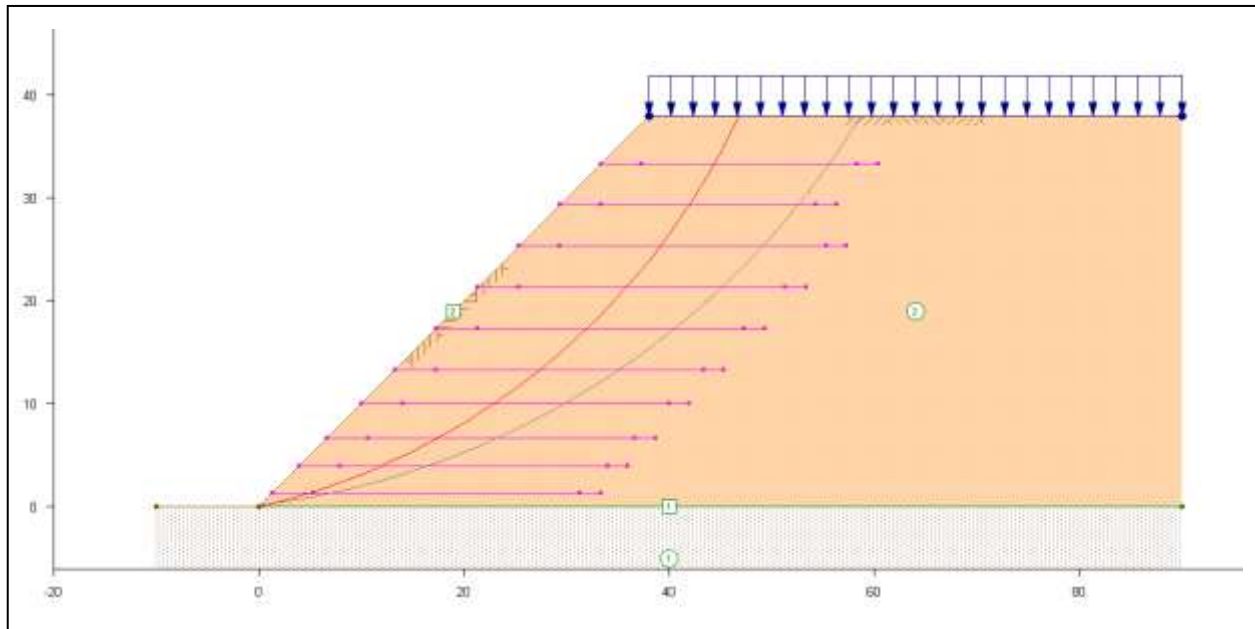


GMS 10.0 Tutorial

UTEXAS – Reinforced Slope

Build a UTEXAS model that uses soil reinforcement to strengthen a slope



Objectives

Learn how to build a UTEXAS model in GMS that uses soil reinforcement to stabilize a slope. This tutorial is similar to tutorial number five in the UTEXAS tutorial manual. (Wright, Stephen G. “UTEXPREP4 Preprocessor for UTEXAS4 Slope Stability Software,” Shinoak Software, Austin, Texas: 2003.)

Prerequisite Tutorials

UTEXAS – Natural Slope

Required Components

- GIS Module
- Map Module
- UTEXAS

Time

- 25–40 minutes



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1 Introduction

This tutorial illustrates how to build a UTEXAS model in GMS that uses soil reinforcement to stabilize a slope. This tutorial is similar to tutorial number five in the UTEXAS tutorial manual.¹

A fairly steep embankment is subjected to loading. The slope has several reinforcement elements to help strengthen it against failure. Reinforcement elements include geotextiles, nails, piers etc.

The “UTEXAS – Embankment on Soft Clay” tutorial explains more about UTEXAS and provides a good introduction to the GMS/UTEXAS interface. The user may wish to complete it before attempting this tutorial.

1.1 Outline

In this tutorial, the user will be examining a reinforced embankment problem that looks like the one shown in on page 1.² Here are the steps to this tutorial:

1. Wright, S.G. (2003). UTEXPREP4 Preprocessor for UTEXAS4 Slope Stability Software. (Shinoak Software, Austin, Texas.), p. 1.

