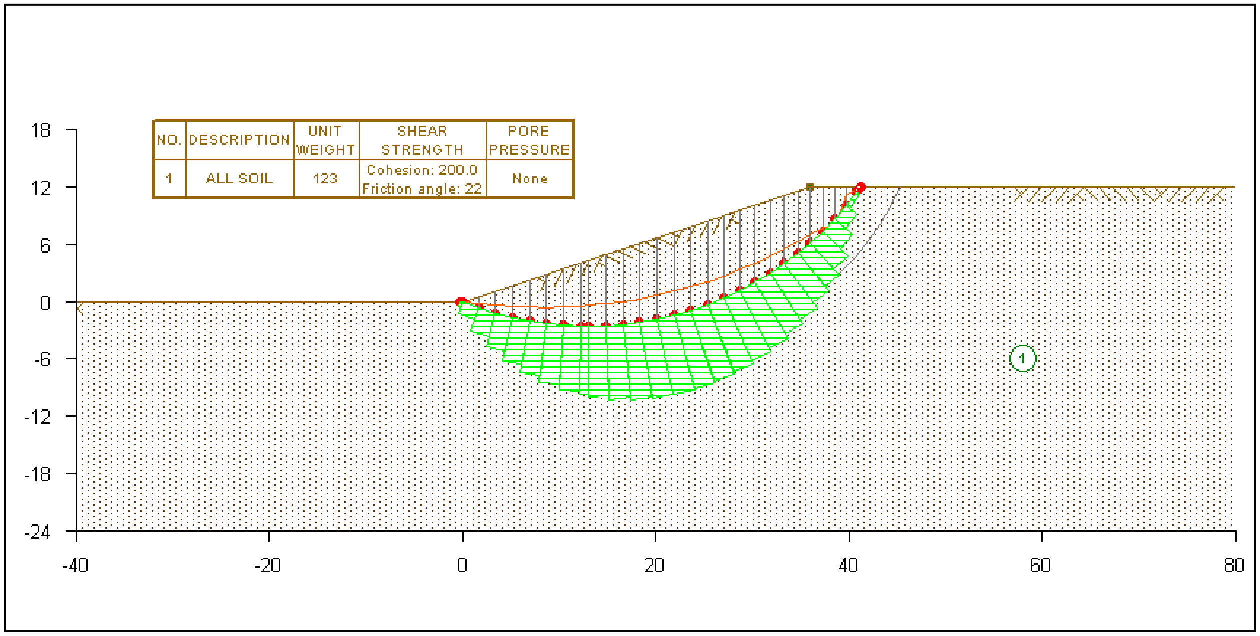
v. 9.2

GMS 9.2 Tutorial

UTEXAS – Embankment On Soft Clay

Introduction to the UTEXAS interface in GMS for a simple embankment analysis



Objectives

Learn how to build a simple UTEXAS model in GMS.

Prerequisite Tutorials

- None

Required Components

- GIS
- Map
- UTEXAS

Time

- 30-60 minutes

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2 Introduction

UTEXAS4 is a slope stability software package created by Dr. Stephen G. Wright of the University of Texas at Austin. UTEXAS4 is used to analyze slope stability using the limit equilibrium method. The user provides the geometry and shear strength parameters for the slope in question and UTEXAS4 computes a factor of safety against slope failure. The factor of safety for a candidate failure surface is computed as the forces driving failure along the surface divided by the shear resistance of the soils along the surface. UTEXAS4 is a state-of-the-art slope stability code and has been widely used in industry for many years.

This tutorial illustrates how to build a simple UTEXAS model in GMS. This tutorial is similar to the Utexam1.dat sample file distributed with UTEXAS and tutorial number one 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. A simple embankment is being modeled to determine the factor of safety and critical failure surface.

This tutorial uses the GIS feature objects in the GMS Map module to build the geometric input to UTEXAS. You may wish to complete the *Feature Objects* tutorial prior to beginning this tutorial.

2.1 Outline

In this tutorial, we will examine different approaches for creating the input geometry required by UTEXAS4. This is what you will do:

1. Import an existing UTEXAS4 model into GMS.
2. Create a UTEXAS4 model in GMS by digitizing.
3. Create a UTEXAS4 model in GMS by typing point coordinates.
4. Assign attributes to the model and adjust the analysis options.
5. Save the model, run UTEXAS4 to get a solution, and view the solution in GMS.

3 Profile Lines vs. Arcs and Polygons

The input to UTEXAS4 is in the form of a two-dimensional description of the soils and pore water at the site in question (i.e., a vertical "slice" or cross-section). It is assumed that the geometry is relatively constant in the direction perpendicular to the cross-section. UTEXAS4 uses profile lines to define the soil stratigraphy. A profile line is a polyline representing the top of a soil unit. Each profile line is associated with a soil id (a material id). Profile lines are defined from left-to-right, and cannot overlap.

