A Presentation to
U.S. Office Of Management and
Budget

December 14, 2009

Specific Use of Coal Fly Ash in the Stabilization
of Underground Mines
in the Kansas City Area

Burns & McDonnell
Founded 1898
History of USC

- Small company started in 1994 to solve underground mine stabilization for Briarcliff Development.

- Has since performed stabilization services for third parties to backfill and stabilize underground limestone mines.
Use of Flyash as Recyclable Material

- The first step for $200 million of commercial and residential development over 80 acre limestone mine in Kansas City.

- Backfill of City streets and State and Federal Highways located above limestone mines to prevent collapse.
Long Track Record of Successful Backfilling

• Backfilling has been in process for more than 15 years, with support by many parties:
  – Missouri DNR
  – Kansas Dep’t. of Health and Environment
  – U.S. EPA Region 7
  – City of Kansas City, Missouri
  – Unified Government of Wyandotte County and Kansas City, Kansas
  – MoDOT (Missouri Department of Transportation)
Coal Flyash in Mine Stabilization

- Mine Stabilization
  - The Material is Well Suited to Purpose
  - Suited to Specific KC Mine Geology and Hydrogeology

- Flyash as a Recyclable Material
  - Comparable Materials Likely Not Feasible

- Impact of Regulations
  - Could Disrupt Mine Stabilization Projects
Mine Stabilization

• Typical Underground Mines in KC
  – Limestone Rock
  – 14-Foot High Room-and-Pillar Mines
  – 200 feet Below Ground Surface

• This Project: Over 90 Acres

• Principal Stability Issue: Strong Limestone Versus Weak Shale
Mine Stabilization

Briarcliff Mine Entry
(Active Mining 1952 – 1969)
Mine Stabilization

Mine Rooms and Pillars

Dry Floor
TYPICAL KANSAS CITY LIMESTONE MINE
GEOLOGIC PROFILE

Elevation in Feet

NORTH

SOUTH

700
HUSHPUCKNEY SHALE
TYPICAL DOMEOUT

750
WESTERVILLE LIMESTONE
WEA SHALE
WINTERSER LIMESTONE

800
WEA SHALE
STARK/GALESBURG SHALES

850
SHALES AND LIMESTONES

900
SOIL

GEOLOGIC PROFILE

GENERALIZED GROUND SURFACE

ENTRY

APPROX. 2000 FEET

BETHANY FALLS LIMESTONE.
Typical Roof Defect ("Pothole"): Shaley Zone in Limestone Roof
Later: Chunks Down
Later Again: Roof Falls

Typical “Domeout”

Strong Limestone

Weak shales now massively exposed to moist mine air—accelerating deterioration
Weak Shales now Exposed in Domeout

FORMATION OF DOMEOUT

WINTerset LIMESTONE

WINTerset "PICTURE PUZZLE"

STARK SHALE

GALESBURG SHALE

SPALLING

STRESS RELIEF

MINE ROOMS

BREAKDOWN PILE

HUSHPUCKNEY SHALE

PILLARS (BETHANY FALLS LIMESTONE)

"BETHANY ROOF"

"PEANUT ROCK"

BETHANY FALLS

TENSION FRACTURES
Multiple-Room Domeout with Surrounded Internal Pillar

Shale Slabs Spall Off; Pillar Size Diminishes
Progression of Collapse to Surface

1. Spalling  
2. Spalling
3. Pillar Crushed
4. Shear Failure of Winterset & Younger (May extend to surface)

WEA Shale
Winterset
"Picture Puzzle" Stark & Galesburg
"Peanut Rock"
Bethany
Hushpuckney
Mine Stabilization

Rapid Mine Collapse, KCK: Kansas City Star 1998

Morning temblor makes appearance in KCK

The effects of Thursday's minor earthquake in Kansas City, Kan., could be seen in the parking lot of the Indian Springs Medical Building. Don Denney walked near the crevice as he talked on a cellular phone following the morning temblor.

Mild quake strong enough to cause damage

Rare event leads to dozens of phone calls

By MARK WEBB
The Kansas City Star

An earthquake briefly shook parts of Kansas City, Kan., at 9:18 a.m. Thursday, jarring some nerves, damaging one structure, forcing the evacuation of several buildings, but injuring no one.

