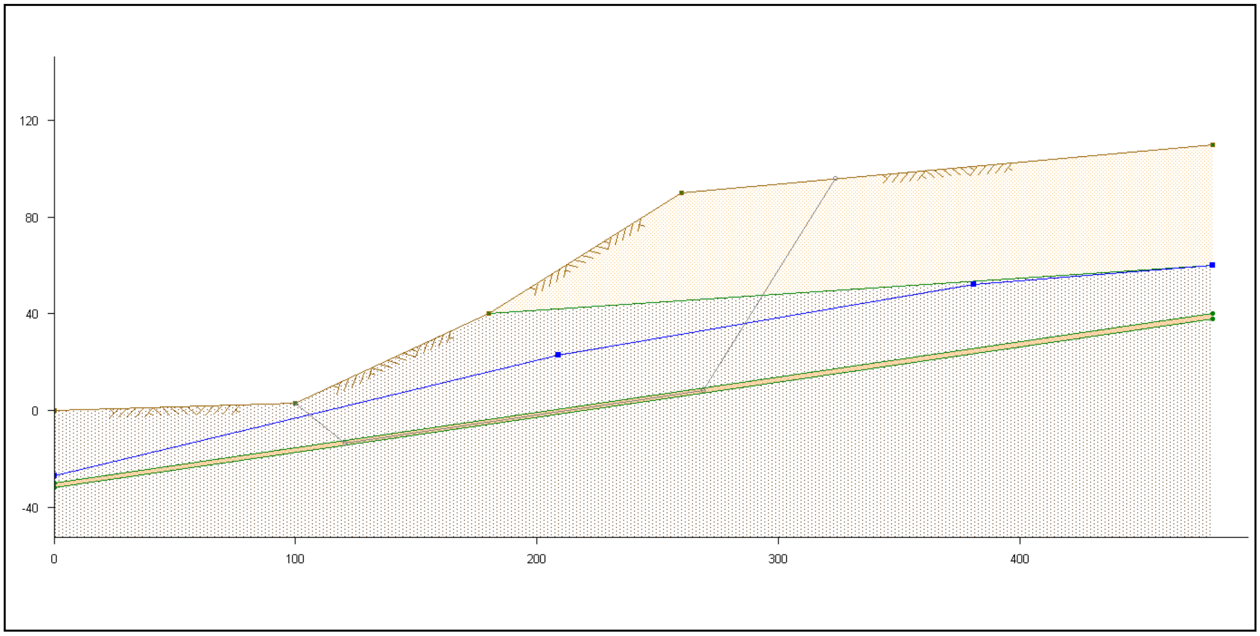
v. 9.2

*GMS 9.2 Tutorial*

# ***UTEXAS – Natural Slope***

Use the noncircular shear surface option with UTEXAS




## Objectives

Learn 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.)

## Prerequisite Tutorials

- None

## Required Components

- GIS
- Map
- UTEXAS

## Time

- 30-60 minutes

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# 2 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 on page 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 to the GMS/UTEXAS interface. You may wish to complete it before beginning this tutorial.

## 2.1 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.

# 3 Program Mode

This tutorial assumes that we are operating in the GMS 2D mode. If you are not already in GMS 2D mode, do the following. If you are already in GMS 2D mode, you can skip ahead to the next section.

1. Launch GMS.

2. Select the *Edit* | *Preferences* command.

3. Select the *Program Mode* option on the left side of the dialog.

4. On the right side of the dialog, change the mode to *GMS 2D*.

5. Click on the *OK* button.

6. Click *Yes* in response to the warning.

7. Click OK to get rid of the *New Project* window and then select the *File* | *Exit* command to exit GMS.

# 4 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.

At this point, you should see the *New Project* window. This window is used to set up a GMS conceptual model. A conceptual model is a set of GIS features (points, lines, and polygons) that are used to define the model input. The data in the conceptual model are organized into a set of layers or groups called *coverages*. Each coverage is used to define a portion of the input and the properties that are assigned to the features in a coverage are dependent on the coverage type. GMS 2D allows us to quickly and easily define all of the coverages needed for our conceptual model using the *New Project* window.

