C/041/002 Incoming

#4584

Canyon Fuel Company, LLC
A Subsidiary of Arch Western Bituminous Group, LLC

Sufco Mine
Kenneth E. May
General Manager
597 South SR24
Salina, Utah 84654
(435) 286-4400
Fax (435) 286-4499

RECEIVED
APR 29 2014
DIV. OF OIL, GAS & MINING

April 28, 2014

Permit Supervisor, Utah Coal Regulatory Program
Utah Division of Oil, Gas and Mining
1594 West North Temple, Suite 1210
PO Box 145801
Salt Lake City, UT 84114-5801

Re: Soil Nail Slope Stabilization for Annex Building, Canyon Fuel Company, LLC, Sufco Mine, C/041/002

Dear Sirs:

Please find enclosed with this letter two copies of an amendment to address the proposed stabilization of a slope behind the permitted annex building. Drawings associated with the project are to be added to Appendix 5-11.

If you have questions or need addition information please contact Vicky Miller at (435)286-4481.

CANYON FUEL COMPANY, SUFCO Mine

Vicky A Miller for

John Byars
Technical Services Manager

Encl.

cc: DOGM Correspondence File

APPLICATION FOR COAL PERMIT PROCESSING

Permit Change ☒ New Permit ☐ Renewal ☐ Exploration ☐ Bond Release ☐ Transfer ☐

Permittee: Canyon Fuel Company, LLC
Mine: Sufco Mine **Permit Number:** C/041/0002
Title: Soil Nail Slope Stabilization for Annex Building
Description, Include reason for application and timing required to implement:

Instructions: If you answer yes to any of the first eight (gray) questions, this application may require Public Notice publication.

☐ Yes ☒ No 1. Change in the size of the Permit Area? Acres: _____ Disturbed Area: _____ ☐ increase ☐ decrease.
☐ Yes ☒ No 2. Is the application submitted as a result of a Division Order? DO# _____
☐ Yes ☒ No 3. Does the application include operations outside a previously identified Cumulative Hydrologic Impact Area?
☐ Yes ☒ No 4. Does the application include operations in hydrologic basins other than as currently approved?
☐ Yes ☒ No 5. Does the application result from cancellation, reduction or increase of insurance or reclamation bond?
☐ Yes ☒ No 6. Does the application require or include public notice publication?
☐ Yes ☒ No 7. Does the application require or include ownership, control, right-of-entry, or compliance information?
☐ Yes ☒ No 8. Is proposed activity within 100 feet of a public road or cemetery or 300 feet of an occupied dwelling?
☐ Yes ☒ No 9. Is the application submitted as a result of a Violation? NOV # _____
☐ Yes ☒ No 10. Is the application submitted as a result of other laws or regulations or policies?
Explain: _____
☐ Yes ☒ No 11. Does the application affect the surface landowner or change the post mining land use?
☐ Yes ☒ No 12. Does the application require or include underground design or mine sequence and timing? (Modification of R2P2)
☐ Yes ☒ No 13. Does the application require or include collection and reporting of any baseline information?
☐ Yes ☒ No 14. Could the application have any effect on wildlife or vegetation outside the current disturbed area?
☐ Yes ☒ No 15. Does the application require or include soil removal, storage or placement?
☐ Yes ☒ No 16. Does the application require or include vegetation monitoring, removal or revegetation activities?
☐ Yes ☒ No 17. Does the application require or include construction, modification, or removal of surface facilities?
☐ Yes ☒ No 18. Does the application require or include water monitoring, sediment or drainage control measures?
☐ Yes ☒ No 19. Does the application require or include certified designs, maps or calculation?
☐ Yes ☒ No 20. Does the application require or include subsidence control or monitoring?
☐ Yes ☒ No 21. Have reclamation costs for bonding been provided?
☐ Yes ☒ No 22. Does the application involve a perennial stream, a stream buffer zone or discharges to a stream?
☐ Yes ☒ No 23. Does the application affect permits issued by other agencies or permits issued to other entities?

Please attach four (4) review copies of the application. If the mine is on or adjacent to Forest Service land please submit five (5) copies, thank you. (These numbers include a copy for the Price Field Office)

I hereby certify that I am a responsible official of the applicant and that the information contained in this application is true and correct to the best of my information and belief in all respects with the laws of Utah in reference to commitments, undertakings, and obligations, herein.

John D. Byars
Print Name

Sign Name, Position, Date, Mgr. Tech Servs. 4-28-14

Subscribed and sworn to before me this 28 day of April, 2014

Notary Public

My commission Expires: 3/24, 2015

Attest: State of _____ } ss:
County of _____

JACQUELYN NEBEKER
Notary Public
State Of Utah
My Commission Expires 3/24/2015
Commission# 606049

For Office Use Only:	Assigned Tracking Number:	Received by Oil, Gas & Mining
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Form DOGM- C1 (Revised March 12, 2002)

APPLICATION FOR COAL PERMIT PROCESSING
Detailed Schedule Of Changes to the Mining And Reclamation Plan

Permittee: Canyon Fuel Company, LLC
Mine: Sufco Mine **Permit Number:** C/041/002
Title: Soil Nail Slope Stabilization for Annex Building

Provide a detailed listing of all changes to the Mining and Reclamation Plan, which is required as a result of this proposed permit application. Individually list all maps and drawings that are added, replaced, or removed from the plan. Include changes to the table of contents, section of the plan, or other information as needed to specifically locate, identify and revise the existing Mining and Reclamation Plan. Include page, section and drawing number as part of the description.

			DESCRIPTION OF MAP, TEXT, OR MATERIAL TO BE CHANGED
☐ Add	☐ Replace	☐ Remove	M&RP
☐ Add	☒ Replace	☐ Remove	Chapter 2, Pages 2-20 and 2-21
☐ Add	☒ Replace	☐ Remove	Chapter 5, Page 5-68A
☐ Add	☒ Replace	☐ Remove	Appendix 5-9 - Bond
☒ Add	☐ Replace	☐ Remove	Appendix 5-11, add Annex Building Soil Nail Wall Exhibit Drawing & Engineering Design
☐ Add	☐ Replace	☐ Remove	Waste Rock Disposal Site
☐ Add	☒ Replace	☐ Remove	Pages WRDS 3-4 and 3-5
☐ Add	☐ Replace	☐ Remove	
☐ Add	☐ Replace	☐ Remove	
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☐ Add	☐ Replace	☐ Remove	

Any other specific or special instruction required for insertion of this proposal into the Mining and Reclamation Plan.

April 2014

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VOLUME 3

WASTE ROCK DISPOSAL SITE

Based on analyses of material that has been placed in the waste rock disposal site to date, no acid forming problems are anticipated. There is a potential for borderline toxicity problems from boron. Samples of the waste material will be collected for every 10,000 tons deposited at the waste rock site and will be analyzed for acid or toxic forming potential. All identified potential acid or toxic forming materials will be buried or otherwise treated.

Copies of laboratory reports on toxicity/acid-base accountability from representative waste samples are included in Volume 8 of the M&RP prior to 2005 and starting in 2005 will be included in the annual report.

3.1.6 Subsoil Stockpile

Excess subsoil material and a small amount of topsoil from the minesite is stockpiled at the Waste Rock Disposal Site for possible use during final reclamation of SUFCO minesite facilities. The location of the subsoil and topsoil material is shown on Map 2. Total acreage of the subsoil stockpile and associated topsoil piles 1A and 1B is 1.19 acres. Approximately 11,~~260~~341 cubic yards of subsoil material and approximately 8.2 cubic yards of minesite topsoil material are stockpiled at the site. The associated original topsoil pile 1B and new topsoil piles 2 and 3 removed from the subsoil stockpile area contains about 756.4 cubic yards. The top 24 inches of soil material was removed from the subsoil stockpile area as described in Section 3.1.2, Site Preparation. This topsoil was stored along the westerly boundary and east of the subsoil stockpile as shown on Map 2. Topsoil handling procedures complied with those described in Section 3.2.3, Topsoil Handling. These topsoil stockpiles will be stored and seeded using the grasses and forbes of the standard seed mix, Table 4.6.1-1. When the subsoil and minesite topsoil are removed the topsoil will be redistributed and the area reclaimed and seeded in accordance with sections 4.5 and 4.6.

Subsoil material was placed in 2-3 ft. lifts using dump trucks and a D-7 Cat dozer. Exterior slopes of the subsoil stockpile are approximately 1v:1.25h. At this slope the material will be stable as placed. The subsoil stockpile was seeded using the grasses and forbes of the standard seed mix, Table 4.6.1-1. This subsoil may be taken to the minesite and used for fill material during final reclamation of the minesite.

Run off from the subsoil and associated topsoil stockpiles is collected and routed through a silt fence treatment located as shown on Map 2. The total acreage of the five stockpiles is 1.24 acres. Alternate sediment control measures are in place as described above. This area is classified as an approved Alternate Sediment Control Area (ASCA).

Topsoil and Subsoil Storage Piles at Waste Rock Disposal Site

TOPSOIL			
Description	Volume (cy)[(a)]	Area (acres)	Distribution Location
1A	8.2	1.19*	Mine Site
1B	456.9	0*	Waste Rock
2	161.4	0.03	Waste Rock
3	138	0.02	Waste Rock
Sediment Pond	634.9	0.293	Waste Rock
Lift # 4 Area**	1847	0.34	Waste Rock
TOTAL	3246.2	NA	NA
SUBSOIL			
Subsoil	11,260	0*	Mine Site
Soil Nail Wall	81	0*	Mine Site

(a) Estimated Quantity

* The acreages for Piles 1A,1B and Subsoil are combined

** Topsoil stored in piles on top of Lift #4, estimated depth of stored topsoil - 3.5 feet

3.2 Components of Operation

3.2.1 Sedimentation Pond

A sedimentation pond was constructed down gradient from the rock fill area to control sediment removed from the disturbed areas by surface runoff. The pond was constructed prior to disturbing any other areas of the site. It will remain in place until the waste rock disposal area has been completely reclaimed.

CHAPTER 2

SOILS

runoff and erosion. This soil will not be moved or disturbed until it is required for redistribution during final reclamation. A figure of the surveyed topsoil stockpile and estimated quantity of soil stored in the pile is included in Appendix 2-2. Plate 5-2B shows the as-built features associated with the overflow pond.

Topsoil from the Link Canyon Substation No. 1 will be placed and stored on the outslope of the pad. This storage area will be protected with berms and/or silt fences, a three-strand barbwire fence, and revegetated to control erosion. This soil will not be moved or disturbed until it is required for redistribution during final reclamation.

Soil from the Link Canyon Substation No. 2 will be placed in a soil stock pile located at the south end of the pad area. The storage area will be protected with berms and/or silt fences, a three strand barbwire fence, and revegetated to control erosion. This soil will not be moved or disturbed until it is required for redistribution during final reclamation.

Soil from the Link Canyon Mine Portal area will be placed in a topsoil pile located south of the disturbed portal pad area out of the floodplain (Plate 5-2F). The storage area will be protected by installing a topsoil storage sign at the base of the pile, berms and/or silt fences, a three strand barbwire fence, and protected from wind and water erosion by surface pitting the stockpile to retain moisture and reduce erosion and by being revegetated with a quick growing vegetative cover (standard seed mix in section 3.4.1.2 minus the shrubs and trees) to control erosion. This soil will not be moved or disturbed until it is required for redistribution during final reclamation. The surface of the topsoil pile will be pitted to reduce runoff and erosion. Vegetation removed during site construction, such as sage brush and other woody plants, will be placed on top of the pile.

Excess subsoil associated with construction of a run of mine coal stockpile and the West Lease portal tunnel development is stored at SUFCO Mine's waste rock disposal site. At the mine site the substation binwall has approximately 2,160 cubic yards of subsoil material and 5,300 cubic yards of road base, with the additional ~~11,260~~ 11,341 cubic yards of subsoil material (Soil Nail Wall/West Lease/run of mine stockpile) being stored at the waste rock site there is a total of 18,801~~720~~ cubic yards (approximate) that will be available for use as subsoil material during final reclamation of the mine site facilities. Reference Appendix 2-3 for the analyses of the subsoil being stored at the waste rock site to be used during reclamation of the mine site.

Approximately 81 cyds of subsoil was removed during the stabilization construction of a soil nail wall located behind the Warehouse Annex Building.

Immediately adjacent to the subsoil pile at the waste rock site is stored 756.3 cubic yards of topsoil collected from beneath the footprint of the subsoil pile. This total represents the removal of approximately 12" of topsoil prior to placement of the subsoil. Section 3.1.6 of Volume 3 of this M&RP contains more information pertaining to the soils stored at the waste rock disposal site.

2.3.2 Topsoil and Subsoil Removal

2.3.2.1 Topsoil Removal and Segregation

All topsoil thicker than 6 inches will be removed as a separate layer from the subsoil, segregated, and stockpiled separately. Topsoil less than 6 inches thick will be removed according to Section 2.3.2.3. However, in the areas of the Link Canyon Substation Nos. 1 and 2 pads, all soil will be removed and stored in one area as a single soil resource. At substation pad No. 1, the maximum projected volume of topsoil salvage based on the soil survey depth of 20 inches and the projected topsoil salvage area of 0.08 acres is 224 cubic yards. The salvaged topsoil will be removed as a separate layer, segregated and placed on the south end of the pad outslope. The remaining excavated material in the deeper cuts will be used as fill material for the access road and the north end of the substation pad. At substation No. 2, the volume of soil projected to be removed is 118 CY.

2.3.2.2 Poor Topsoil

Topsoil that is of an insufficient quantity, or of poor quality (for sustaining vegetation) will be removed as a separate layer and segregated. Such operations will be done with approval of the UDOGM, and in compliance with R645-301-233.100 (Section 2.3.3.1).

2.3.2.3 Thin Topsoil

Topsoil to be removed that is less than 6 inches thick will be removed with the immediately underlying unconsolidated materials (up to a total of 6 inches). This material mixture will be treated as topsoil and stockpiled together without any horizon segregation.

CHAPTER 5

ENGINEERING

A soil nail wall will be constructed to stabilize the slope directly behind the Annex building. The technique uses grouted tension-resisting steel elements drilled into an exposed soil face and grouted into place. Design details and drawings associated with the soil nail wall (shotcrete) and soil nails is located in Appendix 5-11. Sheet 1.2 illustrates the location of the wall and soil nails. As noted on Sheet 1.2 the exact length of the wall will need to be field-fit, thus on the illustration the location of soil nails extends beyond the end of the wall. Sheet No. 1.4 illustrates the soil material to be removed to facilitate the instillation of the wall and facilitate the insertion of the soil nails.

The soil nails will remain in the slope and covered with soil during reclamation, the shotcrete wall will be broken up and buried during reclamation. Bonding for the removal of the shotcrete wall has be provided in Appendix 5-9. The reclamation contours of the slope are shown on Plate 5-3B.

Building and Utility Demolition. Prior to significant regrading activities at the East Spring Canyon facility, existing buildings, walls, utilities, coal-handling facilities, and other above-ground structures will be removed from the area. To the extent possible, these structures and facilities will be salvaged. Those materials requiring off-site disposal will be placed in a licensed landfill. Final decisions regarding salvage or disposal of structures and equipment will be made just prior to reclamation following an assessment of the salvageability of the structures and equipment. If foundations and buried utilities will not interfere with regrading activities, they will be left in place for on-site burial. The water and sewer lines were installed and buried prior to Aug. 3, 1977 under a Special Use Permit with the Forest Service and will be left in place upon completion of mining activities.

Southern Slope Regrading. The present slope at the southern end of the mine yard will be cut from its existing continuous slope of approximately 1.4H:1V to a slope of 2.5H:1V in the center of the slope. The regraded slope will taper along the east and west sides of the slope to blend with the natural slopes. The recontoured slope will have 10-foot wide benches on 80-foot vertical centers to collect slope runoff and minimize the potential for erosion.

Proposed post-reclamation contours of the East Spring Canyon site are presented in Plate 5-3A&B. Analyses presented in Appendix 2-4 indicate that the fill under this configuration will have a minimum static safety factor against failure of 1.51.

APPENDIX 5-9

Reclamation Bond Estimate

Bonding Calculations

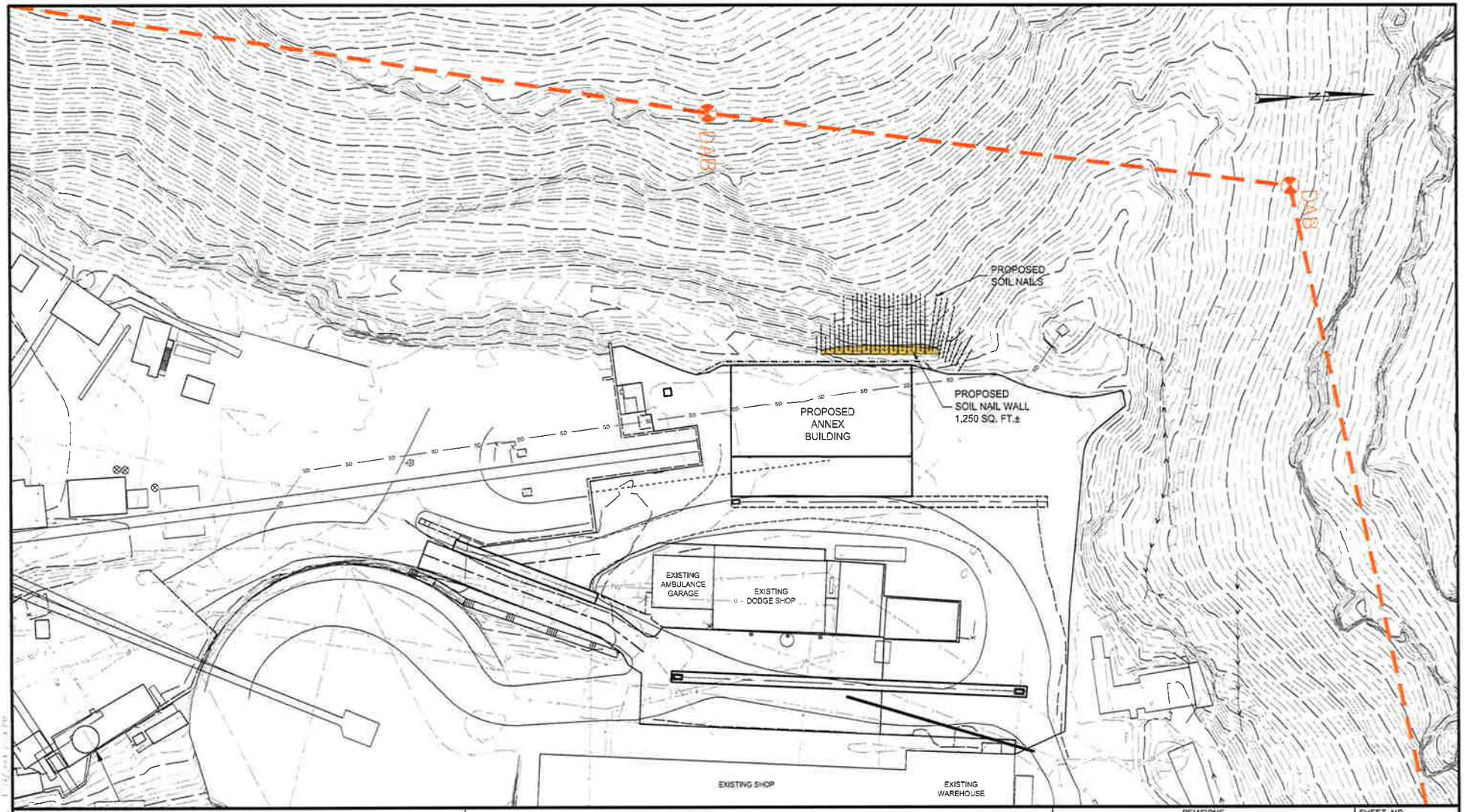
Direct Costs		
Subtotal Demolition and Removal	$1,233,662.50	
Subtotal Backfilling and Grading	$548,005.00	
Subtotal Revegetation	$171,967.00	
Direct Costs	$1,953,634.50	
Indirect Costs		
Mob/Demob	$195,363.00	10.0%
Contingency	$97,682.00	5.0%
Engineering Redesign	$48,841.00	2.5%
Main Office Expense	$132,847.00	6.8%
Project Mainagement Fee	$48,841.00	2.5%
Subtotal Indirect Costs	$523,574.00	26.8%
Total Cost	$2,477,208.50	
Escalation factor		0.019
Number of years		5
Escalation	$244,449.00	
Reclamation Cost Escalated	$2,721,657.50	
Bond Amount (rounded to nearest $1,000)	$2,722,000.00	
2016 Dollars		
Posted Bond	$2,874,000.00	
Difference Between Cost Estimate and Bond	$152,000.00	
Percent Difference	5.29%	

Ref.	Description	Materials	Means Reference Number	Unit Cost	Unit	Length	Width	Height	Diameter	Area	Volume	Weight	Density	Time	Number	Unit	Swell Factor	Quantity	Unit	Cost
	Ambulance Garage																			$2,504.00
	Belt Deicer Tank																			$13.00
	Blast Channels A																			$143,211.00
	Blast Channels B																			$53,488.00
	Bulk and Used Oil Storage																			$1,518.00
	Cap Magazine																			$22.00
	Chlorinator Bld																			$18.00
	Covered Storage*																			$0.00
	Diesel Tank																			$995.00
	Drainage Culvets																			$25,423.00
	Electrical Bld																			$602.00
	Fan																			$8,435.50
	Fire Water Tank 300000 Gal																			$11,126.00
	Fuel Dock																			$928.00
	Guard House																			$349.00
	Loadout Belt																			$2,593.00
	Lower Stacker Coal Storage																			$2,149.00
	Lump Coal Belt																			$533.00
	Lump Coal Storage																			$2,139.00
	No 1 Belt																			$3,404.00
	Office Building																			$67,377.00
	Pavement Removal																			$35,857.50
	Powder Magazine																			$22.00
	Pulley Racks *																			$0.00
	Pump Houses																			$972.00
	Riprap Filter Fabric																			$259,568.00
	Rock Dust Bin																			$3,557.00
	ROM Coal Storage																			$21,139.00
	ROM MCC Bld																			$1,022.00
	Sampler Building																			$991.00
	Sand and Salt Storage																			$2,905.00
	Seal Portals																			$62,400.00
	Sediment Trap																			$1,533.00
	Septic Tanks																			$0.00
	Shelves *																			$0.00
	Shop and Warehouse																			$121,933.00
	Shop Garage																			$11,941.00
	Shop Office																			$2,322.00
	Side Release Tank																			$161.00
	Steam Cleaner Building																			$7,747.00
	Stoker Belt																			$1,104.00
	Stoker Bin																			$6,755.00
	Stoker Coal Storage																			$3,127.00
	Stoker Oil Tanks																			$1,539.00
	Storage Trailers																			$1,256.00
	Substation Lower*																			$79,848.00
	Substation Upper*																			$0.00
	Ticket Printers																			$69.00
	Tipple Building																			$36,194.00
	Tipple MCC Buidling																			$2,759.00
	Tipple Office Building																			$3,161.00
	Transfer Building																			$10,303.00
	Trash Pit																			$542.00
	Truck Loader Bin																			$1,895.00
	Truck Scale																			$36,352.00
	Water Tank Upper																			$0.00
	Water Tank Lower																			$0.00
	West Lease Tunnels & Belt																			$83,424.00
	Yard Hoist																			$945.50
	Northwater Mitigation																			$4,117.00
	Link Canyon Facilities																			
	Link Canyon Portals																			$8,042.00
	Link Canyon Substation																			$39,150.00
	Fourth East Facilities																			
	Fan Generator Building																			$2,591.00
	Four East Fan																			$18,066.00
	Mine 1 Pad																			$10,807.00
	Annex Building																			$20,718.00
	Total																			$1,233,662.50

Ref.	Description	Materials	Means Reference Number	Unit Cost	Unit	Length	Width	Height	Diameter	Area	Volume	Weight	Density	Time	Number	Unit	Swell Factor	Quantity	Unit	Cost
	Annex Building																			
	Structure's Demolition Cost	Steel removal	02220 110 0012	0.31	/CF						11263					CF		11263	CF	3492
	Structure's Vol. Demolished																0.2	83	CY	
	Rubble's Weight (exclude steel)																			
	Truck's Capacity																			
	Haulage																			
	Transportation Cost Non Steel Truck																			
	Transportation Cost Non Steel Drive																			
	Disposal Cost Non Steel																			
	Steel's Weight																			
	Truck's Capacity										16					CY		5	Trips	
	Haulage														3	Trip/Day				
	Transportation Cost Steel Truck	Truck dump 16 ton payload	01590 200 5300	718.44	/day													1.7	DAY	
	Transportation Cost Steel Truck Drive	Truck Driver, Heavy	Trhv	50.55	HR													13.6	HR	
	Disposal Cost Steel																			
	Subtotal																			3492
	Equipment 's Disposal Cost																			
	Dismantling Cost																			
	Equipment 's Vol. Demolished																			
	Loading Costs																			
	Transport Costs																			
	Disposal Costs																			
	Subtotal																			
	Concrete Demolition																			
	Demolition Cost	Concrete demolition	ConcreteDemo1	11.38	/CY						563					CY		563	CY	6407
	Concrete's Vol. Demolished																1.3	732	CY	
	Loading Cost	Front end loader 3 CY	02315 424 1300	1.06	/CY													732	CY	776
	Transportation Cost	12 CY (16 Ton) Dump Truck 1/2 mi. rnd. trip	02315 490 0320	2.9	/CY													732	CY	2123
	Disposal Costs	On site disposal	02220 240 5550	9.15	/CY													732	CY	6698
	Subtotal																			16004
	Soil Nail Wall																			
	Concrete Demolition																			
	Demolition Cost	Concrete demolition	ConcreteDemo1	11.38	/CY						42.5					CY		43	CY	489
	Concrete's Vol. Demolished																1.3	56	CY	
	Loading Cost	Front end loader 3 CY	02315 424 1300	1.06	/CY													56	CY	59
	Transportation Cost	12 CY (16 Ton) Dump Truck 1/2 mi. rnd. trip	02315 490 0320	2.9	/CY													56	CY	162
	Disposal Costs	On site disposal	02220 240 5550	9.15	/CY													56	CY	512
	Subtotal																			1222
	Concrete Demolition																			
	Demolition Cost																			
	Concrete's Vol. Demolished																			
	Loading Cost																			
	Transportation Cost																			
	Disposal Costs																			
	Subtotal																			
	Total																			20718

APPENDIX 5-11

Upper Mine Yard Details



Canyon Fuel Company, LLC
SUFCO Mine
597 South SR 24 - Salina, UT 84654
(435) 286-4880 Phone
(435) 286-4499 Fax

ANNEX BUILDING

SOIL NAIL WALL EXHIBIT

SCALE: 1" = 50'	DATE: 4/24/2014	DRAWN BY: T.R.B.	ENGINEER:	CHECKED BY:
FILE NAME: M:\PROJ\0112-001\dwg\SOIL_NAIL_WALL.dwg				PROJ: 0112-001

REVISIONS

NO.	DATE	REQ. BY	DWG. BY	REMARKS

SHEET NO.

