# Soil Nail Analysis Program SNAP



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# **Program Objectives**

- Develop a complete soil nail analysis package following AASHTO requirements
  - Soil nail elements
  - Facing Elements
  - External Stability Analysis
  - Slope stability analysis (Modified Bishop)
  - Seismic analysis
- Manual for Design and Construction of Soil Nail Walls Report No. FHWA-SA-96-069R

# **FHWA Guidelines**

 Manual for Design and Construction of Soil Nail Walls Report No. FHWA-SA-96-069R

Calculates the coulomb active earth load and uniformly distributes the load to the nails with consideration of nail spacing (tributary area).

 Geotechnical Engineering Circular No. 7 Soil Nail Walls Report No. FHWA-IF-03-017

Uses the SNAIL program, searching for "internal" slip surfaces with consideration for available nail resistances (controlled by facing, tensile yield or pullout) to determine the maximum average nail loading at a FS=1.0 (active state).

# **Project Information**



### Slope Geometry



### Slope Geometry



# Soil Layer Boundary & Properties

Pn	ject	Geometry So	oil Layers	iroun	d Water Nails	Seismic Coefficient	s Wall Facing	External Stability	Modified Bishop	Model SlideShow	Report				
														Calc Bearing	Capacity Factors
	[	Description	Color		y, pcf	ø, deg	C <sub>U</sub> , psf	q <sub>u</sub> , psi	Q <sub>u</sub> , Ibf/ft	Nc	Ny	N <sub>q</sub>	Modulus, psi	Tensile Strength,	Consolidation, %
	1	Α	Yellow	•	125	36	150	20	3958	50.6	56.3	37.8	10000	1000	50
Þ	2	В	Green	•	125	36	150	20	3958	50.6	56.3	37.8	10000	1000	50
*				-											
S	oil La	ayer B Points					•								
		Point X, ft		_	Point Z, ft				So	il Nail W	/all Stati	on 750-	L00		
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	4	4/.2/ 50.01			16.7										
	6	79.27		_	17.03			4						- 4	
		13.21			17.05										
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### **Ground Water Elevation**



# **Soil Nail Properties**



## **Soil Nail Properties**



# Nail Stress vs. Stage Cut



# Seismic Loading



# Soil Nail Wall Facing



# Soil Nail Wall Facing Checks



# **Interactive Display**



# **External Stability Analysis**



# **Global Stability Analysis**



# **Global Stability Analysis**



# Soil Nail Wall Design Report

Princet Set Layer Ground Water Neil Steams Walk from Steams Walking Model Steams Model Stea	E							
	F	Project Geometry Soil Layers Ground Water Nails Seismic Coefficients Wall Facing	External Stability	Modified B	Bishop Moo	lel Slide	how Repo	ort
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DownSlope Points								
DownSlope Points								
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English Units S/ Units			E	English	Units	SI	Units	]
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Point 2 X -58.75 ft -17.91 m		Point 2	X	-58.75	ft	-17.91	m	1
Z 6.36 ft - <i>1.94 m</i>			Z	-6.36	ft	-1.94	m	
Angle 0.08 deg 0.08 deg	11		Angle (	0.08	deg	0.08	deg	

# **Numerical Modeling**



# Numerical Modeling Results

Project	Geometry	Soil Layers	Ground Water	Nails	Seismic Co	efficients				
Setup	Displacem	ent/Load								
	Displaceme	ent, ft	Load, Ibf/ft	Load, Ibf/ft						
▶ 1	0.02		49880.21							
2	0.04		95742.8							
3	0.06		121287.51	121287.51						
4	0.08		134780.37	134780.37						
5	0.1		160229.74	160229.74						
6	0.12		172372.57	172372.57						
7	0.14		190366.9							
8	0.16		198283.29	)						
9	0.18		228818.68	}		_				
10	0.2		223217.75	5						
11	0.22		227049.49	227049.49						
12	0.24		241746.86	241746.86						
13	0.26		253119.71							
14	0.28		257994.38	3						
15	0.3		264935.87	264935.87						
16	0.32		273994.58	273994.58						
17	0.34		286522.81	286522.81						
18	0.36		298134.05	298134.05						
19	0.38		322401.52	322401.52						
20	0.4		330293.82	330293.82						
21	0.42		331606.81							
22	0.44		335188.51	335188.51						
23	0.46		355764	355764						
24	0.48		354135.36	354135.36						
25	0.5		358435.54	358435.54						
26	0.52		365602.98	365602.98						
27	0.54		386975.06	386975.06						
28	0.56		385156.85	385156.85						
29	0.58		397699.19	397699.19						
30	0.6		397254.77			<b>▼ ▼</b> ₹				