 

2. Change the *Conceptual model name* to **Nat Slope Model**.

3. Turn **off** the *SEEP2D* option in the *Numerical models* section.

4. Select the following coverage options:

   *Profile lines*
   *Piezometric line*
   *Shear surface*

5. Select the *OK* button.

You should see a new conceptual model object appear in the *Project Explorer*.

# 5 Set the Units

Before we continue, we will establish the units we will be using. GMS will display the appropriate units label next to each of the input fields to remind us to be sure and use consistent units.

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.

# 6 Save the GMS Project File

Before continuing, we will save our project to a GMS project file.

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

2. Path to a location where you wish to save your project

3. Locate and open the directory entitled **Tutorials\UTEXAS\natural_slope**

4. Change the name of the project file to **embankment**.

5. Click on the *Save* button.

As you continue with the tutorial, click on the Save macro  frequently to save your changes.

 

# 7 Create the Embankment

The first step is to create the GIS features defining the embankment geometry. We will begin by entering a set of points corresponding to the key locations in the geometry. We will then connect the points with lines called "arcs" to define the outline of the embankment. We will then convert the arcs to a closed polygon defining our problem domain.

## 7.1 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. Click on the *Profile lines* coverage to make it active.

2. Right-click on the *Profile lines* coverage and select the *Attribute Table* command from the pop-up menu.

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

4. 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 |
| 480 | -50 |
| 480 | 40 |
| 480 | 60 |
| 480 | 110 |
| 480 | 38 |

5. Select the *Frame* macro to center the view on the new points.

You should now see the points.

## 7.2 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. 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.

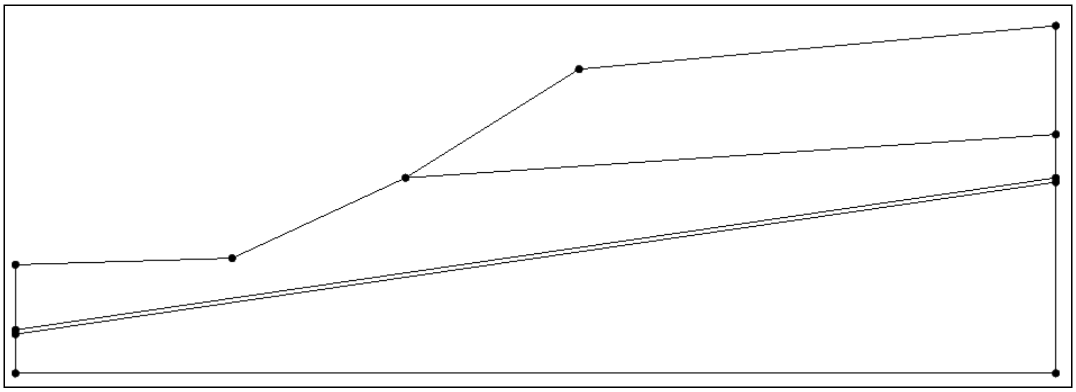

*Figure 1. Natural slope profile.*

### 7.3 Create the Polygons

Now that the arcs are created, we can use the arcs to build polygons representing the regions enclosed by the arcs. Later in this tutorial we will use the polygons to assign material properties. To build the polygons:

1. Select the *Build Polygons* macro at the top of the GMS window (or select the *Feature Objects* | *Build Polygons* command).

Your model should now see gray polygons in the background.

## 8 Create Piezometric Line

In this model we use a piezometric line to define the pore water pressures (Figure 2). We'll create it now.