APPENDIX
5-11

PROJECT LOCATION MAP

ADVANCED SHORING+UNDERPINNING

DESIGN PACKAGE
PERMANENT SOIL NAIL WALL
SUFCO MINE ANNEX BUILDING
CONVULSION CANYON
EMERY COUNTY, UTAH

TABLE OF CONTENTS

1. SHOP DRAWINGS
   - SHEET 1.1 - COVER SHEET
   - SHEET 1.2 - PLAN VIEW
   - SHEET 1.3 - ELEVATION VIEW
   - SHEET 1.4 - TYPICAL SECTION VIEW
   - SHEET 1.5 - SOIL NAIL WALL DETAILS
   - SHEET 1.6 - GENERAL NOTES
   - SHEET 1.7 - TESTING DETAILS

2. DESIGN CALCULATION PACKAGE
   - 2.1 DESIGN CRITERIA
   - 2.2 ENGINEERING ANALYSIS
   - 2.3 DESIGN CALCULATIONS

PROFESSIONAL ENGINEER No. 6370734 DAVID A. GLASS 04/17/14 ELECTRONIC SEAL STATE OF UTAH

PREPARED BY:
DAVID A. GLASS, P.E.

REVIEWED BY:
BRADLEY M. JOHNSON, P.E.

PLOT DATE: APR 17, 2014

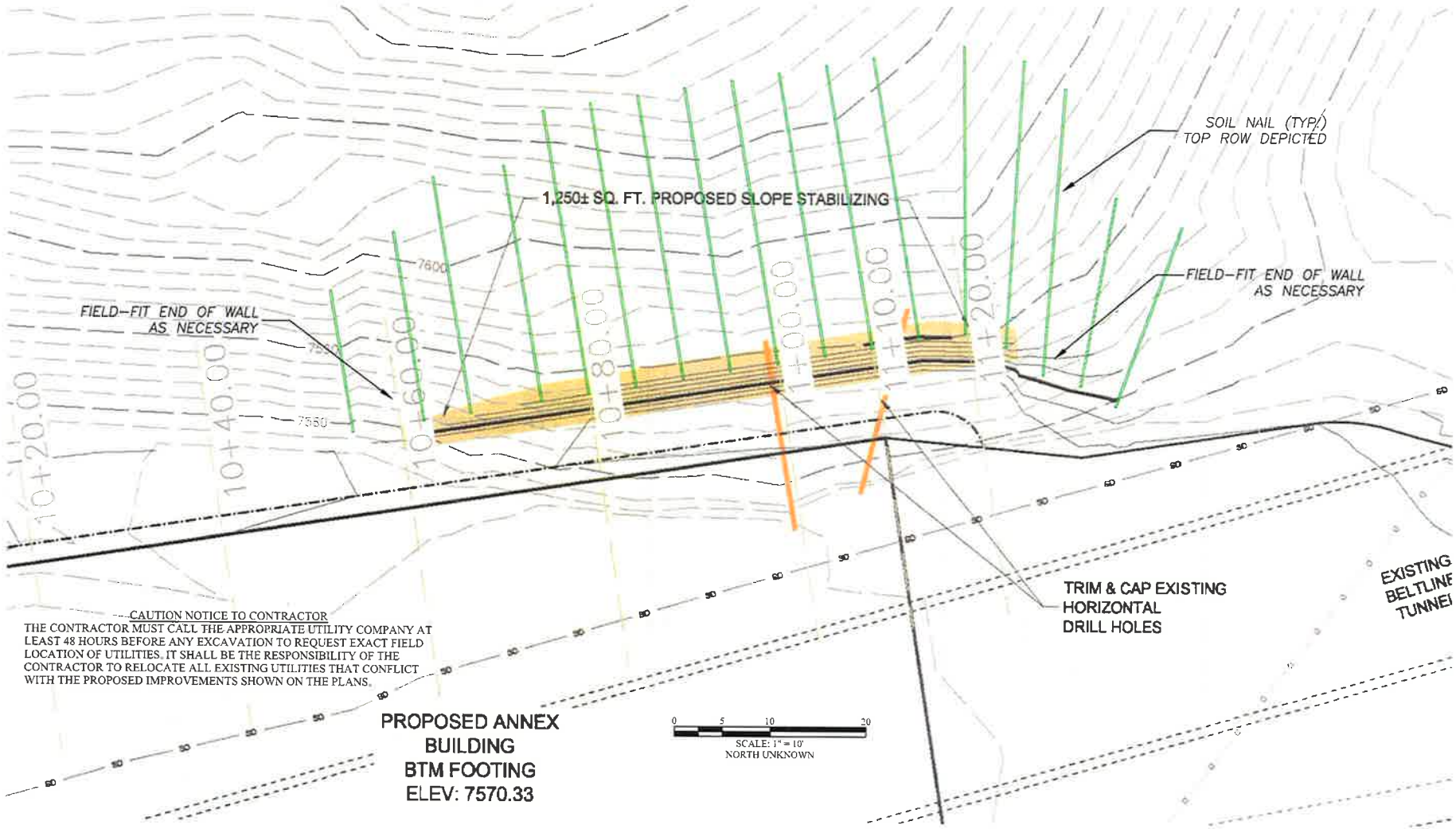
MARK		DATE	BY	CHK

REVISIONS

IGES®
12429 SOUTH 300 EAST, STE. 100
DRAPER, UTAH 84020
(801) 748-4044 FAX: (801) 748-4045

PERMANENT SOIL NAIL WALL DESIGN
SUFCO MINE ANNEX BUILDING
EMERY COUNTY, UTAH
COVER SHEET

DESIGNED BY:	DAG	APR 16, 2014	PLOT SCALE 1=1
DRAWN BY:	DAG	APR 16, 2014	
CHECKED BY:	BMJ	APR 17, 2014	DWG SCALE NTS
APPROVED BY:	DAG	APR 17, 2014	
IGES PROJECT NO. 01108-010	SHEET NO. 1.1		REV. n/a



CAUTION NOTICE TO CONTRACTOR

THE CONTRACTOR MUST CALL THE APPROPRIATE UTILITY COMPANY AT LEAST 48 HOURS BEFORE ANY EXCAVATION TO REQUEST EXACT FIELD LOCATION OF UTILITIES. IT SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR TO RELOCATE ALL EXISTING UTILITIES THAT CONFLICT WITH THE PROPOSED IMPROVEMENTS SHOWN ON THE PLANS.

BASEMAP: SHEET TITLED "SUFCO MINE ANNEX BUILDING SLOPE STABILIZATION PLAN", SHEET 1, DATED FEBRUARY 2 2014, PREPARED BY CANYON FUEL COMPANY

PERMANENT SOIL NAIL WALL LAYOUT - SUFCO MINE ANNEX BUILDING

APPROXIMATE GRAPHICAL SCALE: 1 INCH = 10 FEET (11X17 ONLY)

PLOT DATE: APR 17, 2014

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PERMANENT SOIL NAIL WALL DESIGN
SUFCO MINE ANNEX BUILDING
EMERY, UTAH

PLAN VIEW

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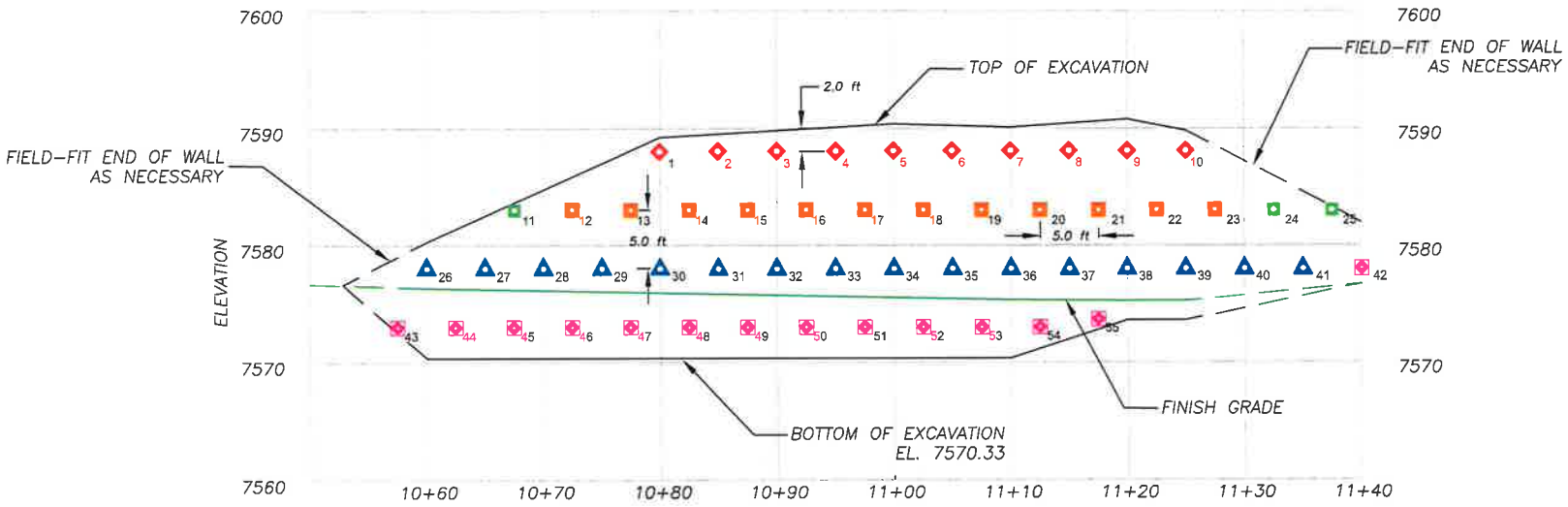
APPROVED BY:	DAG	APR 17, 2014	1"=10'
IGES PROJECT NO. 01108-010	SHEET NO. 1.2		REV. n/a



PERMANENT SOIL NAIL WALL ELEVATION VIEW

SCALE : 1" = 10'

LEGEND:

SYMBOL	NAIL LENGTH	QUANTITY
◇	29	10
□	24	12
□	19	3
△	14	16
◇	9	14

NOTES:

1. R38N OR AN ENGINEER-APPROVED EQUIVALENT, SOIL NAIL WITH LENGTH (MEASURED FROM FACE OF WALL)
2. FOR ALL SOIL NAILS, 4 IN. MIN. GROUTED DIAMETER (NOMINAL)

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PERMANENT SOIL NAIL WALL DESIGN
SUFCO MINE ANNEX BUILDING
EMERY COUNTY, UTAH
ELEVATION VIEW

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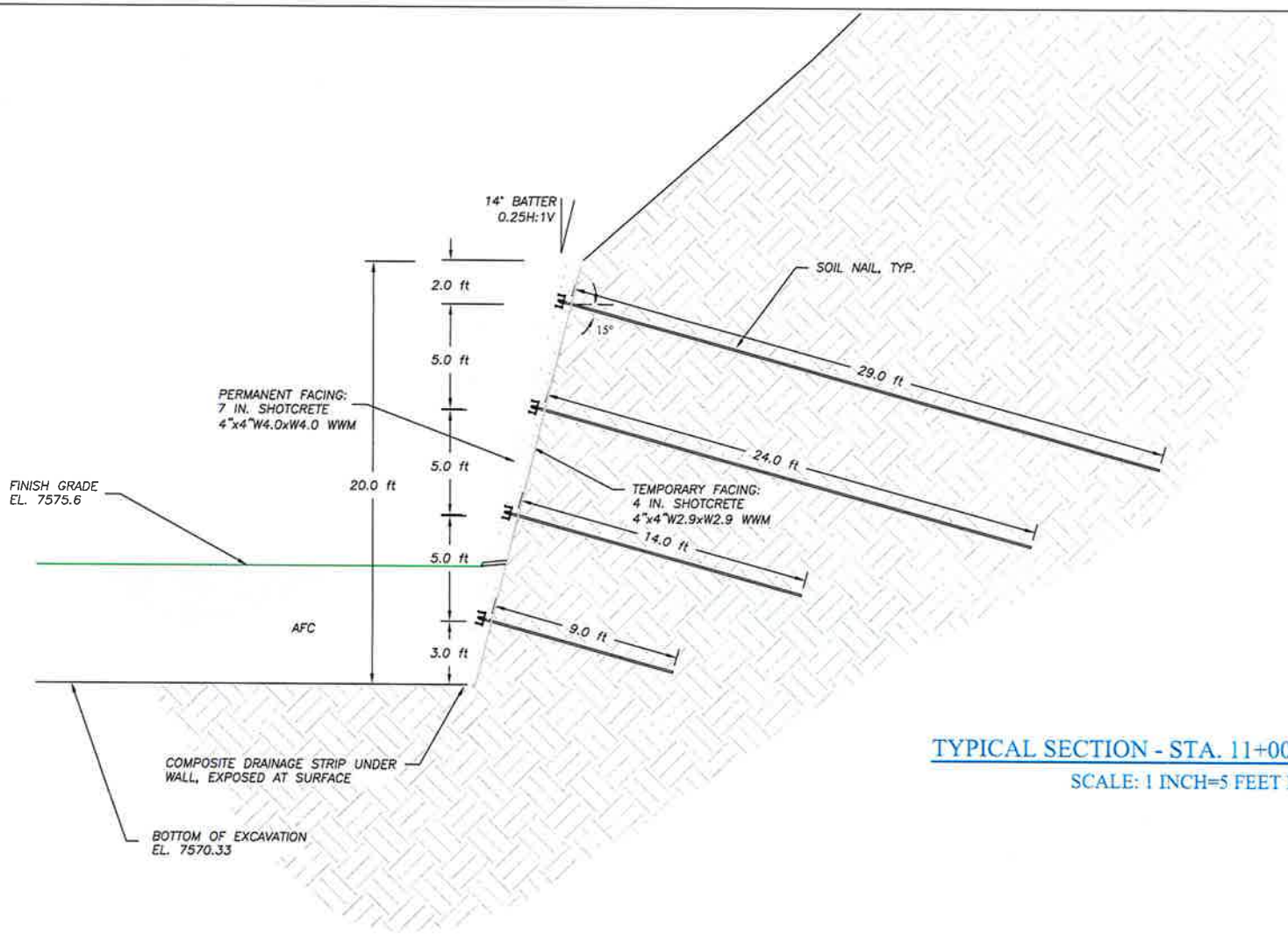
APPROVED BY:	DAG	APR 17, 2014	
IGES PROJECT NO. 01108-010	SHEET NO. 1.3		REV. n/a



TYPICAL SECTION - STA. 11+00 ILLUSTRATED

SCALE: 1 INCH=5 FEET H&V

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PERMANENT SOIL NAIL WALL DESIGN
SUFCO MINE ANNEX BUILDING
EMERY COUNTY, UTAH

SECTION VIEW

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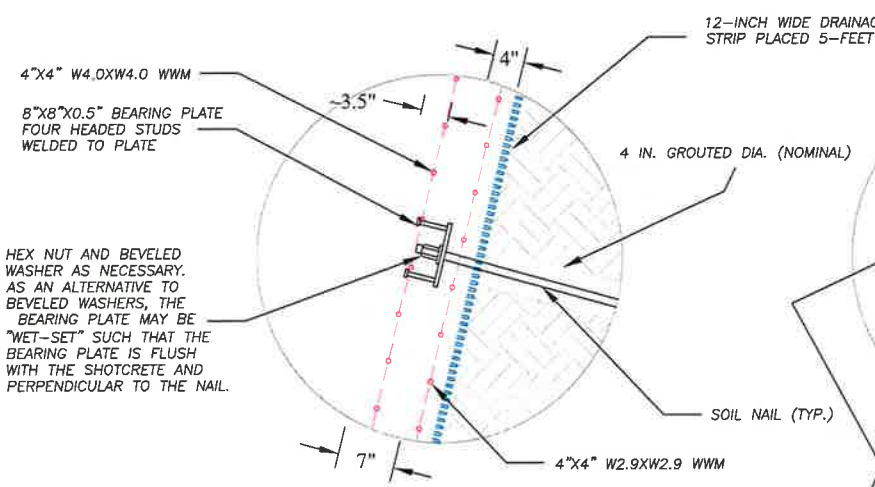
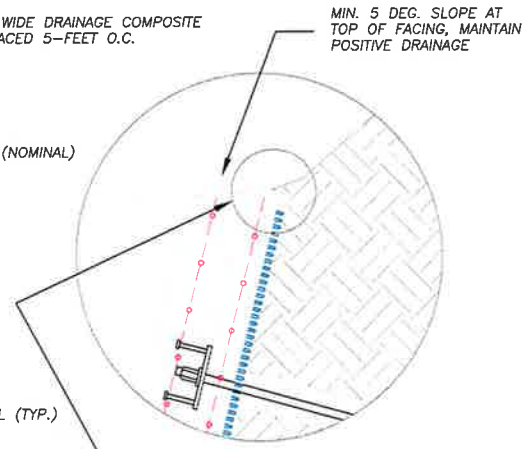
IGES PROJECT NO. 01108-010	SHEET NO. 1.4		REV. n/a



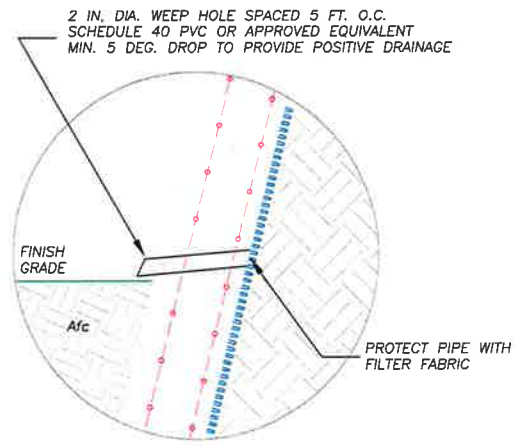
SHOTCRETE FACING TYPICAL DETAIL

SCALE 1:15



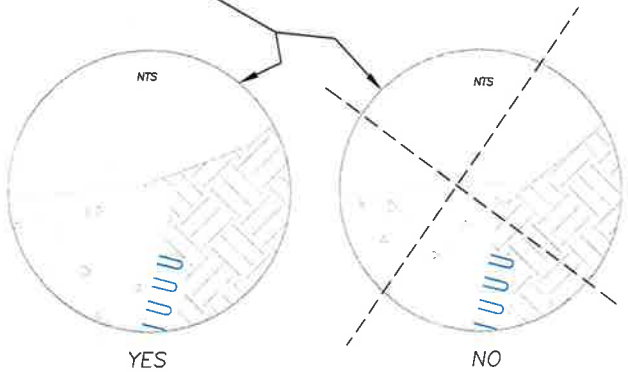
SHOTCRETE FACING TOP DETAIL

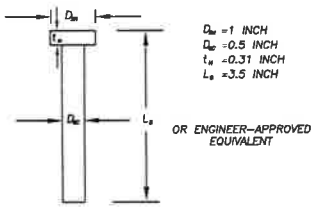
SCALE 1:15



SHOTCRETE FACING WEEPHOLE DETAIL

SCALE 1:15





HEADED STUD DETAIL

NTS

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PERMANENT SOIL NAIL WALL DESIGN
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EMERY COUNTY, UTAH

SOIL NAIL WALL DETAILS

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APPROVED BY:	DAG	APR 17, 2014	
IGES PROJECT NO. 01108-010	SHEET NO. 1.5		REV. n/a

1.0 GENERAL

1.1 SOIL NAILS TO BE INSTALLED AT THE LOCATIONS INDICATED IN THESE DRAWINGS SUBJECT TO FIELD VERIFICATION BY CONTRACTOR. ANY CHANGE WILL REQUIRE THE WRITTEN APPROVAL OF IGES. ENDS OF WALL WILL REQUIRE FIELD-FIT IN COORDINATION WITH OWNER'S REPRESENTATIVE. *INDIVIDUAL* SOIL NAILS MAY BE MOVED UP TO 12 INCHES IN ANY DIRECTION BY SHORING CONTRACTOR; GREATER CHANGES MUST HAVE PRIOR WRITTEN APPROVAL BY IGES.

1.2 ALL UTILITIES MUST BE VERIFIED BY CONTRACTOR PRIOR TO EXCAVATION OR INSTALLATION OF SOIL ANCHORS. IGES SHALL BE NOTIFIED IMMEDIATELY IF THE SOIL ANCHORS CONFLICT WITH UTILITY LOCATIONS.

1.3 THESE DOCUMENTS ARE INSTRUMENTS OF SERVICE AND SHALL REMAIN THE INTELLECTUAL PROPERTY OF IGES, INC. NO USE OR RE-USE OF THESE DOCUMENTS SHALL BE PERMITTED IN PART OR IN TOTAL UNLESS EXPRESSLY AUTHORIZED IN WRITING BY IGES, INC.

2.0 EXCAVATION

2.1 EXCAVATION IS TO BE PERFORMED AT THE APPROPRIATE LINES AND GRADES INDICATED IN THESE DRAWINGS SUBJECT TO FIELD VERIFICATION BY THE CONTRACTOR. ANY CHANGE WILL REQUIRE THE WRITTEN APPROVAL OF IGES.

2.2 ANY UN-REINFORCED EXCAVATIONS AT THE SITE MUST COMPLY WITH OSHA STANDARDS FOR TEMPORARY EXCAVATIONS.

2.3 INSTALL TEMPORARY ACCESS RESTRICTION, NOTICE, AND/OR WARNING BEHIND TOP OF EXCAVATION OR OTHER OSHA-APPROVED FALL PROTECTION.

2.4 INSTALL TEMPORARY HANDRAIL ALONG THE TOP OF THE EXCAVATION TO PREVENT FALL INJURIES. HANDRAIL SHALL COMPLY WITH OSHA REQUIREMENTS.

2.5 EXCAVATION SHALL BE PERFORMED TO PROVIDE A WORK AREA FOR THE INSTALLATION OF A ROW OF SOIL ANCHORS AND SHALL NOT EXTEND LOWER THAN 4 FEET BELOW THE LOWEST ANCHOR LOCATION WITHIN THE ROW.

2.6 EXCAVATION MAY BE EXTENDED ONLY AFTER THE SOIL ANCHORS HAVE BEEN TESTED AND LOCKED-OFF (SEE NOTE 4.5).

2.7 THESE DOCUMENTS DO NOT ADDRESS ROCKFALL HAZARDS. IF ROCKFALL HAZARDS ARE IDENTIFIED ABOVE THE EXCAVATION, APPROPRIATE ROCKFALL PROTECTION MEASURES SHALL BE IMPLEMENTED TO PROTECT WORKERS. SCALE ALL POTENTIALLY HAZARDOUS ROCKS OBSERVED ABOVE THE CUT.