In GMS, we don't create profile lines – rather, we create arcs and polygonal zones from which the profile lines are later extracted automatically. For most users, it's probably more intuitive to think in terms of soil zones than it is to think in terms of profile lines. GMS, therefore, simplifies the process of creating UTEXAS models.

For example, consider the figure below which is derived from an actual UTEXAS example and represents a dam cross section showing different zones for the shell, core, filter, riprap etc.

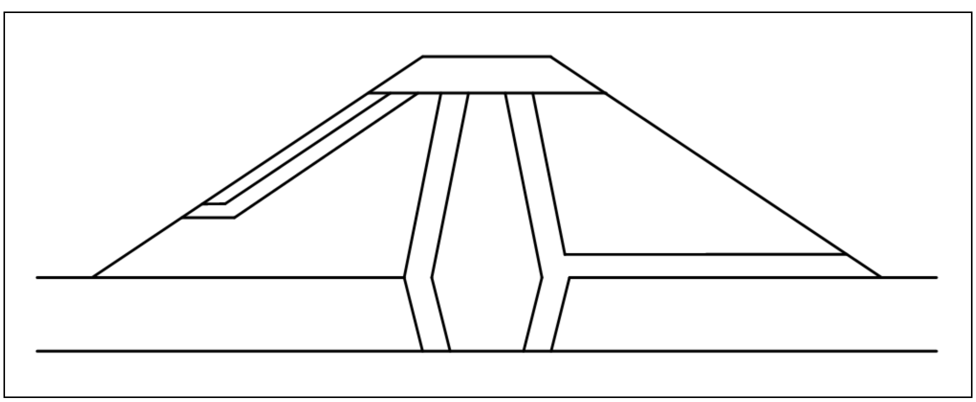


Figure 1. A cross section diagram of a dam.

The profile lines corresponding to this model are shown in Figure 2 below.

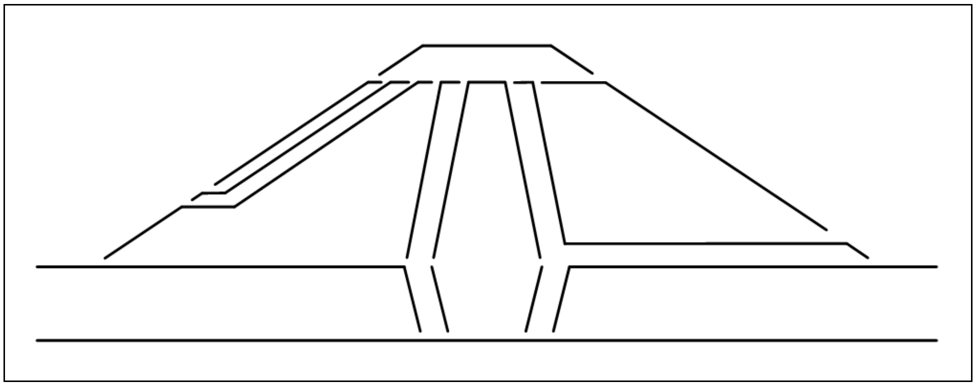


Figure 2. The profile lines needed to define the cross section.

The profile lines in Figure 2 are shown with the lines separated at the endpoints to help illustrate where the profile lines begin and end (the actual profile lines will touch but not overlap). As you can see from this example, trying to figure out how to define the profile lines on a complex model can be challenging. In GMS, we define the model as shown in Figure 1 and GMS automatically determines how to define the profile lines.

4 Program Mode

The GMS interface can be modified by selecting a Program Mode. When you first install and run GMS it is in the standard or "GMS" mode with provides access to the complete GMS interface, including all of the MODFLOW tools. There is another mode called "GMS 2D" that provides a greatly simplified interface to the SEEP2D and UTEXAS codes. This mode hides all of the tools and menu commands not related to SEEP2D and UTEXAS. This tutorial assumes that we are operating in the GMS 2D mode. Once the mode is changed, you can exit and restart GMS repeatedly and the interface stays in the same mode until you change it back. Thus, you only need to change the mode once if you intend to repeatedly solve SEEP2D/UTEXAS problems. 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.

