

Environmental and Coal Technologies ECT Group



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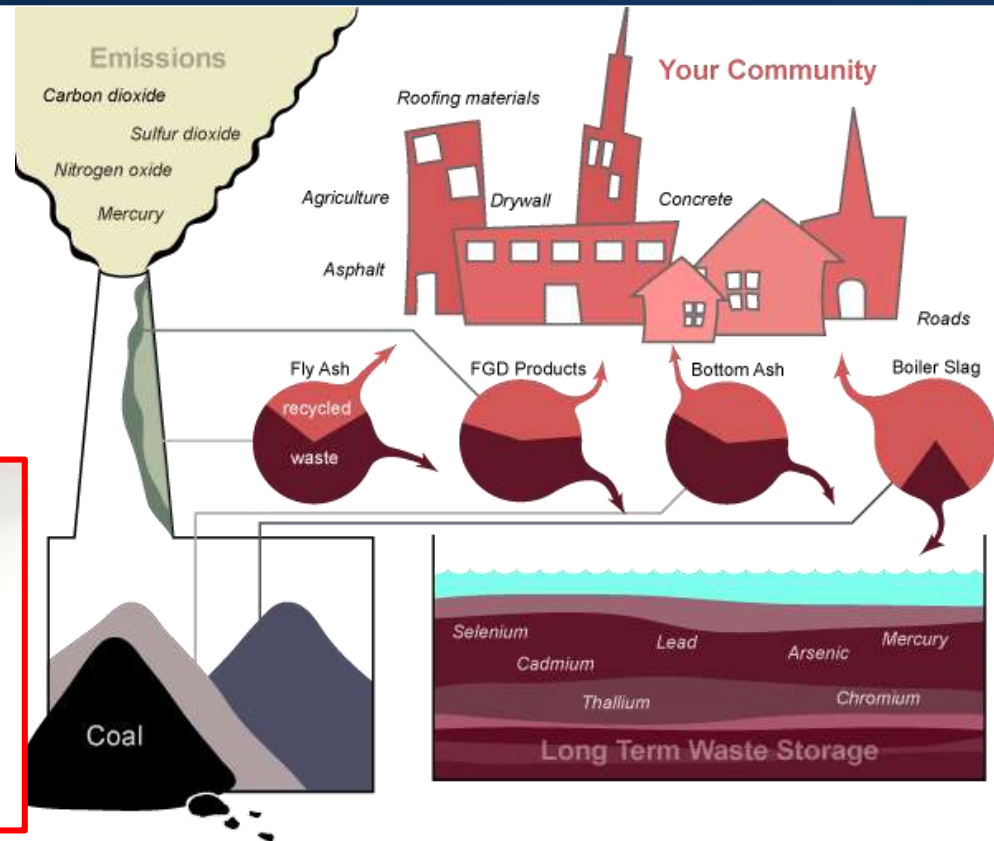
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What does this group do?

- What are Coal Combustion By-products: minerals that remain after coal is burned to generate electricity:

- Fly ash
- Bottom ash
- FGD products
- Boiler slag



<http://www.groundtruthtrekking.org/Issues/AlaskaCoal/Coal-Ash-Combustion-Wastes.html>

- The ECT group **develops products and processes that manufacture construction materials from CCB's** such as cements, grouts, wallboard, masonry blocks, fillers, etc.
- The ECT group **investigates all aspects of coal combustion by-product utilization.** As such, it generates information for the transfer of new ideas to benefit the innovative utilization, handling, storage and disposal of CCBs

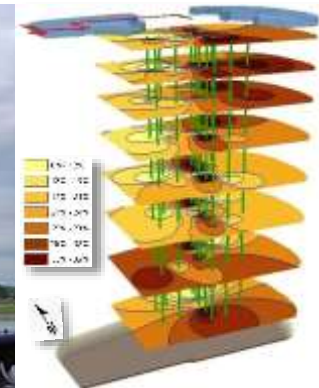
What does this group do?