3.0 SOIL NAIL WALL MATERIALS

3.1 SOIL ANCHORS

3.1.1 SOIL NAIL TENDONS SHALL BE R38N, NO. 10 ALL-THREAD, OR AN ENGINEER-APPROVED EQUIVALENT.

3.1.2 ALL BARS SHALL BE STRAIGHT AND UNDAMAGED.

3.1.3 SOIL NAIL LENGTHS SHALL BE ACCORDING TO THESE PLANS AND INSTALLED AT THE ANGLES NOTED ON THESE PLANS.

3.1.4 SOIL NAIL TENDONS MAY BE INJECTION BORED OR INSTALLED IN AN OPEN HOLE WITH PVC CENTRALIZERS SPACED NO MORE THAN 8 FT O.C. BEGINNING NO MORE THAN 2 FEET FROM THE END OF THE TENDON. CENTRALIZERS SHALL BE SCHEDULE 40 PVC AND 1/2 INCH SMALLER IN OUTSIDE DIAMETER THAN THE DIAMETER OF THE BORE HOLE ALLOWING FREE GROUT FLOW.

3.1.5 BORE HOLE DIAMETER SHALL BE 4 INCHES MINIMUM FOR INJECTION BORED ANCHORS.

3.1.6 SOIL NAIL GROUT SHALL HAVE A MINIMUM 28-DAY COMPRESSIVE STRENGTH OF 3,000 PSI AND A 3-DAY COMPRESSIVE STRENGTH OF 1,500 PSI. MAINTAIN A WATER-CEMENT RATIO BETWEEN 0.45 AND 0.55. GROUT MAY BE A NEAT CEMENT, OR CEMENT DEVELOPED USING A FINE AGGREGATE.

3.2 SOIL NAIL HARDWARE

3.2.1 ALL BEARING PLATE STEEL SHALL BE 8"X8"X0.5" A36 MILD STEEL OR BETTER. BEARING PLATES SHALL HAVE FOUR HEADED STUDS WELDED WITH $\frac{1}{4}$ IN. FILLET WELD AROUND THE CIRCUMFERENCE OF THE HEADED STUD SHAFT; HEADED STUD SIZING IS PRESENTED ON SHEET 1.5.

3.2.2 SUPPLY BEVELED WASHERS AS REQUIRED TO SQUARELY ATTACH NUTS. ALTERNATIVELY, THE BEARING PLATES MAY BE WET-SET AGAINST THE SHOTCRETE SUCH THAT THE PLATE IS PERPENDICULAR TO THE NAIL.

3.2.3 ALL NUTS AND WASHERS SHALL CONFORM TO SOIL NAIL TENDON MANUFACTURER'S SPECIFICATIONS.

3.3 WELDED WIRE MESH

3.3.1 REINFORCEMENT LAYERS SHALL CONSIST OF 4"X4" W2.9XW2.9 (TEMPORARY FACING) AND 4"X4" W4.0XW4.0 (PERMANENT FACING) WELDED WIRE MESH (WWM). ALL WWM SHALL CONFORM TO ASTM A185. ALTERNATIVE WWM SIZING MAY BE ALLOWED, SUBJECT TO APPROVAL BY IGES.

3.3.2 MESH SHALL BE SPLICED WITH WIRE TIES AT 3-FOOT INTERVALS MINIMUM WITH AN OVERLAP OF AT LEAST 12 INCHES.

3.4 SHOTCRETE

3.4.1 SHOTCRETE THICKNESS SHALL BE 4 INCHES MINIMUM (TEMPORARY FACING) AND 7 INCHES MINIMUM (PERMANENT FACING).

3.4.2 SHOTCRETE SHALL HAVE A 28-DAY COMPRESSIVE STRENGTH OF 4,000 PSI. WITH A 3-DAY COMPRESSIVE STRENGTH OF 2,000 PSI. THE WATER-CEMENT RATIO SHOULD BE ABOUT 0.4.

3.4.3 SHOTCRETE SHALL CONFORM TO ACI 506.2-95.

4.0 SOIL ANCHOR CONSTRUCTION

4.1 EXCAVATE SUFFICIENTLY TO ALLOW ACCESS FOR DRILLING EQUIPMENT USED DURING INSTALLATION.

4.2 INSTALL SOIL ANCHORS USING INJECTION BORE OR OPEN-HOLE.

4.3 INSTALL NAIL TO REQUIRED LENGTH AND CONTINUE GROUTING UNTIL A GOOD GROUT RETURN IS OBSERVED.

4.4 ALLOW 3 DAYS OR DEVELOPMENT OF 50% OF THE 28-DAY GROUT COMPRESSIVE STRENGTH (AASHTO T106) BEFORE TESTING AND LOCK OFF.

4.5 LOCK-OFF: HAND-TIGHTEN NUT UNTIL CONTACT IS MADE WITH THE BEVELED WASHER; NEXT, USE A WRENCH TO TIGHTEN NUT AN ADDITIONAL 1 TO 2 TURNS UNTIL THE BEARING PLATE HAS ACHIEVED INTIMATE, FIRM CONTACT WITH THE BEARING SURFACE.

5.0 MONITORING

5.1 DAILY INSPECTION OF SOIL NAIL WALL SHALL BE PERFORMED BY A QUALIFIED PERSON PRIOR TO ENTRY INTO EXCAVATION TO COMPLY WITH OSHA REGULATIONS. ADDITIONAL MONITORING AND/OR SURVEY MAY BE REQUIRED AS A PART OF THE PROJECT SPECIFICATIONS AND SHOULD BE FOLLOWED WHERE APPLICABLE.

6.0 TESTING

6.1 ONE SACRIFICIAL VERIFICATION TEST SHOULD BE PERFORMED BY IGES TO 200 PERCENT OF THE DESIGN LOAD. THE MAXIMUM BONDED NAIL LENGTH SHOULD BE 10 FEET TO ENSURE THE MAXIMUM BAR YIELD STRENGTH IS NOT EXCEEDED AND TO ALLOW THE GROUT/SOIL BOND TO FAIL. VERIFICATION TEST LOAD SHALL BE DETERMINED BASED ON THE BONDED LENGTH AND THE ASSUMED DESIGN SOIL-GROUT ADHESION (SEE SHEET 1.7). ADDITIONAL VERIFICATION TESTS MAY BE REQUIRED IF SUBSURFACE CONDITIONS VARY GREATLY, WHICH MAY NOT BE EVIDENT UNTIL CONSTRUCTION.

6.2 PROOF TESTS SHOULD BE PERFORMED ON 5 PERCENT OF PRODUCTION SOIL NAILS IN EACH ROW TO 130 PERCENT OF THE DESIGN LOAD (MINIMUM OF ONE TEST PER ROW).

6.3 DESIGN LOAD SHALL BE DETERMINED BASED ON THE BONDED LENGTH AND THE VALUES PRESENTED ON SHEET 1.7.

6.4 MAXIMUM TEST LOAD SHALL NOT EXCEED 90 PERCENT OF THE SOIL NAIL TENDON YIELD LOAD (81 KIPS FOR AN R38N BAR). THE MAXIMUM TEST LOAD MAY BE BELOW 130 PERCENT DL FOR LONGER SOIL NAILS.

6.5 SOIL NAILS TO BE TESTED SHALL HAVE A 1 FOOT MINIMUM TEMPORARY UNBONDED LENGTH.

7.0 CONSTRUCTION CONSIDERATIONS

7.1 BEDROCK MAY BE ENCOUNTERED DURING EXCAVATION AND/OR DRILLING. IF BEDROCK IS ENCOUNTERED DURING EXCAVATION, IGES SHOULD BE CONTACTED TO ASSESS COMPATIBILITY WITH THE DESIGN PRESENTED HEREIN. IF BEDROCK IS ENCOUNTERED DURING DRILLING, THE SOIL NAIL LENGTH SHALL BE THE DESIGN LENGTH OR THE LENGTH REQUIRED TO PENETRATE 8 FEET INTO BEDROCK, WHICHEVER IS LESS.

7.2 IF SOILS THAT ARE PARTICULARLY SUSCEPTIBLE TO FROST HEAVE (E.G., CLAY SOILS) ARE EXPOSED ON THE CUT FACE, OR IF WATER IS ENCOUNTERED ON THE CUT FACE (E.G., A SPRING), THE OWNER SHOULD CONSIDER INCORPORATING INSULATION INTO THE WALL IN ORDER TO MINIMIZE THE POTENTIAL FOR DAMAGING FROST HEAVE.

7.3 SHRINKAGE CRACKS IN SOIL NAIL WALLS IS NORMAL, AND ARE LARGELY A COSMETIC ISSUE ONLY; IF THE OWNER WOULD LIKE TO MINIMIZE THE APPEARANCE OF SHRINKAGE CRACKS, THE OWNER SHOULD CONSIDER THE ADDITION OF FIBER REINFORCEMENT OR OTHER SPECIALTY ADDITIVES TO THE SHOTCRETE MIX. ADDITIONALLY, VERTICAL CONTROL JOINTS SPACED 10-FEET O.C. CAN MINIMIZE THE VISUAL IMPACT OF SHRINKAGE CRACKS.

7.4 IF FREE WATER (SPRINGS, GROUNDWATER) OR VERY MOIST CONDITIONS ARE IDENTIFIED DURING EXCAVATION, CONSTRUCTION SHALL CEASE AND IGES SHOULD BE CONTACTED TO ASSESS THE IMPACT OF WATER TO THE DESIGN.

PLOT DATE: APR 17, 2014

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PERMANENT SOIL NAIL WALL DESIGN
SUFCO MINE ANNEX BUILDING
EMERY COUNTY, UTAH

GENERAL NOTES

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APPROVED BY:	DAG	APR 17, 2014	n/a
IGES PROJECT NO. 01108-010	SHEET NO. 1.6		REV. n/a

PROOF TEST SCHEDULE

LOAD	HOLD TIME (MIN. 5 MINUTES)
AL (0.05 DL MAXIMUM)	UNTIL STABLE
0.25 DL*	UNTIL STABLE
0.50 DL	UNTIL STABLE
0.75 DL	UNTIL STABLE
1.00 DL	UNTIL STABLE
1.25 DL	UNTIL STABLE
1.30 DL CREEP TEST **	SEE BELOW

*DESIGN LOAD (DL) = 2.4 KIP/FT

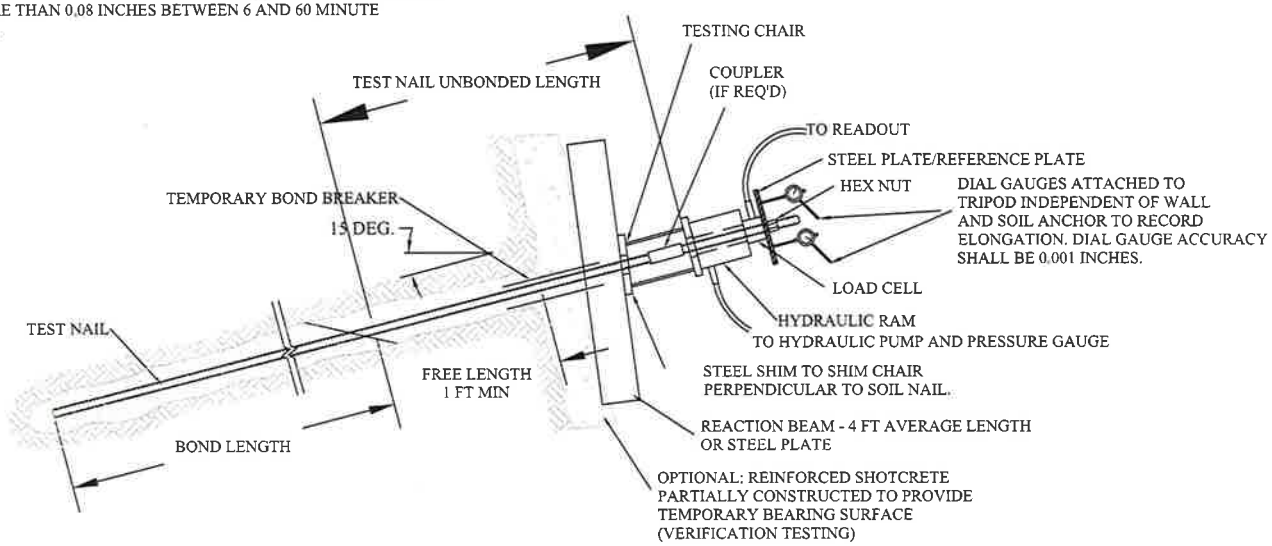
**CREEP TEST. 10 MIN. HOLD. NAIL MOVEMENTS SHALL BE MEASURED AND RECORDED AT THE FOLLOWING TIMES AFTER APPLICATION OF THE FULL CREEP TEST LOAD: 1 MINUTE, 2, 3, 4, 5, 6 AND 10 MINUTES. IF THE NAIL MOVES MORE THAN 0.04 INCHES DURING THE 10 MINUTES HOLD, MAINTAIN LOAD FOR AN ADDITIONAL 50 MINUTES AND MOVEMENTS SHALL BE RECORDED AT 20, 30, 50 AND 60 MINUTES. THE LOAD DURING ALL LOAD INCREMENTS SHALL BE MAINTAINED WITHIN 5 PERCENT OF THE INTENDED LOAD. THE NAIL SHOULD NOT MOVE MORE THAN 0.08 INCHES BETWEEN 6 AND 60 MINUTE READINGS.

VERIFICATION TEST SCHEDULE

LOAD	HOLD TIME
AL (0.05 DL MAXIMUM)	UNTIL STABLE
0.25 DL*	UNTIL STABLE
0.50 DL	10 MIN.**
0.75 DL	10 MIN.**
1.00 DL	10 MIN.**
1.25 DL	10 MIN.**
1.50 DL	10 MIN.**
1.75 DL	10 MIN.**
2.00 DL	10 MIN.**
>2.00DL	PULL TO FAILURE***

*DESIGN LOAD (DL) = 2.4 KIP/FT

***DO NOT EXCEED 90% OF YIELD STRESS (46 KIPS FOR R32N)



SOIL NAIL TESTING
NOT TO SCALE

PLOT DATE: APR 17, 2014

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PERMANENT SOIL NAIL WALL DESIGN
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EMERY COUNTY, UTAH
SOIL NAIL TESTING DETAILS

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CHECKED BY:	BMJ	APR 17, 2014	DWG SCALE
APPROVED BY:	DAG	APR 17, 2014	n/a
IGES PROJECT NO. 01108-010	SHEET NO. 1.7		REV. n/a

April 17, 2014

Design Calculation Package
SUFCO Mine Annex Building
Emery County, Utah
Permanent Soil Nail Wall

ADVANCED
SHORING+UNDERPINNING

IGES®

Intermountain GeoEnvironmental Services, Inc.
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PROFESSIONAL ENGINEER
No. 6370734
DAVID A. GLASS
04-17-14
ELECTRONIC SEAL
STATE OF UTAH

Prepared by

David A. Glass, P.E.

Reviewed by

Bradley M. Johnson, P.E.

Table of Contents

2.1 Design Criteria
2.2 Engineering Analysis
2.3 Design Calculations

011108-010 D1

2.1 Design Criteria

Project Description

Our understanding of the project is based on the plan set titled "SUFCO Mine Annex Building Slope Stabilization" Sheets 1 and 2, dated February 18, 2014, and other information provided by Advanced Shoring and Underpinning. The project is located at the SUFCO Mine located in Convulsion Canyon, Emery County, Utah. We understand that a new metal storage building will be constructed at the mine facility; as a part of the construction, a part of the natural slope behind the new building must be cut back, necessitating the construction of a permanent soil nail wall wall. The new wall will be about 15 feet tall (finished height) and will shore about 1,250 square feet; the proposed excavation layout is conceptually illustrated on Sheet 1.2.

Design Parameters

For our assessment of native site soils, IGES has reviewed soil data presented in the geotechnical report by RB&G (2011) completed for a different area several hundred feet away from the project site. The referenced geotechnical report by RB&G includes two borings that indicate the site is underlain by upwards of 20 to 30 feet of undocumented fill, which in turn overlies sandstone bedrock. There is no subsurface data for the area to be excavated for the new wall. In addition to the referenced geotechnical report, IGES was provided several photos of the slope; the photos provided poor data as there was substantial amounts of snow on the ground, but the photos did suggest that the slope was covered with relatively coarse, boulder colluvium. IGES also reviewed a geologic map for the area (Doelling, 2004); the map indicated that the mine area consists largely of exposures of sandstone (Blackhawk Formation), with lesser amounts of shale located near the floor of the canyon surrounding the coal mine. The existing slope is currently varies from about 40 to 45 degrees (about 1H:1V).

Considering the available geotechnical data, the following engineering parameters have been selected for our model:

Table 1
Parameters for Subsurface Model

Soil Type	Elevation	Friction angle (deg.)	Cohesion (psf)	Ultimate soil/grout bond (psi)	Unit Weight (pcf)
Colluvium	n/a	42	0	32	125

The ground anchors were designed assuming *ultimate* effective grout/soil bond strengths of 32 psi; this value is based on assumed subsurface soil types (coarse, boulder colluvium), correlations with published data by FHWA, and our engineering judgment. A factor-of-safety of 2.0 was applied to the ultimate soil-grout bond for design. Anchors are assumed to have a nominal grouted diameter of 4 inches.

Groundwater is not known to occur on the slope; as such, our analysis does not consider the presence of groundwater or underground springs. If groundwater is identified during construction, construction must cease and IGES must be notified so that the impact to the design can be properly assessed.

For the seismic (pseudo-static) assessment of the proposed wall, a seismic coefficient K_h was taken as ½ of the peak ground acceleration (PGA) resulting from an earthquake having a 2 percent probability of exceedance in 50 years (2PE50). Since the site is located in the mountains and is mapped largely as Cretaceous sandstone, the site is assumed to be best represented as Site Class B (rock); hence, no near-source ground amplification factor was used. The ground motion was assessed using the *DesignMaps* online application available at the USGS website. Based on information provided by the *DesignMaps* application, the PGA at the site, for a 2PE50 event, is estimated to be 0.252g. Based on this result, the seismic coefficient K_h was taken as 0.126g. A summary of the *DesignMaps* output is presented in Section 2.3.

2.2 Engineering Analysis

Based on the information provided and the design parameters discussed in the previous paragraphs, a representative section was analyzed using the computer software SnailWin to determine nail pattern and length; the section analyzed is Station 11+00, illustrated on Sheets 1.2, 1.3, and 1.4.

The permanent wall has been designed assuming a 0.25H:1V cut (about 14 degrees batter). A minimum static factor-of-safety of 1.50 (permanent) and 1.20 (temporary) (internal/external SnailWin) was considered acceptable for this project based on the available information and design assumptions. For seismic conditions, a minimum factor-of-safety of 1.1 was adopted. The results of the SnailWin analyses are included in Section 2.3.

The shotcrete facing was designed in general accordance with the recommendations contained in Lazarte et al., 2003. A summary of the shotcrete facing design is included in Section 2.3.

The global stability of the retained slope was modeled using GSTABL7 slope stability software, a computer application incorporating (among others) Bishop's Simplified Method of analysis and Spencer's method. Calculations for stability were developed by searching for the minimum factor-of-safety for a circular-type failure (Bishop) and a wedge-type block failure (Spencer). A minimum static factor-of-safety of 1.50 (global) for permanent conditions and 1.2 for temporary conditions was considered acceptable for this project considering the available information and design assumptions. Homogeneous earth materials (existing site soils) and arcuate failure surfaces were assumed. For our analysis, we evaluated two of the most critical sections (Section A-A', Section F-F'). Based on our analysis, the global stability of the currently proposed soil nail wall configuration meets the minimum design factor-of-safety of 1.20. The results of the global stability analyses are included in Section 2.3.

References

Byrne, R.J., Cotton, D., Porterfield, J., Wolschlag, C., Ueblacker, G., 1998, *Manual for Design and Construction Monitoring of Soil Nail Walls*, Federal Highway Administration Report No. FHWA-SA-96-069R, prepared by Golder Associates Inc. (A420-C3), dated November 1996, Revised October 1998.

Doelling, H.H., 2004, Interim Geologic Map of the Salina 30' X 60' Quadrangle, Emery, Sevier, and Wayne Counties, Utah, UGS Open-Fine Report 438, dated October 2004.

Lazarte, C.A., Elias, V., Espinoza, R.D., Sabatini, P.J., 2003, *Geotechnical Engineering Circular No. 7: Soil Nail Walls*, Federal Highway Administration Report No. FHWA0-IF-03-017, dated March 2003.

RB&G, 2011, Geotechnical Study, Canyon Fuel SufCo Mine Conveyor, Salina Canyon, Utah, Project No. 201101-026, dated June 2011.

2.3 Design Calculations

SnailWin Soil Nail Wall Design Calculations

Shotcrete Facing Design Calculations

GSTABL7 Global Stability Calculations

DesignMaps Summary – Assessment of Seismic Coefficient

PROJECT TITLE: Advanced/SUFCO; Sta. 11+00 20H Temp Static

Date: 04-15-2014

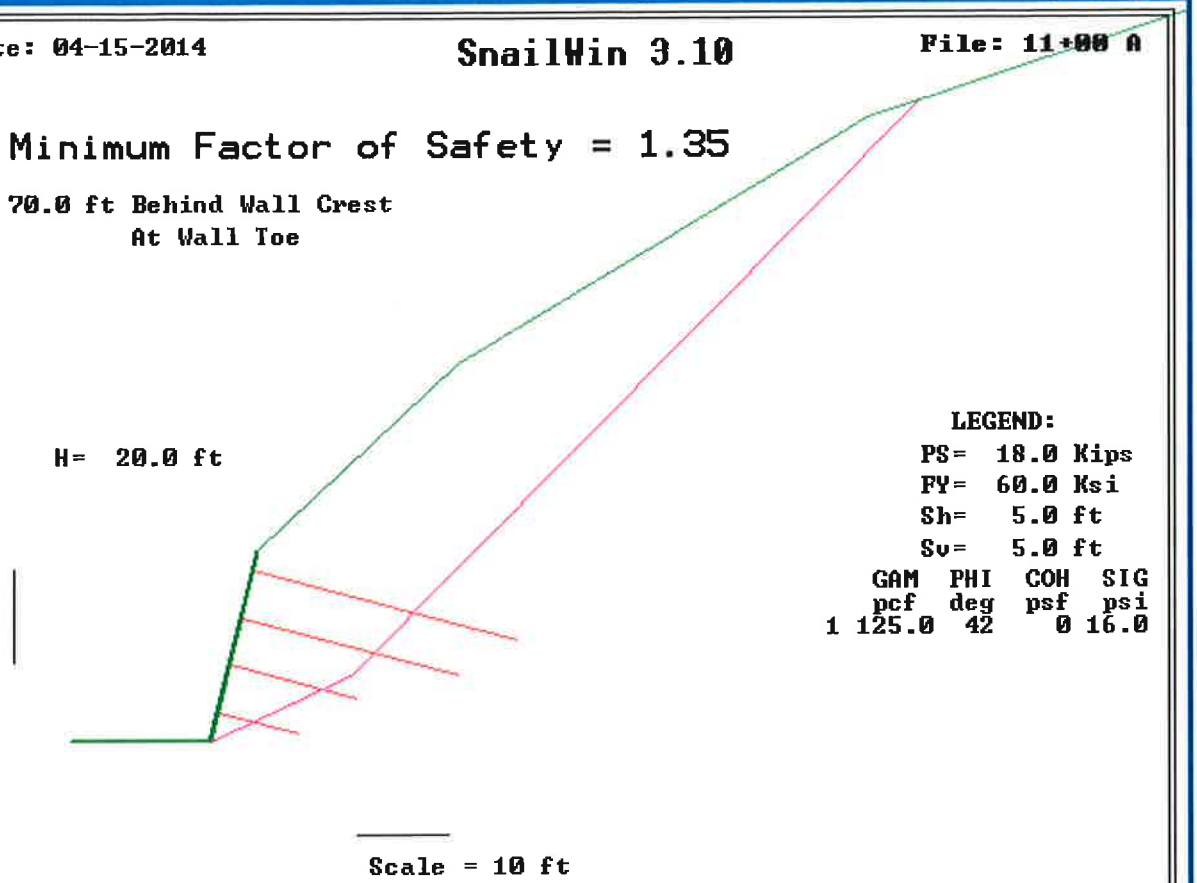
SnailWin 3.10

File: 11+00 A

Minimum Factor of Safety = 1.35

70.0 ft Behind Wall Crest
At Wall Toe

H= 20.0 ft



LEGEND:

PS= 18.0 Kips
FY= 60.0 Ksi
Sh= 5.0 ft
Sv= 5.0 ft

	GAM pcf	PHI deg	COH psf	SIG psi
1	125.0	42	0	16.0

Scale = 10 ft

```
*****************************************************
*    CALIFORNIA DEPARTMENT OF TRANSPORTATION        *
*          ENGINEERING SERVICE CENTER               *
*     DIVISION OF MATERIALS AND FOUNDATIONS         *
*   Office of Roadway Geotechnical Engineering      *
*    Date: 04-15-2014          Time: 14:19:37       *
*****************************************************
```

Project Identification - Advanced/SUPCO; Sta. 11+00 20H Temp Static

--------- WALL GEOMETRY ---------

Vertical Wall Height	=	20.0 ft	
Wall Batter	=	14.0 degree	
		Angle (Deg)	Length (Feet)
First Slope from Wallcrest.	=	43.0	29.0
Second Slope from 1st slope.	=	31.0	19.3
Third Slope from 2nd slope.	=	31.3	31.3
Fourth Slope from 3rd slope.	=	18.0	40.0
Fifth Slope from 3rd slope.	=	0.0	0.0
Sixth Slope from 3rd slope.	=	0.0	0.0
Seventh Slope Angle.	=	0.0	

--------- SLOPE BELOW THE WALL ---------

There is NO SLOPE BELOW THE TOE of the wall

--------- SURCHARGE ---------

There is NO SURCHARGE imposed on the system.

