# GMS TUTORIALS

# *UTEXAS – Natural Slope*

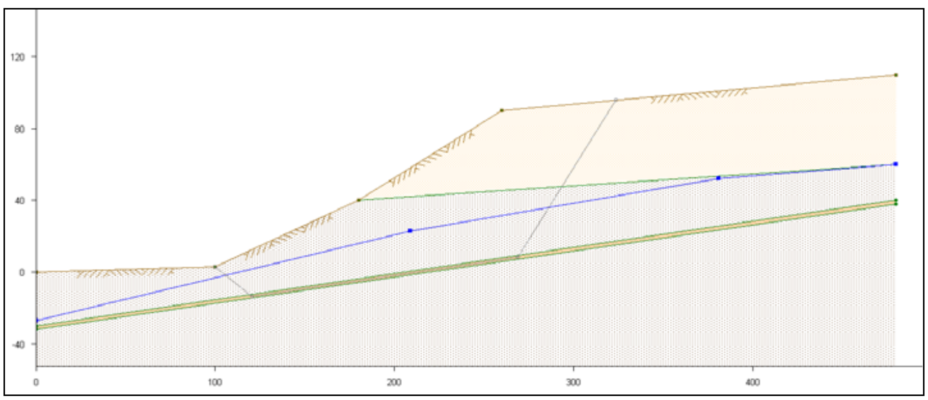


*Figure 1. Natural Slope subjected to steady-state seepage*

## 1 Introduction

This tutorial illustrates how to use GMS to create a UTEXAS model that uses a noncircular shear surface to model a weak soil layer. This tutorial is similar to tutorial number two in the UTEXAS tutorial manual ("UTEXPREP4 Preprocessor For UTEXAS4 Slope Stability Software" by Stephen G. Wright, Shinoak Software, Austin Texas, 2003.).

The problem is illustrated in Figure 1. We will analyze a natural slope that includes a weak clay seam for long-term stability.

The *UTEXAS – Embankment on Soft Clay* tutorial explains more about UTEXAS and provides a good introduction. You may wish to complete it before beginning this tutorial.


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## 1.1 Contents



## 1.2 Outline

Here are the main steps we will complete in this tutorial:

1. Create a UTEXAS4 model in GMS with a noncircular shear surface.
2. Create Piezometric lines defining the pore water pressures.
3. Assign attributes to the model and adjust the analysis options.
4. Save the model, run UTEXAS4 to get a solution, and view the solution in GMS.

## 1.3 Required Modules/Interfaces

You will need the following components enabled to complete this tutorial:

- Map

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- UTEXAS

You can see if these components are enabled by selecting the *File* | *Register*.

## 2 Getting Started

Let's get started.

1. If necessary, launch GMS. If GMS is already running, select the *File* | *New* command to ensure that the program settings are restored to their default state.

## 3 Set the Units

We will start by setting the units we are using. GMS will display the units we select next to the input fields to remind us what they are.

1. Select the *Edit* | *Units* command.
2. Select **ft** for the *Length* units.
3. Select **lb** for the *Force* units.
4. Select the *OK* button.

## 4 Save the GMS Project File

Before continuing, we will save what we have done so far to a GMS project file:

1. Select the *Save* button. This brings up the *Save As* dialog.
2. Locate and open the directory entitled **tutfiles\UTEXAS\natural slope**
3. Enter a name for the project file (ex. "**embankment.gpr**") and select the *Save* button.

You may wish to select the *Save* button occasionally to save your work as you continue with the tutorial.

## 5 Create the Embankment

The first step is to create the geometry defining the embankment.


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## 5.1 Create the Conceptual Model

The geometry will be organized in coverages associated with a UTEXAS conceptual model.

1. Right-click in the *Project Explorer* and select the *New* | *Conceptual Model* menu command.
2. In the *Conceptual Model Properties* dialog, change the *Name* to “**Subsurface**”.
3. Change the *Type* to **SEEP2D/UTEXAS**.
4. Turn **off** the *SEEP2D* option.
5. Select the OK button to exit the dialog.

## 5.2 Create a New Coverage

Next, we’ll create a coverage for the profile lines defining the embankment.

1. In the *Project Explorer*, right-click on the *Subsurface* conceptual model you just created and select the *New Coverage* command from the pop-up menu.
2. In the *Coverage Setup* dialog, change the *Coverage Name* to **Profile Lines** and click *OK* (we don’t need to turn on any properties for the coverage).

