# UTEXASED4

## A COMPUTER PROGRAM FOR SLOPE STABILITY CALCULATIONS

## (Educational version of the UTEXAS4 and TexGraf4 software)



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**Austin, Texas**

# Section 1 - Introduction

UTEXASED4 is the educational version of the UTEXAS4 and TexGraf4 software for slope stability calculations. The software performs limit equilibrium slope stability calculations for a factor of safety. Computations can be performed for homogeneous and inhomogeneous slopes using both circular and noncircular slip (potential sliding) surfaces. The factor of safety, F, is defined with respect to shear strength as,

$$F = \frac{\text{Available shear strength}}{\text{Shear stress for equilibrium}} = \frac{s}{\tau} \tag{1.1}$$

Shear strength may be expressed using either effective stresses or total stresses. For effective stresses the shear strength is expressed as,

$$s = c' + (\sigma - u) \tan\phi' \tag{1.2}$$

where c' and $\phi'$ are the cohesion and friction angle, respectively, expressed in terms of effective stresses. For total stresses the shear strength is expressed as,

$$s = c + \sigma \tan\phi \tag{1.3}$$

where c and $\phi$ are the cohesion and friction angle, respectively, expressed in terms of total stresses.

For circular slip surfaces computations can be performed using either Bishop's (1955) "Simplified" procedure or Spencer's (1967) procedure. For noncircular slip surfaces Spencer’s (1967) procedure is always used. Several different computation options including analyses for a single, specified slip surface and automatic searches to locate a minimum factor of safety are available. These options are described as part of the Analysis/Computation Data in Section 4 of this manual.

## Coordinate System and Units

Coordinates for the slope geometry, slip surfaces, piezometric line, etc. are specified using a right-hand Cartesian coordinate system with the x axis being horizontal and positive to the right and the y axis being vertical and positive in the upward direction. Coordinate values may be both positive and negative and the slope may face to either the left or the right.

Any consistent set of length and force units may be used for a problem. For example if feet are used for length units and pounds are used for force units, the units will be feet, pounds, pounds per foot, pounds per square foot and pounds per cubic foot. The software provides for three specific, “standard” sets of units for which the default value for the unit weight of water and the numbers of decimals places used to output coordinates, strengths, distributed loads, etc. are preset. Use of one of the three “standard” sets of units is recommended. The three standard sets of units are as follows:

1. Feet and pounds.
2. Meters and Newtons (SI units).
3. Meters and Kilonewtons

The type of units is selected using the ***Units*** command in the UTEXASED4 ***Data*** menu. Units are described in further detail in Section 4.

# Section 2 - Description of Problem

Several "Groups" of data are required to describe a problem. The groups of data include the following:

1. ***Profile Lines***, which define the slope profile and subsurface stratigraphy,

2. ***Material properties*** for the soils in the cross-section,

3. A ***piezometric line***, which is used as one of the options for defining pore water pressures,

4. ***Distributed loads*** (stresses, pressures) on the exposed surface of the slope.

5. ***Reinforcement lines*** which are used to describe internal reinforcement such as geogrids, soil nails, tie-back anchors and piles or piers,

6. ***Analysis/Computation*** data that describe the type of slip surface (circular or noncircular) to be used and whether a single slip surface is to be analyzed or an automatic search is to be conducted to find a “critical” slip surface with a minimum factor of safety. The Analysis/Computation data also include several other parameters that affect the computations, including the presence of a “tension crack”.

Each of the groups of input data is described further in this section.

## Profile Lines

Profile Lines define the slope geometry and subsurface stratigraphy (Figure 2.1). The soil beneath a Profile Line is assumed to have a given set of material properties until another Profile Line is encountered at a lower depth. The Profile Lines are defined by the coordinates of two or more points along the line from left-to-right. Straight lines are assumed to connect the points. Profile Lines cannot intersect (cross) other Profile Lines; however, Profile Lines can meet (touch). Profile Lines cannot coincide over any portion of their length; if two Profile Lines were to coincide, the underlying soil would not be uniquely defined.

