INTERFACE SHEAR RESISTANCE ANALYSIS
SHERCO POND NO. 3 SLOPE LINER

Sherco Generating Plant
NPDES Permit No. 0002186
Becker, MN
Project #3404-01

Prepared for:

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April 22, 2016

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Interface Shear Resistance Analysis
Sherco Pond No. 3 Slope Liner

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Attachments

Certification

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

License No. 21835
April 22, 2016

Interface Shear Resistance Analysis
Sherco Pond No. 3 Slope Liner

1.0 Objective

The objective of this analysis is to evaluate the interface shear resistance of the Sherco Pond No. 3 (Pond 3) slope liner based upon the as-constructed design.

2.0 Analysis

The analysis was conducted using Slope/W slope stability analysis software developed by Geo-Slope International, Ltd. The Pond 3 liner system was analyzed for interface shear resistance using in-situ material properties and reinforcement loads in Slope/W.

The liner system on the slopes of Pond 3 consists of Bentoliner NWL GCL, overlain by 60-mil textured HDPE geomembrane, overlain by 4-feet of granular drainage material.

The analysis of the pond slope was based on the following assumptions:

- The critical circular slip surface for the pond slopes were determined using Slope/W's auto-locate random search routine to locate the failure surface with the lowest factor of safety.
- The minimum allowable factor of safety was determined to be 1.5 for long-term static conditions.
- The Veneer Stability was analyzed for global stability from right to left.
- The Slope/W veneer stability was modeled using three reinforcement loads; one with the surface friction angle of the sand cover soils to geomembrane interface, which is the critical friction angle; one with the surface friction angle and interface shear strength of the geomembrane to the gcl; one with the surface friction angle and interface shear strength of the gcl to the subgrade sandy soils.
- The accumulated head on the geomembrane will be negligible as the transmissivity of the granular drainage material will be much higher than that of the cover soils.

Material Properties

Soils collected during the preconstruction site investigation were tested in the laboratory for unit weight, Atterberg limits, and soil classification. These values were used to determine the internal friction angle and cohesion using typical values according to USCS. The results and assumptions for each soil are listed in Table 1 below.

Table 1
Material Geotechnical Properties

Material	Unit weight (pcf)	Friction Angle[5] (deg)	Cohesion (psf)
Subgrade[1]	131.8	37	0
GCL[2]	57.43	0	200
60-mil Textured HDPE Geomembrane[3]	59	0	1512
Granular Drainage Material[4]	126.8	32	0

Material Notes:

