Stability of Geosynthetic Lined Slopes-I

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in conjunction with

The North American Chapter of the International Geosynthetics Society
Overview

- Importance of Slope Stability
- Common Failure Modes
- Design Interface Strengths
- Summary
Importance of Slope Stability

(Stark et al., 1998)
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MSW Shear Strength

(Stark et al. 2009)

Normal
- $c' = 6$ kPa, $\phi' = 35^\circ$  \hspace{1cm} $\sigma'_v < 200$ kPa
- $c' = 30$ kPa, $\phi' = 30^\circ$  \hspace{1cm} $\sigma'_v \geq 200$ kPa

Thermally Degraded
- $c' = 0$ kPa, $\phi' = 20^\circ$
Failure Modes

- Translational
- Rotational
- Infinite Slope
Infinite Slope
Infinite Slope
Analysis Scenarios

- Liner Construction
- Interim Slope
- Weak Geosynthetic Interface
- Weak Soil Interface
- Leachate Recirculation
- Rapid Waste Placement
- Waste Relocation
Liner Construction
Analysis Scenarios

- Liner Construction
- Interim Slope
- Weak Geosynthetic Interface
- Weak Soil Interface
- Elevated Liquid Pressure
- Rapid Waste Placement
- Waste Relocation
Interim Slopes
Analysis Scenarios

- Liner Construction
- Interim Slope
- **Weak Geosynthetic Interface**
- Weak Foundation Soils
- Elevated Liquid Pressure
- Rapid Waste Placement
- Waste Relocation
Weak Geosynthetic Interface

(Stark and Poeppel, 1994)
Weak Geosynthetic Interface

• CRITICAL INTERFACE –
  - normal stress
  - interface can change

(Stark and Poeppel, 1994)
Weak Geosynthetic Interface

- Geosynthetic Interfaces
  - $\phi = 12 - 14^0$
- Post-Peak Strength Loss
- Interface Testing and Analyses
- Huge Cost

(Stark and Poeppel, 1994)
Analysis Scenarios

- Liner Construction
- Interim Slope
- Weak Geosynthetic Interface
- Weak Soil Interface
- Elevated Liquid Pressure
- Rapid Waste Placement
- Waste Relocation
Weak Soil Interface

(Stark et al., 2001)
Weak Soil Interface

(Stark et al., 2001)
Weak Soil Interface

(Stark et al., 2012)
Analysis Scenarios

- Liner Construction
- Interim Slope
- Weak Geosynthetic Interface
- Weak Soil Interface
- Elevated Liquid Pressure
- Rapid Waste Placement
- Waste Relocation
Elevated Liquid Pressure

(Stark et al., 2000)
Elevated Liquid Pressure

(Stark and Calder, 2010)
Analysis Scenarios

- Liner Construction
- Interim Slope
- Weak Geosynthetic Interface
- Weak Soil Interface
- Elevated Liquid Pressure
- Rapid Waste Placement
- Waste Relocation
Rapid Waste Placement

(Stark et al., 2000)
Analysis Scenarios

- Liner Construction
- Interim Slope
- Weak Geosynthetic Interface
- Weak Soil Interface
- Elevated Liquid Pressure
- Rapid Waste Placement
- Waste Relocation
Waste Relocation

(Stark et al., 1998)
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Design Interface Strengths

- Stress Dependent Strengths
- Peak v. Residual Strengths
Stress Dependent Strengths

(Stark and Poeppel, 1994)
Peak v. Residual Interface Strengths

(Stark and Choi, 2004)
Post-Peak Strength Loss

(Stark et al., 1996)
Liner System Design Strengths

- Residual interface strength on slopes & Peak interface strength on flat areas & $FS \geq 1.5$
- Residual interface strength on slopes & flat areas & $FS \geq 1.0$ (1.1 if Direct Shear)

(Stark and Poeppel, 1994)
Cover System Design Strengths

- Peak interface strength & FS ≥ 1.5
- Residual interface strength if β ≥ ϕ_{peak}

(Stark and Choi, 2004)
Design Strength Envelopes

- Determine Peak and Residual combined strength envelopes
- Determine critical interface for FULL range of normal stresses
- Determine Critical Peak Combined Strength Envelope
- Use Critical Peak Combined Strength Envelope to determine Critical Residual/Large Displacement Envelope

(Stark and Choi, 2004)
Peak Combination Strength Envelope

(Stark and Poeppel, 1994)
Residual Combination Strength Envelope

(Stark and Poeppel, 1994)
Peak Strength Envelope Required

(Stark and Choi, 2004)
Overview

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Summary

- Small Displacements Damage Geosynthetics
- Evaluate Common Failure Scenarios
- Geosynthetic Interface Testing and Strengths
- Use Residual Interface Strengths
- Include Liquid Pressures
Slope Stability II – Testing and Analyses

- Geosynthetic Interface Testing and Interpretation
- Geosynthetic Specifications for Stability
- Slope Stability Analyses
- Summary
References


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Residual Combination Strength Envelope

(Stark and Choi, 2004)