5 Import an Existing UTEXAS Model

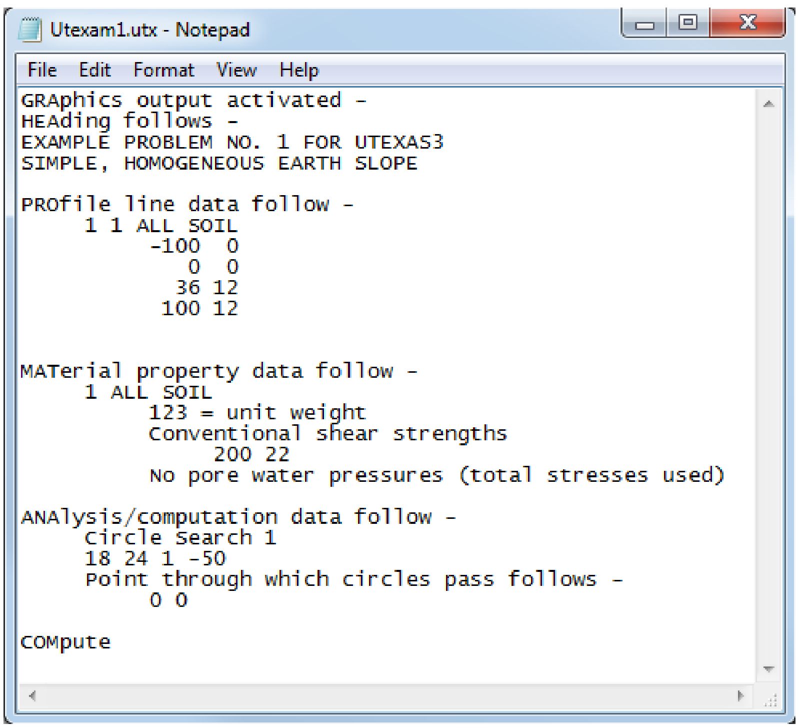
We'll first start by importing an existing model into GMS. This model is one of the standard UTEXAS4 example problems. Later in the tutorial we will create this same model from scratch.

5.1 View the File

First let's look at the file we're going to import. It is a plain text file.

1. Launch a text editor such as Notepad.
2. Locate and open the directory entitled **Tutorials\UTEXAS\embankment**.
3. Open the file named **Utexam1.utx**.

You should now see the file as shown in Figure 3 below:




```
GRAphics output activated -
HEAding follows -
EXAMPLE PROBLEM NO. 1 FOR UTEXAS3
SIMPLE, HOMOGENEOUS EARTH SLOPE

PROfile line data follow -
     1 1 ALL SOIL
          -100  0
             0  0
            36 12
           100 12


MATerial property data follow -
     1 ALL SOIL
          123 = unit weight
          Conventional shear strengths
               200 22
          No pore water pressures (total stresses used)

ANAlysis/computation data follow -
     Circle Search 1
     18 24 1 -50
     Point through which circles pass follows -
          0 0

COMpute
```

Figure 3. Utexam1.utx file.

This file defines a simple embankment model. The file serves to both define the geometry and provide instructions to UTEXAS4 on how to analyze the problem.

4. Notice the four main sections of this file: 1) headings 2) profile lines 3) material properties and 4) analysis options.
5. Further notice that there is just one profile line which defines the embankment. The line does not form a closed polygonal area – it is simply a polyline.

Later in the tutorial we will create a model from scratch in GMS and export it. The exported file will look similar to the one in Figure 3.

5.2 Open the File

Now let's import this file in to GMS. GMS will read and interpret the file and display the embankment.

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. Later in this tutorial we will use the coverage options to set up a conceptual model. But in this case we are simply importing an existing file so we can ignore most of the options for now.

2. Select *Open an existing project* and click on the *OK* button

3. At the bottom of the *Open* dialog, change the *Files of type* to **All Files (*.*)**.

4. Open the file named **Utexam1.utx**.

You should now see the embankment model as shown in Figure 4 below.

