Storing Coal Combustion Residuals in an Upstream Raise

Geological, Mining, and Geotechnical Engineering

2nd Technical Conference and Alumni Reunion
Introduction

• Coal Combustion Residuals (CCR)
  • Fly Ash, Bottom Ash, Flue Gas Desulfurization Sludge, etc.

• Containment in ponds and landfills

• Considerations:
  • Environment, operations, economics
Overview

- What is and upstream raise?
- Site overview
- Design concept
  - Seepage
  - Stability
- Operations
  - Field observations
  - Planning
  - Advantages and disadvantages
- Conclusions
What is an upstream raise?

- Upstream
- Raise

Hydraulically upgradient

Vertical containment of a lower strength material “behind” a more coarse-grained competent material

- Raises are common in mining applications (i.e. tailings stored behind a coarse-grained sand dam)
  - Typically downstream or centerline (more stability, especially in seismic zones)

- Upstream raises are built in an upstream fashion (newer parts of the facility are built over older, low-strength deposits)
Upstream Raise

Upstream Method
- Peripheral tailings
- Spigot or cyclone
- Ponded water
- Tailings
- Starter dike (natural soils)

Downstream Method
- Impervious core (optional)
- Raises (natural soils, tailings, or mine waste)
- Tailings or water
- Drain (optional)

Centerline Method
- Peripheral tailings
- Spigot or cyclone
- Tailings
- Starter dike (natural soils)
- Impervious core (optional)
- Raises (natural soils, tailings, or mine waste)
- Drain (optional)
Why an Upstream Raise
Materials

• Fly Ash
  • Cemented and higher strength (~100+ psi UCS)
  • Trafficking and erosion
• Bottom Ash
  • “Sandy,” friction angle of ~40 degrees
  • Well-draining (10^{-3} \text{ cm/sec})
• FGD
  • Silty and lower strength
  • Deposited hydraulically
• Smooth Geomembrane and Clay (historic)
• Smooth Geomembrane and Clay (historic)
Seepage and Stability

- Key components
  - FGD Material
  - Smooth geomembrane and Clay interface

FS = 1.5

Seepage collection piping
Monitoring - Water

The graph illustrates the water elevation data from various locations over a period from July 2006 to June 2017. Each location is represented by a different line color, with specific codes like PZ-1, PZ-2, etc. The x-axis represents the dates, while the y-axis shows the water elevation in feet. The data shows fluctuations and trends over the years, indicating changes in water levels at these locations.
Monitoring - Inspection
Monitoring - Consolidation

- FLY ASH BLOCK SUBJECT TO SETTLEMENT
- BOTTOM ASH FILLED IN DURING NORMAL OPERATIONS
- BOTTOM ASH BLOCK SUBJECT TO SETTLEMENT
- SLUDGE

FLY ASH

BOTTOM ASH (NEGLIGIBLE CONSOLIDATION)

<1'

~5'-6'
Monitoring - Consolidation
Considerations

• Zonal Deposition
  • Use engineering properties of the CCRs in the containment design

• Hydraulic Conveyance
  • Move CCRs once (no double-handling)
  • Cheaper to pump vs. haul

• Water Management
  • Process water and stormwater controls
  • Importance of water management for stability of raise
Conclusions

• Effective use of and existing lined footprint
• Cost savings
• Seepage and stability important and depend on laboratory testing and monitoring during construction
• Importance of monitoring:
  • Traditional piezometers
  • Nested piezometers
  • Vibrating wire piezometers?
    • Pore pressure measurements during operation
  • Inclinometers