Meeting New Specifications with Fly Ash Based Cements and Products

CeraTech, Inc.

World of Coal Ash
Denver Colorado
May, 2011
Company History

Company & Technology History Overview

- Began initial pozzolan cement development effort (1994)

- Original ceramic cement technology (1998 - 2005)
  - Worldwide technology leader
  - Raw material costs limit market opportunities
Company History

Fly ash cement technology (2005 - present)

- Leveraged pozzolan expertise
- Developed high performance “GREEN” cement
- Superior performance characteristics to ordinary Portland cement (OPC)
- Recent technical advancements have reduced costs to less than OPC in scale.

15 years and more than $20M expended towards technology development effort
History of Activated Ash Cements

1970s - 1980s
- Geopolymers: Davidovits, Handy
- Ash / Slag / Cement Blends: Dodson
- Chloride Salts: Turpin

1990s
- Acid-Base Reactions w/Class C Fly Ash: Gravitt
- Class C Fly Ash w/ Portland Cement: Kirkpatrick, Styron, Heitzman, Brook
- Alkali Activated Fly Ash: Roy

2000s
- Organic Acid / Alkali Metal Salts: Hicks
- Mono-Chemical Approach: Schumacher et al
CERATECH’s Approach
Activated Ash Cements

- Develop Products That Utilize As Much Fly Ash As Possible (Up to 92%)
- Develop Products That Do Not Use Portland Cement

Open The Design Approach To Accommodate:

- Fly Ash
- Bottom Ash
- Biosolids Ash
- Crushed Glass
- Other Waste Pozzolans
CERATECH’s Approach

Controlled Ash Activation Using A Mono-Chemical Activator

- Roadmap of Ash “Reactivity”
- Understanding of Fly Ash “Mineralogy”
- Understanding of Power Plant Operating Environment
Cement Science

- Consists almost entirely of coal combustion by-products (Fly ash)
- Not manufactured
- Combines with water to form Gehlenite hydrate and calcium sulfoaluminate hydrates
Portland Cement Issues:
- Slow setting
- Slow strength development
- Surplus calcium formation $\text{Ca(OH)}_2$
- $\text{NaOH}$ reacts with aggregates to cause ASR
- $\text{NaOH}$ reacts with aggregates to cause ACR
- $\text{Ca(OH)}_2$ causes alkali burns
- Requires high water content resulting in shrinkage
- Major hydrates are gels with high porosity
- High porosity results in poor durability
- Weak bond to aggregates and itself
Advantages of CERATECH Cement:
- Densely packed crystal structure
- High durability
- ASR resistant
- Low water demand = high strength
- Flexible working times
- Bonds to Concrete, aggregates and steel
Cement Science
PERFORMANCE BASED CEMENT DESIGN

- Optimize Different Ash Reactivity For Different Products
- High Early Strength Repair Products
- Cement For Volumetric Mixers
- General Ready Mix Cement
- High Temperature End Use Cements
- Masonry Block System (Block, Mortar, Grout)
- Shot-Crete Cement
- Ultra High Strength Cement
SPECIFICATIONS

Performance-Based Design Optimizes Critical Parameters Based Upon:

- **ASTM: C - 928** (Rapid Hardening Mortars, Concrete)
- **ASTM: C - 1600** (Rapid Hardening Cement)
- **ASTM: C - 115 7** (Hydraulic Cement)
- **ASTM: C - 90** (Block)
- **ASTM: C - 91** (Masonry Cement)
- **ASTM: C - 270** (Masonry Mortar)
- **ASTM: C - 476** (Grout)
Specifications Parameter Overview

- Compressive Strengths C109, C 39
- Coefficient of Thermal Expansion AASHTO TP 60
- Freeze / Thaw C 666A
- Corrosion Resistance ASTM C1202, C1556, C1543 - Ponding
- Modulus of Elasticity ASTM C 469
- Shrinkage C 157, C 1038, C 596
- ASR C 1567
- Sulfate Resistance C 1012
- Scaling Resistance ASTM C672
- Abrasion Resistance ASTM C 944, C 779
- Flexural Strength C 78 (15% of Compressive strength)
Existing Environmental Impact

US Landfills Burdened By Fly Ash

- 70 - 80% of All Coal Ash is Landfilled  
  Source: US EPA

- Over 50 Million Tons In The US
CO₂ Emissions By US Ordinary Portland Cement Plants

- Approximately 3 Billion Tons of CO₂ Produced Annually
- Consumes 2 Million BTUs / Ton
- Requires 70 to 100% Virgin, Quarried Material
Immediate Environmental Advantages
Through The Displacement of Portland Cement

One Ton of Cement

PORTLAND CEMENT
100% - Virgin Resources
0% - Renewable Substances
2000 lbs. - CO₂ Generated Via Production Process
0 lbs. - Material Diverted From Landfills
55 Gallons of Crude Oil - Required For Production

CERATECH GREEN CEMENT TECHNOLOGY
2% - Virgin Resources
0% - Portland Cement
8% - Renewable Substances
90% Coal Ash
0 lbs. - CO₂ Generated Via Production Process
1800 lbs. - Material Diverted From Landfills
0 Gallons of Crude Oil - Required For Production

One Cubic Yard of Concrete

CONCRETE PRODUCED FROM PORTLAND CEMENT
100% - Virgin Resources
0% - Renewable Substances
0 - 30% Coal Ash
0% - Coarse Aggregate from Re-cycled Materials
667 lbs. - CO₂ Associated With Portland Cement Binder
Up to 225 lbs. - Material Diverted From Landfills

CONCRETE PRODUCED FROM CERATECH GREEN CEMENT TECHNOLOGY
2% - Virgin Resources
0% - Portland Cement
8% - Renewable Substances
90% Coal Ash
Up to 50% - Coarse Aggregate from Re-cycled Post Consumer Materials
0 lbs. - CO₂ Associated With CERATECH Cement Binder
600 lbs. - Material Diverted From Landfills
Construction Cements

- General Use to Ultra High Performance Cement
- Thermal Resistant High Performance Specialty Cement
- Chemical Resistant, High Performance Cement
- Ultra High Performance Cement For Volumetric Concrete Delivery Systems
Case Study
USMC Rapid Warehouse
Bridgeport, California  September 2007
Case Study

Georgia DOT I-16
Full Depth Slab Replacement
Macon, GA February 2008
Case Study
Savage Sulfur Flume - Galveston Texas
January 2010

- Superior Durability and Resistance To Sulfuric Acids and other Caustic Compounds
- Broad Mix Design / Rapid Return To Service
- GREEN Sustainable Technology
Case Study
Industrial Facility Slab

Thermal Resistant Cement
FUTURE EFFORTS

- Continued Mineralogy Fingerprinting
- Synthetic C Production In Conjunction With Power Companies
- Incorporation of Other Post-industrial Waste Streams
CONCLUSIONS

CERATECH Has Developed The Next Generation of Activated Ash Cementitious Products

CERATECHs Approach Has Been Based On A Specific Chemical Design Methodology

This Approach Requires A Great Deal of Analysis of Fly Ash Chemistry and Mineralogy

Results To Date Have Shown That A Wide Range of Products Can Result From This Approach, Overcoming Issues From Previous Approaches

CERATECH Continues To Advance Our Research To Expand The Ability To Utilize More Forms of Wastes, Including CCBs
End Presentation