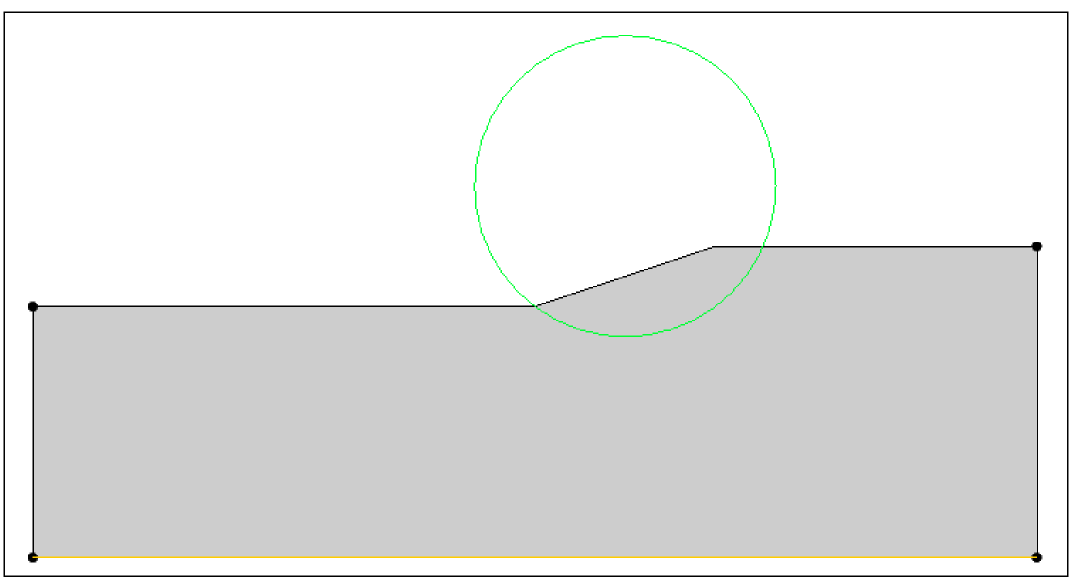


Figure 4. Embankment in Utexam1.utx file.

Notice that the filled area represents the soil mass with the slope that we are analyzing. The circle is the starting circle which is used as an initial guess when finding the critical failure surface.

Notice what GMS put in the *Project Explorer*, as shown in Figure 5 below. GMS created a conceptual model called **Utexam1.utx**, a **UTEXAS** model, and a coverage named **Profile lines**. These items define the UTEXAS simulation and will be described in more detail below.

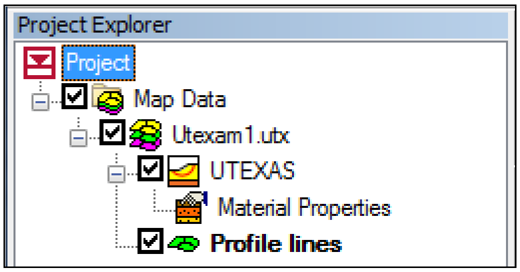


Figure 5. Project Explorer showing the UTEXAS model.

As you can see, if you have existing UTEXAS input files, you can import them into GMS to view and edit.

6 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. Enter a name for the project file (ex. "**embank-utexas.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.

7 Create the Embankment Graphically

Now we'll create the same model from scratch using the GMS interface.

7.1 Create the Conceptual Model

The first step is to create a conceptual model. A conceptual model consists of one or more layers called "coverages" containing GIS feature objects (points, lines, and polygons) defining the model geometry. This process can be done automatically in GMS 2D mode.

1. Select the *New* button to delete the current project and start from scratch. If you are asked if you want to save your changes, select *No*.

2. Change the *Conceptual model name* to **Embankment**.

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

At this point we would normally select a set of coverages corresponding to the features/processes we wish to include in our model. However, our model is so simple we only need two coverages.

4. Select the following coverage options:

   Profile lines
   Starting circle

5. Click the *OK* button.

You should see a new conceptual model object appear in the Project Explorer with a UTEXAS icon.

7.2 Turn on Snapping

Before we draw the embankment, we'll turn on the *snap* option so the points we click snap to the nearest integer coordinate.

1. Select the *Display Options* button.

2. Select the *Drawing Grid* options in the upper left.

3. Change the *Spacing* to **2.0** (all of our coordinates are a multiple of 2) and turn on the *Snap* option.

4. Click *OK* to exit the dialog.

7.3 Set the Window Bounds

The embankment coordinates are as shown in the figure below.

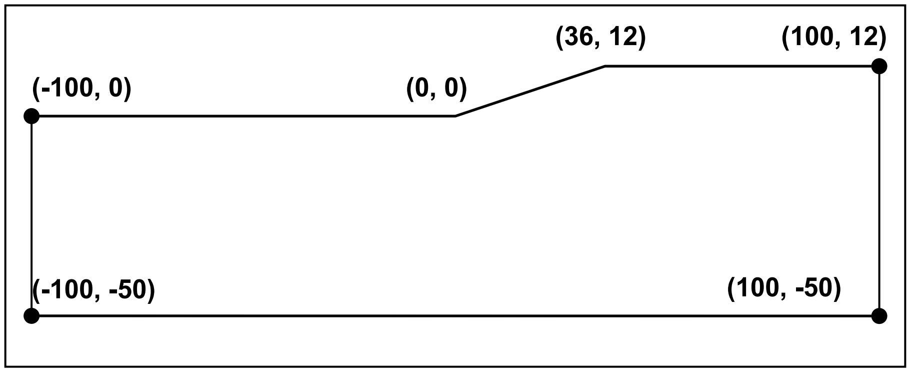


Figure 6. Embankment coordinates.

Before we can draw the embankment, we need to set our view so that it includes this space.

1. Select the *Display* | *View* | *Window Bounds* menu command.
2. Select the first option, *X range to be specified (preserves aspect ratio)*.
3. Set the coordinates as shown in the figure below, and click *OK*.

