

Stability of Slope Reinforced with Soil Nails

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This tutorial will demonstrate the modeling of support in *HYRCAN*. Three different types of slope reinforcement can be modeled in *HYRCAN*, including soil nails, tiebacks and end anchored rock bolts.

Project Settings

Various important modeling and analysis options are set in the Project Settings dialog, including Failure Direction, Units of Measurement, Analysis Methods and Groundwater property. For this analysis make sure the failure direction is set to "Right to Left" then press Apply.

Select: Analysis → Project S Project S General

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Project Settii	ngs

General		Met	hods	Groundwater
Jnits of I Jnit:	Measurment Metric	~	Failure Direction Right to Left Left to Right 	7
Current l .anguag	anguage e: 😰 English	~	Surface Type Circular Non-Circular	
			Search Method Slope Search	~

Figure 1- Project Settings dialog.



Create Geometry

• External Boundaries

The first boundary that must be defined for every model, is the External Boundary. To add the External Boundary, select External Boundary from the toolbar or the Boundaries menu.

Select:	Geometry	\rightarrow
Select:	Geometry	7



External Boundary

Enter the following coordinates in the prompt line at the bottom right of the main window.

Enter vertex [esc=cancel]: 0 0
Enter vertex [esc=cancel]: 0 6.1
Enter vertex [esc=cancel]: 11 6.1
Enter vertex [c=close,esc=cancel]: 11 -2
Enter vertex [c=close,esc=cancel]: -6 -2
Enter vertex [c=close,esc=cancel]: -6 0
Enter vertex [c=close,esc=cancel]: c

Note that entering \mathbf{c} after the last vertex has been entered, automatically connects the first and last vertices (closes the boundary), and exits the External Boundary option. Your screen should now look as follows:



Figure 2- External boundary is created.

Properties

It's time to define our material properties. Select Define Materials from the toolbar or the Properties menu.

Select: Properties \rightarrow





Material	c (kN/m²)	φ (degrees)	γ (kN/m³)		
Soil	35.0	0.0	18.9		

With the first (default) tab selected in the Define Materials dialog, enter the following properties:

Soil	^	Soil		
Material 2				
Material 3		Name:	Soil	
Material 4				
Material 5		Unit Weight (kN/m3):	18.9 Sat. U.W. (kN/m3): 20	
Material 6				
Material 7		Strength Type:	Mohr-Coulomb	
Material 8		Strength Parameter	re .	
Material 9		o o chigo n o chiece	•	
Material 10		Cohesion (kPa)	35 Friction (degrees): 0	
Material 11				
Material 12				
Material 13				
Material 14				
Material 15				
Material 16				
Material 17				
Material 18				

Enter the parameters shown above. When all parameters are entered press Apply.

Add Support Pattern

Before adding the support let's first define the support type and corresponding properties. To do so, select Define Support from the toolbar or the Properties menu.

Select: Properties \rightarrow



With the first (default) tab selected in the Define Materials dialog, enter the following properties:

Support Type	Name	Out-of-plane Spacing (m)	Tensile Capacity (kN)	Plate Capacity (kN)	Bond Strength (kN/m)
Soil Nail	Soil_Nail	1.5	118	86	15

Soil_Nail	Soil Nail		
Support 2			
Support 3	Name: Soil_Nail		
Support 4	Support Type	Force Application	
Support 5	Environ Contraction Contraction		
Support 6	Soli Nail	Active Of	rassive
Support 7	Liced for: Soil Nales	Capacity and Spacing	
Support 8	Cace for Sol Heles		
Support 9		Out-of-plane spacing (m):	1.5
Support 10		Tensile Capacity (kN):	118
Support 11		Plate Capacity (M)	94
Support 12	_	Plate Capacity (NV).	00
Support 13			
Support 14		Pullout Strength	
Support 15			E.e.
Support 16		Bond Strength (kN/m):	15
Support 17			
Support 18			
Support 19			
Support 20			



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Now let's add Support elements. Support elements can be added to a model individually, with the Add Single Support option in the Support menu. If multiple support elements in a regular pattern are to be added, you can use the Add Support Pattern option in the Support menu. In this tutorial We will use the Add Support Pattern option, to add a uniformly spaced support pattern to the slope.

Select: Support

 \rightarrow



You will first see the Support Pattern dialog. Set the Orientation = Angle from Horizontal, Angle = -15 degrees, Length = 4.9, and Distance between supports = 1.5. press Apply.

