

Materials Technologies Group

“Cement Group”



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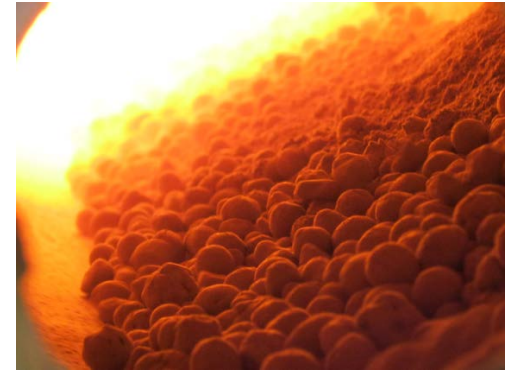
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The Issue: OPC and CO₂ emissions

- **Production of Ordinary Portland cement (OPC):**

Limestone + Shale + Energy → Cement + CO₂

For 1 ton of cement produced → ≈ 1 ton of CO₂ is emitted
≈ 50% from the calcination of limestone
≈ 40% from the fossil fuels to heat kiln



- **Why do we keep producing OPC?**

- Commonly Available Materials
- Easy to Produce
- Great Performance
- But Large Carbon Emission: responsible for 8% of the global CO₂-emissions

- **The issue:**

- Replacing and displacing Portland cement is one of the greatest materials engineering challenges of our time

- **What Can We Do About It?**

- Alternate Cements: “Lower Energy Lower CO₂”
- Increased Use of Supplementary Cementitious Material
- Use Lean Material Strategies

What does this group do?

- The Cement Group develops construction materials and novel cements from coal combustion by-products (CCBs) and industrial waste streams.

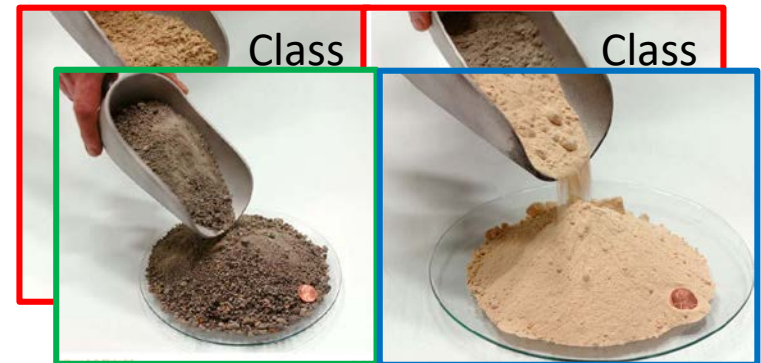
- **What is cement?**

Binder that hardens and adheres to sand (mortar) and/or sand and aggregates (concrete).



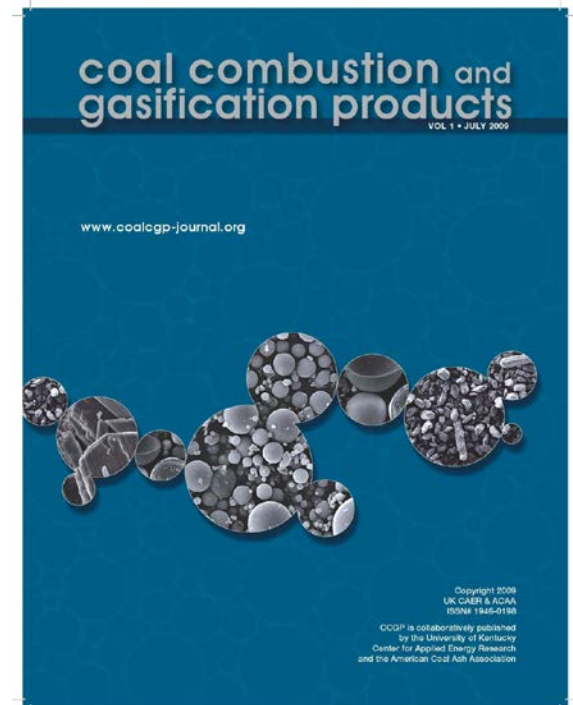
- **What are CCBs and industrial waste streams?**

- | | |
|---------------------------|----------------|
| • Fly ash | • Pondered ash |
| • Bottom ash | • Red mud |
| • FGD products | • Slag |
| • Post-consumer glass,... | |



What does this group do?

