

May 8, 2013

Summit, LLC c/o Mr. Rick Everson, P.E. 1335 North 5900 East Eden, Utah 84310

IGES Project No. 01628-005

- Subject: Rockery Construction Guidelines Powder Mountain Resort Weber County, Utah
- Reference: IGES, Inc., 2012, Design Geotechnical Investigation, Powder Mountain Resort, Weber County, Utah, Project No. 01628-003, dated November 9, 2012

Blake, T.F., Hollingsworth, R.A. and Stewart, J.P., Editors (2002), Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for analyzing and mitigating landslide hazards in California: organized by the Southern California Earthquake Center.

Mr. Everson:

As requested, IGES has prepared the following general guidelines for rockery construction within the Powder Mountain Resort, Weber County, Utah. This document is intended to provide guidance for rockery construction throughout the 200-acre Powder Mountain resort expansion project, the limits of which are detailed in our referenced geotechnical report (IGES, 2012). We understand that several dozen rockeries of varying heights will be constructed throughout the project, most being associated with bridge structures or roadway cuts and fills. These guidelines are intended for basic non-tiered rockeries with a maximum height of eight feet, absent any surcharge beyond an ordinary traffic load of 250 psf, and having backslopes no steeper than 2H:1V; rockeries that fall outside of these parameters shall be assessed and designed by IGES on a case-by-case basis. If there is any question as to the applicability of this document to a particular rockery, IGES must be consulted to assess the proposed rockery configuration for compliance/applicability with these recommendations.

### **Modes of Failure**

When considering rockery design, there are three common modes of failure we have observed in rockeries constructed along the Wasatch Front area:

- 1) Poor rock to rock support *and* outward facing slip planes,
- 2) Loss of support from loose material placed behind the rock facing, and
- 3) Migration of soils from behind the rock facing due to water runoff.

In all of these modes of failure, the introduction of water ultimately causes movement or failure. However, even a poorly constructed rockery can remain stable for a long period of time if water is prevented from saturating the soils above and behind the rocks. Every effort should be made to reduce to the potential for water to impact the rockery. The contractor and owner should be conscious of the circumstances surrounding each rockery constructed and efforts should be made to direct runoff away from the rockery, prevent ponding above and below the rockery, and provide drainage from behind the rockery if necessary.

The information presented in the following paragraphs addresses each of these potential modes of failure. If these recommendations are followed *and* measures are implemented to prevent water from impacting the rockery, then the potential for a failure will be greatly reduced.

# **Rockery Construction**

For rockery construction, the rock facing should not be placed steeper than 0.5 to 1 (horizontal to vertical). The bottom rocks of the rockery should be keyed into the ground a minimum of 12 inches. Rock facing should be placed in general accordance with the Associated Rockery Contractors (ARC) *Rockery Construction Guidelines* as summarized in the *Construction Specifications* and the details shown on Sheet A-2. The guidelines state "rocks should be placed so that there are no continuous joint planes in either the vertical or lateral direction and wherever possible, each rock should bear on at least two rocks below it." In addition, the guidelines state "the upper plane of each rock between courses (the top surface of rock), should slope back towards the protected soil face and away from the face of the rock wall." Conceptualized construction drawings and specifications are included in Appendix A.

### **Engineering Characteristics of Earth Materials**

During our referenced geotechnical investigation (IGES, 2012), the subsurface was observed at several locations across the site. Earth materials were quite variable across the site, ranging from Fat CLAY (CH) to coarse gravel, cobbles, and boulders; however, the majority of the soils encountered consisted of Clayey GRAVEL (GC), grading to Clayey SAND (SC), containing varying amounts of cobble- and boulder-size constituents. Based on our observations, laboratory data presented in our referenced geotechnical report, and experience with similar soil types, a representative soil strength value was selected for the project-wide rockery construction guidelines. For preparation of these guidelines, the following soil parameters were selected:

- Soil Type: Clayey SAND
- Friction Angle: 30 degrees
- **Cohesion**: 150 psf
- Unit Weight of Soil: 120 pcf

Since stacked rocks are expected to behave quite differently than relatively homogenous/isotropic engineered fill, the stacked rocks were modeled as having *anisotropic properties*, with a rock-rock interface strength of  $\varphi=45^{\circ}$  and c=0 psf, and solid rock strength of  $\varphi=0^{\circ}$  and c=3,000 psf. Based on common practice and the recommendations contained in

this report, we expect the rocks to be stacked such that the rock-rock planar interface will be sloped back into the slope on the order of 10 degrees, as illustrated on Sheet A-2. However, to account for possible poor construction practices and/or unusually shaped rocks, we have modeled the rock-rock planar interface strengths ranging from -5 to -12 degrees.

# **Horizontal Ground Acceleration**

Using the criteria outlined in the 2012 IBC, the maximum considered earthquake (MCE) ground motion is taken as that motion represented by an acceleration response spectrum having a 2% probability of exceedance within a 50-year period (2PE50). The probabilistic Peak Horizontal Ground Acceleration (PHGA) corresponding to a 2PE50 event was identified in our referenced geotechnical report as 0.35g (representative PHGA for the site). For pseudo-static (seismic) analysis, a *seismic coefficient* equal to 43% of the PHGA was selected for our model (seismic coefficient equals 0.15g) (Blake et al., 2002).

# **Internal Stability Analysis**

Engineering analysis of representative rockery heights and backslope conditions included determination of minimum rock sizes. Minimum rock size was evaluated by analyzing overturning and sliding for individual rocks within the rockery along a 1-foot unit length. Lateral earth pressures were calculated using the Coulomb approach, incorporating back slope and surcharge. Ultimate minimum shear capacity for boulder-to-boulder contact was assumed to be zero psf and the angle of friction between boulders was assumed to be 45°. It is also assumed that chinking material is not allowed to remain on the boulder surface and that the boulders have a contact area equal to 70% of the assumed bottom surface. Typical minimum factor of safety requirements for these conditions are 2.0 for overturning and 1.5 for sliding. Internal stability design calculations are presented in Appendix B.

### **Global Stability**

The global stability of the maximum rockery height was modeled using GSTABL7 slope stability software, using the soil parameters listed previously. For our global stability model, we have assumed the failure mode will be a circular-type (arcuate) failure surface shearing through homogenous/isotropic earth materials, with the failure surface passing either under or through the rockery. For the maximum rockery height, two conditions were modeled; one with a flat backfill and a traffic surcharge of 250 psf, and one with a 2H:1V backslope and no external surcharge.

The problem associated with modeling global stability of a rockery is in using a circular failure surface through homogenous/isotropic material (engineered fill), which in turn must pass through stacked rocks that have heterogeneous/anisotropic engineering characteristics. IGES has evaluated this unusual slope stability problem and has developed a method of analysis that we believe provides a realistic approach with respect to rock slope stability. Our method of analysis is a two-step approach, detailed below:

• <u>Model A</u>: The rock slope is analyzed as if there were no rockery, i.e., the stacked rocks are given the same strength parameters as the backfill. The point of this first step is to evaluate the circular failure surface with the lowest factor-of-safety *as if the stacked rocks were not present*.

• <u>Model B</u>: A second model is analyzed using the circular failure surface obtained in the Model A analysis. However, for this analysis the Model A failure surface is truncated at the rock/soil interface. The circular failure surface is now modeled as a series of point-blocks using the method prescribed by Janbu. At the rock/soil interface, the GSTABL7 software randomly searches to find the lowest factor-of-safety through the rockery.

In addition to the two slope stability models discussed above, circular failure surfaces passing *under* the rockery were also modeled.

For this project minimum design factors-of-safety of 1.5 and 1.0 for static and pseudo-static conditions, respectfully, were considered reasonable. The results of global stability analysis on the most critical rockery sections are presented in Appendix C.

### **Conclusions and Limitations**

The results of our analysis indicate adequate factors of safety will be achieved provided the rockeries are constructed as recommended in this report. The batter, bench widths, and burial depth were established in order to meet the factor of safety requirements. A representative profile drawing of the maximum 8-foot section and *General Construction Guidelines* are provided in Appendix A.

Conditions such as leaky or broken irrigation lines and/or runoff from precipitation or snow melt can lead to saturation of the soil behind the rockery, which can cause slope and/or rock movement. The Owner/Client should be aware of the risks if these or similar conditions occur that could saturate or erode the soil behind the rockery. We recommend irrigation above the rockeries and on benches be minimized or avoided. Drip irrigation or hand watering should be considered.

It is imperative that rockeries do not exceed the maximum heights or other constraints presented in this document; if the proposed rockery geometry exceeds the maximums set forth herein, IGES shall be contacted so that the proposed configuration can be evaluated. Also, if water is observed emanating from any cut slope, IGES should be consulted to assess any drainage requirements that may be necessary.

### **Inspection Scheduling**

In order to evaluate compliance with our design documents and facilitate a final acceptance letter (if required), we propose the following inspection schedule:

- 1. Inspect the first course of rocks for size, embedment and filter fabric (if needed).
- 2. Inspect the second or third course of rocks for size, position and placement, and filter fabric.
- 3. Inspect finished walls for conformance to design requirements such as maximum heights, batter, minimum terrace widths, front and back slope geometries, and rock sizing, positioning and placement.

# Closure

The construction recommendations presented assume an appropriate amount of testing and inspection will be performed. An IGES representative should visit the site during construction to observe compliance with the recommendations and drawings provided.

We appreciate the opportunity to provide you with our services. If you have any questions please contact the undersigned at your convenience (801) 748-4044.

Respectfully Submitted,



David A. Glass, P.E. Senior Geotechnical Engineer

Attachments:

Appendix A – Rockery Construction Specifications and Drawings

Appendix B – Internal/External Analysis

Appendix C – Global Stability Analysis

# **APPENDIX A**





CONCEPTUAL SECTION VIEW

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### **Rock Stacking Construction Guidelines:**

Rocks should be stacked in general accordance with the Associated Rockery Contractors (ARC) Rockery Construction Guidelines, summarized as follows:

- · Rocks should be placed so that there are no continuous joint planes in either the vertical or lateral direction (see detail A)
- Wherever possible, each rock should bear on at least two rocks below it.

• The upper plane of each rock between courses (the top surface of rock), should slope back towards the slope face and away from the face of the rock wall (see detail B)

DATE BY CHK





REVISIONS



# **Rock Stacking Construction Specifications:**

# INTRODUCTION

• The rock stacking guidelines provided include installation of the rock facing, erosion protection fabric, and backfill material.

# MATERIALS

- Retained soils are to consist of native cut soils. If granular fill is required the material should consist of 4-inch minus granular soils compacted to a minimum of 90 percent ASTM D-1557 in landscape areas and 95 percent underneath structures. Any backfill material should be approved by IGES prior to importing.
- Erosion protection fabric (filter fabric) shall consist of a 6-oz. non-woven fabric or an approved equivalent.
- Rock Boulders to be used as facing should be durable angular particles with a minimum nominal diameter of 1.5 feet. Rock sizes should be in accordance with design drawings.

# **INSTALLATION**

- Rocks should be stacked in general accordance with the Associated Rockery Contractors (ARC) Rockery Construction Guidelines, summarized as follows:
  - ORocks should be placed so that there are no continuous joint planes in either the vertical or lateral direction.
  - Wherever possible, each rock should bear on at least two rocks below it. • The upper plane of each rock between courses (the top surface of rock), should
- Rock facing should be stacked at a maximum steepness of  $\frac{1}{2}$  horizontal to 1 vertical.
- Rock wall should be inspected at regular intervals by IGES to accommodate final inspection and acceptance letter.