- **Coal combustion and coal gasification by-products processing**

➡ Develop beneficiation technologies to produce high-quality, consistent products from ash/slag

- **Concrete and mortar**

➡ Develop an intensive research program focused on CCB chemistry and end-use quality considerations



Density separation – Spiral Method



Production of mortar in a Hobart mixer

Mortar cubes



Concrete cylinder tested for compressive strength



Carbonation testing



Freezing and thawing testing

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

What does this group do?

- **Project: Tekcrete Fast**

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.



<http://www.kentucky.com/news/politics-government/article44364165.html>

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- **Collaboration with the College of Design**

Creation of viable products using geopolymer concrete produced entirely from coal ash



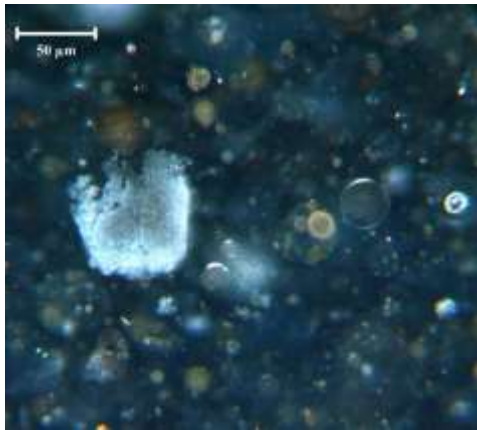
What does this group do?

- **Dry FGD Material Research (Longjin project)**

This project involves both fundamental studies of the dry flue gas desulfurization (FGD) material, and its interaction with OPC.

- **Spray Drier Absorber Materials (EPRI project)**

Determine their potential use as replacement for Portland cement in concrete



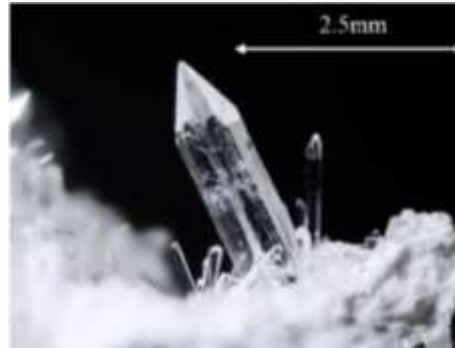
- **Materials Testing Support for Industrial By-products**

ECT group has the capability to contract out characterization and testing services, as applied to CCBs in cement, among other types of materials.

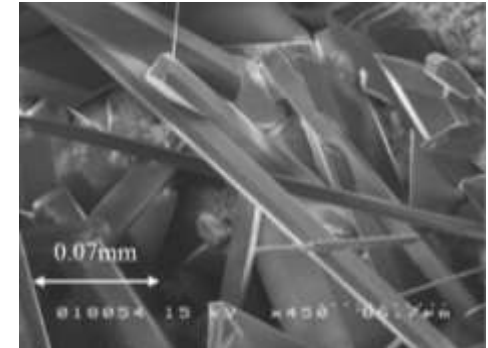
Ongoing project: Cement as a Novel Electric Source for Energy-Harvesting Materials

- **Ettringite:**

- ➡ provides the primary strength in CSA cements (low-energy low CO₂ cements = alternatives to OPC), and early strength in OPC



Prismatic Ettringite Crystal



Ettringite Crystals in a cementitious matrix

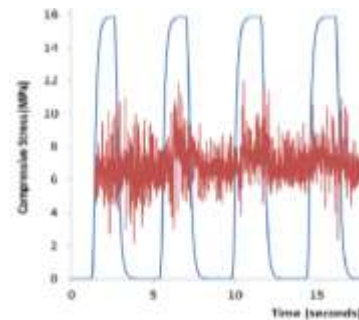
- **Piezoelectric materials:**

- ➡ have the ability to interchange mechanical strain energy into electrical charge