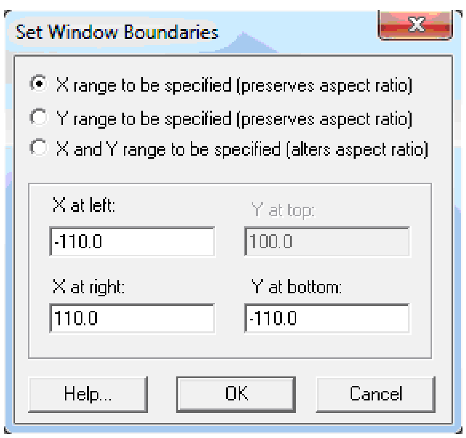


Figure 7. Setting the Window Boundaries.

7.4 Create Arcs and Polygons

Now we'll click out the arcs and build a polygon.

1. Click on the *Profile lines* coverage to make it active.
2. Select the *Create Arcs* tool.
3. Use the tracking coordinates in the bottom of the *Graphics Window* to position your mouse in the right place for each click (see the figure below).

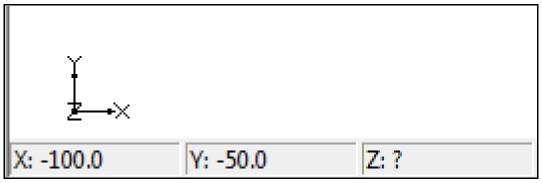


Figure 8. Tracking coordinates.

4. Click out the two arcs shown in the figure below. Double-click to end each arc. If you accidentally click somewhere and you are still in the process of drawing the arc, you can hit the backspace key which will delete the point last clicked. If you finish the arc and there are points in the wrong place, you can use the *Select Node* tool or the *Select Vertex* tool to move the points to the correct place.

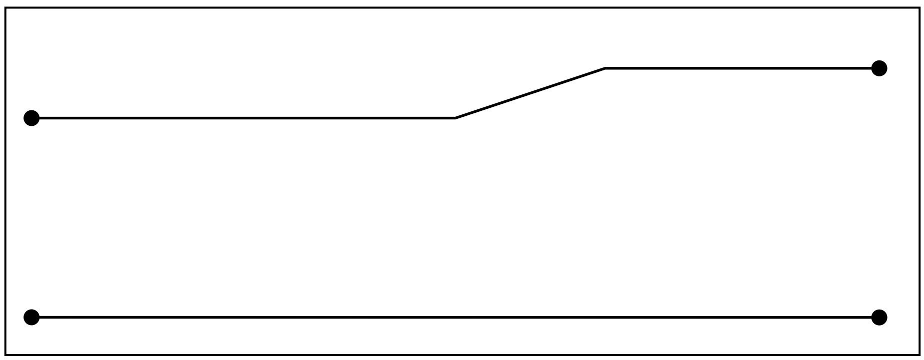


Figure 9. Drawing the top and bottom arcs.

5. Using the *Create Arcs* tool, draw the vertical side arcs as shown in the figure below.

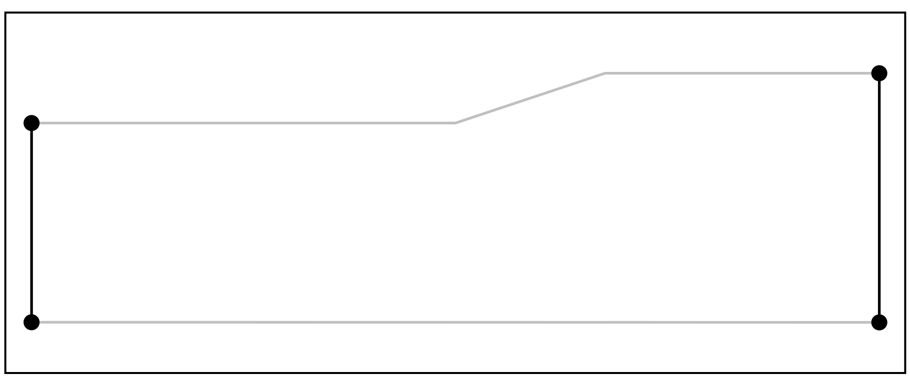


Figure 10. Drawing the side arcs.

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

8 Create the Embankment by Entering Text Coordinates

Another way to define the model is to enter the coordinates directly. If you already know the coordinates of the profile lines, it may be easier to just type in those coordinates instead of clicking out the profile lines with the mouse. Or, if you already have the coordinates entered in a file, you can copy and paste them in to GMS. We'll do that now.

First we'll delete the arcs we just created.

1. Switch to the *Select Arcs* tool.
2. Select the *Edit* | *Select All* menu command to select all the arcs or drag a box around the arcs.
3. Hit the *Delete* key to delete all the arcs.
4. In the *Project Explorer*, right-click on the **Profile lines** coverage and select the *Attribute Table* command from the pop-up menu.
5. Change the *Feature type* to **Points**.
6. Make sure the *Show point coordinates* option is turned on.
7. Enter the X and Y coordinates show in the table below. If you are viewing this tutorial electronically, you can copy and paste these values into the GMS spreadsheet. Don't worry about the z values. They can be left at zero since they are ignored by UTEXAS.