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slope back towards the slope face and away from the face of the rock wall.

Bottom row of rocks should be buried (keyed in) a minimum depth of 1 foot.

# **APPENDIX B**

# Lateral Earth Pressure Coefficients



Mononobe-Okabe Equation:

ψ=	8.5308	degrees
K <sub>ae</sub> =	0.2322	



### **Rockery Minimum Rock Size Stability Checks**

Project: Powder Mountain Resort Location: Weber County, Utah				Engineer Date:	DAG 05/07/13
Project No: 01628-005					
Case: Flat backfill, 250psf surcharge	Soil and Wall Pa	rameters:			
	INPUT ONLY VALU	JES IN BLUE			
γ Rock Boulder =	135 pcf	δbackfill =	20.00	degrees	
γsoil =	120 pcf	β =	0	degrees	
Csoil =	150 psf	θ =	-26.6	degrees	
surcharge =	250 psf	Kah =	0.117		
φfoundation =	40 degrees	δfoundation =	26.67	degrees	
Burial Depth =	1 ft	φbackfill =	30	degrees	
Ult. Shear Cap. Between Boulders =	0 lb/ft	φsubgrade =	40	degrees	
Angle of Friction Between Boulders =	45 degrees				
Rock Interface Red. Factor =	0.7 * Adjust Depen	ding on Boulder Geometi	у		
Rock Stacking Red. Factor =	0.8				

Factor of Safety (FOS) against OVERTURNING = 2.0, FOS against SLIDING = 1.5, FOS for BEARING = 3.0 (vertical force along back of wall neglected in sliding and overturning)

*Rock Diameter (ft)	1.5	2.0	3.0	4.0	5.0				
Rock Area (ft <sup>2</sup> )	1.8	3.1	7.1	12.6	19.6	0.0	0.0	0.0	0.0
D From Top of Rockery (ft)	1.5	3.1	5.5	8.7	12.7	12.7	12.7	12.7	12.7
P <sub>ah</sub> (lb/ft)	60	158	373	785	1501	1501	1501	1501	1501
Center of Gravity	0.8	1.0	1.5	2.0	2.5	0.0	0.0	0.0	0.0
Hinge Ht (H <sub>h</sub> ) (ft)	1.5	3.1	5.5	8.0	10.0	0.0	0.0	0.0	0.0
Avg Col. Diam. Above H <sub>h</sub> (ft)	1.5	1.8	2.2	3.0	4.0	4.5	5.0	#DIV/0!	#DIV/0!
Wt Above Base Rock (lb/ft)		239	663	1617	3313	5964	#DIV/0!	#DIV/0!	#DIV/0!
Total Wt (lb/ft)	239	663	1617	3313	5964	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Wt Above H <sub>h</sub> (lb/ft)	0	0	0	227	1152	6060	6733	#DIV/0!	#DIV/0!
Adjusted Total Wt (lb/ft)	239	663	1617	3087	4813	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

\*CHECK: Minimum Average Base Course Diameter = 0.4(Ht<sub>wall</sub>) ARC Guidelines

### OVERTURNING ANALYSIS: Wall Ht (ft) 1.5 3.1 5.5 8.7 12.7 12.7 12.7 12.7 12.7 163 2275 6355 6355 6355 6355 6355 Movt 30 683 M<sub>res</sub> 125 592 2406 6479 12627 #DIV/0! #DIV/0! #DIV/0! #DIV/0! FS<sub>ovt</sub> 4.2 3.6 3.5 2.8 2.0 #DIV/0! #DIV/0! #DIV/0! #DIV/0! CHECK #DIV/0! #DIV/0! ок ок οк ок ARS #DIV/0! #DIV/0!

SLIDING/BULGING ANALYSIS:	

Wall Ht (ft)	1.5	3.1	5.5	8.7	12.7	12.7	12.7	12.7	12.7
R <sub>slide</sub>	60	158	373	785	1501	1501	1501	1501	1501
R <sub>res at wall base</sub> (Ib/ft)	2450	2870	3938	5615	8006	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
R <sub>res rock to rock</sub> (Ib/ft)	167	464	1132	2319	4175	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
**FS <sub>base slide</sub>	41.1	18.2	10.6	7.2	5.3	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
CHECK	ОК	ок	ок	ОК	ОК	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
FS <sub>rock to</sub> rock slide (bulging)	2.8	2.9	3.0	3.0	2.8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
CHECK	OK	OK	OK	ок	ОК	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

BEARING CAPACITY:									
Wall Ht (ft)	1.5	3.1	5.5	8.7	12.7	12.7	12.7	12.7	12.7
Soil Load (lb/ft)	159.0	331.3	539.0	828.3	1192.8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Soil Capacity	16402.5	19302.1	25101.5	30900.8	36700.2	7703.4	7703.4	7703.4	7703.4
FS <sub>bearing</sub>	103.1	58.3	46.6	37.3	30.8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
CHECK	ОК	ОК	ОК	ОК	OK	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Wall Ht (ft)	1.5	3.1	5.5	8.7	12.7	12.7	12.7	12.7	12.7
	PASS	PASS	PASS	PASS	FAIL	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
		MAXIMU		E HEIGHT:	8	FT			

\*\*Resisting force for Rockery Foundation - Only Value at Maximum D Applies ARS: ADJUST ROCK SIZE

# Lateral Earth Pressure Coefficients

### Project: Powder Mountain Resort Location: Weber County, Utah

# Project No: 01628-005

# Case: 2H:1V Backfill, no surcharge

Input Parameters:

Wall Inclination ( $\theta$ ) = Friction Angle of Backfill ( $\phi$ ) = Backfill Slope Inclination ( $\beta$ ) = Backfill/Wall Friction Angle ( $\delta$ ) = Seismic Coefficient = Friction Angle of Subgrade = Engineer Date:

DAG 05/07/13

-26.6 degrees
30 degrees
26.5 degrees
20.0 degrees (typically 2/3 x phi of backfill)
0.15 g
40 degrees

Couloumbs Equation:

K <sub>a</sub> =	0.2329
K <sub>ah</sub> =	0.1957
K <sub>p</sub> =	3.3206
K <sub>ab</sub> =	2,7901

Mononobe-Okabe Equation:

ψ=	8.5308	degrees
K <sub>ae</sub> =	#NUM!	



### **Rockery Minimum Rock Size Stability Checks**

Project: Powder Mountain Resort Location: Weber County, Utah			Engineer Date:	DAG 05/07/13
Project No: 01628-005				
Case: 2H:1V backfill, no surcharge	Soil and Wall Pa	rameters:		
	INPUT ONLY VALU	JES IN BLUE		
γ Rock Boulder =	135 pcf	δbackfill =	20.00 degrees	
ysoil =	120 pcf	β =	26.5 degrees	
Csoil =	150 psf	θ =	-26.6 degrees	
surcharge =	0 psf	Kah =	0.196	
φfoundation =	40 degrees	δfoundation =	26.67 degrees	
Burial Depth =	1 ft	φbackfill =	30 degrees	
Ult. Shear Cap. Between Boulders =	0 lb/ft	φsubgrade =	40 degrees	
Angle of Friction Between Boulders =	45 degrees			
Rock Interface Red. Factor =	0.7 * Adjust Depen	ding on Boulder Geomet	ry	
Rock Stacking Red. Factor =	0.8			

Factor of Safety (FOS) against OVERTURNING = 2.0, FOS against SLIDING = 1.5, FOS for BEARING = 3.0 (vertical force along back of wall neglected in sliding and overturning)

*Rock Diameter (ft)	1.5	2.0	3.0	4.0	5.0				
Rock Area (ft <sup>2</sup> )	1.8	3.1	7.1	12.6	19.6	0.0	0.0	0.0	0.0
D From Top of Rockery (ft)	1.5	3.1	5.5	8.7	12.7	12.7	12.7	12.7	12.7
P <sub>ah</sub> (lb/ft)	26	113	355	889	1894	1894	1894	1894	1894
Center of Gravity	0.8	1.0	1.5	2.0	2.5	0.0	0.0	0.0	0.0
Hinge Ht (H <sub>h</sub> ) (ft)	1.5	3.1	5.5	8.0	10.0	0.0	0.0	0.0	0.0
Avg Col. Diam. Above H <sub>h</sub> (ft)	1.5	1.8	2.2	3.0	4.0	4.5	5.0	#DIV/0!	#DIV/0!
Wt Above Base Rock (lb/ft)		239	663	1617	3313	5964	#DIV/0!	#DIV/0!	#DIV/0!
Total Wt (lb/ft)	239	663	1617	3313	5964	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Wt Above H <sub>h</sub> (lb/ft)	0	0	0	227	1152	6060	6733	#DIV/0!	#DIV/0!
Adjusted Total Wt (lb/ft)	239	663	1617	3087	4813	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
TOUTOK MINING A STATE DAYS	D'		A distance of						

\*CHECK: Minimum Average Base Course Diameter = 0.4(Ht<sub>wall</sub>) ARC Guidelines

### OVERTURNING ANALYSIS: Wall Ht (ft) 1.5 3.1 5.5 8.7 12.7 12.7 12.7 12.7 12.7 117 2577 8016 8016 8016 8016 8016 Movt 13 651 M<sub>res</sub> 125 592 2406 6479 12627 #DIV/0! #DIV/0! #DIV/0! #DIV/0! FS<sub>ovt</sub> 9.5 5.1 3.7 2.5 1.6 #DIV/0! #DIV/0! #DIV/0! #DIV/0! #DIV/0! #DIV/0! CHECK ок ок οк ок ARS #DIV/0! #DIV/0!

SLIDING/BULGING ANALYSIS:	

Wall Ht (ft)	1.5	3.1	5.5	8.7	12.7	12.7	12.7	12.7	12.7
R <sub>slide</sub>	26	113	355	889	1894	1894	1894	1894	1894
R <sub>res at wall base</sub> (Ib/ft)	552	971	2040	3716	6108	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
R <sub>res rock to rock</sub> (Ib/ft)	167	464	1132	2319	4175	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
**FS <sub>base slide</sub>	20.9	8.6	5.7	4.2	3.2	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
CHECK	ок	ок	ок	ОК	ОК	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
FS <sub>rock</sub> to rock slide (bulging)	6.3	4.1	3.2	2.6	2.2	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
CHECK	ОК	OK	ОК	ОК	OK	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

BEARING CAPACITY:									
Wall Ht (ft)	1.5	3.1	5.5	8.7	12.7	12.7	12.7	12.7	12.7
Soil Load (lb/ft)	159.0	331.3	539.0	828.3	1192.8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Soil Capacity	16402.5	19302.1	25101.5	30900.8	36700.2	7703.4	7703.4	7703.4	7703.4
FS <sub>bearing</sub>	103.1	58.3	46.6	37.3	30.8	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
CHECK	ОК	ОК	ОК	ОК	ОК	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Wall Ht (ft)	1.5	3.1	5.5	8.7	12.7	12.7	12.7	12.7	12.7
	PASS	PASS	PASS	PASS	FAIL	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
		MAXIMU		E HEIGHT:	8	FT			

\*\*Resisting force for Rockery Foundation - Only Value at Maximum D Applies ARS: ADJUST ROCK SIZE

