Rapid Solidification of Coal Combustion Residuals (CCR) Leachate & Wet Ash Wastes

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Coal combustion residuals (CCRs) include fly ash, bottom ash, boiler slag and flue gas desulfurization, or scrubber, materials such as synthetic gypsum, which are produced when coal is burned for electricity generation. CCRs are one of the largest industrial waste streams generated in the United States. In 2012, more than 470 coal-fired electric utilities burned over 800 million tons of coal, generating approximately 140 million tons annually of CCRs in 47 states and Puerto Rico.

In the Southeast alone there ≈400 known coal ash storage facilities with a total capacity to hold over 584,234,000 Cys of ash.
The “typical” CCR Waste Impoundment Site

CCR disposal currently occurs at more than 310 active on-site landfills, averaging more than 120 acres in size with an average depth of over 40 feet, and at more than 735 active on-site surface impoundments, averaging more than 50 acres in size with an average depth of 20 feet with ≈1.6 MCys/ea.
Examples of a “bad day at the CCR office”……

Saturated CCR waste is “thixotropic” and will “liquefy” and flow when agitated/vibrated from rehandling or machine operations.

Nolan Run Surface Impoundment Facility Dam Failure Accident (Drowning) November 30, 2012

A CATD6 LGP bulldozer was blading CCR waste along the bank of an impoundment. Without warning a slope failure ≈200 feet wide and ≈850 feet long occurred carrying the dozer and operator into the pool area where it went 25’ beneath the liquidized CCR slurry. Commercial divers recovered the operator’s body 14 days later.


Superabsorbents versus Absorbents

- Super Absorbent Polymers (SAP – Sodium Polyacrylate) developed in 1960’s
- Used predominantly child (85%) & adult (10%) diapers, feminine hygiene products
- Only 2% is used to solidify:
  - Meat packaging
  - Medical bio wastes (blood, body fluids, etc.)
  - Liquid industrial /radioactive waste streams
  - Dredge sediments
  - Biosolids and sludges

SAPs reduce waste transportation and disposal costs from these operations by solidifying liquid waste while minimizing an increase in weight and volume. With the capability of solidifying up to 300x its weight in water, 1# of SAP can solidify ≈36 gallons of water (2,500#).

➢ Chemically bond with water  ➢ Don’t biodegrade  ➢ Minimize waste volume increase
Past SAP Application Practices

Since it’s development in the 1960’s, SAP has been used for over 55 years in solidification of industrial, radioactive waste streams, slurries, drilling muds and sediments. Means & Methods for SAP application has been typically “broadcasting” the SAP on top of the waste matrix at application rates of 2 – 5%, dependent upon how careful the operator was and how cost-conscious the superintendent was.

The CALM CCR/SAP solidification treatability results have shown:

LESS IS MORE.
Bench-Scale Moisture & Strength Evaluation of Ponded CCR Ash Using ZapZorb SAPs

Phase I - Screening Key Objectives

1. **Coal Ash & Liquid Management Office - UNC** secured 5 CCR Ash samples from 4 different power utilities within the SE Region

2. Establish a water content at which each of the ash samples fail the Paint Filter Test

3. Add pre-determined mass fractions of SAPs and evaluate for the **Paint Filter Test**, **Undrained Cohesion** and **Shear Strengths** of the CCR SAP solidified samples.
Phase I - SAP Material Blends Evaluated

- **P1**: 100% SAP
- **P2**: 50% ZapZorb SAP + 50% Bentonite
- **P4**: 50% ZapZorb SAP + 25% Bentonite + 25% Portland Cement
- **P6**: 75% ZapZorb SAP + 8% Portland + 8% Bentonite + 8% wood flour
- **Power Pellets**: 5% ZapZorb SAP + 95% wood pellets
- **P7**: 25% ZapZorb SAP + 75% wood fiber
Example of Pre- & Post SAP Addition

CCR Ash at 70% Water Content
- Failing Paint Filter Test

CCR Ash at 70% Water Content +1% SAP
- Passing Paint Filter Test
Phase I Screening of ZapZorb Super Absorbent Polymer Formulations for Wet CCR Waste Solidification

**TESTING PROTOCOL:**

Once the CCR samples are characterized, they were amended with the SAPs and the following tests performed before and after amending the samples.