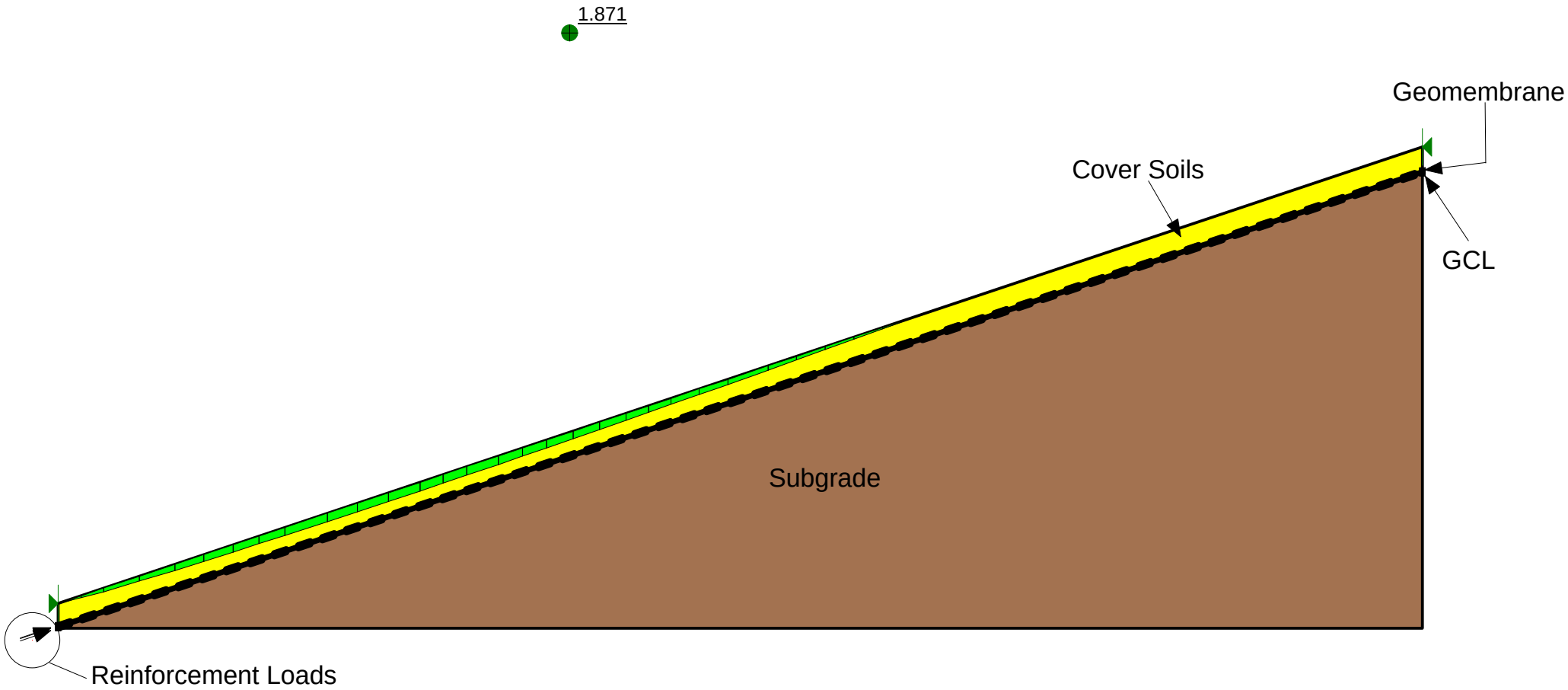
1. The subgrade was determined to be poorly graded sand-compacted (SP) attained during the preliminary site investigation.
2. The GCL is a Bentoliner NWL, which is a needlepunched reinforced composite Geosynthetic clay liner composed of a uniform layer of granular sodium bentonite encapsulated between a nonwoven and a scrim-nonwoven geotextile.
3. The material properties for the 60-mil Textured HDPE Geomembrane have been taken from manufacturer liner specifications.
4. Granular drainage material was obtained from an onsite stockpile of wash sand that was excavated during prior projects. The data presented is typical of material tested from the stockpile.
5. The friction angles used for all the soils refers to the internal friction angle.

3.0 Results

The results of the interface shear resistance analyses show that the interface between the geotextile of the GCL and the geomembrane is the critical interface of the liner system. The analysis for this interface shows a factor of safety of 1.871, which is greater than the allowable factor of safety of 1.5. The internal shear resistance of the GCL is was shown to not be the most critical phase of the liner system and has a factor of safety greater than 1.871. The factor of safety calculated for each interface of the liner system were found acceptable during interface shear analyses. The full graphical results can be found in the Appendix.

Slope/W Graphical Results

Analysis of Interface Shear Resistance



Slope/W Outputs

Materials Information

Subgrade

Model: Mohr-Coulomb
Unit Weight: 131.8 pcf
Cohesion: 0 psf
Phi: 37 °
Phi-B: 0 °

Cover Sand

Model: Mohr-Coulomb
Unit Weight: 126.8 pcf
Cohesion: 0 psf
Phi: 32 °
Phi-B: 0 °

Geomembrane

Model: Mohr-Coulomb
Unit Weight: 59 pcf
Cohesion: 1512 psf
Phi: 0 °
Phi-B: 0 °

Material Property information for the geomembrane is taken from Table 2.1 of Drop-In Specifications, Standard Geomembranes, GSE Environmental.