# **APPENDIX C**



01628-005; Powder Mtn.; Global Stability; 8' H Max; Flat w/ Traffic; "A"; Static

*** GSTABL7 ***						1	User Specified Y-Origin = 40.00(ft)						
	*	* GSTABL7	by Garry H.	Gregory, E	·E· **	Ţ							
** Original	L Version	1.0, Janua	ry 1996; Cu	rrent Versi	on 2.002,		ISOTROPIC	SOIL PARAMETE	RS				
December 2001 **	(All Ri	ghts Reser	ved-Unautho	rized Use B	Prohibited)		1 Type(	s) of Soil					
SLOPE STABILITY ANALYSIS SYSTEM Modified Bishop, Simplified Janbu, or GLE Method of Slices. (Includes Spencer & Morgenstern-Price Type Analysis) Including Pier/Pile, Reinforcement, Soil Nail, Tieback, Nonlinear Undrained Shear Strength, Curved Phi Envelope, Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water Surfaces, Pseudo-Static Earthquake, and Applied Force Options.						1	Soil To Type Uni No. (p 1 12 BOUNDARY	tal Saturated t Wt. Unit Wt. cf) (pcf) 0.0 125.0 LOAD(S) ad(s) Specifie	Cohesion Intercept (psf) 150.0	Friction Angle P (deg) 30.0	Pore Pressure Param. 0.00	Pressure Constant ( (psf) 0.0	Piez. Surface No. O
							1 10	au(s) specifie	1				
Analysis Run Time of Run: Run By: Input Data Fi Output Filena Unit Sustem:	Date: ilename: ame:	5/7/20 3:27PM DAG X:A1. X:A1.0 Englis	UT				Load No.	X-Left (ft)	X-Right (ft)	Intensi (psf) 250	ty	Deflection (deg)	
Distand Output	+ Filonom		т. т.				Ţ	20.00	40.00	230.	0	0.0	
Piotted outpu	it ritenam	e: A:A1.P	<u>1</u>			1	NOTE - I F	ntensity Is Sp orce Acting On	ecified As A Horizon <sup>.</sup>	A Uniforml tally Proje	y Distr cted Su	ibuted rface.	
PROBLEM DESCR	RIPTION:	01628-005; ; 8' H Max	Powder Mtn ; Flat w/ T	.; Global S raffic; "A"	Stability ; Static		A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.					∍d.	
BOUNDARY COOP	RDINATES						2500 Tri	al Surfaces Ha <sup>.</sup>	ve Been Ge	nerated.			
4 Top E 8 Total E	Boundaries Boundaries						50 Sur Along Th	face(s) Initia e Ground Surfa	te(s) From ce Between and	Each Of X = 15.0 X = 23.0	50 Poi 0(ft) 0(ft)	nts Equally	/ Spaced
Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd		Each Sur	face Terminate	s Between and	X = 25.0 X = 40.0	0(ft) 0(ft)		
1 2 3 4 5	20.00 24.00 25.50 20.00	50.00 50.00 58.00 58.00 50.00	20.00 24.00 25.50 50.00 21.00	58.00 58.00 58.00 49.00	1 1 1 1		Unless F At Which	urther Limitat. A Surface Exto	ions Were S ends Is Y	Imposed, Th = 0.0	e Minim 0(ft)	um Elevatio	n
6 7 8	21.00 23.00 24.00	49.00 49.00 51.00	23.00 24.00 25.50	49.00 51.00 58.00	1 1 1		2.00(ft	) Line Segment:	s Define Ea	ach Trial F	ailure	Surface.	

Following Is Displayed The Most Critical Of The Trial Failure Surfaces Evaluated.

\*\*\*\* END OF GSTABL7 OUTPUT \*\*\*\*

```
* * Safety Factors Are Calculated By The Modified Bishop Method * *
```

Total Number of Trial Surfaces Evaluated = 2500

```
Statistical Data On All Valid FS Values:
FS Max = 11.358 FS Min = 1.398 FS Ave = 3.307
Standard Deviation = 1.393 Coefficient of Variation = 42.13 %
```

Failure Surface Specified By 8 Coordinate Points

Point	X-Surf	Y-Surf
No.	(ft)	(ft)
1	00.00	F 0 1 0
1	20.06	50.12
2	21.80	51.11
3	23.46	52.22
4	25.04	53.45
5	26.53	54.79
6	27.92	56.22
7	29.21	57.76
8	29.38	58.00

Circle Center At X = 7.12; Y = 74.89; and Radius = 27.95

Factor of Safety \*\*\* 1.398 \*\*\*

Individual data on the 11 slices

			Water	Water	Tie	Tie	Earthqu	ıake	
			Force	Force	Force	Force	Ford	ce Suro	charge
Slice	Width	Weight	Top	Bot	Norm	Tan	Hor	Ver	Load
No.	(ft)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)
1	1.7	259.2	0.0	0.0	0.	0.	0.0	0.0	0.0
2	1.7	717.1	0.0	0.0	Ο.	Ο.	0.0	0.0	0.0
3	0.5	324.3	0.0	0.0	Ο.	Ο.	0.0	0.0	0.0
4	0.4	263.0	0.0	0.0	Ο.	Ο.	0.0	0.0	0.0
5	0.6	356.8	0.0	0.0	Ο.	Ο.	0.0	0.0	0.0
6	0.5	238.4	0.0	0.0	Ο.	Ο.	0.0	0.0	0.0
7	0.5	234.9	0.0	0.0	Ο.	Ο.	0.0	0.0	0.0
8	0.5	220.2	0.0	0.0	Ο.	Ο.	0.0	0.0	132.9
9	1.4	416.3	0.0	0.0	Ο.	Ο.	0.0	0.0	347.6
10	1.3	155.7	0.0	0.0	Ο.	Ο.	0.0	0.0	321.1
11	0.2	2.6	0.0	0.0	Ο.	Ο.	0.0	0.0	44.0







*** GSTABL7 ***	User Specified Y-Origin = 40.00(ft)							
** GSTABL7 by Garry H. Gregory, P.E. **	Ţ							
<pre>** Original Version 1.0, January 1996; Current Version 2.002, Decomber 2001 **</pre>		ISOTROPIC SC	DIL PARAMETE	RS				
(All Rights Reserved-Unauthorized Use Prohibited)		2 Type(s)	of Soil					
SLOPE STABILITY ANALYSIS SYSTEM Modified Bishop, Simplified Janbu, or GLE Method of Slices. (Includes Spencer & Morgenstern-Price Type Analysis) Including Pier/Pile, Reinforcement, Soil Nail, Tieback, Nonlinear Undrained Shear Strength, Curved Phi Envelope, Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water Surfaces, Pseudo-Static Earthquake, and Applied Force Options.		Soil Total Type Unit W No. (pcf) 1 120.0 2 140.0	Saturated Vt. Unit Wt. (pcf) 125.0 140.0	Cohesior Intercept (psf) 150.0 0.0	h Friction Angle (deg) 30.0 45.0	Pore Pressure Param. 0.00 0.00	Pressure Constant (psf) 0.0 0.0	Piez. Surface No. 0 0
***************************************		ANISOTROPIC 1 soil	STRENGTH PA type(s)	RAMETERS				
Analysis Run Date:5/7/2013Time of Run:3:36PMRun By:DAGInput Data Filename:X:A2.Output Filename:X:A2.OUTUnit Suston:Finclich		Soil Type Number Of I	2 Is Anisot Direction Ra	ropic nges Speci	ified = 3			
Plotted Output Filename: X:A2.PLT		Direction Range No.	Countercl Directio (deg	ockwise n Limit )	Cohesion Intercept (psf)	Frio An (o	ction ngle deg)	
PROBLEM DESCRIPTION: 01628-005; Powder Mtn.; Global Stability ; 8' H Max; Flat w/ Traffic; "B"; Static		1 2 3 ANISOTROPIO (1) An i	-12. -5. 90. C SOIL NOTES input value	0 0 : of 0.01 fc	3000.00 0.00 3000.00	Phi wil:	0.00 45.00 0.00 1 cause An	niso
BOUNDARY COORDINATES 4 Top Boundaries 8 Total Boundaries	1	(2) An i C ec (3) An i C ec	input value qual to zero input value qual to zero	of 0.02 fc , with no of 0.03 fc , with wat	or Phi will water weig or Phi will cer weight	set both ht in the set both in the te	h Phi and e tension h Phi and ension cra	crack. ack.
Boundary X-Left Y-Left X-Right Y-Right Soil Type No. (ft) (ft) (ft) (ft) Below Bnd		BOUNDARY LOF	AD(S)					
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		l Load Load No.	(s) Specifie X-Left (ft)	d X-Right (ft)	Intens (psf	ity )	Deflection (deg)	ı
8 24.00 51.00 25.50 58.00 1		1	26.00	40.00	250	.0	0.0	

	4	25.04	53.45
NOTE - Intensity Is Specified As A Uniformly Distributed	5	26.53	54.79
Force Acting On A Horizontally Projected Surface.	6	27.92	56.22
	7	29.21	57.76
Janbus Empirical Coef is being used for the case of $$ c & phi both > 0 $$	8	29.28	58.00

1

2

3

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6

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10

11

0.8

1.6

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0.6

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0.5

0.5

1.4

1.3

0.1

97.8

758.4

284.6

6.2

410.9

249.6

234.7

219.3

416.2

156.3

1.0

	Fact	or of Saf	fety
A Critical Failure Surface Searching Method, Using A Random	* * *	2.087	* * *
Technique For Generating Sliding Block Surfaces, Has Been			
Specified.			

1000 Trial Surfaces Have Been Generated.

5 Boxes Specified For Generation Of Central Block Base

Length Of Line Segments For Active And Passive Portions Of Sliding Block Is 2.0

Box No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Height (ft)
1	24.40	52.90	24.40	52.90	0.00
2	25.04	53.45	25.04	53.45	0.00
3	26.53	54.79	26.53	54.79	0.00
4	27.92	56.22	27.92	56.22	0.00
5	29.21	57.76	29.21	57.76	0.00

Following Is Displayed The Most Critical Of The Trial Failure Surfaces Evaluated.