2. Ibid.

1. Create the slope.
2. Create material properties and assign materials to polygons.
3. Assign the distributed load.
4. Create the reinforcement lines.
5. Set the analysis options.
6. Export the UTEXAS input file, run UTEXAS, and view the solution in GMS.

2 Program Mode

This tutorial assumes that the user is operating in the GMS 2D mode. If the user is already in GMS 2D mode, skip ahead to the next section. If the user is not already in GMS 2D mode, do the following.

1. Launch GMS.
2. Select the *Edit* / **P**references 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* dialog.
8. Select the *File* / **E**xit command to exit GMS.

3 Getting Started

Do the following to get started:

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

At this point, the user should see the *New Project* dialog. This dialog 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 the user to quickly and easily define all of the coverages needed for the conceptual model using the *New Project* dialog.

3. Change the *Conceptual model name* to “Reinforced Slope.”
4. Turn off the *SEEP2D* option in the *Numerical models* section.
5. Select the following coverage options:
 - *Profile lines*
 - *Distributed loads*
 - *Reinforcement*
6. Select the **OK** button.

The user should see a new conceptual model object appear in the Project Explorer.

4 Set the Units


Before continuing, the user will establish the units to be used. GMS will display the appropriate units label next to each of the input fields to remind the user to be sure to use consistent units.

1. Select the *Edit / Units* command.
2. If necessary, select “ft” for the *Length* units.
3. If necessary, select “lb” for the *Force* units.
4. Select the **OK** button.

5 Save the GMS Project File

Before continuing, save that project as a GMS project file.

1. Select the *File / Save As* command.
2. Locate and open the directory entitled *Tutorials\UTEXAS\reinforcement*.
3. Enter a name for the project file (e.g., “reinforced.slope.gpr”).
4. Select the **Save** button.

Click on the **Save**  macro frequently to save all changes.

6 Create the Slope

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

6.1 Create the Profile Geometry


First, the user will create the profile lines defining the slope.

Create the Points

The locations of the points defining the slope were determined beforehand. The user 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.
3. Select the Attribute Table command from the pop-up menu. This brings up the coverage *Attribute Table* dialog.
4. Make sure the *Feature type* is “Points.”
5. Make sure the *Show coordinates* option is turned on.
6. Enter the X and Y coordinates shown in the table below. If the user is viewing this tutorial electronically, he or she can copy and paste these values into the GMS spreadsheet.


X	Y
-10	0
90	0
0	0
38	38
90	38
-10	-10
90	-10

7. Click **OK** to exit the dialog.
8. Click the **Frame**  button to center the view on the new points.

The user should now see the seven points defining the corners of the slope.


Connect the Points to Create Arcs

Next, the user will connect the points to form arcs:

9. Select the **Create Arcs**  tool.
10. 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 to stop creating an arc.
11. Using Figure 1 as a guide, click on the points to connect them with arcs to create the slope.

Create the Polygons

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

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

At this point, the user should see something like Figure 1 below.

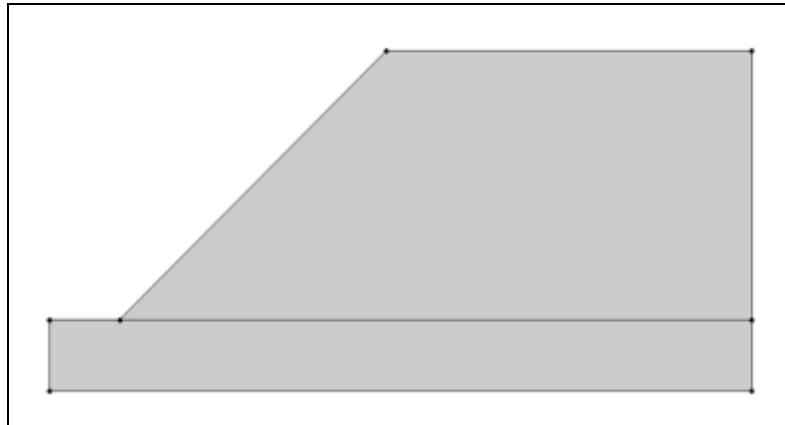



Figure 1 The basic slope

7 Material Properties

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

7.1 Create the Materials

1. Select the **Materials** macro  (or select the *Edit / Materials* menu command). This will open the *Materials* dialog.
2. Select the *UTEXAS* tab.
3. Click on the material named “material_1” and rename it “Bedrock.”