 

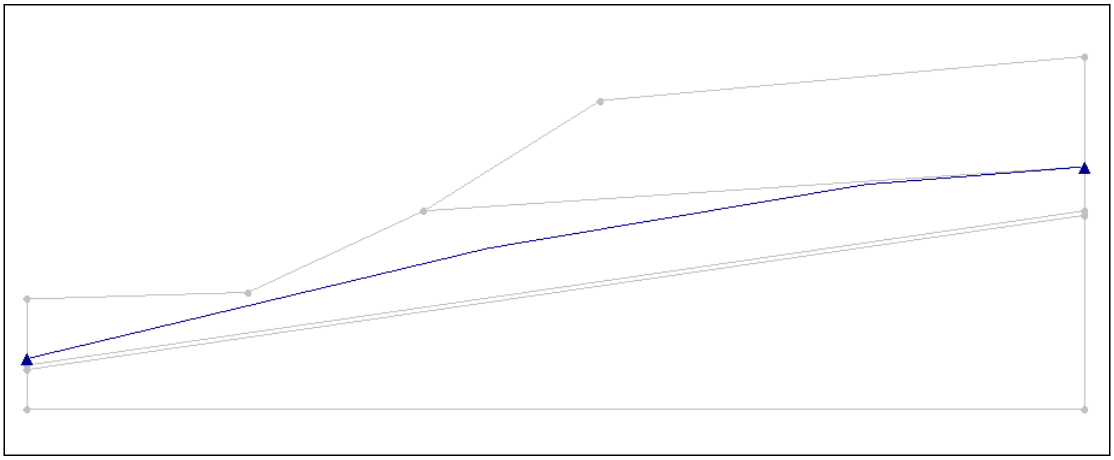

*Figure 2. Piezometric line.*

## 8.1 Create the Points

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

1. Click on the *Piezometric line* coverage to make it active.
2. Right-click on the *Piezometric line* coverage and select the *Attribute Table* command from the pop-up menu.
3. Make sure the *Feature type* is set to **Points** and the *Show point coordinates* option is **on**.
4. 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 |

5. Click *OK* to exit the dialog.

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

6. In the *Project Explorer*, turn **off** the *Profile lines* coverage.

## 8.2 Connect the Points with Arcs

Next we will connect the points to create arcs.

1. In the *Project Explorer,* click on the *Piezometric line* coverage to activate it.

 

2. Select the *Create Arc* tool
3. Connect the points to form the arcs shown in Figure 2.

When we start with a set of four points and connect them to form arcs, we end up with three separate arcs. However, the UTEXAS input requires that we use a single arc to define the piezometric line. To convert the three arcs to a single arc, we will select the two interior nodes and convert them to vertices.

4. Using the *Select Node* tool, select the two middle nodes (by dragging a box or holding down the shift key).
5. 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.

# 9 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).

## 9.1 Create the Points

1. Click on the *Shear surface* coverage to make it active.
2. Right-click on the *Shear Surface* coverage and select the *Attribute Table* command from the pop-up menu.
3. Make sure the *Feature type* is set to **Points** and the *Show point coordinates* option is **on**.
4. 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 |

5. Click *OK* to exit the dialog.

You should now see the points.

 

## 9.2 Connect the Points with Arcs

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

1. In the *Project Explorer,* click on the *Shear surface* coverage to activate it.

2. 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).

The shear surface should look like this:

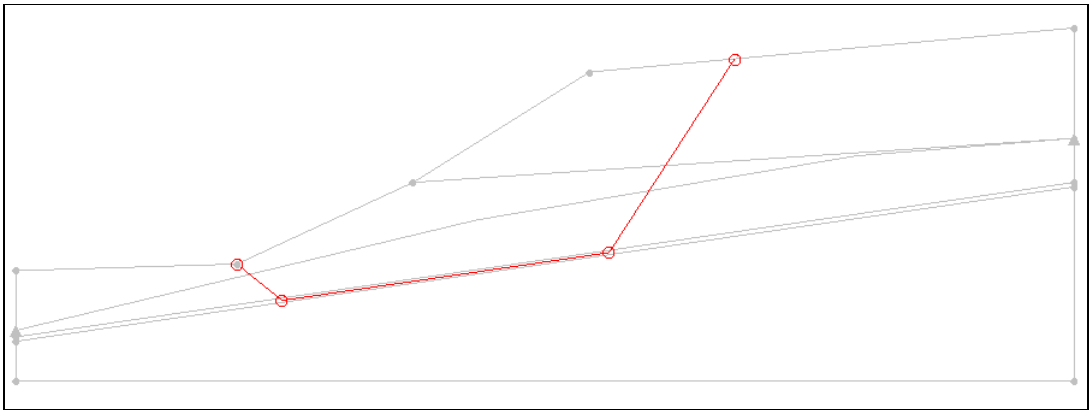

*Figure 3. Initial shear surface.*

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.

## 9.3 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 the *Properties* tool to bring up the *Properties* 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.

 

# 10 Material Properties

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

## 10.1 Create the Materials

1. Select the Materials macro (or select the *Edit* | *Materials* menu command).
2. Select the *UTEXAS* tab.
3. Double click on **material_1** in the list in the upper left of the dialog.
4. Change the name to "**Silty Clay**".
5. Change the *Color/Pattern* from black to a lighter color, like **Gold**.

To create a new material:

6. Type "**Highly Plastic Clay**" in the *Name* column of the blank row at the bottom of the spreadsheet.
7. Change its color to **Lime** or some other color of your choice.
8. Create another material named "**Sandy Gravel**".
9. Change the color of this material to **Brown** or some other color of your choice.

## 10.2 Set the Material Properties

1. 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.

2. Click *OK* to exit the dialog.

## 10.3 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:

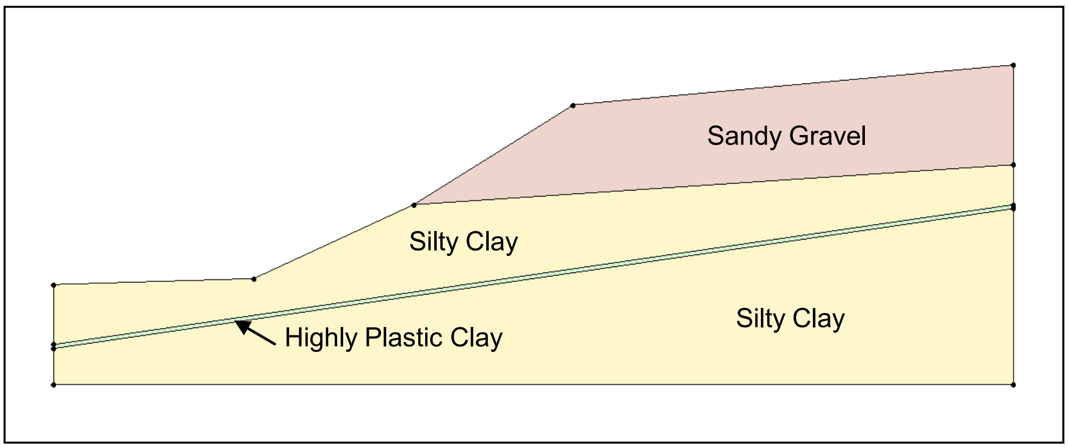


*Figure 4. Materials for each polygon.*

# 11 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.

 