 $^{\star}$  \* Safety Factors Are Calculated By The Simplified Janbu Method \* \*

Total Number of Trial Surfaces Evaluated = 1000

Statistical Data On All Valid FS Values: FS Max = 10.397 FS Min = 2.087 FS Ave = 7.516 Standard Deviation = 1.759 Coefficient of Variation = 23.41 %

Failure Surface Specified By 8 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	21.60	53.21 53.08
3	24.40	52.90

			Water	Water	Tie	Tie	Eartho	quake	
			Force	Force	Force	Force	Foi	ce	Surcharge
Slice	Width	Weight	Top	Bot	Norm	Tan	Hor	Ver	Load
No.	(ft)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs	) (lbs)

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0.0

0.0

0.0

0.0

0.0

132.5

347.5

322.5

17.8

Individual data on the 11 slices

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

\*\*\*\* END OF GSTABL7 OUTPUT \*\*\*\*

1



01628-005; Powder Mtn.; Global Stability; 8' HMax; Flat w/ Traffic; "B"; P-Static

X:\GSTABLE\01628005\A2P.PLT Run By: DAG 5/7/2013 3:38PM

*** GSTABL7 ***	User Specified Y-Origin = 40.00(ft)					
** GSTABL7 by Garry H. Gregory, P.E. **						
** Original Version 1.0, January 1996; Current Version 2.002,	ISOTROPIC SOIL PARAMETERS					
(All Rights Reserved-Unauthorized Use Prohibited)	2 Type(s) of Soil					
SLOPE STABILITY ANALYSIS SYSTEM Modified Bishop, Simplified Janbu, or GLE Method of Slices. (Includes Spencer & Morgenstern-Price Type Analysis) Including Pier/Pile, Reinforcement, Soil Nail, Tieback, Nonlinear Undrained Shear Strength, Curved Phi Envelope, Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water Surfaces, Pseudo-Static Earthquake, and Applied Force Options.	Soil Total Saturated Cohesion FrictionPorePressurePiez.Type Unit Wt. Unit Wt. InterceptAnglePressure Constant SurfaceNo. (pcf)(pcf)(psf)(deg)Param.(psf)1120.0125.0150.030.00.000.002140.0140.00.045.00.000.00					
***************************************	ANISOTROPIC STRENGTH PARAMETERS 1 soil type(s)					
Analysis Run Date:5/7/2013Time of Run:3:38PMRun By:DAGInput Data Filename:X:A2P.Output Filename:X:A2P.OUTUnit Sustom:Frequence	Soil Type 2 Is Anisotropic Number Of Direction Ranges Specified = 3					
Plotted Output Filename: X:A2P.PLT	Direction Counterclockwise Cohesion Friction Range Direction Limit Intercept Angle No. (deg) (psf) (deg)					
PROBLEM DESCRIPTION: 01628-005; Powder Mtn.; Global Stability ; 8' HMax; Flat w/ Traffic; "B";P-Static	1       -12.0       3000.00       0.00         2       -5.0       0.00       45.00         3       90.0       3000.00       0.00         ANISOTROPIC SOIL NOTES:       (1) An input value of 0.01 for C and/or Phi will cause Aniso					
BOUNDARY COORDINATES 4 Top Boundaries 8 Total Boundaries	<ul> <li>(2) An input value of 0.02 for Phi will set both Phi and C equal to zero, with no water weight in the tension crack.</li> <li>(3) An input value of 0.03 for Phi will set both Phi and C equal to zero, with water weight in the tension crack.</li> </ul>					
I Boundary X-Left Y-Left X-Right Y-Right Soil Type No. (ft) (ft) (ft) Below Bnd	BOUNDARY LOAD(S)					
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	<pre>1 Load(s) Specified Load X-Left X-Right Intensity Deflection No. (ft) (ft) (psf) (deg)</pre>					
6       21.00       49.00       23.00       49.00       1         7       23.00       49.00       24.00       51.00       1         8       24.00       51.00       25.50       58.00       1	1 26.00 40.00 250.0 0.0					

	NOTE - Int Fo: A Horizoni Of0.150 Ha	tensity Is Sp rce Acting On tal Earthquak as Been Assign	ecified As A A Horizontal e Loading Coe ned	Uniformly E ly Projecte fficient	d Surface	1		4 5 6 7 8 9 10 11	0.0 0.6 0.5 0.5 1.4 1.3 0.1	6.2 410.9 249.6 234.7 219.3 416.2 156.3 1.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.9 61.6 37.4 35.2 32.9 62.4 23.5 0.2	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 132.5 347.5 322.5 17.5
	A Vertica	l Earthquake :	Loading Coeff	icient					*	**Table 2 -	- Base	Stress Da	ta on the	e 11 S	lices**'	ł	
	Cavitatio	n Pressure =	0.0(psf)					Slice No. *	Alpha (deg)	X-Coord. Slice Cnt (ft)	r	Base Leng. (ft)	Avai Shear S (ps	lable Strength sf)		Mobil Shear S (psf	ized tress )
1	Janbu's Er	mpirical Coef	. is being us	ed for the	case of (	c & phi b	oth > 0	1 2 3	-8.43 -5.17 -5.17	22.01 23.20 24.20	- ) )	0.82		134.76 504.81 754.11		2 4	0.22 8.25 2.19
	Trial Fai	lure Surface :	Specified By	8 Coordina	te Points			4 5 6 7	40.67 40.67 41.97 41.97	24.40 24.72 25.27 25.75	) ? ?	0.01 0.83 0.62 0.67	2	537.86 478.40 434.72		54 49 42 36	6.18 8.31 3.38 6.22
	Point No.	X-Surf (ft)	Y-Surf (ft)					8 9 10	41.97 45.81 50.05	26.26 27.23 28.57	3	0.71 1.99 2.01		550.63 497.99 404.81		49 42 29	0.03 5.26 6.23
	1 2 3 4 5	21.60 22.41 24.40 25.04 26.53	53.20 53.08 52.90 53.45 54.79					11 Sur So:	73.74 n of the i il Nail,	29.25 Resisting F and Applied	o Corces 1 Force	0.25 (includinges if appl:	g Pier/Pi icable) =	502.02 le, Tie 456	back, Re 7.80 (lk	25 einforcin os)	4.43 g
	6 7 8	27.92 29.21 29.28	56.22 57.76 58.00					Ave So:	erage Ava il Nail,	ilable Shea and Applied	ar Stre 1 Force	ength (inc es if appl	luding Ti icable) =	eback, 460	Pier/Pil .56(psf)	le, Reinf	orcing,
	Janbu's Er	mpirical Coef:	ficient (fo)	= 1.070				Sur	n of the 3	Driving For	ces =	2847.	54 (lbs)				
	* * Facto:	r Of Safety I	s Calculated	By The Simp	lified Jar	nbu Metho	d * *	Ave	erage Mob	ilized Shea	ar Stre	ess = :	287.11 (ps	sf)			
	Factor Of	Safety For T	ne Preceding	Specified S	urface =	1.717		Tot	al lengt	h of the fa	ilure	surface =	9.	92(ft)			
	***T	able 1 - Indi <sup>.</sup>	vidual Data o	n the 11	Slices***					* *	** ENI	D OF GSTAB	L7 OUTPUI	****			
Slice No.	Width Weid (ft) (1)	Water M Force S ght Top bs) (lbs)	Nater Tie Force Forc Bot Norm (lbs) (lbs	Tie Force Tan ) (lbs)	Earthqua Force Hor (lbs)	ake 9 Surch Ver L (lbs) (	arge oad lbs)										
1 2 3	0.8 1.6 0.4 2	98.70.057.30.084.60.0	0.0 0.0 0.0	0.0 0.0 0.0 0.0 0.0 0.0	14.8 113.6 42.7	0.0 0.0 0.0	0.0 0.0 0.0										

1



01628-005; Powder Mtn.; Global Stability; 8' H Max; Flat w/ Traffic; Static

*** GSTABL7 ***	User Specif	ied Y-Origin	_ =	40.00(ft)			
** GSTABL7 by Garry H. Gregory, P.E. **							
** Original Version 1.0, January 1996; Current Version 2.002,	ISOTROPIC SO	IL PARAMETER	.S				
December 2001 ** (All Rights Reserved-Unauthorized Use Prohibited)	2 Type(s)	of Soil					
SLOPE STABILITY ANALYSIS SYSTEM Modified Bishop, Simplified Janbu, or GLE Method of Slices. (Includes Spencer & Morgenstern-Price Type Analysis) Including Pier/Pile, Reinforcement, Soil Nail, Tieback, Nonlinear Undrained Shear Strength, Curved Phi Envelope, Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water Surfaces, Pseudo-Static Earthquake, and Applied Force Options.	Soil Total Type Unit W No. (pcf) 1 120.0 2 140.0	Saturated t. Unit Wt. (pcf) 125.0 140.0	Cohesion Intercept (psf) 150.0 0.0	Friction Angle (deg) 30.0 45.0	Pore Pressure Param. 0.00 0.00	Pressure Constant (psf) 0.0 0.0	Piez. Surface No. 0 0
***************************************	ANISOTROPIC 1 soil	STRENGTH PAR type(s)	AMETERS				
Analysis Run Date:5/7/2013Time of Run:4:00PMRun By:DAGInput Data Filename:X:a3.Output Filename:X:a3.OUTUnit System:English	Soil Type Number Of D	2 Is Anisotr irection Ran	opic ges Speci:	fied = 3			
Plotted Output Filename: X:a3.PLT	Direction Range No.	Counterclo Direction (deg)	ckwise Limit	Cohesion Intercept (psf)	I Fri A (	ction ngle deg)	
PROBLEM DESCRIPTION: 01628-005; Powder Mtn.; Global Stability ; 8' H Max; Flat w/ Traffic; Static	1 2 3 ANISOTROPIC (1) An i	-12.0 -5.0 90.0 SOIL NOTES: nput value o	f 0.01 for	3000.00 0.00 3000.00 r C and/or	Phi wil	0.00 45.00 0.00 1 cause A	niso
BOUNDARY COORDINATES 4 Top Boundaries 8 Total Boundaries 1	(2) An i C eq (3) An i C eq	nput value o gual to zero, nput value o gual to zero,	f 0.02 fo: with no v f 0.03 fo: with wate	r Phi will water weig r Phi will er weight	set bot ht in th set bot in the t	h Phi and e tension h Phi and ension cr	crack. I rack.
Boundary X-Left Y-Left X-Right Y-Right Soil Type No. (ft) (ft) (ft) Below Bnd	BOUNDARY LOA	.D(S)					
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	l Load( Load	<pre>s) Specified X-Left (f+)</pre>	X-Right	Intens	ity	Deflectio	n
5       20.00       50.00       21.00       49.00       1         6       21.00       49.00       23.00       49.00       1         7       23.00       49.00       24.00       51.00       1         8       24.00       51.00       25.50       58.00       1	NO. 1	26.00	(IT) 40.00	(psi 250	.0	(deg) 0.0	

NOTE - Intensity Is Specified As A Uniformly Distributed Force Acting On A Horizontally Projected Surface.		1	7 8 9 0 1 2	26.74 28.21 29.39 30.24 30.73 30.75	50.7 52.0 53.6 55.5 57.4 58.0	73 08 59 50 14 00				
A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.		Circ	le Center	At X =	20.52	; Y =	58.91 ;	and Rad:	ius =	10.28
2500 Trial Surfaces Have Been Generated.			Factor *** 1	of Safet	ty ***					
50 Surface(s) Initiate(s) From Each Of 50 Points Equally Spaced Along The Ground Surface Between $X = 15.00(ft)$ and $X = 20.00(ft)$			Tadiridua	l data (	on the	17 01;				
			Individua	uata (	JII LIIE	1/ 511	ces			
Each Surface Terminates Between X = 26.00(ft) and X = 35.00(ft)				Water	Water	Tie	Tie	Earthqu	lake	charge
	Slice	Width	Weight	Top	Bot	Norm	Tan	Hor	Ver Sul	Load
Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is $Y = 0.00(ft)$	No.	(ft)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)
	1	1.8	89.6	0.0	0.0	0.	0.	0.0	0.0	0.0
	2	1.9	243.9	0.0	0.0	0.	0.	0.0	0.0	0.0
2.00(ft) Line Segments Define Each Trial Failure Surface.	3	0.8	125.8	0.0	0.0	0.	0.	0.0	0.0	0.0
	4	1.0	307.4	0.0	0.0	0.	0.	0.0	0.0	0.0
	5	0.2	87.9	0.0	0.0	0.	0.	0.0	0.0	0.0
	6	1.8	1360.0	0.0	0.0	0.	0.	0.0	0.0	0.0
	7	0.2	155.6	0.0	0.0	0.	0.	0.0	0.0	0.0
Following Is Displayed The Most Critical Of The Trial	8	0.8	930.3	0.0	0.0	0.	0.	0.0	0.0	0.0
Failure Surfaces Evaluated.	9	1.0	1146.9	0.0	0.0	0.	0.	0.0	0.0	0.0
	10	0.5	470.9	0.0	0.0	0.	0.	0.0	0.0	0.0
	11	0.5	4/2.6	0.0	0.0	0.	0.	0.0	0.0	0.0
* * Safety Factors Are Calculated by The Modified Bishop Method * *	12	0.7	66Z.3	0.0	0.0	0.	0.	0.0	0.0	184.0
	1.5	1.5	726 0	0.0	0.0	0.	0.	0.0	0.0	205.0
	14	1.2	726.0	0.0	0.0	0.	0.	0.0	0.0	293.8
Total Number of Trial Surfaces Evaluated - 2500	16	0.0	240.9	0.0	0.0	0.	0.	0.0	0.0	121 1
iotal Mulliper of fillar Suffaces Evaluated - 2500	17	0.5	00.7	0.0	0.0	0.	0.	0.0	0.0	121.1
Statistical Data On All Valid ES Values.	1	0.0	0.9	0.0	0.0	υ.	0.	0.0	0.0	/.0
FS May = $17.278$ FS Min = 1.937 FS Ave = 3.071										
Standard Deviation = 0.979 Coefficient of Variation = 31.86 %										
			* * * *	END OF	GSTABL7	OUTPUT *	* * *			

