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 might require reconstruction of the embankment. Consequently, 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.

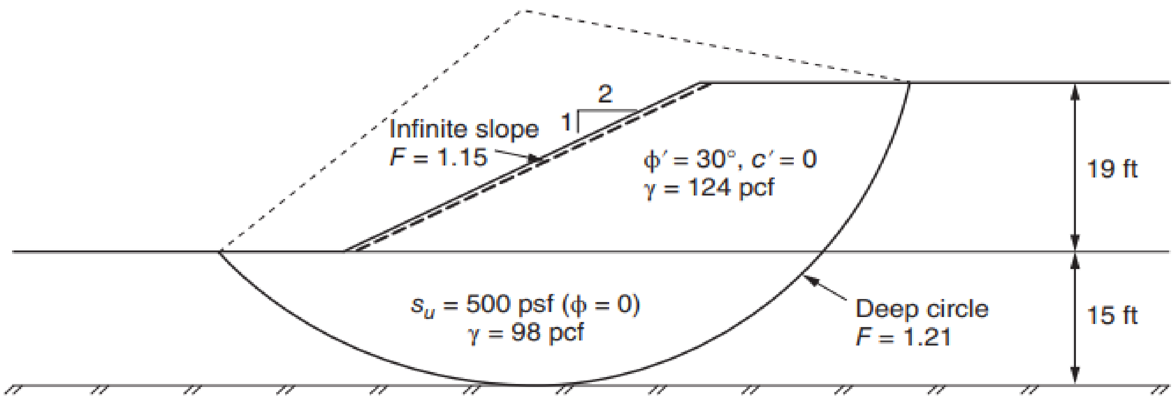

Figure 14.7 Slope with shallow critical slip surface and deeper, locally critical circle.

We have used Scribe[2] 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.

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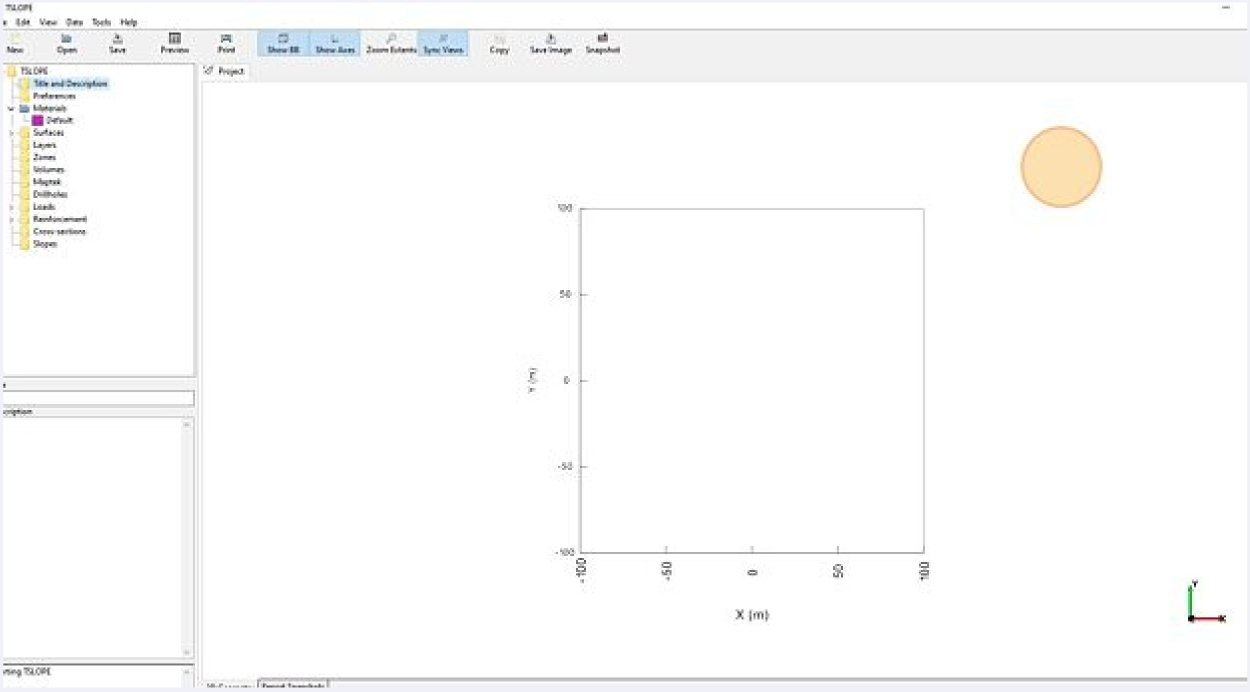
[1] Duncan, J.M.; S.G. Wright; T.L. Brandon 2014 Soil strength and slope stability. John Wiley & Sons, Inc. 317pp

[2] https://scribehow.com

Duncan et al Fig 14.7

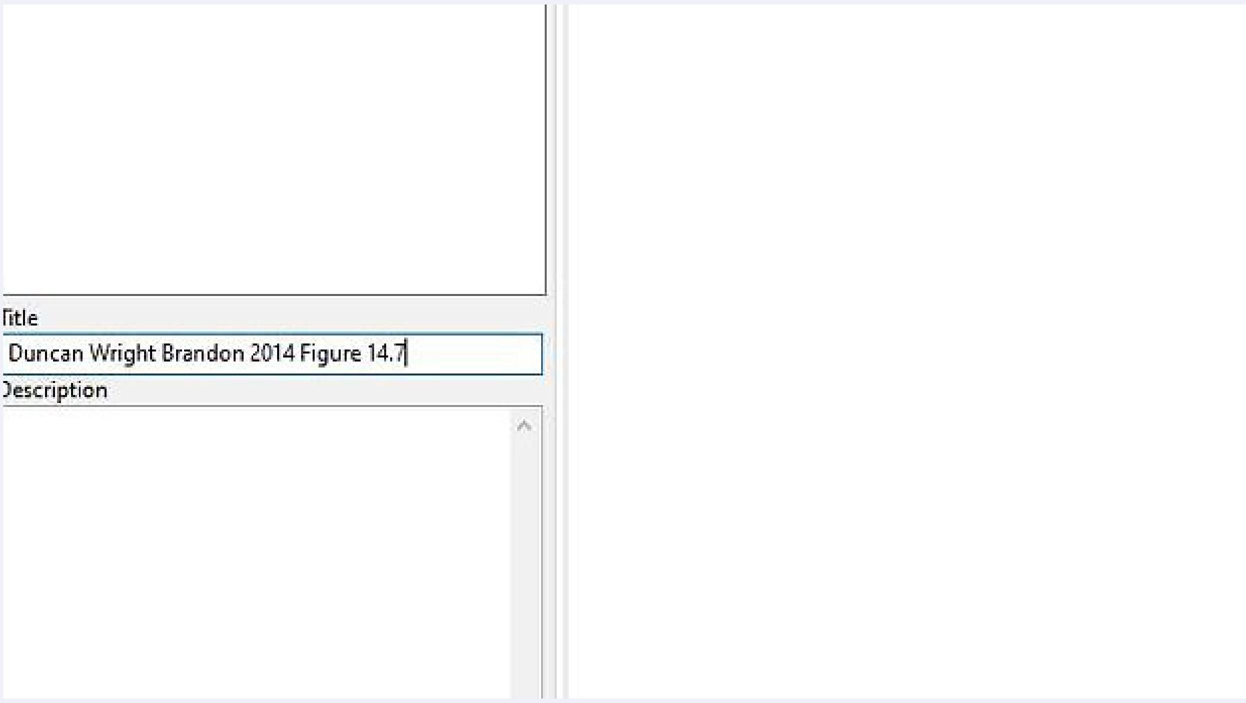
Screen shots captured by Scribe

1 Open TSLOPE

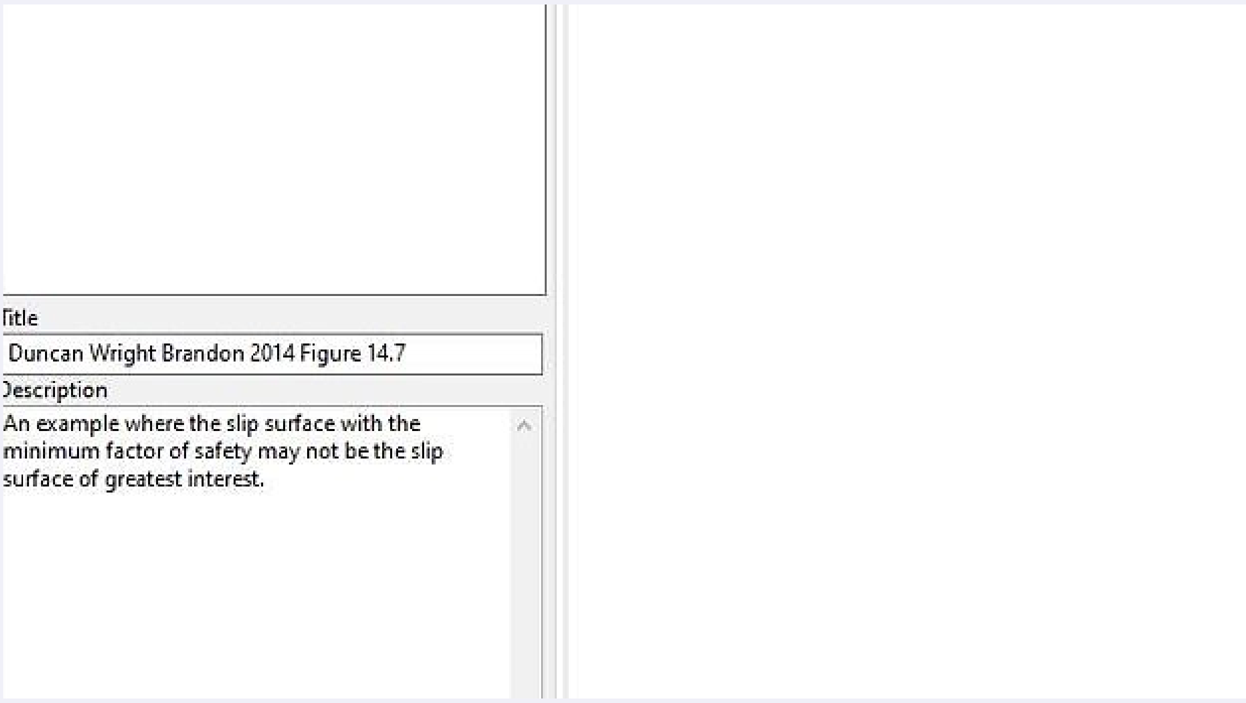


2 Click here:

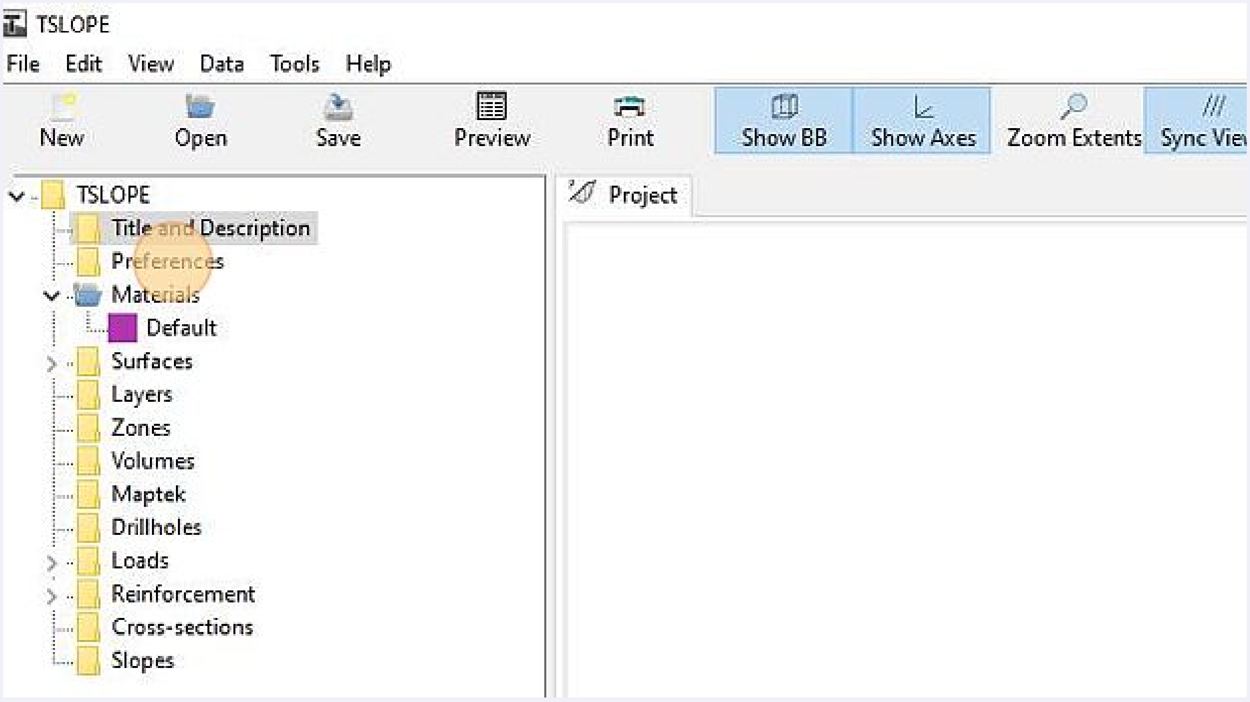
3 Type "Duncan Wright Brandon 2014 Figure 14.7 [[tab]]"



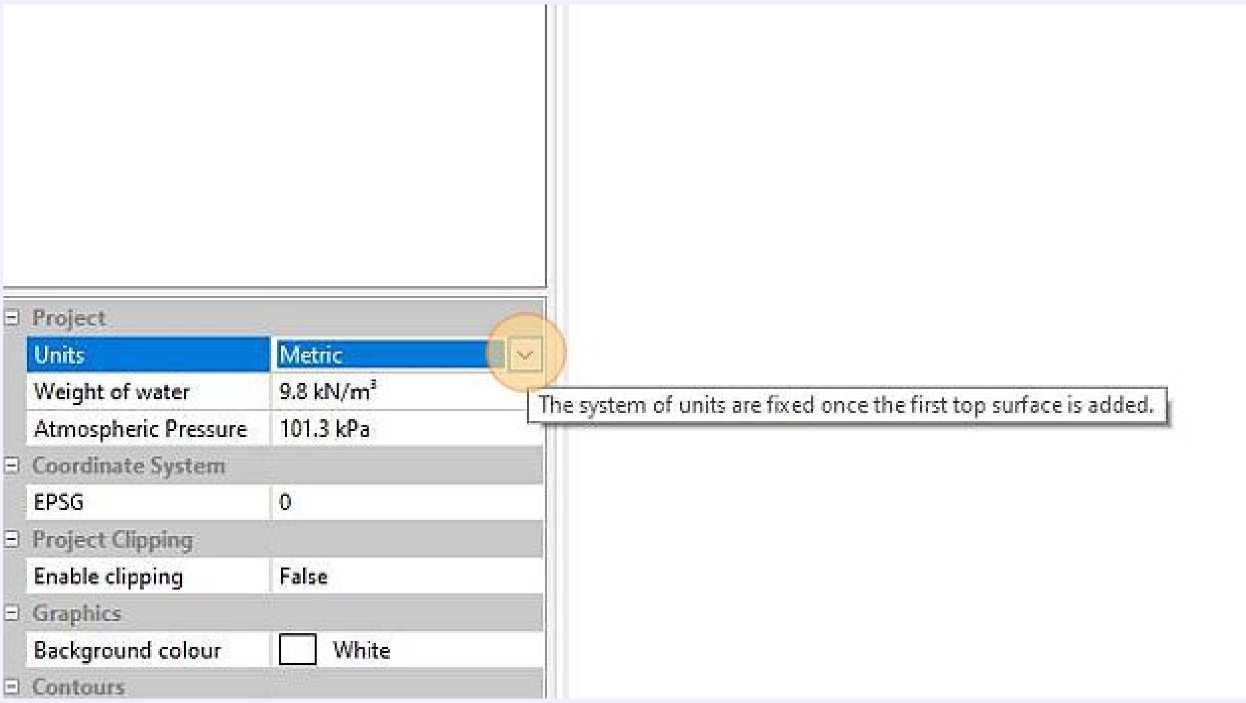
4 Type "An example where the slip surface with the minimum factor of safety may not be the slip surface of greatest interest."



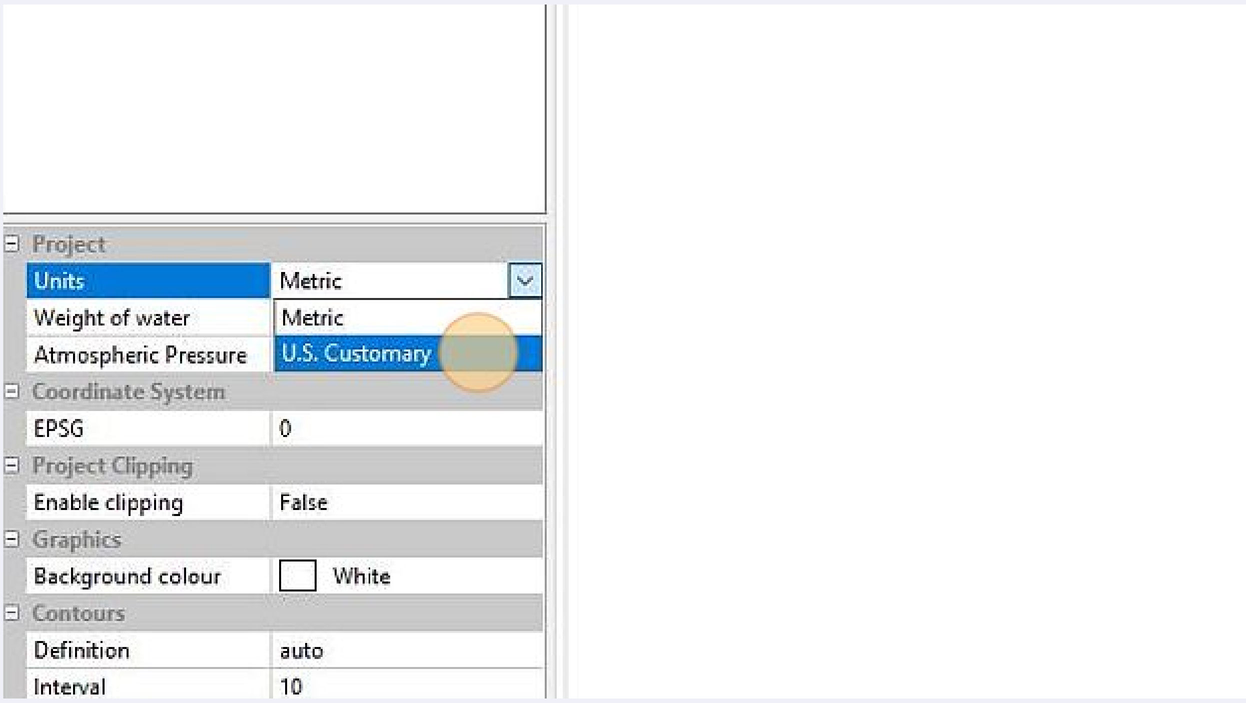
5 Click "Preferences"



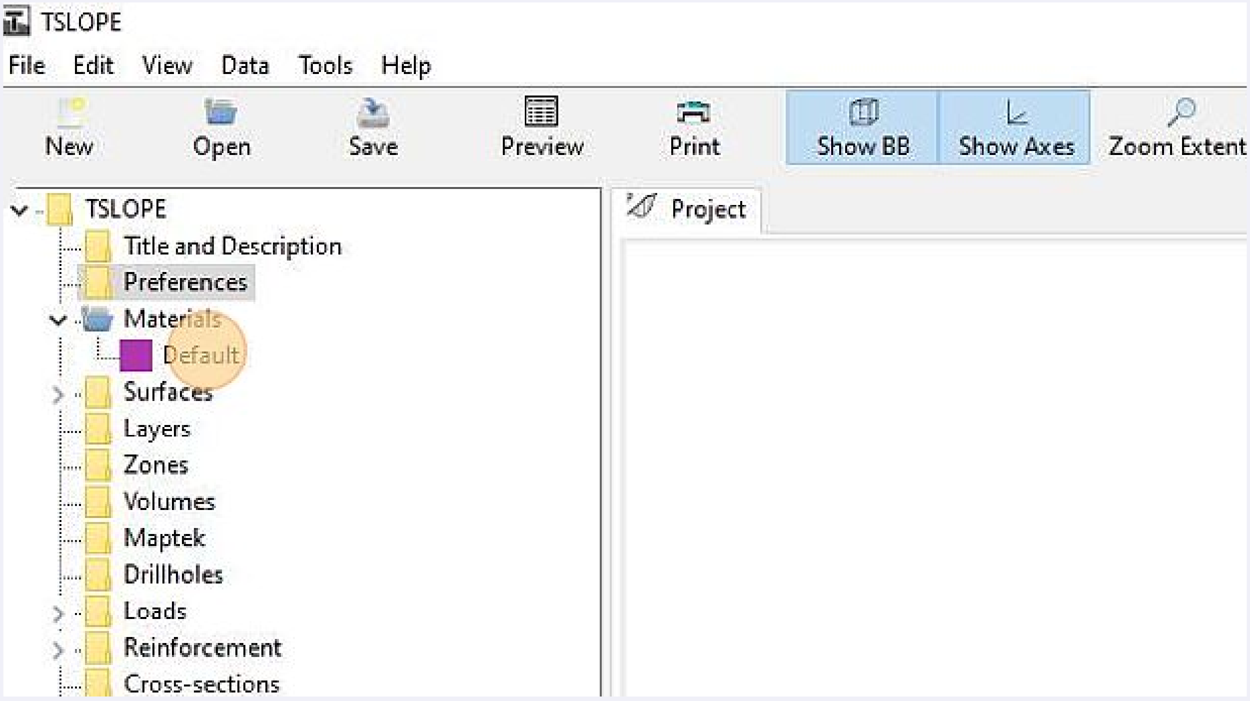
6 Click the pull down box to change from Metric to U.S. Customary



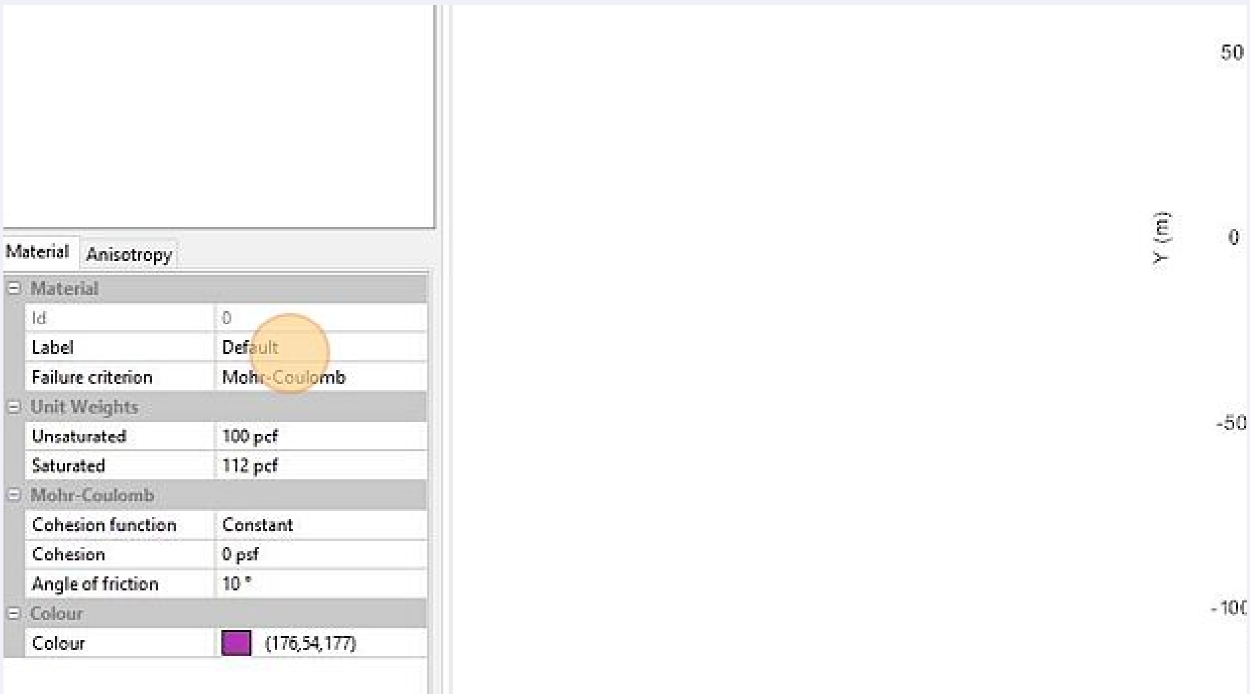
7 Click U.S. Customary



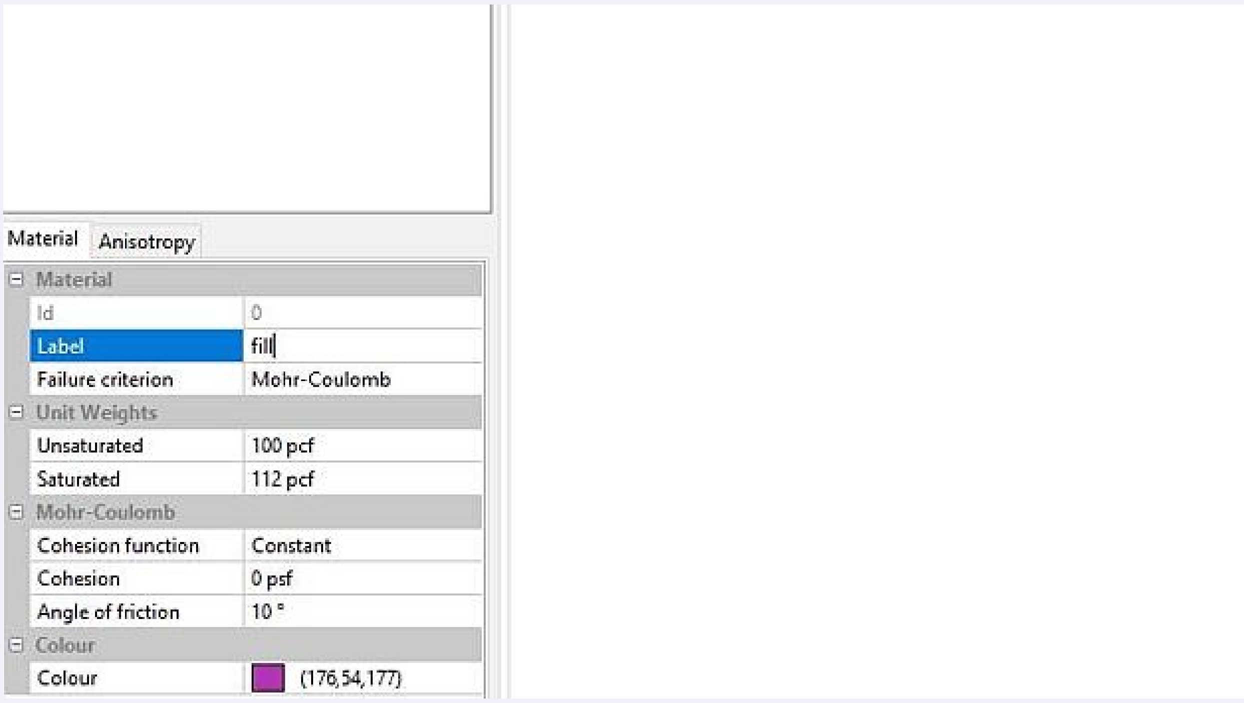
8 Click "Default"



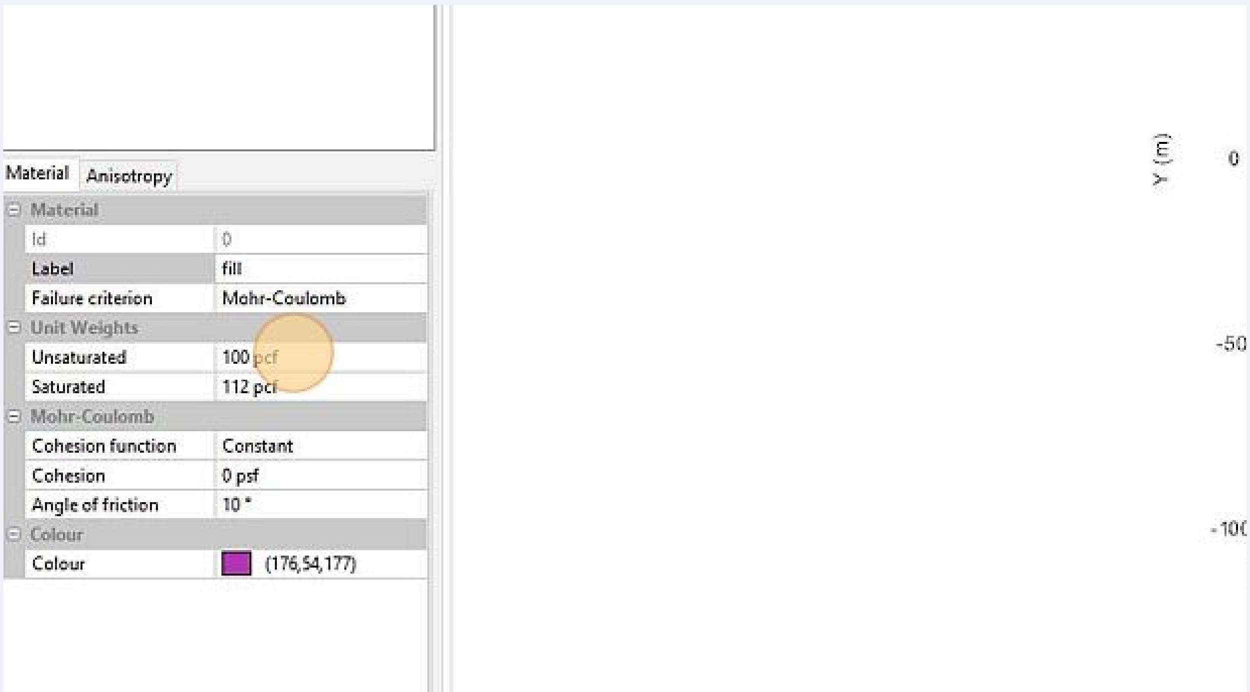
9 Change the Label



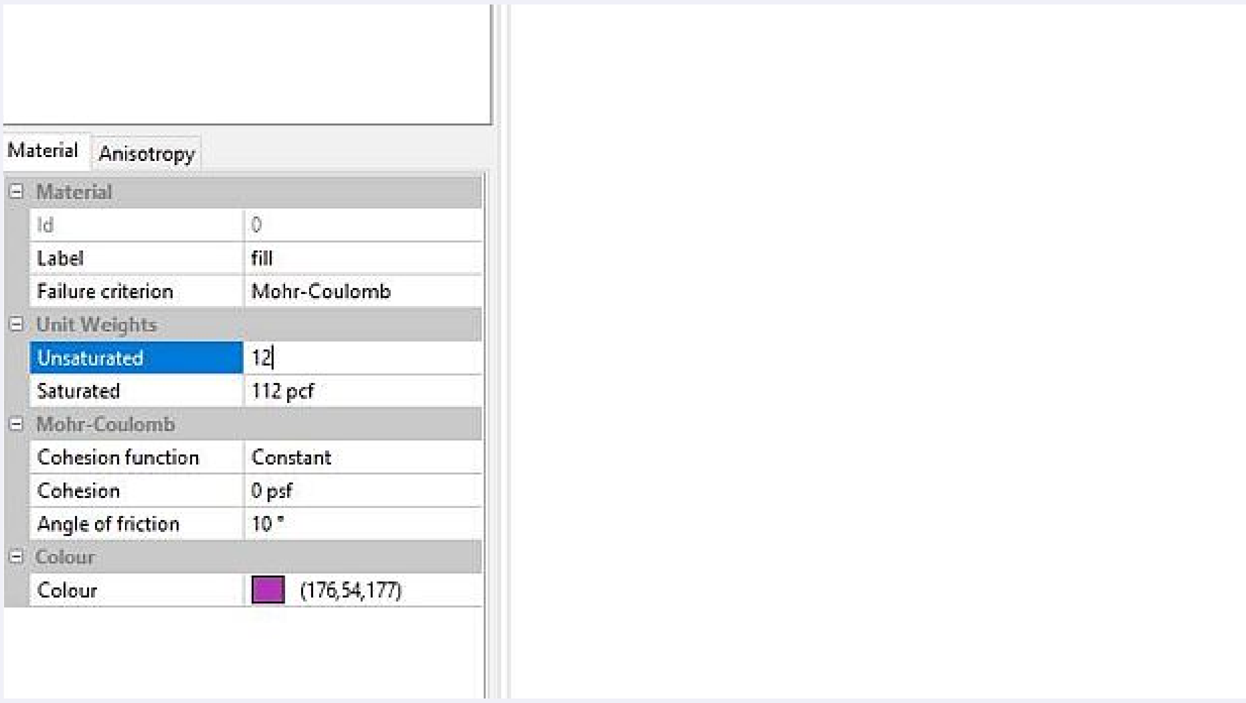
10 Type "fill"



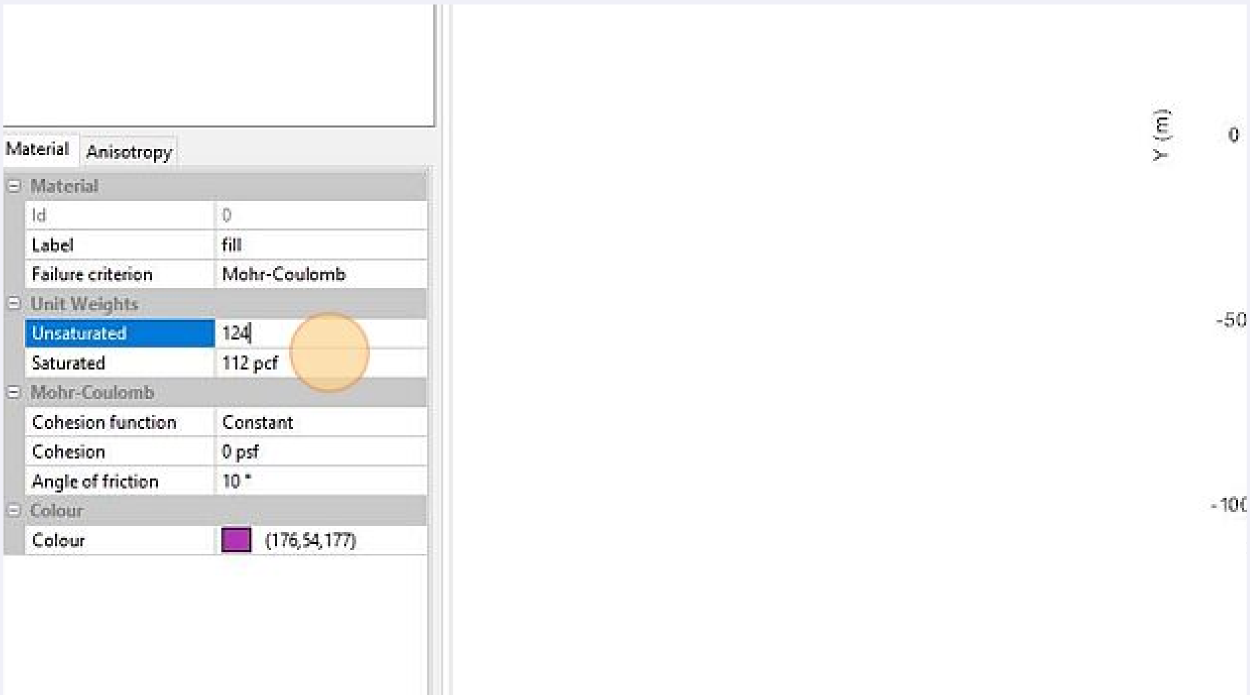
11 Change the Unit Weights



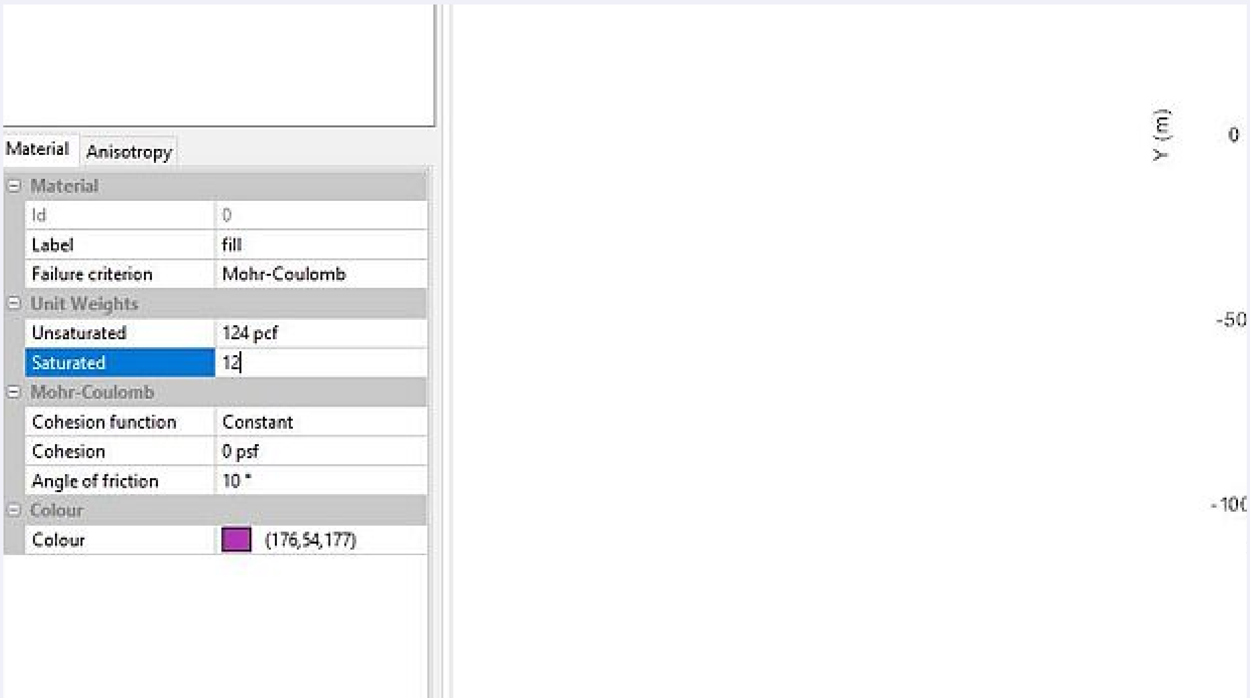
12 Type "124"