### Verification & Proof Test Results



# Verification & Proof Test Results

SNAP	Proof/Verification	n Testing						
Desigr	n Test Load Tes	t Loading Data	Report					
•	BL	15			ft	*	*	
	L	6			ft			
	DTL	203.6			kip			
Cr	eep Acceptance	0.0001000	0.0001000					
	TMA	12.2853		1	in			
	А	0.790			in²			
	E	29000			ksi			
	LI	HT	P, kip	ADG, in		i		
1	0.05*DTL (Align	1 min	10.18	0.0000				
▶ 2	0.25*DTL	>10 min	50.90	0.0400				
3	0.50*DTL	>10 min	101.80	0.0900				
4	0.75*DTL	>10 min	152.70	0.1700				
5	1.00*DTL	>10 min	203.60	0.2400				
6	1.25*DTL	>10 min	254.50	0.3200			h	
7	1.50°DTL 🌒	1 min	305.40	0.4100			Ξ	
8		2 min		0.4130			-	
9		3 min		0.4150				
10		5 min		0.4160				
11		6 min		0.4164				
12		10 min		0.4166				
13		20 min		0.4167				
14		30 min		0.4168				
15		50 min		0.4168				
16		60 min		0.4168		=		
17	1.75*DTL	>10 min	356.30	0.5000				
18	2.00*DTL	>10 min	407.20	0.6100				
								•
						-	-	



# Verification & Proof Test Report

SNAP Proof/Verification Testing	
Design Test Load Test Loading Data Report	
Generate Page Setup Print Preview Print	
Soil Nail Analysis ProgramSNAP 1.0	Â
Verification Testing Analysis	iew 🗖 🗖 💌
	□ □ □ □ H H H Close Page 1 -
<u>FROJECT INFORMATION</u>	
Project Name Madel Text	
Project Number 18-3584	
Company Name ABC Engineering	
Location Anytown, USA Designer Jane Doe	
Reviewer Kris Kringle	
Date 7-4-09	
Dosign Tost Load	
English Units S/ //nits	
q <sub>u</sub> 15         psi         103.4         kPa	
D 6 in 152.4 mm	
73 2.00 2.00 f <sub>v</sub> 75000.0 psi 517107.0 kPa	
<u>Ć 0.9</u> 0.9	
$\frac{A_s}{P_r}$ 0.79 in <sup>2</sup> 509.68 mm <sup>2</sup>	
Levused 10.0 ft 3.0 m	
$Q_{\nu}$ 40715.0 lbf/ft 594191.2 N/m $Q_{\nu}$ 20257.5 lbf/ft 202705.6 N/m	
Leycale 9.8 ft 3 m	
DTL 203.6 kip 905.5 kN	
I we will Must be a minimum of 40 fact - OK	
LEV used. Invisit De a minimum of To reet - OK	
Test Leading Date	
BL 15 ft 4.6 m	
	-



- 1. SNAP 1.0 is completed and was internally tested by the developers.
- 2. Beta testing by Dr. John Turner, University of Wyoming is in progress
- 3. The program should be available for free distribution once all testing is completed.



# Colorado Rockfall Simulation Program CRSP 3D

Rick Andrew, Yeh & Associates, Inc. Matt DeMarco, FHWA Central Federal Lands Ty Ortiz, Colorado Department of Transportation Jerry Higgins, Colorado School of Mines Howard Hume, PhD, Yeh & Associates, Inc. Alan Rock, GAP Engineering, Inc. Runing Zhang, PhD, Metro State College

Central Federal Lands Highway Division



# **Program Objectives**

- Develop an analyses and statistical predictions of rockfall behavior, providing the user with both 2D and 3D hazard characterization and mitigation tools.
  - Accept three-dimensional terrain data
  - Analysis of the final dispersion of rocks along slope
  - Ability to designate multiple rockfall origin locations
  - Incorporate rock and slope parameters
  - Ability to place analysis segments along the slope of userdefined dimension to evaluate mitigation alternatives
- Incorporate lessons learned from CRSP v1.0 4.0

### **Program Calibration**



# **Program Calibration**

#### **Rock Runout Distance**



# **Geostructural Analysis Package**

The visco-elastic contact model is the most popular constitutive contact model used a Discrete Element Model. Because of its simplicity, the calculations are very efficient. The assumption of a linear elastic contact force-displacement relationship between two impact bodies is a good approximation.