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	15.41	50.00
2	17.23	49.18
3	19.18	48.73
4	21.18	48.67
5	23.16	48.99
6	25.03	49.68

1



01628-005; Powder Mtn.; Global Stability; 8' HMax; Flat w/ Traffic; P-Static

X:\GSTABLE\01628005\A3P.PLT Run By: DAG 5/7/2013 3:40PM

### \*\*\* GSTABL7 \*\*\*

\*\* GSTABL7 by Garry H. Gregory, P.E. \*\*

\*\* Original Version 1.0, January 1996; Current Version 2.002, December 2001 \*\*

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SLOPE STABILITY ANALYSIS SYSTEM Modified Bishop, Simplified Janbu, or GLE Method of Slices. (Includes Spencer & Morgenstern-Price Type Analysis) Including Pier/Pile, Reinforcement, Soil Nail, Tieback, Nonlinear Undrained Shear Strength, Curved Phi Envelope, Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water Surfaces, Pseudo-Static Earthquake, and Applied Force Options.

Analysis Run Date:	5/7/2013
Time of Run:	3:40PM
Run By:	DAG
Input Data Filename:	X:A3P.
Output Filename:	X:A3P.OUT
Unit System:	English

Plotted Output Filename: X:A3P.PLT

# PROBLEM DESCRIPTION: 01628-005; Powder Mtn.; Global Stability ; 8' HMax; Flat w/ Traffic; P-Static

### BOUNDARY COORDINATES

4 Top Boundaries 8 Total Boundaries

0	τU	LUL	DU	uu	uur	TC

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	50.00	20.00	50.00	1
2	20.00	50.00	24.00	58.00	2
3	24.00	58.00	25.50	58.00	2
4	25.50	58.00	50.00	58.00	1
5	20.00	50.00	21.00	49.00	1
6	21.00	49.00	23.00	49.00	1
7	23.00	49.00	24.00	51.00	1
8	24.00	51.00	25.50	58.00	1
User Speci	fied Y-Origi	n =	40.00(ft)		

1

ISOTROPIC	SOIL	PARAMETERS

### 2 Type(s) of Soil

Soil	Total	Saturated	Cohesion	Friction	Pore	Pressure	Piez.
Туре	Unit Wt.	. Unit Wt.	Intercept	Angle	Pressure	Constant	Surface
No.	(pcf)	(pcf)	(psf)	(deg)	Param.	(psf)	No.
1	120.0	125.0	150.0	30.0	0.00	0.0	0
2	140.0	140.0	0.0	45.0	0.00	0.0	0

ANISOTROPIC STRENGTH PARAMETERS 1 soil type(s)

### Soil Type 2 Is Anisotropic

Number Of Direction Ranges Specified = 3

Direction Counterclockwise		Cohesion	Friction
Range	Direction Limit	Intercept	Angle
No.	(deg)	(psf)	(deg)
1	-12.0	3000.00	0.00
2	-5.0	0.00	45.00
3	90.0	3000.00	0.00

ANISOTROPIC SOIL NOTES:

- (1) An input value of 0.01 for C and/or Phi will cause Aniso C and/or Phi to be ignored in that range.
- (2) An input value of 0.02 for Phi will set both Phi and C equal to zero, with no water weight in the tension crack.
- (3) An input value of 0.03 for Phi will set both Phi and C equal to zero, with water weight in the tension crack.
  - c equal to zero, with water weight in the tension crack

BOUNDARY LOAD(S)

1

1 Load(s) Specified

Load	X-Left	X-Right	Intensity	Deflection
No.	(ft)	(ft)	(psf)	(deg)
1	26.00	40.00	250.0	0.0

NOTE - Intensity Is Specified As A Uniformly Distributed

Force Acting On A Horizontally Projected Surface.	6	1.8	1359.8	0.0	0.0	0.0	0.0	204.0	0.0	0.0
	7	0.2	160.3	0.0	0.0	0.0	0.0	24.0	0.0	0.0
	8	0.8	925.5	0.0	0.0	0.0	0.0	138.8	0.0	0.0
A Horizontal Earthquake Loading Coefficient	9	1.0	1146.5	0.0	0.0	0.0	0.0	172.0	0.0	0.0
Of0.150 Has Been Assigned	10	0.5	471.4	0.0	0.0	0.0	0.0	70.7	0.0	0.0
	11	0.5	472.7	0.0	0.0	0.0	0.0	70.9	0.0	0.0
A Vertical Earthquake Loading Coefficient	12	0.7	665.8	0.0	0.0	0.0	0.0	99.9	0.0	185.0
Of0.000 Has Been Assigned	13	1.5	1163.4	0.0	0.0	0.0	0.0	174.5	0.0	367.5
	14	1.2	724.3	0.0	0.0	0.0	0.0	108.6	0.0	295.0
Cavitation Pressure = 0.0(psf)	15	0.9	347.3	0.0	0.0	0.0	0.0	52.1	0.0	212.5
	16	0.5	90.0	0.0	0.0	0.0	0.0	13.5	0.0	122.5
	17	0.0	0.7	0.0	0.0	0.0	0.0	0.1	0.0	5.0
Janbu's Empirical Coef. is being used for the case of $$ c & phi both > 0 $$			***Table 2	- Base	Stress Da	ata on the	17	Slices***		

1

Trial Failure Surface Specified By 12 Coordinate Points

Point	X-Surf	Y-Surf
No.	(ft)	(ft)
1	15 41	50.00
1	15.41	50.00
2	17.23	49.18
3	19.18	48.73
4	21.18	48.67
5	23.16	48.99
6	25.03	49.68
7	26.74	50.73
8	28.21	52.08
9	29.39	53.69
10	30.24	55.50
11	30.73	57.44
12	30.75	58.00

Janbu's	Empirical	Coefficient	(fo) =	1.084
	1		· · /	

 $\star$   $\star$  Factor Of Safety Is Calculated By The Simplified Janbu Method  $\star$   $\star$ 

Factor Of Safety For The Preceding Specified Surface = 1.500

\*\*\*Table 1 - Individual Data on the 17 Slices\*\*\*

a1.			Water Force	Water Force	Tie Force	Tie Force	Earthqu Ford	lake Ce Suro	charge
Slice	Width	Weight	Top	Bot	Norm	Tan	Hor	Ver	Load
No.	(ft)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)
1	1.8	89.5	0.0	0.0	0.0	0.0	13.4	0.0	0.0
2	1.9	244.5	0.0	0.0	0.0	0.0	36.7	0.0	0.0
3	0.8	126.2	0.0	0.0	0.0	0.0	18.9	0.0	0.0
4	1.0	307.2	0.0	0.0	0.0	0.0	46.1	0.0	0.0
5	0.2	87.2	0.0	0.0	0.0	0.0	13.1	0.0	0.0

bilized
ar Stress
(psf)
-13.48
-9.87
18.46
36.84
58.11
229.84
308.23
536.46
541.98
653.05
615.50
716.58
791.84
751.14
622.19
427.14
283.60

Sum of the Resisting Forces (including Pier/Pile, Tieback, Reinforcing Soil Nail, and Applied Forces if applicable) = 11408.86 (lbs)

Average Available Shear Strength (including Tieback, Pier/Pile, Reinforcing, Soil Nail, and Applied Forces if applicable) = 554.99(psf)

Sum of the Driving Forces = 8245.94 (lbs)

Average Mobilized Shear Stress = 401.13(psf)

Total length of the failure surface = 20.56(ft)

\*\*\*\* END OF GSTABL7 OUTPUT \*\*\*\*



# 01628-005; Powder Mtn.; Global Stability; 8' H Max;2H:1V; "A"; Static



	*** GSTABL7 ***					User Spec:	fied Y-Origi.	.n =	40.00(ft)					
		*	* GSTABL7 1	by Garry H.	Gregory, P	.E. **	1	*	2					
December	** Origin 2001 **	al Version	1.0, Janua:	ry 1996; Cu	rrent Versi	on 2.002,		ISOTROPIC S	OIL PARAMETE	IRS				
		(All Ri	ghts Reser	ved-Unautho:	rized Use P	rohibited)								
								1 Type(s)	of Soil					
*******	******	********** SI.	*********** OPE_STABIL	************ TTY ANALYST:	*********** S SYSTEM	* * * * * * * * * * * * * * * *		Soil Tota	1 Saturated	Cohesion	Friction 1	Pore F	ressure	Piez.
	Modi	fied Bishop	, Simplifi	ed Janbu, o	r GLE Metho	d of Slices.		Type Unit	Wt. Unit Wt.	Intercept	Angle Pre	essure C	Constant S	urface
(Includes Spencer & Morgenstern-Price Type Analysis) Including Pier/Pile Reinforcement Soil Nail Tieback						No. (pc:	) (pcf)	(psf)	(deg) I	Param.	(psf)	No.		
Nonlinear Undrained Shear Strength, Curved Phi Envelope,				1 120	0 125.0	150.0	30.0 0	.00	0.0	0				
	Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water Surfaces, Pseudo-Static Earthquake, and Applied Force Options.			1										
*******	*****	* * * * * * * * * * *	* * * * * * * * * * *	* * * * * * * * * * * *	* * * * * * * * * * *	* * * * * * * * * * * * * * * * * *		BOUNDARY LO	AD(S)					
						1 Load	l(s) Specifie	d						
	Analysis Ru Time of Run	n Date: :	5/7/20 3:44PM	13										
	Run By:		DAG					Load	X-Left	X-Right	Intensity	y De	eflection	
	Input Data Output File	Filename: name:	X:B1. X:B1.0	UTT				No.	(it)	(it)	(psi)		(deg)	
	Unit System	:	Englis	h										
	Plotted Out	put Filenam	e: X:B1.P	LT				1	66.00	80.00	250.0		0.0	
								NOTE - Int	ensity Is Sp	ecified As	A Uniformly	Distrik	outed	
							1	FOI	ce Acting Un	I A HOTIZON	tally Project	ted Suri	ace.	
	PROBLEM DES	CRIPTION:	01628-005;	Powder Mtn	.; Global S	tability								
			; о п Мах	;2 <b>π:</b> 1V; A	; SLALIC			A Critical Failure Surface Searching Method, Using A I					Random	
								Technique	For Generati	ng Circula.	r Surfaces, H	Has Beer	n Specifie	d.
	BOUNDARY CO	ORDINATES						2500 Tria	Surfaces Ha	ve Been Ge	nerated.			
	5 Top	Boundaries												
	9 Total	Boundaries						50 Surfa	ce(s) Initia Ground Surfa	ite(s) From	Each Of $x = 15.00$	50 Point (f+)	s Equally	Spaced
								Along The	Ground Surra	and	X = 23.00	(ft)		
	Boundary	X-Left	Y-Left	X-Right	Y-Right	Soil Type								
	NO.	(11)	(11)	(11)	(11)	BETOM RUG		Each Surfa	ce Terminate	s Between	X = 30.00	(ft)		
	1	0.00	50.00	20.00	50.00	1				and	X = 75.00	(ft)		
	2	20.00	50.00 58 00	24.00	58.00 58.00	1								
	4	25.50	58.00	65.50	78.00	1		Unless Fur	ther Limitat	ions Were	Imposed, The	Minimum	1 Elevatio	n
	5	65.50	78.00	80.00	78.00	1		At Which A	Surface Ext	ends Is Y	= 0.00	(ft)		
	6	20.00	50.00	21.00	49.00	1								
	7	21.00	49.00	23.00	49.00	1								
	8	23.00	49.00	24.00	51.00	1		2.00(ft)	Line Segment	s Define E	ach Trial Fa	ilure Su	irface.	
	9	24.00	51.00	25.50	58.00	1								