1. Pre- and post-moisture content
2. Specific gravity
3. Bulk density
4. Pocket Penetrometer;
5. Pocket Vane Shear (Torvane)
6. Unconfined Compression Test
7. Paint Filter
Phase I - Summary Conclusions

1. As little as 0.5% of SAP by dry weight was sufficient to stabilize the moisture in fly ash containing as high as 70% water.

2. All polymers stabilized free water and the strength improved from a material that is at liquid limit to a material that can stand at undrained shear strength ranging from 2 to 10 psi. **CATD6 LGP Dozer needs 5.1 psi bearing capacity.**

3. P2, P-4 and P-7 provided the most strength for the amount of SAP they contained.
SmartFeed™ Sequential Mixer/Blending of ZapZorb Amendments with CCR

High-solids Content Dredge Slurry

Mineral Processing Services (www.mpsmaine.com) bench-scale evaluation of Sequential Mixer/Blending of ZapZorb Amendments with wet CCR (64% moisture) slurry showed SAP CCR solidification effective at addition dosages as low as 0.3% (wet weight) with amended CCR stackable and passing EPA Paint Filter criteria for no free liquids in 3 minutes of blending.

<=>

LESS IS MORE.
MPS Bench-scale evaluation of SmartFeed™ Sequential Mixer/Blending of 0.3% ZapZorb SAP with wet CCR (64% moisture) paste sludge for 180 Second Contact Time
High Solids Production Dredging of CCR wastes

Application for high-solids dredging within Pits, Ponds, Lagoons and Dam impoundment areas

JAVELER DP-150
3,000 GPM @ ≈ 175 – 200 Cys/hr

- Discharge Diameter: 10"
- Standard Motor HP: 150
- Depth Range: 0'-150'
- Capacity BEP (gpm@head): 3,200 @ 72'
- Production (yd³/hr): 0-250+
- Power Source: 300kW Generator
- Electric Cable Length: 220'
- Max Sold: 4.5"
- Pump Weight: 8,000 lbs.
High Solids Production Dredging of CCR wastes

Application for 70% high-solids dredging of CCR solids from Power Plant Impoundment

1991 YouTube Video Clip showing TOYO Pumping 70% CCR Solids Sludge:

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# High Solids Production Dredging of CCR wastes

<table>
<thead>
<tr>
<th>Pump Model</th>
<th>TO-15</th>
<th>TO-75</th>
<th>TO-150</th>
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<td>55 gpm @ 3000 psi</td>
<td>85-115 gpm @ 3000 psi</td>
<td>100-160 gpm @ 3000 psi</td>
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Hydraulically Pump up to 70% Solids Slurries

TOYO TO-150 Pump dredging of CCR solids from Impoundment

3,000 GPM @ ≈ 175 – 200 Cys/hr

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Phone: 601-497-1404
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www.hevvypumps.com
Hydraulically Pump up to 70% Solids Slurries

Hydraulic Cutter Assemblies for Homogenization / Liquefaction of CCR Wastes
Dual Processing Operations:

1. **SmartFeed™ Sequential Mixer for Blending of ZapZorb Amendments with TOYO Pump**
   high-solids CCR dredged waste materials for >45% CCR solids feed

2. **Geotube dewatering for <45% CCR solids feed operations**
Dual Processing Operations:

1. **SmartFeed™ Sequential Mixer for Blending of ZapZorb Amendments with TOYO Pump**
   - high-solids CCR dredged waste materials for >45% CCR solids feed

2. **High-rate Clarifier/ Paste Thickener conditioning operations for <45% CCR solids feed**
   - operations followed by ZapZorb Amendment Blending
Controlled Metering of ZapZorb Amendments into Modified SmartFeed™
Sequential Mixer / Blending for CCR wet paste sludge solidification

Model 2500 EM
- Treats up to 2,500 gpm slurry flow
- Process slurry up to 12% d.s
- Can deliver up to 400 gpm of 0.5% polymer dilution