--------- OPTION #1 ---------

Factored Punching shear, Bond & Yield Stress are used.

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	125.0	42.0	0.0	16.0	0.0	0.0	0.0	0.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 50.0 to 100.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels	=	4
Horizontal Spacing	=	5.0 ft
Yield Stress of Reinforcement	=	60.0 ksi
Diameter of Grouted Hole	=	4.0 in
Punching Shear	=	18.0 kips

---------- (Varying Reinforcement Parameters) ---------

Level	Length (ft)	Inclination (degrees)	Vertical Spacing (ft)	Bar Diameter (in)	Bond Stress Factor
1	29.0	15.0	2.0	1.22	1.00
2	24.0	15.0	5.0	1.22	1.00
3	14.0	15.0	5.0	1.22	1.00
4	9.0	15.0	5.0	1.22	1.00

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
Toe	1.415	55.0	19.1	17.5	53.2	64.3

Reinf. Stress at Level 1 = 22.117 Ksi (Pullout controls...)
2 = 16.237 Ksi (Pullout controls...)
3 = 3.479 Ksi (Pullout controls...)
4 = 9.044 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 2	1.399	60.0	26.6	13.4	48.5	72.4

Reinf. Stress at Level 1 = 28.559 Ksi (Pullout controls...)
2 = 23.735 Ksi (Pullout controls...)
3 = 9.466 Ksi (Pullout controls...)
4 = 11.289 Ksi (Pullout controls...)

MINIMUM DISTANCE LOWER FAILURE UPPER FAILURE

11+00 A

```
          SAFETY      BEHIND          PLANE           PLANE
          FACTOR     WALL TOE     ANGLE  LENGTH   ANGLE  LENGTH
                       (ft)       (deg)   (ft)    (deg)   (ft)

NODE 3
     1.378        65.0        25.9   14.5     47.6   77.1

  Reinf. Stress at Level  1 =  26.937 Ksi (Pullout controls...)
                          2 =  22.317 Ksi (Pullout controls...)
                          3 =   8.988 Ksi (Pullout controls...)
                          4 =  11.110 Ksi (Pullout controls...)

          MINIMUM     DISTANCE     LOWER FAILURE   UPPER FAILURE
          SAFETY       BEHIND          PLANE           PLANE
          FACTOR     WALL TOE     ANGLE  LENGTH   ANGLE  LENGTH
                       (ft)       (deg)   (ft)    (deg)   (ft)

NODE 4
     1.363        70.0        25.3   15.5     46.8   81.7

  Reinf. Stress at Level  1 =  25.344 Ksi (Pullout controls...)
                          2 =  20.923 Ksi (Pullout controls...)
                          3 =   8.528 Ksi (Pullout controls...)
                          4 =  10.938 Ksi (Pullout controls...)

          MINIMUM     DISTANCE     LOWER FAILURE   UPPER FAILURE
          SAFETY       BEHIND          PLANE           PLANE
          FACTOR     WALL TOE     ANGLE  LENGTH   ANGLE  LENGTH
                       (ft)       (deg)   (ft)    (deg)   (ft)

NODE 5
     1.353        75.0        24.3   16.5     45.5   85.6

  Reinf. Stress at Level  1 =  23.410 Ksi (Pullout controls...)
                          2 =  19.299 Ksi (Pullout controls...)
                          3 =   7.821 Ksi (Pullout controls...)
                          4 =  10.673 Ksi (Pullout controls...)

          MINIMUM     DISTANCE     LOWER FAILURE   UPPER FAILURE
          SAFETY       BEHIND          PLANE           PLANE
          FACTOR     WALL TOE     ANGLE  LENGTH   ANGLE  LENGTH
                       (ft)       (deg)   (ft)    (deg)   (ft)

NODE 6
     1.354        80.0        23.4   17.4     44.3   89.4

  Reinf. Stress at Level  1 =  21.555 Ksi (Pullout controls...)
                          2 =  17.734 Ksi (Pullout controls...)
                          3 =   7.168 Ksi (Pullout controls...)
                          4 =  10.428 Ksi (Pullout controls...)

          MINIMUM     DISTANCE     LOWER FAILURE   UPPER FAILURE
          SAFETY       BEHIND          PLANE           PLANE
          FACTOR     WALL TOE     ANGLE  LENGTH   ANGLE  LENGTH
                       (ft)       (deg)   (ft)    (deg)   (ft)

NODE 7
     1.360        85.0        22.7   18.4     43.2   93.3
```

11+00 A

```
  Reinf. Stress at Level  1 =  19.772 Ksi (Pullout controls...)
                          2 =  16.224 Ksi (Pullout controls...)
                          3 =   6.563 Ksi (Pullout controls...)
                          4 =  10.201 Ksi (Pullout controls...)

          MINIMUM     DISTANCE     LOWER FAILURE   UPPER FAILURE
          SAFETY       BEHIND          PLANE           PLANE
          FACTOR     WALL TOE     ANGLE  LENGTH   ANGLE  LENGTH
                       (ft)       (deg)   (ft)    (deg)   (ft)

NODE 8
     1.371        90.0        22.0   19.4     42.2   97.3

  Reinf. Stress at Level  1 =  18.055 Ksi (Pullout controls...)
                          2 =  14.763 Ksi (Pullout controls...)
                          3 =   6.002 Ksi (Pullout controls...)
                          4 =   9.990 Ksi (Pullout controls...)

          MINIMUM     DISTANCE     LOWER FAILURE   UPPER FAILURE
          SAFETY       BEHIND          PLANE           PLANE
          FACTOR     WALL TOE     ANGLE  LENGTH   ANGLE  LENGTH
                       (ft)       (deg)   (ft)    (deg)   (ft)

NODE 9
     1.385        95.0        21.4   20.4     41.3  101.2

  Reinf. Stress at Level  1 =  16.398 Ksi (Pullout controls...)
                          2 =  13.347 Ksi (Pullout controls...)
                          3 =   5.478 Ksi (Pullout controls...)
                          4 =   9.794 Ksi (Pullout controls...)

          MINIMUM     DISTANCE     LOWER FAILURE   UPPER FAILURE
          SAFETY       BEHIND          PLANE           PLANE
          FACTOR     WALL TOE     ANGLE  LENGTH   ANGLE  LENGTH
                       (ft)       (deg)   (ft)    (deg)   (ft)

NODE10
     1.400       100.0        20.8   21.4     40.5  105.2

  Reinf. Stress at Level  1 =  14.796 Ksi (Pullout controls...)
                          2 =  11.973 Ksi (Pullout controls...)
                          3 =   4.990 Ksi (Pullout controls...)
                          4 =   9.611 Ksi (Pullout controls...)

     ***************************************************************
     *                 For Factor of Safety = 1.0                  *
     *          Maximum Average Reinforcement Working Force:       *
     *                      6.010 Kips/level                       *
     ***************************************************************
```

PROJECT TITLE: Advanced/SUFCO; Sta. 11+00 14.7H Final Static

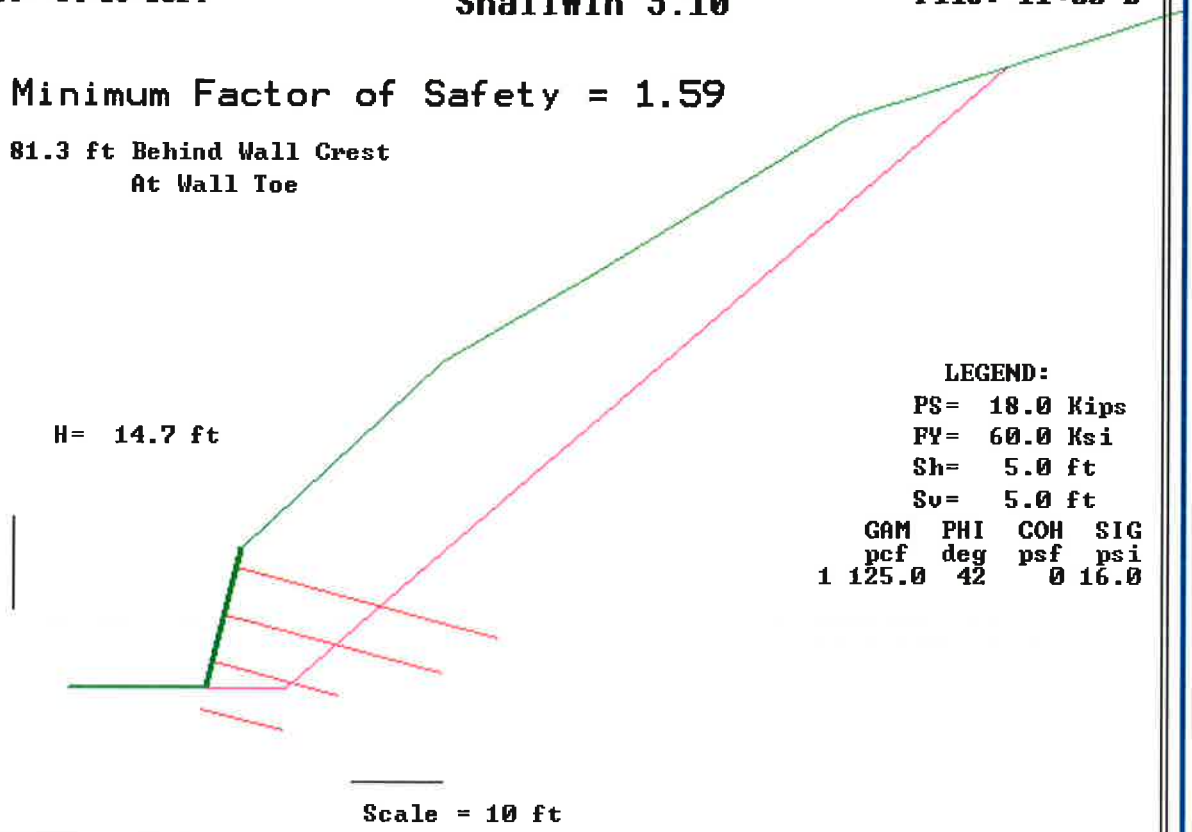
Date: 04-15-2014

SnailWin 3.10

File: 11+00 B

Minimum Factor of Safety = 1.59

81.3 ft Behind Wall Crest
At Wall Toe



LEGEND:

PS= 18.0 Kips
FY= 60.0 Ksi
Sh= 5.0 ft
Sv= 5.0 ft

	GAM pcf	PHI deg	COH psf	SIG psi
1	125.0	42	0	16.0

```
*************************************************
*    CALIFORNIA DEPARTMENT OF TRANSPORTATION    *
*          ENGINEERING SERVICE CENTER           *
*     DIVISION OF MATERIALS AND FOUNDATIONS     *
*   Office of Roadway Geotechnical Engineering  *
*    Date: 04-15-2014          Time: 13:46:51   *
*************************************************
```

Project Identification - Advanced/SUFCO; Sta. 11+00 14.7H Final Static

--------- WALL GEOMETRY ---------

Vertical Wall Height	=	14.7 ft
Wall Batter	=	14.0 degree

		Angle (Deg)	Length (Feet)
First Slope from Wallcrest.	=	43.0	29.0
Second Slope from 1st slope.	=	31.0	19.3
Third Slope from 2nd slope.	=	31.3	31.3
Fourth Slope from 3rd slope.	=	18.0	40.0
Fifth Slope from 3rd slope.	=	0.0	0.0
Sixth Slope from 3rd slope.	=	0.0	0.0
Seventh Slope Angle.	=	0.0	

--------- SLOPE BELOW THE WALL ---------

There is NO SLOPE BELOW THE TOE of the wall

--------- SURCHARGE ---------

There is NO SURCHARGE imposed on the system.

--------- OPTION #1 ---------

Factored Punching shear, Bond & Yield Stress are used.

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	125.0	42.0	0.0	16.0	0.0	0.0	0.0	0.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 50.0 to 100.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels	=	4
Horizontal Spacing	=	5.0 ft
Yield Stress of Reinforcement	=	60.0 ksi
Diameter of Grouted Hole	=	4.0 in
Punching Shear	=	18.0 kips

---------- (Varying Reinforcement Parameters) ---------

Level	Length (ft)	Inclination (degrees)	Vertical Spacing (ft)	Bar Diameter (in)	Bond Stress Factor
1	29.0	15.0	2.0	1.22	1.00
2	24.0	15.0	5.0	1.22	1.00
3	14.0	15.0	5.0	1.22	1.00
4	9.0	15.0	5.0	1.22	1.00

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
Toe	1.749	55.0	40.4	65.0	62.4	11.9

Reinf. Stress at Level 1 = 34.497 Ksi (Punching Shear controls..)
2 = 26.977 ksi (Punching Shear controls..)
3 = 19.458 ksi (Punching Shear controls..)
4 = 0.000 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 2	1.714	60.0	0.0	6.0	45.9	77.6

Reinf. Stress at Level 1 = 34.170 Ksi (Pullout controls...)
2 = 29.955 Ksi (Pullout controls...)
3 = 15.421 Ksi (Pullout controls...)
4 = 0.000 Ksi (Pullout controls...)

MINIMUM DISTANCE LOWER FAILURE UPPER FAILURE

11+00 B

```
          SAFETY      BEHIND          PLANE           PLANE
          FACTOR     WALL TOE     ANGLE  LENGTH   ANGLE  LENGTH
                       (ft)       (deg)   (ft)    (deg)   (ft)

NODE 3
    1.675        65.0        0.0     6.5     45.1   82.9

  Reinf. Stress at Level  1 =  32.903 Ksi (Pullout controls...)
                          2 =  28.878 Ksi (Pullout controls...)
                          3 =  14.533 Ksi (Pullout controls...)
                          4 =   0.000 Ksi (Pullout controls...)

          MINIMUM    DISTANCE     LOWER FAILURE    UPPER FAILURE
          SAFETY      BEHIND          PLANE            PLANE
          FACTOR     WALL TOE     ANGLE  LENGTH    ANGLE  LENGTH
                       (ft)       (deg)   (ft)     (deg)   (ft)

NODE 4
    1.639        70.0        0.0     7.0     44.2   87.9

  Reinf. Stress at Level  1 =  31.558 Ksi (Pullout controls...)
                          2 =  27.762 Ksi (Pullout controls...)
                          3 =  13.646 Ksi (Pullout controls...)
                          4 =   0.000 Ksi (Pullout controls...)

          MINIMUM    DISTANCE     LOWER FAILURE    UPPER FAILURE
          SAFETY      BEHIND          PLANE            PLANE
          FACTOR     WALL TOE     ANGLE  LENGTH    ANGLE  LENGTH
                       (ft)       (deg)   (ft)     (deg)   (ft)

NODE 5
    1.611        75.0        0.0     7.5     43.0   92.3

  Reinf. Stress at Level  1 =  30.045 Ksi (Pullout controls...)
                          2 =  26.561 Ksi (Pullout controls...)
                          3 =  12.757 Ksi (Pullout controls...)
                          4 =   0.000 Ksi (Pullout controls...)

          MINIMUM    DISTANCE     LOWER FAILURE    UPPER FAILURE
          SAFETY      BEHIND          PLANE            PLANE
          FACTOR     WALL TOE     ANGLE  LENGTH    ANGLE  LENGTH
                       (ft)       (deg)   (ft)     (deg)   (ft)

NODE 6
    1.596        80.0        0.0     8.0     41.9   96.7

  Reinf. Stress at Level  1 =  28.593 Ksi (Pullout controls...)
                          2 =  25.400 Ksi (Pullout controls...)
                          3 =  11.887 Ksi (Pullout controls...)
                          4 =   0.000 Ksi (Pullout controls...)

          MINIMUM    DISTANCE     LOWER FAILURE    UPPER FAILURE
          SAFETY      BEHIND          PLANE            PLANE
          FACTOR     WALL TOE     ANGLE  LENGTH    ANGLE  LENGTH
                       (ft)       (deg)   (ft)     (deg)   (ft)

NODE 7
    1.591        85.0        0.0     8.5     40.9  101.1

  Reinf. Stress at Level  1 =  27.196 Ksi (Pullout controls...)
                          2 =  24.275 Ksi (Pullout controls...)
                          3 =  11.034 Ksi (Pullout controls...)
                          4 =   0.000 Ksi (Pullout controls...)

          MINIMUM    DISTANCE     LOWER FAILURE    UPPER FAILURE
          SAFETY      BEHIND          PLANE            PLANE
          FACTOR     WALL TOE     ANGLE  LENGTH    ANGLE  LENGTH
                       (ft)       (deg)   (ft)     (deg)   (ft)

NODE 8
    1.591        90.0        0.0     9.0     39.9  105.6

  Reinf. Stress at Level  1 =  25.848 Ksi (Pullout controls...)
                          2 =  23.182 Ksi (Pullout controls...)
                          3 =  10.196 Ksi (Pullout controls...)
                          4 =   0.000 Ksi (Pullout controls...)

          MINIMUM    DISTANCE     LOWER FAILURE    UPPER FAILURE
          SAFETY      BEHIND          PLANE            PLANE
          FACTOR     WALL TOE     ANGLE  LENGTH    ANGLE  LENGTH
                       (ft)       (deg)   (ft)     (deg)   (ft)

NODE 9
    1.595        95.0        0.0     9.5     39.1  110.1

  Reinf. Stress at Level  1 =  24.545 Ksi (Pullout controls...)
                          2 =  22.118 Ksi (Pullout controls...)
                          3 =   9.372 Ksi (Pullout controls...)
                          4 =   0.000 Ksi (Pullout controls...)

          MINIMUM    DISTANCE     LOWER FAILURE    UPPER FAILURE
          SAFETY      BEHIND          PLANE            PLANE
          FACTOR     WALL TOE     ANGLE  LENGTH    ANGLE  LENGTH
                       (ft)       (deg)   (ft)     (deg)   (ft)

NODE10
    1.602       100.0        0.0    10.0     38.3  114.6

  Reinf. Stress at Level  1 =  23.283 Ksi (Pullout controls...)
                          2 =  21.082 Ksi (Pullout controls...)
                          3 =   8.560 Ksi (Pullout controls...)
                          4 =   0.000 Ksi (Pullout controls...)

     ***************************************************************
     *                For Factor of Safety = 1.0                   *
     *         Maximum Average Reinforcement Working Force:        *
     *                     2.758 Kips/level                        *
     ***************************************************************
```

11+00 B

PROJECT TITLE: Advanced/SUFCO; Sta. 11+00 14.7H Final Pseudo-Static

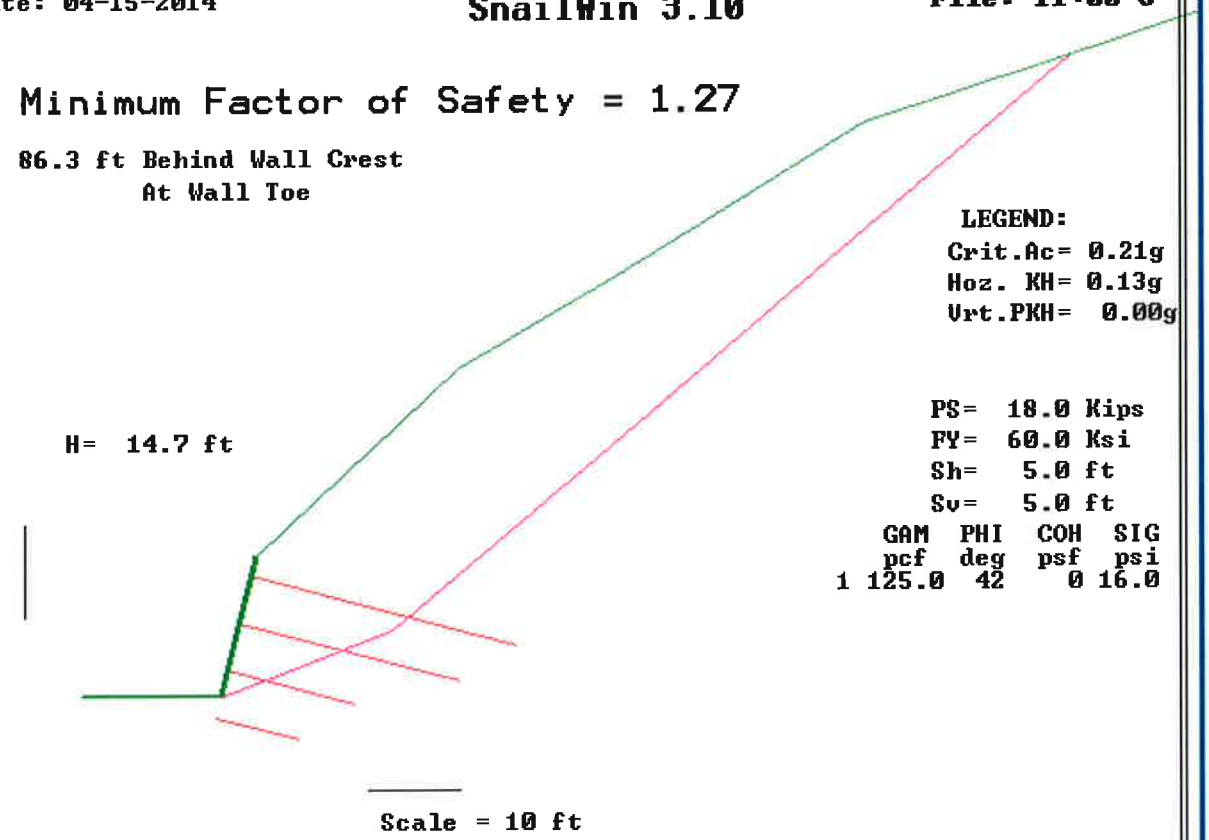
Date: 04-15-2014

SnailWin 3.10

File: 11+00 C

Minimum Factor of Safety = 1.27

86.3 ft Behind Wall Crest
At Wall Toe



LEGEND:
Crit.Ac= 0.21g
Hoz. KH= 0.13g
Vrt.PKH= 0.00g

PS= 18.0 Kips
FY= 60.0 Ksi
Sh= 5.0 ft
Sv= 5.0 ft

	GAM pcf	PHI deg	COH psf	SIG psi
1	125.0	42	0	16.0

```
*****************************************
*   CALIFORNIA DEPARTMENT OF TRANSPORTATION   *
*          ENGINEERING SERVICE CENTER         *
*    DIVISION OF MATERIALS AND FOUNDATIONS    *
*  Office of Roadway Geotechnical Engineering *
*   Date: 04-15-2014        Time: 13:47:24    *
*****************************************
```

Project Identification - Advanced/SUFCO; Sta. 11+00 14.7H Final Pseudo-Static

--------- WALL GEOMETRY ---------

Vertical Wall Height	=	14.7 ft	
Wall Batter	=	14.0 degree	
		Angle (Deg)	Length (Feet)
First Slope from Wallcrest.	=	43.0	29.0
Second Slope from 1st slope.	=	31.0	19.3
Third Slope from 2nd slope.	=	31.3	31.3
Fourth Slope from 3rd slope.	=	18.0	40.0
Fifth Slope from 3rd slope.	=	0.0	0.0
Sixth Slope from 3rd slope.	=	0.0	0.0
Seventh Slope Angle.	=	0.0	

--------- SLOPE BELOW THE WALL ---------

There is NO SLOPE BELOW THE TOE of the wall

--------- SURCHARGE ---------

There is NO SURCHARGE imposed on the system.

--------- OPTION #1 ---------

Factored Punching shear, Bond & Yield Stress are used.

