Mechanically Stabilized Earth Berms
Pennsylvania Landfill Overview

Presented by
Charles P. Ballod, PE
Practice Leader,
Golder Associates Inc.

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About the Presenter

Charles Ballod, PE
39 years in Engineering Waste Industry

Reference information and pictures are from previous technical presentations


Today’s Presentation

- Introduction of MSE berms
  - Concept
  - Advantages
  - Safety

- Leachate Management
  - Stormwater and leachate controls
  - Staged Construction

- Brief Overview of MSE Berm Design

- Pennsylvania MSE Landfill Berms

- How are MSE berms holding-up

- Conclusions and Recommendations
Introduction of MSE berms

Concept

Traditional Retaining wall

MSE Berm Landfill Application
Introduction of MSE berms

Advantages

MSE Berm Advantages for Landfills:

- Increases airspace
- Benefits usually outweigh costs
- Standard Construction Techniques
- Flexibility
- Longevity
- Aesthetics
- Low Maintenance
Introduction of MSE berms

Safety

A safety system for construction workers include a harness tied to an anchored cable.

Staging of construction to limit vehicular access is also an important safety consideration.
Leachate Management

Stormwater and leachate Controls

Leachate controls can be easily integrated into the MSE Berm design incorporating stormwater ditches and leachate piping and collection systems
The MSE Berm can easily be staged to allow for the discharge of stormwater so runoff can be enhanced and leachate production reduced.
Brief Overview of MSE Berm Design

- Cost Benefits Analysis
- FHWA Design Guidelines for Reinforced Slopes
  - Establish Geometric, Load, and Performance Requirements
  - Determine Engineering Properties of In-Situ Soil and Reinforced Fill
  - Evaluate Design Parameters for Slope Reinforcement
  - Design Slope Reinforcement
  - Analyze Static and Seismic Slope Stability
  - Evaluate Criteria for Subsurface and Surface Water Control
  - Develop Specifications and Contract Documents
Brief Overview of MSE Berm Design

Cost Benefits Analysis

Evaluation/Feasibility
- Determine additional cost of berm construction
- Determine potential increase in airspace over conventional berm
- Determine cost/benefit ratio

Other Factors
- Permitting challenges
- Visual impacts
- Additional monitoring
- Maintenance
Brief Overview of MSE Berm Design

Existing Conditions

Determine Subsurface Profile
- Establish Layer Boundaries and Thicknesses
- Determine Groundwater Table

Perform Site-Specific Testing (Field and/or Lab) to Determine the following properties of in-situ foundation soils:
- Shear Strength
- Unit Weight
- Moisture
- Consolidation Properties (for cohesive soils)
Critical Design Items

- Drainage … free draining material
- For lower perm soils will need a drainage system designed
- Reinforced Fill
- Locate and secure reinforced fill – preferably aggregate
- AASHTO No. 57 stone
- Gradation (Maximum Particle Size and Percent Fines)
- Retained Fill
- Gradation (Maximum Particle Size and Percent Fines)
- Aggregate/geotextile filter to separate
- No infiltration from top
- Biggest concern for long-term performance

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing (by Weight)</th>
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<tbody>
<tr>
<td>4-inch</td>
<td>100</td>
</tr>
<tr>
<td>No. 40</td>
<td>0-60</td>
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<tr>
<td>No. 200</td>
<td>0-15</td>
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</table>

*From FHWA Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design & Construction Guidelines (March 2001)
Typical Factors of Safety

Internal Stability of Reinforced Berm
- Geogrid Pullout (FS_{STATIC} = 1.5, FS_{SEISMIC} = 1.0)
- Geogrid Strength (FS_{STATIC} = 1.5, FS_{SEISMIC} = 1.0)
- Sliding at Geogrid (FS_{STATIC} = 1.5, FS_{SEISMIC} = 1.0)

External Stability of Reinforced Berm
- Sliding at Base (FS_{STATIC} = 1.5, FS_{SEISMIC} = 1.0)
- Maximum Eccentricity (e/L) (Static = 1/6, Seismic = 1/3)

Global Stability of Reinforced Berm
- Short-Term Stability (FS_{STATIC} = 1.3, FS_{SEISMIC} = 1.0) (based on Total Stress Analysis)
- Long-Term Stability (FS_{STATIC} = 1.5, FS_{SEISMIC} = 1.0) (based on Effective Stress Analysis)
Construction

Construction Documents include:
- Specifications
- Drawings
- CQA Manual

Construction Quality Assurance
- Oversee materials
- Oversee Contractor installation
- Testing
- Certification