X	Y
-100	0
0	0
36	12
100	12
-100	-50
100	-50

8. Verify that the dialog looks like the figure below and click *OK*.

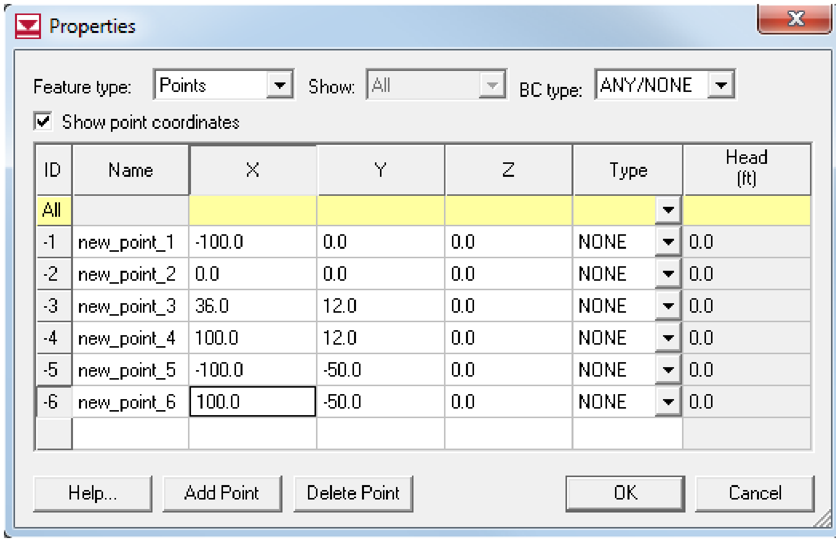


Figure 11. Typing in the point coordinates.

You should now see the points on the screen.

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 whenever you want to stop creating arcs.
11. Click on the points to connect them with arcs to create the same embankment we had before.
12. Select the *Build Polygons* icon in the map toolbar.

At this point you've seen there is more than one way to create a UTEXAS model in GMS. In the *UTEXAS – Dam Profile Analysis* tutorial, you will learn yet another way, which is to import a CAD file.

9 Material Properties

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

1. In the Project Explorer, double click on *Material Properties* under *UTEXAS*.
2. Change the material properties to the following:

Unit Weight Stage 1	Shear Strength Method Stage 1	Cohesion Stage 1	Angle of Internal Friction Phi Stage 1
123	Conventional	200	22

3. Leave all the other settings at the defaults.
4. Click *OK* to exit the dialog.

10 Create the Starting Circle

For most slope stability problems, our objective is to find the failure surface with the minimum factor of safety. We will be using a circular failure surface and we will let UTEXAS perform an automatic search for the critical failure surface. To begin this process we must supply the size and position of the initial circle ("starting circle"). This can be accomplished either by entering some numerical parameters defining the circle location in the Analysis Options dialog (see the following section) or by graphically entering a circle. We will use the graphical option in this case.

When we set up the conceptual model, we created a Starting circle coverage as a placeholder for our starting circle. We define the location of the starting circle by creating a single arc segment corresponding to the radius of the circle. The first point on the arc corresponds to the circle center and the ending point corresponds to a point on the perimeter of the circle. To create the circle:

1. Click on the *Starting circle* coverage to make it active.
2. Select the *Create Arc* tool .
3. Create the arc by clicking on a starting point somewhere above the slope and double-clicking on a point near the toe of the slope as shown in Figure 12.

Once the circle is created, it can be edited by dragging the nodes at the ends of the arc.

4. Select the *Select Point/Node* tool .
5. Click on node at the center of the circle (the first end point) and drag it to a new location. Note how the circle changes.

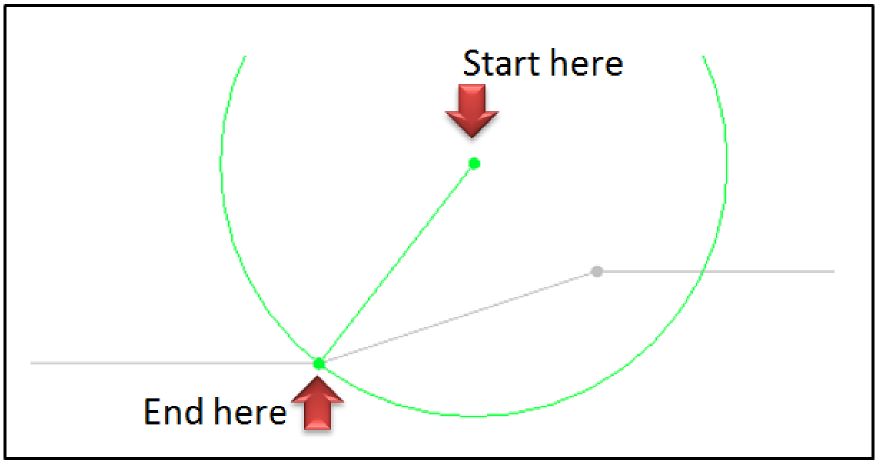


Figure 12. Creating the ctarting circle.