## 5.3 Create the Profile

The locations of the points defining the slope were determined beforehand. We will simply enter the points and then connect them with arcs.

1. Right-click on the *Profile Lines* coverage and select the *Attribute Table* command from the pop-up menu.
2. Make sure the *Feature type* is set to **Points** and the *Show point coordinates* option is **on**.
3. Enter points at the following XY locations. If you are viewing this tutorial electronically you can simply copy and paste these values into GMS. Don’t worry about the Z coordinates.

| X | y |
|---|---|
| 0 | -32 |
| 0 | -50 |
| 0 | -30 |
| 0 | 0 |
| 100 | 3 |
| 180 | 40 |
| 260 | 90 |


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| | |
|---|---|
| 480 | -50 |
| 480 | 40 |
| 480 | 60 |
| 480 | 110 |
| 480 | 38 |

4. Select the *Frame* macro.

You should now see the points.

## 5.4 Connect the Points With Arcs

Now we'll connect the points to form arcs and create the polygons.

1. Select the *Create Arc* tool.
2. Hold down the *Shift* key. This makes it so that you can create multiple arcs continuously without having to stop and restart at each point. Release the shift key, or double-click whenever you want to stop creating arcs.
3. Connect the points to make the profile look like the figure below. You may need to zoom in to connect the points that are close together.

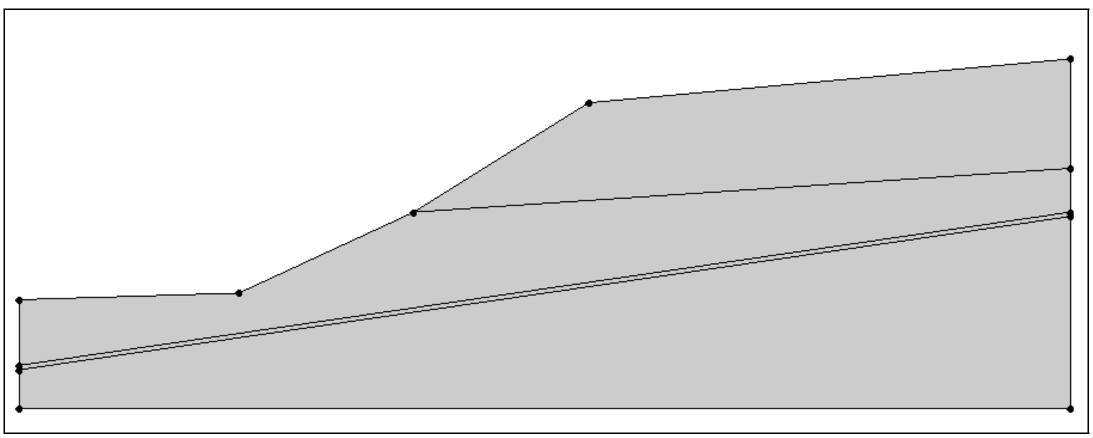

*Figure 2. Natural slope profile.*

4. Select the *Feature Objects | Build Polygons* menu command.

Your model should now resemble the one shown in Figure 2.

# 6 Create Piezometric Line

In this model we use a piezometric line to define the pore water pressures (Figure 3). We'll create it now.


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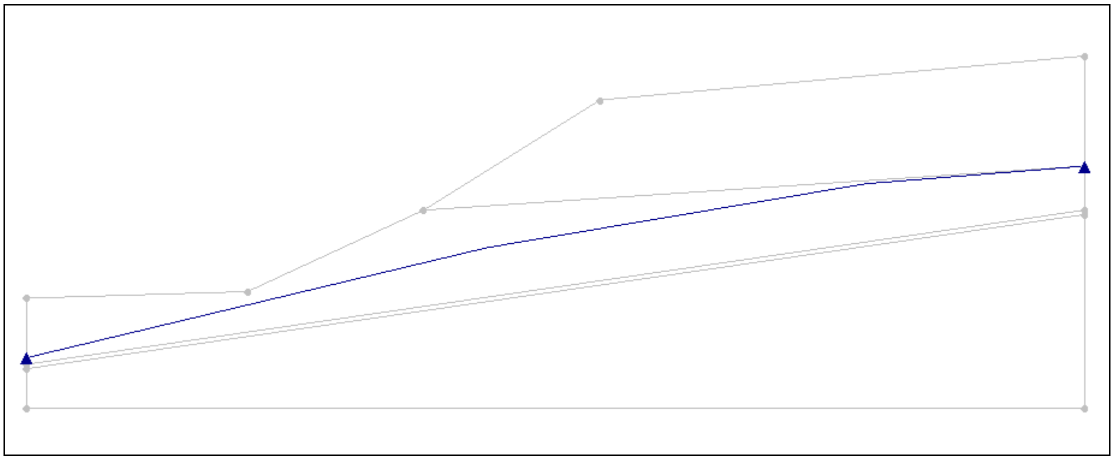

