWC ash. A= Untreated sample; B= Sample fused in NaOH.

Zeolites Production from MSWC Ash

- Ion exchange processes by MSWC Ash-based zeolites
- Presentation at International Conference
Coal Combustion By-Products (CCBs) Grout Injection and Weathering Research

Background

- Maryland power plants currently generate \( \approx 1.2 \) million tons of CCBs annually.

- Only 30% of CCBs are beneficially used.
  - Remainder CCBs are placed in landfills.
Background

- MD’s Objective:
  - To expand beneficial use of CCBs.

- Need to demonstrate that any CCBs use is:
  - Economically feasible; and
  - Better alternative (environmentally) to land filling.

- CCBs-use demonstration is:
  - High-profile
  - Targeted to members of government, and the public.

What Is the Kempton Mine Complex

- A large abandoned underground coal mine
  - Complex straddles the MD-WV border
  - Kempton pool estimated to be a 1.1 billion-gallon reservoir

- Abandoned in 1950 (active for about 50 yrs)

- Largest single source of AMD in Maryland

- Discharges 3.5 million gallons a day
  - Discharges bulk of its AMD into MD's Laurel Run

- Mean pH (annual range 3.0 – 3.3)
Winding Ridge Project

- 5,600 cu yd CCB grout injected into Frazee mine.

- Grout consisted of:
  - 60% conditioned FBC product,
  - 20% Class F fly ash, and
  - 20% FGD product mixed with mine water.

- Grout was gravity fed
  - Free fall into mine from boreholes at ground surface
CCB Grout Injection at Winding Ridge
(Friendsville Area)
Boreholes ≈ 100 ft. above mine pavement.

Strategy: bulk filling of mine.
- Bulk filling prevents acid production.
- Grout flowed ≥100 ft along mine pavement at a 4% slope.

Conventional concrete-industry equipment used for grout mixing and injection.

Observations
- Grout pumped ≈ 50% farther than concrete in conventional concrete pumps.

- Appropriate method of grout placement
  - Did not result in detrimental segregation of grout mixture into its component materials.
  - Grout remained competent in acid mine environment.

- The 100% CCP grout:
  - Isolated pyritic surfaces and mine debris from air and water.
  - Created effective barrier to reduce formation of acid.
Siege of Acre I
Project
Siege of Acre (SOA) Phase I

- Characterization of Siege of Acre
  - Mapping and Database Development

- Drilling Program
  - Collected cores of mine pavement subsequently.
  - Cores analyzed at Temple University
    - Totals; TCLP
  - Boreholes remain intact for later use.

- Baseline Water Quality Monitoring
  - Monitoring to assess mine water generation and characteristics

Siege of Acre (SOA) Phase I

- Materials Research and CCB Grout Development

- Laboratory Testing
  - Chemical and Mineralogical Composition
  - Particle Size Analysis
  - XRD patterns
  - TGD