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 assume a circular failure surface and will let UTEXAS search for the critical circle. We will provide the initial or starting circle by defining the circle center and a point through which the circle passes.

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:

   Embankment Model
   GMS UTEXAS Tutorial

3. Change the options to match those shown in the dialog below. Don't bother changing the coordinates of the circle. Your center point coordinates and the coordinates of the point on the circle at the toe may not correspond exactly to the values shown but that is OK since the starting circle is just a starting location for the automated search.

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

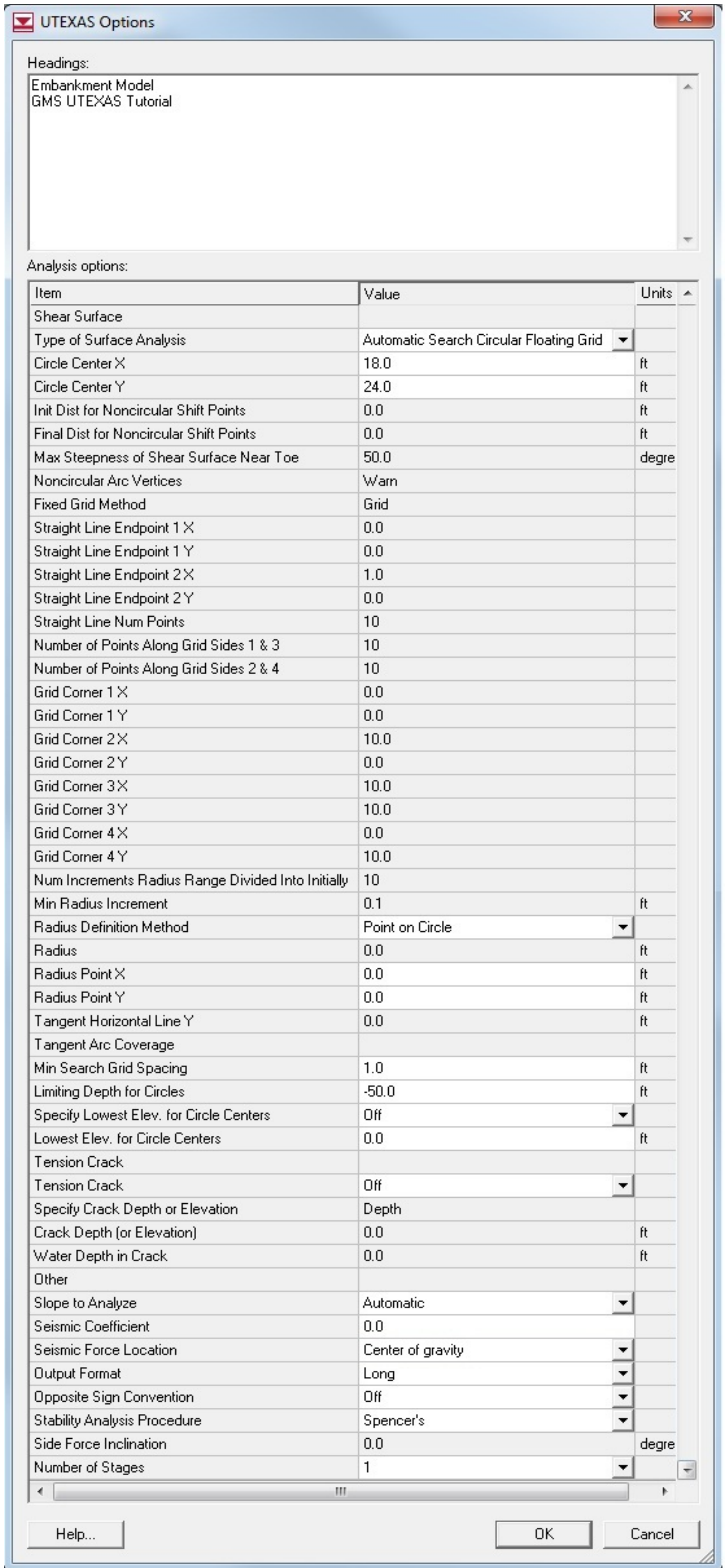


Figure 13. UTEXAS Options.