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	125.0	42.0	0.0	16.0	0.0	0.0	0.0	0.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

--------- EARTHQUAKE ACCELERATION ---------

Horizontal Earthquake Coefficient = 0.13 (a/g)
Vertical Earthquake Coefficient = 0.00

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 50.0 to 100.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels	=	4
Horizontal Spacing	=	5.0 ft
Yield Stress of Reinforcement	=	60.0 ksi
Diameter of Grouted Hole	=	4.0 in
Punching Shear	=	18.0 kips

---------- (Varying Reinforcement Parameters) ---------

Level	Length (ft)	Inclination (degrees)	Vertical Spacing (ft)	Bar Diameter (in)	Bond Stress Factor
1	29.0	15.0	2.0	1.22	1.00
2	24.0	15.0	5.0	1.22	1.00
3	14.0	15.0	5.0	1.22	1.00
4	9.0	15.0	5.0	1.22	1.00

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
Toe	1.351	55.0	40.4	65.0	62.4	11.9

Reinf. Stress at Level 1 = 34.497 Ksi (Punching Shear controls...)
2 = 26.977 ksi (Punching Shear controls...)
3 = 19.458 ksi (Punching Shear controls...)
4 = 0.000 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 2						
	1.327	60.0	39.5	70.0	61.7	12.7

11+00 C

```
 Reinf. Stress at Level  1 =  35.109 Ksi (Punching Shear controls..)
                         2 =  27.349 ksi (Punching Shear controls..)
                         3 =  19.589 ksi (Punching Shear controls..)
                         4 =   0.000 Ksi (Pullout controls...)

          MINIMUM    DISTANCE    LOWER FAILURE   UPPER FAILURE
          SAFETY      BEHIND         PLANE           PLANE
          FACTOR     WALL TOE    ANGLE  LENGTH   ANGLE  LENGTH
                       (ft)      (deg)   (ft)    (deg)   (ft)

NODE 3
    1.307        65.0       38.8   75.0     61.1   13.4

 Reinf. Stress at Level  1 =  35.651 Ksi (Punching Shear controls..)
                         2 =  27.677 ksi (Punching Shear controls..)
                         3 =  19.704 ksi (Punching Shear controls..)
                         4 =   0.000 Ksi (Pullout controls...)

          MINIMUM    DISTANCE    LOWER FAILURE   UPPER FAILURE
          SAFETY      BEHIND         PLANE           PLANE
          FACTOR     WALL TOE    ANGLE  LENGTH   ANGLE  LENGTH
                       (ft)      (deg)   (ft)    (deg)   (ft)

NODE 4
    1.293        70.0       37.9   79.8     60.3   14.1

 Reinf. Stress at Level  1 =  36.307 Ksi (Punching Shear controls..)
                         2 =  28.075 ksi (Punching Shear controls..)
                         3 =  19.843 ksi (Punching Shear controls..)
                         4 =   0.000 Ksi (Pullout controls...)

          MINIMUM    DISTANCE    LOWER FAILURE   UPPER FAILURE
          SAFETY      BEHIND         PLANE           PLANE
          FACTOR     WALL TOE    ANGLE  LENGTH   ANGLE  LENGTH
                       (ft)      (deg)   (ft)    (deg)   (ft)

NODE 5
    1.289        75.0       40.0   97.9     89.9    0.0

 Reinf. Stress at Level  1 =  34.792 Ksi (Punching Shear controls..)
                         2 =  27.157 ksi (Punching Shear controls..)
                         3 =  19.521 ksi (Punching Shear controls..)
                         4 =   0.000 Ksi (Pullout controls...)

          MINIMUM    DISTANCE    LOWER FAILURE   UPPER FAILURE
          SAFETY      BEHIND         PLANE           PLANE
          FACTOR     WALL TOE    ANGLE  LENGTH   ANGLE  LENGTH
                       (ft)      (deg)   (ft)    (deg)   (ft)

NODE 6
    1.280        80.0       38.9  102.8     89.9    0.0

 Reinf. Stress at Level  1 =  35.574 Ksi (Punching Shear controls..)
                         2 =  27.631 ksi (Punching Shear controls..)
                         3 =  19.687 ksi (Punching Shear controls..)
                         4 =   0.000 Ksi (Pullout controls...)

          MINIMUM    DISTANCE    LOWER FAILURE   UPPER FAILURE
          SAFETY      BEHIND         PLANE           PLANE
          FACTOR     WALL TOE    ANGLE  LENGTH   ANGLE  LENGTH
                       (ft)      (deg)   (ft)    (deg)   (ft)

NODE 7
    1.274        85.0       21.3   18.2     41.2   90.4

 Reinf. Stress at Level  1 =  25.852 Ksi (Pullout controls...)
                         2 =  26.924 Ksi (Pullout controls...)
                         3 =  20.967 Ksi (Pullout controls...)
                         4 =   0.000 Ksi (Pullout controls...)

          MINIMUM    DISTANCE    LOWER FAILURE   UPPER FAILURE
          SAFETY      BEHIND         PLANE           PLANE
          FACTOR     WALL TOE    ANGLE  LENGTH   ANGLE  LENGTH
                       (ft)      (deg)   (ft)    (deg)   (ft)

NODE 8
    1.270        90.0       20.6   19.2     40.3   94.4

 Reinf. Stress at Level  1 =  24.427 Ksi (Pullout controls...)
                         2 =  26.402 Ksi (Pullout controls...)
                         3 =  20.784 Ksi (Pullout controls...)
                         4 =   0.000 Ksi (Pullout controls...)

          MINIMUM    DISTANCE    LOWER FAILURE   UPPER FAILURE
          SAFETY      BEHIND         PLANE           PLANE
          FACTOR     WALL TOE    ANGLE  LENGTH   ANGLE  LENGTH
                       (ft)      (deg)   (ft)    (deg)   (ft)

NODE 9
    1.270        95.0       20.1   20.2     39.4   98.4

 Reinf. Stress at Level  1 =  23.047 Ksi (Pullout controls...)
                         2 =  25.918 Ksi (Pullout controls...)
                         3 =  20.614 Ksi (Pullout controls...)
                         4 =   0.000 Ksi (Pullout controls...)

          MINIMUM    DISTANCE    LOWER FAILURE   UPPER FAILURE
          SAFETY      BEHIND         PLANE           PLANE
          FACTOR     WALL TOE    ANGLE  LENGTH   ANGLE  LENGTH
                       (ft)      (deg)   (ft)    (deg)   (ft)

NODE10
    1.273       100.0       19.6   21.2     38.6  102.4

 Reinf. Stress at Level  1 =  21.708 Ksi (Pullout controls...)
                         2 =  25.467 Ksi (Pullout controls...)
                         3 =  20.456 Ksi (Pullout controls...)
                         4 =   0.000 Ksi (Pullout controls...)

*****************************************************************
*                 For Factor of Safety = 1.0                    *
*          Maximum Average Reinforcement Working Force:         *
*                      14.081 Kips/level                        *
*****************************************************************
```

11+00 C

Soil Nail Wall Facing Design: FHWA A0-IF-03-017 GEC7

Project : SUFCO Mine Soil Nail Wall
Location: Emery County, Utah
Client: Adanced
Section: Sta. 11+00
Soil Nail Wall Type: ("Permanent" or "Temporary"): Permanent
Sheet modified by DAG 9/30/09

1. Global Stability Results: (from SNAIL)

Inputs:			
Hole Diameter, D_{DH} =	4.0	in	
Cross-sectional Area of soil nails used in SNAIL, A_t =	1.16	in^2	R32N
Equivalent Diameter of IBO Bar used in SNAIL =	1.22	in	
Facing Punching Shear Capacity used in SNAIL =	18.00	kips	
Horizontal Nail Spacing (S_h) =	5.00	ft	
Vertical Nail Spacing (S_v) =	5.00	ft	
PGA =	0.25	g	(normalized peak ground accelerations)
A_m =	0.30	g	(normalized horizontal acceleration)
k_h =	0.15	g	(horizontal seismic coefficient)

			Permanent	Temporary
Calculated Min. FS =	1.59	Static	OK	OK
Calculated Min. FS =	1.27	P-Static	OK	—

Reinforcement Stress at Level	Static	P-Static	
1	25.848	23.047	ksi
2	23.182	25.918	ksi
3	10.196	20.614	ksi
4			ksi
5			ksi
6			ksi

	Static	P-Static		
$T_{avg\text{-}s}$ =	2.758	14.081	kips	(Maximum average reinforcement working force calculated for a FSG = 1.0)
T_{max} =	29.984	30.065	kips	
T_{avg} =	22.901	26.904	kips	

2. Sliding Stability Analysis

$FS_{SL} = \Sigma R/\Sigma D$ (eq. 5.7)

$\Sigma R = c_b B_L + (W+Q_D+P_A \sin\beta)\tan\phi_b$ (eq. 5.8)

$\Sigma D = P_A \cos\beta$ (eq. 5.9)

H =	14.7	ft	(wall height)
ΔH =	0	ft	(slope rise up to bench if present)
β =	40	degrees	(backslope angle)
β_{eq} =	0.0	degrees	(equivalent backslope angle)
α =	14.00	degrees	(face batter angle, from vertical)
theta =	104.00	degrees	(inclination of wall face from horizontal = α + 90)
c_b =	0	psf	(soil cohesion strength along the base)
B_L =	9	ft	(length of the horizontal failure surface where cb is effectively acting)
W =	64.3125	kips/ft	(weight of soil nail block)
Q_D =	2.5	kips/ft	(permanent portion of total surcharge load Q_T)
$\phi'b$ =	42	degrees	(effective angle of internal friction of the base)
ϕ' =	42	degrees	(effective friction angle of soil behind soil nail block)
δ =	21	degrees	(wall-soil interface friction angle)
γ =	125	pcf	(total unit weight of soil mass)
H_1 =	14.7	ft	(effective height over which the earth pressure acts $H_1 = H+(B+\tan\alpha)\tan B_{eq}$)
K_A =	0.41		(active earth pressure coefficient)
P_A =	5.47	kips	

		Permanent		Temporary
		Static	P-Static	
ΣR =	63.32			
ΣD =	4.19			
FS_{SL} =	15.1	OK	OK	OK

3. Nail Tensile Resistance

$T_{max\text{-}s} = (T_{avb\text{-}s}/T_{avg})T_{max}$ (eq. 5.37)

	Static	P-Static	
$T_{max\text{-}s}$ =	3.61	15.74	kips

	Permanent		Temporary
	Static	P-Static	
FS_T =	1.80	1.35	1.80

F_y = 75 ksi (yield strength of nail tendon)

$At = (T_{max\text{-}s}*FS_T)/fy$ (required cross-sectional area of steel soil nail bar)

	Permanent		Temporary	
	Static	P-Static		
At =	0.09	0.28	0.09	in^2
	OK	**OK**	**OK**	

4. Nail Pullout Capacity

D_{DH} = 4.0 in (Drill Hole Diameter)

q_u = 32 psi (ultimate soil-grout bond strength)

Qu = 4.83 kips/ft (Ultimate pullout capacity per foot of bonded length)
Global stabililty analyses in SNAIL satisfies conditions for pullout resistance.

5. Facing Flexural Capacity

Input parameters:

Horizontal nail spacing, S_H = 5.00 ft

Vertical nail spacing, S_V = 5.00 ft

welded wire mesh area =

*(4x4 W4.0xW4.0) **(4x4 W2.9xW2.9)		
*Permanent	**Temporary	
0.120	0.087	in^2/ft

See Appendix A, Table A.2

horizontal "waler" bar area, A_{hw}= 0 in^2

See Appendix A, Table A.3

vertical "bearing" bar area, A_{vw} = 0 in^2

yield strength of reinforcement, f_y = 65 ksi

concrete compressive strength, f'c = 4000 psi

nominal trial facing thickness, h =

*Permanent	**Temporary	
7	4	in

*Flexure Pressure Factor, C_F = 1

**Flexure Pressure Factor, C_F = 2

(Table 5.1, p. 98)

bearing plate thickness, t_p = 0.5 in

bearing plate length, L_{bp} = 8 in

For Permanent Facing with Studded Plates: Yes (Using Studded Plates: Yes or No?)

Headed-Stud Selection: See Appendix A, Table A.6

Headed-stud shaft diameter, Ds = 0.5 in

Head diameter, D_H = 1 in

Headed-stud thickness, t_H = 0.31 in

Length of headed-stud, L_s = 3.5 in

Headed-stud spacing S_{HS} = 7 in

Number of Studs, N_H = 4

yield strength of studs, f_y = 60 ksi

Grade of Steel = A307 or A325?

	Permanent	Temporary	
Area of steel at nail head (vertical), a_{vn} =	0.12	0.087	in^2/ft
Area of steel at midspan (vertical), a_{vm} =	0.12	0.087	in^2/ft
Area of steel at nail head (horizontal), a_{hn} =	0.12	0.087	in^2/ft
Area of steel at midspan (horizontal), a_{hm} =	0.12	0.087	in^2/ft

Note: for vertical and horizontal waler,
$a_{vn} = a_{vm} + (A_{vw}/S_H)$
$a_{hn} = a_{hm} + (A_{hw}/S_V)$

$T_o = T_{max\text{-}s}*(0.6+0.057*(S_{max}[ft]-3))$ (eq. 5.41, design nail head tensile force at the face)

Smax = 5.00 ft (Maximum soil nail spacing, Sv or Sh)

	Static	P-Static	
T_o =	2.58	11.24	kips

	Permanent		Temporary		
	Static	P-Static			
Facing Flexural Capacity, R_{FF} =	34.58	34.58	28.6520	kips	R_{FF}[kips-ft/ft]=3.8xC_Fx(a_{vn}+a_{vm})[in2/ft]x(S_H*h[ft]/S_V)xf_y[ksi]
Facing Flexural Capacity, R_{FF} =	34.58	34.58	28.6520	kips	R_{FF}[kips-ft/ft]=3.8xC_Fx(a_{hn}+a_{hm})[in2/ft]x(S_V*h[ft]/S_H)xf_y[ksi]
Minimum Flexural Capacity, R_{FF} =	34.58	34.58	28.6520	kips	(Eq. 5.43a, p.96)
					(Eq. 5.43b, p.96)

FS_{FF} =	13.41	3.08	11.11
	OK	**OK**	**OK**

	Permanent		Temporary	
Reinforcement Ratio, ρ_{vn}=	0.29	OK	0.36	OK
Reinforcement Ratio, ρ_{vm}=	0.29	OK	0.36	OK
Reinforcement Ratio, ρ_{hn}=	0.29	OK	0.36	OK
Reinforcement Ratio, ρ_{hm}=	0.29	OK	0.36	OK

ρij=(aij/0.5h)*100 (eq.5.49, p. 99) i= direction (horizontal or vertical)
j = location (nail head or midspan)

ρ_{min}= 0.23
ρ_{max}= 1.79

ρmin=0.24*(f'c[psi])^0.5/fy[ksi] (eq.5.51, p.100)
ρmax=0.05*(f'c[psi]/fy[ksi])*(90/(90+fy[ksi])) (eq.5.53, p.100)

6. Punching Shear Capacity

Facing Punching Shear Capacity, $R_{FP} = C_p{*}V_F$ (eq. 5.54, p. 101)

	Permanent	Temporary	
Punching Shear Force, V_F =	21.58	38.41	kips

Punching Pressure Factor, C_P = 1 (Typically 1.0, p.102)
V_F = 0.58(f'c[psi])^0.5πD'c[ft]hc[ft] (eq. 5.56, p. 102)

	Permanent	Temporary	
D'_c =	0.61	1.00	ft
h'_c=	0.31	0.33	ft

For temporary or permanent facing without headed-studs:
$D'_c = L_{BP} + h$ = effective diameter of conical failure surface
$h'_c = h$ = effective depth of conical surface

	Permanent	Temporary	
R_{FP} =	21.58	38.41	kips
(Also Check that R_{FP}>Punching Sh	OK	OK	

For permanent facing with headed-studs:
D'_c = min of (S_{HS} +h'c and 2h'c)
h'_c= Ls-ts+tp

	Permanent		Temporary
	Static	P-Static	
FS_{FP} =	8.37	1.92	14.90
	OK	OK	OK

$FS_{FP} = R_{FP}/T_o$ (eq. 5.59, p. 103)

7. Facing Headed-Stud Resitance - Permanent Facing

Headed-Stud Resistance, R_{FH} = 47.12 kips $R_{FH} = N_H A_{SH} fy$ (eq. 5.60, p. 103)

	Permanent		Temporary
	Static	P-Static	
FS_{HT} =	18.28	4.19	18.28
	OK	OK	OK

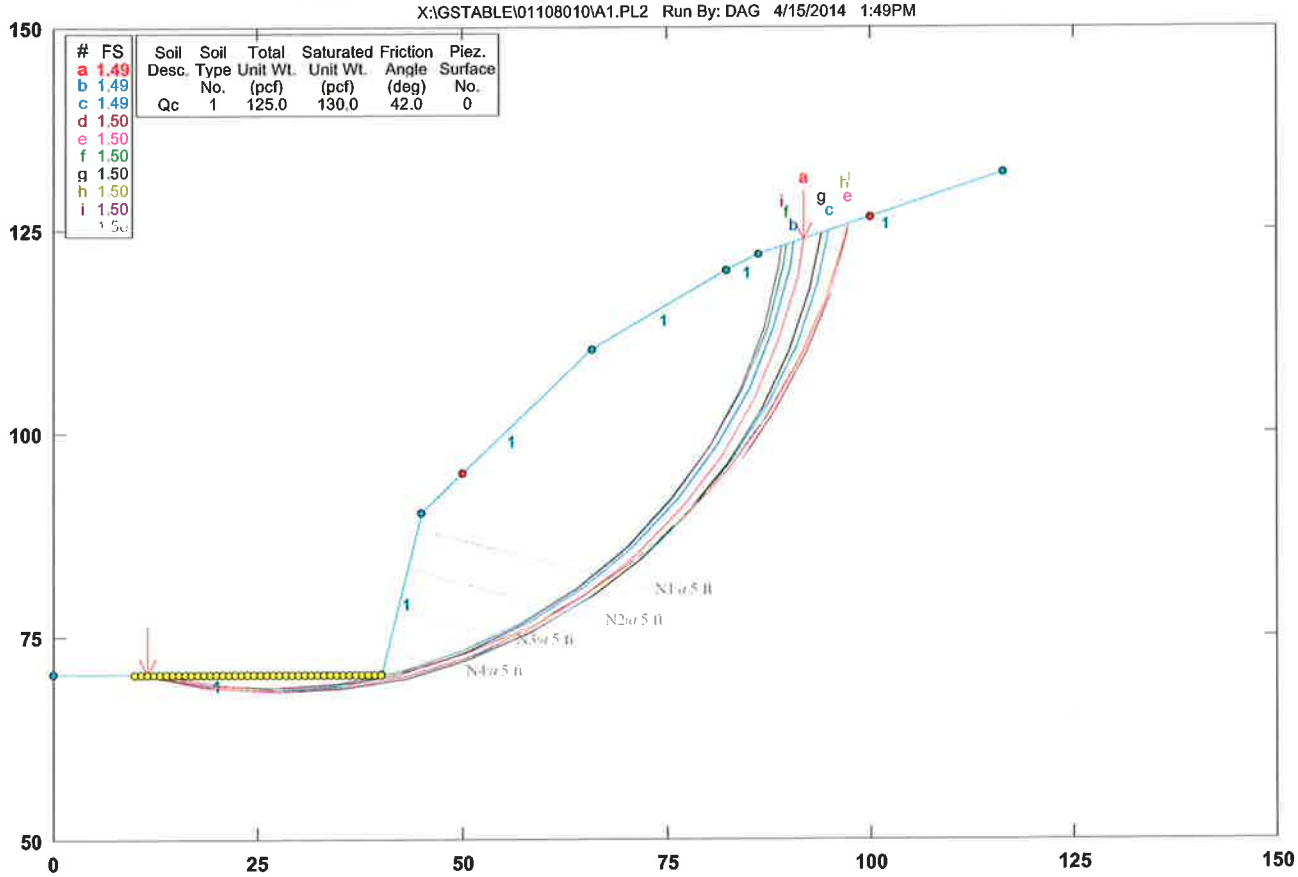
$FS_{HT} = R_{FH}/T_o$ (eq. 5.61, p. 103)

Check: $A_H >= 2.5A_{SH}$ OK
A_H = 0.79 in^2 Cross-sectional area of the stud head
A_{SH} = 0.20 in^2 Cross-sectional area of headed-stud shaft

Check: $t_H >= 0.5(D_H-D_S)$ OK
t_H = 0.31 in
$0.5(D_H-D_S)$ = 0.25 in

Advanced/SUFCO; 01108-010; Sta. 11+00 ; 20H Temp; Static

X:\GSTABLE\01108010\A1.PL2 Run By: DAG 4/15/2014 1:49PM



GSTABL7 v.2 FSmin=1.49

Safety Factors Are Calculated By The Modified Bishop Method

*** 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: 4/15/2014
Time of Run: 1:49PM
Run By: DAG
Input Data Filename: X:a1.
Output Filename: X:a1.OUT
Unit System: English

Plotted Output Filename: X:a1.PLT

PROBLEM DESCRIPTION: Advanced/SUFCO; 01108-010; Sta. 11+00
; 20H Temp; Static

BOUNDARY COORDINATES

6 Top Boundaries
6 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	70.30	40.00	70.30	1
2	40.00	70.30	45.00	90.30	1
3	45.00	90.30	65.80	110.30	1
4	65.80	110.30	82.30	120.00	1
5	82.30	120.00	86.30	122.00	1
6	86.30	122.00	116.30	132.00	1

User Specified Y-Origin = 50.00(ft)

ISOTROPIC SOIL PARAMETERS

1 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	125.0	130.0	0.0	42.0	0.00	0.0	0

SOIL NAIL LOAD(S)

4 SOIL NAIL LOAD(S) SPECIFIED

Nail No.	X-Pos (ft)	Y-Pos (ft)	Nail Dia (in)	Tendon Dia (in)	Spacing (ft)	Inclin. (deg)	Length (ft)
1	44.50	88.30	4.0	1.2	5.00	15.00	29.00
2	43.25	83.30	4.0	1.2	5.00	15.00	24.00
3	42.00	78.30	4.0	1.2	5.00	15.00	14.00
4	40.75	73.30	4.0	1.2	5.00	15.00	9.00

SOIL NAIL LOAD DATA

Soil Nail No. 1 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	44.50	88.30	3600.00
2	53.53	85.47	9088.50
3	72.51	80.79	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

Soil Nail No. 2 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	43.25	83.30	3600.00
2	49.91	81.12	7831.86
3	66.43	77.09	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

Soil Nail No. 3 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	42.00	78.30	3600.00
2	43.87	77.42	5318.58
3	55.52	74.68	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

Soil Nail No. 4 3 Load Points Apply to This Nail

Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	40.75	73.30	3600.00
2	40.25	73.06	4061.95
3	49.44	70.97	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

NOTE - An Equivalent Line Load Is Calculated For Each Row Of Soil Nails
Assuming A Uniform Distribution Of Load Horizontally Between
Individual Nails.

1

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.

1600 Trial Surfaces Have Been Generated.

40 Surface(s) Initiate(s) From Each Of 40 Points Equally Spaced
Along The Ground Surface Between X = 10.00(ft)
and X = 40.00(ft)

Each Surface Terminates Between X = 50.00(ft)
and X = 100.00(ft)

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00(ft)

8.00(ft) Line Segments Define Each Trial Failure Surface.