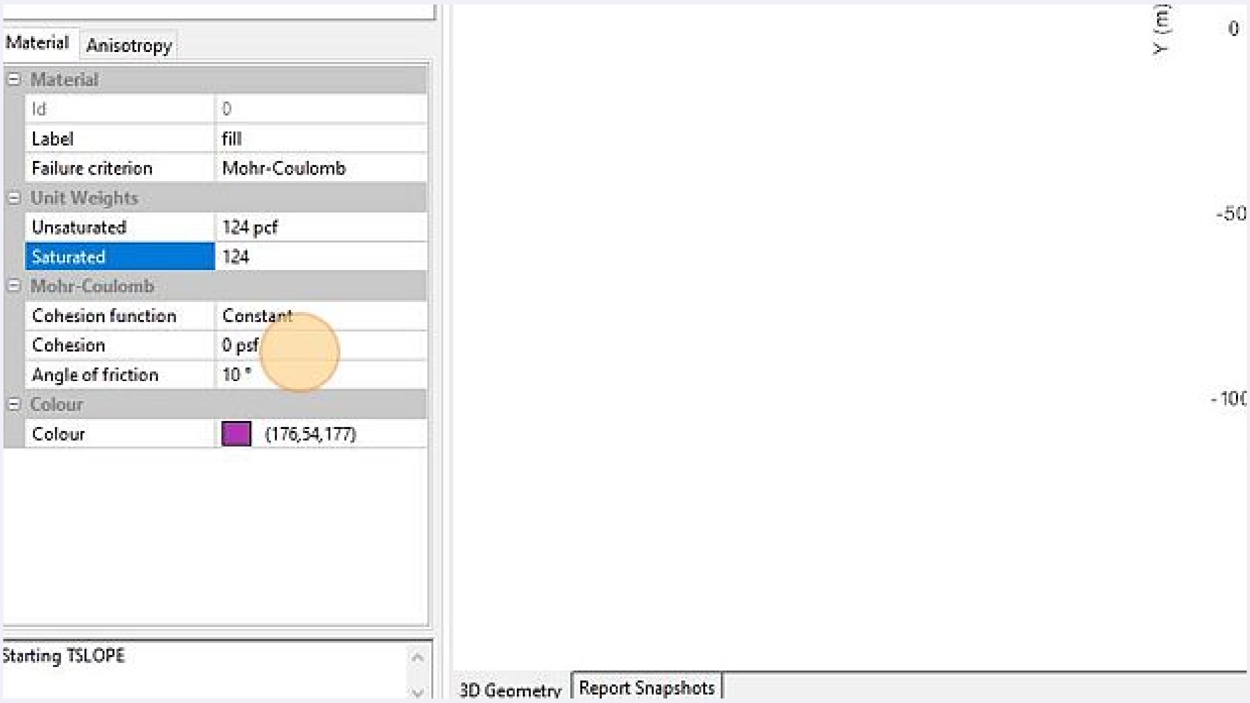
13 Click here:



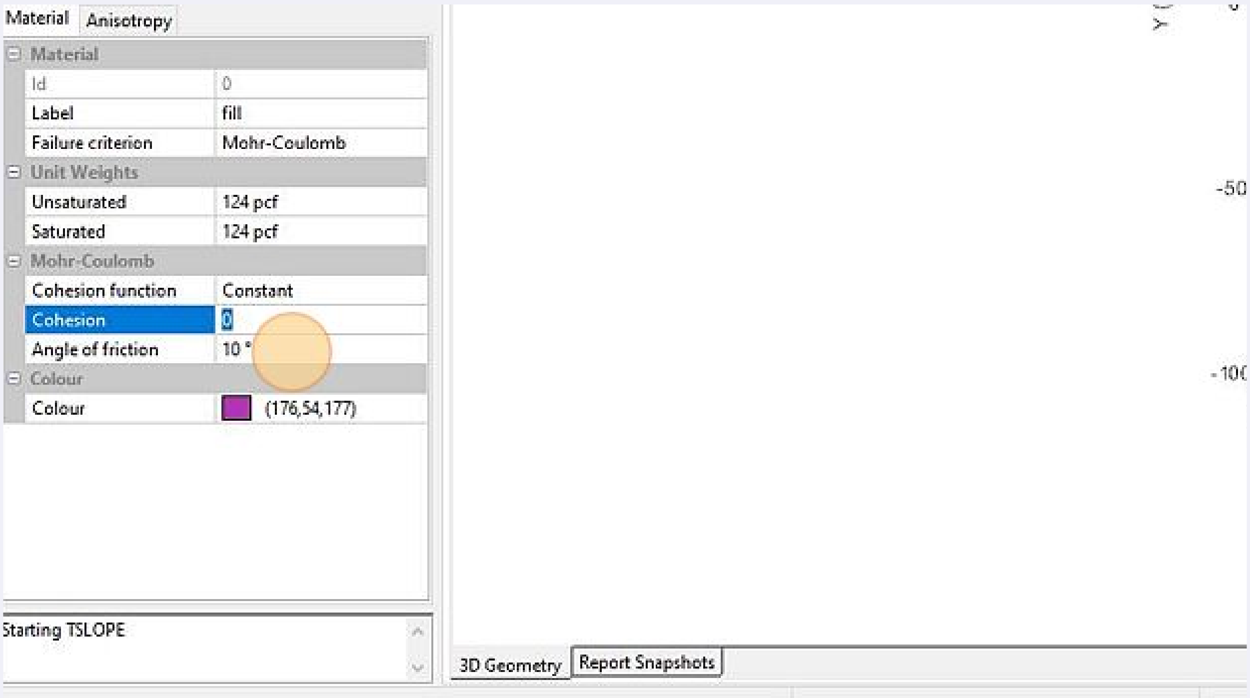
14 Type "124"



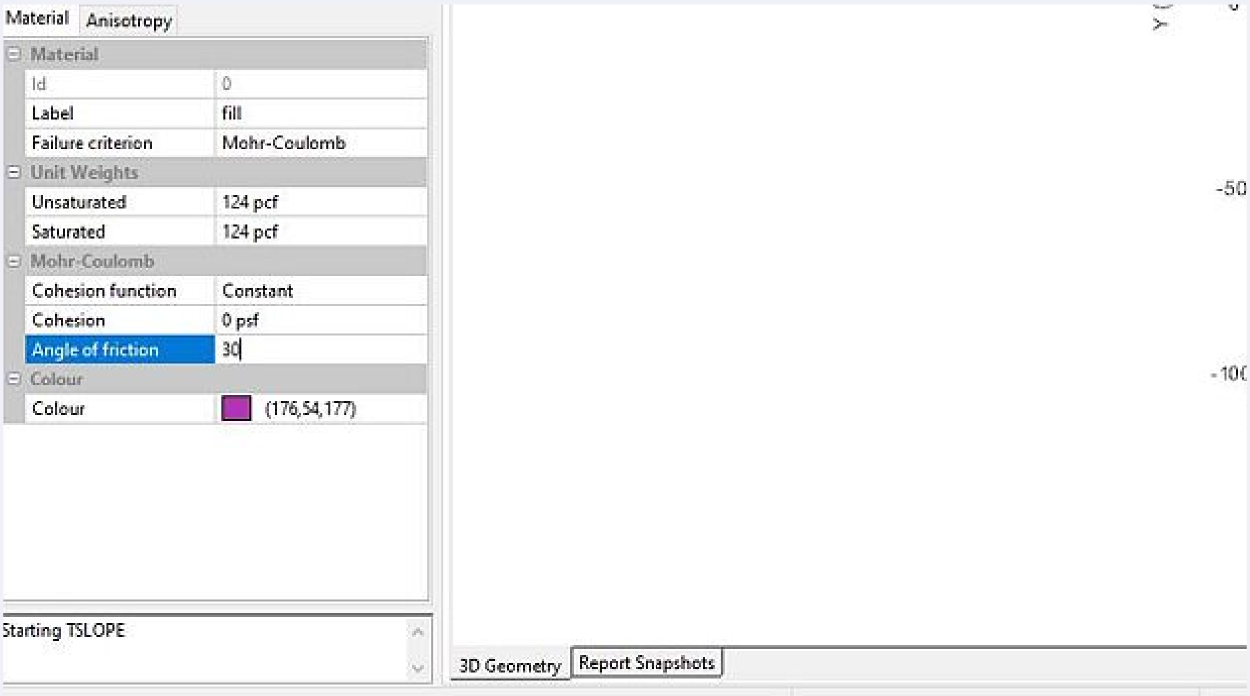
15 Change Mohr-Coulomb values



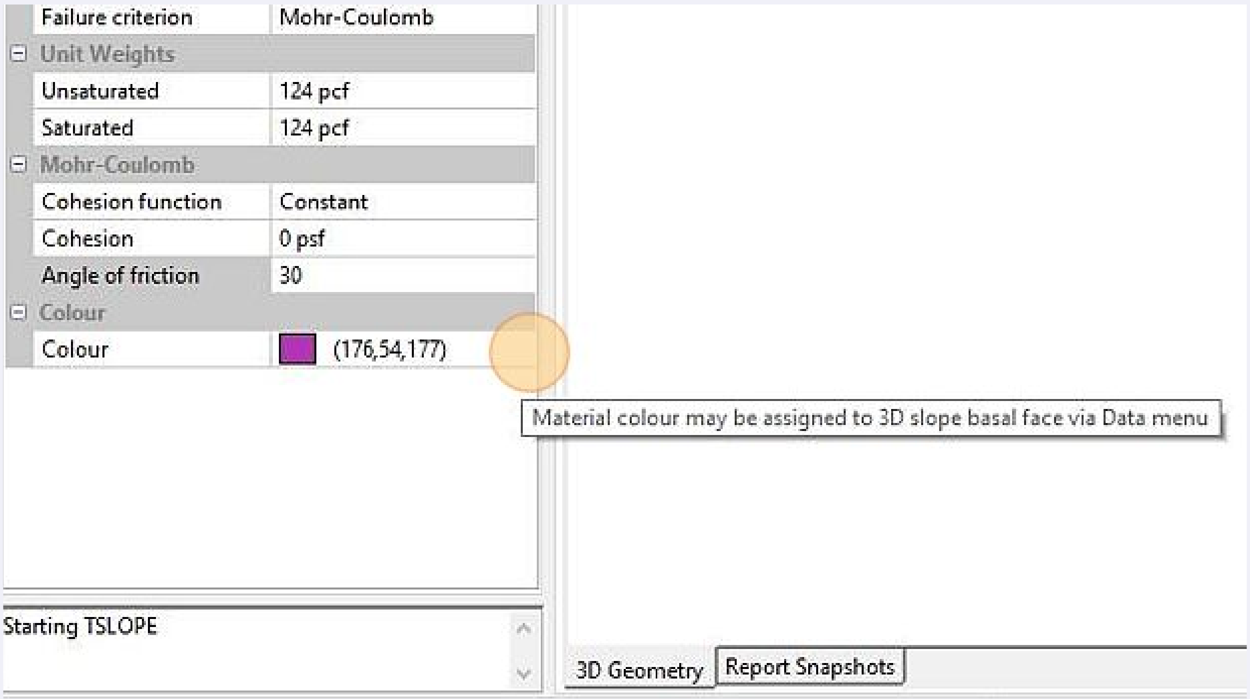
16 Click here:



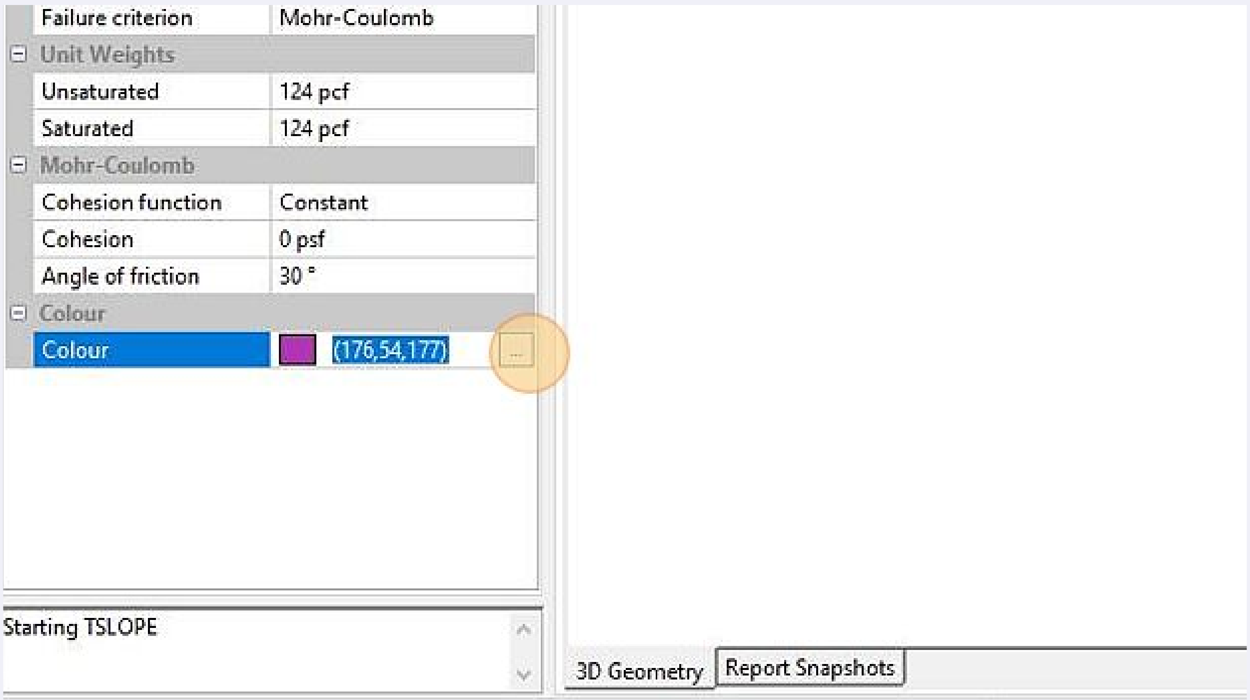
17 Type "30"



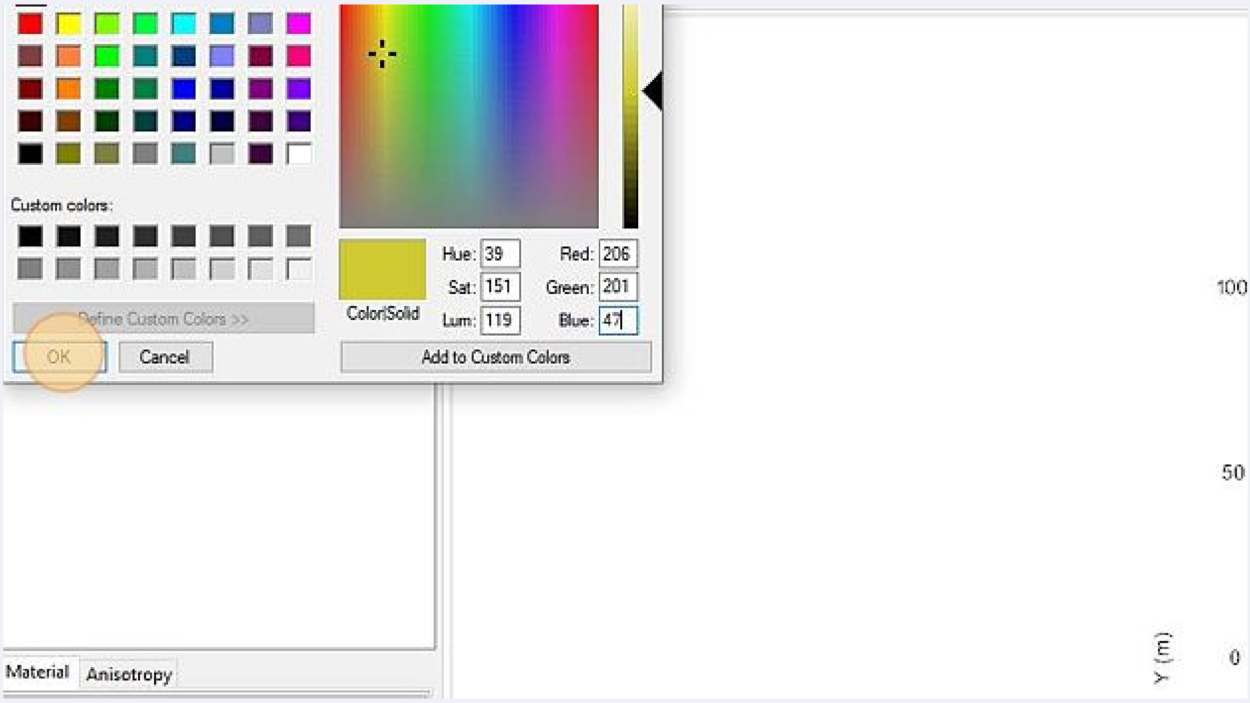
18 Change the material colour



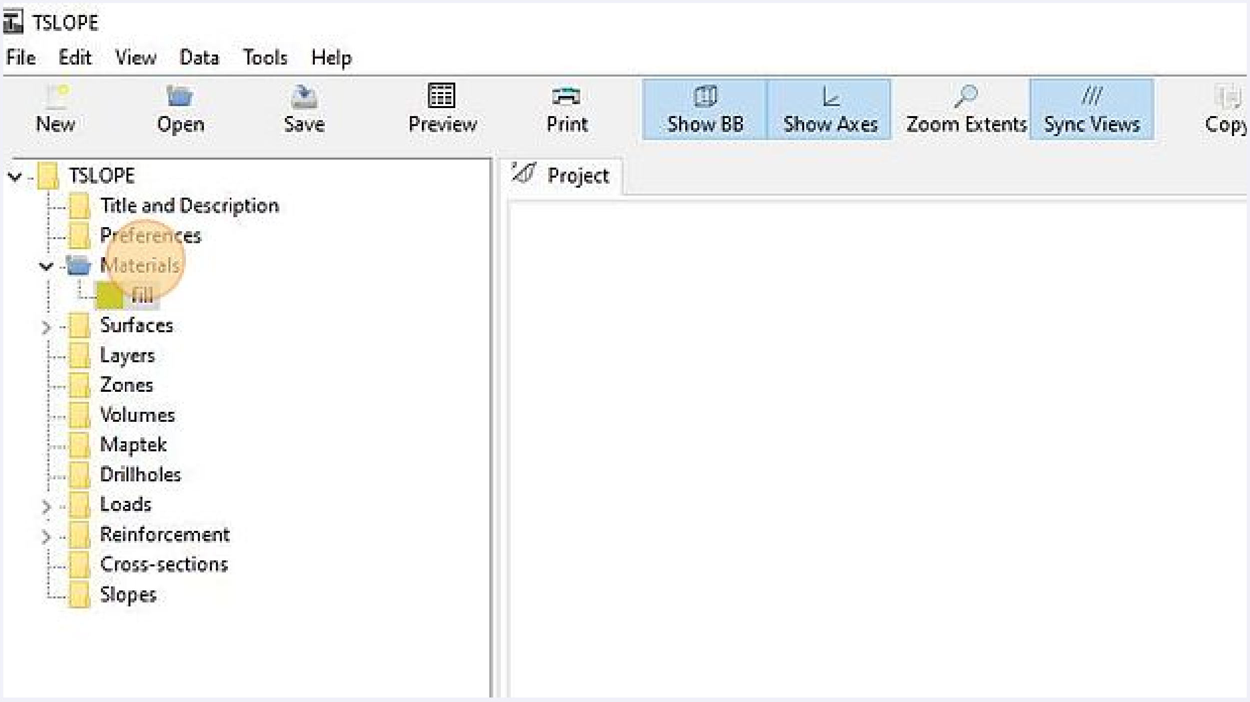
19 Click "..."



20 Click "OK"



21 Click "Materials"



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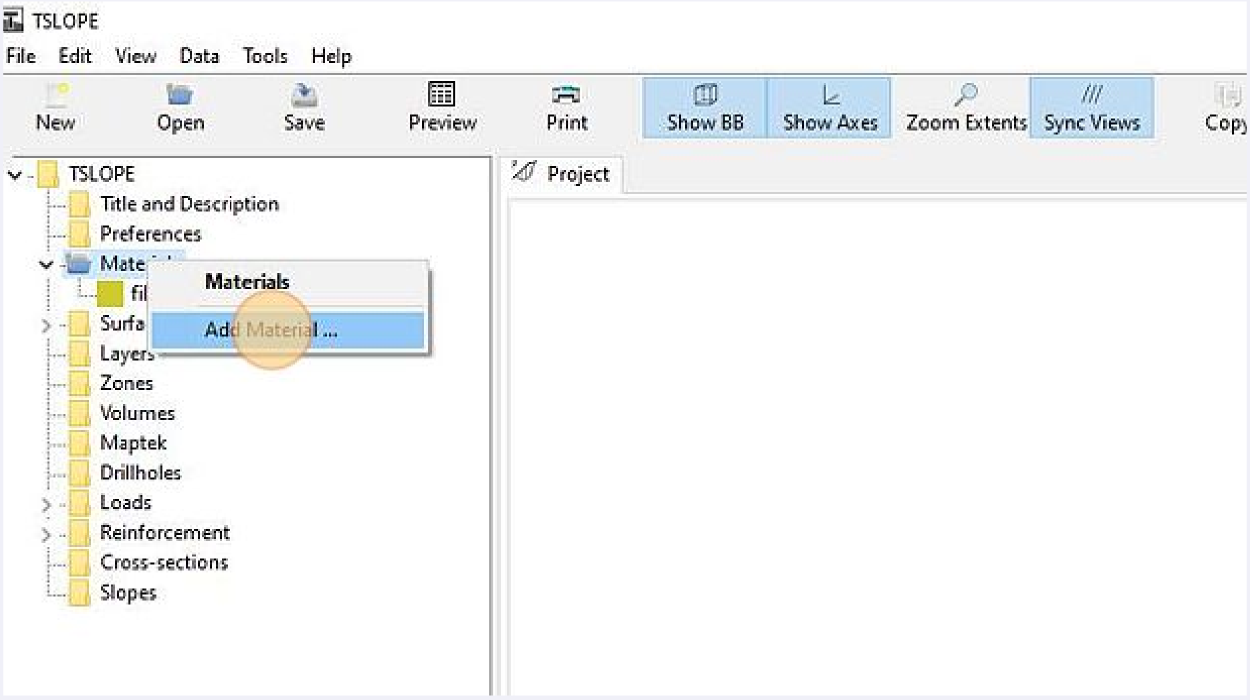

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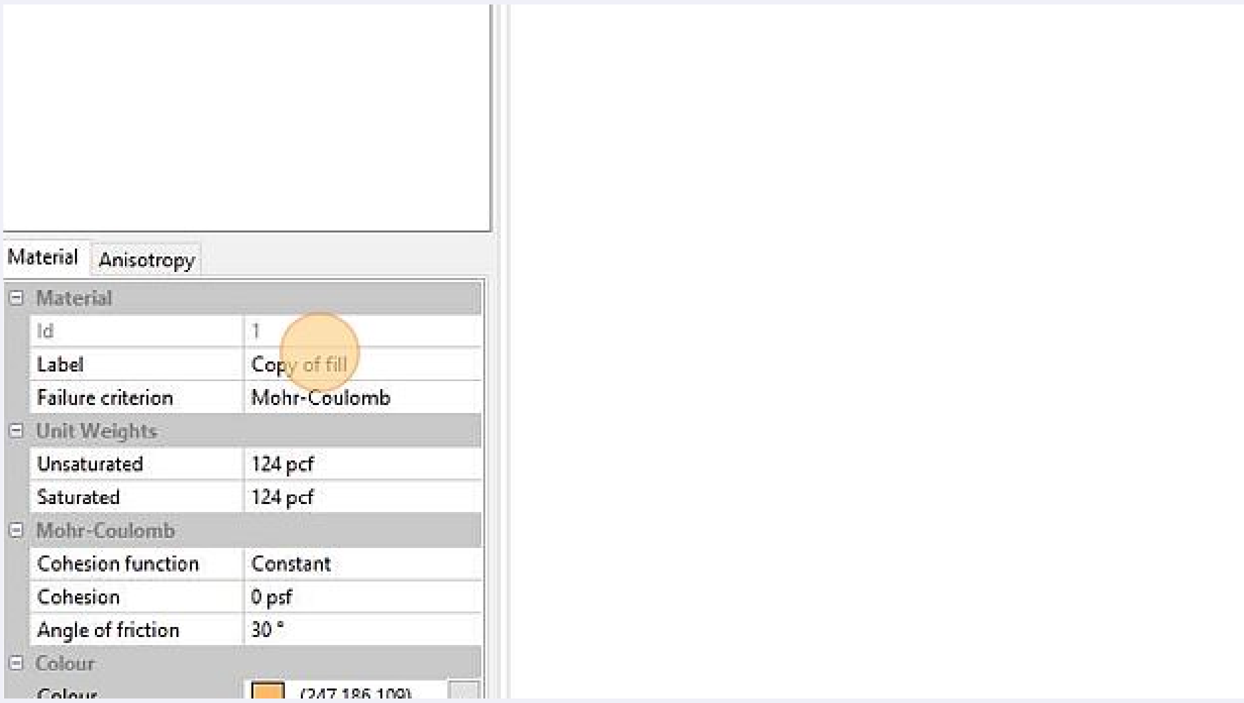

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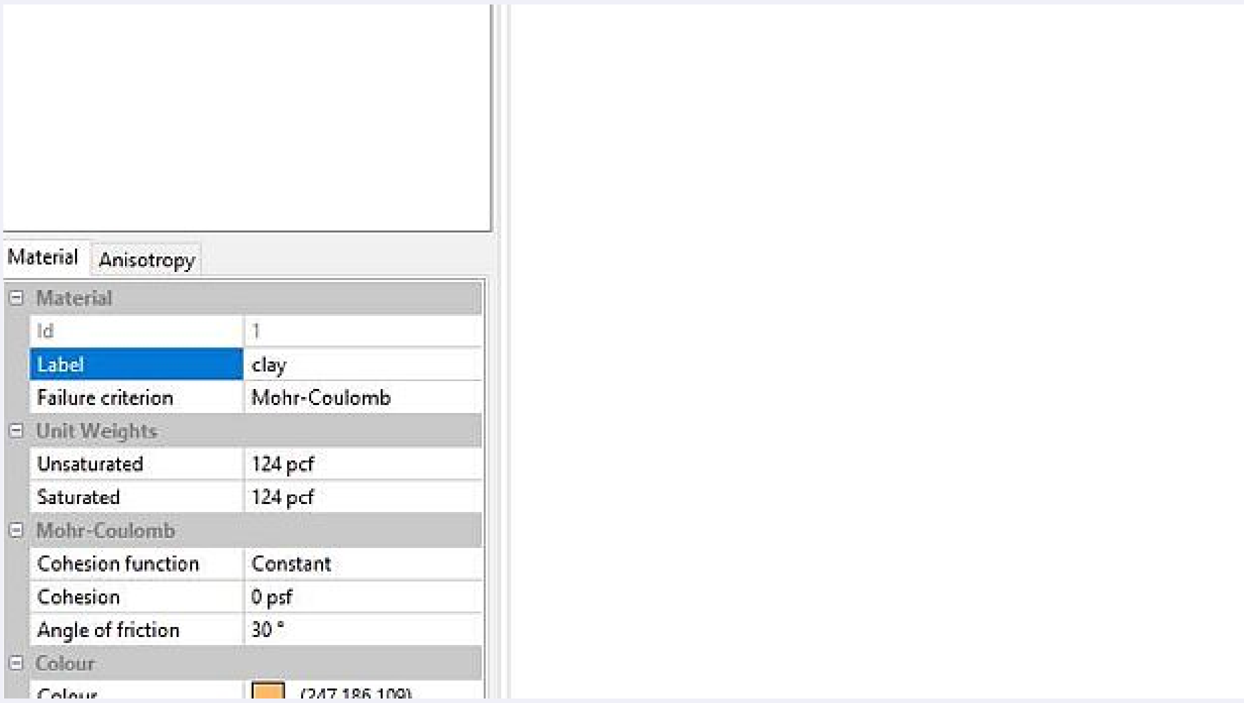
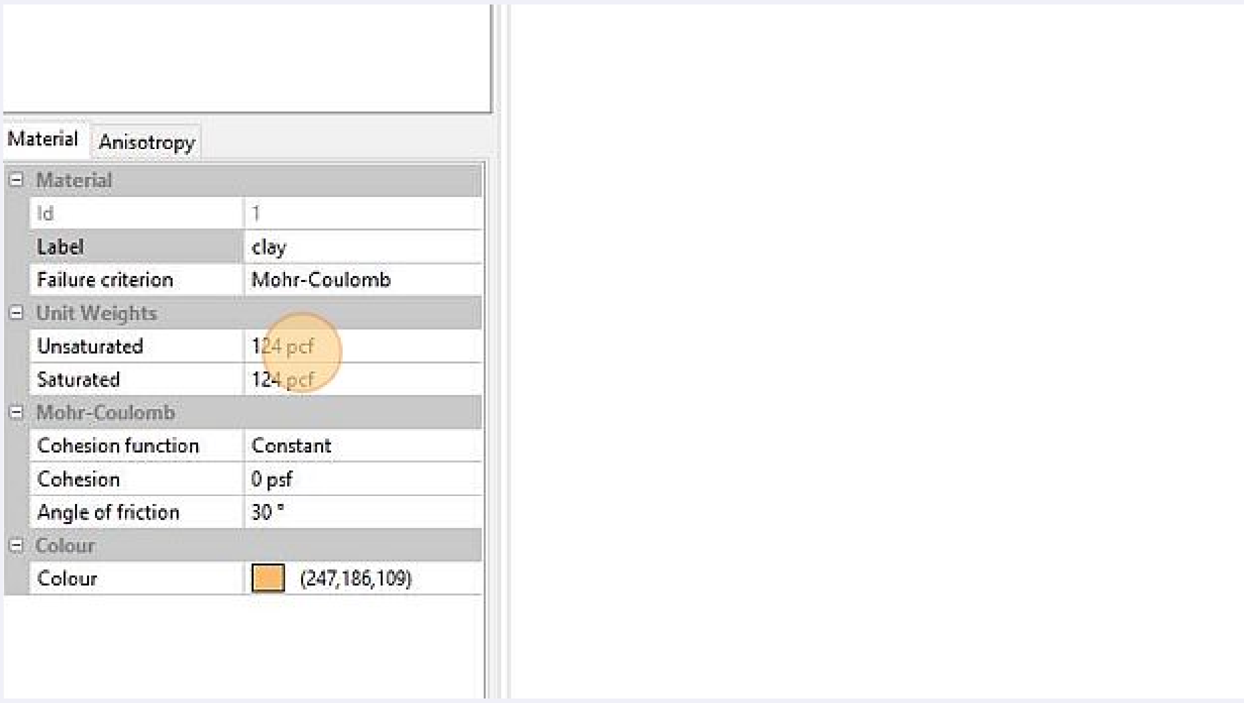


25 Change Unit Weights



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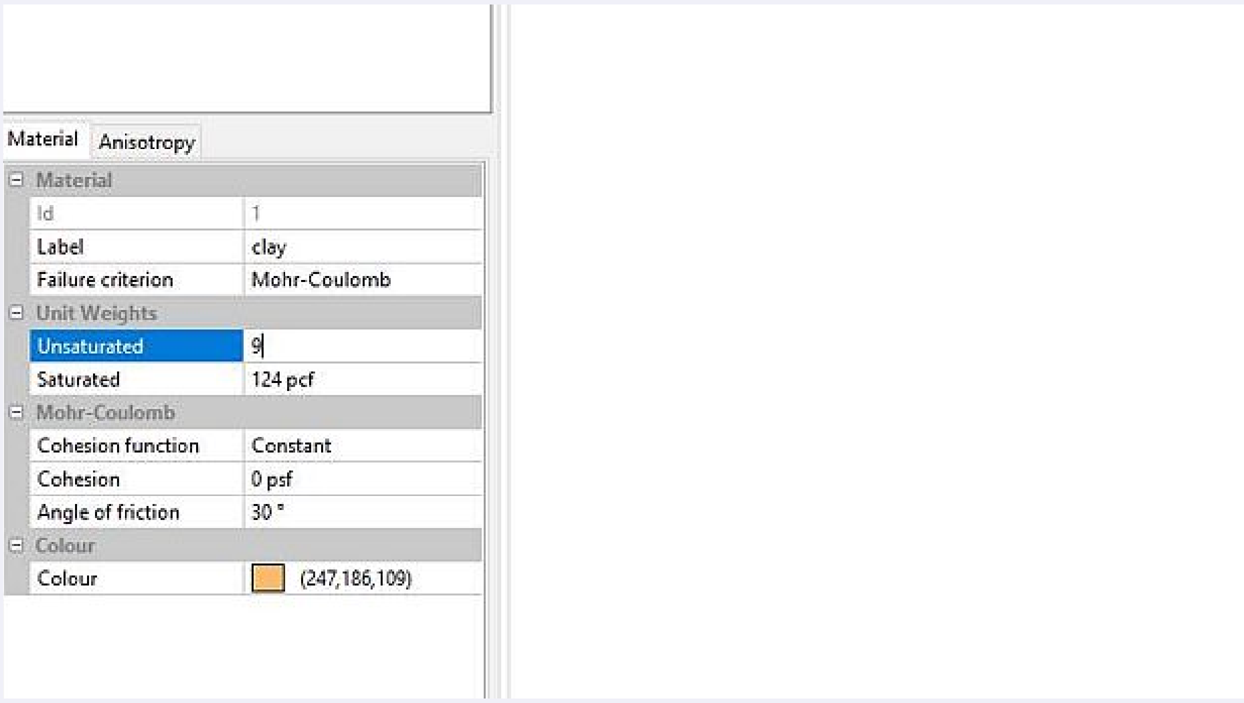