*Figure 3. Piezometric line.*

## 6.1 Create a New Coverage

The piezometric line overlaps other the arcs in the *Profile lines* coverage, so we'll put it in a separate coverage.

1. In the *Project Explorer*, right-click on the *Subsurface* conceptual model and select the *New Coverage* command from the pop-up menu.

2. In the *Coverage Setup* dialog, change the *Coverage Name* to **Piezometric Line.**

3. Turn **on** the *Piezometric Line* option.

4. Click *OK* to exit the dialog.

## 6.2 Create the Points

Again, we'll enter the points first and then later connect them to form arcs.

1. Right-click on the *Piezometric Line* coverage and select the *Attribute Table* command from the pop-up menu.

2. Make sure the *Feature type* is set to **Points** and the *Show point coordinates* option is **on**.

3. Enter points at the following XY locations. If you are viewing this tutorial electronically you can simply copy and paste these values into GMS.

| x | y |
|---|---|
| 0 | -27 |
| 209 | 23 |
| 381 | 52 |
| 480 | 60 |

4. Click OK to exit the dialog.


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You should now see the points. Some of the points may be obscured by the other coverage. We'll turn it off.

5. In the *Project Explorer*, turn **off** the *Profile Lines* coverage.

### 6.3 Connect the Points With Arcs

1. Select the *Create Arc* tool
2. Connect the points to form the arcs shown in Figure 3.
3. Using the *Select Node* tool, select the two middle nodes (by dragging a box or holding down the shift key).
4. Right-click on either one of the nodes and select the *Node->Vertex* command from the pop-up menu.

Now the three arcs have been converted into a single arc.

5. Select the *Select Arc* tool .
6. Double-click the newly created arc to bring up the *Properties* dialog.
7. Change the *Type* to **Piezometric line** and click *OK*.
8. Click anywhere not on the arc to unselect it.

You should notice that the color of the arc has changed to reflect its type.

## 7 Create Trial Shear Surface

We will now create an initial noncircular slip surface that lies partially in the weak soil zone. UTEXAS uses this as the initial guess at the failure plane. Then it iteratively moves the surface to find the critical surface (i.e., the surface with the minimal factor of safety).

### 7.1 Create a New Coverage

1. In the *Project Explorer*, right-click on the *Subsurface* conceptual model you just created and select the *New Coverage* command from the pop-up menu.
2. In the *Coverage Setup* dialog, change the *Coverage Name* to **Shear Surface.**
3. In the list of Sources/Sinks/BCs, turn **on** the *Shear Surface* option.
4. Click *OK* to exit the dialog.


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## 7.2 Create the Points

1. Right-click on the *Shear Surface* coverage and select the *Attribute Table* command from the pop-up menu.
2. Make sure the *Feature type* is set to **Points** and the *Show point coordinates* option is **on**.
3. Enter points at the following XY locations. If you are viewing this tutorial electronically you can simply copy and paste these values into GMS.

| x | y |
|---|---|
| 100 | 3 |
| 120.5 | -13.5 |
| 269 | 8.2 |
| 326 | 96 |

4. Click OK to exit the dialog.

You should now see the points.

## 7.3 Connect the Points with Arcs

Next, we will connect the points to form arcs defining the shear surface.

1. Select the *Create Arc* tool and connect the nodes (you may want to hold down the shift key as you do so you don't have to stop and restart at each point).
2. Select the *Select Arc* tool .
3. Double-click on each of the three arcs to bring up its *Properties* dialog and change the *Type* to **shear surface**.
4. Click anywhere not on an arc to unselect it.