**** ERROR - RC11 ****

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

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

Total Number of Trial Surfaces Evaluated = 1600

Statistical Data On All Valid FS Values:
FS Max = 3.840 FS Min = 1.491 FS Ave = 0.167
Standard Deviation = 0.466 Coefficient of Variation = 278.70 %

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	11.54	70.30
2	19.40	68.80
3	27.38	68.28
4	35.37	68.75
5	43.24	70.19
6	50.87	72.58
7	58.15	75.90
8	64.97	80.09
9	71.22	85.08
10	76.81	90.80
11	81.66	97.16
12	85.68	104.08
13	88.83	111.43
14	91.05	119.12
15	91.81	123.84

Circle Center At X = 27.61 ; Y = 133.28 ; and Radius = 65.00

Factor of Safety
*** 1.491 ***

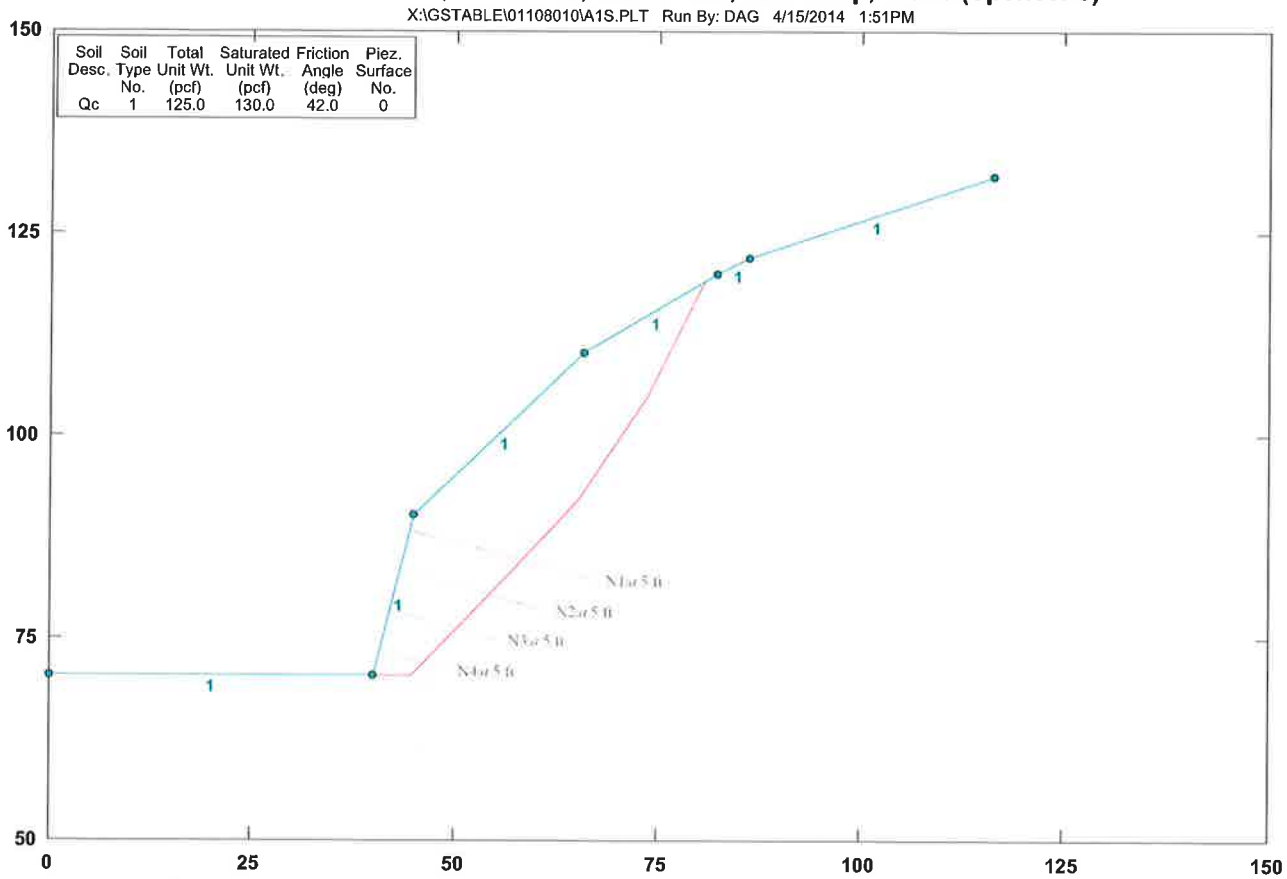
Individual data on the 19 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Tie Force Norm (lbs)	Tie Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	7.9	735.5	0.0	0.0	0.	0.	0.0	0.0	0.0
2	8.0	1754.1	0.0	0.0	0.	0.	0.0	0.0	0.0
3	8.0	1783.3	0.0	0.0	0.	0.	0.0	0.0	0.0
4	4.6	654.5	0.0	0.0	0.	0.	0.0	0.0	0.0
5	3.2	2784.0	0.0	0.0	0.	0.	0.0	0.0	0.0
6	1.8	3595.6	0.0	0.0	0.	0.	0.0	0.0	0.0
7	5.9	15742.1	0.0	0.0	0.	0.	0.0	0.0	0.0
8	7.3	22933.5	0.0	0.0	0.	0.	0.0	0.0	0.0
9	6.8	24056.0	0.0	0.0	0.	0.	0.0	0.0	0.0
10	0.8	3071.3	0.0	0.0	0.	0.	0.0	0.0	0.0
11	5.4	19627.2	0.0	0.0	0.	0.	0.0	0.0	0.0
12	5.6	19004.4	0.0	0.0	0.	0.	0.0	0.0	0.0
13	4.8	14669.3	0.0	0.0	0.	0.	0.0	0.0	0.0
14	0.6	1778.3	0.0	0.0	0.	0.	0.0	0.0	0.0
15	3.4	8321.3	0.0	0.0	0.	0.	0.0	0.0	0.0
16	0.6	1313.3	0.0	0.0	0.	0.	0.0	0.0	0.0
17	2.5	4414.6	0.0	0.0	0.	0.	0.0	0.0	0.0
18	2.2	2204.4	0.0	0.0	0.	0.	0.0	0.0	0.0
19	0.8	210.2	0.0	0.0	0.	0.	0.0	0.0	0.0

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

Advanced/SUFCO; 01108-010; Sta. 11+00 ; 20H Temp; Static (Spencer's)

X:\GSTABLE\01108010\A1S.PLT Run By: DAG 4/15/2014 1:51PM



GSTABL7 v.2 FSmin=1.36

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-1)

GSTABL7

*** 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: 4/15/2014
Time of Run: 1:51PM
Run By: DAG
Input Data Filename: X:als.
Output Filename: X:als.OUT
Unit System: English

Plotted Output Filename: X:als.PLT

PROBLEM DESCRIPTION: Advanced/SUFCO; 01108-010; Sta. 11+00
; 20H Temp; Static (Spencer's)

BOUNDARY COORDINATES

6 Top Boundaries
6 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	70.30	40.00	70.30	1
2	40.00	70.30	45.00	90.30	1
3	45.00	90.30	65.80	110.30	1
4	65.80	110.30	82.30	120.00	1
5	82.30	120.00	86.30	122.00	1
6	86.30	122.00	116.30	132.00	1

User Specified Y-Origin = 50.00(ft)

1

ISOTROPIC SOIL PARAMETERS

1 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	125.0	130.0	0.0	42.0	0.00	0.0	0

1

SOIL NAIL LOAD(S)

4 SOIL NAIL LOAD(S) SPECIFIED

Nail No.	X-Pos (ft)	Y-Pos (ft)	Nail Dia (in)	Tendon Dia (in)	Spacing (ft)	Inclin. (deg)	Length (ft)
1	44.50	88.30	4.0	1.2	5.00	15.00	24.00
2	43.25	83.30	4.0	1.2	5.00	15.00	19.00
3	42.00	78.30	4.0	1.2	5.00	15.00	14.00
4	40.75	73.30	4.0	1.2	5.00	15.00	9.00

SOIL NAIL LOAD DATA

Soil Nail No. 1 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	44.50	88.30	3600.00
2	51.12	86.12	7831.86
3	67.68	82.09	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

Soil Nail No. 2 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	43.25	83.30	3600.00
2	47.49	81.77	6575.22
3	61.60	78.38	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

Soil Nail No. 3 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO. X-COORD.(ft) Y-COORD.(ft) FORCE(lbs)

1	42.00	78.30	3600.00
2	43.87	77.42	5318.58
3	55.52	74.68	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

Soil Nail No. 4 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	40.75	73.30	3600.00
2	40.25	73.06	4061.95
3	49.44	70.97	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

NOTE - An Equivalent Line Load is Calculated For Each Row Of Soil Nails Assuming A Uniform Distribution Of Load Horizontally Between Individual Nails.

Trial Failure Surface Specified By 7 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	40.00	70.30
2	44.80	70.30
3	55.01	81.29
4	65.30	92.20
5	73.57	104.71
6	80.25	118.15
7	80.82	119.13

Sum of the Soil Nail Forces = 9029.66(lbs)

Theta (deg) (ki=1.0)	FOS (Moment) (Equil.)	FOS (Force) (Equil.)	Lambda
37.50	1.362	1.259	0.767
56.25	-1.508	256.488	1.497
37.51	1.362	1.259	0.768
37.52	1.361	1.361	0.768

Factor Of Safety For The Preceding Specified Surface = 1.361
Theta (ki = 1.0) = 37.52 Deg Lambda = 0.768

Factor Of Safety Is Calculated By GLE (Spencer's) Method (0-1)

Forces from Reinforcement, Piers/Piles, Applied Forces, and Soil Nails (if applicable) have been applied to the slice base(s) on which they intersect.

Selected ki function = Constant (1.0)

Selected Lambda Coefficient = 1.00

The option of water in the tension crack on the last slice has been selected.

*** Line of Thrust and Side Force Data ***

Slice No.	X Coord.	Y Coord.	L/H	Side Force (lbs)	ki	Force Angle (Deg)
1	44.80	72.14	0.096	9769.	1.000	37.52
2	45.00	72.32	0.091	9643.	1.000	37.52
3	55.01	80.09	-0.064	7212.	1.000	37.52
4	65.30	85.40	-0.386	3681.	1.000	37.52
5	65.80	84.83	-0.468	3239.	1.000	37.52
6	73.57	118.34	1.342	-2159.	1.000	37.52
7	80.25	118.60	0.704	-4439.	1.000	37.52
8	80.82	119.04	0.000	-4449.	1.000	37.52

Table 1 - Individual data on the 8 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Tie Force Norm (lbs)	Tie Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	4.8	5760.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.2	487.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	10.0	24036.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	10.3	23316.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.5	1092.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	7.8	13355.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	6.7	4510.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.6	23.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

- TABLE 2 - Base Stress Data on the 8 Slices -

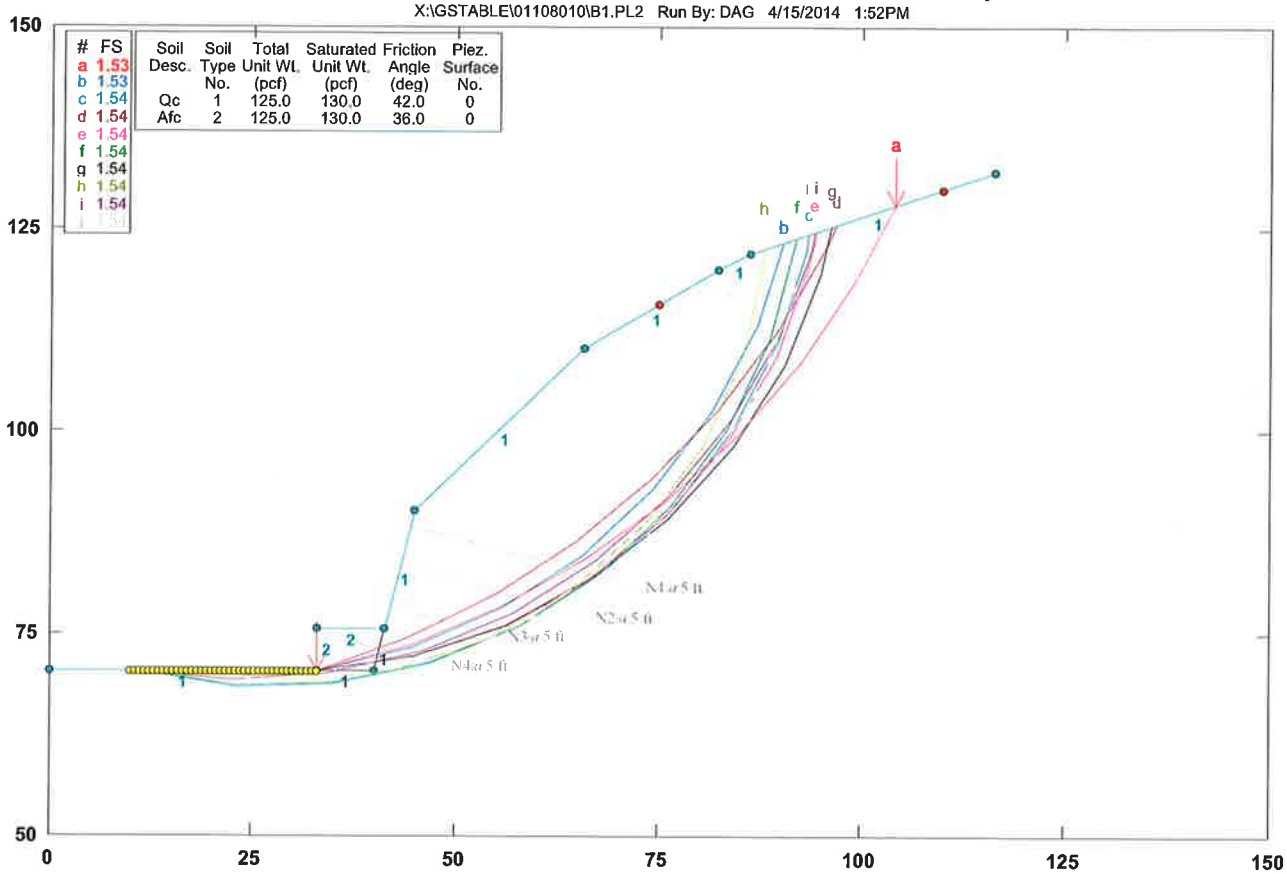
Slice No. *	Alpha (deg)	X-Coord. Slice Cntr (ft)	Base Leng. (ft)	Total Normal Stress (psf)	Total Vert. Stress (psf)	Mobilized Shear Stress (psf)
1	0.00	42.40	4.80	2439.41	1200.00	1614.21
2	47.11	44.90	0.29	1199.88	1658.39	793.98
3	47.11	50.00	14.71	1139.92	1634.35	754.31
4	46.68	60.15	15.00	1104.22	1554.70	730.68
5	56.53	65.55	0.91	823.24	1205.05	544.75
6	56.53	69.68	14.09	647.55	947.88	428.50
7	63.57	76.91	15.01	200.46	300.50	132.65
8	59.81	80.54	1.13	13.66	20.26	9.04

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

A1S

Advanced/SUFCO; 01108-010; Sta. 11+00 ; 14.7H Final; Bishop; Static

X:\GSTABLE\01108010\B1.PL2 Run By: DAG 4/15/2014 1:52PM



GSTABL7 v.2 FSmin=1.53

Safety Factors Are Calculated By The Modified Bishop Method

GSTABL7

*** 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: 4/15/2014
Time of Run: 1:52PM
Run By: DAG
Input Data Filename: X:b1.
Output Filename: X:b1.OUT
Unit System: English

Plotted Output Filename: X:b1.PLT

PROBLEM DESCRIPTION: Advanced/SUFCO; 01108-010; Sta. 11+00
; 14.7H Final; Bishop; Static

BOUNDARY COORDINATES

8 Top Boundaries
10 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	70.30	33.00	70.30	1
2	33.00	70.30	33.10	75.60	2
3	33.10	75.60	41.30	75.60	2
4	41.30	75.60	45.00	90.30	1
5	45.00	90.30	65.80	110.30	1
6	65.80	110.30	82.30	120.00	1
7	82.30	120.00	86.30	122.00	1
8	86.30	122.00	116.30	132.00	1
9	33.00	70.30	40.00	70.30	1
10	40.00	70.30	41.30	75.60	1

User Specified Y-Origin = 50.00(ft)

1

ISOTROPIC SOIL PARAMETERS

2 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	125.0	130.0	0.0	42.0	0.00	0.0	0
2	125.0	130.0	0.0	36.0	0.00	0.0	0

1

SOIL NAIL LOAD(S)

4 SOIL NAIL LOAD(S) SPECIFIED

Nail No.	X-Pos (ft)	Y-Pos (ft)	Nail Dia (in)	Tendon Dia (in)	Spacing (ft)	Inclin. (deg)	Length (ft)
1	44.50	88.30	4.0	1.2	5.00	15.00	29.00
2	43.24	83.30	4.0	1.2	5.00	15.00	24.00
3	41.98	78.30	4.0	1.2	5.00	15.00	14.00
4	33.09	75.30	4.0	1.2	5.00	15.00	16.00

SOIL NAIL LOAD DATA

Soil Nail No. 1 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	44.50	88.30	3600.00
2	53.53	85.47	9088.50
3	72.51	80.79	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

Soil Nail No. 2 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	43.24	83.30	3600.00
2	49.90	81.12	7831.86
3	66.42	77.09	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

Soil Nail No. 3 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	41.98	78.30	3600.00
2	43.85	77.42	5318.58
3	55.50	74.68	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

Soil Nail No. 4 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	33.09	75.30	3600.00
2	36.24	74.16	5821.24
3	48.55	71.16	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

NOTE - An Equivalent Line Load Is Calculated For Each Row Of Soil Nails Assuming A Uniform Distribution Of Load Horizontally Between Individual Nails.

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

1600 Trial Surfaces Have Been Generated.

40 Surface(s) Initiate(s) From Each Of 40 Points Equally Spaced
Along The Ground Surface Between X = 10.00(ft)
and X = 33.00(ft)

Each Surface Terminates Between X = 75.00(ft)
and X = 110.00(ft)

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 0.00(ft)

12.00(ft) Line Segments Define Each Trial Failure Surface.

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

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

Total Number of Trial Surfaces Evaluated = 1600

Statistical Data On All Valid FS Values:
FS Max = 2.089 FS Min = 1.534 FS Ave = 1.756
Standard Deviation = 0.102 Coefficient of Variation = 5.80 %

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	33.00	70.33
2	44.52	73.67
3	55.59	78.32
4	66.04	84.22
5	75.74	91.28
6	84.56	99.41
7	92.39	108.51
8	99.12	118.45
9	104.03	127.91

Circle Center At X = 9.85 ; Y = 171.61 ; and Radius = 103.89

Factor of Safety
*** 1.534 ***

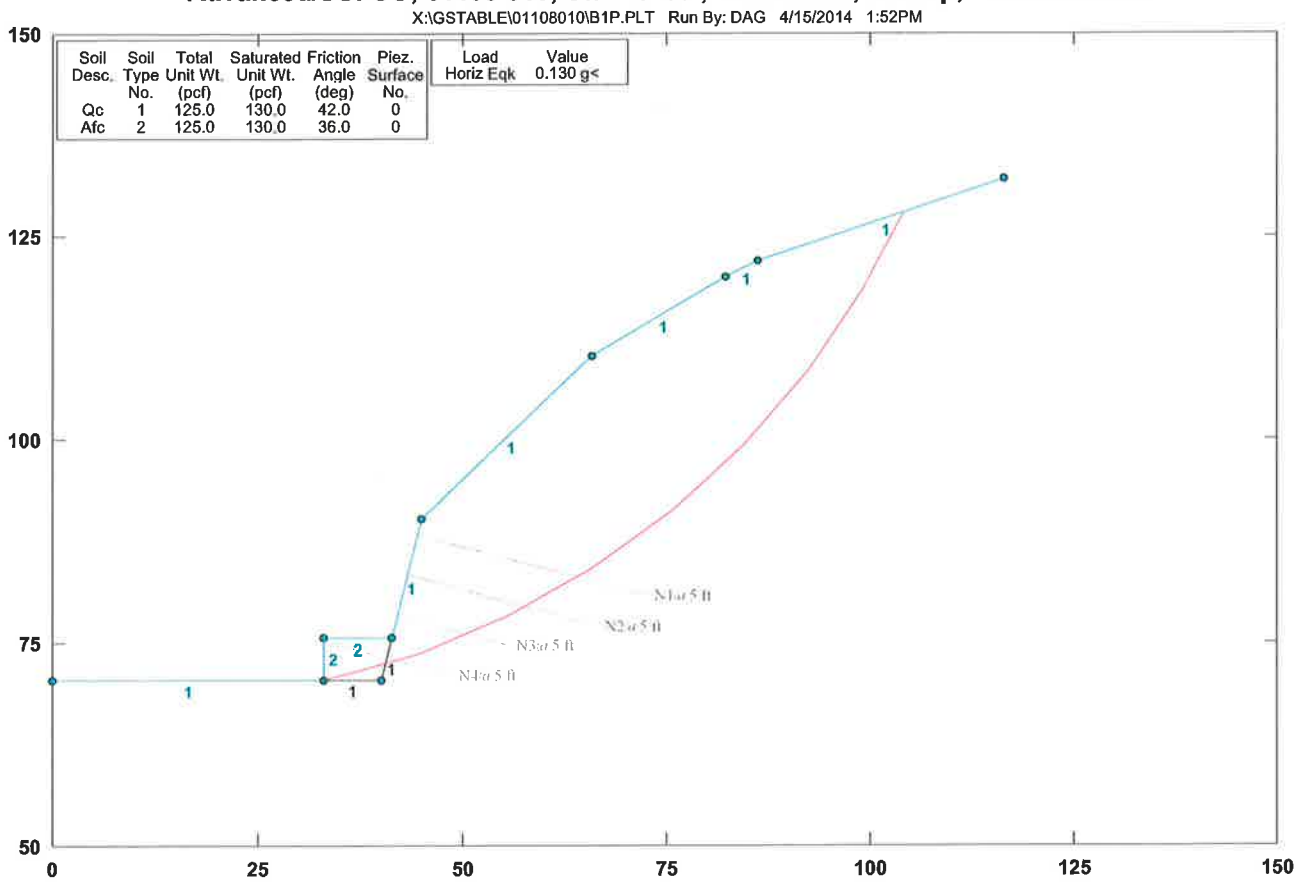
Individual data on the 15 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Tie Force Norm (lbs)	Tie Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	0.1	32.6	0.0	0.0	0.	0.	0.0	0.0	0.0
2	7.4	3873.6	0.0	0.0	0.	0.	0.0	0.0	0.0
3	0.8	281.0	0.0	0.0	0.	0.	0.0	0.0	0.0
4	3.2	3548.2	0.0	0.0	0.	0.	0.0	0.0	0.0
5	0.5	925.3	0.0	0.0	0.	0.	0.0	0.0	0.0
6	10.6	25529.9	0.0	0.0	0.	0.	0.0	0.0	0.0
7	10.2	30876.0	0.0	0.0	0.	0.	0.0	0.0	0.0
8	0.2	782.0	0.0	0.0	0.	0.	0.0	0.0	0.0
9	9.7	30976.2	0.0	0.0	0.	0.	0.0	0.0	0.0
10	6.6	19486.8	0.0	0.0	0.	0.	0.0	0.0	0.0
11	2.3	6281.2	0.0	0.0	0.	0.	0.0	0.0	0.0
12	1.7	4587.9	0.0	0.0	0.	0.	0.0	0.0	0.0
13	6.1	13736.5	0.0	0.0	0.	0.	0.0	0.0	0.0
14	6.3	9811.1	0.0	0.0	0.	0.	0.0	0.0	0.0
15	4.9	2404.5	0.0	0.0	0.	0.	0.0	0.0	0.0

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

Advanced/SUFCO; 01108-010; Sta. 11+00 ; 14.7H Final; Bishop; Pseudo-Static

X:\GSTABLE\01108010\B1P.PLT Run By: DAG 4/15/2014 1:52PM



GSTABL7 v.2 FSmin=1.25

Factor Of Safety Is Calculated By The Modified Bishop Method

GSTABL7

*** 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: 4/15/2014
Time of Run: 1:52PM
Run By: DAG
Input Data Filename: X:blp.
Output Filename: X:blp.OUT
Unit System: English

Plotted Output Filename: X:blp.PLT

PROBLEM DESCRIPTION: Advanced/SUFCO; 01108-010; Sta. 11+00
; 14.7H Final; Bishop; Pseudo-Static

BOUNDARY COORDINATES

8 Top Boundaries
10 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	70.30	33.00	70.30	1
2	33.00	70.30	33.10	75.60	2
3	33.10	75.60	41.30	75.60	2
4	41.30	75.60	45.00	90.30	1
5	45.00	90.30	65.80	110.30	1
6	65.80	110.30	82.30	120.00	1
7	82.30	120.00	86.30	122.00	1
8	86.30	122.00	116.30	132.00	1
9	33.00	70.30	40.00	70.30	1
10	40.00	70.30	41.30	75.60	1

User Specified Y-Origin = 50.00(ft)

1

ISOTROPIC SOIL PARAMETERS

2 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	125.0	130.0	0.0	42.0	0.00	0.0	0
2	125.0	130.0	0.0	36.0	0.00	0.0	0

A Horizontal Earthquake Loading Coefficient
Of0.130 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of0.000 Has Been Assigned

Cavitation Pressure = 0.0(psf)

1

SOIL NAIL LOAD(S)

4 SOIL NAIL LOAD(S) SPECIFIED

Nail No.	X-Pos (ft)	Y-Pos (ft)	Nail Dia (in)	Tendon Dia (in)	Spacing (ft)	Inclin. (deg)	Length (ft)
1	44.50	88.30	4.0	1.2	5.00	15.00	29.00
2	43.24	83.30	4.0	1.2	5.00	15.00	24.00
3	41.98	78.30	4.0	1.2	5.00	15.00	14.00
4	33.09	75.30	4.0	1.2	5.00	15.00	16.00

SOIL NAIL LOAD DATA

Soil Nail No. 1 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	44.50	88.30	3600.00
2	53.53	85.47	9088.50
3	72.51	80.79	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

Soil Nail No. 2 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	43.24	83.30	3600.00
2	49.90	81.12	7831.86
3	66.42	77.09	0.00

B1P

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

Soil Nail No. 3 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	41.98	78.30	3600.00
2	43.85	77.42	5318.58
3	55.50	74.68	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

Soil Nail No. 4 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	33.09	75.30	3600.00
2	36.24	74.16	5821.24
3	48.55	71.16	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

NOTE - An Equivalent Line Load is Calculated For Each Row Of Soil Nails Assuming A Uniform Distribution Of Load Horizontally Between Individual Nails.