4. Click on the *Color/Pattern* button and change the color to Yellow.
5. Create a new material by entering “Sand” in the *Name* column of the blank row at the bottom of the spreadsheet.
6. Change the material color to Light orange.
7. Change the material properties to those shown in the following table:

Category	Unit Weight Stage 1	Shear Strength Method Stage 1	Cohesion Stage 1	Angle of Internal Friction Phi Stage 1
Bedrock	160	Very Strong material	N/A	N/A
Sand	120	Conventional	0	32

8. Make sure the *Pore Water Pressure Method Stage 1* is set to “No Pore Pressure” for the second material (Sand). The user may have to scroll the spreadsheet to the right to see this column.
9. Leave the other settings at the defaults.
10. Click **OK** to exit the dialog.

7.2 Assign Materials to Polygons

Next, the user will associate the materials with the polygons defining the soil zones in the profile:

1. Switch to the **Select**  tool.
2. Double-click on the upper polygon (the big one) to open the *Attribute Table* dialog.
3. Change the *Material* to “Sand.”
4. Click **OK** to exit the dialog.
5. Double-click on the lower polygon.
6. Change the *Material* to “Bedrock” (it may already be set to this).
7. Click **OK** to exit the dialog.

8 Assign the Distributed Load

Now the user will set up the distributed load.

8.1 Create the Points

The user will simply enter the points and then connect them with an arc.


1. Turn off the “Profile lines” coverage by unselecting its toggle.
2. Click on the “Distributed loads” coverage to make it active.
3. Right-click on the “Distributed loads” coverage.
4. Select the **Attribute Table** command from the pop-up menu. This brings up the *Attribute Table* dialog.
5. Make sure the *Feature type* is “Points.”
6. Make sure the *Show coordinates* option is turned on.
7. Enter the X and Y coordinates shown in the table below. If the user is viewing this tutorial electronically, he or she can copy and paste these values into the GMS spreadsheet.

X	Y
38	38
90	38

8. Click **OK** to exit the dialog.

8.2 Connect the Points to Create Arcs

Next, the user will connect points to form an arc representing a distributed load:

9. Select the **Create Arcs**  tool.
10. Click on the two points representing the top of the sand embankment to connect them with an arc. This will create an arc representing a distributed load as shown below in Figure 2.

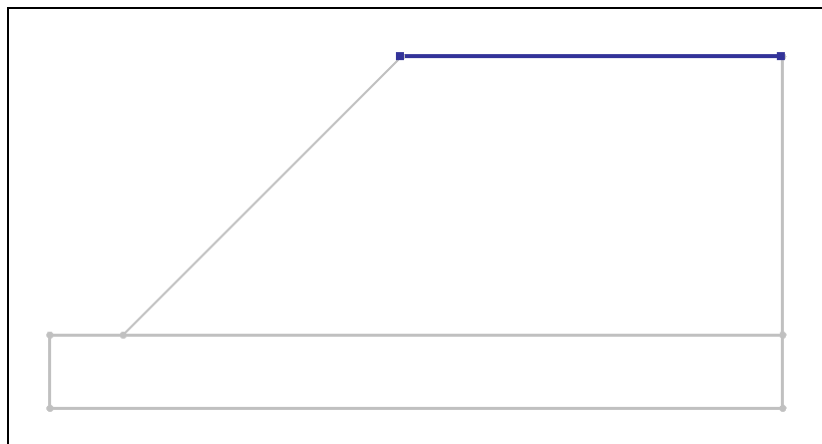



Figure 2 Selecting the distributed load arc

11. Switch to the **Select**  tool.
12. Double-click on the distributed load arc that was just created. This will open the *Attribute Table* dialog.
13. Change *Beg. Load Stage 1* to “240.0.”
14. Change *End Load Stage 1* to “240.0.”
15. Leave the other values alone.
16. Click **OK** to exit the dialog.
17. Turn on the display toggle for the “Profile lines” coverage.

The user should now see the arrow heads indicating there is a distributed load.