At this point you should see the starting circle displayed.

Note that while GMS supports many of the analysis options that are available in UTEXAS, some of the options are not supported.

12 Export the Model

We're ready to export the UTEXAS input file prior to running UTEXAS.

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 **Tutorials\UTEXAS\embankment** (you should already be there).

3. Change the *File name* to **embank-utexas** and click *Save*.

You have now created a UTEXAS input file called *embank-utexas.utx*. You may want to open this file in a text editor and examine its contents. You could also compare it to the *Utexam1.utx* file we imported earlier.

13 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 **embank-utexas.utx** file you just saved (in the **Tutorials\UTEXAS\embankment**) folder and open it.

5. Press Save on *Open file for graphic output* dialog box.

6. When UTEXAS4 finishes, look at the things mentioned in the *Errors, Warnings* window, then close the window.

14 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 **embank-utexas.OUT**.

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

15 Display Options

Let's take a look at the UTEXAS display options in GMS.

1. Select the *Display Options* button.

2. Make sure the *Map Data* item is selected in the list in the upper left of the dialog.

3. Select the *UTEXAS* tab. The dialog should appear as shown in the figure below.

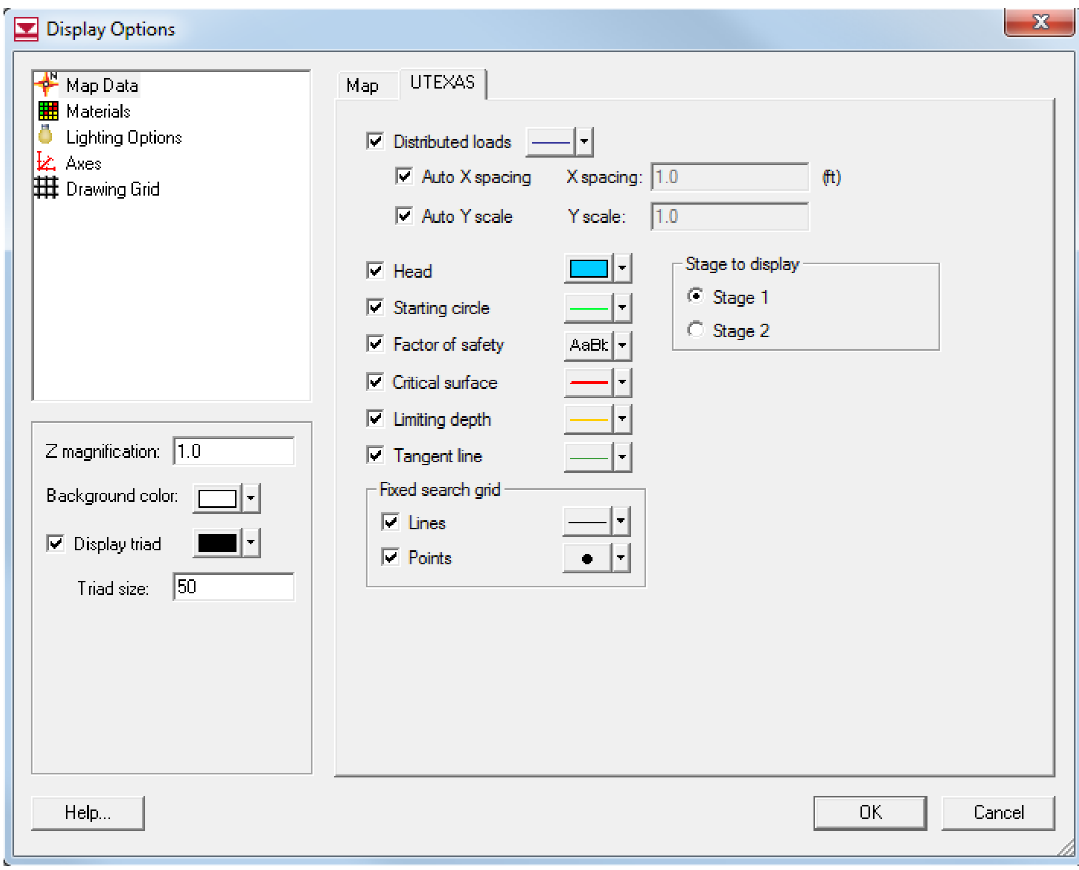


Figure 14. UTEXAS Display Options.

4. Try changing the display options and see how it affects the display.

16 Conclusion

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

- UTEXAS uses the profile line approach to define the model geometry, but GMS uses arcs and polygons. GMS automatically extracts the profile lines from the arcs and polygons when exporting the UTEXAS input file.
- GMS can read UTEXAS input files created outside of GMS.
- You can create a UTEXAS model in GMS by drawing the arcs, or by entering in the coordinates of the profile lines and connecting the points with arcs.