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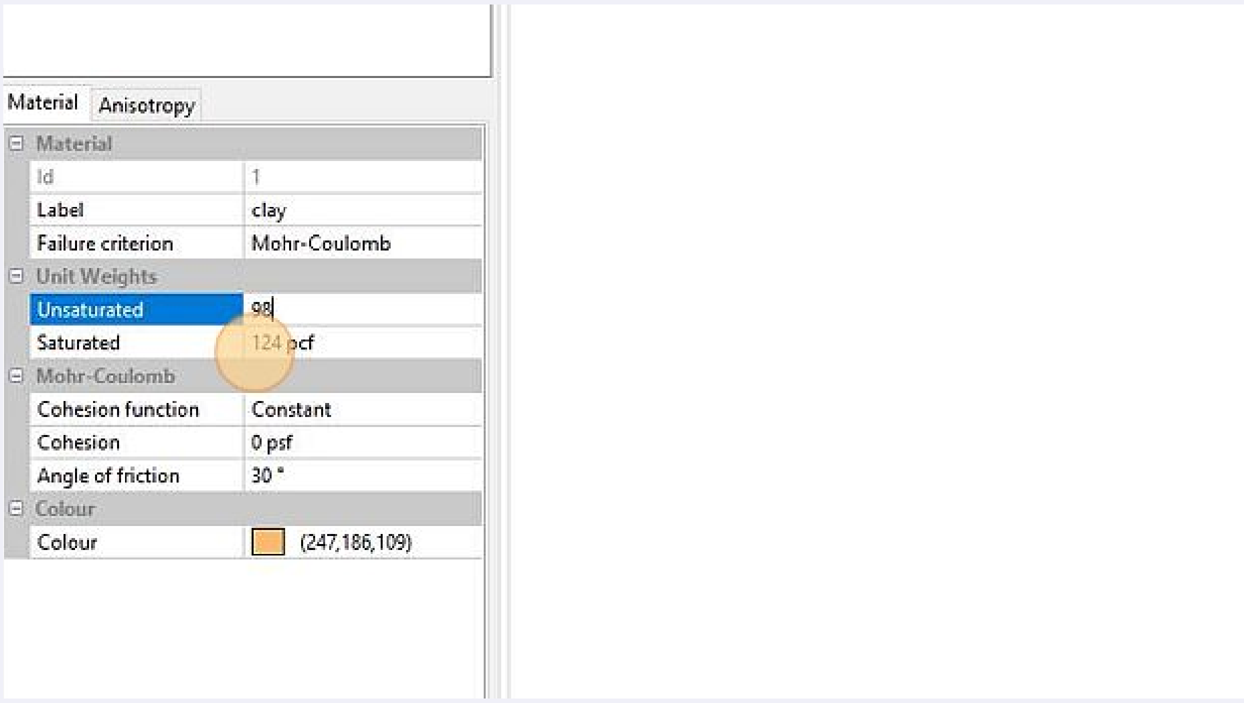

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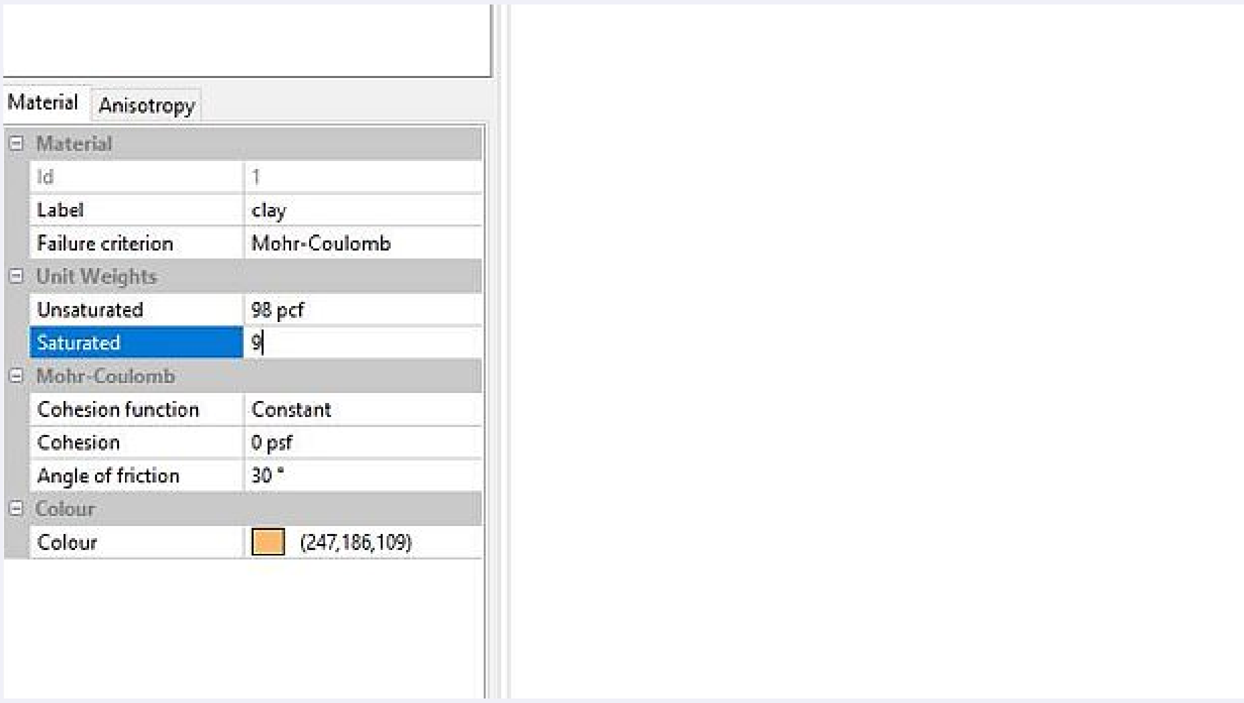
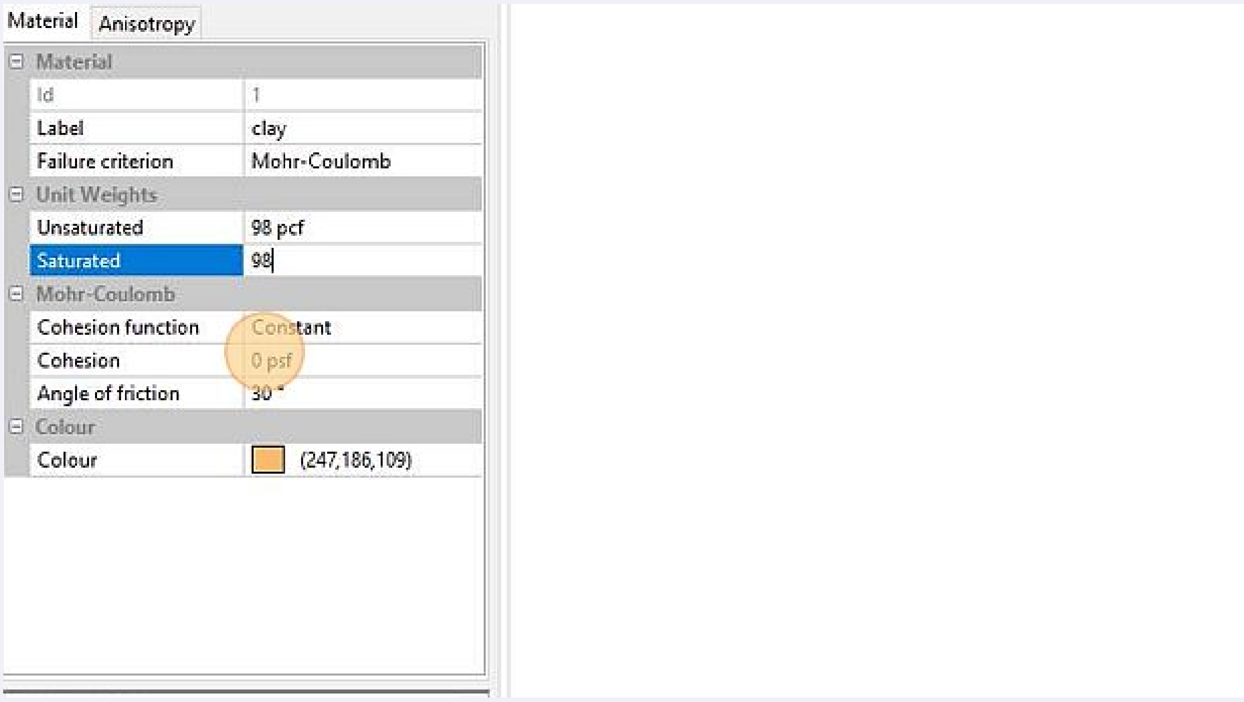


29 Change Mohr-Coulomb values



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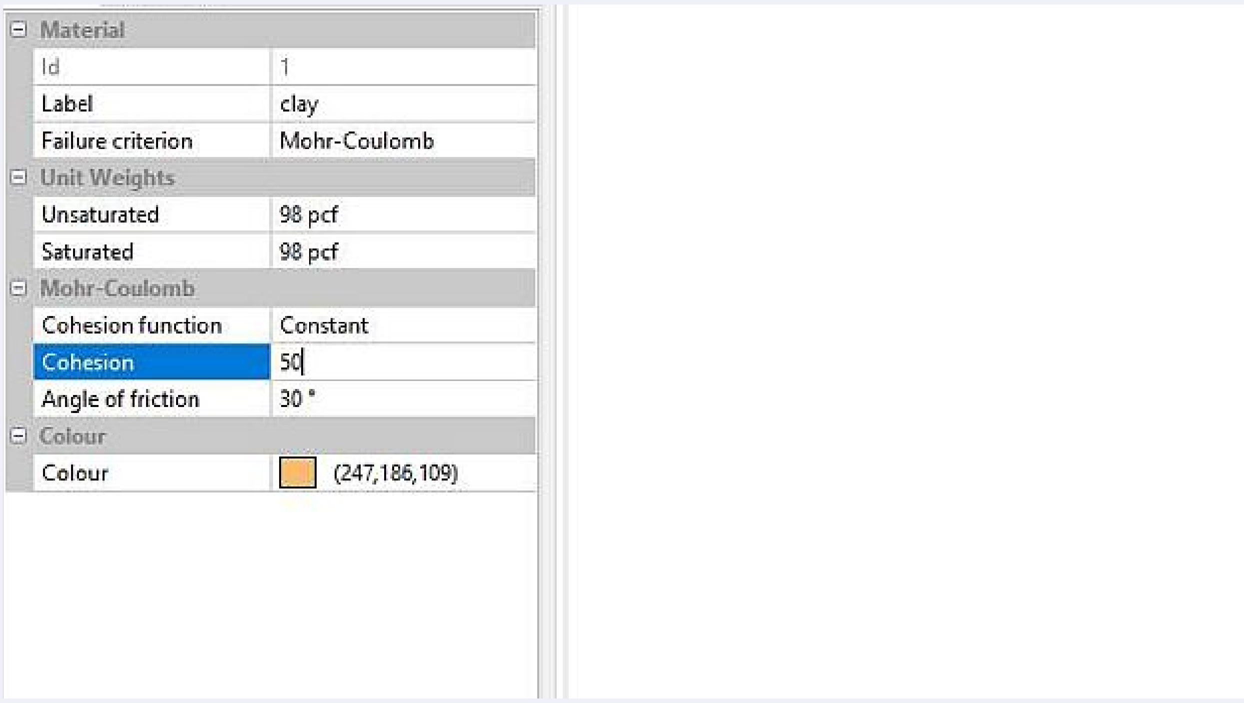
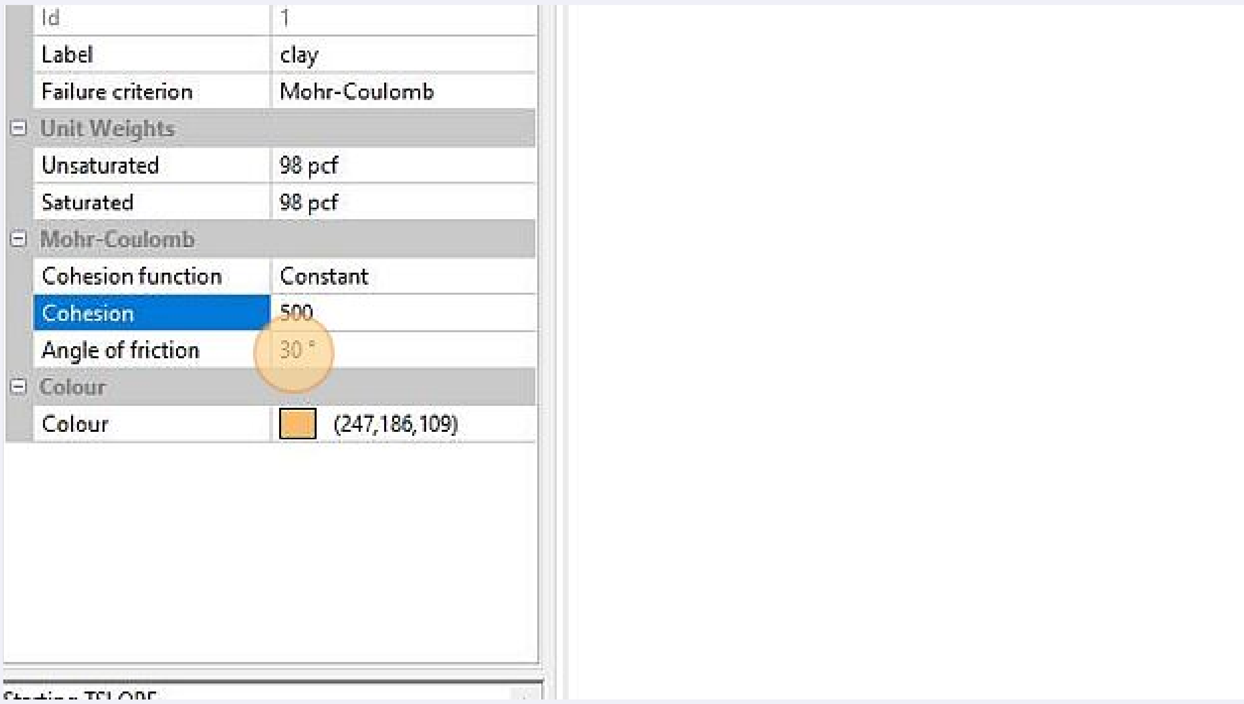
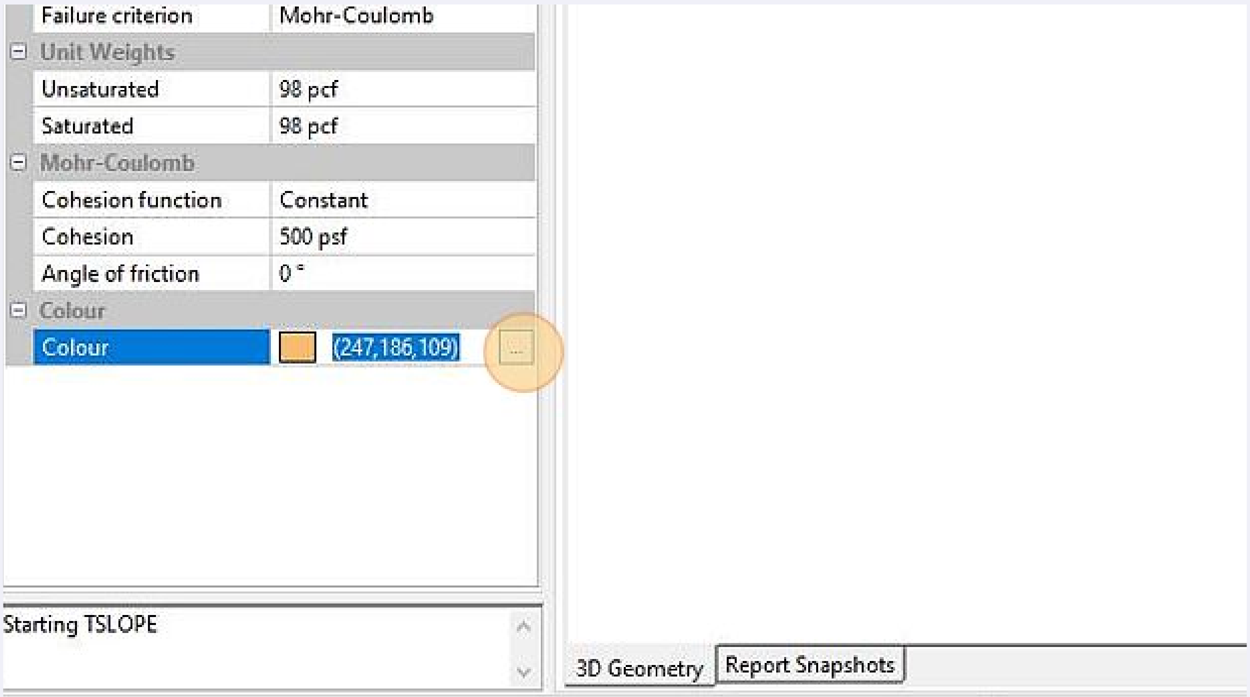


31 Click here:



32 Change Material colour



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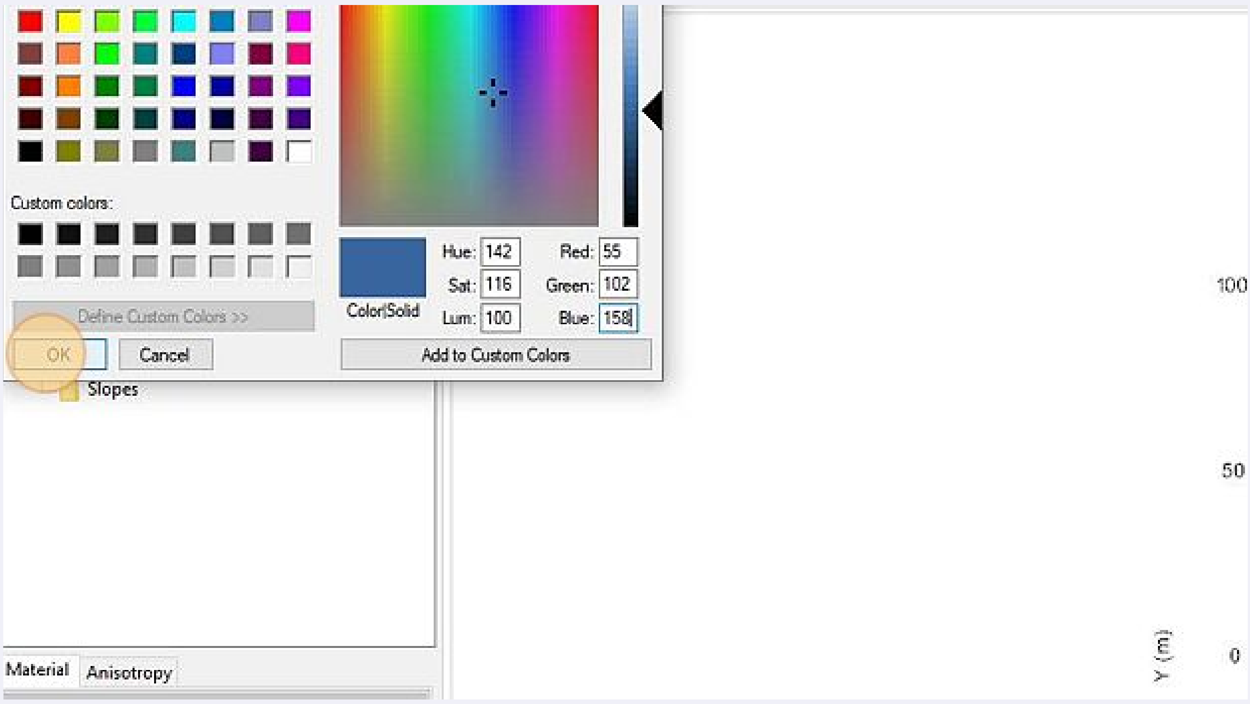

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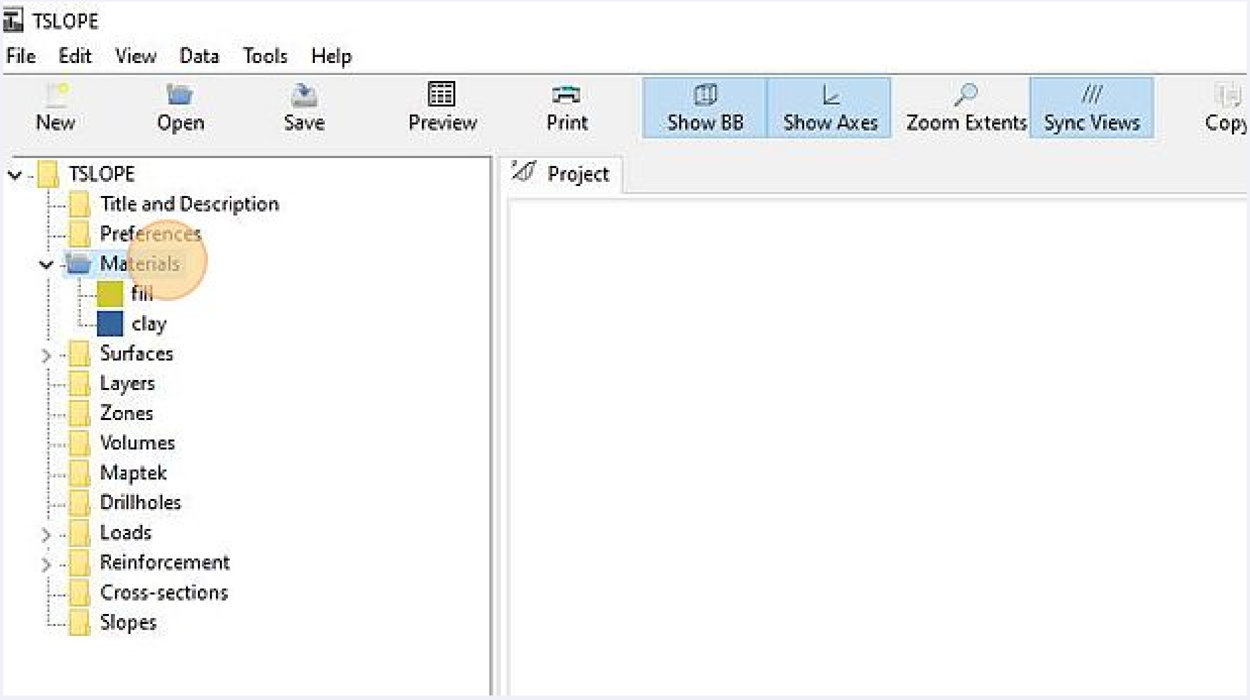
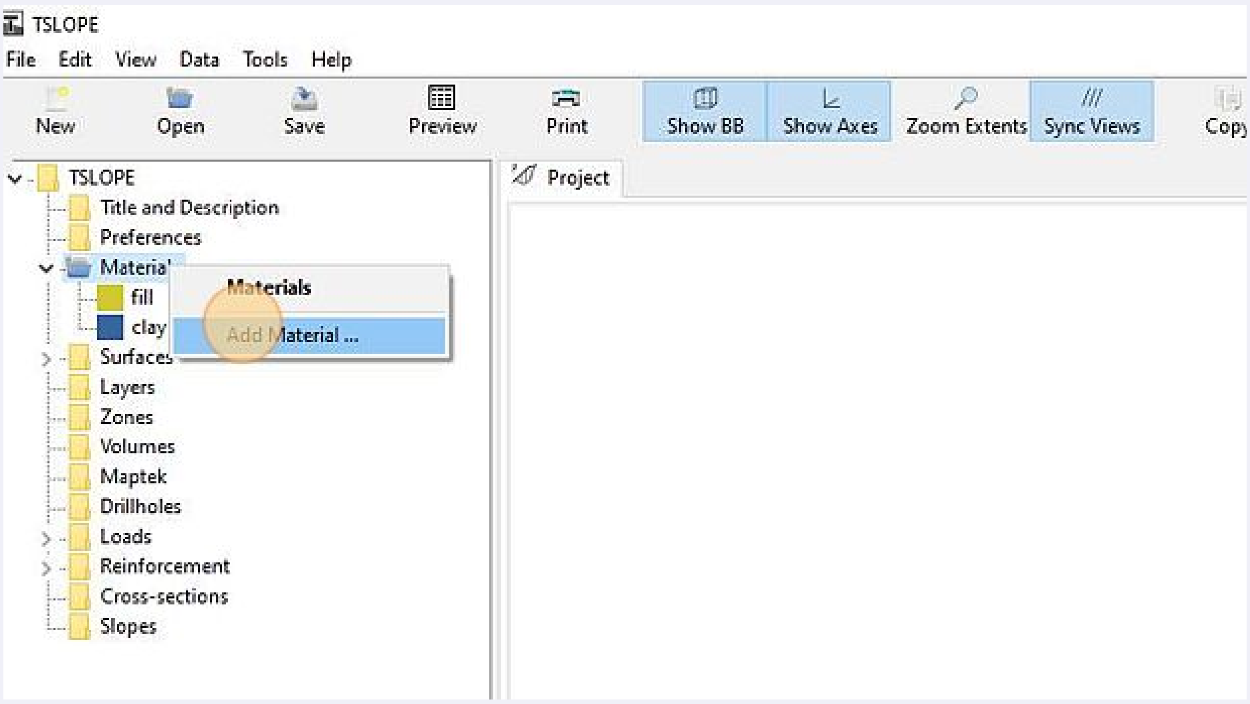
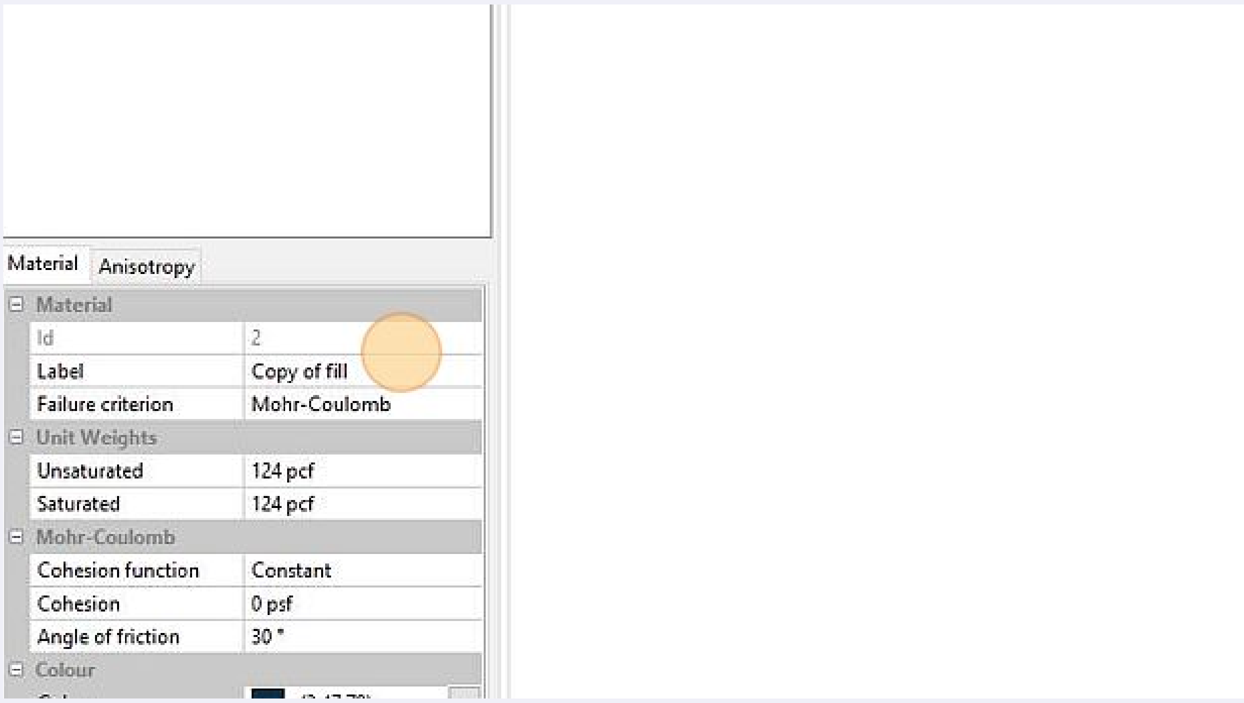


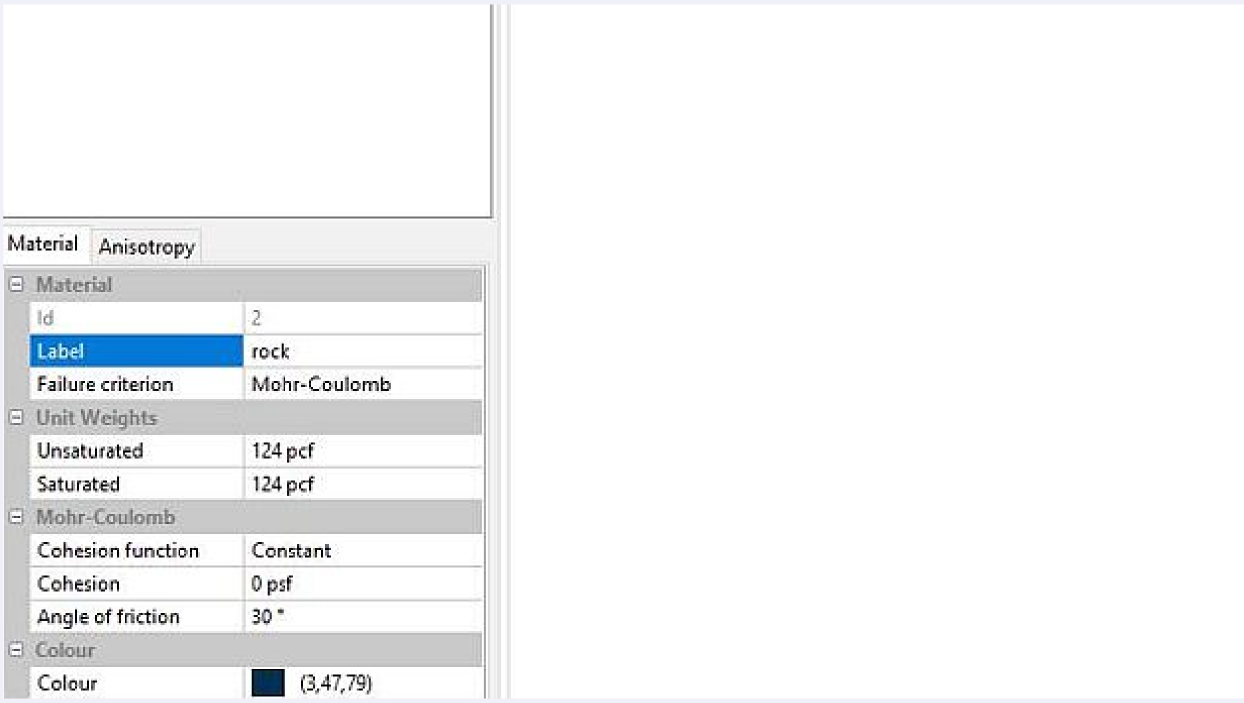
35 Click "Add Material..."