The shear surface should look like this:

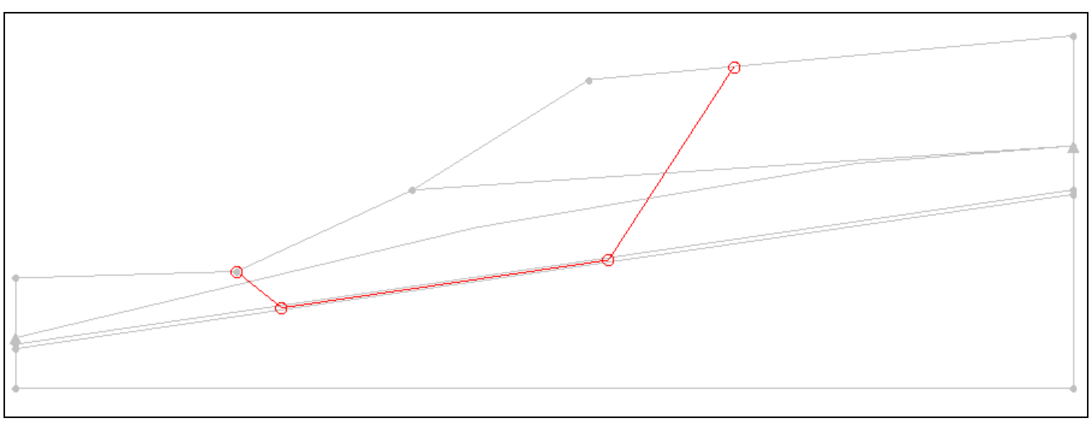

*Figure 4. Initial shear surface.*


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In this case we do not want to merge the three arcs into one. We want separate arcs so that we can assign attributes to the nodes.

### 7.4 Assign the Node Attributes

UTEXAS moves the initial surface according to the options you specify at the nodes. You can tell UTEXAS that a node is fixed, or that it can only move in a specified direction, or that UTEXAS can move it in any direction it wishes.

1. Using the *Select Node* tool, select the two middle nodes by clicking on one and holding the shift key to click on the other or by dragging a box around the two nodes.

2. Select *Properties* tool to bring up the dialog.

3. In the *All* row, change *Point Shift* to **Specified**, and enter **“8.4”** for *Angle*.

This option will allow these two nodes to move only along the weak clay seam. The other nodes will be left at their default settings, which is **Automatic**. For nodes on the slope exterior, UTEXAS moves the nodes such that they move laterally along the ground surface.

4. Click *OK* to close the dialog.

## 8 Material Properties

The next step is to define the properties associated with the soil material.

### 8.1 Create the Materials

1. Select the *Edit | Materials* menu command.

2. Double click on **material_1** in the list in the upper left of the dialog.

3. Change the name to “**Silty Clay**”.

4. Change the *Material color / pattern* from black to a nice looking color, like **Gold**.

5. Click the *New* button to create a new material.

6. Double-click the new material you just created and rename it “**Highly Plastic Clay**”.

7. Change it’s color to **Lime** or some other color of your choice.

8. Click the *New* button one last time.

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9. Double-click this third material and rename it "**Sandy Gravel**".

10. Change the color of this material to **Brown** or some other color of your choice.

## 8.2 Set the Material Properties

1. On the right side of the dialog, make sure the *UTEXAS* tab is displayed.

2. Change the material properties to the following (make sure the Silty Clay ID is 1, Highly Plastic ID is 2, and Sandy Gravel ID is 3):

| ID | Unit Weight Stage 1 | Shear Strength Method Stage 1 | Cohesion Stage 1 | Angle of Internal Friction Phi Stage 1 | Pore Water Pressure Method Stage 1 |
|---|---|---|---|---|---|
| 1 | 126 | Conventional | 100 | 29 | Piezometric Line |
| 2 | 115 | Conventional | 0 | 14 | Piezometric Line |
| 3 | 131 | Conventional | 0 | 38 | Piezometric Line |

The above table does not show the column titled *Piezometric Line Coverage Stage 1* because the values in that column are set automatically when you change the *Pore Water Pressure Method* to **Piezometric Line**. Thus you don't need to worry about it.

3. Click *OK* to exit the dialog.

## 8.3 Assign Materials to Polygons

Now we'll change each polygon in the Profile Lines coverage to be associated with the correct material.

1. In the *Project Explorer*, select the *Profile Lines* coverage to make it the active coverage. Also, turn it **on** so it's visible again.