#### **Project Information**



#### **Slope Geometry**



#### **Slope Geometry**



# **Slope Mechanical Properties**

Contract and derived a	
File Units Help Upgrade	
Cnp20 Cnp20	
Project   Sope Geometry Sope Mechanical Properties   Analysis Segments   Faling Rock Parameters   Model   Output	
D Cdor Roughness	Herdness
1 Talua • Yellow • 2	07
x soler • migrae • x	01
4 Bedrock • Red • 1	4
Pointa di n	Material
X1 Y1 Z1	_ 20 _ 40 _ 100 _ 100 _ 1000 _ 8
1 359.47 247.65 378.98	<i>₽</i>
2 564.2 362.59 414.63	
€ 580.94 152.22 383.89 E contre 84.5 450.95	8
5 684.81 387.91 345.13	
7 643.09 288.32 198.93	80
E 781.29 138.18 263.95	19
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A: -30,15 C: 438,59, 307,01, 350,75 V: 850,12	

# **Analysis Segments**

1 50	ne Georgen	Sone	Machanical Property	Arialysia Se	omenta Fallog Rock Parameters Mc	odel Output		
Analys	is Segment	Name	and the state of the state	Color	Base X	Base Y	Base Z	H, N
1 2.32	6			Blue	• 566	277	376	15
z Z 206	i.			Cyan	• 836	271	206	15
					*			
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41	1.11	474	H. R.	1				
7. 865	19	4/1	10				Analysi	s Segment 1 8
3 565	25	455	15					- S
4 565	37	455	15	-				35
5. 566	49	453	15					
6 566	61	450	15					
7 566	73	43?	15					
8 566	85	424	15					
9 565	97	417	15					
10 566	109	414	15					8
11 566	121	413	15				<b>N</b>	Analusia Compant 2
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21 566	241	374	15	0 9		Sogmont		8
22 566	253	376	15	-	18 4	Segment		S //*
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25 565	288	382	15	-	a.			14
26:566	301	393	15			(Comp)		

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# **Falling Rock Properties**

Crsp3D2: G File Units	rorgetown 1 Help: Upgrade					- 8 - *
Crap20 Crap3	D		- HIGHAR			1.5
Project Slope	Geometry Stope Mechanical Properties Anal	yas Segments Faling Rock Parameters Model	Output	Rocks to Reference	Church City B	
> 1 Talue	• 165	400x400x100-200	Tox10x30	5	Columnat v 3x4x5	1 =
2 Talus	• 165	1000	0	5	Round + 4	
*	•				•	
	Talus Identified a Source area location and properties 1.Unit weigh 2.Tensile str 3.No. of rock 4.Shape 5.Size	rock t ength ks		Material t t t t t t t t t t t t t t t t t t t		
Menue (670 21	675 64 021 55) Surface(.550 0 2678 02 824 8	(7) Cantar (\$39.50 307.01 350 75) Span (507)				1 ·

#### Model Settings





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Generate Report Page Setup Print Preview Print

#### Colorado Rockfall Simulation Program--CRSP 5.0

#### **CRSP Rockfall Analysis**

CRSP was used to determine the expected kinetic energy and bouncing height of falling rocks at various points along the slope. In the analysis, it was assumed that rounded boulders with a maximum diameter of 5.0 feet would impact the rockfall retaining system. For each simulation, the model rolled 10 spherical shaped rocks from a source area at 330 - 332 feet. A slope surface roughness of 0.0 - 4.0, and hardness of 0.0 - 0.7 were used.





	Analysis Prit X (ft)	Diameter ft)	Mass (bm)	Vix.(ft/s)	Vy 件/8)	V (ft/s)	W (rad/s)	Height (ft)	KEv (t-kips)	KEw (ft-kips)	KE (ft-kipe)	Start X (ft)	Start Y (ft)	Stop X (t)	Stop Y (R)
Г	513	4.6	8698	51.1	1.6	51.1	-22.1	33	353	140	493	3	332	577	21
Ľ	513	4.2	6437	53.0	2.0	53.0	-25.6	2.4	281	114	395	2	332	601	21
L	513	3.4	3563	45.3	-4.4	45.5	-26.5	2.1	115	46	160	1	332	572	21
	513	4.6	9110	51,7	5.0	51.9	-22.0	3.4	382	150	532	2	332	610	22
Ľ	513	2.2	1000	32.5	7.2	33.3	-31.6	5.4	17	8	25	1	332	564	20
Ľ	513	3.8	4854	52.6	1.2	52.6	-27.7	2.9	209	84	293	2	332	571	21
	513	2.8	1819	51.9	-18.1	55.0	-38.2	2.2	85	31	116	1	332	579	20









- 1. CRSP 3D is nearing completion (June 2010).
- 2. Beta testing by rockfall panel.
- 3. The program should be available for free distribution once all testing is completed.