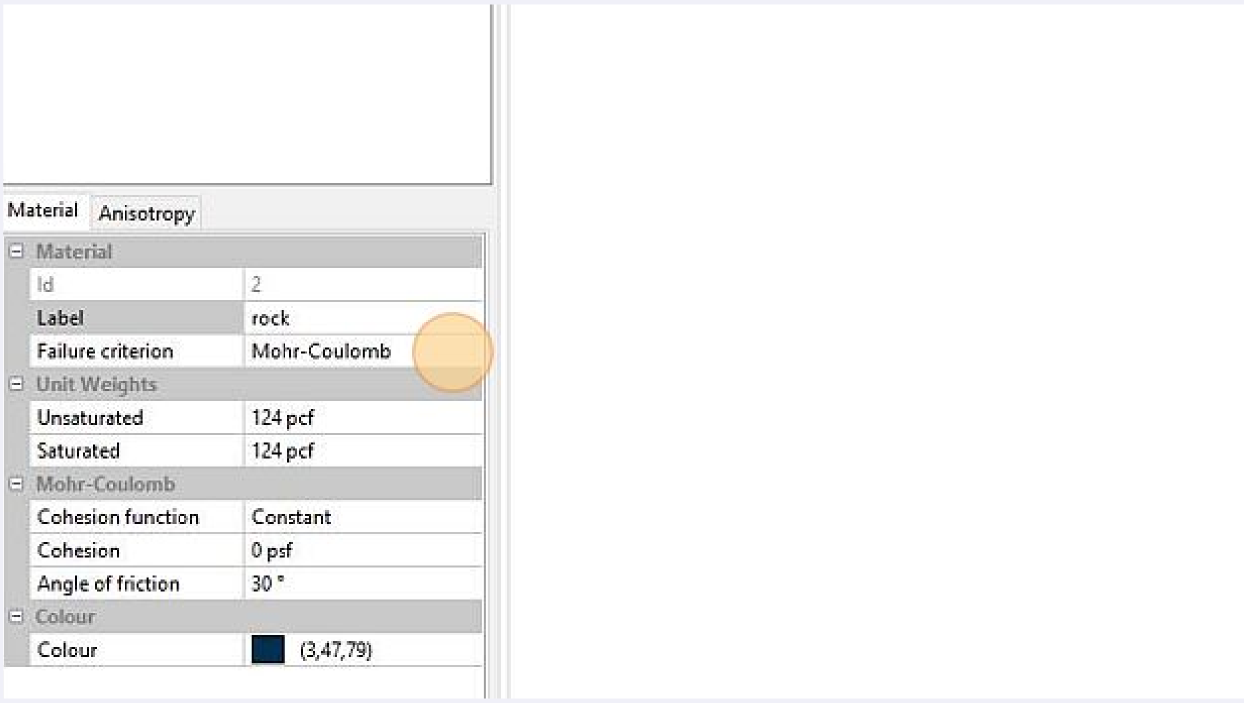
36 Change Label



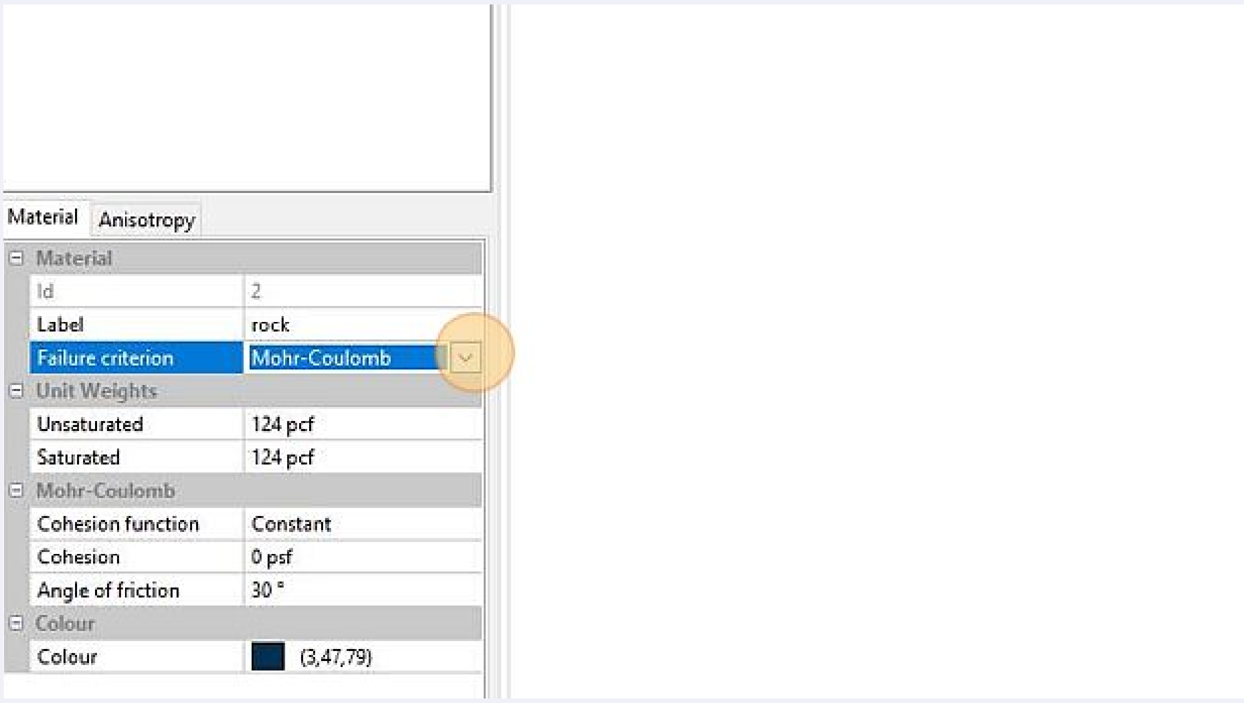
37 Type "rock"



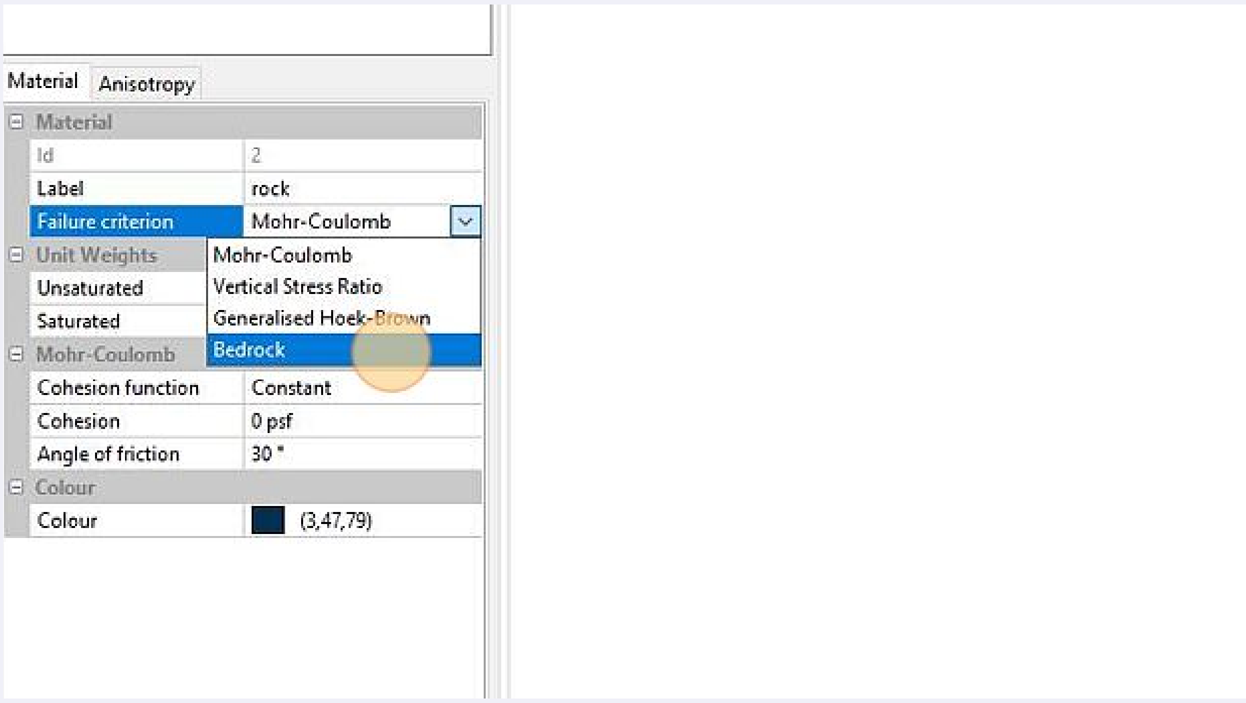
38 Change Failure criterion



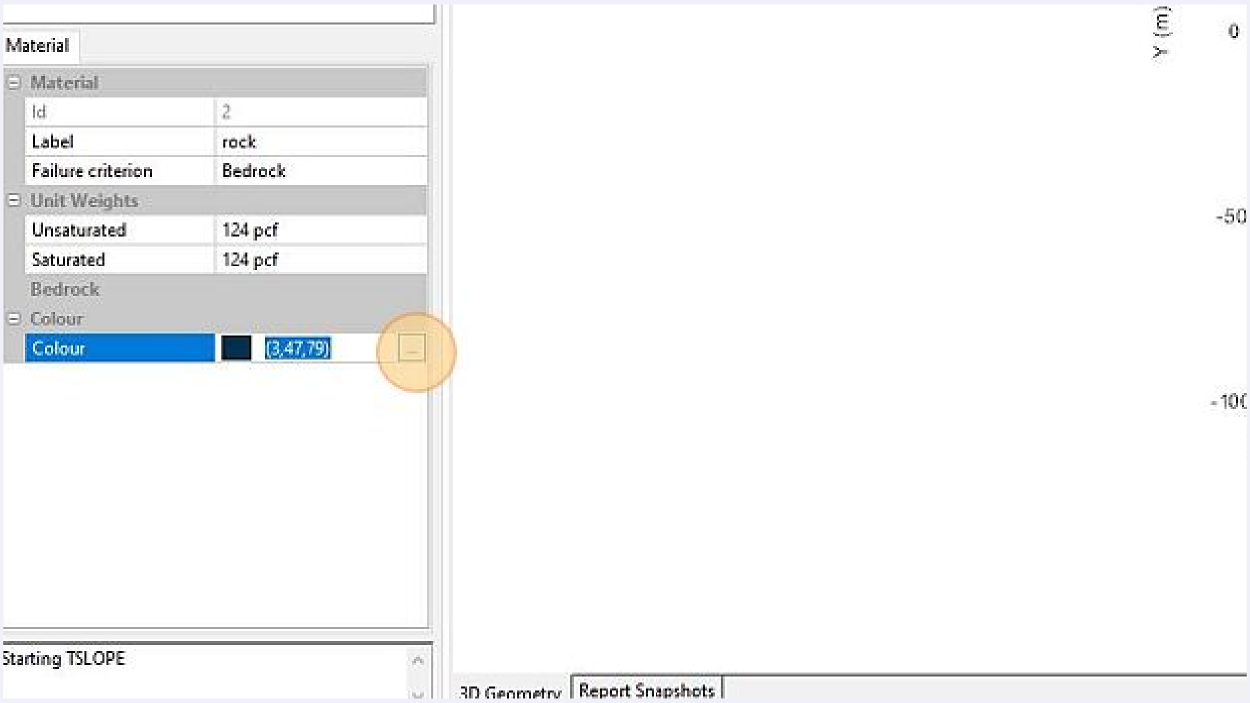
39 Click the pull down box to change the Failure criterion



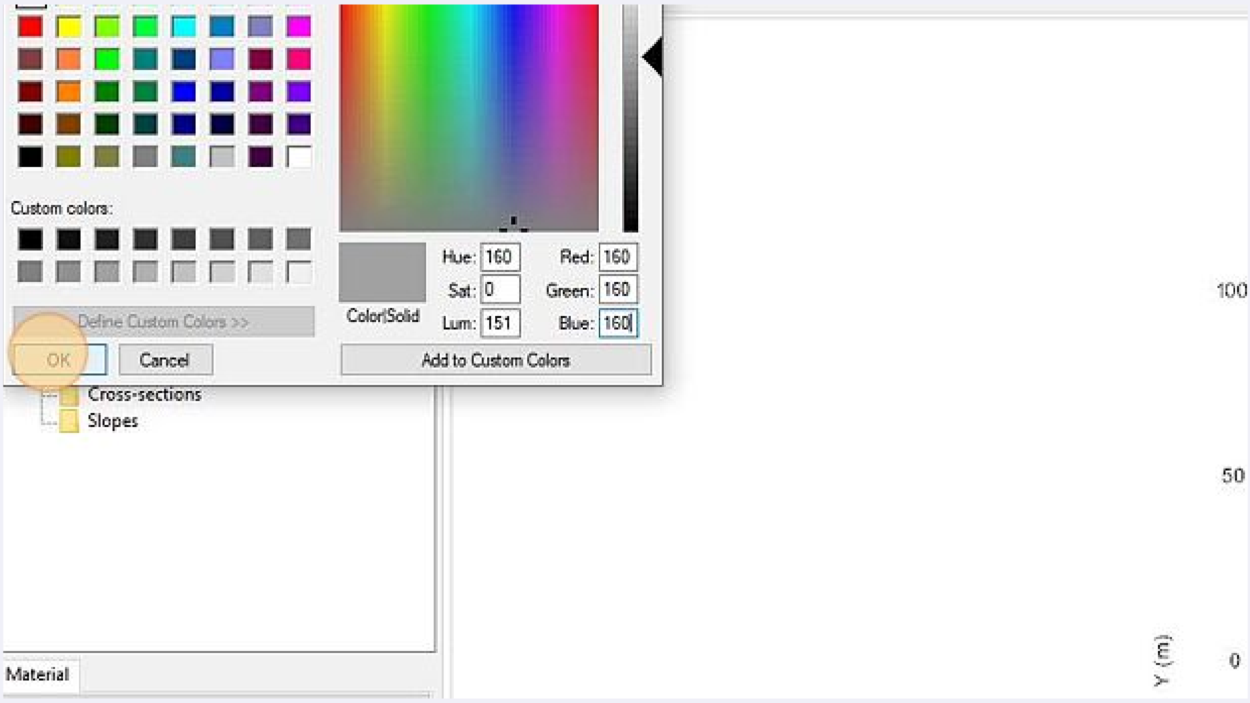
40 Select Bedrock



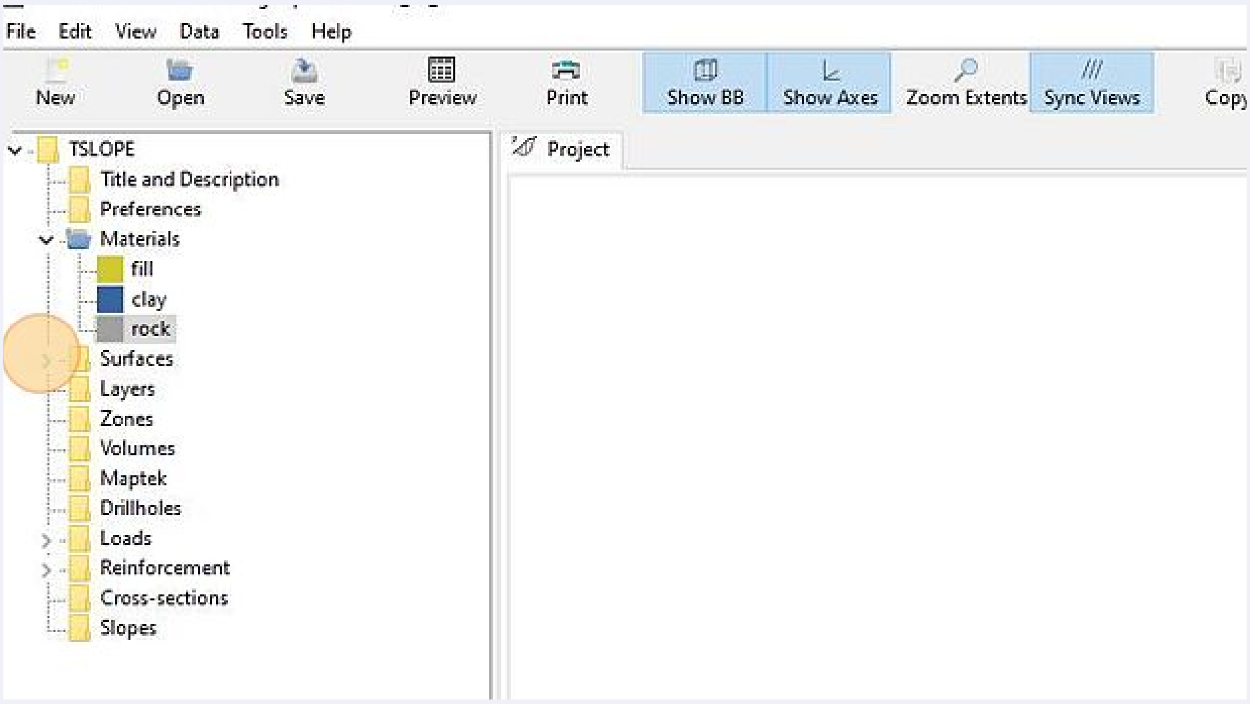
41 Change the material colour



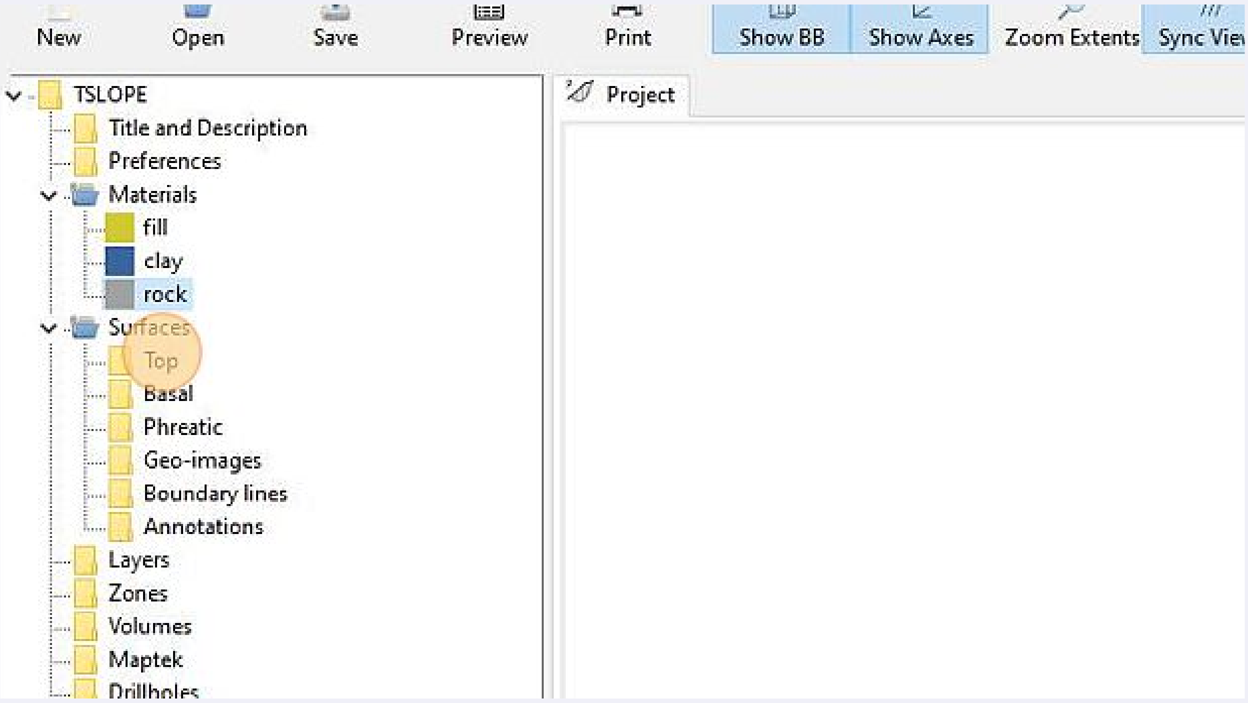
42 Click "OK"



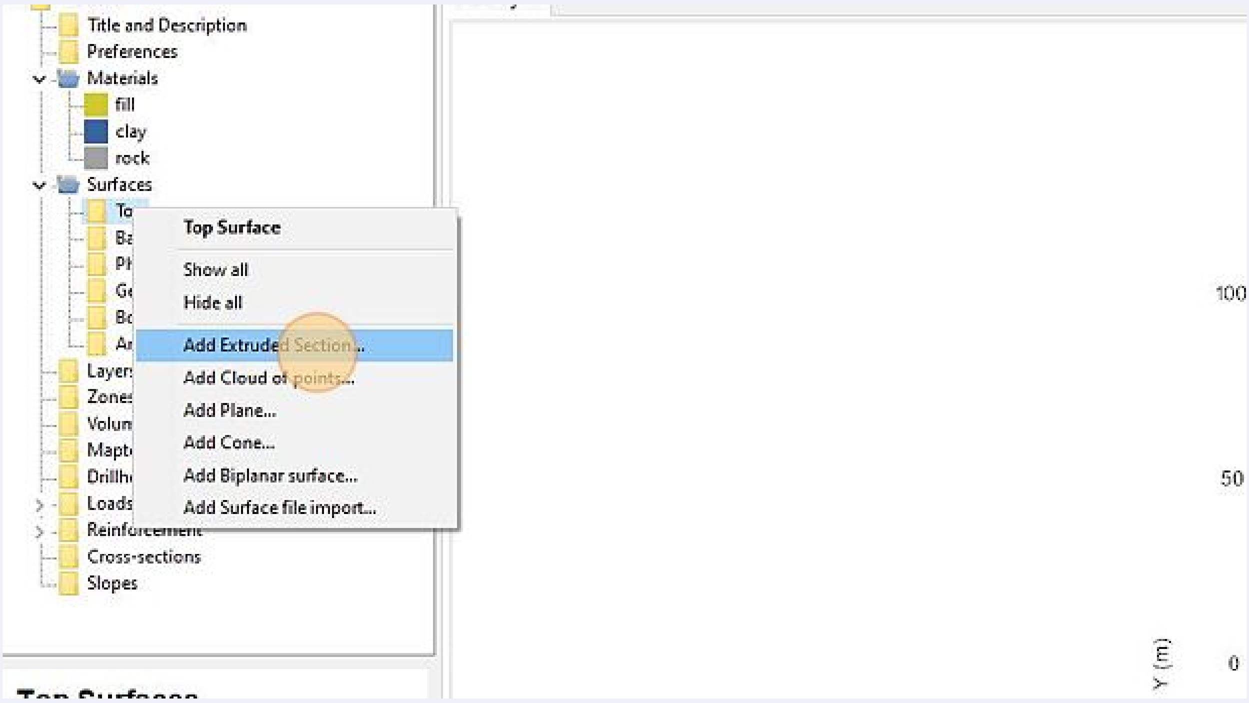
43 Click "Surfaces"



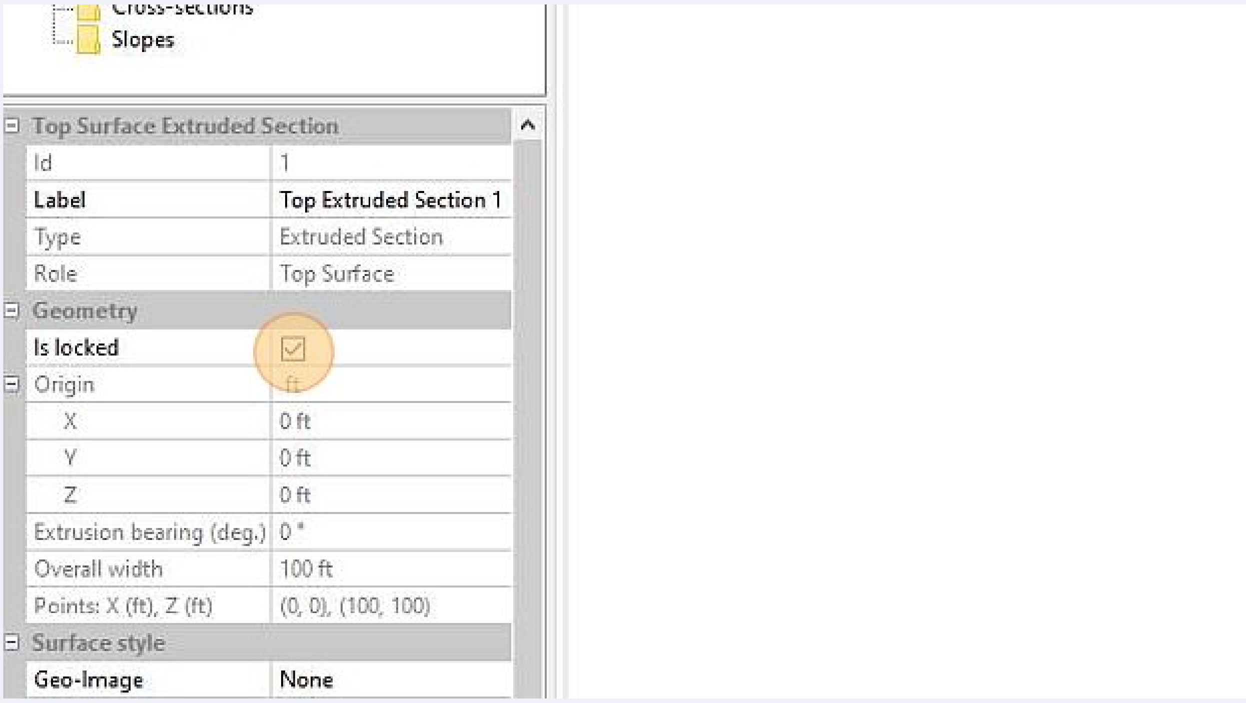
44 Click "Top"



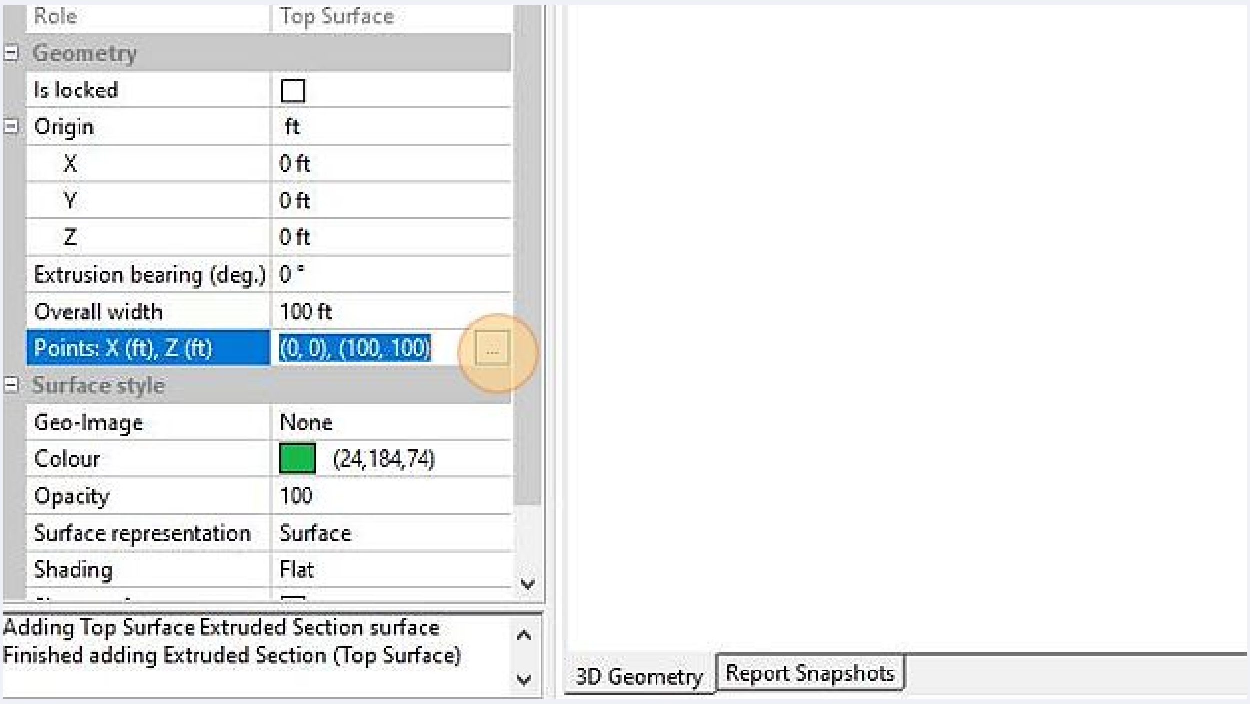
45 Click "Add Extruded Section..."



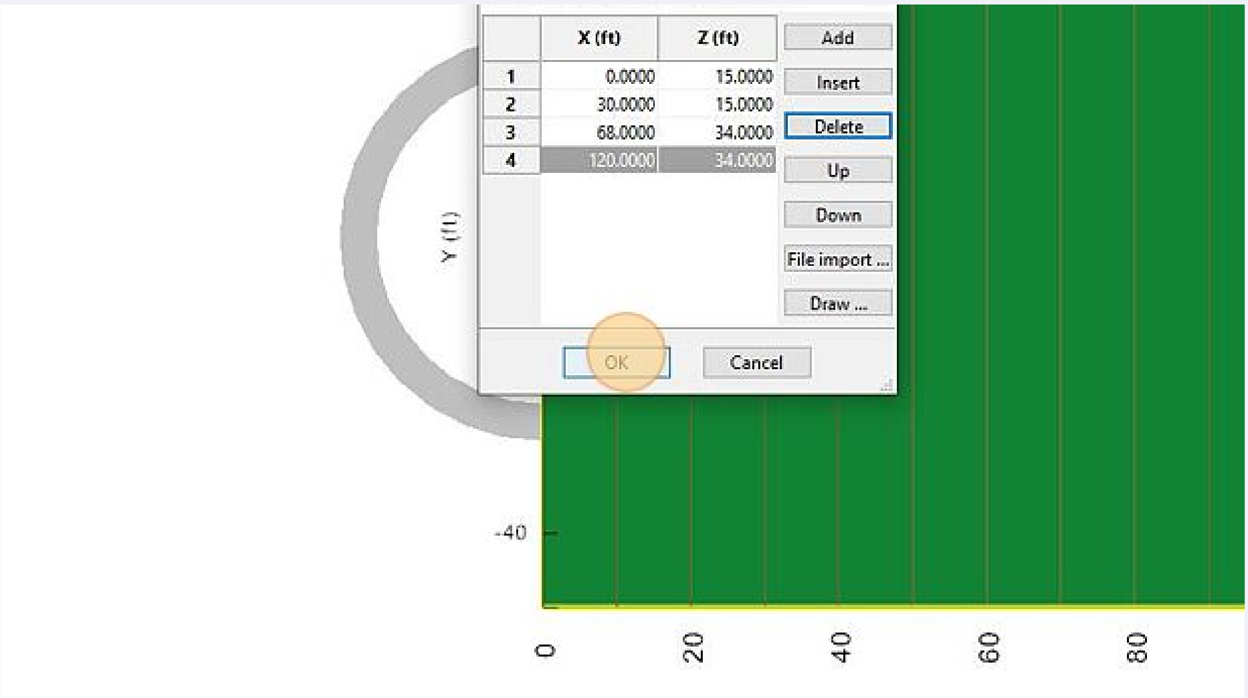
46 Unlock the extruded section



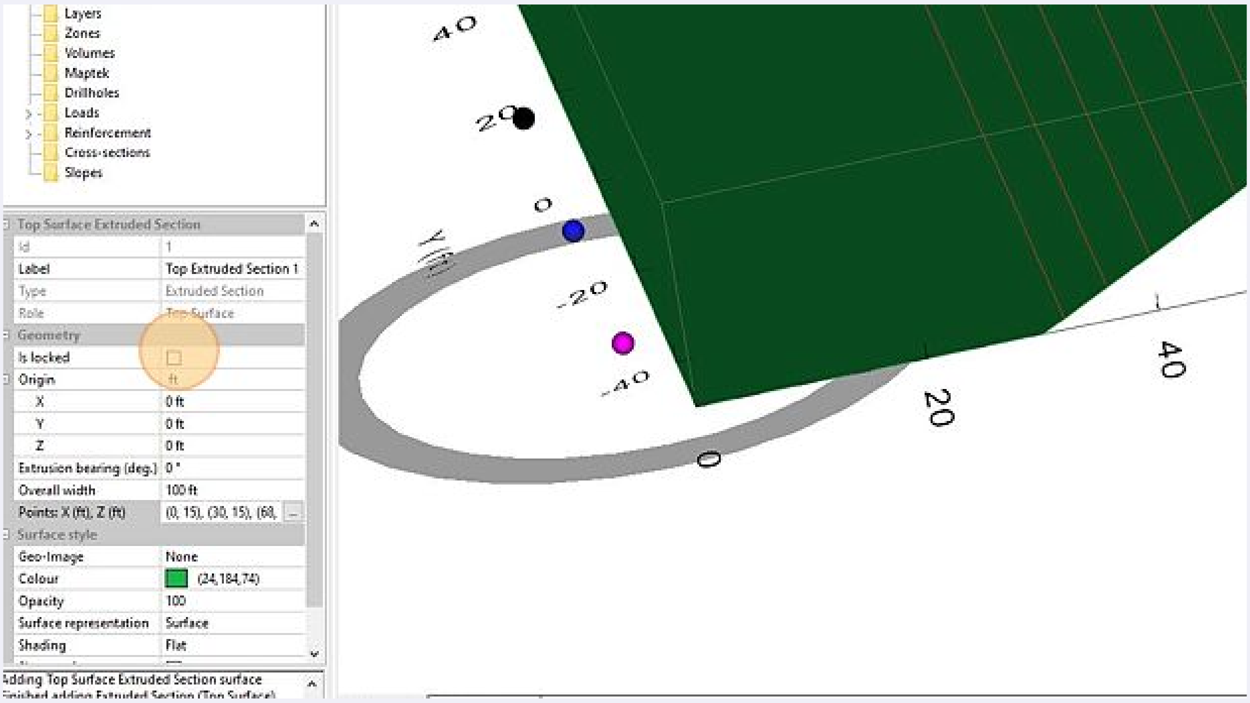
47 Open the points file to add points



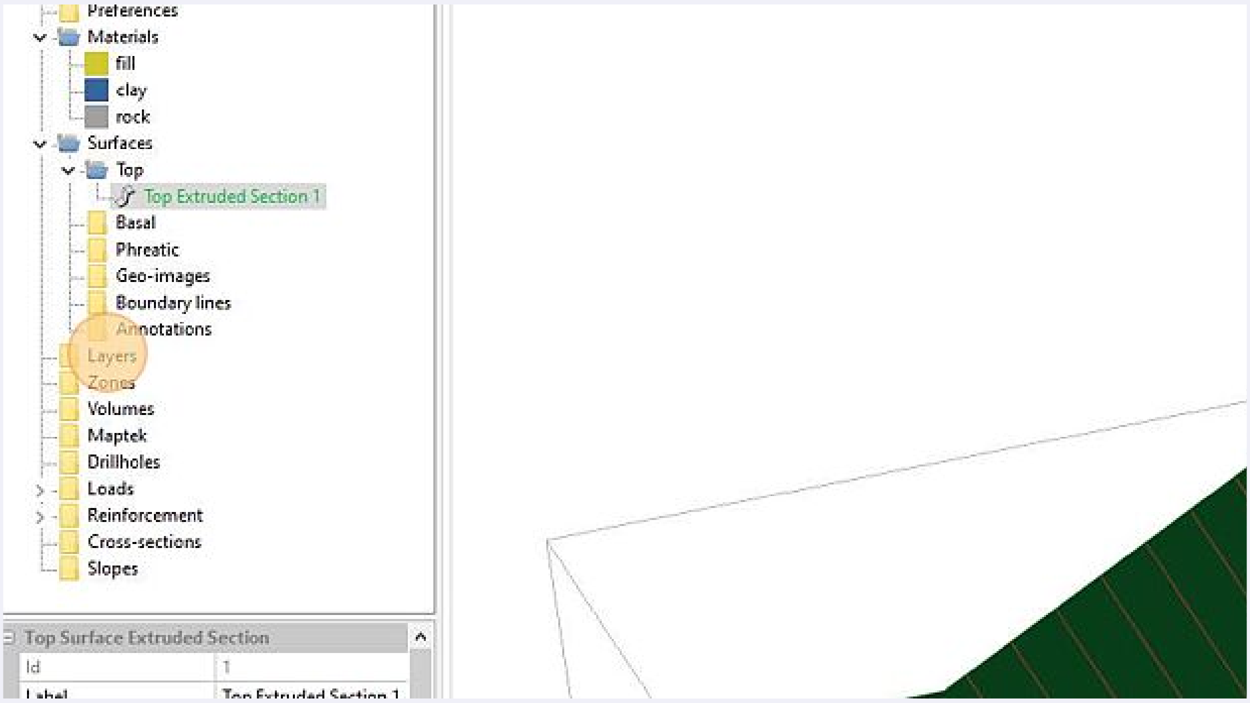
48 Add the points (X,Z pairs) Click "OK"



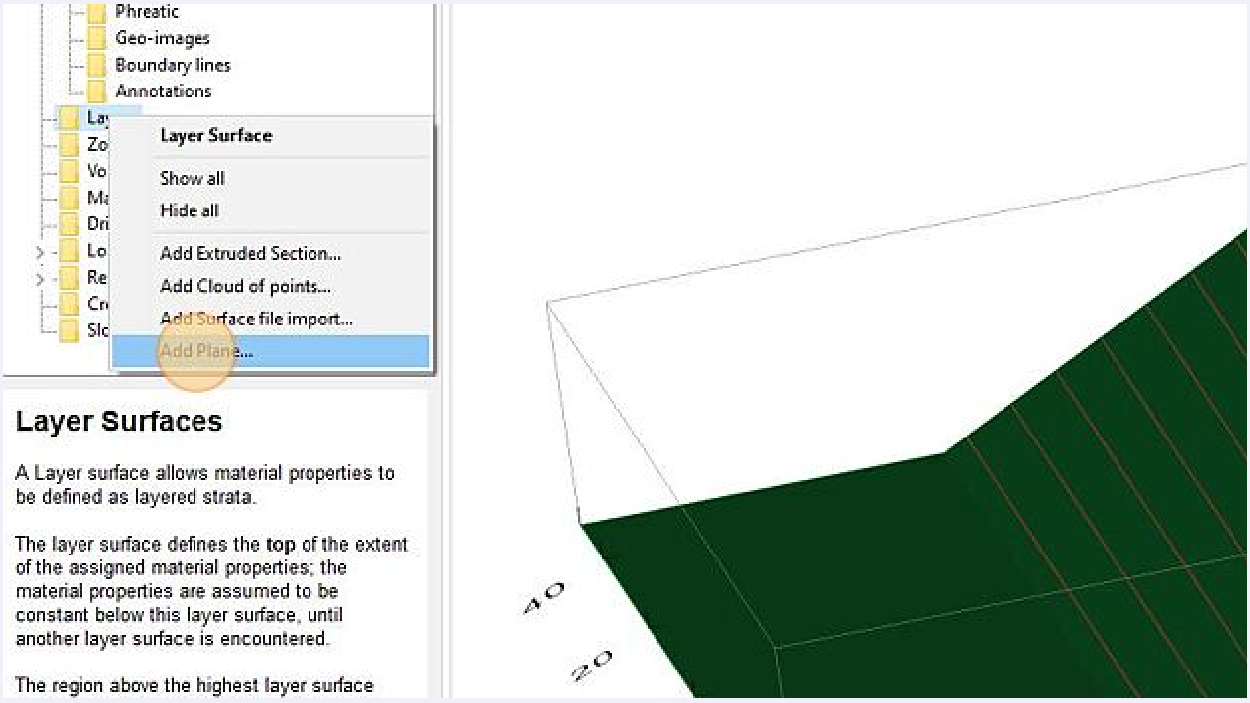
49 Lock the surface



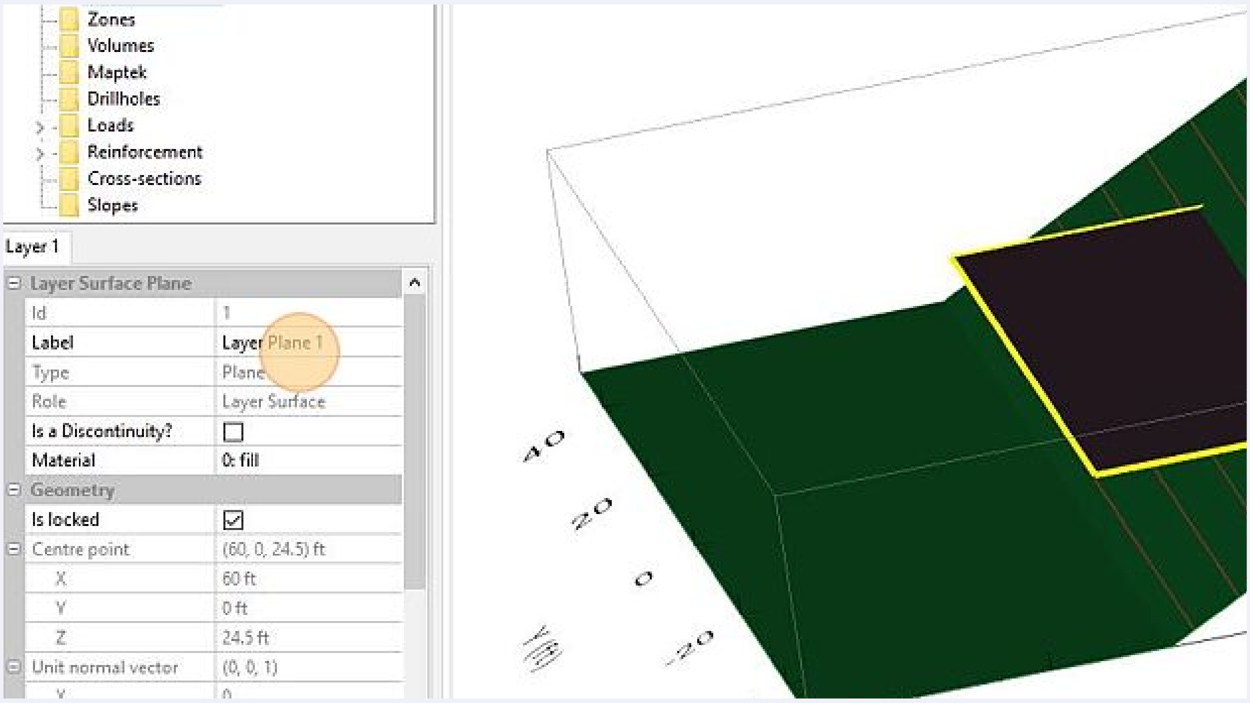
50 Click "Layers"



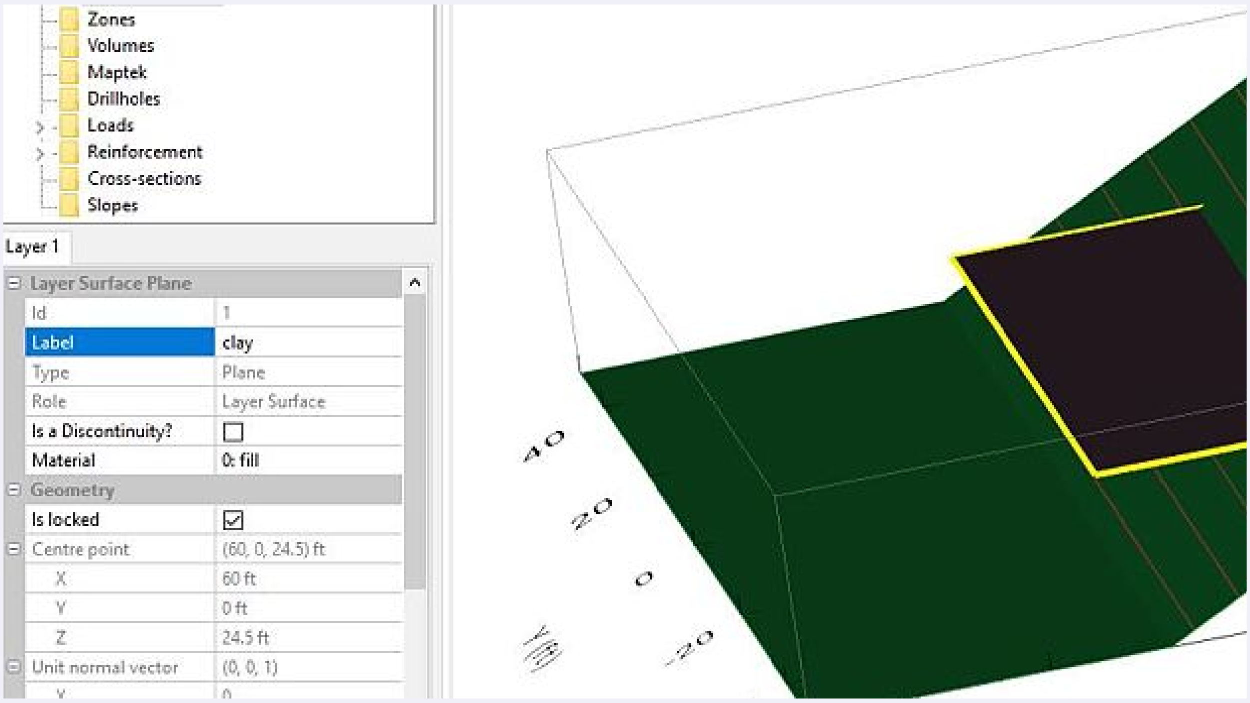
51 Click "Add Plane..."