GCL (at yeild)

Model: Mohr-Coulomb
Unit Weight: 57.43 pcf
Cohesion: 200 psf
Phi: 0 °
Phi-B: 0 °

Values for the unit weight of GCL were taken from Table 1(a) of GRI-GCL3 from http://www.geosynthetic-institute.org/grispecs/gcl3.pdf. Cohesion information is taken from the Cetco direct shear testing.

Slip Surface Limits

Left Coordinate: (0, 942) ft
Right Coordinate: (216, 1014.21) ft

Reinforcements

Reinforcement loads were used the model the interface shear strengths between materials.

Reinforcement 1 (Models the interface shear strength between GCL and the subgrade sand)

Type: Fabric
Outside Point: (0, 938) ft
Inside Point: (216, 1010) ft
Slip Surface Intersection: (0, 0) ft
Total Length: 227.68399 ft
Reinforcement Direction: 198.43 °
Applied Load Option: Variable
F of S Dependent: Yes
Contact Cohesion: 150 psf
Contact Phi: 17.4 °
Interface Factor: 1
Bond Safety Factor: 1
Fabric Capacity: 0 lbs
Fabric Safety Factor: 1
Fabric Load: 0 lbs
Load Distribution: Conc. in 1 slice
Load Orientation: 0
Applied Load: 0 lbs
Fabric Load Used: 0 lbs
Resisting Force Used: 0 lbs/ft
Available Bond Length: 0 ft
Required Bond Length: 0 ft
Governing Component: Fabric

Reinforcement 2 (Models the interface shear strength between the HPDE liner and the GCL, contact information has been taken from Table 3 of http://www.cetco.com/DesktopModules/Bring2mind/DMX/Download.aspx?Command=Core_Download&PortalId=0&EntryId=326, which is *Shear Strength of HDPE Geomembrane/GCL interfaces,* Cetco, 3/07,) Values taken are for coextruded textured HPDE and Nonwoven geotextile.

Type: Fabric
Outside Point: (0, 938.4) ft
Inside Point: (216, 1010.4) ft
Slip Surface Intersection: (0, 0) ft
Total Length: 227.68399 ft
Reinforcement Direction: 198.43 °
Applied Load Option: Variable
F of S Dependent: Yes
Contact Cohesion: 150 psf
Contact Phi: 28.3 °
Interface Factor: 1

Bond Safety Factor: 1
Fabric Capacity: 0 lbs
Fabric Safety Factor: 1
Fabric Load: 0 lbs
Load Distribution: Conc. in 1 slice
Load Orientation: 0
Applied Load: 0 lbs
Fabric Load Used: 0 lbs
Resisting Force Used: 0 lbs/ft
Available Bond Length: 0 ft
Required Bond Length: 0 ft
Governing Component: Fabric

Reinforcement 3 (Models the interface shear strength between the geomembrane and the cover soils sand. The contact phi information is taken from *A report on Comparison of PVC and HDPE Geomembranes*, PVC Geomembrane institute. It can be found here: P:\Library\Slope stability (global and veneer)

Type: Fabric
Outside Point: (0, 938.5) ft
Inside Point: (216, 1010.5) ft
Slip Surface Intersection: (0, 0) ft
Total Length: 227.68399 ft
Reinforcement Direction: 198.43 °
Applied Load Option: Variable
F of S Dependent: Yes
Contact Cohesion: 0 psf
Contact Phi: 22 °
Interface Factor: 1
Bond Safety Factor: 1
Fabric Capacity: 0 lbs
Fabric Safety Factor: 1
Fabric Load: 0 lbs
Load Distribution: Conc. in 1 slice
Load Orientation: 0
Applied Load: 0 lbs
Fabric Load Used: 0 lbs
Resisting Force Used: 0 lbs/ft
Available Bond Length: 0 ft
Required Bond Length: 0 ft
Governing Component: Fabric