2. Select the *Select Polygons*  tool.

3. Double-click on the top polygon to bring up its properties.

4. In the *Properties* dialog, change the *Material* to **Sandy Gravel** and click *OK*.

5. Do the same for the other three polygons assigning them materials according to the following diagram:

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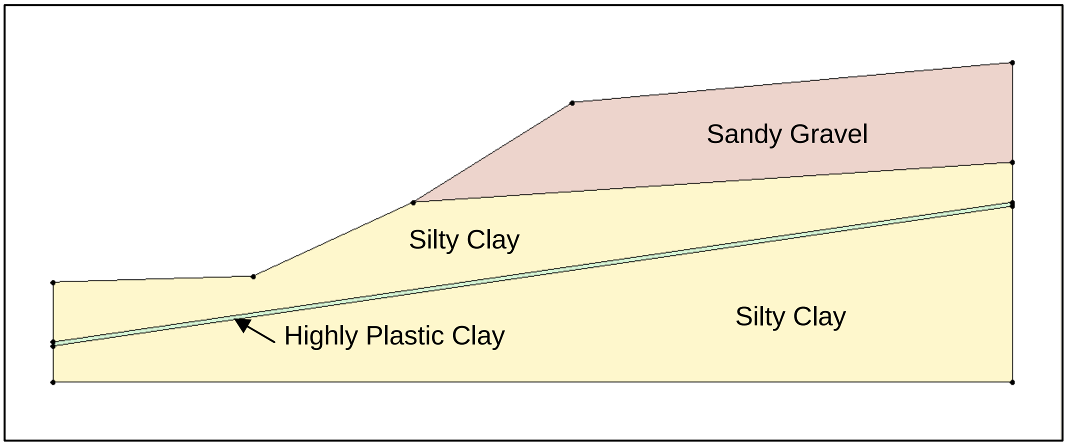


*Figure 5. Materials for each polygon.*

# 9 Analysis Options

The only thing left to do before we save and run the model is to set the UTEXAS analysis options. We will perform an automatic search using a non-circular surface using Spencer's Method.

1. In the *Project Explorer*, right-click on the **UTEXAS** model and select the *Analysis Options* command from the pop-up menu.

2. In the *Headings* section, enter the following headings:

   **Natural Slope**
   **GMS UTEXAS Tutorial**

3. Change the options to match those shown in the dialog below.

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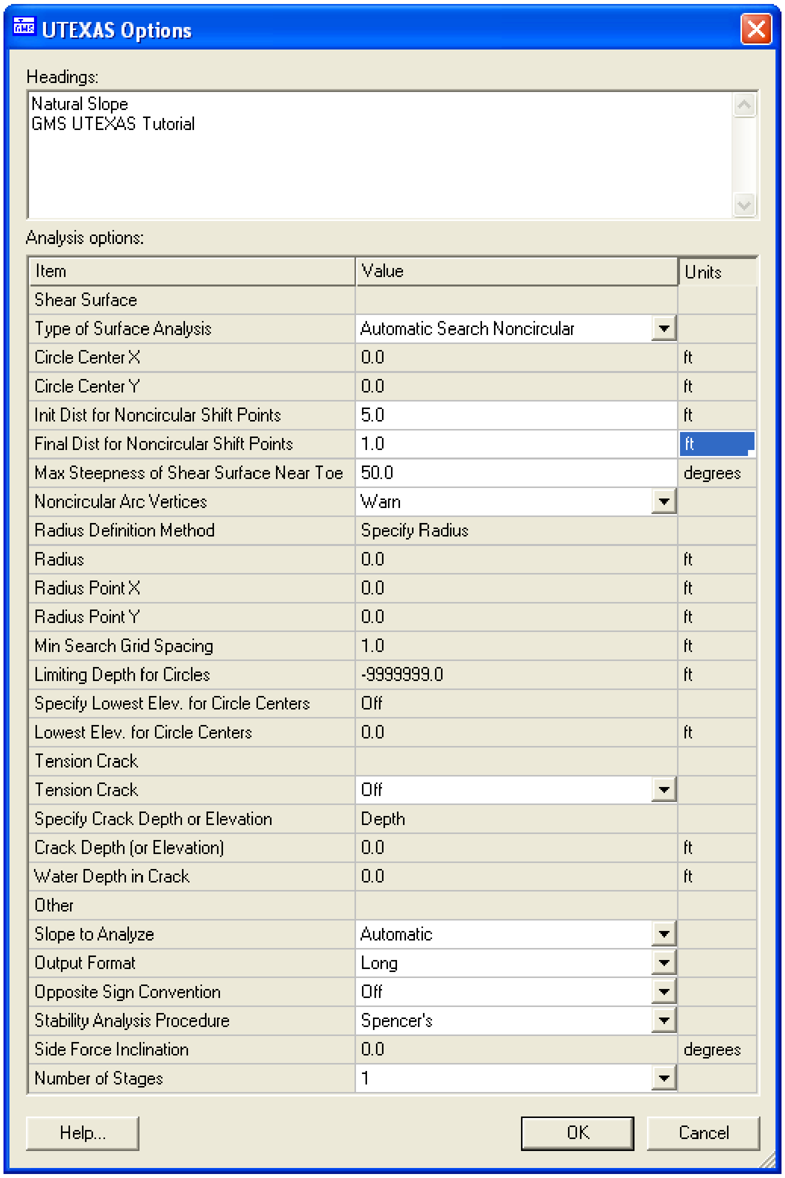