View of Installation Damage to Geogrid
## Pennsylvania MSE Berm Landfills

<table>
<thead>
<tr>
<th>Pennsylvania Landfill</th>
<th>Year</th>
<th>Type</th>
<th>Configuration</th>
<th>Length (m)</th>
<th>Height (m)</th>
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</thead>
<tbody>
<tr>
<td>Pottstown Landfill</td>
<td>1996</td>
<td>Setback</td>
<td>Linear</td>
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<tr>
<td>Tullytown Resource Recovery Facility Southern Expansion</td>
<td>1998</td>
<td>Setback</td>
<td>Linear</td>
<td>89</td>
<td>4.3</td>
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<tr>
<td>Mountain View Reclamation</td>
<td>1998</td>
<td>Stream Crossing</td>
<td>Linear</td>
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<td>12.2</td>
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<tr>
<td>GROWS Landfill SW Expansion</td>
<td>2000</td>
<td>Landuse</td>
<td>Horseshoe</td>
<td>314</td>
<td>9.8</td>
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<tr>
<td>GROWS Landfill NE Expansion</td>
<td>2001</td>
<td>Landuse</td>
<td>Linear</td>
<td>584</td>
<td>13.4</td>
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<tr>
<td>Mountain View Reclamation Eastern Expansion</td>
<td>2002</td>
<td>Landuse</td>
<td>Circumferential</td>
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<td>12.2</td>
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<td>Tullytown Resource Recovery Facility Western Expansion</td>
<td>2003</td>
<td>Landuse</td>
<td>Winding</td>
<td>1,110</td>
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<tr>
<td>Cumberland County Landfill</td>
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<td>Landuse</td>
<td>Circumferential</td>
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<tr>
<td>Western Berks Landfill</td>
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<td>Landuse</td>
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<tr>
<td>Lanchester Landfill</td>
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<td>Linear</td>
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<tr>
<td>GROWS North Landfill</td>
<td>2007</td>
<td>Landuse</td>
<td>Circumferential</td>
<td>1,690</td>
<td>14.8</td>
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<tr>
<td>Grand Central Sanitation Landfill</td>
<td>Permitted</td>
<td>Landuse</td>
<td>Linear</td>
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<td>11.0</td>
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<tr>
<td>Alliance Landfill</td>
<td>Permitted</td>
<td>Landuse</td>
<td>Circumferential</td>
<td>914</td>
<td>13.7</td>
</tr>
</tbody>
</table>
Pottstown Landfill 1996

Characteristics:
- Used to meet setback
- 61M length
- 4.3M height
- Linear
- Slope 1V:1H
- Gravel Tensar wrapped fascia
- Free Draining Soils
- Low maintenance
TRRF Southern Expansion 1998

Characteristics:
• Used to meet setback
• 89M length
• 4.3M height
• Linear
• Slope 1V:1H
• Free Draining Soils
• Low maintenance
Mountain View Stream Crossing 1998

Characteristics:
• Used as stream crossing
• 61M length
• 12.2M height
• Linear
• Free Draining Soils
• Use of wire basket fascia
• Low maintenance
GROWS Southwest Expansion 2000

Characteristics:
• Used to optimize land use
• 314M length
• 9.8M height
• Horseshoe
• Internal Access Road
• Flexible Design
• Free Draining Soils
• Use of wire basket fascia
• Low maintenance
GROWS Northeast
Expansion 2001

Characteristics:
• Used to optimize landuse
• 584M length
• 13.4M height
• Linear
• Big Large Berm
• Flexible Design
• Free Draining Soils
• Use of wire basket fascia
• Low maintenance
Mountain View Eastern Expansion 2002

Characteristics:
• Used to optimize land use
• 619M length
• 12.2M height
• Circumferential
• Large Berm
• Flexible Design
• Free Draining Soils
• Use of wire basket fascia
• Low maintenance
Characteristics:
• Used to optimize landuse
• 1,110M length
• 12.2M height
• Winding
• Large Berm
• Flexible Design
• Free Draining Soils
• Use of wire basket fascia
• Use of special construction
• External Access Road
• Low maintenance
GROWS North Landfill 2007

Characteristics:
• Used to optimize landuse
• 1,690M length
• 14.8M height
• Circumferential
• Large Berm
• Flexible Design
• Free Draining Soils
• Use of wire basket fascia
• Use of special construction
• External Access Road
• Low maintenance
How are MSE berms holding-up?

There are many MSE Landfill Berms installed as of 2015 with many being monitored by inclinometers.

Inclinometer Cable, Trolley, and Readout Box

Inclinometer Casing
How are MSE berms holding-up?

Since their construction there has been very little detected movement in the reinforced berms. The movement that has been detected appears to peak at the base of the MSE berm for all inclinometers. The extremely small movement currently experienced by the reinforced berms does not appear a stability concern at this point. Through several years of operation to date, it can be reasonably stated that the geogrid-reinforced MSE berms are performing well and maintaining the stability of the berm.
Conclusions

- Valuable Environmental & Engineering Design Tool
- MSE Berms are very flexible and fit many configurations
- Leachate Reduction can be accomplished while gaining valuable airspace
- MSE Berms have proved their durability

Recommendations

- MSE Berms are structures and have to be designed properly.
- A Cost/Benefits analysis should be performed.
- Safety considerations are required.

Questions?

Charlie Ballod
cballod@golder.com
Cell: (610) 220-5405
Thank You!