Support Prope	rty: Soil_Nail ~
Orientation Orientation Vertical Horizontal Angle from horizontal15	Support Length Length (m): 4.9 Spaced by Spacing measured: Along the boundary ~
	Distance between support (m): 1.5 Number of support objects: 10

Figure 3- Add Distributed dialog.

Now as you move the cursor, you will see a small black cross which follows the cursor and snaps to the nearest point on the nearest boundary.

You can enter the location of start and end points of the pattern graphically, on the external boundary. However, to enter exact coordinates, it is easier and more accurate in this case to enter the coordinates in the prompt line.



Figure 4- Geometry setup with applied distributed load.



Modifying the Slope Limits

The Slope Limits are automatically calculated by *HYRCAN* as soon as the External Boundary is created. If you wish to narrow the Slope Search to more specific areas of the model, the Slope Limits can be customized with the Define Limits dialog.

Select:	Surfaces	÷	Define Slope Limits
			Define Slope Limits X
			Limits Left x coordinate: -3 Right x coordinate: 0
			Second set of limits Limits Left x coordinate: 2 Right x coordinate: 7
			Apply Cancel

MM

In this tutorial the left and right coordinates are set to -3 and 0 and the left and right coordinates of the second set of limits are set to 2 and 7. Later on, by refining the slope limits you will be able to estimate more accurate global minimum slip surface. We are now finished creating the model, and can proceed to run the analysis and interpret the results.

Compute

The model is now ready to run.



The engine will proceed in running the analysis. When completed, you are ready to view the

results in Result Tab.

Results and Discussions

When calculation completed, you are ready to view the results in Result Tab. By default, when Result Tab opened, the Global Minimum slip surface, for the Bishop Simplified analysis method will be shown. This resulted in total of approximately 7500 trial slip surfaces. The results of the factor of safety calculation is shown in Figure 6. Table 1 summarize the comparisons of calculated factor of safety for the same model using different commercial programs.



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Method	Slide2	HYRCAN
Bishop Simplified	1.347	1.290

Table 1- Comparison of Minimum Factor of Safety



Figure 5- Result of automatic slope search.

To view ALL valid slip surfaces generated by the analysis, select the All Surfaces option from the toolbar or the Result menu.



Figure 6- Circular surface search – All surfaces shown.

The Show Slices option can be used to display the actual slices used in the analysis.



Select:	Result	\rightarrow									
			Sh	ow Sl	ices						
WRCAN 3.0 - [unnamed model]											- 0
File View Geometry Loading Supp	oort Suifaces Properties Analy	sis Result Help									
	L2223	18 2 200	9 2 2 3		× = 300	RQQ					
Bahop Simplified 🗸 🍎 🦞	<i>D D</i>										
E Hodel Q Re											
2023 Rooth Gernill M Factor of Safety Jafo. Mede Biologi Safeffel Markov Dissource Safety Jafo. Genere 4: 2020 Control Control Bigle Starbor Endpoint 0 Bigle Starbor Endpoint 0 Head Safety Jafo.	6.1			1.200			R.R.				
	-20	-16	10	4	1	0		8	12	10	20
Command Line											
InvaSorot Python MINELANCS Sett (Method , Bengton , or , HINELANCS compute) HINELANCS compute) HINELANCS Indeq("Index") HINELANCS Indeq("Index")	Metroar, U.S./M.P., on , Netroor , 191	визан, эп, метис, зрекси	, 01)								
javaeoript command											

Figure 7- Slice displayed.

HYRCAN will also display the mobilized force in each support when Show Slices option is turned on.

Script

After finishing the model, you will be able to save the generated script by HYRCAN in the text file.

Select:



The commands for this tutorial are listed below.

newmodel()
set("failureDir", "r2l")
extboundary(-6,0,0,0,0,6.1,11,6.1,11,-2,-6,-2,-6,0)
definemat("ground", "matID",1, "matName", "Soil", "uw", 18.9, "cohesion", 35, "friction", 0)
definemat("support", "matID", 1, "supportType", "SoilNail", "matName", "Soil_Nail", "spacing", 1.5, "tensC
apacity", 118, "plateCapacity", 86, "bondStrength", 15)
addsupport("pattern", "id", 1, "matid", 1, "orientation", "anglefromhoriz", "angle", 15, "length", 4.9, "spaced", "along", "dist", 1.5, "frompoint", 0, 1.5, "topoint", 0, 5)
definelimits("limit", -3, 0, "limit2", 2, 7)
compute()