UTEXAS Options

Headings:

Natural Slope
GMS UTEXAS Tutorial

Analysis options:

| Item | Value | Units |
|---|---|---|
| Shear Surface | | |
| Type of Surface Analysis | Automatic Search Noncircular | |
| Circle Center X | 0.0 | ft |
| Circle Center Y | 0.0 | ft |
| Init Dist for Noncircular Shift Points | 5.0 | ft |
| Final Dist for Noncircular Shift Points | 1.0 | ft |
| Max Steepness of Shear Surface Near Toe | 50.0 | degrees |
| Noncircular Arc Vertices | Warn | |
| Radius Definition Method | Specify Radius | |
| Radius | 0.0 | ft |
| Radius Point X | 0.0 | ft |
| Radius Point Y | 0.0 | ft |
| Min Search Grid Spacing | 1.0 | ft |
| Limiting Depth for Circles | -9999999.0 | ft |
| Specify Lowest Elev. for Circle Centers | Off | |
| Lowest Elev. for Circle Centers | 0.0 | ft |
| Tension Crack | | |
| Tension Crack | Off | |
| Specify Crack Depth or Elevation | Depth | |
| Crack Depth (or Elevation) | 0.0 | ft |
| Water Depth in Crack | 0.0 | ft |
| Other | | |
| Slope to Analyze | Automatic | |
| Output Format | Long | |
| Opposite Sign Convention | Off | |
| Stability Analysis Procedure | Spencer's | |
| Side Force Inclination | 0.0 | degrees |
| Number of Stages | 1 | |

Help... OK Cancel

*Figure 6. UTEXAS Options.*

4. When you're finished, click *OK* to exit the dialog.

## 10 Save the GMS file

Before continuing, we will save the GMS project file.

1. Select the *File* | *Save* command.

## 11 Export the Model

We're ready to export the model for use in UTEXAS.

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1. In the *Project Explorer*, right-click on the **UTEXAS** model and select the *Export* command from the pop-up menu.
2. If necessary, locate and open the directory entitled **tutfiles\UTEXAS\natural slope** (you should already be there).
3. Change the *File name* to **nat_slope** and click *Save*.

## 12 Run UTEXAS

Now that we've saved the UTEXAS input file, we're ready to run UTEXAS.

1. In the *Project Explorer*, right-click on the **UTEXAS** model and select the *Launch UTEXAS4* command from the pop-up menu. This should bring up the UTEXAS4 program.
2. In UTEXAS4, select the *Open File* button.
3. Change the *Files of type* to **All Files (*.*)**.
4. Locate the **nat_slope.utx** file you just saved (in the **tutfiles\UTEXAS\natural slope**) folder and open it.
5. When UTEXAS4 finishes, look at the things mentioned in the *Errors, Warnings* window, then close the window.

## 13 Read the Solution

Now we need to read the UTEXAS solution.

6. In the *Project Explorer*, right-click on the **UTEXAS** model and select the *Read Solution* command from the pop-up menu.
7. Locate and open the file named **nat_slope.out**.

You should now see a line representing the critical failure surface, and the factor of safety.

## 14 Conclusion

This concludes the tutorial. Here are some of the key concepts in this tutorial:

- UTEXAS can calculate a noncircular slip surface, given the slope angle and an initial guess at the shear surface.


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- You tell UTEXAS how to move the initial shear surface by specifying options at the nodes of the shear surface arcs.

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