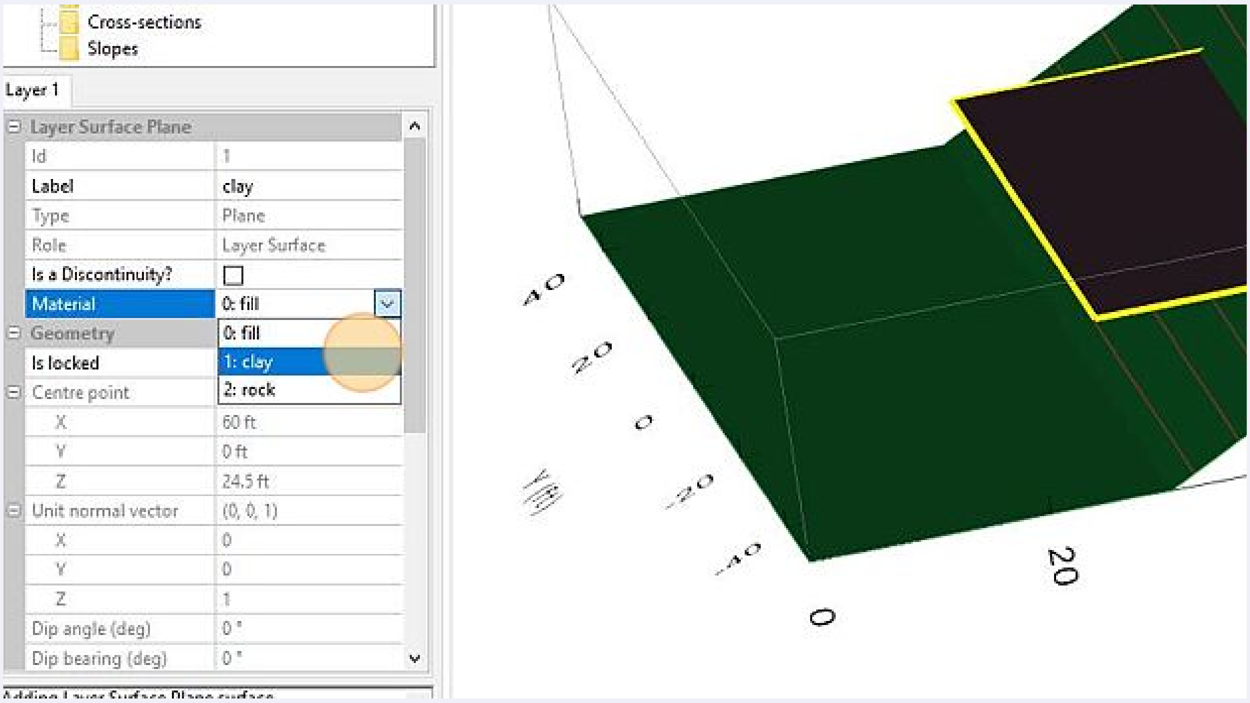
52 Change the Label



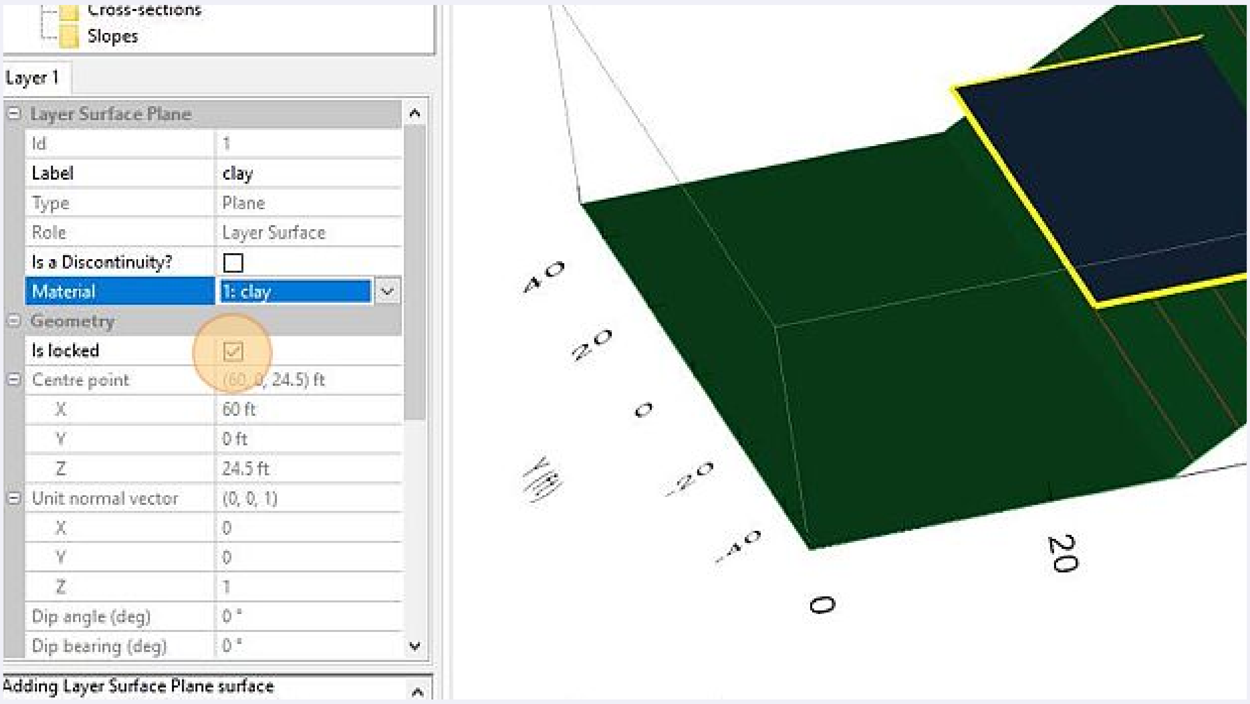
53 Type "clay"



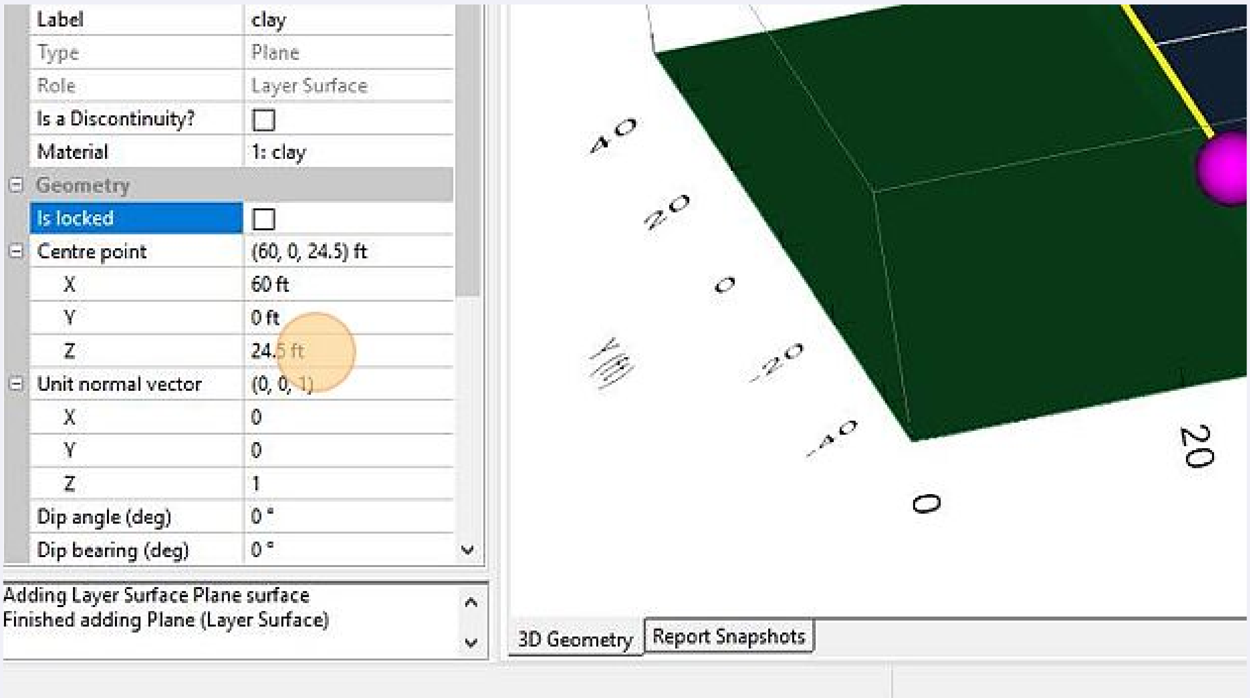
54 Assign the Material "clay" to the Layer



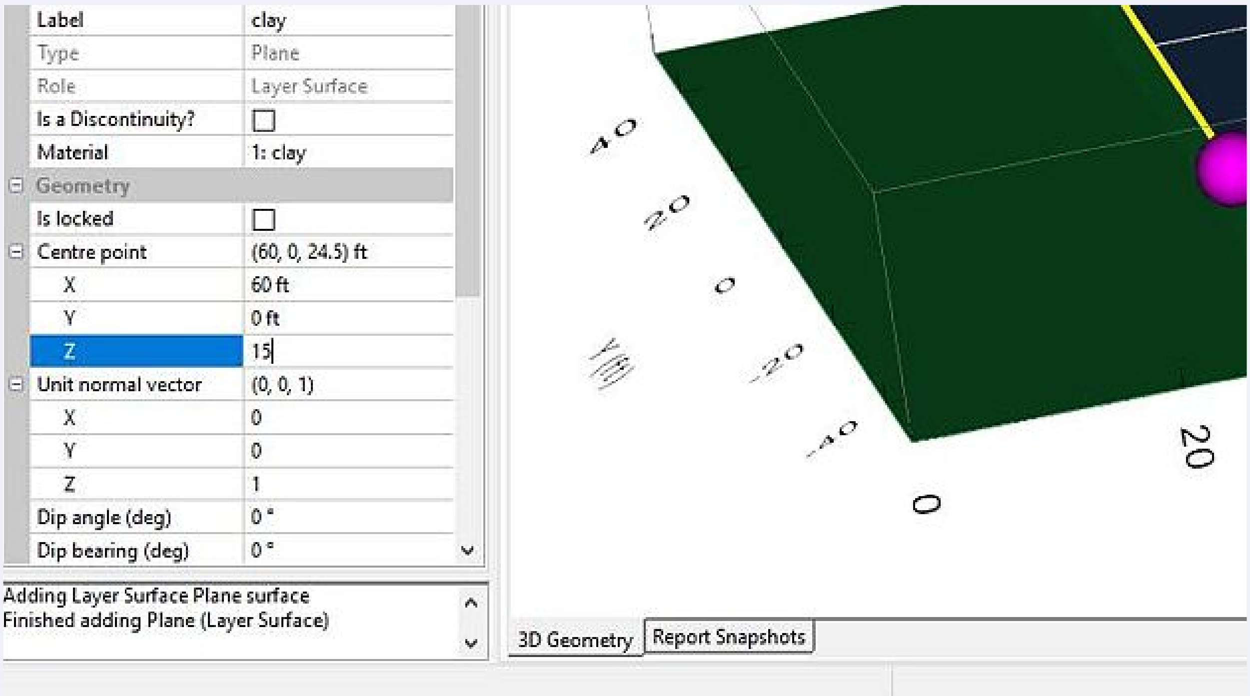
55 Unlock the Plane



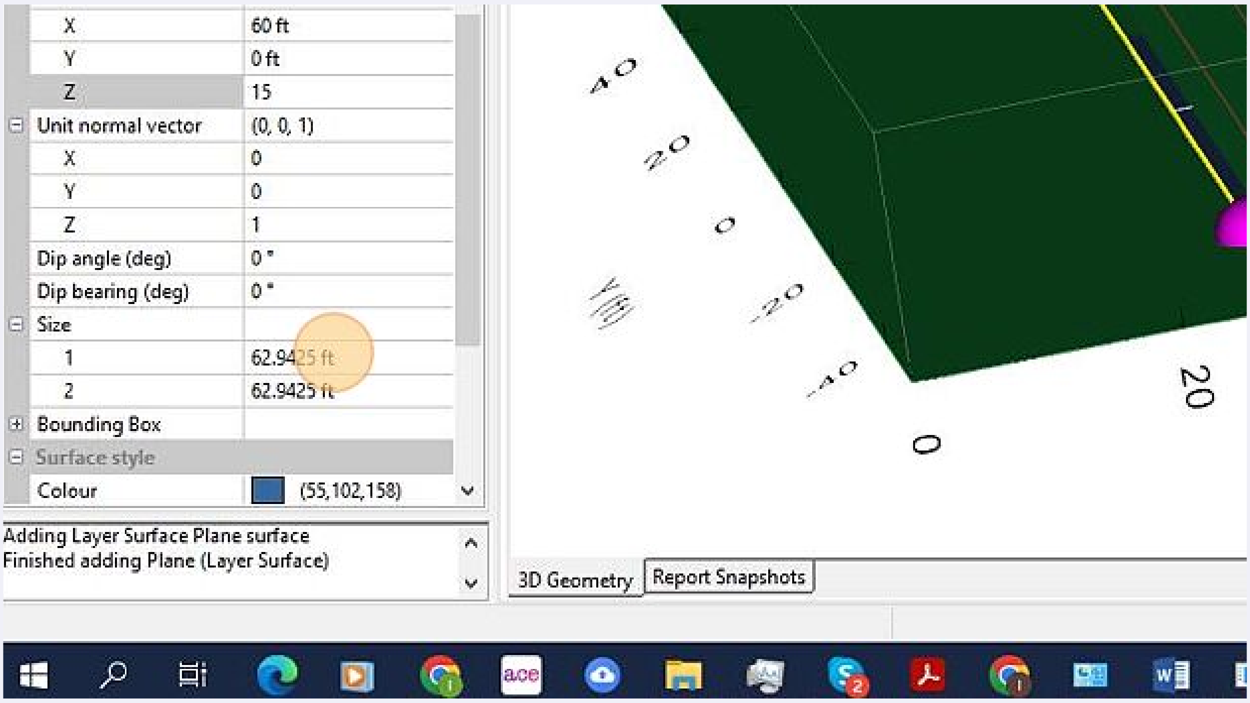
56 Change the Z value of Centre point



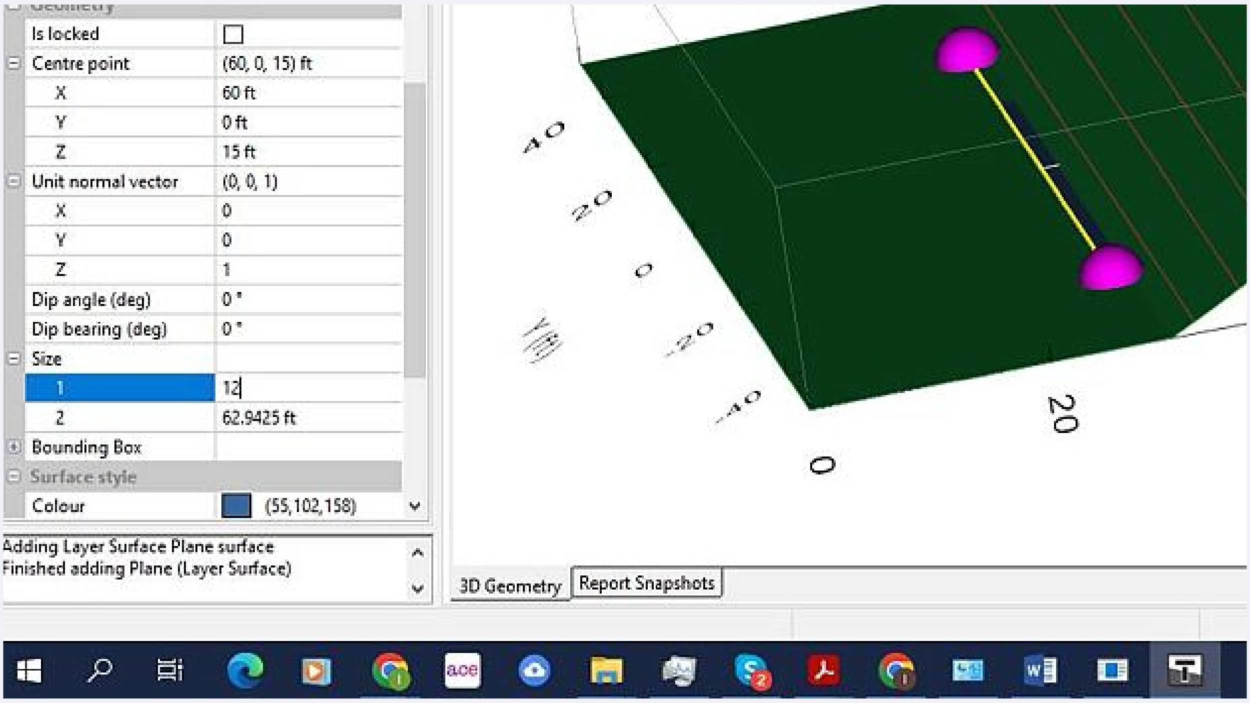
57 Type "15"



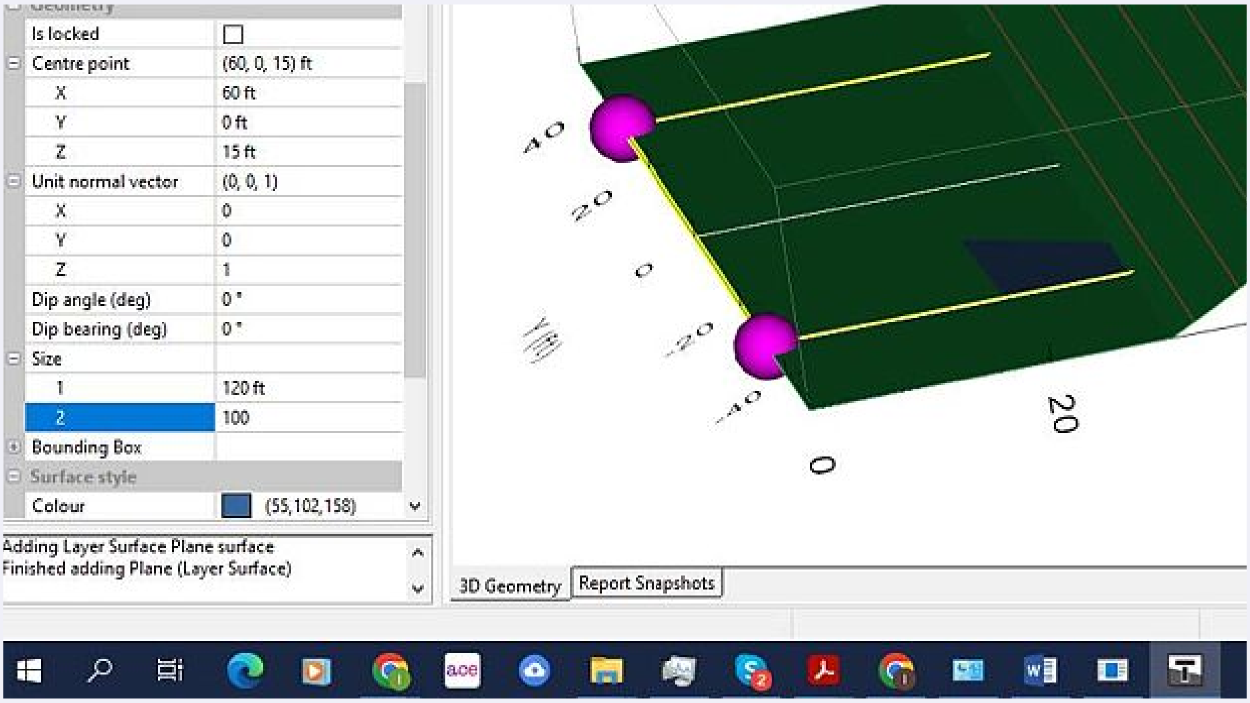
58 Change the size of the plane



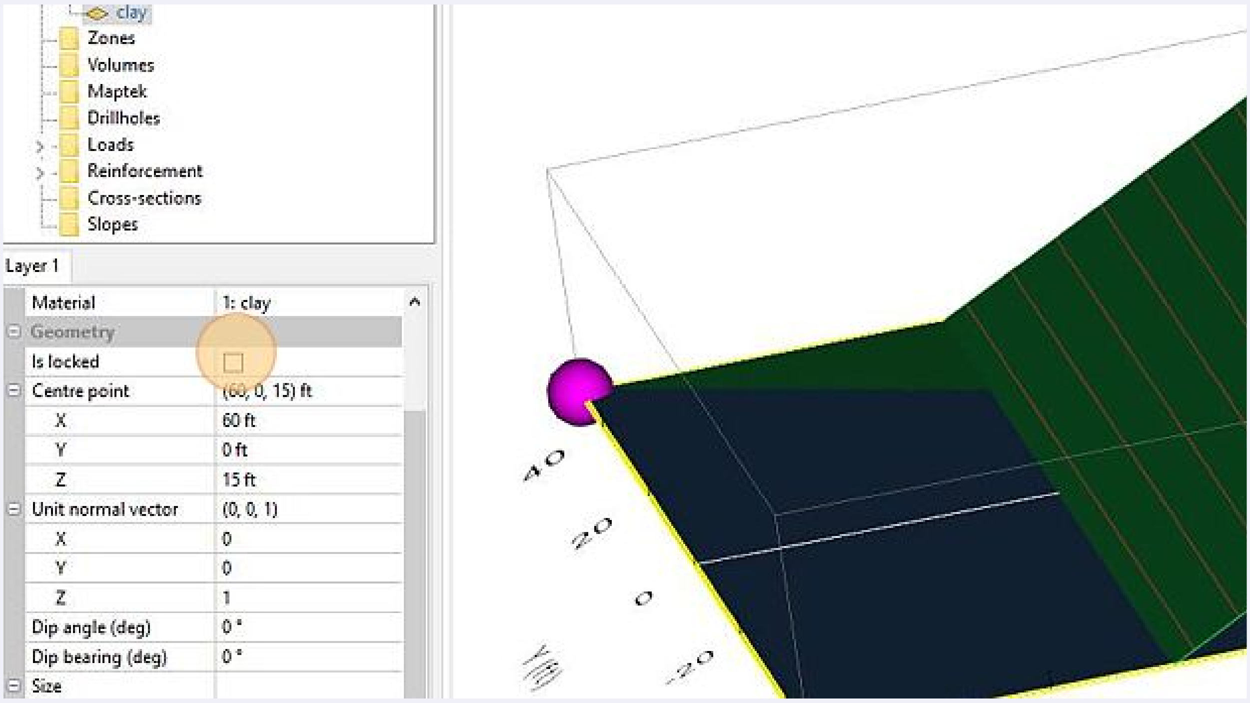
59 Type "120"



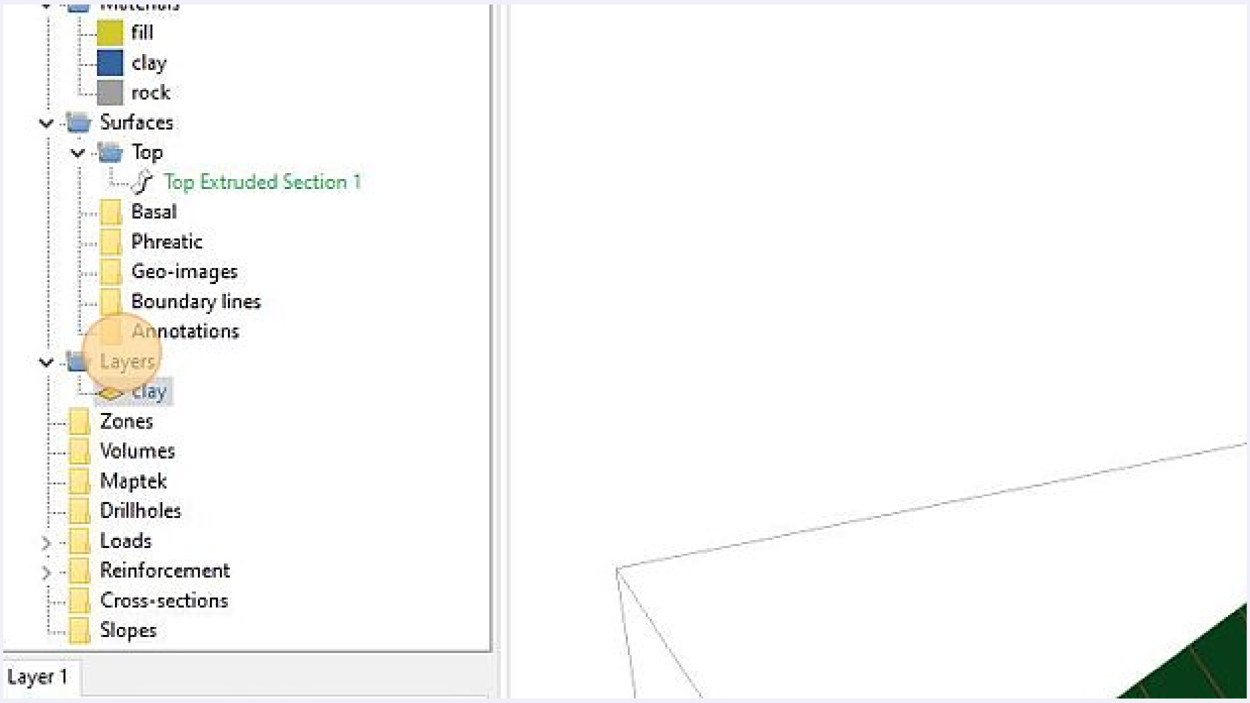
60 Type "100"



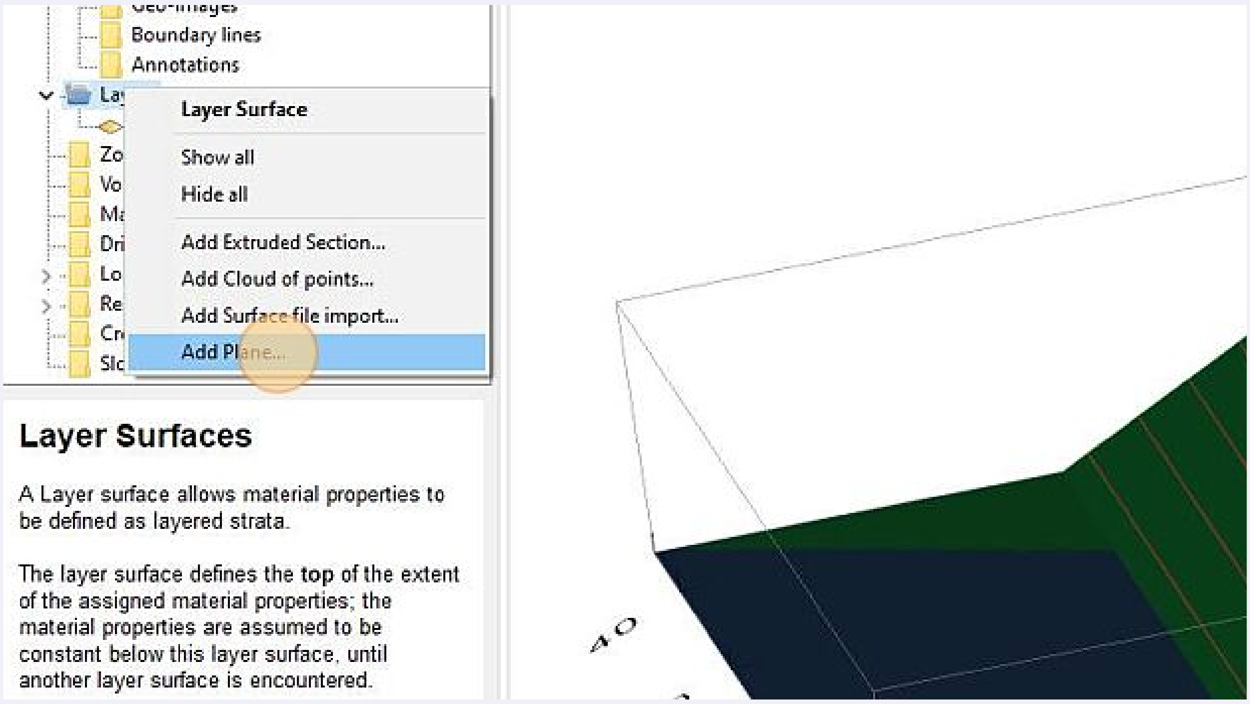
61 Lock the plane



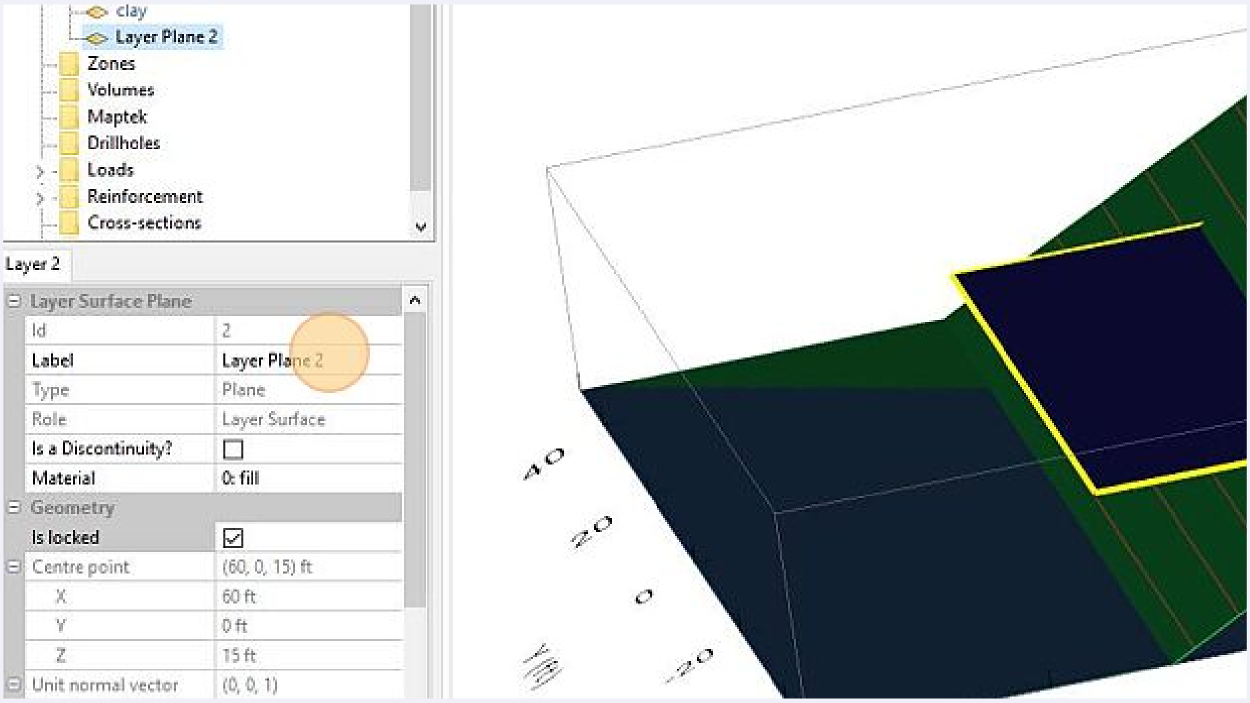
62 Click "Layers"



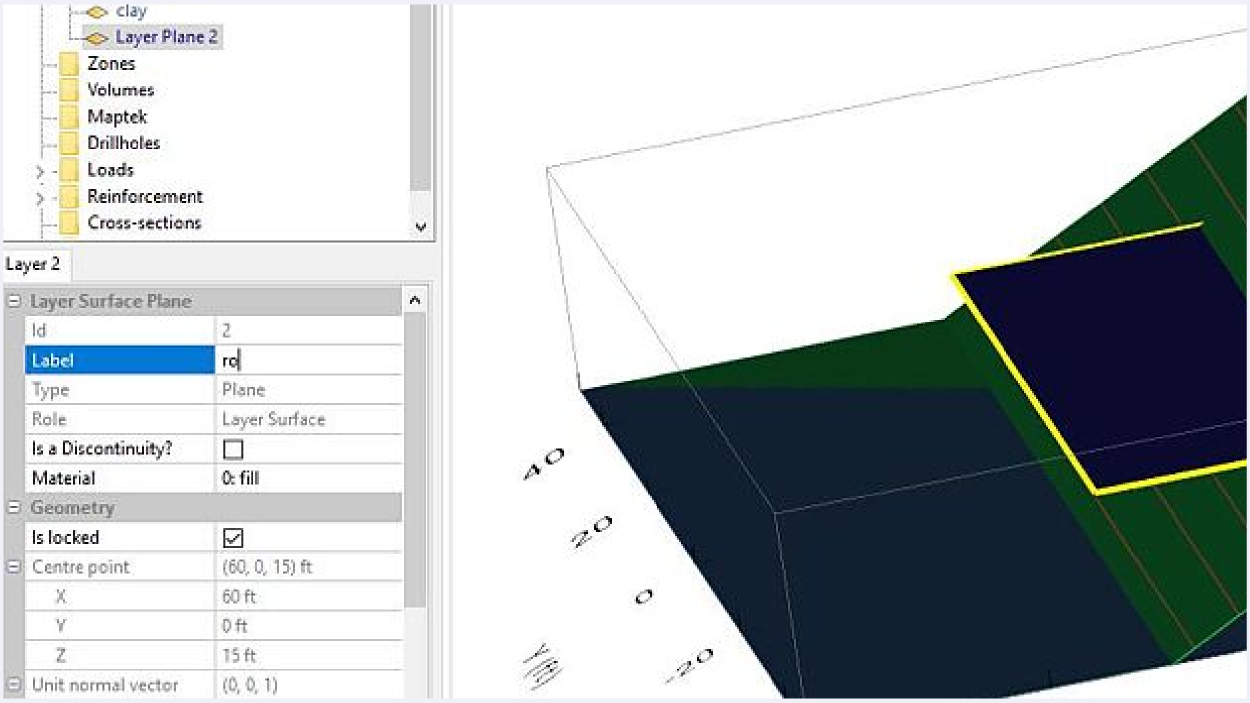
63 Click "Add plane..."