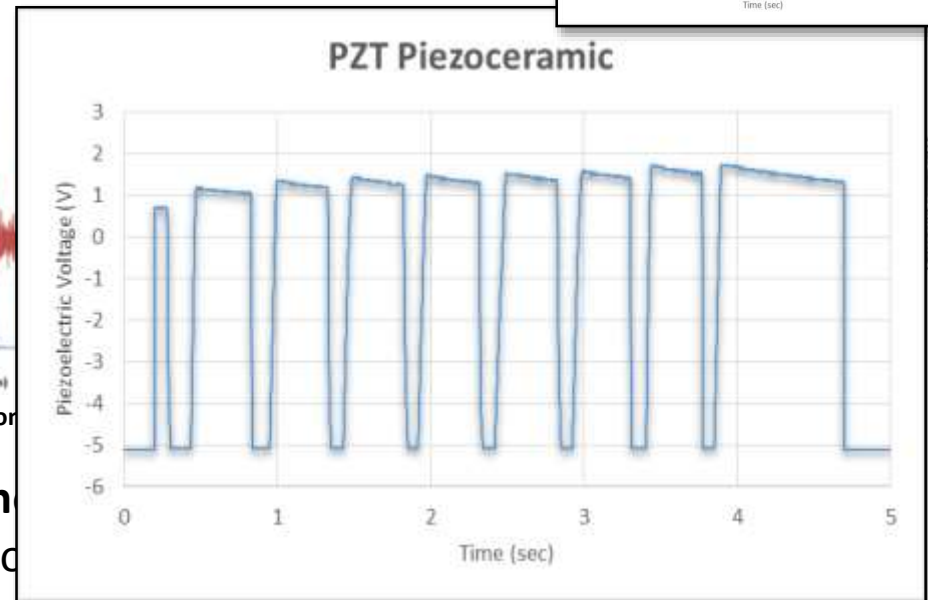
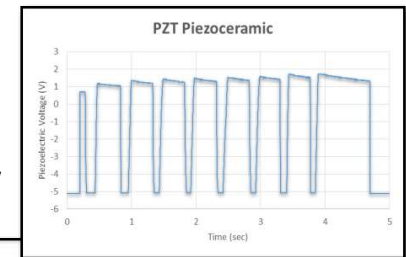
- ➡ commonly used in dynamic applications involving vibration suppression, mechanical impact and sensing, **but** not so much for energy harvesting (by mechanical processing)



Set up of experiments



Piezoelectric response



Goal:

To quantitatively and unambiguously **verify** this discovery will lead to numerous applications in the energy harvesting industry.

Ongoing project: Development of Low-CO₂, Low-Energy Hybrid Cements



Ordinary Portland cement (OPC)

- Alite
- Belite
- Tricalcium Aluminate
- Ferrite



Calcium Sulfoaluminate cement (CSA)

- Calcium Sulfoaluminate
- Belite
- Ferrite

Parameters:

- Choice of raw materials
- Composition
- Firing temperature
- Dwell time



Quenching process



Rotary kiln

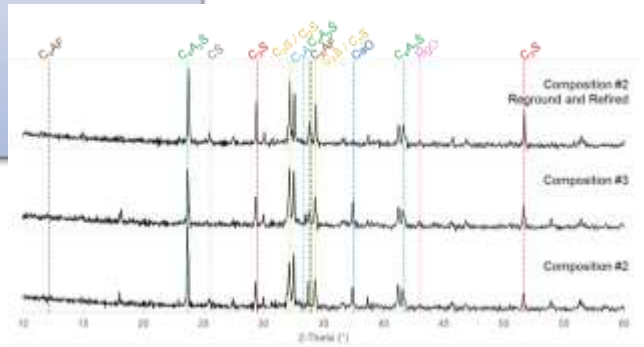


Hybrid Cement

- Calcium Sulfoaluminate
- Alite



Clinker pellets



X-ray diffractograms of hybrid clinkers

Goal:
Optimize production of hybrid cement from exclusively by-products

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 ECT group has collaborations all over the world:**
 - Australia, China, France, Scotland, Turkey,...
- **Where does the ECT 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 ECT 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 ECT 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 ECT group go afterwards?**
 - Academia (ESIREM, Middle East Technical University, Nanjing Tech University)
 - Industries / Utilities (Palmer Engineering, Vantage Engineering, Boral, C&I Engineering)