	7	1.5	938.4	0.0	0.0	Ο.	Ο.	0.0	0.0	0.0
	8	1.5	791.2	0.0	0.0	Ο.	Ο.	0.0	0.0	0.0
	9	1.3	591.4	0.0	0.0	Ο.	Ο.	0.0	0.0	0.0
Following Is Displayed The Most Critical Of The Trial	10	1.1	384.5	0.0	0.0	Ο.	Ο.	0.0	0.0	0.0
Failure Surfaces Evaluated.	11	1.0	189.5	0.0	0.0	Ο.	Ο.	0.0	0.0	0.0
	12	0.5	32.3	0.0	0.0	0.	Ο.	0.0	0.0	0.0

\* \* Safety Factors Are Calculated By The Modified Bishop Method \* \*

\*\*\*\* END OF GSTABL7 OUTPUT \*\*\*\*

Total Number of Trial Surfaces Evaluated = 2500

```
Statistical Data On All Valid FS Values:
FS Max = 7.128 FS Min = 1.567 FS Ave = 2.200
Standard Deviation = 0.407 Coefficient of Variation = 18.49 %
```

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	20.06	50.12
2	21.95	50.79
3	23.75	51.66
4	25.46	52.70
5	27.04	53.92
6	28.50	55.29
7	29.80	56.80
8	30.94	58.45
9	31.91	60.20
10	32.44	61.47

Circle Center At X = 14.60 ; Y = 68.52 ; and Radius = 19.19

Factor of Safety \*\*\* 1.567 \*\*\*

Individual data on the 12 slices

			Water	Water	Tie	Tie	Earthqu	ıake	
			Force	Force	Force	Force	Ford	ce Sur	charge
Slice	Width	Weight	Top	Bot	Norm	Tan	Hor	Ver	Load
No.	(ft)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)
1	1.9	350.3	0.0	0.0	0.	0.	0.0	0.0	0.0
2	1.8	968.4	0.0	0.0	Ο.	Ο.	0.0	0.0	0.0
3	0.2	180.1	0.0	0.0	Ο.	Ο.	0.0	0.0	0.0
4	0.2	146.7	0.0	0.0	Ο.	Ο.	0.0	0.0	0.0
5	1.3	857.5	0.0	0.0	Ο.	Ο.	0.0	0.0	0.0
6	0.0	27.6	0.0	0.0	Ο.	Ο.	0.0	0.0	0.0

### 01628-005; Powder Mtn.; Global Stability; 8' H Max;2H:1V; "B"; Static X:\GSTABLE\01628005\B2.PL2 Run By: DAG 5/7/2013 3:51PM Soil Soil Total Saturated Cohesion Friction Piez.





	*** GSTABL7 ***			User Specifi	ed Y-Origin =	40.00(ft)	
* *	GSTABL7 by Garry H. Gregory, P.	E. **	1	obor opcorri		10.00(10)	
** Original Version 1. December 2001 ** (All Righ	0, January 1996; Current Versio ts Reserved-Unauthorized Use Pr	on 2.002, rohibited)		ISOTROPIC SOI	IL PARAMETERS		
				2 Type(s) c	of Soil		
SLOP Modified Bishop, (Includes Spencer Including Pier/Pi Nonlinear Undrain Anisotropic Soil, Surfaces, Pseudo-	*************** sis) ieback, nvelope, y Loads, Water Force Options.		Soil Total Type Unit Wt No. (pcf) 1 120.0 2 140.0	Saturated Cohesion Unit Wt. Intercep (pcf) (psf) 125.0 150.0 140.0 0.0	n Friction Porr t Angle Press (deg) Par 30.0 0.00 45.0 0.00	e Pressure Piez. ure Constant Surface am. (psf) No. 0.0 0 0.0 0	
******	***********	****		ANTCOMPODIC O			
Analysis Run Date: Time of Run: Run By: Input Data Filename: Output Filename: Unit System:	5/7/2013 3:51PM DAG X:B2. X:B2.OUT English			ANISOTROPIC S 1 soil t Soil Type 2 Number Of Di	TRENGTH PARAMETERS :ype(s) ? Is Anisotropic .rection Ranges Spec:	ified = 3	
Plotted Output Filename:	X:B2.PLT			Direction Range No.	Counterclockwise Direction Limit (deg)	Cohesion Intercept (psf)	Friction Angle (deg)
PROBLEM DESCRIPTION: 01	628-005; Powder Mtn.; Global St 8' H Max;2H:1V; "B"; Static	ability		1 2 3	-12.0 -5.0 90.0	3000.00 0.00 3000.00	0.00 45.00 0.00
BOUNDARY COORDINATES 5 Top Boundaries 9 Total Boundaries				ANISOTROPIC (1) An ir C and (2) An ir C equ (3) An ir C equ	SOIL NOTES: nput value of 0.01 for l/or Phi to be ignore nput value of 0.02 for al to zero, with no nput value of 0.03 for al to zero, with war	or C and/or Phi ed in that range or Phi will set 1 water weight in or Phi will set 1 ter weight in th	will cause Aniso both Phi and the tension crack. both Phi and e tension crack.
Boundary X-Left No. (ft)	Y-Left X-Right Y-Right (ft) (ft) (ft)	Soil Type Below Bnd	1	Janbus Empir	rical Coef is being w	used for the cas	e of c & phi both > 0
$\begin{array}{ccccccc} 1 & 0.00 \\ 2 & 20.00 \\ 3 & 24.00 \\ 4 & 25.50 \\ 5 & 65.50 \\ 6 & 20.00 \\ 7 & 21.00 \\ 0 & 22.00 \end{array}$	50.00         20.00         50.00           50.00         24.00         58.00           58.00         25.50         58.00           58.00         65.50         78.00           78.00         80.00         78.00           50.00         21.00         49.00           40.00         23.00         49.00	1 2 2 1 1 1 1		A Critical Failure Surface Searching Method, Using A Random Technique For Generating Sliding Block Surfaces, Has Been Specified. 1000 Trial Surfaces Have Been Generated.			
8 23.00 9 24.00	49.00         24.00         51.00           51.00         25.50         58.00	1					

8 Boxes Specified For Generation Of Central Block Base

### Individual data on the 12 slices

Bot

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

Tie

Force

(lbs)

Ο.

Ο.

0.

Ο.

Ο.

Ο.

Ο.

Ο.

Ο.

0.

Ο.

Ο.

Norm

Tie

Force

Tan

(lbs)

Ο.

Ο.

Ο.

Ο.

Ο.

Ο.

0.

Ο.

0.

0.

Ο.

0.

Earthquake

(lbs) (lbs)

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

Hor

Force Surcharge

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

Load

(lbs)

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

Ver

Water Water

Force Force

(lbs) (lbs)

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

0.0

Top

Slice Width

(ft)

1.0

1.9

0.1

0.1

1.3

0.0

1.5

1.5

1.3

1.1

1.0

0.5

No.

1

2

3

4

5

6

7

8

9

10

11

12

Weight

(lbs)

146.4

85.3

90.3

930.9

25.4

935.0

793.7

589.7

384.4

190.6

32.0

1080.4

Length Of Line Segments For Active And Passive Portions Of Sliding Block Is 2.0

Box No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Height (ft)
1	24.10	51.90	24.10	51.90	0.00
2	25.46	52.70	25.46	52.70	0.00
3	27.04	53.92	27.04	53.92	0.00
4	28.50	55.29	28.50	55.29	0.00
5	29.80	56.80	29.80	56.80	0.00
6	30.94	58.45	30.94	58.45	0.00
7	31.91	60.20	31.91	60.20	0.00
8	32.44	61.47	32.44	61.47	0.00

Following Is Displayed The Most Critical Of The Trial Failure Surfaces Evaluated.

\*\*\*\* END OF GSTABL7 OUTPUT \*\*\*\*

\* \* Safety Factors Are Calculated By The Simplified Janbu Method \* \*

Total Number of Trial Surfaces Evaluated = 1000

Statistical Data On All Valid FS Values: FS Max = 7.666 FS Min = 2.278 FS Ave = 5.958 Standard Deviation = 1.142 Coefficient of Variation = 19.17 %

Failure Surface Specified By 10 Coordinate Points

Point	X-Surf	Y-Surf
No.	(ft)	(ft)
1	21.12	52.23
2	22.11	52.13
3	24.10	51.90
4	25.46	52.70
5	27.04	53.92
6	28.50	55.29
7	29.80	56.80
8	30.94	58.45
9	31.91	60.20
10	32.44	61.47