9 Create Reinforcement Lines

Now the user needs to create the arcs for the reinforcement. The following diagram from the UTEXAS tutorials shows the location of the reinforcement:

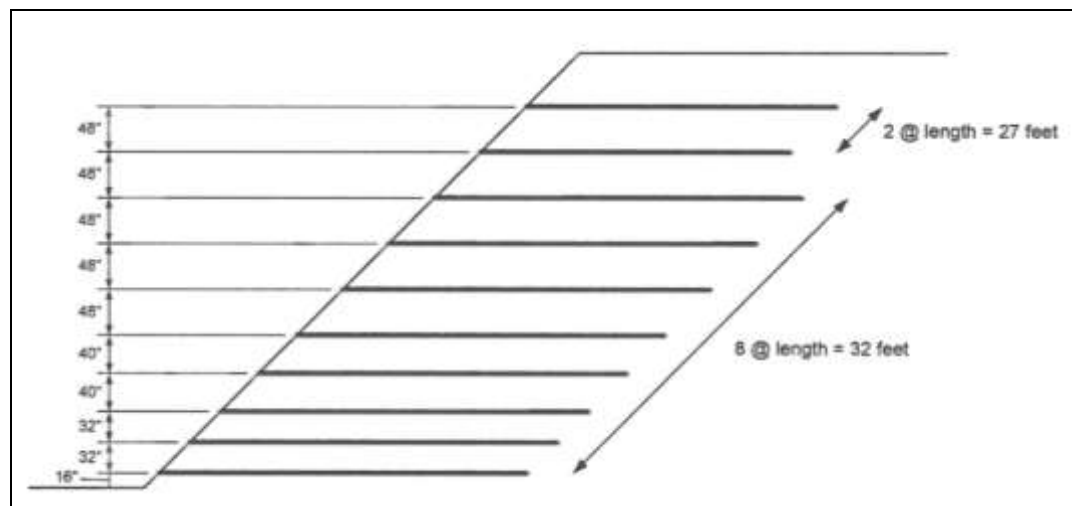


Figure 3 Reinforcement layout diagram³

3. Wright, S.G. (2003). UTEXPREP4 Preprocessor for UTEXAS4 Slope Stability Software. (Shinoak Software, Austin, Texas.)

9.1 Enter the Points

The XY coordinates of the reinforcement lines have been computed and are provided below. The user simply needs to enter them in to GMS.

1. Click on the “Reinforcement lines” coverage to make it active.
2. Right-click on the “Reinforcement lines” coverage.
3. Select the **Attribute Table** command from the pop-up menu.
4. In the dialog, make sure the *Feature type* is set to “Points.”
5. Make sure the *Show coordinates* option is turned on.
6. Enter the X and Y coordinates shown in the table below. If the user is viewing this tutorial electronically, the user can copy and paste these values into the GMS spreadsheet.


X	Y
1.33	1.33
5.33	1.33
31.33	1.33
33.33	1.33
6.67	6.67
10.67	6.67
36.67	6.67
38.67	6.67
13.33	13.33
17.33	13.33
43.33	13.33
45.33	13.33
17.33	17.33
21.33	17.33
47.33	17.33
49.33	17.33
21.33	21.33
25.33	21.33
51.33	21.33
53.33	21.33
25.33	25.33
29.33	25.33
55.33	25.33
57.33	25.33
29.33	29.33
33.33	29.33
54.33	29.33
56.33	29.33
33.33	33.33

37.33	33.33
58.33	33.33
60.33	33.33
4	4
8	4
34	4
36	4
10	10
14	10
40	10
42	10

7. Click **OK** to exit the dialog.

9.2 Connect the Points to Create Arcs

Now the user will connect the points to create arcs.

1. Select the **Create Arcs**  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 to stop creating an arc.
3. Using Figure 4 (below) as a guide, click on the points to connect them with arcs to create the slope.

At this point, the user should see something like Figure 4 below.