1

Trial Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	33.00	70.30
2	44.52	73.67
3	55.59	78.32
4	66.04	84.22
5	75.74	91.28
6	84.56	99.41
7	92.39	108.51
8	99.12	118.45
9	104.03	127.91

Circle Center At X = 9.71 ; Y = 171.76; and Radius = 104.10

* * Factor Of Safety is Calculated By The Modified Bishop Method * *

Sum of Soil Nail Forces on Failure Surface = 12642.68 (lbs)

Factor Of Safety For The Preceding Specified Surface = 1.249

The calculated factor of safety for the specified surface without piers/piles,
reinforcement, soil nails, or applied forces = 1.051

Table 1 - Individual Data on the 15 Slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Tie Force Norm (lbs)	Tie Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	0.1	32.9	0.0	0.0	0.0	0.0	4.3	0.0	0.0
2	7.4	3890.2	0.0	0.0	0.0	0.0	505.7	0.0	0.0
3	0.8	283.0	0.0	0.0	0.0	0.0	36.8	0.0	0.0
4	3.2	3541.0	0.0	0.0	0.0	0.0	460.3	0.0	0.0
5	0.5	934.5	0.0	0.0	0.0	0.0	121.5	0.0	0.0
6	10.6	25542.5	0.0	0.0	0.0	0.0	3320.5	0.0	0.0
7	10.2	30871.3	0.0	0.0	0.0	0.0	4013.3	0.0	0.0
8	0.2	786.5	0.0	0.0	0.0	0.0	102.3	0.0	0.0
9	9.7	30970.0	0.0	0.0	0.0	0.0	4026.1	0.0	0.0
10	6.6	19490.1	0.0	0.0	0.0	0.0	2533.7	0.0	0.0
11	2.3	6270.5	0.0	0.0	0.0	0.0	815.2	0.0	0.0
12	1.7	4598.8	0.0	0.0	0.0	0.0	597.8	0.0	0.0
13	6.1	13735.9	0.0	0.0	0.0	0.0	1785.7	0.0	0.0
14	6.7	9818.8	0.0	0.0	0.0	0.0	1276.4	0.0	0.0
15	4.9	2400.8	0.0	0.0	0.0	0.0	312.1	0.0	0.0

Table 2 - Base Stress Data on the 15 Slices

Slice No. *	Alpha (deg)	X-Coord. Slice Cntr (ft)	Base Leng. (ft)	Available Shear Strength (psf)	Mobilized Shear Stress (psf)
1	16.31	33.05	0.10	236.63	1412.45
2	16.31	36.82	7.75	375.54	158.67
3	16.31	40.92	0.79	319.09	274.90
4	16.31	42.91	3.35	941.07	337.44
5	22.79	44.76	0.52	1532.25	960.07
6	22.79	50.29	11.49	1898.19	873.20
7	29.45	60.69	11.72	2180.93	1306.25
8	29.45	65.92	0.28	2363.89	1903.48
9	36.05	70.89	12.00	2104.51	1530.59
10	42.67	79.02	8.92	1776.50	1496.07
11	42.67	83.43	3.07	1659.02	1427.57
12	49.29	85.43	2.67	1417.19	1358.40
13	49.29	89.35	9.34	1209.41	1129.89
14	55.90	95.75	12.00	689.16	688.80
15	62.57	101.57	10.66	197.39	212.86

NOTE: Pier/Pile, reinforcement, soil nail, and applied forces (if applicable)

B1P

are included in the Available Shear values in Table 2 by uniform distribution on each slice base, based upon the converged factor of safety.

Sum of the Resisting Forces (including Pier/Pile, Tieback, Reinforcing Soil Nail, and Applied Forces if applicable) = 127006.92 (lbs)

Average Available Shear Strength (including Tieback, Pier/Pile, Reinforcing, Soil Nail, and Applied Forces if applicable) = 1341.57(psf)

Sum of the Driving Forces = 101703.55 (lbs)

Average Mobilized Shear Stress = 1074.29(psf)

Total length of the failure surface = 94.67(ft)

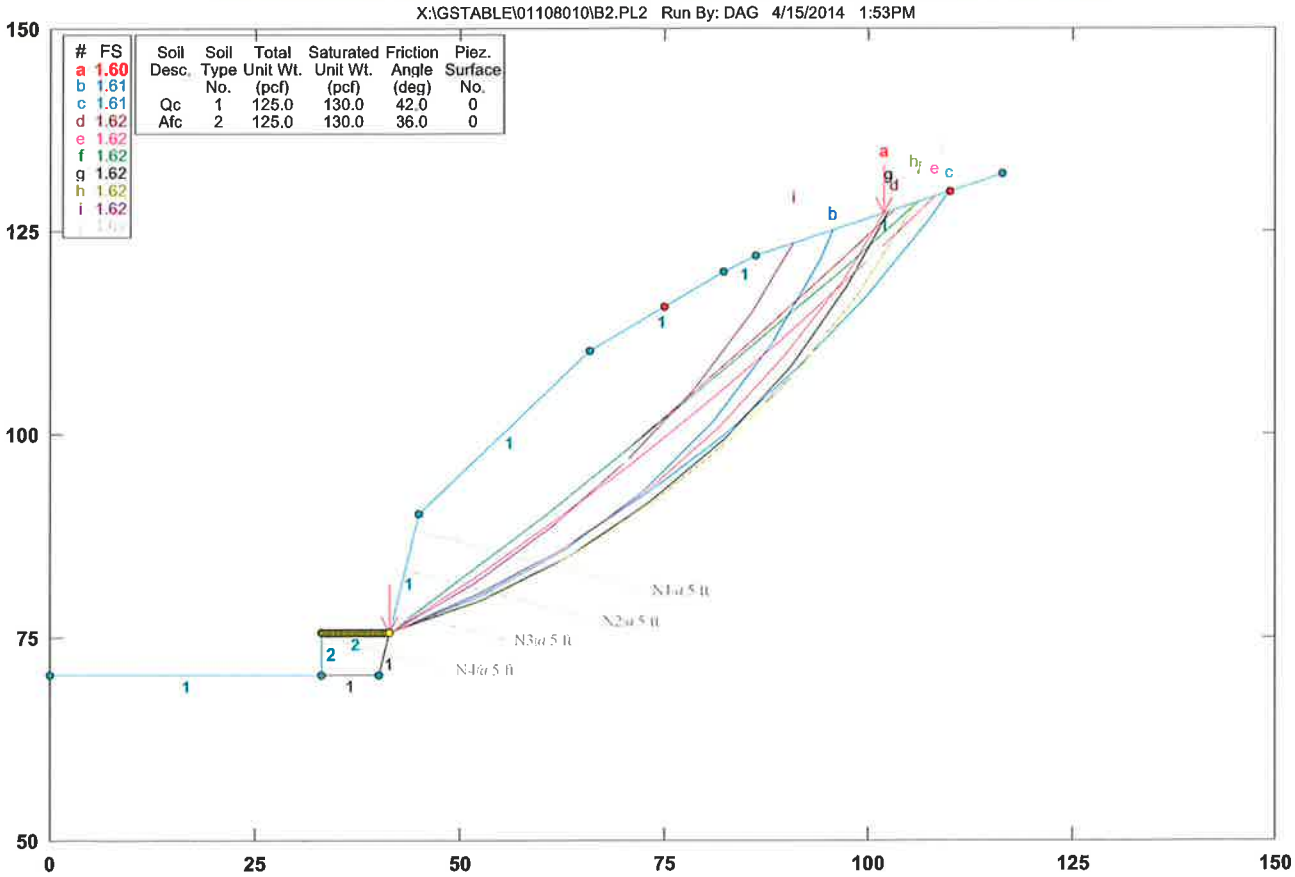
CAUTION - Factor Of Safety Is Calculated By The Modified Bishop Method. This Method Is Valid Only If The Failure Surface Approximates A Circular Arc.

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

B1P

Advanced/SUFCO; 01108-010; Sta. 11+00 ; 14.7H Final; Bishop (FG) Static

X:\GSTABLE\01108010\B2.PL2 Run By: DAG 4/15/2014 1:53PM



GSTABL7 v.2 FSmin=1.60

Safety Factors Are Calculated By The Modified Bishop Method

GSTABL7

*** 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: 4/15/2014
Time of Run: 1:53PM
Run By: DAG
Input Data Filename: X:b2.
Output Filename: X:b2.OUT
Unit System: English

Plotted Output Filename: X:b2.PLT

PROBLEM DESCRIPTION: Advanced/SUFCO; 01108-010; Sta. 11+00
; 14.7H Final; Bishop (FG) Static

BOUNDARY COORDINATES

8 Top Boundaries
10 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	70.30	33.00	70.30	1
2	33.00	70.30	33.10	75.60	2
3	33.10	75.60	41.30	75.60	2
4	41.30	75.60	45.00	90.30	1
5	45.00	90.30	65.80	110.30	1
6	65.80	110.30	82.30	120.00	1
7	82.30	120.00	86.30	122.00	1
8	86.30	122.00	116.30	132.00	1
9	33.00	70.30	40.00	70.30	1
10	40.00	70.30	41.30	75.60	1

User Specified Y-Origin = 50.00(ft)

ISOTROPIC SOIL PARAMETERS

2 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	125.0	130.0	0.0	42.0	0.00	0.0	0
2	125.0	130.0	0.0	36.0	0.00	0.0	0

SOIL NAIL LOAD(S)

4 SOIL NAIL LOAD(S) SPECIFIED

Nail No.	X-Pos (ft)	Y-Pos (ft)	Nail Dia (in)	Tendon Dia (in)	Spacing (ft)	Inclin. (deg)	Length (ft)
1	44.50	88.30	4.0	1.2	5.00	15.00	29.00
2	43.24	83.30	4.0	1.2	5.00	15.00	24.00
3	41.98	78.30	4.0	1.2	5.00	15.00	14.00
4	33.09	75.30	4.0	1.2	5.00	15.00	16.00

SOIL NAIL LOAD DATA

Soil Nail No. 1 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	44.50	88.30	3600.00
2	53.53	85.47	9088.50
3	72.51	80.79	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

Soil Nail No. 2 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	43.24	83.30	3600.00
2	49.90	81.12	7831.86
3	66.42	77.09	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

Soil Nail No. 3 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	41.98	78.30	3600.00
2	43.85	77.42	5318.58
3	55.50	74.68	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

Soil Nail No. 4 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	33.09	75.30	3600.00
2	36.24	74.16	5821.24
3	48.55	71.16	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

NOTE - An Equivalent Line Load Is Calculated For Each Row Of Soil Nails
Assuming A Uniform Distribution Of Load Horizontally Between
Individual Nails.

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.

1600 Trial Surfaces Have Been Generated.

40 Surface(s) Initiate(s) From Each Of 40 Points Equally Spaced
Along The Ground Surface Between X = 33.10(ft)
and X = 41.30(ft)

Each Surface Terminates Between X = 75.00(ft)
and X = 110.00(ft)

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00(ft)

12.00(ft) Line Segments Define Each Trial Failure Surface.

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

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

Total Number of Trial Surfaces Evaluated = 1600

Statistical Data On All Valid FS Values:
FS Max = 2.370 FS Min = 1.601 FS Ave = 1.974
Standard Deviation = 0.076 Coefficient of Variation = 3.87 %

Failure Surface Specified By 8 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	41.30	75.60
2	52.34	80.31
3	62.83	86.13
4	72.66	93.02
5	81.72	100.89
6	89.91	109.66
7	97.15	119.23
8	101.98	127.23

Circle Center At X = 2.04 ; Y = 183.23 ; and Radius = 114.56

Factor of Safety
*** 1.601 ***

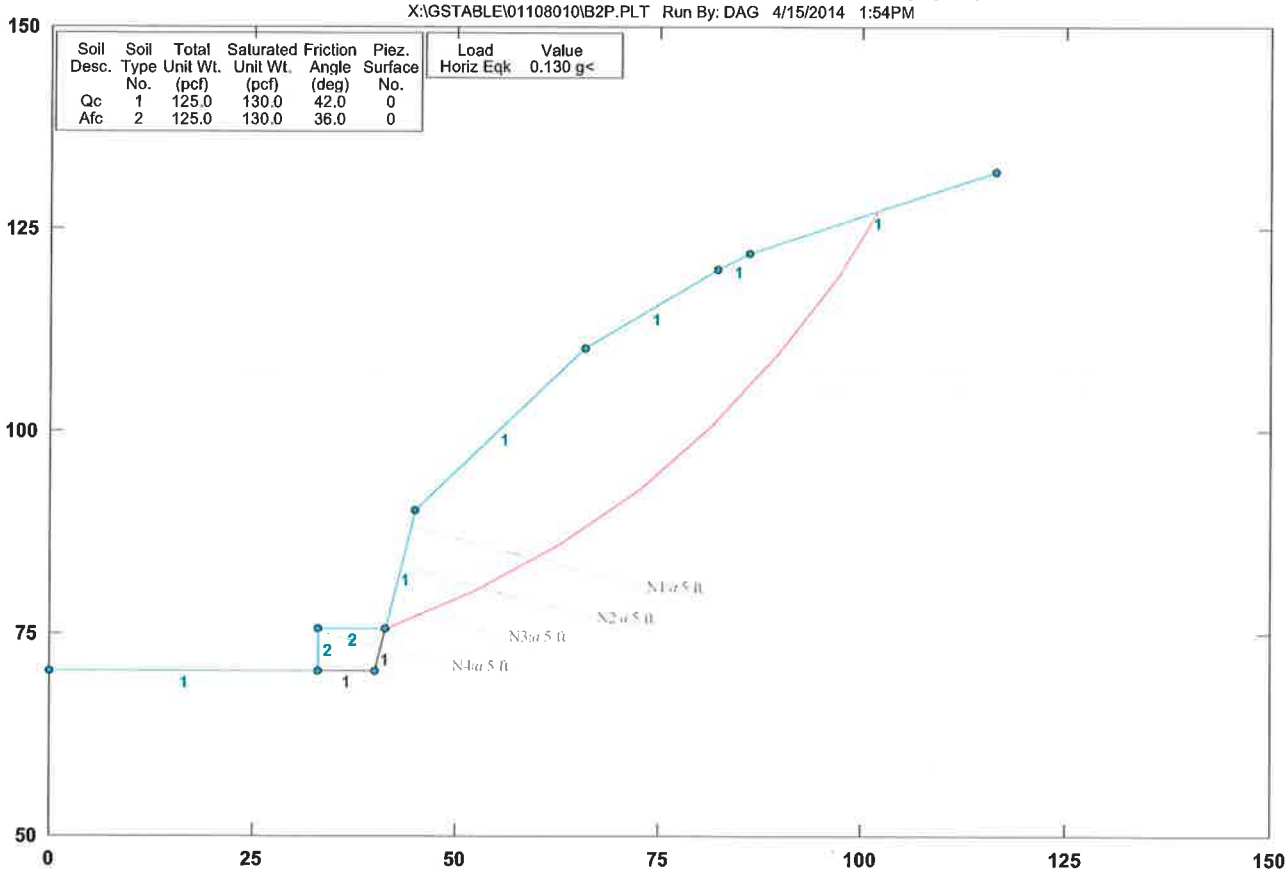
Individual data on the 11 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Tie Force Norm (lbs)	Tie Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	3.7	3034.0	0.0	0.0	0.	0.	0.0	0.0	0.0
2	7.3	13840.0	0.0	0.0	0.	0.	0.0	0.0	0.0
3	10.5	25150.8	0.0	0.0	0.	0.	0.0	0.0	0.0
4	3.0	8055.8	0.0	0.0	0.	0.	0.0	0.0	0.0
5	6.9	18601.5	0.0	0.0	0.	0.	0.0	0.0	0.0
6	9.1	22695.8	0.0	0.0	0.	0.	0.0	0.0	0.0
7	0.6	1355.9	0.0	0.0	0.	0.	0.0	0.0	0.0
8	4.0	8674.3	0.0	0.0	0.	0.	0.0	0.0	0.0
9	3.6	6715.3	0.0	0.0	0.	0.	0.0	0.0	0.0
10	7.2	9018.7	0.0	0.0	0.	0.	0.0	0.0	0.0
11	4.8	1929.4	0.0	0.0	0.	0.	0.0	0.0	0.0

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

Advanced/SUFCO; 01108-010; Sta. 11+00 ; 14.7H Final; Bishop (FG) Pseudo-Static

X:\GSTABLE\01108010\B2P.PLT Run By: DAG 4/15/2014 1:54PM



GSTABL7 v.2 FSmin=1.31

Factor Of Safety Is Calculated By The Modified Bishop Method

GSTABL7

*** 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: 4/15/2014
Time of Run: 1:54PM
Run By: DAG
Input Data Filename: X:b2p.
Output Filename: X:b2p.OUT
Unit System: English

Plotted Output Filename: X:b2p.PLT

PROBLEM DESCRIPTION: Advanced/SUFCO; 01108-010; Sta. 11+00
; 14.7H Final; Bishop (FG) Pseudo-Static

BOUNDARY COORDINATES

8 Top Boundaries
10 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	70.30	33.00	70.30	1
2	33.00	70.30	33.10	75.60	2
3	33.10	75.60	41.30	75.60	2
4	41.30	75.60	45.00	90.30	1
5	45.00	90.30	65.80	110.30	1
6	65.80	110.30	82.30	120.00	1
7	82.30	120.00	86.30	122.00	1
8	86.30	122.00	116.30	132.00	1
9	33.00	70.30	40.00	70.30	1
10	40.00	70.30	41.30	75.60	1

User Specified Y-Origin = 50.00(ft)

1

ISOTROPIC SOIL PARAMETERS

2 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	125.0	130.0	0.0	42.0	0.00	0.0	0
2	125.0	130.0	0.0	36.0	0.00	0.0	0

A Horizontal Earthquake Loading Coefficient
Of0.130 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of0.000 Has Been Assigned

Cavitation Pressure = 0.0(psf)

1

SOIL NAIL LOAD(S)

4 SOIL NAIL LOAD(S) SPECIFIED

Nail No.	X-Pos (ft)	Y-Pos (ft)	Nail Dia (in)	Tendon Dia (in)	Spacing (ft)	Inclin. (deg)	Length (ft)
1	44.50	88.30	4.0	1.2	5.00	15.00	29.00
2	43.24	83.30	4.0	1.2	5.00	15.00	24.00
3	41.98	78.30	4.0	1.2	5.00	15.00	14.00
4	33.09	75.30	4.0	1.2	5.00	15.00	16.00

SOIL NAIL LOAD DATA

Soil Nail No. 1 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	44.50	88.30	3600.00
2	53.53	85.47	9088.50
3	72.51	80.79	0.00

B2P

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

Soil Nail No. 2 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	43.24	83.30	3600.00
2	49.90	81.12	7831.86
3	66.42	77.09	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

Soil Nail No. 3 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	41.98	78.30	3600.00
2	43.85	77.42	5318.58
3	55.50	74.68	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

Soil Nail No. 4 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	33.09	75.30	3600.00
2	36.24	74.16	5821.24
3	48.55	71.16	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

NOTE - An Equivalent Line Load is Calculated For Each Row Of Soil Nails
Assuming A Uniform Distribution Of Load Horizontally Between
Individual Nails.

1

Trial Failure Surface Specified By 8 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	41.30	75.60
2	52.34	80.31
3	62.83	86.13
4	72.66	93.02
5	81.72	100.89
6	89.91	109.66
7	97.15	119.23
8	101.98	127.23

Circle Center At X = 2.03 ; Y = 183.23; and Radius = 114.57

* * Factor Of Safety Is Calculated By The Modified Bishop Method * *

Sum of Soil Nail Forces on Failure Surface = 15568.73 (lbs)

Factor Of Safety For The Preceding Specified Surface = 1.310

The calculated factor of safety for the specified surface without piers/piles,
reinforcement, soil nails, or applied forces = 1.000

Table 1 - Individual Data on the 11 Slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Tie Force Norm (lbs)	Tie Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	3.7	3034.3	0.0	0.0	0.0	0.0	394.5	0.0	0.0
2	7.3	13840.1	0.0	0.0	0.0	0.0	1799.2	0.0	0.0
3	10.5	25151.0	0.0	0.0	0.0	0.0	3269.6	0.0	0.0
4	3.0	8056.6	0.0	0.0	0.0	0.0	1047.4	0.0	0.0
5	6.9	18608.2	0.0	0.0	0.0	0.0	2419.1	0.0	0.0
6	9.1	22696.3	0.0	0.0	0.0	0.0	2950.5	0.0	0.0
7	0.6	1350.6	0.0	0.0	0.0	0.0	175.6	0.0	0.0
8	4.0	8673.6	0.0	0.0	0.0	0.0	1127.6	0.0	0.0
9	3.6	6712.1	0.0	0.0	0.0	0.0	872.6	0.0	0.0
10	7.2	9018.3	0.0	0.0	0.0	0.0	1172.4	0.0	0.0
11	4.8	1928.0	0.0	0.0	0.0	0.0	250.6	0.0	0.0

Table 2 - Base Stress Data on the 11 Slices

B2P

Slice No. *	Alpha (deg)	X-Coord. Slice Cntr (ft)	Base Leng. (ft)	Available Shear Strength (psf)	Mobilized Shear Stress (psf)
1	23.10	43.15	4.02	698.45	327.35
2	23.10	48.67	7.98	1605.88	696.37
3	29.02	57.58	12.00	1884.85	1027.65
4	35.03	64.32	3.63	1960.56	1309.74
5	35.03	69.23	8.38	1960.50	1289.98
6	40.98	77.19	12.00	1657.16	1250.75
7	46.96	82.01	0.85	1397.68	1309.97
8	46.96	84.30	5.86	1301.51	1103.19
9	46.96	88.11	5.29	1115.99	951.32
10	52.89	93.53	12.00	670.51	609.84
11	58.87	99.57	9.34	188.94	190.15

NOTE: Pier/Pile, reinforcement, soil nail, and applied forces (if applicable)
are included in the Available Shear values in Table 2 by uniform distribution on each slice base, based upon the converged factor of safety.

Sum of the Resisting Forces (including Pier/Pile, Tieback, Reinforcing Soil Nail, and Applied Forces if applicable) = 106274.24 (lbs)

Average Available Shear Strength (including Tieback, Pier/Pile, Reinforcing, Soil Nail, and Applied Forces if applicable) = 1306.45(psf)

Sum of the Driving Forces = 81150.83 (lbs)

Average Mobilized Shear Stress = 997.60(psf)

Total length of the failure surface = 81.35(ft)

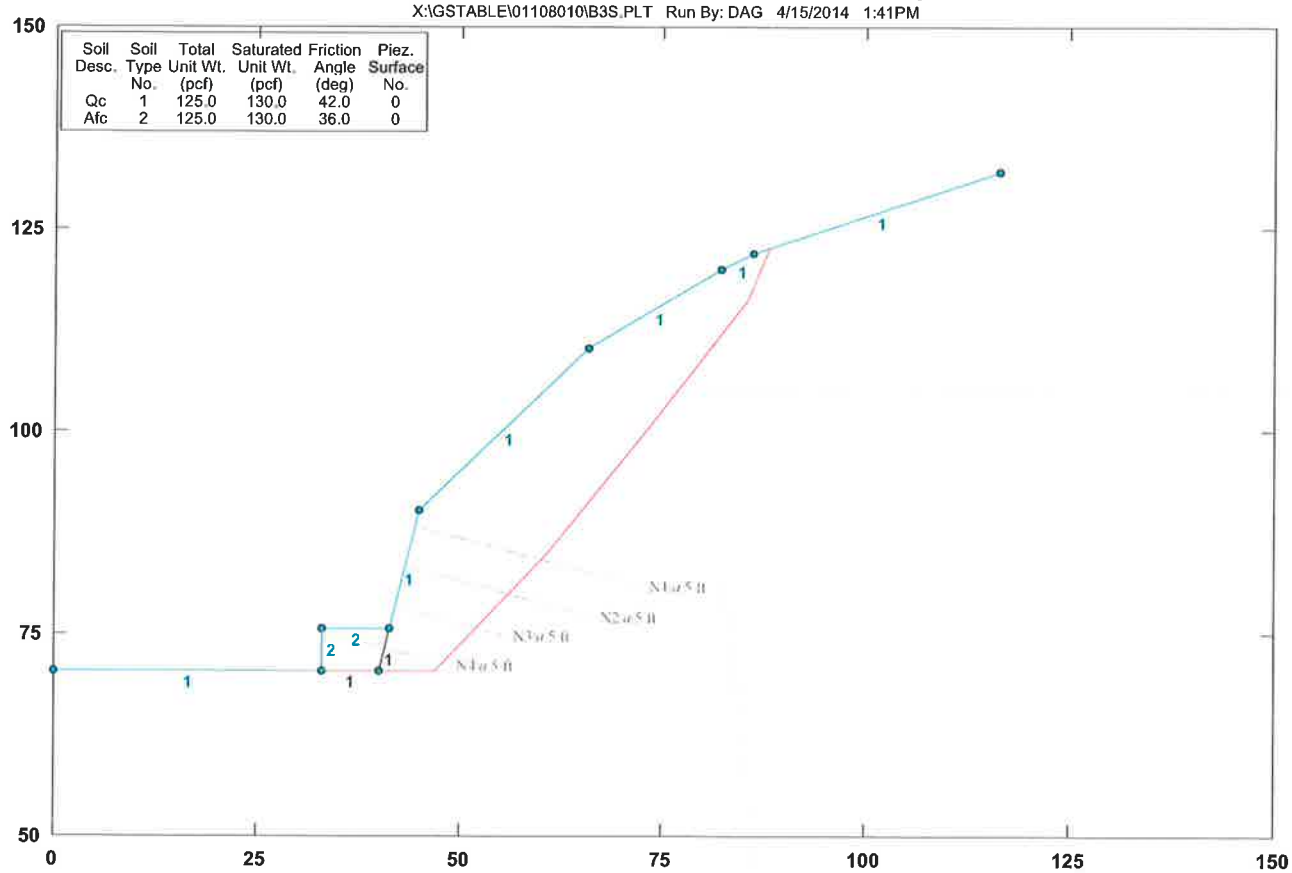
CAUTION - Factor Of Safety Is Calculated By The Modified Bishop Method. This Method Is Valid Only If The Failure Surface Approximates A Circular Arc.