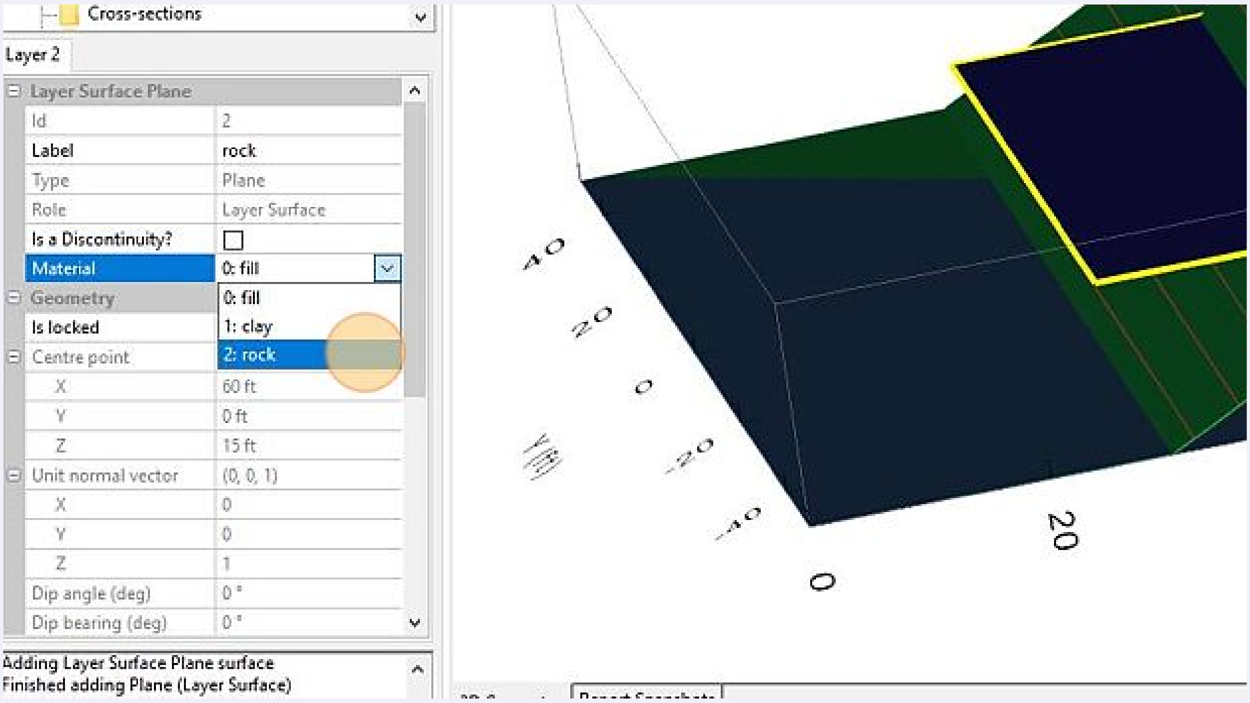
64 Change Label



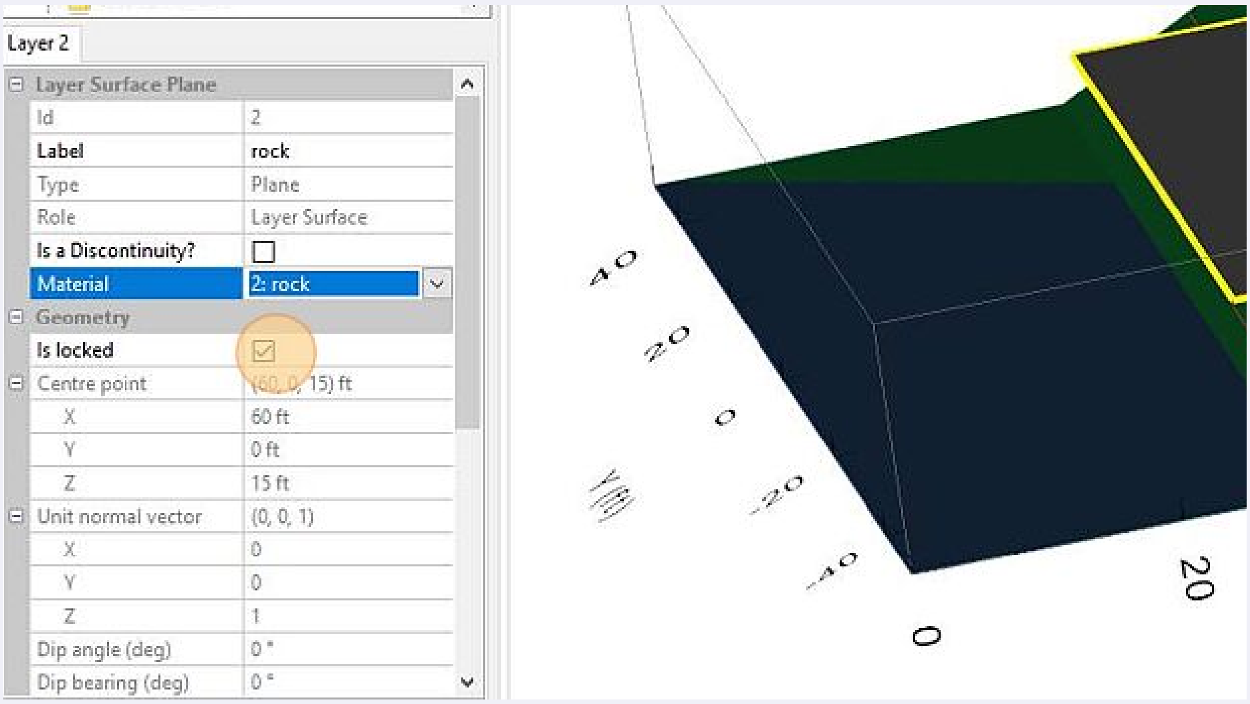
65 Type "rock"



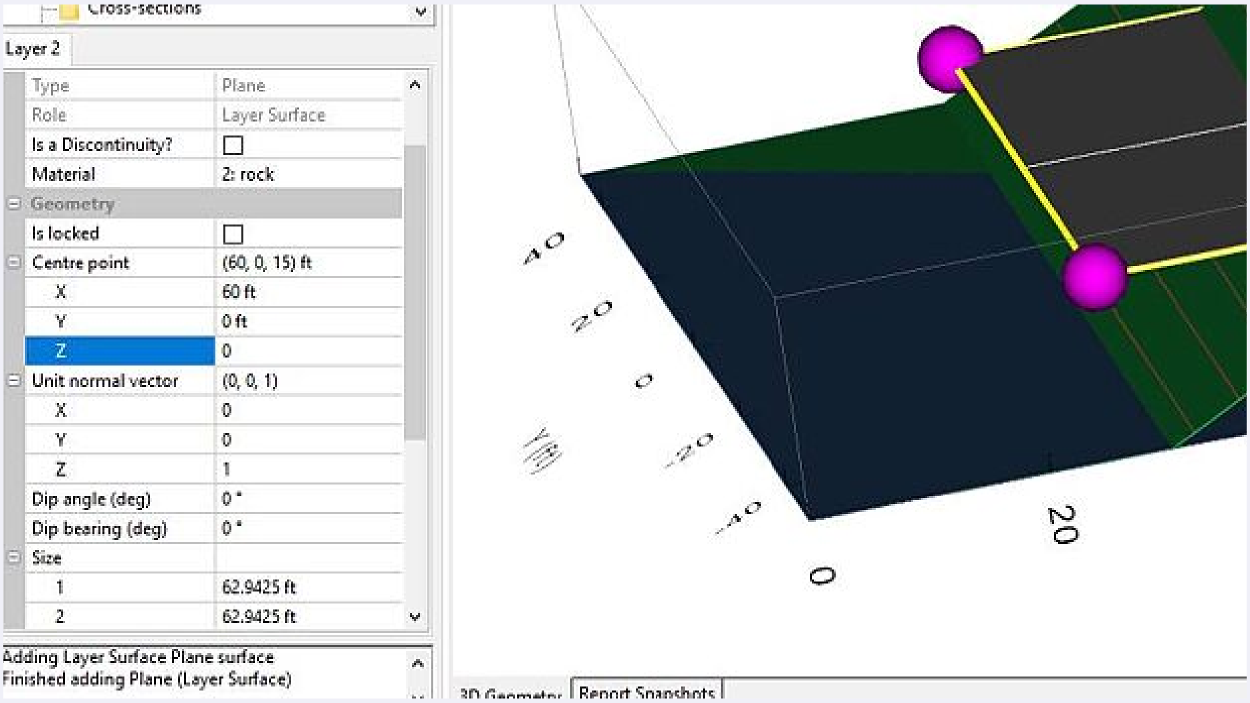
66 Assign Material "rock" to the layer



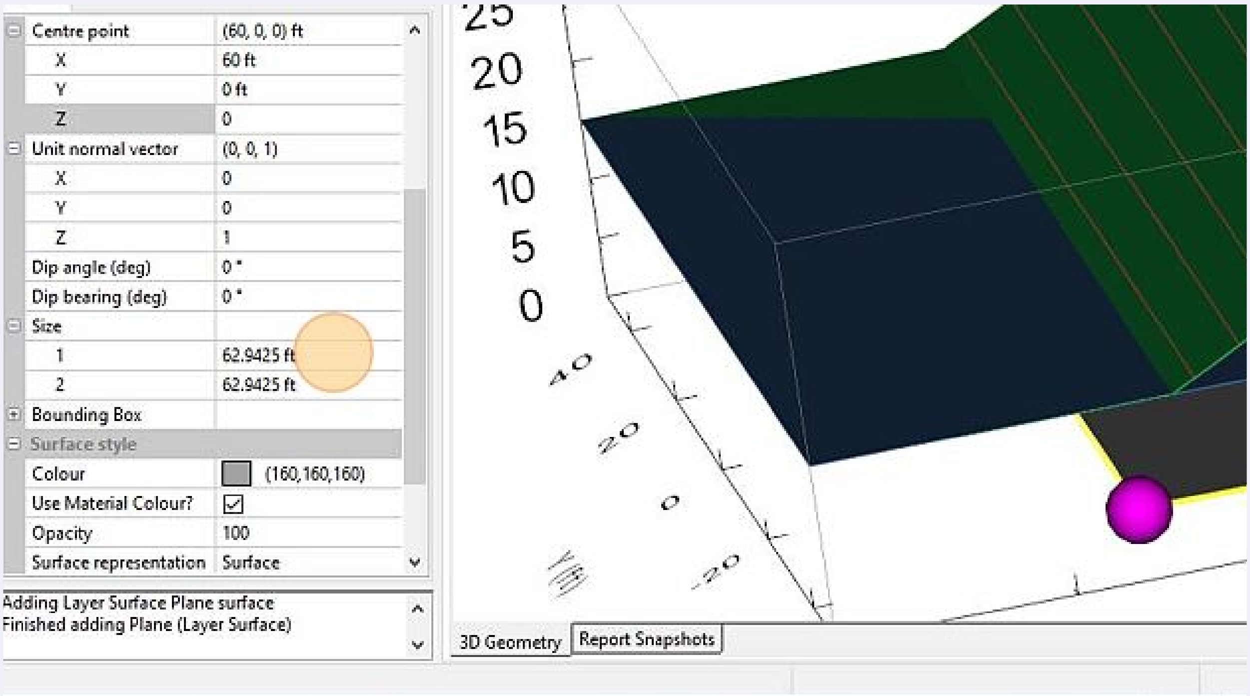
67 Unlock plane geometry



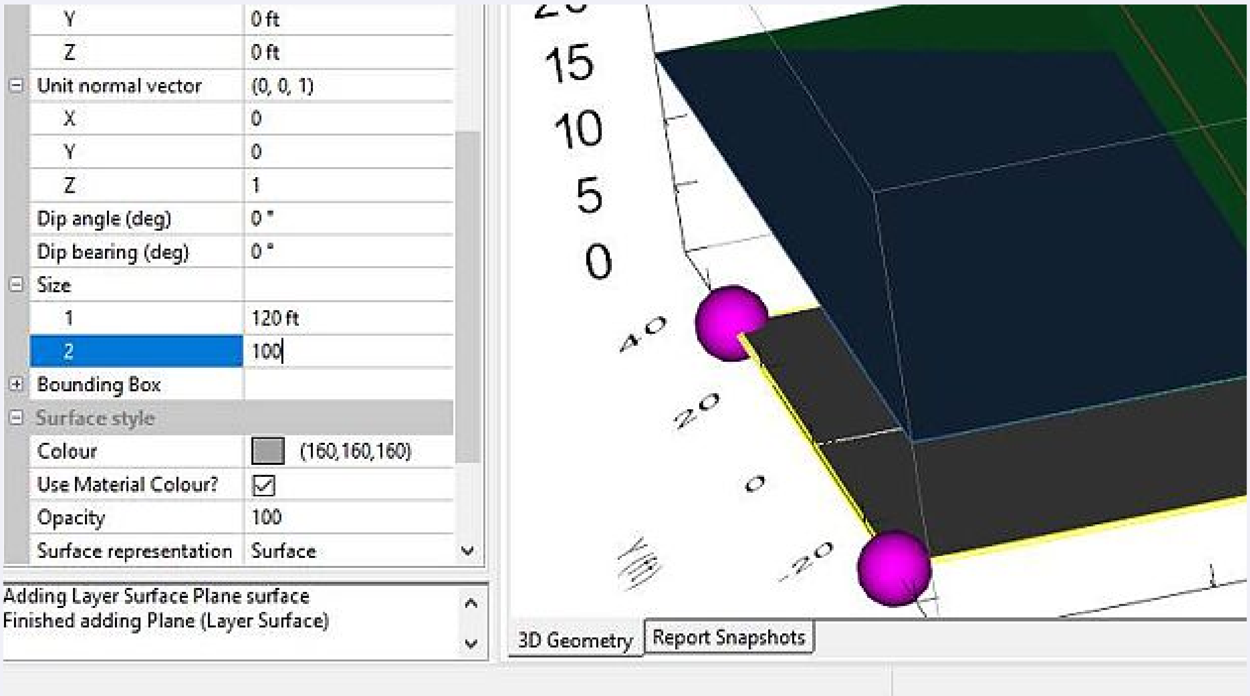
68 Change Z coordinate of Centre point to "0"



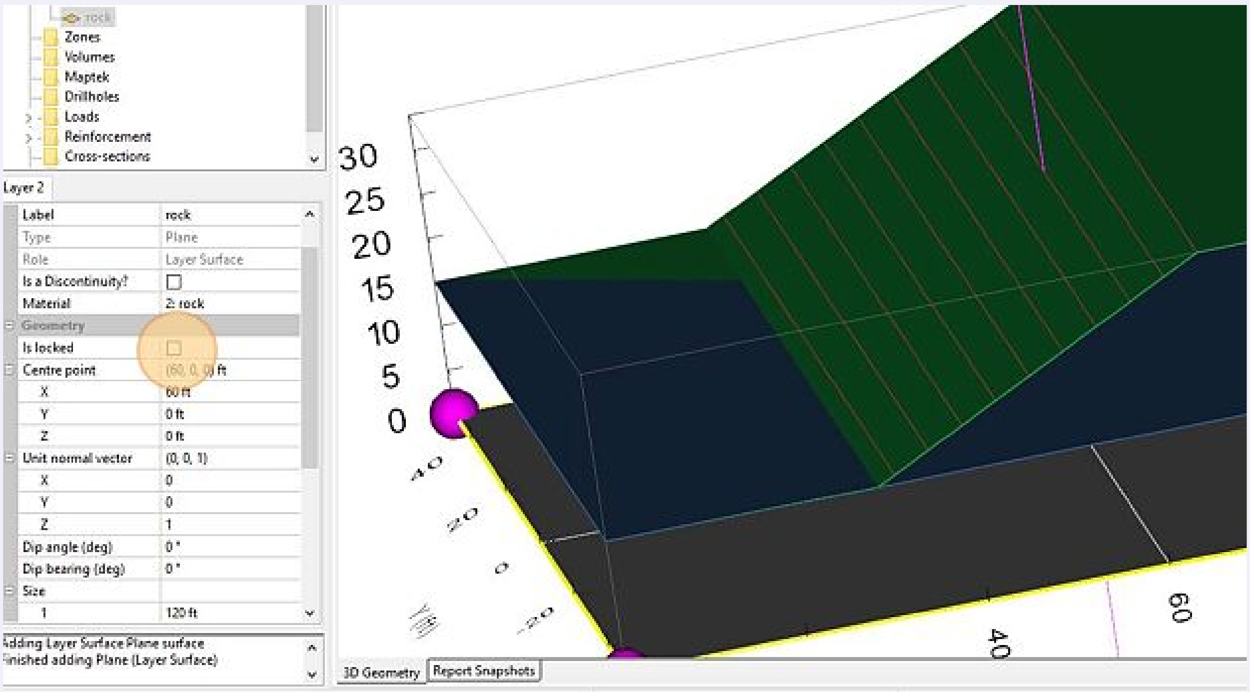
69 Change plane size



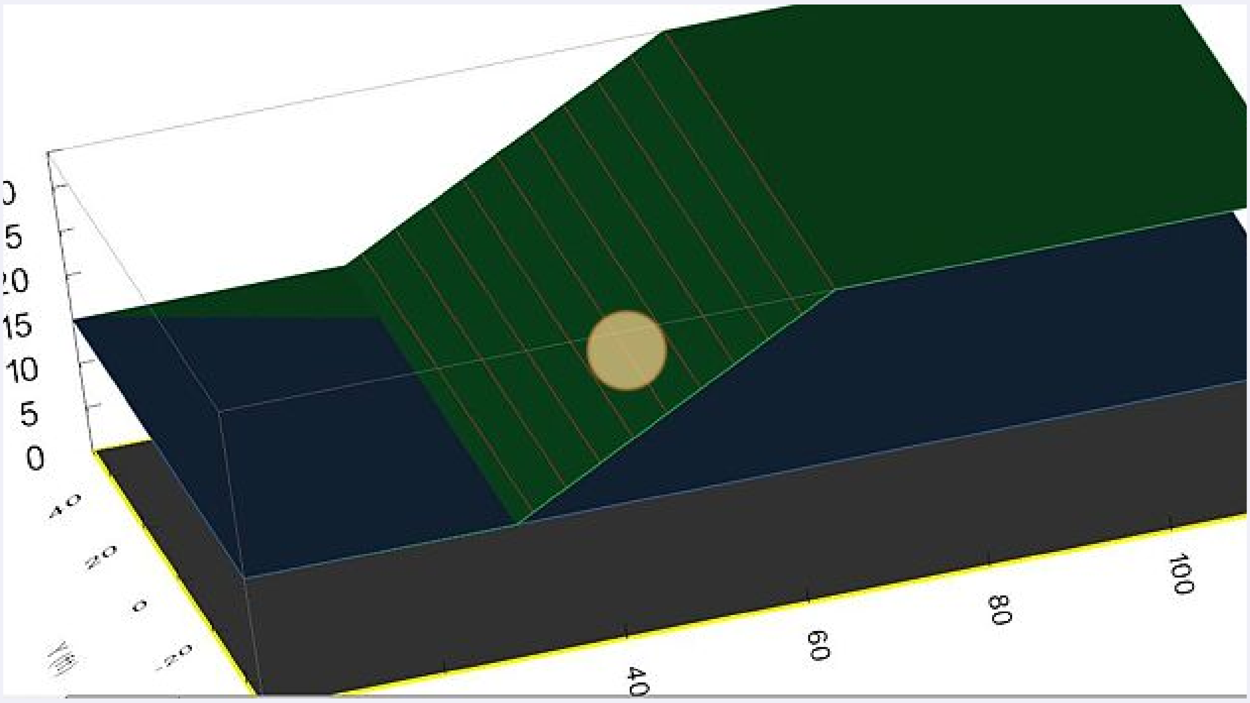
70 Type "100"



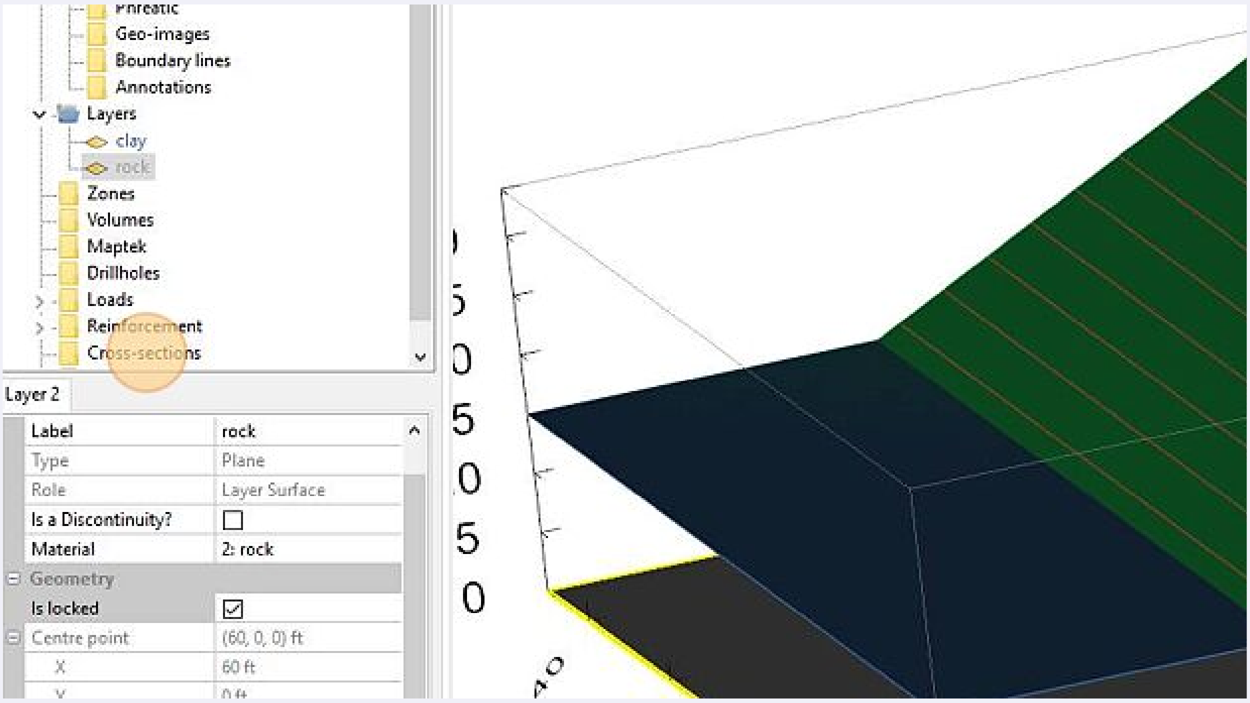
71 Lock plane geometry



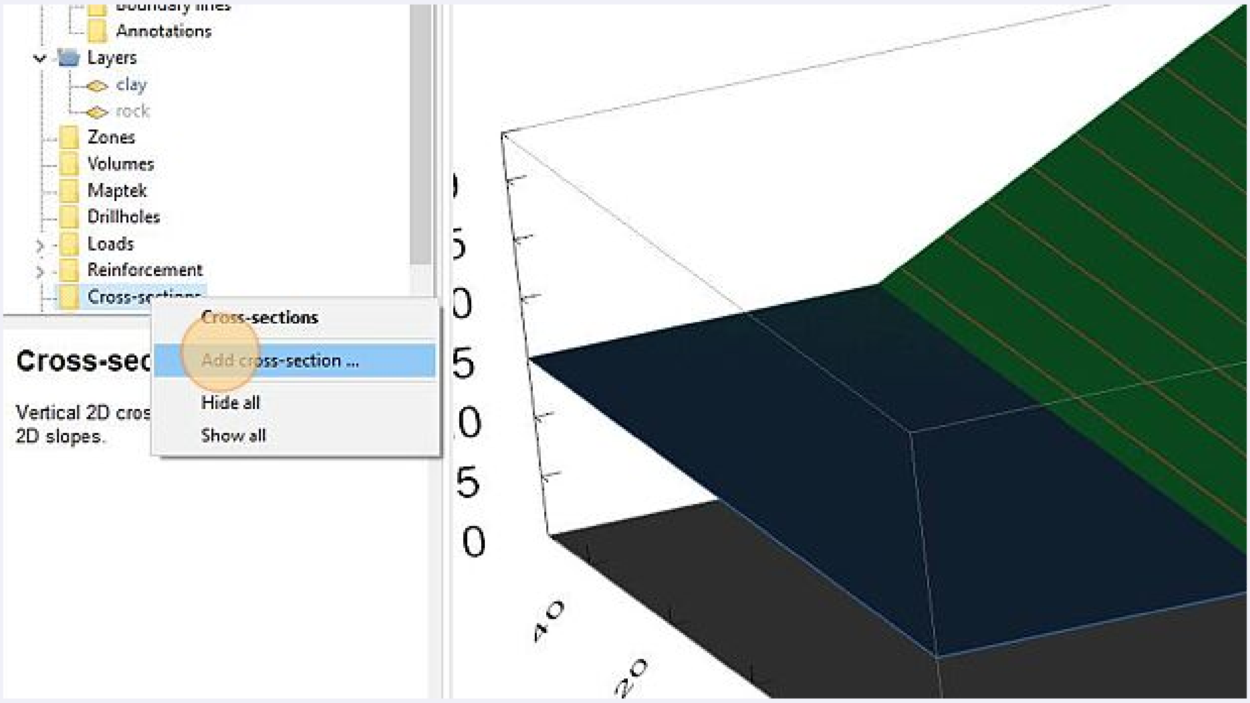
72 Perspective view of extruded slope model



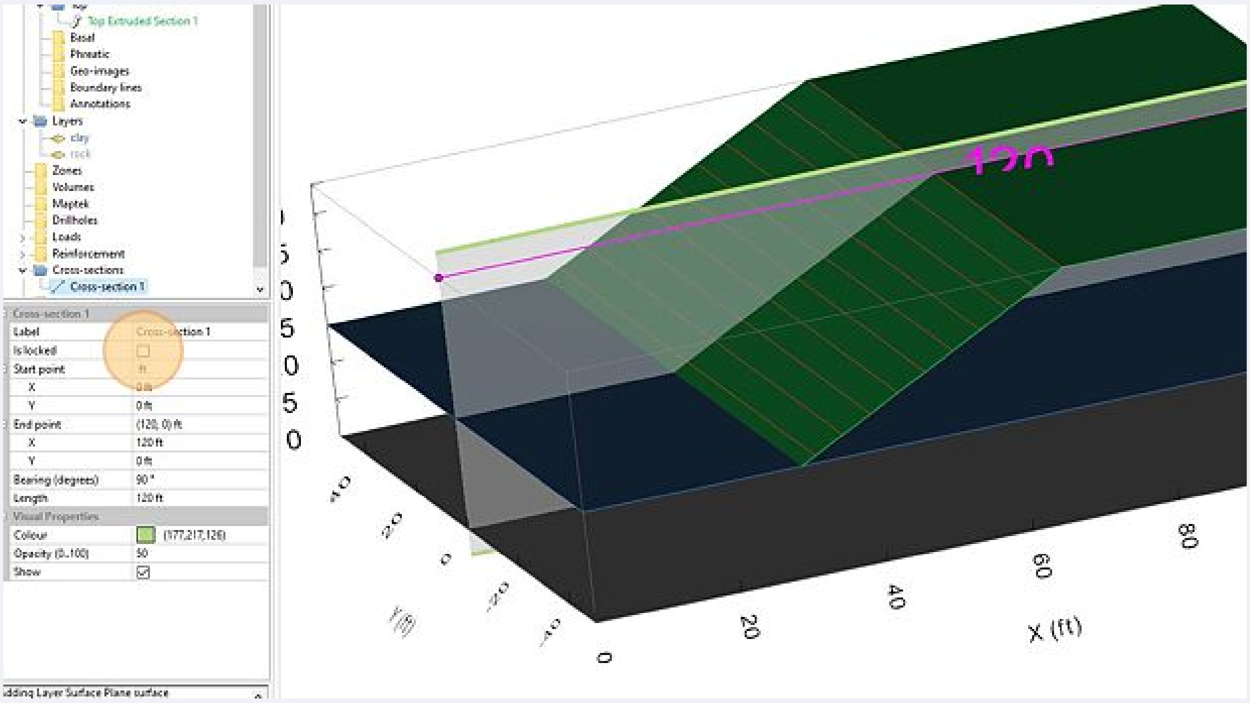
73 Click "Cross-sections"



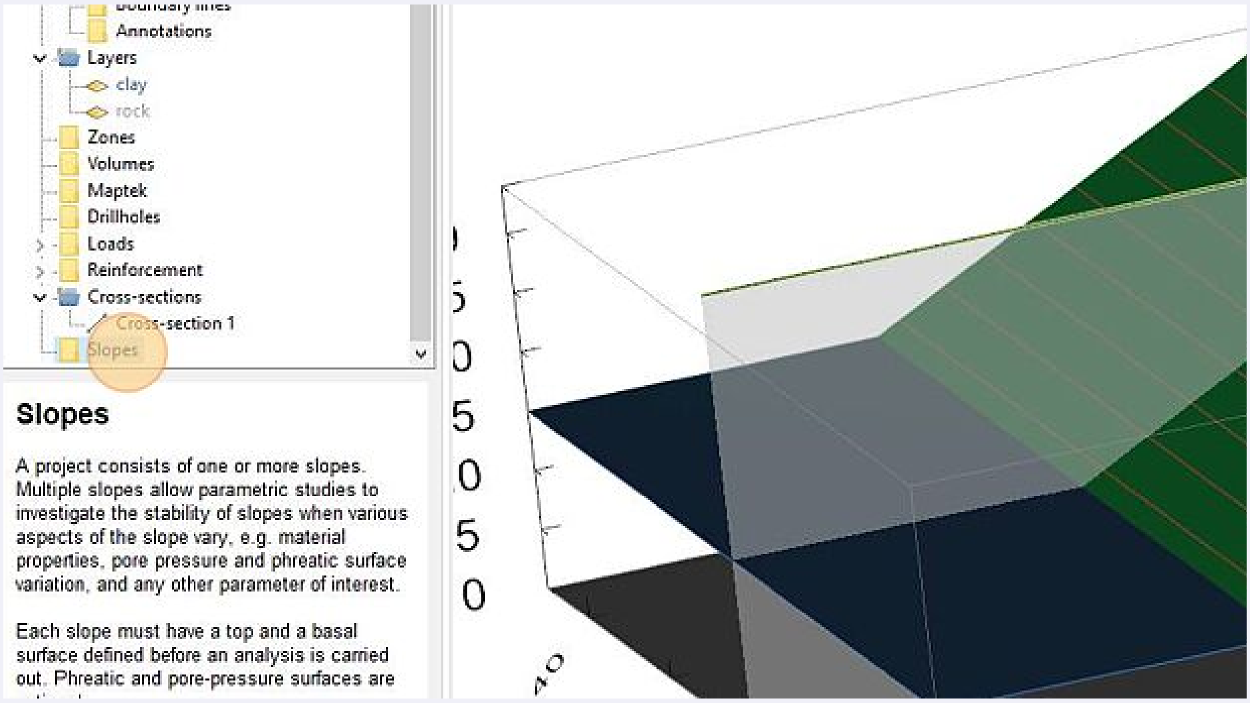
74 Click "Add cross-section..."