Factor of Safety \*\*\* 2.278 \*\*\*



GSTABL7

# 01628-005; Powder Mtn.; Global Stability; 8' H Max;2H:1V; "B"; P-Static

X:\GSTABLE\01628005\B2P.PLT Run By: DAG 5/7/2013 3:52PM

			;	*** GSTABL	7 ***										
		** GS	TABL7 }	by Garry H.	Gregory, P	.E. **	1	User	Specifi	ed Y-Origi	n =	40.00(ft)			
** ( December 2001 **	Driginal Versi * (All	ion 1.0, L Rights	Janua: Reserv	ry 1996; Cu ved-Unautho	rrent Versi rized Use P	on 2.002, rohibited)		ISOTRO	PIC SOI	L PARAMETE	RS				
								2 Ту	vpe(s) o	f Soil					
****	Modified Bis (Includes Sp Including Pi Nonlinear Uf Anisotropic Surfaces, Ps	SLOPE shop, Sin pencer & ler/Pile ndrained Soil, F seudo-St.	****** STABIL mplifie Morgen , Rein: Shear iber-Re atic Ea	ATTY ANALYSI ed Janbu, o nstern-Price forcement, Strength, pinforced S arthquake,	S SYSTEM r GLE Metho e Type Anal Soil Nail, Curved Phi Dil, Bounda and Applied	**************** d of Slices. ysis) Tieback, Envelope, ry Loads, Water Force Options.		Soil Type No. 1 2	Total Unit Wt (pcf) 120.0 140.0	Saturated . Unit Wt. (pcf) 125.0 140.0	Cohesion Intercept (psf) 150.0 0.0	A Friction Angle (deg) 30.0 45.0	Pore Pressure Param. 0.00 0.00	Pressure Constant (psf) 0.0 0.0	Piez. Surface No. O O
****	* * * * * * * * * * * * * * * *	******	* * * * * * *	* * * * * * * * * * *	* * * * * * * * * * *	****									
Analy	sis Run Date:		5/7/202	13				ANISO1 1	ROPIC S	TRENGTH PA ype(s)	RAMETERS				
Run B	/:		J:52PM DAG					Soil	Type 2	Is Anisot	ropic				
Input Output Unit S	Data Filename Filename: System:	2:	X:B2P. X:B2P.( English	DUT n				Number Of Direction Ranges Specified = 3							
Plotte	ed Output File	ename:	X:B2P.1	PLT				Direc Rar No	tion ge ).	Countercl Direction (deg	ockwise n Limit )	Cohesior Intercept (psf)	n Fri : A (	ction ngle deg)	
PROBLI	EM DESCRIPTION	J: 0162 ; 8'	8-005; H Max,	Powder Mtn ;2H:1V; "B"	.; Global S ; P-Static	tability		1 2 3	-	-12. -5. 90.	0 0 0	3000.00 0.00 3000.00	) )	0.00 45.00 0.00	
BOUND 5 9	ARY COORDINATH Top Boundar Total Boundar	IS ries ries						ANISC (1 (2	DTROPIC ) An in C and ?) An in C equ 3) An in C equ	SOIL NOTES put value /or Phi to put value al to zero put value al to zero	: of 0.01 fc be ignore of 0.02 fc , with no of 0.03 fc , with wat	or C and/or d in that or Phi will water weight er weight	Phi wil range. set bot ght in th set bot in the t	l cause A h Phi and e tension h Phi and ension cr	niso crack. ack.
Bounda No	ary X-Left . (ft)	. Y-:	Left ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd		A llos	icontal	Farthquak	o Iooding	Coofficion	.+		
1 2 3 4	0.00 20.00 24.00 25.50	) 5 <sup>-</sup> ) 5- ) 5-	0.00 0.00 8.00 8.00	20.00 24.00 25.50 65.50	50.00 58.00 58.00 78.00	1 2 2		A HOI Of0.1 A Vei	tical E	Been Assig arthquake Been Assig	e Loading ned Loading Cc	efficient	IL		
5 6 7 °	65.50 20.00 21.00	) 7 ) 5 ) 4	8.00 0.00 9.00	80.00 21.00 23.00	78.00 49.00 49.00	1 1 1 1		Cavit	ation P	ressure =	0.0(psf	Ē)			
9	24.00	) 5	1.00	25.50	58.00	1		Janbı	ı's Empi	rical Coef	. is being	used for	the case	of c &	phi both > 0

B2P	

Trial Failure Surface Specified By 10 Coordinate Points

Point	X-Surf	Y-Surf
No.	(ft)	(ft)
1	21.12	52.24
2	22.11	52.13
3	24.10	51.90
4	25.46	52.70
5	27.04	53.92
6	28.50	55.29
7	29.80	56.80
8	30.94	58.45
9	31.91	60.20
10	32.44	61.47

Janbu's Empirical Coefficient (fo) = 1.064

\* \* Factor Of Safety Is Calculated By The Simplified Janbu Method \* \*

Factor Of Safety For The Preceding Specified Surface = 1.787

\*\*\*Table 1 - Individual Data on the 12 Slices\*\*\*

			Water	Water	Tie	Tie	Earthqu	ake	
			Force	Force	Force	Force	Forc	e Suro	charge
Slice	Width	Weight	Top	Bot	Norm	Tan	Hor	Ver	Load
No.	(ft)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)
1	1.0	144.8	0.0	0.0	0.0	0.0	21.7	0.0	0.0
2	1.9	1082.0	0.0	0.0	0.0	0.0	162.3	0.0	0.0
3	0.1	85.3	0.0	0.0	0.0	0.0	12.8	0.0	0.0
4	0.1	90.3	0.0	0.0	0.0	0.0	13.5	0.0	0.0
5	1.3	930.9	0.0	0.0	0.0	0.0	139.6	0.0	0.0
6	0.0	25.4	0.0	0.0	0.0	0.0	3.8	0.0	0.0
7	1.5	935.0	0.0	0.0	0.0	0.0	140.3	0.0	0.0
8	1.5	793.7	0.0	0.0	0.0	0.0	119.0	0.0	0.0
9	1.3	589.7	0.0	0.0	0.0	0.0	88.5	0.0	0.0
10	1.1	384.4	0.0	0.0	0.0	0.0	57.7	0.0	0.0
11	1.0	190.6	0.0	0.0	0.0	0.0	28.6	0.0	0.0
12	0.5	32.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0
		***Table	2 - Base	Stress	Data on t	he 12	Slices**	*	

Slice	Alpha	X-Coord.	Base	Available	Mobilized
No.	(deg)	Slice Cntr	Leng.	Shear Strength	Shear Stress

*		(ft)	(ft)	(psf)	(psf)
1	-6.34	21.62	1.00	156.96	5.65
2	-6.59	23.06	1.90	616.16	19.58
3	-6.59	24.05	0.10	918.27	29.18
4	30.47	24.15	0.12	3480.54	540.63
5	30.47	24.83	1.45	564.14	472.45
6	37.67	25.48	0.05	522.96	464.22
7	37.67	26.27	1.95	506.11	443.15
8	43.18	27.77	2.00	488.09	431.43
9	49.27	29.15	1.99	459.02	388.15
10	55.36	30.37	2.01	413.15	306.18
11	61.00	31.42	2.00	343.30	186.15
12	67.35	32.18	1.38	270.46	59.13

Sum of the Resisting Forces (including Pier/Pile, Tieback, Reinforcing Soil Nail, and Applied Forces if applicable) = 7373.14 (lbs)

Average Available Shear Strength (including Tieback, Pier/Pile, Reinforcing, Soil Nail, and Applied Forces if applicable) = 462.25(psf)

Sum of the Driving Forces = 4390.41 (lbs)

Average Mobilized Shear Stress = 275.25(psf)

Total length of the failure surface = 15.95(ft)

\*\*\*\* END OF GSTABL7 OUTPUT \*\*\*\*

# 01628-005; Powder Mtn.; Global Stability; 8' H Max;2H:1V; Static



X:\GSTABLE\01628005\B3.PL2 Run By: DAG 5/7/2013 3:56PM



*** GSTABL7 ***	
** GSTABL7 by Garry H. Gregory, P.E. **	User Specified Y-Origin = 40.00(ft) 1
<pre>** Original Version 1.0, January 1996; Current Version 2.002, December 2001 ** (All Rights Reserved-Unauthorized Use Prohibited)</pre>	ISOTROPIC SOIL PARAMETERS
	2 Type(s) of Soil
SLOPE STABILITY ANALYSIS SYSTEM Modified Bishop, Simplified Janbu, or GLE Method of Slices. (Includes Spencer & Morgenstern-Price Type Analysis) Including Pier/Pile, Reinforcement, Soil Nail, Tieback, Nonlinear Undrained Shear Strength, Curved Phi Envelope, Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water Surfaces, Pseudo-Static Earthquake, and Applied Force Options.	SoilTotalSaturatedCohesionFrictionPorePressurePiez.TypeUnit Wt. Unit Wt. InterceptAnglePressureConstant SurfaceNo.(pcf)(psf)(deg)Param.(psf)No.1120.0125.0150.030.00.000.002140.0140.00.045.00.000.00
***************************************	ANISOTROPIC STRENGTH PARAMETERS
Analysis Run Date:5/7/2013Time of Run:3:56PMRun By:DAGInput Data Filename:X:B3.Output Filename:X:B3.OUTUnit System:English	1 soil type(s) Soil Type 2 Is Anisotropic Number Of Direction Ranges Specified = 3
Plotted Output Filename: X:B3.PLT	Direction Counterclockwise Cohesion Friction Range Direction Limit Intercept Angle No. (deg) (psf) (deg)
PROBLEM DESCRIPTION: 01628-005; Powder Mtn.; Global Stability ; 8' H Max;2H:1V; Static	1-12.03000.000.002-5.00.0045.00390.03000.000.00
BOUNDARY COORDINATES 5 Top Boundaries 9 Total Boundaries	<ul> <li>ANISOTROPIC SOIL NOTES:</li> <li>(1) An input value of 0.01 for C and/or Phi will cause Aniso C and/or Phi to be ignored in that range.</li> <li>(2) An input value of 0.02 for Phi will set both Phi and C equal to zero, with no water weight in the tension crack.</li> <li>(3) An input value of 0.03 for Phi will set both Phi and C equal to zero, with water weight in the tension crack.</li> </ul>
Boundary X-Left Y-Left X-Right Y-Right Soil Type No. (ft) (ft) (ft) (ft) Below Bnd	1 BOUNDARY LOAD (S)
10.0050.0020.0050.001220.0050.0024.0058.002324.0058.0025.5058.002425.5058.0065.5078.001	1 Load(s) Specified
5         65.50         78.00         80.00         78.00         1           6         20.00         50.00         21.00         49.00         1           7         21.00         49.00         23.00         49.00         1           8         23.00         49.00         51.00         1	Load X-Left X-Right Intensity Deflection No. (ft) (ft) (psf) (deg)
9     24.00     51.00     25.50     58.00     1	1 66.00 80.00 250.0 0.0

NOTE - Intensity Is Specified As A Uniformly Distributed Force Acting On A Horizontally Projected Surface.		2 2 10 11	6 7 9 0 1	35.85 40.67 45.37 49.91 54.26 58.40	50.4 51.7 53.5 55.5 58.0 60.8	8 9 0 9 5 6				
A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.		12 13 14 15	2 3 4 5	62.29 65.91 69.24 72.24	64.0 67.4 71.1 75.1	0 5 9 8				
2500 Trial Surfaces Have Been Generated.		Circ	° le Center	At X =	22.31	; Y =	109.47;	and Radi	ius =	60.53
50 Surface(s) Initiate(s) From Each Of 50 Points Equally Spaced Along The Ground Surface Between $X = 10.00$ (ft) and $X = 20.00$ (ft)			Factor *** 1	of Safet 713 *	У Х					
Each Surface Terminates Between X = 50.00(ft) and X = 80.00(ft)			Individua	il data c	on the	22 sli	ces			
Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is $Y = 0.00(ft)$				Water	Water	Tie	Tie	Earthqu	ıake	
5.00(ft) Line Segments Define Each Trial Failure Surface.	Slice No.	Width (ft)	Weight (lbs)	Force Top (lbs)	Force Bot (lbs)	Force Norm (lbs)	Force Tan (lbs)	Ford Hor (lbs)	ve Suro Ver (lbs)	charge Load (lbs)
	1 2 3	4.9 4.0	215.5 413.1 253 9	0.0	0.0	0. 0.	0. 0. 0	0.0	0.0	0.0
Following Is Displayed The Most Critical Of The Trial Failure Surfaces Evaluated.	4 5 6	0.0 2.0 1.0	17.6 1405.3 1099.2	0.0 0.0 0.0	0.0 0.0 0.0	0. 0. 0.	0. 0. 0.	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
$\star$ $\star$ Safety Factors Are Calculated By The Modified Bishop Method $\star$ $\star$	7 8 9 10	1.5 0.5 5.0 4.9	1719.5 497.1 6067.3 7034.4	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0. 0. 0.	0. 0. 0.	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0
Total Number of Trial Surfaces Evaluated = 2500	11 12 13	4.8 4.7 4.5	7665.8 7956.1 7913.8	0.0 0.0 0.0	0.0 0.0 0.0	0. 0. 0.	0. 0. 0.	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
Statistical Data On All Valid FS Values: FS Max = 4.378 FS Min = 1.713 FS Ave = 2.207 Standard Deviation = 0.255 Coefficient of Variation = 11.53 %	14 15 16 17	4.4 4.1 3.9 3.2	7560.2 6929.5 6067.0 4491.4	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0. 0. 0.	0. 0. 0.	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0
Failure Surface Specified By 16 Coordinate Points	18 19 20	0.4 0.1 3.2	531.3 110.8 3351.3	0.0 0.0 0.0	0.0 0.0 0.0	0. 0. 0.	0. 0. 0.	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 808.8
Point X-Surf Y-Surf No. (ft) (ft)	21	1.8	299.9	0.0	0.0	0.	0.	0.0	0.0	443.6
1       11.02       50.00         2       15.97       49.27         3       20.96       48.96         4       25.96       49.05         5       30.93       49.56			* * * *	END OF	GSTABL7	OUTPUT *	* * *			