By California standards, it was a small earthquake. But in this area, where earthquakes are rare, the tremor triggered dozens of phone calls to police, news agencies and Wyandotte County's Unified Government.

It was, after all, the first earthquake in many years that caused noticeable tremors in the Kansas City area, according to Don Steeles, a geophysics professor at the University of Kansas.

Thursday's quake might not have been felt outside of Kansas City, Kan. Dispatchers at the Johnson County Emergency Communications Center and the Kansas City Police Department communications unit didn't receive any reports of tremors.

Steeles said area residents had little reason to worry about earthquakes.

"We don't know what's going to happen," Steeles said. "But statistically, I have a great deal of confidence that there are going to be a hundred times more earthquakes in Los Angeles than in Kansas City over thousands of years."

Steeles said a 1961 earthquake felt here measured nearly 4.0 in magnitude. Its epicenter was about 20 miles northeast of Kansas City, Mo.

More recently, seismographs recorded two earthquakes near Kansas City International Airport in the mid-1980s, he said, but no one felt those.

In addition, the U.S. Geological Survey in Golden, Colo., notes that in 1968, an earthquake centered in southern Illinois registered a magnitude 5.3 and was felt in this area.

See QUAKI, A-8
Mine Stabilization

Surface Subsidence Over Rapid Mine Collapse, Kansas City, Kansas, 1998
Mine Stabilization

• Solution:
  – Protect the Pillars
    • Pillars Are Already Doing Their Job
  – Self-Cementing Flyash Encases the Pillars
    • Strong Enough to Prevent Chunks from Falling Out
    • Immerses Them to Isolate Them from Humid Mine Air
Mine Stabilization

DOMEOUT BACKFILL:
(FLYASH)

BACKFILL HOLE
(DRILLED FROM SURFACE)

VENT HOLE

WINTerset

"PICTURE PUZZLE"
STARK & GALESBURG
"PEANUT ROCK"
"BETHANY ROOF"

FLYASH SLURRY

BERM

PILLAR

BREAKDOWN PILE

HUSHPUCKNEY
Mine Stabilization

DOMEOUT BACKFILL: (FLYASH)

BACKFILL HOLE (DRILLED FROM SURFACE)

VENT HOLE

WINTERSSET

"PICTURE PUZZLE"

STARK & GALESBURG

"PEANUT ROCK"

"BETHANY ROOF"

FLYASH SLURRY

PILLAR

BREAKDOWN PILE

HUSHPUCKNEY

BERM
Mine Stabilization

Backfill Operation
- Building Berms
  (Bottom Ash)
Mine Stabilization

Backfill Operation – Drilling Holes
Mine Stabilization

Backfill Operation – View Up Borehole
Mine Stabilization

Backfill Operation - Placing Flyash
Mine Stabilization

Backfill Operation - Flyash Slurry Flow, 200 feet below ground
Mine Stabilization

Mine Backfill;
Originally 14 foot Room Height
Mine Stabilization: Cutaway View

Mine Roof, 14 feet above floor

Backfill Layers – Typically $\frac{1}{2}$-inch per 25-Ton Truckload
Another Cutaway View in Breakdown Pile in Domeout

- Fallen Stark Shale Slabs
- Solidified Flyash Slurry Filling Former Interstices Between Shale Fragments

Bethany Falls Pillar
Development Above the Mine
Development Above the Mine
Without Mine Stabilization:

- **Ground Above Mines =**
  - **Wasteland**
  - **Infrastructure at Risk**
    - US Hwy 169
    - Briarcliff Pkwy & Mulberry Drive
    - I-435
    - Holliday Drive
    - 59th Street

- **Pozzolonic (self-cementing) Coal Flyash Slurry Fills the Void**
Recyclable Material

• Beneficial Use

  – Used as “Substitute” for Other Commercially Available Products
    • Cement Grout: Low Flow and Extreme pH
    • Sand: Poor Flow Characteristics
    • Mud: No Strength to Preserve Pillars

  – Mine Worker Safety is Improved by Use of Flyash (Can be placed from aboveground)
## Recyclable Material