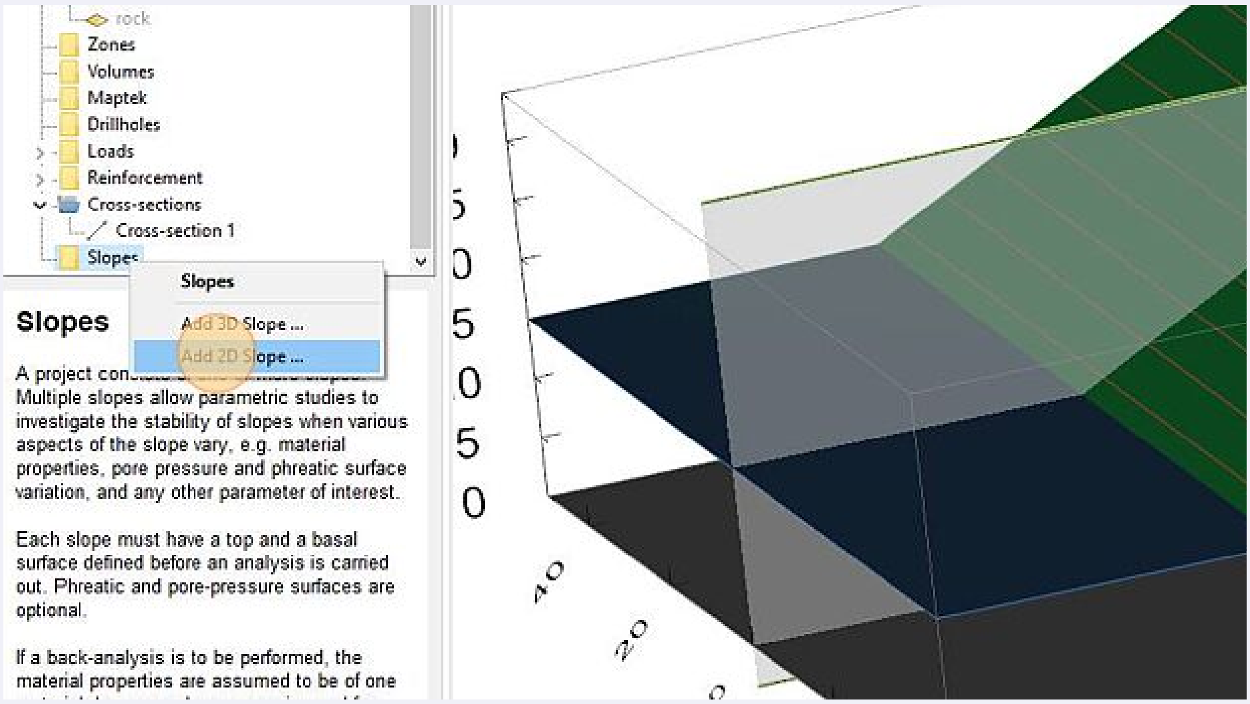
75 A suitable section is presented, so click to lock its position



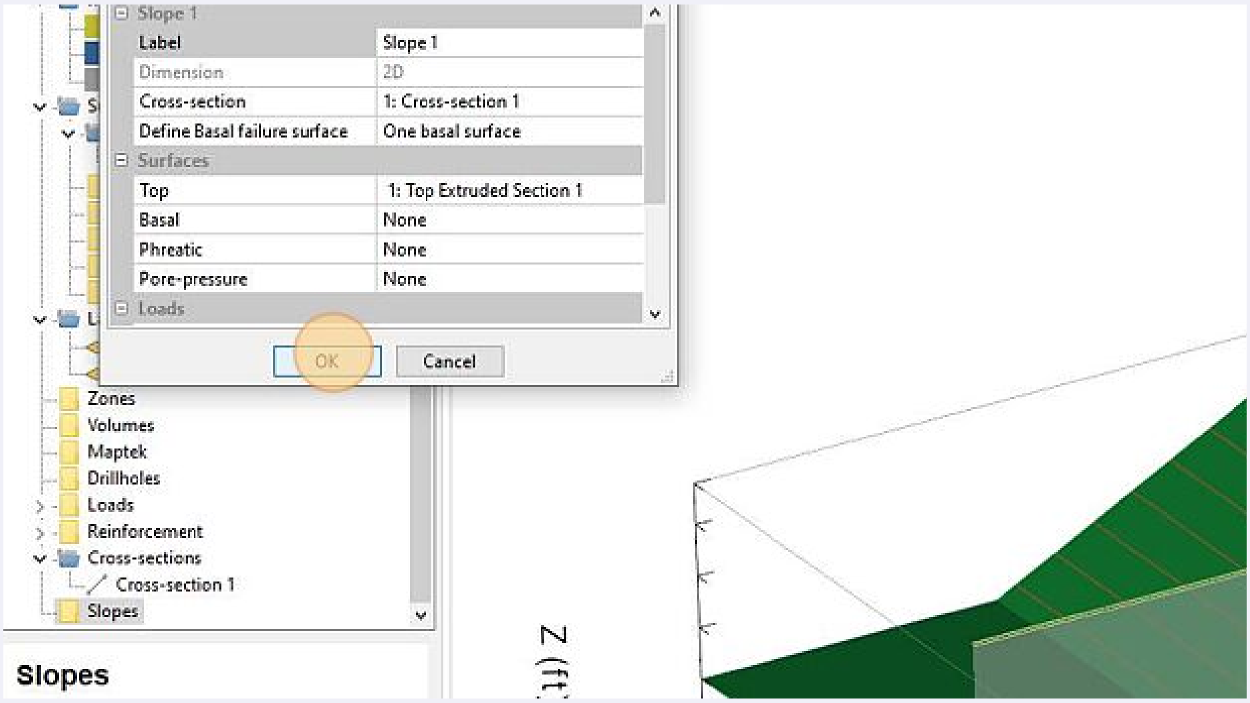
76 Click "Slopes"



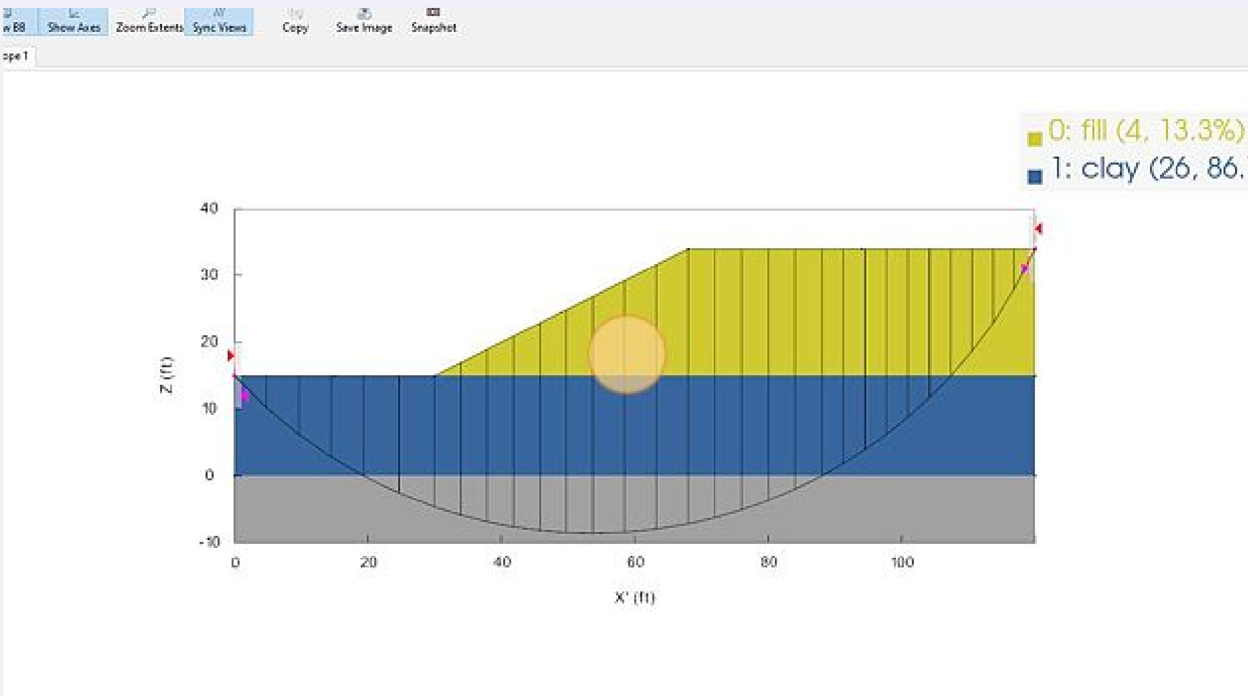
77 Click "Add 2D Slope..."



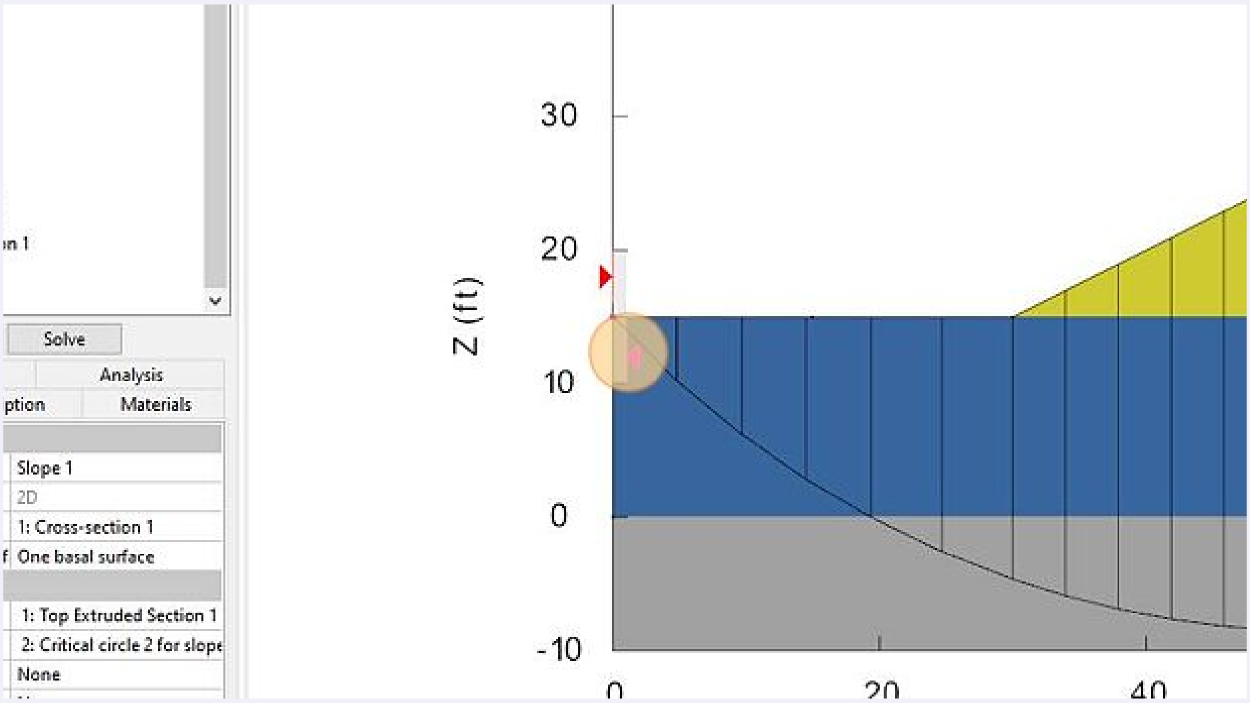
78 Click "OK"



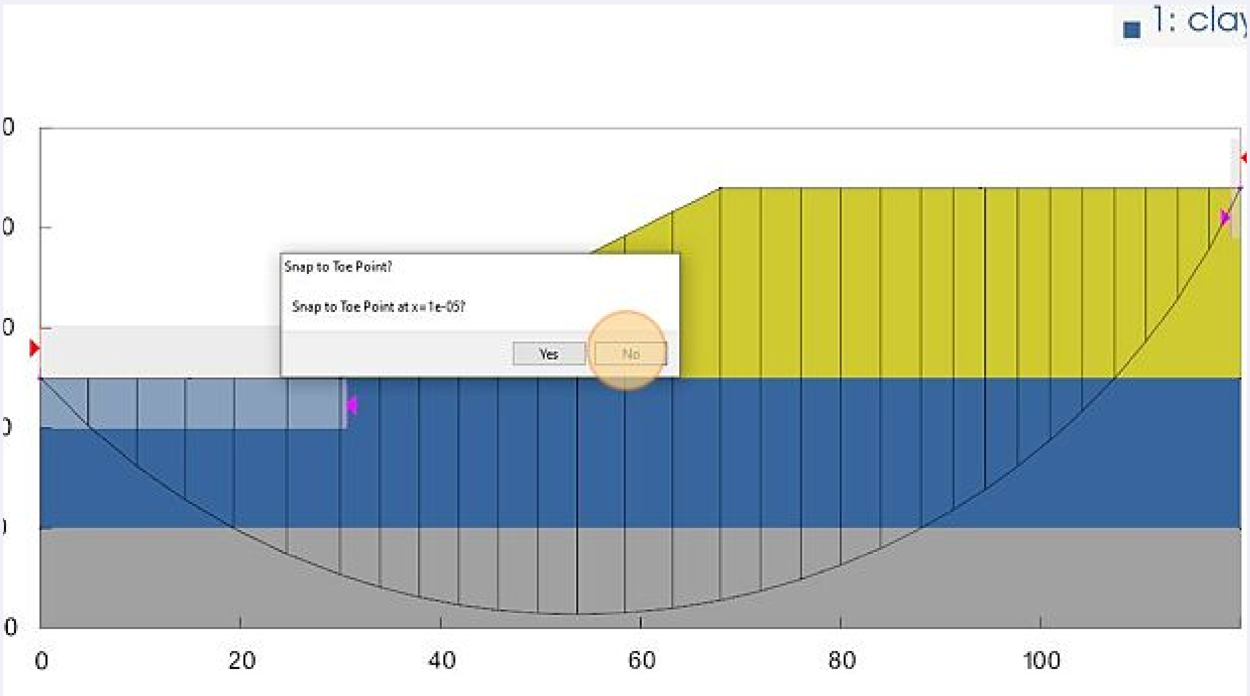
79 The slip circle for the 2D slope case is defined by entry and exit points for a circle



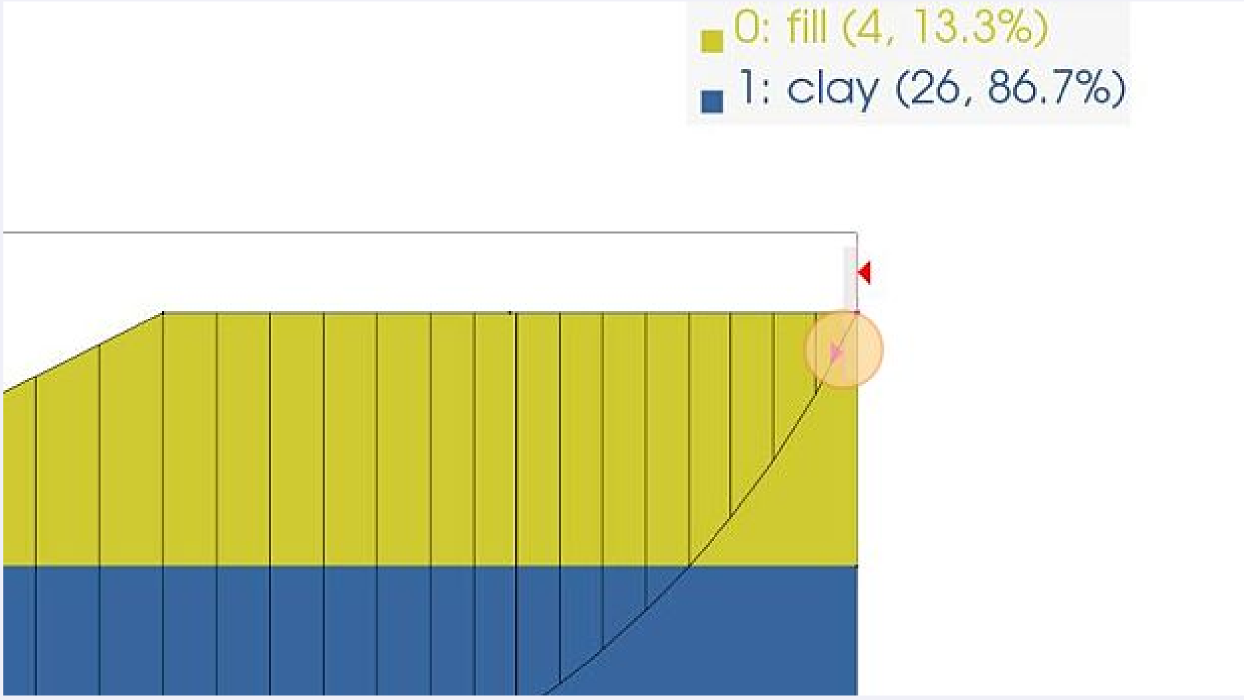
80 We can move the right bound marker to the toe of the slope



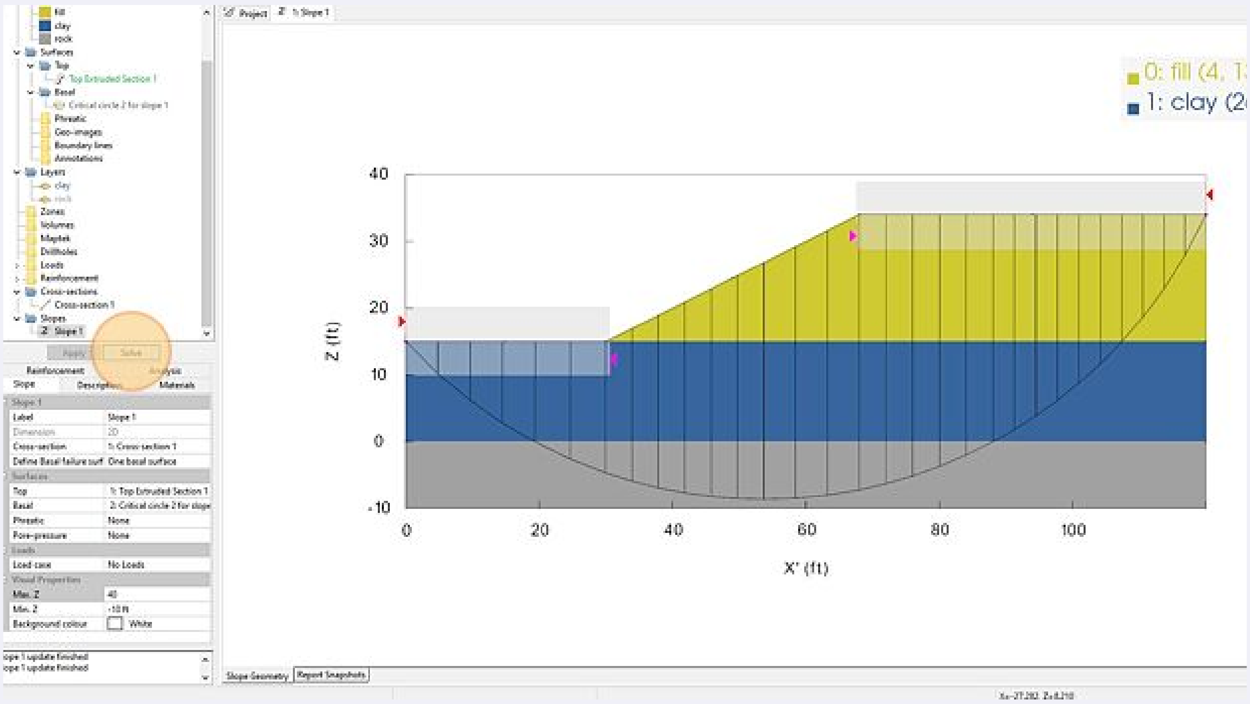
81 Click "No"



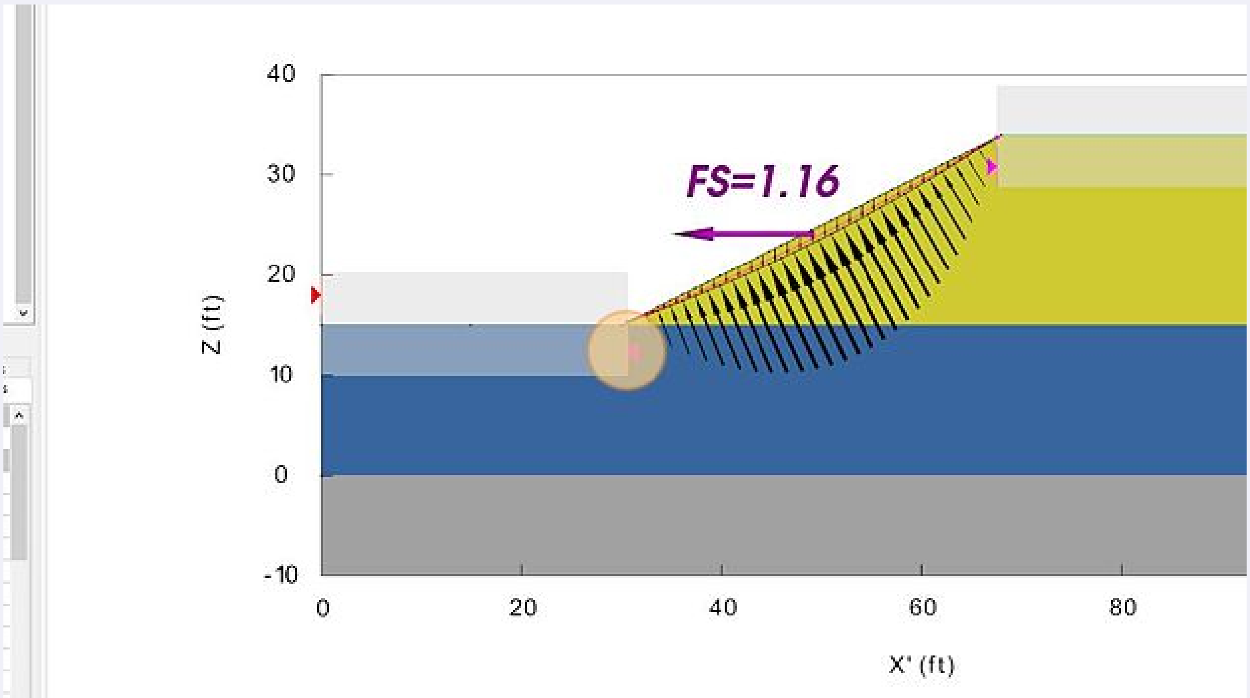
82 We can move the left bound marker to the top of the slope



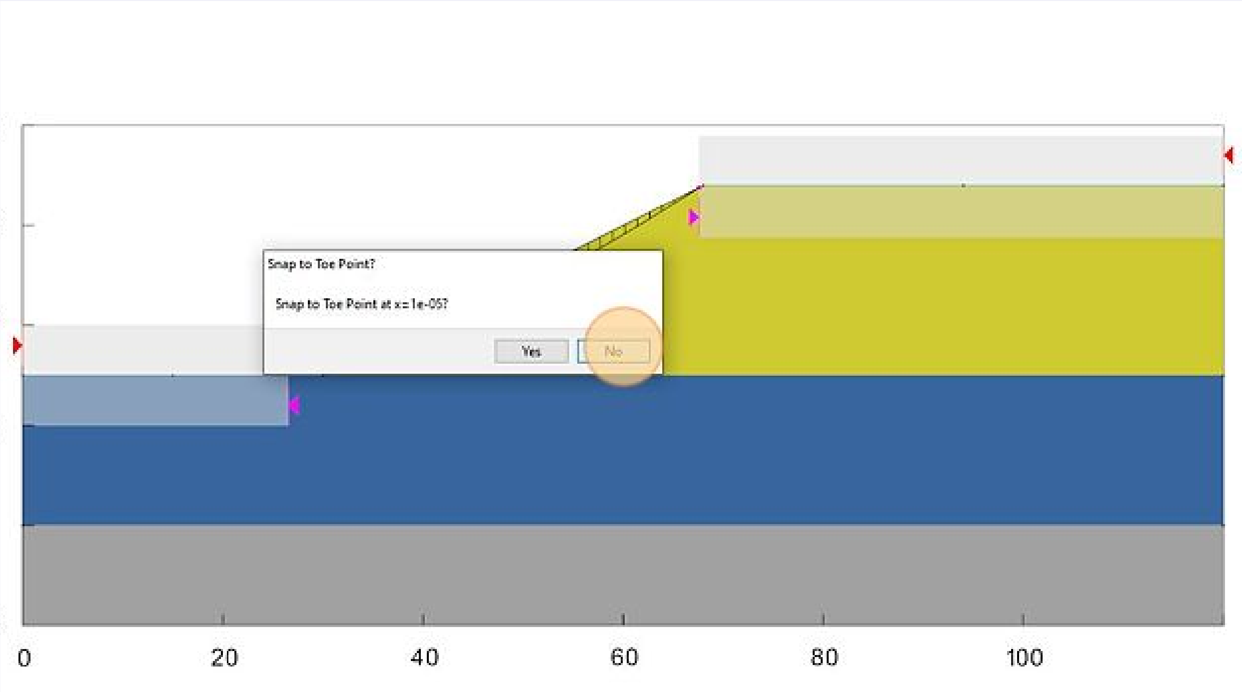
83 The light grey panel shows the limits for entry and exit points for the circular search. We then Click " Solve "



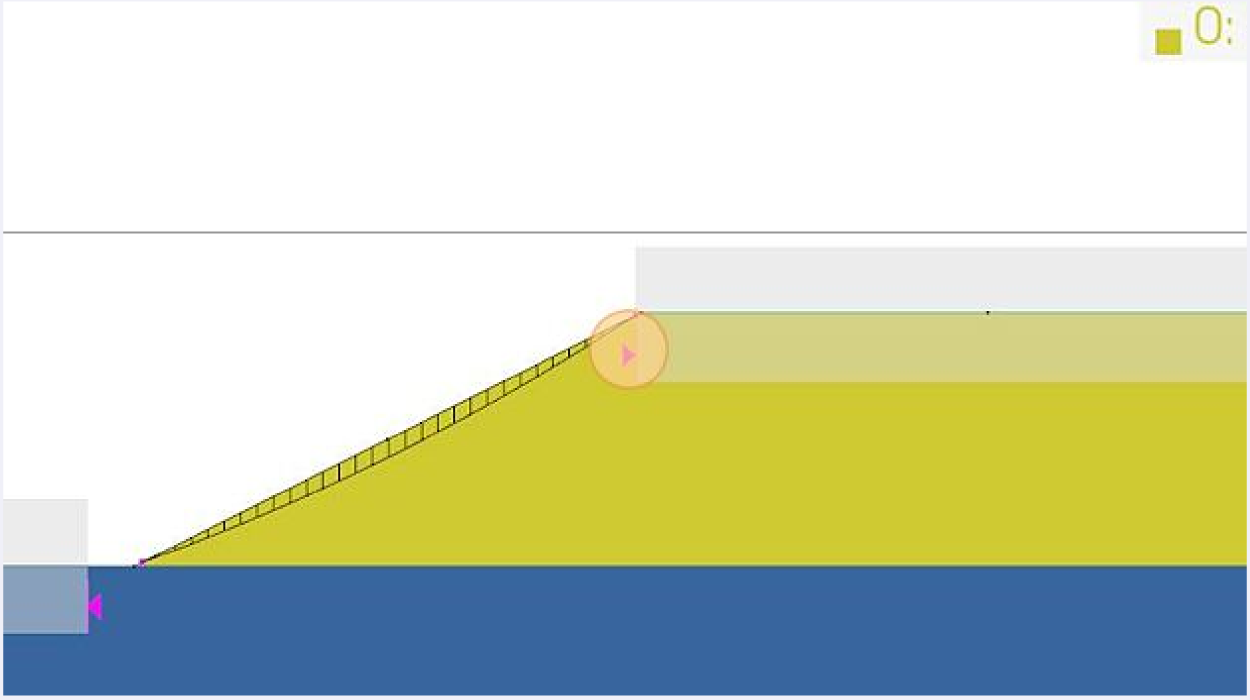
84 The factor of safety is calculated: 1.16 (Duncan et al. reported 1.15)



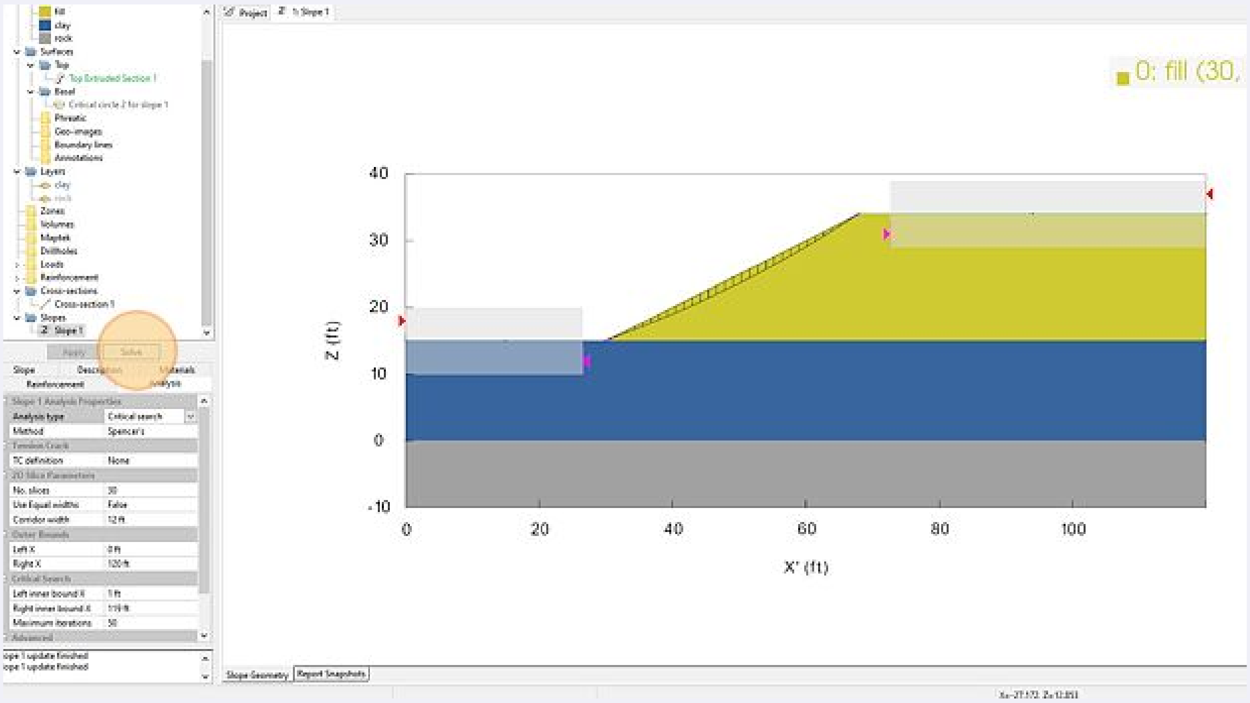
85 To search for a deeper slip surface, we move the limits of the search panel away from the break in slope.



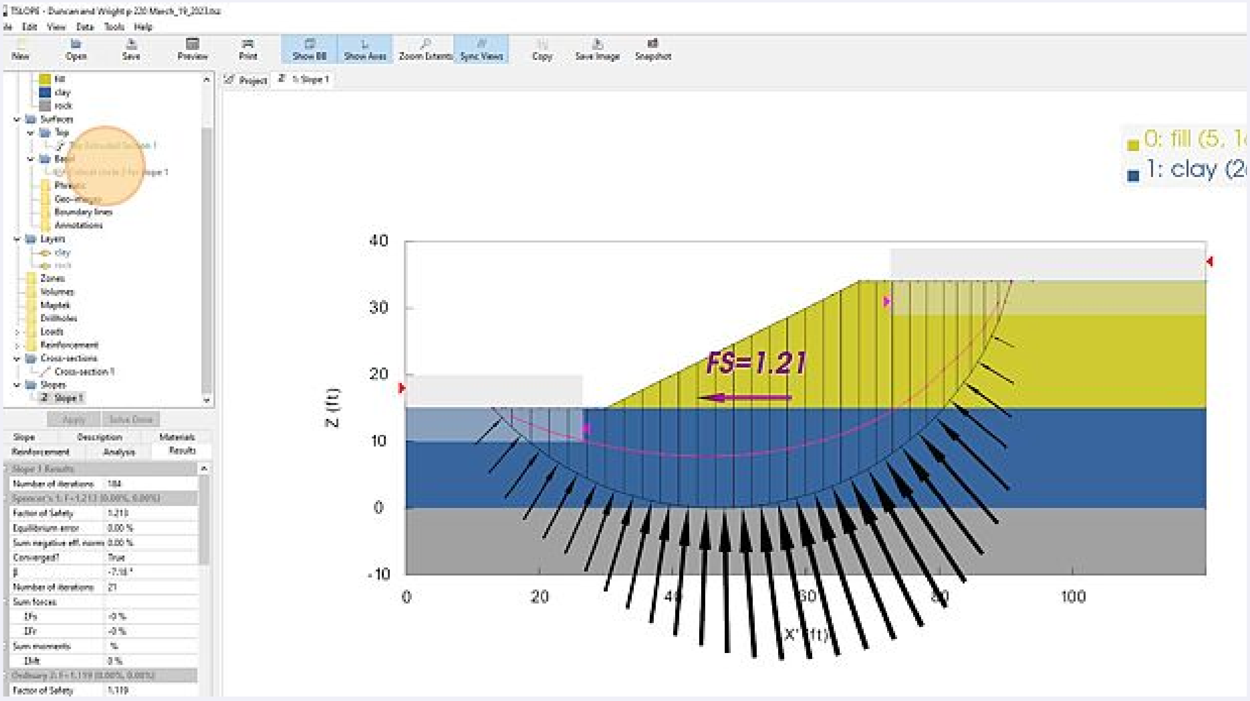
86



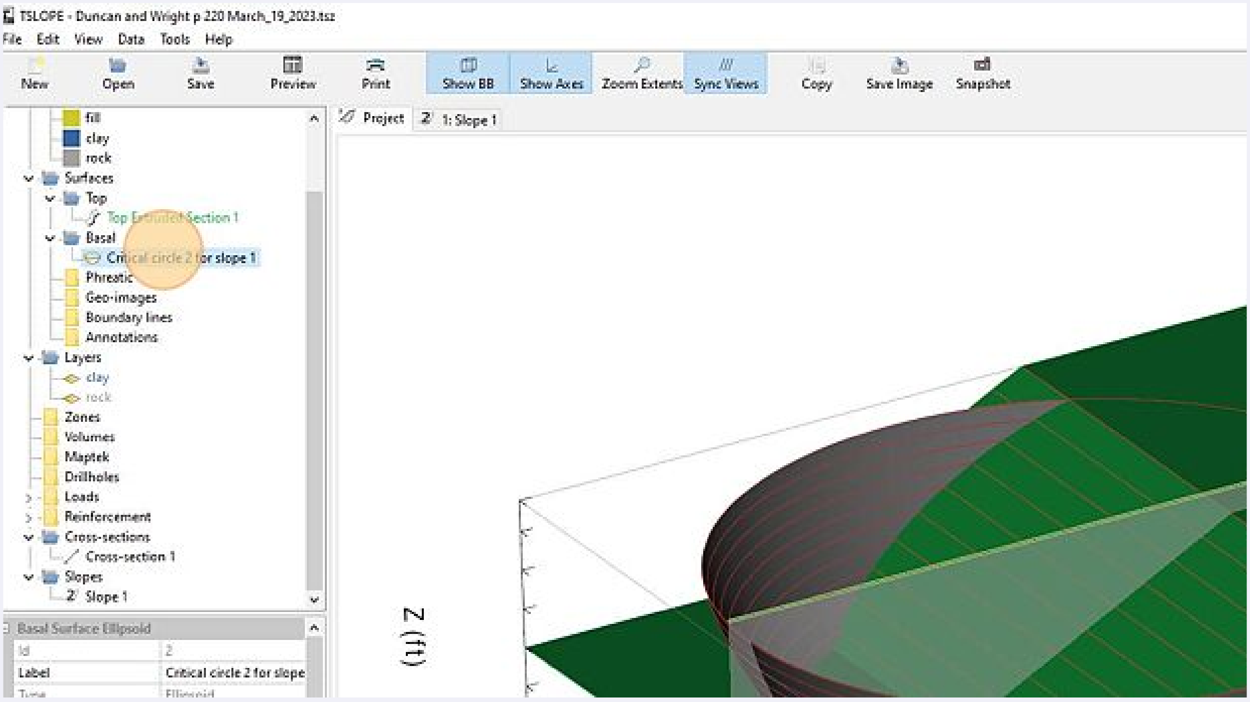
87 Click " Solve "



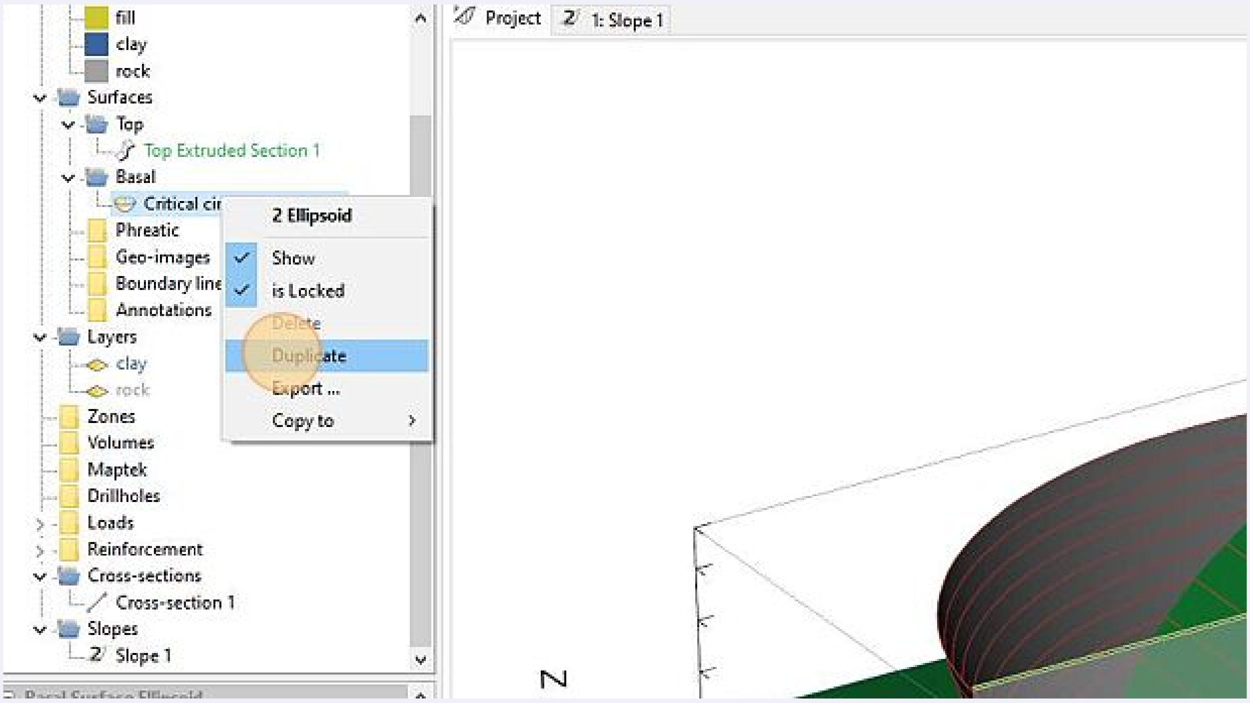
88 The factor of safety is calculated: 1.21 (Duncan et al. reported 1.21)



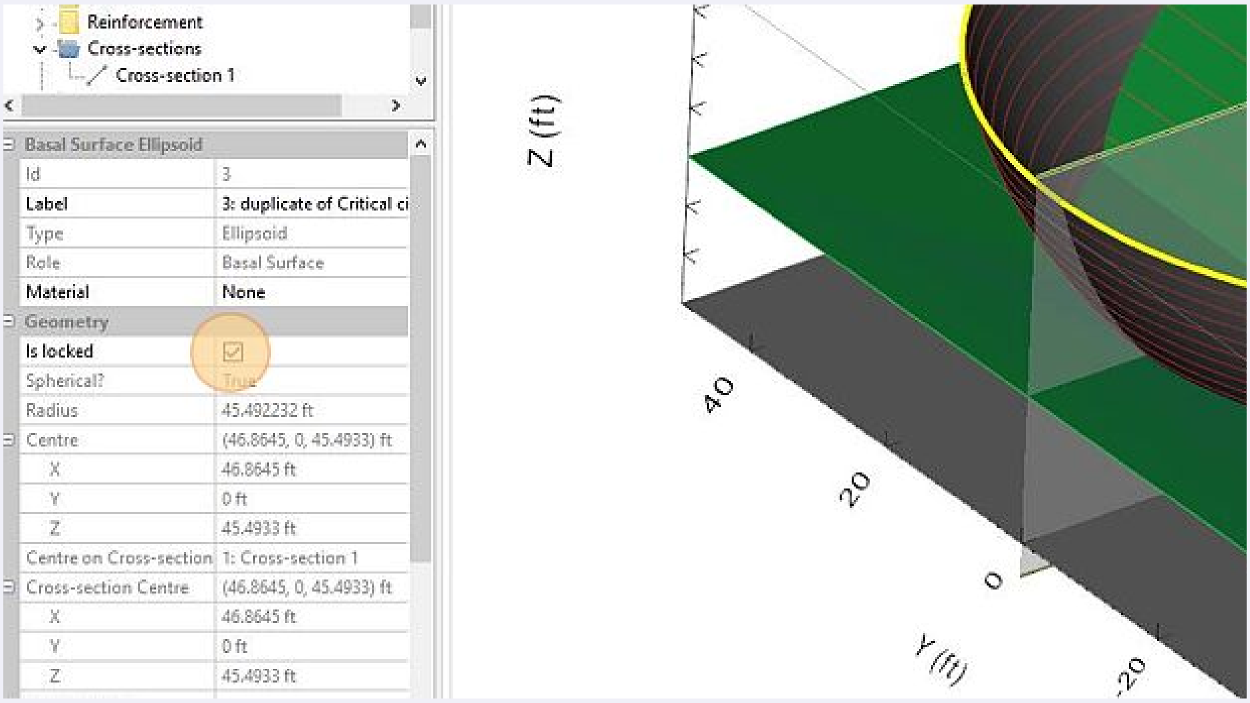
89 The slip circle shown in the 2D slope case is represented in 3D as a sphere. We want to change the sphere to an ellipse which we believe is more representative of a potential 3D failure surface.