1

### 90 Total Saturated Cohesion Friction Piez. Load Value Horiz Eqk 0.150 g< Soil Soil Desc. Type Unit Wt. Unit Wt. Intercept Angle Surface (pcf) 125.0 (deg) 30.0 No. (pcf) (psf) No. Af 1 120.0 150.0 0 Rockery 2 140.0 140.0 Aniso Aniso 0 80 5 70 60 50 40 10 20 30 40 50 60 70 80 0 GSTABL7 v.2 FSmin=1.27

01628-005; Powder Mtn.; Global Stability; 8' H Max;2H:1V; P-Static X:\GSTABLE\01628005\B3P.PLT Run By: DAG 5/7/2013 3:57PM

Factor Of Safety Is Calculated By The Simplified Janbu Method



### \*\*\* GSTABL7 \*\*\*

* *	GSTABL7	by	Garry	Η.	Gregory,	Ρ.Ε.	* *
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\*\* Original Version 1.0, January 1996; Current Version 2.002, December 2001 \*\*

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SLOPE STABILITY ANALYSIS SYSTEM Modified Bishop, Simplified Janbu, or GLE Method of Slices. (Includes Spencer & Morgenstern-Price Type Analysis) Including Pier/Pile, Reinforcement, Soil Nail, Tieback, Nonlinear Undrained Shear Strength, Curved Phi Envelope, Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water Surfaces, Pseudo-Static Earthquake, and Applied Force Options.

### 

Analysis Run Date:	5/7/2013
Time of Run:	3:57PM
Run By:	DAG
Input Data Filename:	X:B3P.
Output Filename:	X:B3P.OUT
Unit System:	English

Plotted Output Filename: X:B3P.PLT

PROBLEM DESCRIPTION: 01628-005; Powder Mtn.; Global Stability
; 8' H Max;2H:1V; P-Static

### BOUNDARY COORDINATES

5 Top Boundaries 9 Total Boundaries

Boundary	X-Left	Y-Left	X-Right	Y-Right	Soil Type
No.	(ft)	(ft)	(ft)	(ft)	Below Bnd
1	0.00	50.00	20.00	50.00	1
2	20.00	50.00	24.00	58.00	2
3	24.00	58.00	25.50	58.00	2
4	25.50	58.00	65.50	78.00	1
5	65.50	78.00	80.00	78.00	1
6	20.00	50.00	21.00	49.00	1
7	21.00	49.00	23.00	49.00	1
8	23.00	49.00	24.00	51.00	1
9	24.00	51.00	25.50	58.00	1
		• .	40.004513		
user Speci:	riea i-Origi	ın =	40.UU(İt)		

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### ISOTROPIC SOIL PARAMETERS

2 Type(s) of Soil

Total	Saturated	Cohesion	Friction	Pore	Pressure	Piez.
Unit Wt.	Unit Wt.	Intercept	Angle	Pressure	Constant	Surface
(pcf)	(pcf)	(psf)	(deg)	Param.	(psf)	No.
120.0	125.0	150.0	30.0	0.00	0.0	0
140.0	140.0	0.0	45.0	0.00	0.0	0
	Total Unit Wt. (pcf) 120.0 140.0	Total Saturated Unit Wt. Unit Wt. (pcf) (pcf) 120.0 125.0 140.0 140.0	Total         Saturated         Cohesion           Unit         Wt.         Unit         Wt.           (pcf)         (pcf)         (psf)           120.0         125.0         150.0           140.0         140.0         0.0	Total         Saturated         Cohesion         Friction           Unit Wt.         Unit Wt.         Intercept         Angle           (pcf)         (pcf)         (psf)         (deg)           120.0         125.0         150.0         30.0           140.0         140.0         0.0         45.0	Total Saturated Cohesion FrictionPoreUnit Wt. Unit Wt. InterceptAnglePressure(pcf)(pcf)(psf)(deg)120.0125.0150.030.00.00140.00.045.00.00	TotalSaturatedCohesionFrictionPorePressureUnit Wt.Unit Wt.InterceptAnglePressureConstant(pcf)(pcf)(psf)(deg)Param.(psf)120.0125.0150.030.00.000.0140.0140.00.045.00.000.0

ANISOTROPIC STRENGTH PARAMETERS 1 soil type(s)

### Soil Type 2 Is Anisotropic

Number Of Direction Ranges Specified = 3

Direction Range No.	Counterclockwise Direction Limit (deg)	Cohesion Intercept (psf)	Friction Angle (deg)
1	-12.0	3000.00	0.00
2	-5.0	0.00	45.00
3	90.0	3000.00	0.00

ANISOTROPIC SOIL NOTES:

- (1) An input value of 0.01 for C and/or Phi will cause Aniso C and/or Phi to be ignored in that range.
- (2) An input value of 0.02 for Phi will set both Phi and C equal to zero, with no water weight in the tension crack.
- (3) An input value of 0.03 for Phi will set both Phi and C equal to zero, with water weight in the tension crack.

### BOUNDARY LOAD(S)

-1	- 1	/ \	~		~ ·	
	1020	$(\alpha)$	900	0.1	+ -	00
-	LUau	101	200		+ +	.eu
		· · /				

Load	X-Left	X-Right	Intensity	Deflection
No.	(ft)	(ft)	(psf)	(deg)
1	66.00	80.00	250.0	0.0

NOTE - Intensity Is Specified As A Uniformly Distributed Force Acting On A Horizontally Projected Surface.

SURCHARGE BOUNDARY LOAD DATA HAS BEEN SUPPRESSED

A Horizontal Earthquake Loading Coefficient Of0.150 Has Been Assigned A Vertical Earthquake Loading Coefficient Of0.000 Has Been Assigned

Cavitation Pressure = 0.0(psf)

Janbu's Empirical Coef. is being used for the case of  $\mbox{ c \& phi both } > 0$ 

Trial Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	11.02 $15.97$ $20.96$ $25.96$ $30.93$ $35.85$ $40.67$ $45.37$ $49.91$ $54.26$ $58.40$ $62.29$ $65.91$ $69.24$ $72.24$	50.00 49.27 48.96 49.05 49.56 50.48 51.79 53.50 55.59 58.05 60.86 64.00 67.45 71.19 75.18
16	74.01	78.00

Janbu's Empirical Coefficient (fo) = 1.061

\* \* Factor Of Safety Is Calculated By The Simplified Janbu Method \* \*

Factor Of Safety For The Preceding Specified Surface = 1.268

\*\*\*Table 1 - Individual Data on the 21 Slices\*\*\*

			Water Force	Water Force	Tie Force	Tie Force	Earthqu Forc	lake Ce Suro	charge
Slice	Width	Weight	Top	Bot	Norm	Tan	Hor	Ver	Load
No.	(ft)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)
1	4.9	216.8	0.0	0.0	0.0	0.0	32.5	0.0	0.0
2	4.0	413.6	0.0	0.0	0.0	0.0	62.0	0.0	0.0
3	1.0	254.6	0.0	0.0	0.0	0.0	38.2	0.0	0.0
4	0.0	16.8	0.0	0.0	0.0	0.0	2.5	0.0	0.0
5	2.0	1405.1	0.0	0.0	0.0	0.0	210.8	0.0	0.0
6	1.0	1099.3	0.0	0.0	0.0	0.0	164.9	0.0	0.0
7	1.5	1719.9	0.0	0.0	0.0	0.0	258.0	0.0	0.0
8	0.5	500.6	0.0	0.0	0.0	0.0	75.1	0.0	0.0
9	5.0	6063.9	0.0	0.0	0.0	0.0	909.6	0.0	0.0
10	4.9	7040.5	0.0	0.0	0.0	0.0	1056.1	0.0	0.0

11	4.8	7660.9	0.0	0.0	0.0	0.0	1149.1	0.0	0.0
12	4.7	7960.9	0.0	0.0	0.0	0.0	1194.1	0.0	0.0
13	4.5	7913.2	0.0	0.0	0.0	0.0	1187.0	0.0	0.0
14	4.4	7554.6	0.0	0.0	0.0	0.0	1133.2	0.0	0.0
15	4.1	6935.3	0.0	0.0	0.0	0.0	1040.3	0.0	0.0
16	3.9	6064.9	0.0	0.0	0.0	0.0	909.7	0.0	0.0
17	3.2	4494.5	0.0	0.0	0.0	0.0	674.2	0.0	0.0
18	0.4	528.7	0.0	0.0	0.0	0.0	79.3	0.0	0.0
19	3.3	3468.5	0.0	0.0	0.0	0.0	520.3	0.0	0.0
20	3.0	1733.4	0.0	0.0	0.0	0.0	260.0	0.0	0.0
21	1.8	299.5	0.0	0.0	0.0	0.0	44.9	0.0	0.0
		***Table 2	- Base	Stress	Data on the	21	Slices***		

Slice No. *	Alpha (deg)	X-Coord. Slice Cntr (ft)	Base Leng. (ft)	Available Shear Strength (psf)	Mobilized Shear Stress (psf)
1	-8.39	13.49	5.00	189.94	0.11
2	-3.55	17.99	4.04	215.75	9.00
3	-3.55	20.48	0.96	312.55	23.26
4	1.03	20.98	0.04	388.65	70.34
5	1.03	22.00	2.00	551.19	118.01
6	1.03	23.50	1.00	778.44	184.65
7	1.03	24.75	1.50	805.53	192.60
8	1.03	25.73	0.46	772.13	182.80
9	5.86	28.44	5.00	820.57	306.61
10	10.59	33.39	5.01	915.19	474.02
11	15.20	38.26	4.99	984.54	646.92
12	19.99	43.02	5.00	1029.68	817.87
13	24.72	47.64	5.00	1052.38	966.36
14	29.49	52.08	5.00	1053.08	1081.66
15	34.17	56.33	5.00	1031.45	1148.70
16	38.91	60.35	5.00	986.88	1161.25
17	43.62	63.90	4.43	923.27	1118.00
18	43.62	65.71	0.57	861.70	1029.61
19	48.32	67.57	5.01	747.60	881.82
20	53.06	70.74	4.99	501.20	513.91
21	57.89	73.12	3,33	270.03	156.80

Sum of the Resisting Forces (including Pier/Pile, Tieback, Reinforcing Soil Nail, and Applied Forces if applicable) = 56070.69 (lbs)

Average Available Shear Strength (including Tieback, Pier/Pile, Reinforcing, Soil Nail, and Applied Forces if applicable) = 764.64(psf)

Sum of the Driving Forces = 46914.41 (lbs)

Average Mobilized Shear Stress = 639.78(psf)

Total length of the failure surface = 73.33(ft)

\*\*\*\* END OF GSTABL7 OUTPUT \*\*\*\*

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