### Comparison of Mine and Landfill: Physical Environment

<table>
<thead>
<tr>
<th><strong>MINE</strong></th>
<th><strong>LANDFILL</strong></th>
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<tbody>
<tr>
<td>• No Weathering or Erosion Potential</td>
<td>• Potential Erosion</td>
</tr>
<tr>
<td>• Direct Contact Pathway Eliminated</td>
<td>• Potential Direct Contact Pathway</td>
</tr>
<tr>
<td>• No Potential Blowing Dust, Eliminates Inhalation Pathway</td>
<td>• Blowing Dust and Inhalation Exposures Possible</td>
</tr>
<tr>
<td>• Negligible Groundwater Impact Potential</td>
<td>• Negligible (But Higher) Groundwater Impact Potential</td>
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Recyclable Material

• Ash Characteristics (Kansas City Project)
  – Fine Grained Particulates: Intrinsically Low Permeability
  – No Significant Leaching via TCLP Testing (Acid Leaching); Results from Over a Decade

• Acid Leached Metals Levels are Lower Than Some Natural Bedrock Groundwaters in KC
Recyclable Material

Example: Metals in Stark Shale Formation (Mine Roof Zone) Natural Groundwater in the KC Region

- **Lead:** up to 82 ppb  (Public Health Goal 0)  
  (Action Level 15 ppb)
- **Cadmium:** up to 71 ppb  (MCL 5)
- **Chromium:** up to 23 ppb  (MCL 100)
- **Zinc:** up to 4,700 ppb  (MCL 5,000)
Recyclable Material

Comparison of Mine and Landfill: Hydrogeological Conditions

Line of Geologic Cross Section
Recyclable Material

Comparison of Mine and Landfill:

Typical KC Mine

Mine Rooms Filled with Ash

Bedrock Permeability: $10^{-7}$ cm/sec

Typical Flyash Landfill

FML plus Clay Liner, 2 ft thick, $10^{-5}$ cm/sec

Groundwater Flow

Sand Permeability: $10^{-1}$ cm/sec
Current Regulations

• (1993) EPA Regulatory Determination on CCBs

  – Subtitle C is inappropriate, based on:
    • Limited risks posed by CCBs
    • Adequate State and Federal regulatory programs
    • Evaluation needs to be on a site-specific basis

  – Exempts wastes from regulation as hazardous wastes under RCRA Subtitle C

Current Regulations

- **(2000) EPA Regulatory Determinations**
  
  - Environmental harm not associated with beneficial use
  
  - CCBs do not warrant regulation as hazardous waste
  
  - Some uses require hydrogeologic evaluation

<http://www.epa.gov/epawaste/conserve/rrr/imr/ccps/resources.htm>
Current Regulations


  - Concluded No Additional Regulations Warranted

  - Stated Barriers on Beneficial Use Should be Avoided
    - Conserves natural resources
    - Reduces disposal costs

  - Agency Supported Increase in Beneficial Use

<http://www.epa.gov/epawaste/conserve/rrr/imr/ccps/resources.htm>
EPA Rulemaking –
Alternatives being Considered

• Reclassify CCBs as Hazardous Waste; or
• Require Subtitle D regulation at a minimum; or
• Hybrid

• May allow exemptions for some beneficial reuse – possible deference to states
Consequences of Regulating Ash as Hazardous Waste

- Specific beneficial uses may become technically or economically infeasible.

- Raw mineral material use would likely increase significantly.

- Utility rates would increase:
  - Waste Volume Increase = Less Airspace
  - Landfill siting / capacity difficulties

- Industry collaboration would diminish.

- Broad, overarching rules would limit flexibility for site-specific beneficial uses.
Consequences of Regulating Ash as Hazardous Waste

• Some Coal Combustion Byproduct Usage Projects Truly Constitute a Beneficial Use

• Not merely cheap waste disposal.
Use of Flyash as Recyclable Material

• Return ground above mines back to more productive use, and make safe for the general public.

• Section 409 in the Surface Mining Control & Reclamation Act of 1977 declares that voids resulting from mining operations constitute a hazard to the public health or safety, and surface impacts of any underground mining operation may degrade the environment.

• New regulations should therefore allow flexibility to allow safe stabilization with CCB’s.
Use of Flyash as Recyclable Material

- Our activity is regulated in Missouri under the State’s Underground Injection Control program.
  - Permit requires groundwater monitoring to ensure the material is not adversely affecting groundwater.
  - More than 10 years’ of monitoring data confirms that no releases are occurring.
Impact to Small Business

- Not Negligible

- Safe use of CCB’s is the foundation of our business.
Discussion