- **Low Energy, Low CO₂ Cement**
 - Calcium Sulfoaluminates (CSA)
 - Clinkerless Cement (FBC)
 - Supplementary Cementitious Materials
 - Fly Ash, Gypsum
 - GGBFS (Ecocem)
 - Dry Scrubber Materials (EPRI, Longking)
- **Coal Ash Beneficiation**
 - Use of ponded ash (EPRI)
 - Ash Guidelines (EPRI)
- **Piezoelectric Properties (NSF)**
- **Polyurethane Foams**
- **Cementitious Coatings (Masco Coatings Group – “BEHR Brands”)**



What does this group do?

- Project: Tekcrete Fast

After Four Years and \$2 MM, the DHS/NIHS Program Resulted in “Breakthrough Technology”

Unique technology that allows a fiber-reinforced, high-strength, ultra-rapid setting concrete to be applied for **almost immediate stabilization** of unstable geological strata for mining purposes, and **damaged infrastructures**.

- Technology that is simple, robust and deliverable with portable equipment
- Works with wide variety of water to cement ratios
- Does not require surface preparation, bonds to portland concrete, wood, steel, aluminum etc.
- Can be tailored to other applications
- Laid the groundwork for a new generation of materials



Military Applications

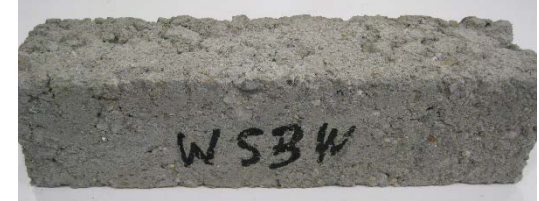
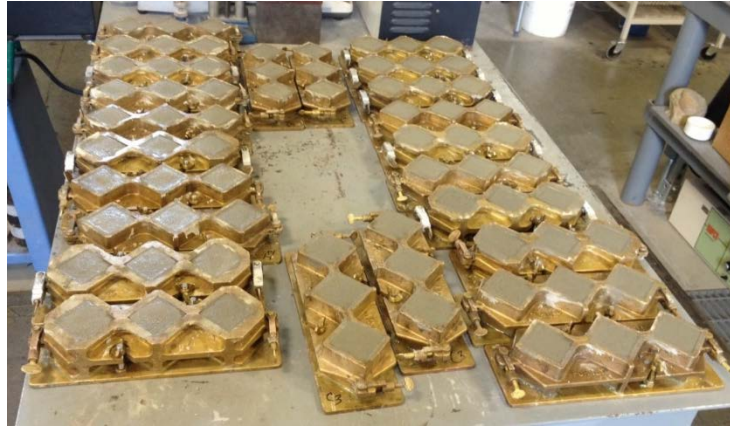
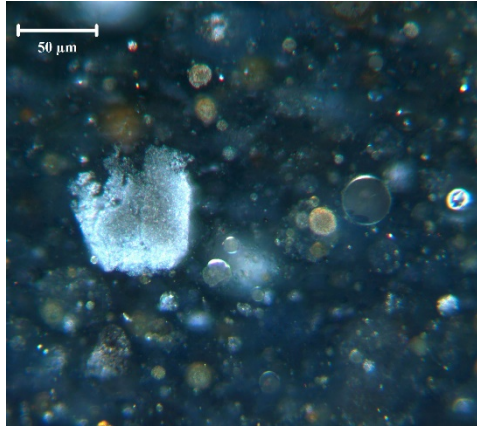


Rapid Placement of
Instant Hardening of
Force Protection “Instant Armor”
Potential Targets