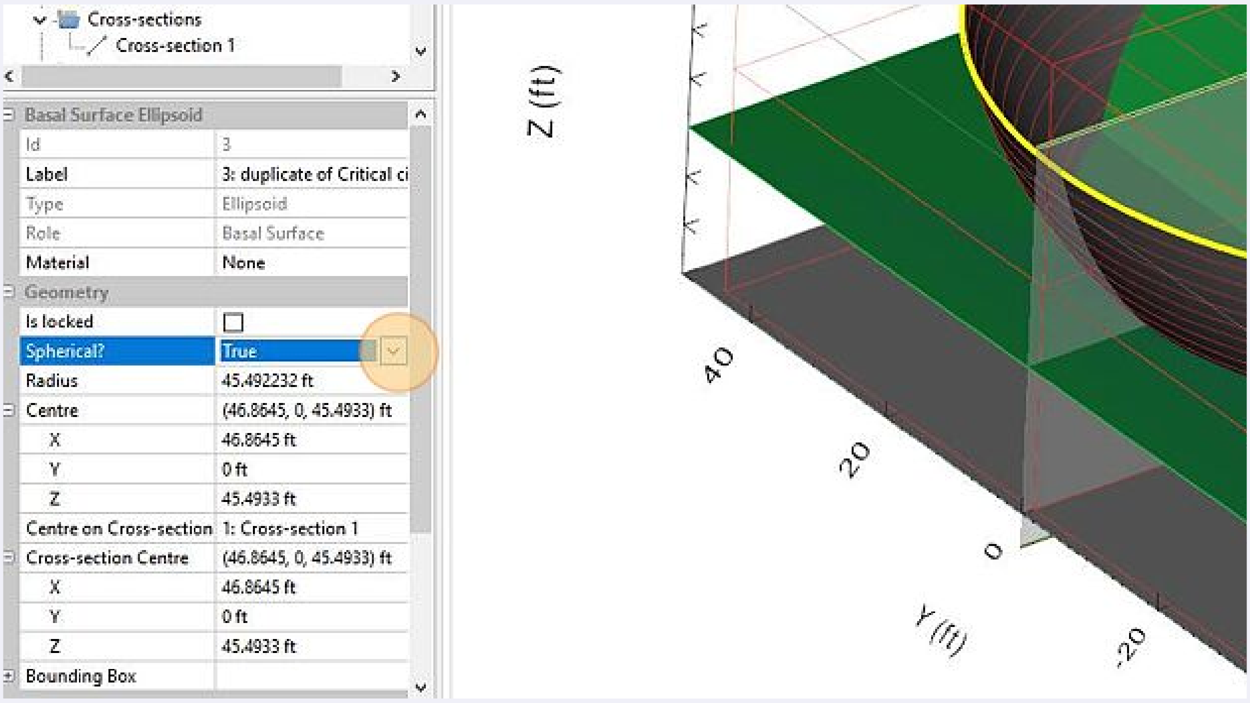
90 We duplicate the Basal surface



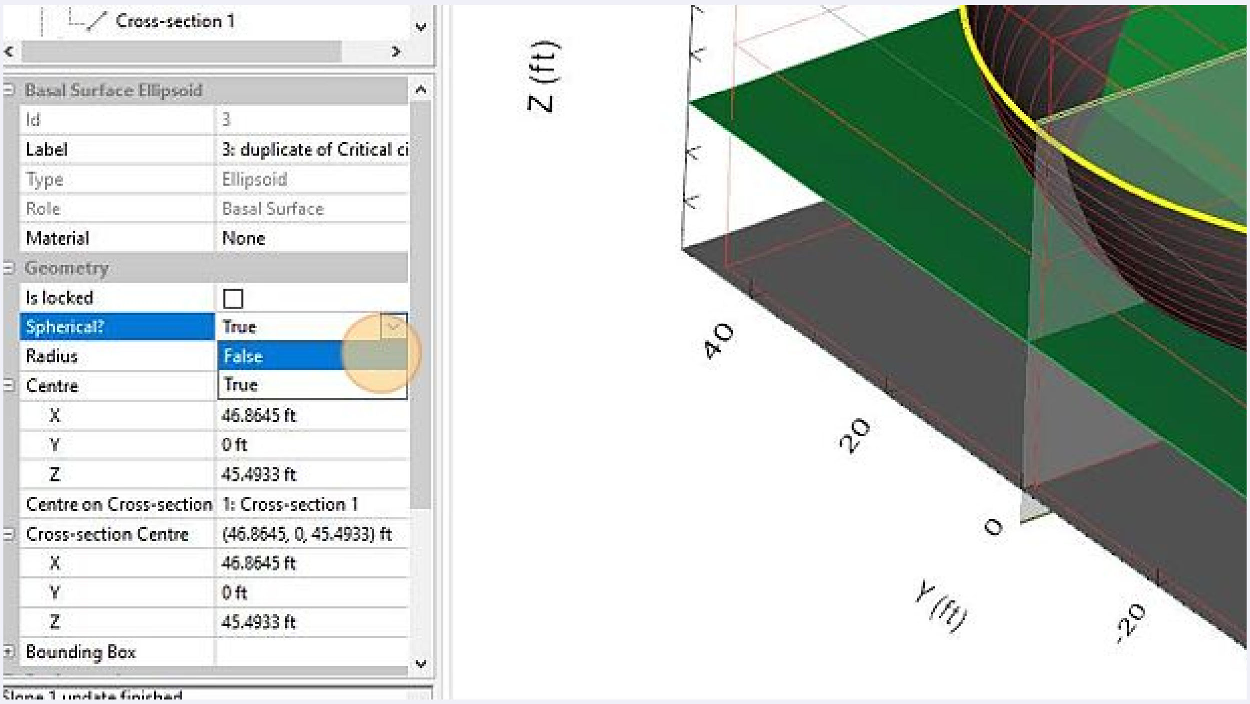
91 Unlock the sphere geometry



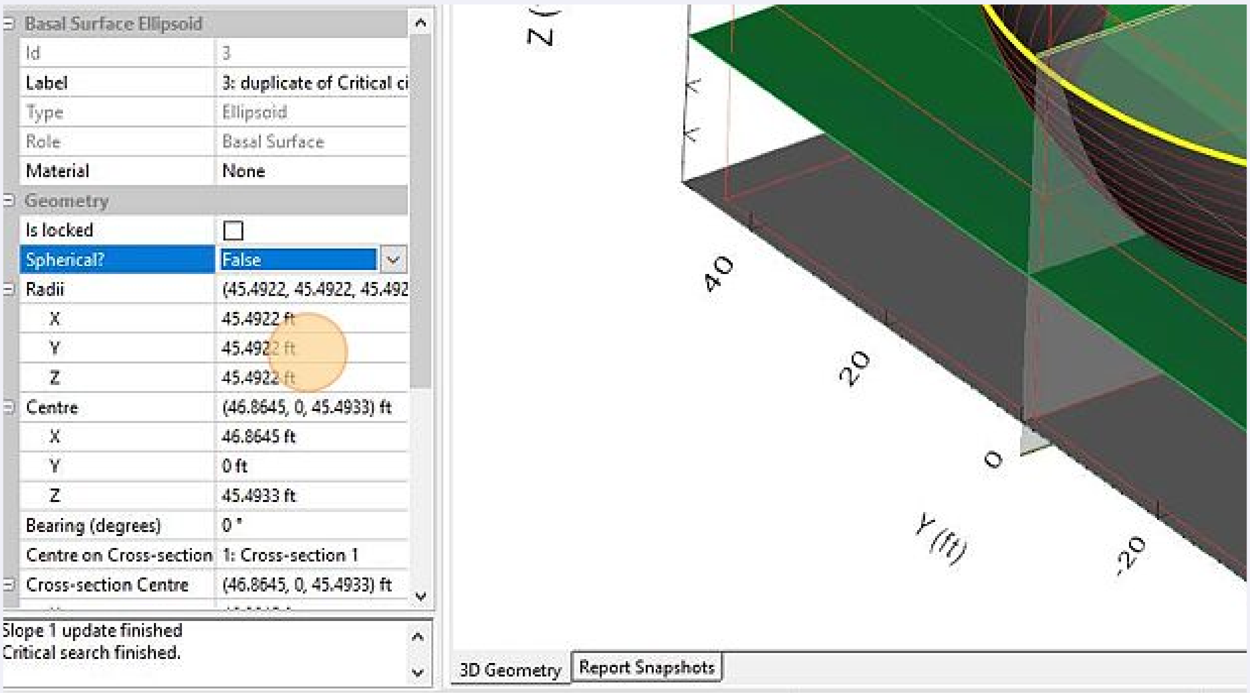
92


Cross-sections
Cross-section 1
Basal Surface Ellipsoid
Id
3
Label
3: duplicate of Critical ci
Type
Ellipsoid
Role
Basal Surface
Material
None
Geometry
Is locked
Spherical?
True
Radius
45.492232 ft
Centre
(46.8645, 0, 45.4933) ft
X
46.8645 ft
Y
0 ft
Z
45.4933 ft
Centre on Cross-section
1: Cross-section 1
Cross-section Centre
(46.8645, 0, 45.4933) ft
X
46.8645 ft
Y
0 ft
Z
45.4933 ft
Bounding Box
Z (ft)
40
20
0
-20
Y (ft)

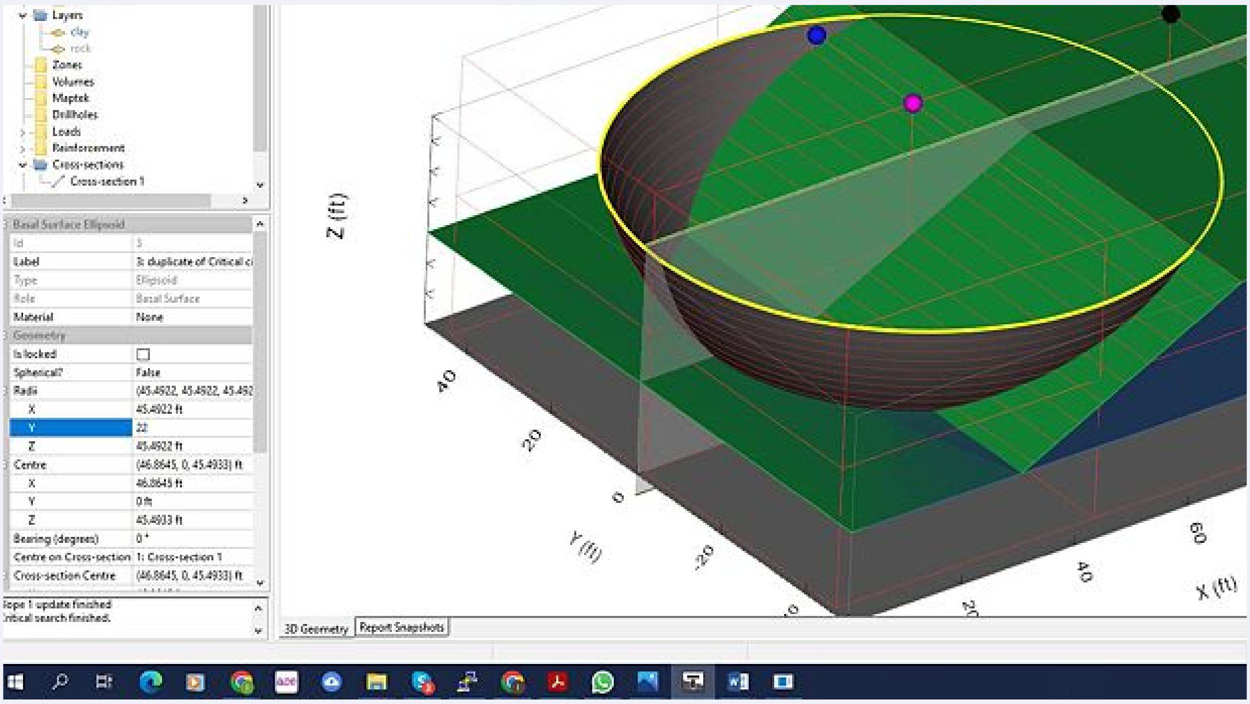
93


Cross-section 1
Basal Surface Ellipsoid
Id
3
Label
3: duplicate of Critical ci
Type
Ellipsoid
Role
Basal Surface
Material
None
Geometry
Is locked
Spherical?
True
Radius
False
Centre
True
X
46.8645 ft
Y
0 ft
Z
45.4933 ft
Centre on Cross-section
1: Cross-section 1
Cross-section Centre
(46.8645, 0, 45.4933) ft
X
46.8645 ft
Y
0 ft
Z
45.4933 ft
Bounding Box
Z (ft)
40
20
0
-20
Y (ft)

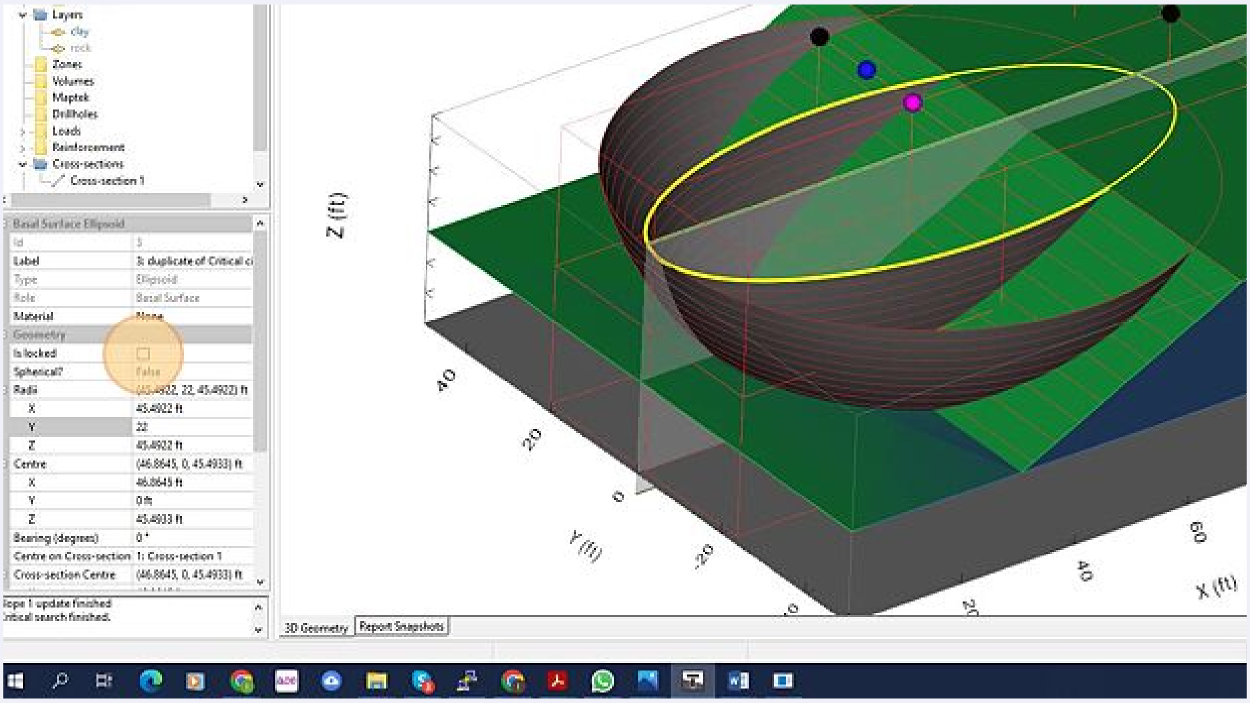
94 change the radius in the Y direction to about half of the x radius



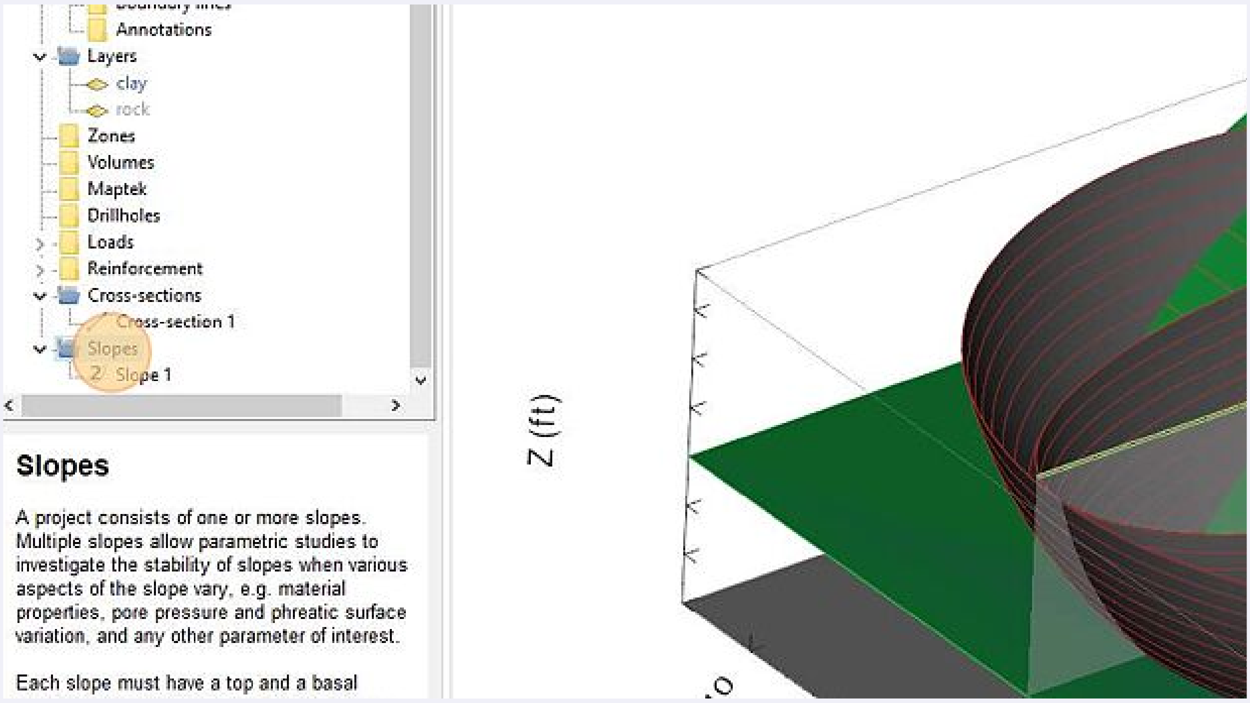
95 Type "22 [[tab]]"



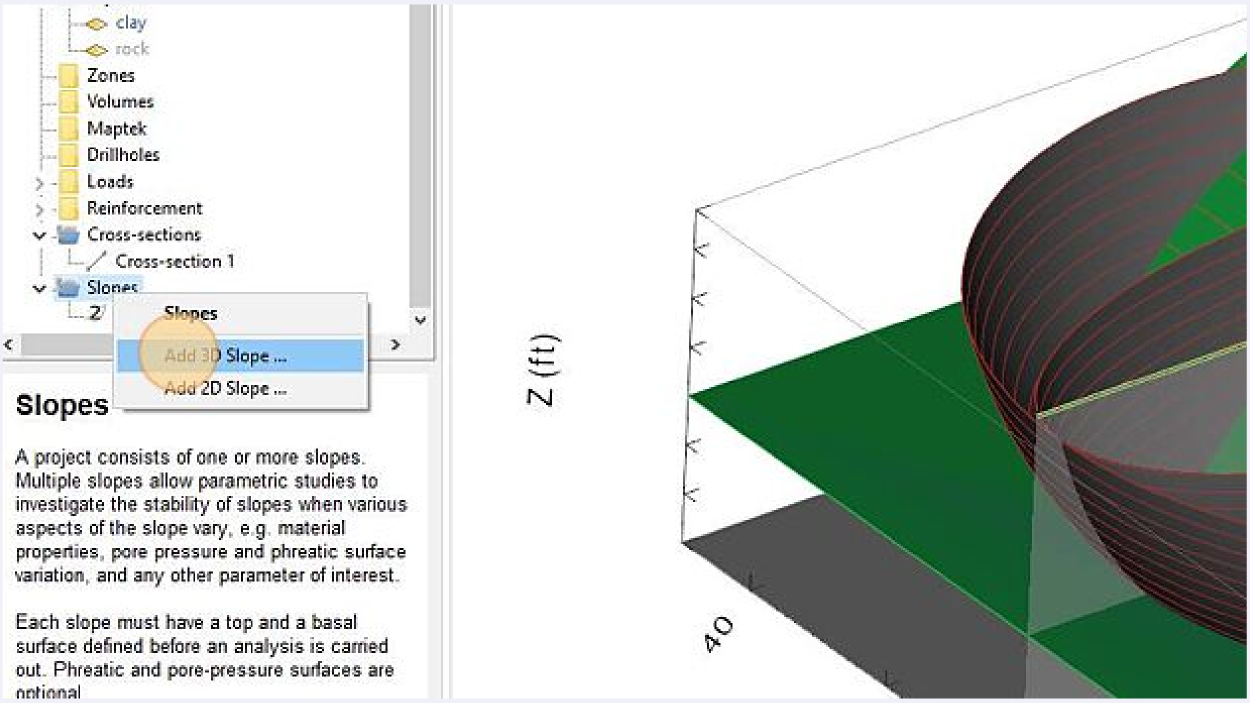
96 Click "control"



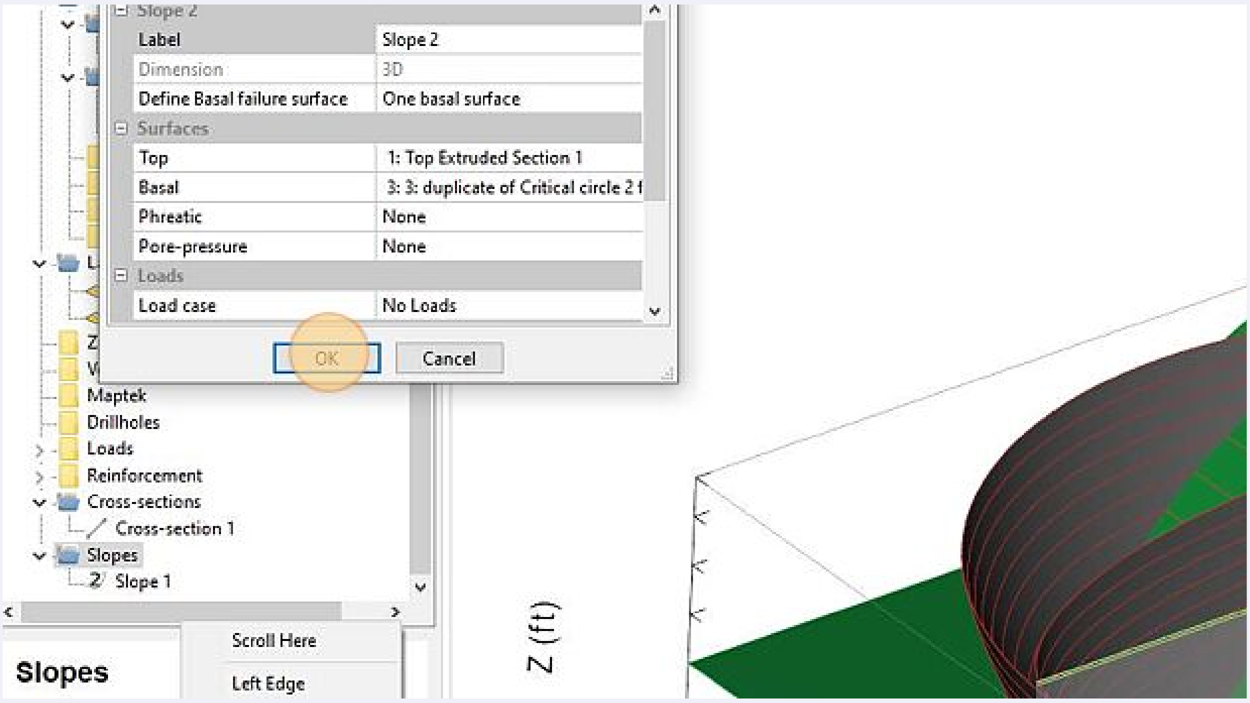
97 Create a new Slope case



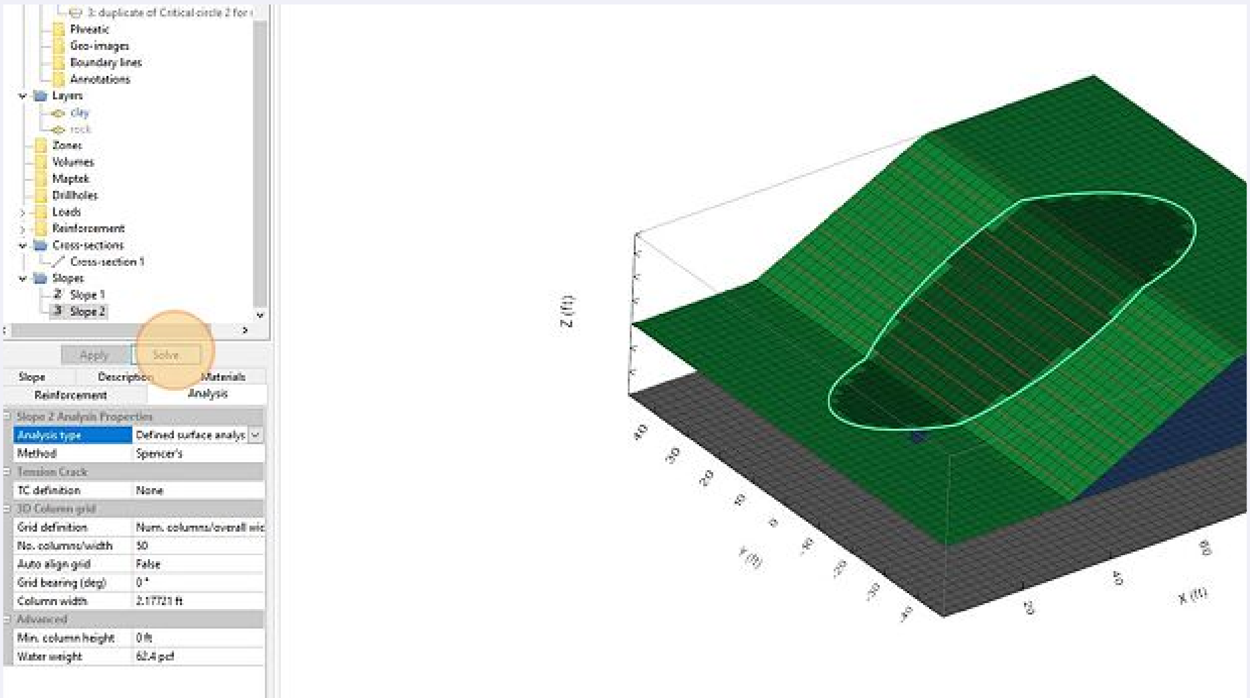
98 Add 3D Slope ...



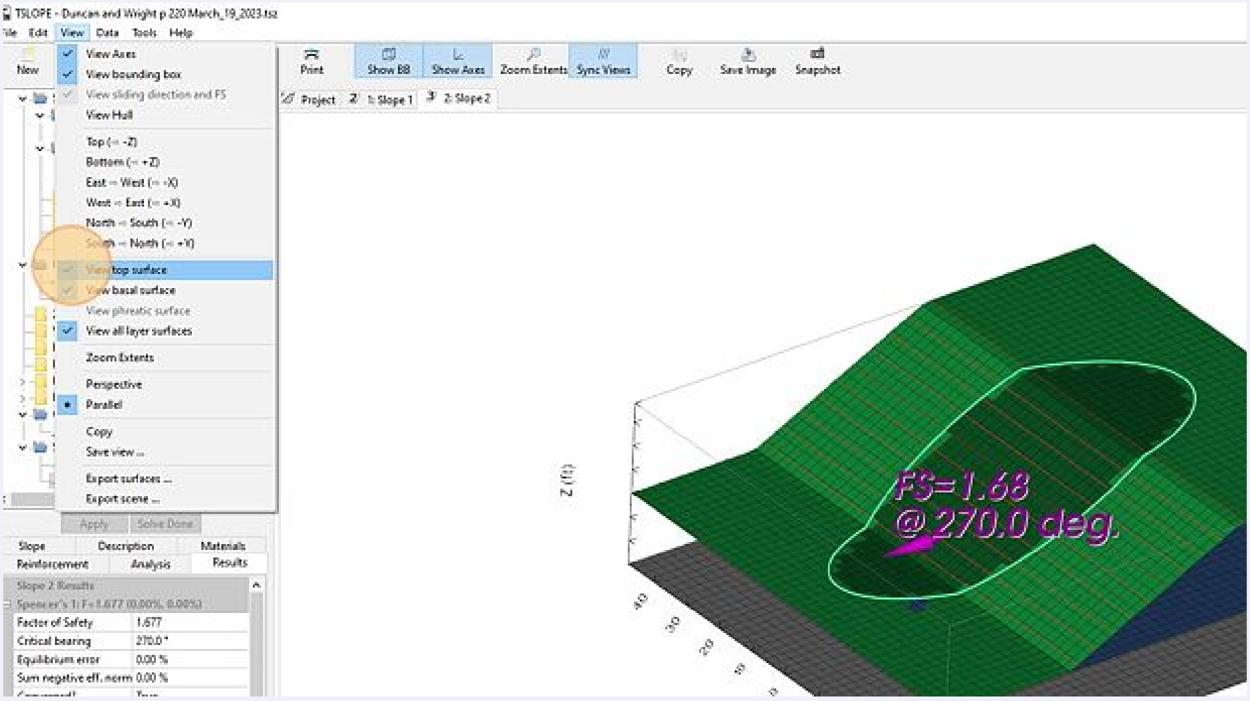
99 Click "OK"



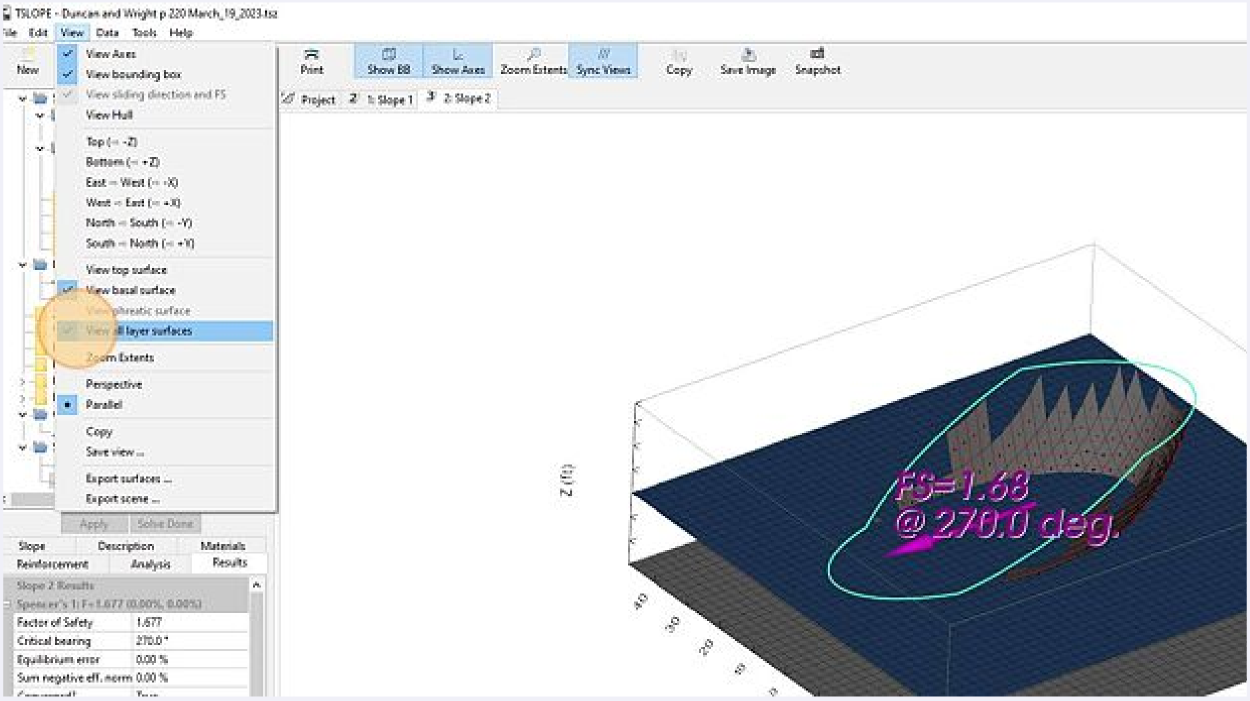
100 Click " Solve "



101 Remove the overlying surfaces to show the slip ellipse



102



103 The 3D factor of safety (1.68) is greater than the 2D (1.21)