- Determine CCB Quantities for Grout

- Identify Sources of Materials
Siege of Acre (SOA) Phase I

- Desirable characteristics

- High reactive components:
  - CaO; Ca(OH)$_2$; SiO$_2$; Al$_2$O$_3$

- Low SO$_3$ content

- Little or no indication of aging/weathering minerals

- Absence of contamination

Table 1. XRF Analytical Results for Grout Admixtures

<table>
<thead>
<tr>
<th>Constituents</th>
<th>FBC By-products</th>
<th>Class F Fly Ash</th>
<th>FGD Material</th>
<th>Quick Lime</th>
</tr>
</thead>
<tbody>
<tr>
<td>K$_2$O</td>
<td>1.6</td>
<td>2.4</td>
<td>0.2</td>
<td>Nil</td>
</tr>
<tr>
<td>MgO</td>
<td>2.3</td>
<td>1.1</td>
<td>0.67</td>
<td>1.5</td>
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<tr>
<td>Fe$_2$O$_3$</td>
<td>6.2</td>
<td>5.6</td>
<td>0.56</td>
<td>0.35</td>
</tr>
<tr>
<td>Al$_2$O$_3$</td>
<td>11.5</td>
<td>28.5</td>
<td>2.6</td>
<td>0.5</td>
</tr>
<tr>
<td>SO$_3$</td>
<td>12.3</td>
<td>0.59</td>
<td>47.1</td>
<td>0.04</td>
</tr>
<tr>
<td>SiO$_2$</td>
<td>24.7</td>
<td>52.4</td>
<td>3.4</td>
<td>1.5</td>
</tr>
<tr>
<td>CaO</td>
<td>24.8</td>
<td>1.6</td>
<td>35.4</td>
<td>97.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trace Constituents</th>
</tr>
</thead>
<tbody>
<tr>
<td>MnO</td>
</tr>
<tr>
<td>Cr$_2$O$_3$</td>
</tr>
<tr>
<td>V$_2$O$_5$</td>
</tr>
<tr>
<td>Chloride</td>
</tr>
<tr>
<td>TiO$_2$</td>
</tr>
<tr>
<td>Na$_2$O</td>
</tr>
</tbody>
</table>

Source: STUC (1996)
Siege of Acre (SOA) Phase I

- **North end of the KMC**
  - Represents ≈ 600 ac sub-aerial mine pavement in KMC
  - Mine pavement: source of most of acid discharged into Laurel Run.

- **SOA Phase I:**
  - Provided a detailed characterization of site:
    - 8 boreholes verified mine geometry & location.
    - Downhole cameras guided subsequent drilling.

- **Drilling program:**
  - Monitoring to assess mine water generation and characteristics
  - Collected cores of mine pavement subsequently.
  - Cores analyzed at Temple University
  - Boreholes remain intact for later use.
Siege of Acre II Project

- Build upon success of SOA I and Winding Ridge Project
- Pozzolan stabilized grout material prepared with:
  - Fluidized bed combustion (FBC),
  - Flue gas de-sulfurization (FGD) products, and
  - Fly ash.
- Develop methods to inject and monitor targeted grouting of acid-producing areas.
- Optimizing combination of:
  - Grout mixing; and
  - Injection equipment and methods
Siege of Acre, Phase II

- Develop and implement techniques for pre- and post-injection monitoring of the area targeted for grout injection

- Develop formulae for using alternate sources of CCPs as a contingency.

Accelerated Weathering and Method Development
Accelerated Weathering and Method’s Development

- ASTM method versus our simplified weathering method
  
  – ASTM Method
  
  – Circle of alternating:
    • Wet period (3 days) with humid air;
    • Dry period (3 days) with dry air.
    • Leaching period (1 day) with DI or mining water
Accelerated Weathering & Method’s Development

- Modified method:
  - Single period (6 days) of humid air (95+ RH)
  - Leaching (1 day) period with DI or mining water

Simplified EERG Method
Accelerated Weathering & Method’s Development

Results
- Modified version just as good as ASTM
- Correlation between ABA (static, standard) and APR (kinetic, from modified accelerated weathering setup) very good
- Establishes usefulness of modified version

Next steps:
- Run (and compare modified setup and ASTM setup) simultaneously.

Conclusions

- EER of TU engaged in variety of ash research:
  - Beneficial use of combustion ash
  - Generating new materials from combustion ash
  - Applications are enormous
  - Received recognition from State, Federal, and private organizations
  - Publications

- Established partnerships/consortia with:
  - Universities (CU, SUNY; Vilanova, PU, Garrett),
  - Agencies (EPA, MD DNR-PPRP),
  - Private organizations (WMD RC&D)
Acknowledgement

- **US EPA (Office of Water)**
  - Grant on beneficial use of MSWC waste ash
  - Technical and collaborative support

- **State of Pennsylvania/BFTDA**
  - Grant (multi-year) on interdisciplinary research on green materials, sustainable design and community outreach.
  - Administrative & technical support

- **Western Maryland RC&D (Mr. Gary Fuhrman, Administrator)**
  - Grant on geotechnical studies on CCBs grout formulations
  - Administrative & technical support

- **MD Department of Natural Resources, Power Plant Research Program (Dr. Peter Dunbar, Director)**
  - Administrative & technical support

- **Universities/Colleges**
  - TU (CST; COE); Drexel; PU; Villanova; Columbia; SUNY; Garrett Community College