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

B2P

Advanced/SUFCO; 01108-010; Sta. 11+00 ; 14.7H Final; Spencer's; Static

X:\GSTABLE\01108010\B3S.PLT Run By: DAG 4/15/2014 1:41PM



GSTABL7 v.2 FSmin=1.52

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-1)

GSTABL7

*** 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: 4/15/2014
Time of Run: 1:41PM
Run By: DAG
Input Data Filename: X:B3S.
Output Filename: X:B3S.OUT
Unit System: English

Plotted Output Filename: X:B3S.PLT

PROBLEM DESCRIPTION: Advanced/SUFCO; 01108-010; Sta. 11+00
; 14.7H Final; Spencer's; Static

BOUNDARY COORDINATES

8 Top Boundaries
10 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	70.30	33.00	70.30	1
2	33.00	70.30	33.10	75.60	2
3	33.10	75.60	41.30	75.60	2
4	41.30	75.60	45.00	90.30	1
5	45.00	90.30	65.80	110.30	1
6	65.80	110.30	82.30	120.00	1
7	82.30	120.00	86.30	122.00	1
8	86.30	122.00	116.30	132.00	1
9	33.00	70.30	40.00	70.30	1
10	40.00	70.30	41.30	75.60	1

User Specified Y-Origin = 50.00(ft)

1

ISOTROPIC SOIL PARAMETERS

2 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	125.0	130.0	0.0	42.0	0.00	0.0	0
2	125.0	130.0	0.0	36.0	0.00	0.0	0

1

SOIL NAIL LOAD(S)

4 SOIL NAIL LOAD(S) SPECIFIED

Nail No.	X-Pos (ft)	Y-Pos (ft)	Nail Dia (in)	Tendon Dia (in)	Spacing (ft)	Inclin. (deg)	Length (ft)
1	44.50	88.30	4.0	1.2	5.00	15.00	29.00
2	43.24	83.30	4.0	1.2	5.00	15.00	24.00
3	41.98	78.30	4.0	1.2	5.00	15.00	14.00
4	33.09	75.30	4.0	1.2	5.00	15.00	16.00

SOIL NAIL LOAD DATA

Soil Nail No. 1 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	44.50	88.30	3600.00
2	53.53	85.47	9088.50
3	72.51	80.79	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

Soil Nail No. 2 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	43.24	83.30	3600.00
2	49.90	81.12	7831.86
3	66.42	77.09	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

Soil Nail No. 3 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	41.98	78.30	3600.00
2	43.85	77.42	5318.58
3	55.50	74.68	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

Soil Nail No. 4 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	33.09	75.30	3600.00
2	36.24	74.16	5821.24
3	48.55	71.16	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

NOTE - An Equivalent Line Load Is Calculated For Each Row Of Soil Nails Assuming A Uniform Distribution Of Load Horizontally Between Individual Nails.

Trial Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	33.00	70.30
2	46.95	70.30
3	60.67	84.85
4	73.31	100.35
5	85.53	116.18
6	88.23	122.64

Sum of the Soil Nail Forces = 9769.12(lbs)

Theta (deg) (ki=1.0)	FOS (Moment) (Equil.)	FOS (Force) (Equil.)	Lambda
39.50	1.636	1.532	0.824
59.25	161.364	20.000	1.681
39.48	1.636	1.532	0.824
39.47	1.518	1.518	0.823

Factor Of Safety For The Preceding Specified Surface = 1.518
Theta (ki = 1.0) = 39.47 Deg Lambda = 0.823

Factor Of Safety Is Calculated By GLE (Spencer's) Method (0-1)

Forces from Reinforcement, Piers/Piles, Applied Forces, and Soil Nails (if applicable) have been applied to the slice base(s) on which they intersect.

Selected ki function = Constant (1.0)

Selected Lambda Coefficient = 1.00

The option of water in the tension crack on the last slice has been selected.

*** Line of Thrust and Side Force Data ***

Slice No.	X Coord.	Y Coord.	L/H	Side Force (lbs)	ki	Force Angle (Deg)
1	33.10	70.34	0.008	34.	1.000	39.47
2	40.00	73.16	0.540	4710.	1.000	39.47
3	41.30	73.50	0.604	6003.	1.000	39.47
4	45.00	73.74	0.172	14787.	1.000	39.47
5	46.95	73.90	0.164	22449.	1.000	39.47
6	60.67	85.74	0.044	17553.	1.000	39.47
7	65.80	89.92	-0.064	12913.	1.000	39.47
8	73.31	93.91	-0.448	7174.	1.000	39.47
9	82.30	83.18	-3.600	2301.	1.000	39.47
10	85.53	60.93	-10.165	1249.	1.000	39.47
11	86.30	46.11	-18.084	978.	1.000	39.47
12	88.23	17.24	0.000	691.	1.000	39.47

Table 1 - Individual data on the 12 slices

Water Water Tie Tie Earthquake

B3S

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

Slice No.	Width (ft)	Weight (lbs)	Force Top (lbs)	Force Bot (lbs)	Force Norm (lbs)	Force Tan (lbs)	Force Hor (lbs)	Force Ver (lbs)	Surcharge Load (lbs)
1	0.1	33.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	6.9	4571.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	1.3	861.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	3.7	5850.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	2.0	5103.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	13.7	36351.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	5.1	12721.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	7.5	15735.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	9.0	12568.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	3.2	2713.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.8	452.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	1.9	479.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0

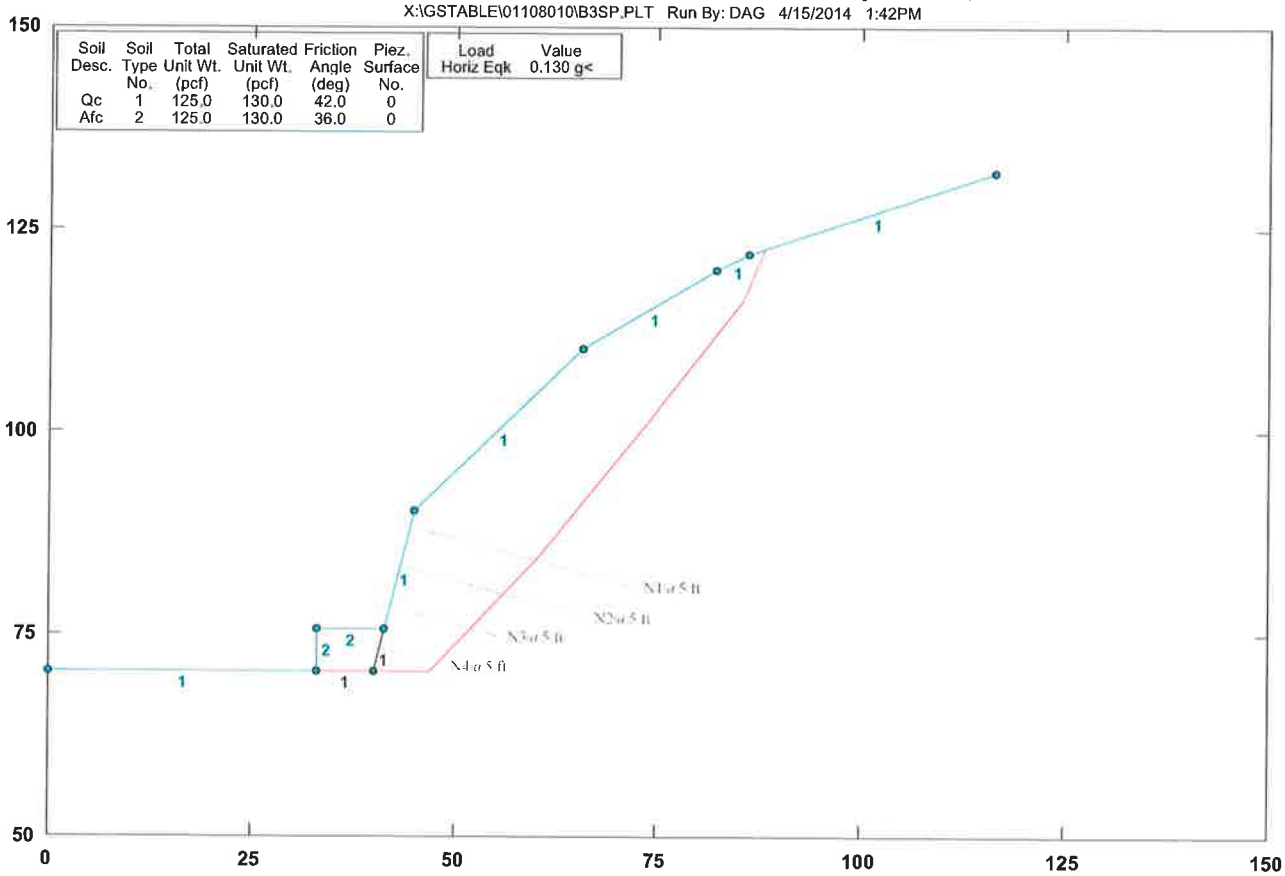
- TABLE 2 - Base Stress Data on the 12 Slices -

Slice No. *	Alpha (deg)	X-Coord. Slice Cntr (ft)	Base Leng. (ft)	Total Normal Stress (psf)	Total Vert. Stress (psf)	Mobilized Shear Stress (psf)
1	0.00	33.05	0.10	546.63	331.25	261.60
2	0.00	36.55	6.90	1093.27	662.50	523.20
3	0.00	40.65	1.30	1294.73	662.50	767.88
4	0.00	43.15	3.70	3090.25	1581.25	1832.77
5	0.00	45.97	1.95	5114.79	2617.19	3033.48
6	46.68	53.81	20.00	1277.79	1817.70	757.83
7	50.80	63.24	8.12	1102.81	1567.19	654.06
8	50.80	69.56	11.88	931.81	1324.17	552.64
9	52.33	77.81	14.71	595.80	854.31	353.36
10	52.33	83.92	5.29	357.95	513.26	212.29
11	67.33	85.92	2.00	150.74	226.74	89.40
12	67.33	87.26	5.01	63.69	95.80	37.77

B3S

Advanced/SUFCO; 01108-010; Sta. 11+00 ; 14.7H Final; Spencer's; Pseudo-Static

X:\GSTABLE\01108010\B3SP.PLT Run By: DAG 4/15/2014 1:42PM



GSTABL7 v.2 FSmin=1.34

Factor Of Safety Is Calculated By GLE (Spencer`s) Method (0-1)

*** GSTABL7 *** 1

** 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: 4/15/2014
Time of Run: 1:42PM
Run By: DAG
Input Data Filename: X:B3SP.
Output Filename: X:B3SP.OUT 1
Unit System: English

Plotted Output Filename: X:B3SP.PLT

PROBLEM DESCRIPTION: Advanced/SUPCO; 01108-010; Sta. 11+00
; 14.7H Final; Spencer's; Pseudo-Static

BOUNDARY COORDINATES

8 Top Boundaries
10 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	70.30	33.00	70.30	1
2	33.00	70.30	33.10	75.60	2
3	33.10	75.60	41.30	75.60	2
4	41.30	75.60	45.00	90.30	1
5	45.00	90.30	65.80	110.30	1
6	65.80	110.30	82.30	120.00	1
7	82.30	120.00	86.30	122.00	1
8	86.30	122.00	116.30	132.00	1
9	33.00	70.30	40.00	70.30	1
10	40.00	70.30	41.30	75.60	1

User Specified Y-Origin = 50.00(ft)

ISOTROPIC SOIL PARAMETERS

2 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	125.0	130.0	0.0	42.0	0.00	0.0	0
2	125.0	130.0	0.0	36.0	0.00	0.0	0

A Horizontal Earthquake Loading Coefficient
Of0.130 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of0.000 Has Been Assigned

Cavitation Pressure = 0.0(psf)

SOIL NAIL LOAD(S)

4 SOIL NAIL LOAD(S) SPECIFIED

Nail No.	X-Pos (ft)	Y-Pos (ft)	Nail Dia (in)	Tendon Dia (in)	Spacing (ft)	Inclin. (deg)	Length (ft)
1	44.50	88.30	4.0	1.2	5.00	15.00	29.00
2	43.24	83.30	4.0	1.2	5.00	15.00	24.00
3	41.98	78.30	4.0	1.2	5.00	15.00	14.00
4	33.09	75.30	4.0	1.2	5.00	15.00	16.00

SOIL NAIL LOAD DATA

Soil Nail No. 1 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	44.50	88.30	3600.00
2	53.53	85.47	9088.50
3	72.51	80.79	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

Soil Nail No. 2 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	43.24	83.30	3600.00
2	49.90	81.12	7831.86
3	66.42	77.09	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

Soil Nail No. 3 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	41.98	78.30	3600.00
2	43.85	77.42	5318.58
3	55.50	74.68	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

Soil Nail No. 4 3 Load Points Apply to This Nail
Load Diagram Type = 3

POINT NO.	X-COORD.(ft)	Y-COORD.(ft)	FORCE(lbs)
1	33.09	75.30	3600.00
2	36.24	74.16	5821.24
3	48.55	71.16	0.00

Allowable Pullout Stress = 2400.0(psf)
Allowable Tendon Stress = 60000.0(psi)
Allowable Nail Head Load = 18000.0(lbs)

NOTE - An Equivalent Line Load Is Calculated For Each Row Of Soil Nails
Assuming A Uniform Distribution Of Load Horizontally Between
Individual Nails.

1

Trial Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	33.00	70.30
2	46.95	70.30
3	60.67	84.85
4	73.31	100.35
5	85.53	116.18
6	88.23	122.64

Sum of the Soil Nail Forces = 9769.12(lbs)

Theta (deg) (ki=1.0)	FOS (Moment) (Equil.)	FOS (Force) (Equil.)	Lambda
39.50	1.350	1.274	0.824
59.25	0.000	0.799	1.681
41.79	1.350	1.315	0.894
36.95	1.341	1.235	0.752
46.59	1.257	1.419	1.057
42.04	1.349	1.320	0.902
41.46	1.351	1.309	0.883
44.09	1.331	1.361	0.969
42.62	1.346	1.331	0.920
42.79	1.345	1.335	0.926
43.33	1.341	1.346	0.943
43.16	1.342	1.342	0.938

Factor Of Safety For The Preceding Specified Surface = 1.342
Theta (ki = 1.0) = 43.16 Deg Lambda = 0.938

Factor Of Safety Is Calculated By GLE (Spencer's) Method (0-1)

Forces from Reinforcement, Piers/Piles, Applied Forces, and Soil Nails
(if applicable) have been applied to the slice base(s)
on which they intersect.

Selected ki function = Constant (1.0)

Selected Lambda Coefficient = 1.00

The option of water in the tension crack on
the last slice has been selected.

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

B3SP

USGS Design Maps Detailed Report

2012 International Building Code (38.9142°N, 111.417°W)

Site Class B – "Rock", Risk Category I/II/III

Section 1613.3.1 — Mapped acceleration parameters

Note: Ground motion values provided below are for the direction of maximum horizontal spectral response acceleration. They have been converted from corresponding geometric mean ground motions computed by the USGS by applying factors of 1.1 (to obtain S_S) and 1.3 (to obtain S_1). Maps in the 2012 International Building Code are provided for Site Class B. Adjustments for other Site Classes are made, as needed, in Section 1613.3.3.

From Figure 1613.3.1(1) [1] $S_S = 0.630$ g

From Figure 1613.3.1(2) [2] $S_1 = 0.175$ g

Section 1613.3.2 — Site class definitions

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class B, based on the site soil properties in accordance with Section 1613.

2010 ASCE-7 Standard – Table 20.3-1
SITE CLASS DEFINITIONS

Site Class	$\bar{v}_s$	$\bar{N}$ or $\bar{N}_{ch}$	$\bar{s}_u$
A. Hard Rock	>5,000 ft/s	N/A	N/A
B. Rock	2,500 to 5,000 ft/s	N/A	N/A
C. Very dense soil and soft rock	1,200 to 2,500 ft/s	>50	>2,000 psf
D. Stiff Soil	600 to 1,200 ft/s	15 to 50	1,000 to 2,000 psf
E. Soft clay soil	<600 ft/s	<15	<1,000 psf
	Any profile with more than 10 ft of soil having the characteristics: • Plasticity index $PI > 20$, • Moisture content $w \geq 40\%$, and • Undrained shear strength $\bar{s}_u < 500$ psf		
F. Soils requiring site response analysis in accordance with Section 21.1	See Section 20.3.1		

For SI: 1ft/s = 0.3048 m/s 1lb/ft² = 0.0479 kN/m²

Section 1613.3.3 — Site coefficients and adjusted maximum considered earthquake spectral response acceleration parameters

TABLE 1613.3.3(1)
VALUES OF SITE COEFFICIENT F_a

Site Class	Mapped Spectral Response Acceleration at Short Period				
	$S_S \leq 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use straight-line interpolation for intermediate values of S_S

For Site Class = B and S_S = 0.630 g, F_a = 1.000

TABLE 1613.3.3(2)
VALUES OF SITE COEFFICIENT F_v

Site Class	Mapped Spectral Response Acceleration at 1-s Period				
	$S_1 \leq 0.10$	$S_1 = 0.20$	$S_1 = 0.30$	$S_1 = 0.40$	$S_1 \geq 0.50$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See Section 11.4.7 of ASCE 7				

Note: Use straight-line interpolation for intermediate values of S_1

For Site Class = B and S_1 = 0.175 g, F_v = 1.000

Equation (16-37): $S_{MS} = F_a S_S = 1.000 \times 0.630 = 0.630$ g

Equation (16-38): $S_{M1} = F_v S_1 = 1.000 \times 0.175 = 0.175$ g

Section 1613.3.4 — Design spectral response acceleration parameters

Equation (16-39): $S_{DS} = \frac{2}{3} S_{MS} = \frac{2}{3} \times 0.630 = 0.420$ g

Equation (16-40): $S_{D1} = \frac{2}{3} S_{M1} = \frac{2}{3} \times 0.175 = 0.117$ g

Section 1613.3.5 — Determination of seismic design category

TABLE 1613.3.5(1)
SEISMIC DESIGN CATEGORY BASED ON SHORT-PERIOD (0.2 second) RESPONSE ACCELERATION

VALUE OF S_{DS}	RISK CATEGORY		
	I or II	III	IV
$S_{DS} < 0.167g$	A	A	A
$0.167g \le S_{DS} < 0.33g$	B	B	C
$0.33g \le S_{DS} < 0.50g$	C	C	D
$0.50g \le S_{DS}$	D	D	D

For Risk Category = I and S_{DS} = 0.420 g, Seismic Design Category = C

TABLE 1613.3.5(2)
SEISMIC DESIGN CATEGORY BASED ON 1-SECOND PERIOD RESPONSE ACCELERATION

VALUE OF S_{D1}	RISK CATEGORY		
	I or II	III	IV
$S_{D1} < 0.067g$	A	A	A
$0.067g \le S_{D1} < 0.133g$	B	B	C
$0.133g \le S_{D1} < 0.20g$	C	C	D
$0.20g \le S_{D1}$	D	D	D

For Risk Category = I and S_{D1} = 0.117 g, Seismic Design Category = B

Note: When S_1 is greater than or equal to 0.75g, the Seismic Design Category is **E** for buildings in Risk Categories I, II, and III, and **F** for those in Risk Category IV, irrespective of the above.

Seismic Design Category ≡ "the more severe design category in accordance with Table 1613.3.5(1) or 1613.3.5(2)" = C

Note: See Section 1613.3.5.1 for alternative approaches to calculating Seismic Design Category.

References

1. *Figure 1613.3.1(1)*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/IBC-2012-Fig1613p3p1(1).pdf
2. *Figure 1613.3.1(2)*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/IBC-2012-Fig1613p3p1(2).pdf

USGS Design Maps Summary Report

User-Specified Input

Report Title SUFCO Mine Wall Site Class B
Tue April 15, 2014 16:08:22 UTC

Building Code Reference Document 2012 International Building Code
(which utilizes USGS hazard data available in 2008)

Site Coordinates 38.9142°N, 111.417°W

Site Soil Classification Site Class B – "Rock"

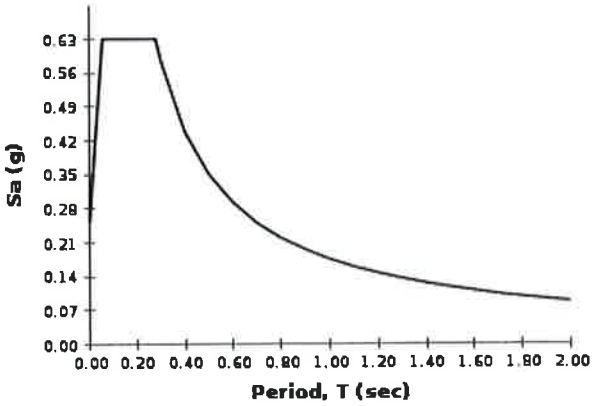
Risk Category I/II/III

USGS-Provided Output

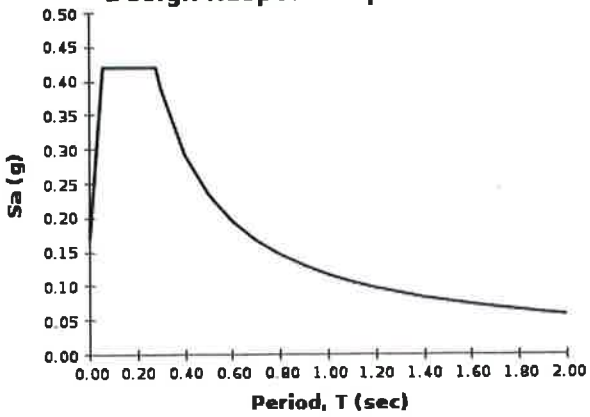
S_S =	0.630 g	S_{MS} =	0.630 g	S_{DS} =	0.420 g
S_1 =	0.175 g	S_{M1} =	0.175 g	S_{D1} =	0.117 g

For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.

MCE_R Response Spectrum



Design Response Spectrum



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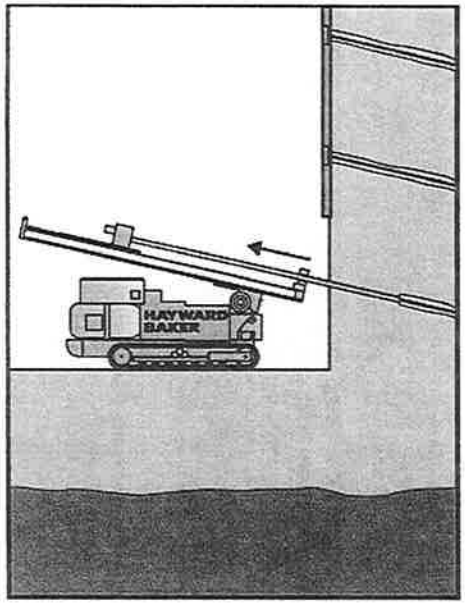

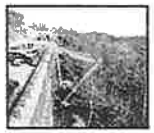

Soil Nailing

Soil nailing is an earth retention technique using grouted tension-resisting steel elements (nails) that can be design for permanent or temporary support. The walls are generally constructed from the top down. Typically, 3 to 6 feet of soil is excavated from the top of the planned excavation. Near-horizontal holes are drilled into the exposed face at typically 3 to 6 foot centers. Tension-resisting steel bars are inserted into the holes and grouted. A drainage system is installed on the exposed face, followed by the application of reinforced shotcrete facing. Precast face panels have also been used instead of shotcrete. Bearing plates are then fixed to the heads of the soil nails. The soil at the base of this first stage is then removed to a depth of about 3 to 6 feet. The installation process is repeated until the design wall depth is reached. The finished soil nails produce a zone of reinforced ground.

Soil nailing equipment is small enough that it can easily negotiate restricted access. For existing steep slopes, such as bluffs or existing retaining walls, the soil nails can be installed from crane-suspended working platforms. Soil nails can also be installed directly beneath existing structures adjacent to excavations. Care should be exercised when applying the system underneath an existing structure. Hayward Baker has used extensive 3D modeling to avoid conflicts between soil nails and other earth retention systems on complex projects that involve the use of multiple techniques, and to ensure the safety of buried utilities.

Soil nailing has been used to stabilize slopes and landslides, provide earth retention for excavations for buildings, plants, parking structures, tunnels, deep cuts, and repair existing retaining walls.

This technique is available in most areas through either Hayward Baker or sister Keller companies. Contact your local Hayward Baker office for more information on soil nailing.