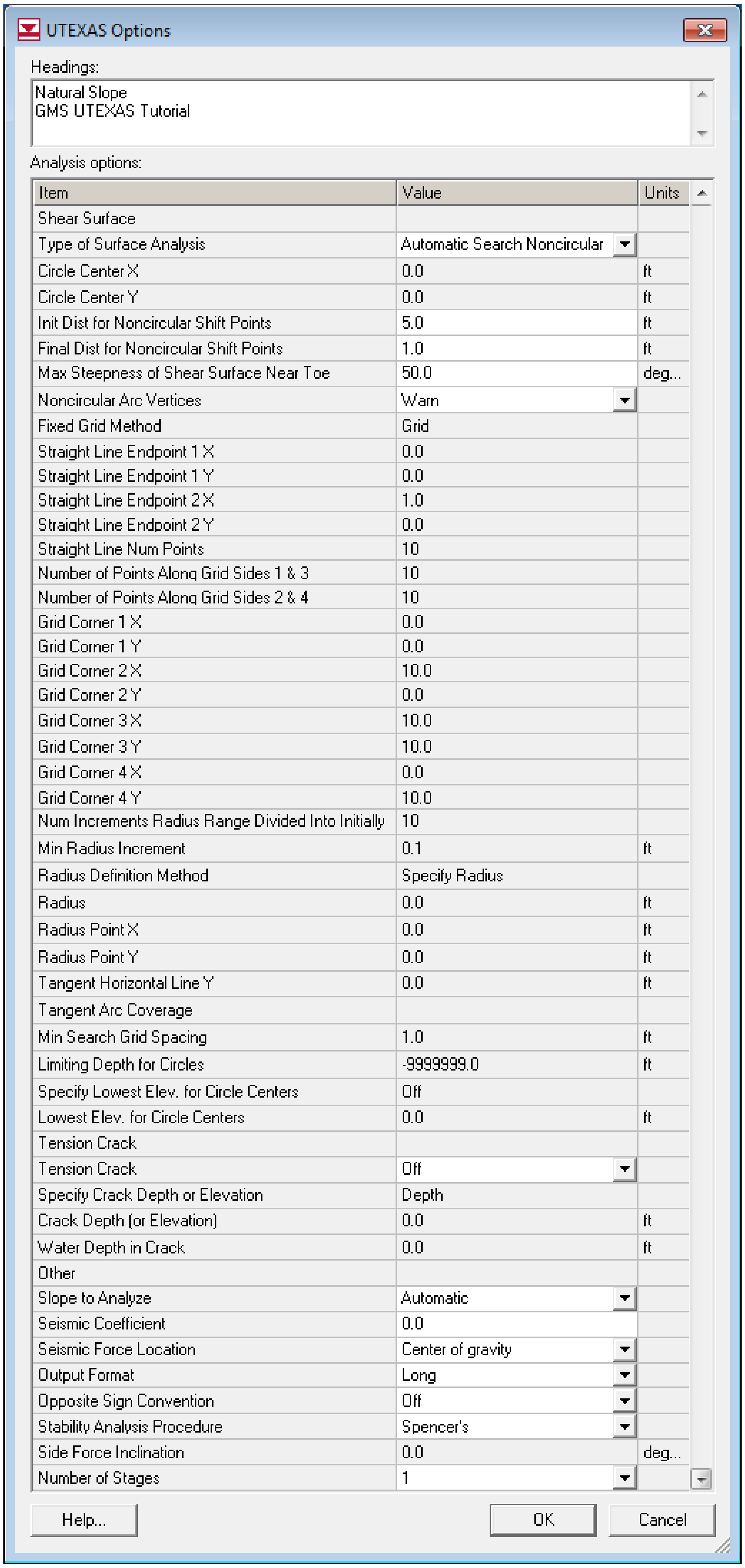


*Figure 5. UTEXAS Options.*

 

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

## 12 Save the GMS file

Before continuing, we will save the GMS project file.

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

## 13 Export the Model

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

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

## 14 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 **Tutorials\UTEXAS\natural_slope**) folder and open it.
5. Press *Save* in the *Open file for graphics output* dialog box. This will save a TexGraf4 output file.
6. Look at the things mentioned in the *Errors, Warnings* window, then close the window.

## 15 Read the Solution

Now we need to read the UTEXAS solution.

 

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

2. 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.

# 16 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.

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

 