Site Requirements
- 8” pipe connection for slurry feed
- 4” pipe connection 400 gpm @ 80 psi
- Power 100 amps 480 volts 3 phase
- Lay-down area 40’ x 30’

Model 4000 EM
- Treats up to 4,000 gpm slurry flow
- Process slurry up to 25% d.s.
- Can deliver up to 1,200 gpm 0.5% polymer dilution

Site Requirements
- 12” pipe connection for slurry feed
- 4” pipe connection 600 gpm @ 100 psi
- "dilution water"
- 4” pipe connection 600 gpm @ 100 psi
- "post dilution"
- Power 200 amps 480 volts 3 phase
- Lay-down area 80’ x 40’
Controlled Metering of ZapZorb Amendments into Modified SmartFeed™ Sequential Mixer /Blending for CCR wet paste sludge solidification

ZapZorb Amendment Delivered in 50 CY “walking floor” bulk material trailers (max. weight 25 tons/load) for metered delivery to SmartFeed™ Sequential Mixer via VFD-controlled Tube Chain Conveyor

Estimated Sequential Mixer Rate: 50 TPH x 24 Hr/day ops @ 80% online = 19 hrs/day = 950 TPD/SmartFeed™ Sequential Mixer

50 tons SAP ZapZorb Amendment metered at 0.5% delivered to SmartFeed™ Sequential Mixer via VFD-controlled Tube Chain Conveyor would solidify 10,000 tons wet CCR Waste at $10/ton SAP/ton CCR solidified
MPS SmartFeed™ Sequential Blending Modules

300 GPM TOYO Hydraulic Pump high solids slurry @ 45% Solids will process ≈88 Cys/hr (≈83 tons/hr) Solidified CCR in 3 minutes

2,000 GPM TOYO Hydraulic Pump high solids slurry @ 45% Solids will process ≈600 Cys/hr (≈570 tons/hr) Solidified CCR in 5 minutes
MPS SmartFeed Portable Clarifier/Paste Thickener

Clarifier Influent
1,500 gpm @ 3 – 12% d.s.
(30,000 – 120,000 ppm TSS)

Floculated Feed to Clarifier

Clarifier Overflow
<30 ppm TSS
99.975% removal efficiency

Clarifier/Thickener Underflow: 45% D.S.
Estimated Laydown Area for 60 – 90 Cy/hr CCR/SAP Sequential Blending System

TOTAL Estimated CCR/SAP material generated from all runs over 5-day trial period is ≈1,200 – 1,800 Cys
Application of EnviroBlend Magnesia Pozzolan for Wet Slurry Stabilization

The sequential addition of 2% EnviroBlend (www.enviroblend.com - a magnesia-based pH buffered pozzolan) followed with 0.3% - 0.5% ZapZorb SAP addition has shown to be very effective in stabilizing liquid waste streams, slurries, sludges and saturated sediment containing the following heavy metals:

- Arsenic
- Arsenate
- Calcium arsenate (CA)
- chromated copper arsenate (CCA)
- Arsenite
- Antimony
- Barium
- Cadmium
- Chromium (tri & hex)
- Cobalt
- Copper
- Lead
- Manganese
- Mercury
- Nickel
- Selenium
- Vanadium
- Zinc

Cost and time savings for the application of 0.5% SAP versus 8 – 10% Portland cement for the solidification of the millions of Cys of wet CCR will have a dramatic impact on reducing costs, shortening project schedules and minimizing the volume of CCR waste to transported and placed within new impoundment cells.
Application of ZapZorb SAP Blends for wet CCR Waste Solidification

There are three primary areas for the application ZappaTec ZapZorb 100% SAP and engineered blends with CCR impoundment closures:

1. Ex-situ solidification of CCR with moisture contents of >55% in preparation for off-site transportation and disposal by ensuring compliance with EPA Paint Filter Test criteria at the point of delivery to the disposal facility by either truck or railcar.

2. In-situ solidification of CCR to bind excess porewater and increase compressive strength thereby permitting tracked excavation equipment access on top of amended areas of the impoundment;

3. Solidification of high-strength (i.e., high Total Dissolved Solids) CCR leachate.