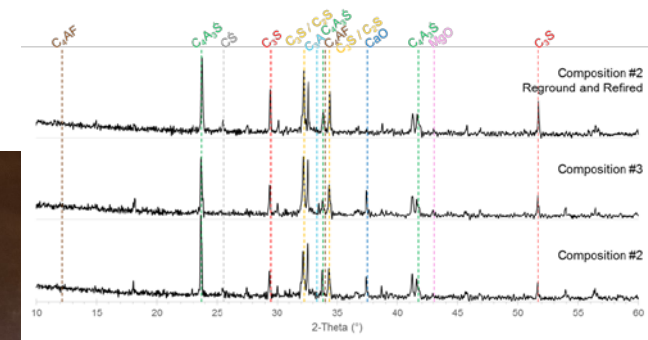
Ongoing Projects: Spray Drier Absorber Materials

Replacement for OPC:

Determine their potential use as replacement for Portland cement in concrete



Use as a raw material for the production of CSA cements



X-ray diffractograms of hybrid clinkers

Ongoing Projects: Ash Guidelines

Use of ponded ash:

Coal combustion by-products (CCBs) are disposed of in ponds (wet storage) or in landfills (dry storage).

In 2012 → 470 coal-fired electric utilities generated 110 millions tons of CCBs

→ 40% were beneficially used

→ Ponds are being closed

→ **Our group is looking to reuse this ponded ash in cement and concrete and create guidelines**



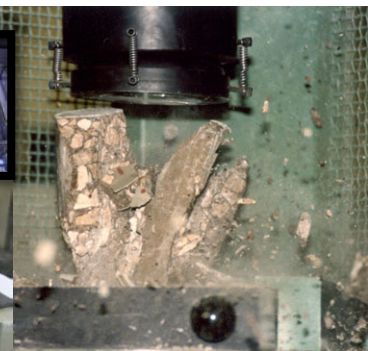
<http://www.kyforward.com/wp-content/uploads/2016/01/coal-ash-plant-bedford.jpg>



Production of mortar in a Hobart mixer



Carbonation testing



Concrete cylinder tested for compressive strength

Freezing and thawing testing

<https://www.epa.gov/coalash/frequent-questions-about-coal-ash-disposal-rule>

<http://sentryair.com/blog/portable-fume-extractors/dangerous-dust-control-measures-during-concrete-testing/>

What skills and expertise can you acquire?

- **Chemical Engineering**

- Processing and analysis of raw materials
- Chemical testing of cement
- Design and safety of cement production

- **Materials Engineering**

- Material characterization (XRF, LOI, XRD, SEM, PSD, Microscope,...)
- Synthesis and optimization of clinker / cement / concrete
- Mechanical testing
- Hydration process

- **Mechanical Engineering**

- Mechanical testing
- Equipment design
- Optimization of process / testing / methods

- **Civil Engineering**

- Material characterization (XRF, LOI, XRD, SEM, PSD, Microscope,...)
- Synthesis and optimization of clinker / cement / concrete
- Mechanical testing

Additional info

- **The Cement group has collaborations all over the world:**
 - Australia, China, France, Scotland, Turkey,...
- **Where does the Cement group get funding from?**
 - National Institute for Hometown Security (Department of Homeland Security)
 - Electric Power Research Institute (EPRI)
 - Companies (Minova, Ecocem)
 - Utilities (WE Energies, Duke, AEP)
 - National Science Foundation (NSF)
 - Longjin (China)
- **Where does the Cement group publish?**
 - Cement and Concrete Research
 - American Concrete Institute (ACI)
 - Shotcrete Magazine
 - Journal of Sustainable Cement-Based Materials
 - Coal Combustion and Gasification Products
- **Where does the Cement group present its results?**
 - World of Coal Ash (WOCA)
 - American Concrete Institute
 - International Concrete Conferences in Dundee
 - Asian Coal Ash Association (ACAA) in China
- **Where do students that work in the Cement group go afterwards?**
 - Academia (ESIREM, Middle East Technical University, Nanjing Tech University)
 - Industries / Utilities (Palmer Engineering, Vantage Engineering, Boral, C&I Engineering)