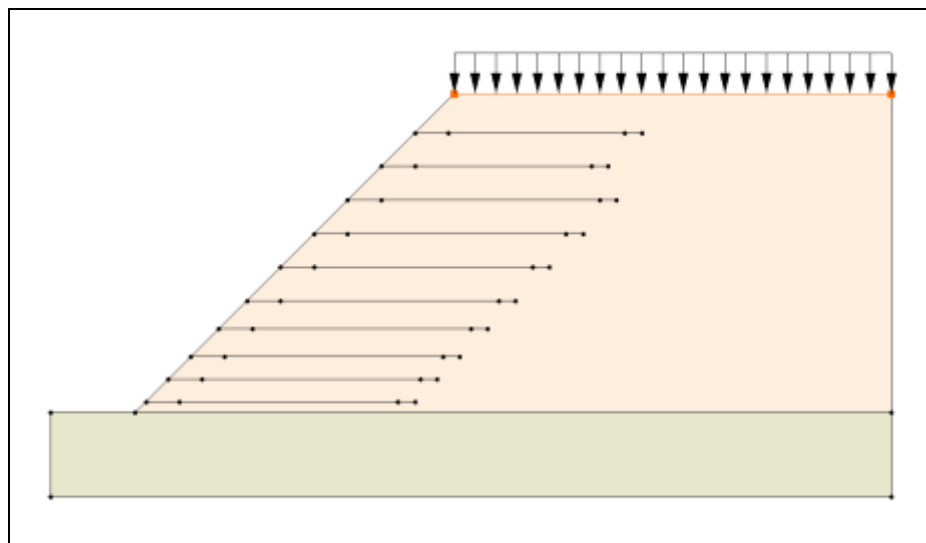



Figure 4 After adding reinforcement lines

9.3 Assign the Forces at the Nodes

At each point along the reinforcement line, UTEXAS requires the user to specify a longitudinal force and a transverse force. The user will assign those now.

Nodes along the Slope

1. Switch to the *Select Points/Nodes*  tool.
2. Hold down the shift key and select all the reinforcement nodes on the left ends of the reinforcement arcs – the nodes that intersect the slope – as shown in Figure 5 below.

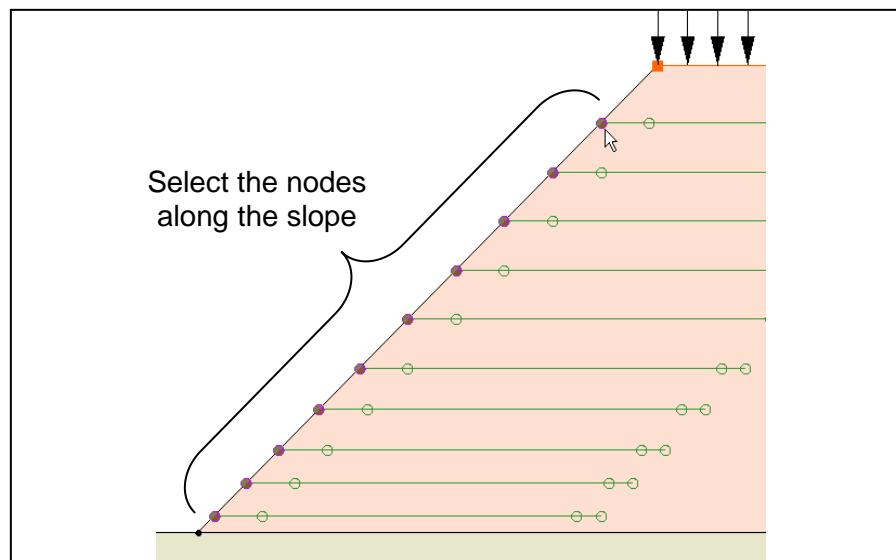



Figure 5 Selecting the reinforcement nodes along the slope

3. Select the **Properties**  button to open the *Attribute Table* dialog.
4. In the *All* row at the top of the spreadsheet, change the *Long. Force* to “500” and hit the tab key. This should change the *Long. Force* to 500 in all the rows.
5. Leave the *Trans. Force* at “0.0.”
6. Click **OK** to exit the dialog.
7. Click anywhere not on the model to unselect the nodes.

Nodes Just to the Right of the Slope


1. Repeat the above procedure to assign a *Long. Force* of “1000” to all the nodes just inside the slope—all the nodes just to the right of the ones the user just selected.

2. Again repeat the above procedure to assign a *Long. Force* of “1000” to the nodes to the right of the ones that the user just assigned—not the nodes on the right ends of the arcs but the nodes just to the left of those.

The nodes on the right ends of the reinforcement arcs are supposed to have both forces at 0.0. That is the default, so those nodes don't need to be changed.

10 Analysis Options

The only thing left to do before saving and running the model is to set the UTEXAS analysis options. The user will select an automated search for the critical factor of safety via circular surfaces using Spencer's Method.

