TSLOPE – how to analyse a slope for noncritical slip surfaces

TSLOPE is a 2D and 3D limit equilibrium analysis program used for slope stability analysis.

This example of the use of TSLOPE shows how we can locate critical slip surfaces using a search methodology, and show the difference in 2D and 3D analysis of the same slope.

The example is from Chapter 14 Important Details of Stability Analyses, of Duncan et al. 2014.¹

They state:

In some cases the slip surface with the minimum factor of safety may not be the slip surface of greatest interest. For example, the minimum factor of safety for the embankment shown in Figure 14.7 is 1.15. This factor of safety corresponds to an infinite slope failure in the cohesionless fill. Also shown in Figure 14.7 is a deep circle that has a factor of safety of 1.21, which is higher than the factor of safety for the shallower, infinite slope slip surface. However, if sliding occurred along the deep circle, it would have a far more severe consequence than slope ravelling on the shallow infinite slope surface. Ravelling of material down the slope might, at the most, represent a maintenance problem. In contrast, failure along the deeper surface and the associated factor of safety of 1.21 would be considered unacceptable, while a factor of safety of 1.15 for the shallower, critical slip surface might be acceptable.



Figure 14.7 Slope with shallow critical slip surface and deeper, locally critical circle.

We have used Scribe² to capture the workflow that shows how the slope model is entered into TSLOPE, and how the stability analyses are carried out to set up the search for the infinite slope and Deep circle slope cases shown on Figure 14.7. We used Spencer's method for all analyses shown in this example.

We enter the geometry of the slope by four points on the ground surface (our Top surface). This simple 2D geometry is automatically extruded to a 3D Extruded Section. There are three layers, fill (19 ft thick), clay (15 ft thick) with underlying rock. We define the top of clay and top of rock with horizontal planes that complete the TSLOPE model. Appropriate material properties are assigned to each layer.

¹ Duncan, J.M.; S.G. Wright; T.L. Brandon 2014 Soil strength and slope stability. John Wiley & Sons, Inc. 317pp

² https://scribehow.com

Duncan et al Fig 14.7

Screen shots captured by Scribe





Type "Duncan Wright Brandon 2014 Figure 14.7 [[tab]]"

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5 Click "Preferences"

TSLOPE

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7 Click U.S. Customary

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8 Click "Default"

TSLOPE





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11 Change the Unit Weights

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18 Change the material colour



19 Click "..."

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21 Click "Materials"

TSLOPE

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22 Click "Add Material..."

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Cohesion	0 psf
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27 Click here:

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	Angle of friction	30 *
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Type "98"

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	Cohesion function	Constant	1
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Change Mohr-Coulomb values

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Change Material colour

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33 Click "OK"		
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34 Click "Materials"

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35 Click "Add Material..."

TSLOPE

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36 Change Label

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37 Type "rock"

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38 Change Failure criterion

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39 Click the pull down box to change the Failure criterion

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	Cohesion function		Constant		
	Cohesion		0 psf		
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40 Select Bedrock



41 Change the material colour



42 Click "OK" Custom colors: Hue: 160 Red: 160 Sat: 0 Green: 160 100 Color/Solid Lum: 151 Define Custom Colors >> Blue: 160 OK Cancel Add to Custom Colors Cross-sections 50 (E) ≻ 0 Material

43 Click "Surfaces"

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44 Click "Top"





Unlock the extruded section

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	Label	Top Extruded Section 1				
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Open the points file to add points

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48 Add the points (X,Z pairs) Click "OK"







51 Click "Add Plane..."



Layer Surfaces

A Layer surface allows material properties to be defined as layered strata.

The layer surface defines the top of the extent of the assigned material properties; the material properties are assumed to be constant below this layer surface, until another layer surface is encountered.

The region above the highest layer surface



52 Change the Label





53 Type "clay"



54 Assign the Material "clay" to the Layer

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Ξ	Centre point	2: rock	~		
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	Y	0 ft			
	Z	24.5 ft			
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55 Unlock the Plane

Layer 1			
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Y	0		
Z	1		
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Change the Z value of Centre point



Type "15"

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Change the size of the plane



Type "120"















Layer Surfaces

A Layer surface allows material properties to be defined as layered strata.

The layer surface defines the top of the extent of the assigned material properties; the material properties are assumed to be constant below this layer surface, until another layer surface is encountered.



64 Change Label







66 Assign Material "rock" to the layer



67 Unlock plane geometry

La	yer 2					
Ξ	Layer Surface Plane					
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	Z	15 ft				
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	Y	.0				
	Z	1				
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68 Change Z coordinate of Centre point to "0"



69 Change plane size



Made with Scribe - https://scribehow.com

70 Type "100"













74 Click "Add cross-section..."



75 A suitable section is presented, so click to lock its position



76 Click "Slopes"



Slopes

A project consists of one or more slopes. Multiple slopes allow parametric studies to investigate the stability of slopes when various aspects of the slope vary, e.g. material properties, pore pressure and phreatic surface variation, and any other parameter of interest.

Each slope must have a top and a basal surface defined before an analysis is carried out. Phreatic and pore-pressure surfaces are



77 Click "Add 2D Slope ... "



aspects of the slope vary, e.g. material properties, pore pressure and phreatic surface variation, and any other parameter of interest.

Each slope must have a top and a basal surface defined before an analysis is carried out. Phreatic and pore-pressure surfaces are optional.

If a back-analysis is to be performed, the material properties are assumed to be of one





79 The slip circle for the 2D slope case is defined by entry and exit points for a circle



We can move the right bound marker to the toe of the slope





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83 The light grey panel shows the limits for entry and exit points for the circular search. We then Click " Solve "

















88 The factor of safety is calculated: 1.21 (Duncan et al. reported 1.21)



The slip circle shown in the 2D slope case is represented in 3D as a sphere. We want to change the sphere to an ellipse which we believe is more representative of a potential 3D failure surface.



89

We duplicate the Basal surface

94 change the radius in the Y direction to about half of the x radius

96 Click "control"

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98 Add 3D Slope ...

Z (ft)

A project consists of one or more slopes. Multiple slopes allow parametric studies to investigate the stability of slopes when various aspects of the slope vary, e.g. material properties, pore pressure and phreatic surface variation, and any other parameter of interest.

Each slope must have a top and a basal surface defined before an analysis is carried out. Phreatic and pore-pressure surfaces are optional

100 Click " Solve "

101 Remove the overlying surfaces to show the slip ellipse