1. In the Project Explorer, right-click on the “UTEXAS”  model.
2. Select the **Analysis Options** command from the pop-up menu.
3. Set *Circle Center X* to “-10.0.”
4. Set *Circle Center Y* to “80.0.”
5. Set the *Radius Definition Method* to “Point on Circle.”
6. Set the *Min Search Grid Spacing* to “0.25.”
7. Set the *Limiting Depth for Circles* to “0.0.”
8. The settings should match those shown in the following figure.

UTEXAS Options

Headings:
 Reinforced Slope
 GMS UTEXAS Tutorial

Analysis options:

Item	Value	Units
Shear Surface		
Type of Surface Analysis	Automatic Search Circular Floating Grid	
Circle Center X	-10.0	ft
Circle Center Y	80.0	ft
Init Dist for Noncircular Shift Points	0.0	ft
Final Dist for Noncircular Shift Points	0.0	ft
Max Steepness of Shear Surface Near Toe	50.0	deg..
Noncircular Arc Vertices	Warn	
Fixed Grid Method	Grid	
Straight Line Endpoint 1 X	0.0	
Straight Line Endpoint 1 Y	0.0	
Straight Line Endpoint 2 X	1.0	
Straight Line Endpoint 2 Y	0.0	
Straight Line Num Points	10	
Number of Points Along Grid Sides 1 & 3	10	
Number of Points Along Grid Sides 2 & 4	10	
Grid Corner 1 X	0.0	
Grid Corner 1 Y	0.0	
Grid Corner 2 X	10.0	
Grid Corner 2 Y	0.0	
Grid Corner 3 X	10.0	
Grid Corner 3 Y	10.0	
Grid Corner 4 X	0.0	
Grid Corner 4 Y	10.0	
Num Increments Radius Range Divided Into Initially	10	
Min Radius Increment	0.1	ft
Radius Definition Method	Point on Circle	
Radius	0.0	ft
Radius Point X	0.0	ft
Radius Point Y	0.0	ft
Tangent Horizontal Line Y	0.0	ft
Tangent Arc Coverage		
Min Search Grid Spacing	0.25	ft
Limiting Depth for Circles	0.0	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	
Seismic Coefficient	0.0	
Seismic Force Location	Center of gravity	
Output Format	Long	
Opposite Sign Convention	Off	
Stability Analysis Procedure	Spencer's	
Side Force Inclination	0.0	deg..
Number of Stages	1	

Help... OK Cancel

Figure 6. UTEXAS Options.

9. When finished, click **OK**.

At this point, the user should see the starting circle displayed.

11 Save the GMS file

Before continuing, save the GMS project file.


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

12 Run UTEXAS

Now it is possible to export and run the model in UTEXAS.



12.1 Export the Model

Do the following to export the model:

1. In the Project Explorer, right-click on the “UTEXAS”  model.
2. Select the **Export** command from the pop-up menu.
3. If necessary, locate and open the directory entitled *Tutorials\UTEXAS\reinforcement*.
4. Change the *File name* to “reinforced slope.”
5. Click **Save**.

12.2 Run UTEXAS


Now that the user has saved the UTEXAS input file, it's possible to run UTEXAS.

1. In the Project Explorer, right-click on the “UTEXAS”  model.
2. Select the **Launch UTEXAS4** command from the pop-up menu. This should bring up the UTEXAS4 program.
3. In UTEXAS4, select the **Open File**  button.
4. Change the *Files of type* to “All Files (*.*)”
5. Locate the “reinforced slope.utx” file that was just saved (in the *Tutorials\UTEXAS\reinforcement* folder).
6. Click **Open**.

7. Press **Save** in the *Open file for graphics output* dialog box. This will save a TexGraf4 output file.
8. Look at the things mentioned in the *Errors, Warnings* window, then close the window.
9. Close the UTEXAS window as well.

12.3 Read the Solution

Now the user needs to read in the UTEXAS solution.

1. In the Project Explorer, right-click on the “UTEXAS”  model.
2. Select the **Read Solution** command from the pop-up menu.
3. Locate the file named “reinforced slope.OUT.”
4. Click **Open**.

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

13 Conclusion

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

- It is possible to use GMS to build reinforced slopes for analysis by UTEXAS.
- Reinforcement lines can be placed alone in a separate coverage or included in an existing coverage.
- In GMS, the forces applied along the length of the reinforcement lines are specified at the nodes.