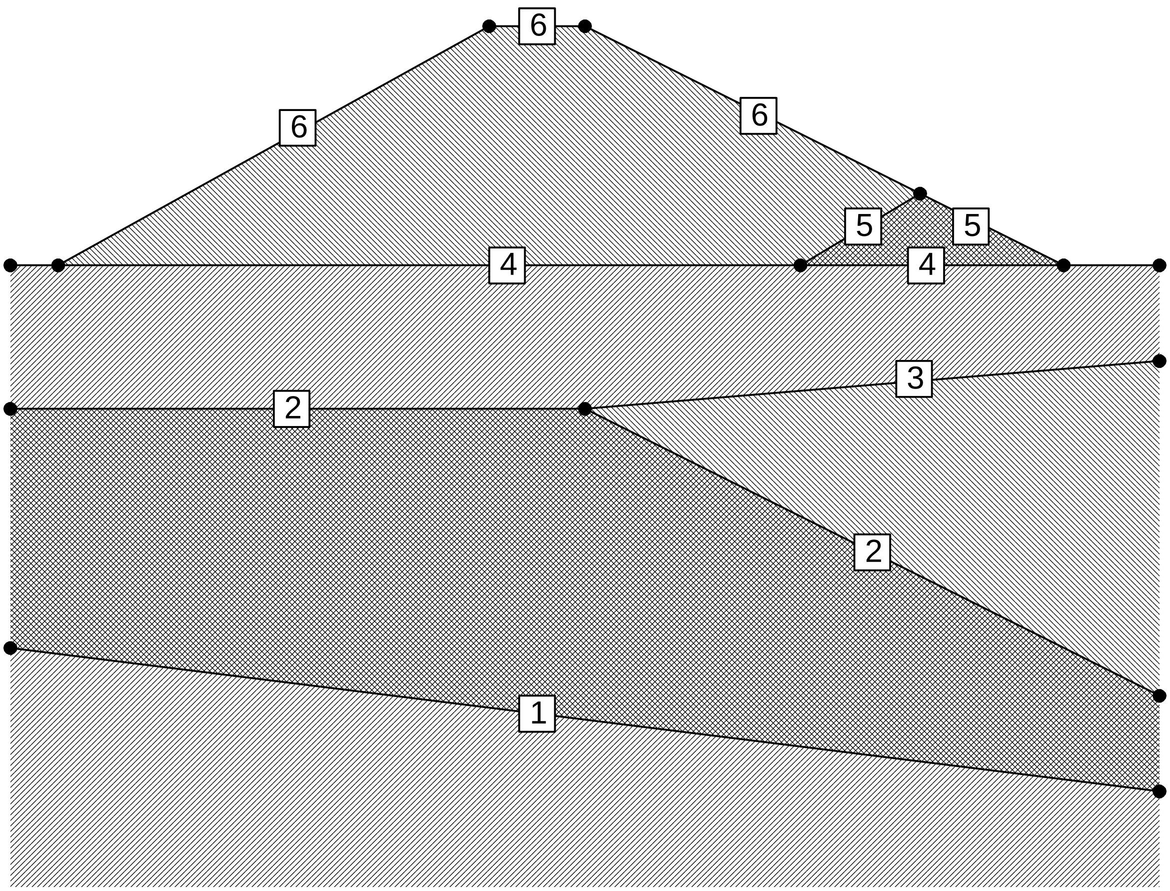
The slope geometry is automatically determined from the input data for the Profile Lines. The slope profile is taken as the uppermost surface formed by one, or possibly several, Profile Lines.

## Material Properties

A set of material properties must be input for each Profile Line. Material properties consist of a unit weight, shear strength properties, and information on how pore water pressures are defined.

### Unit Weight

The unit weight should generally be the total unit weight. Use of submerged unit weights is not recommended: It is always preferable to use total unit weights and specify any pore water pressures and external water pressures, rather than use submerged unit weights.




| | |
|---|---|
| Note: | Solid symbols (●) designate points where coordinates are specified.<br>Profile Line numbers are shown in boxes, e. g. $\boxed{1}$ |

**Figure 2.1 – "Profile Lines" used to define the slope profile and subsurface stratigraphy.**

Shear Strength Properties

Shear strength properties for each material may be defined in any one of the three ways described below. Each material may have the shear strength defined in a different way if appropriate.

Conventional Mohr-Coulomb Cohesion and Friction

The most common way that shear strengths are defined is by a conventional, linear Mohr-Coulomb failure envelope with a cohesion intercept (c, c') and friction angle (ϕ, ϕ') as illustrated in Figure 2.2. The cohesion and friction angle must be entered as input data. The cohesion and friction angle may be the values for either total stresses or effective stresses. Some materials may have the shear strength defined using total stresses, e.g. for a clay where the loading is undrained, while other materials may have their shear strength defined in terms of effective stresses, e. g. for a coarse sand that is freely draining. If the values are defined in terms of effective stresses, it is also necessary to enter appropriate pore water pressure information as described later in the section on pore water pressures.

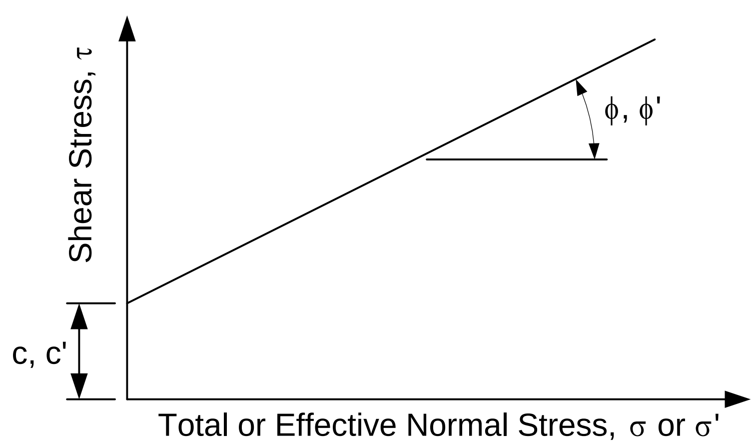



**Figure 2.2 - Conventional Mohr-Coulomb failure envelope.**

No special distinction is made between effective stresses and total stresses in the input data except for the selection of the appropriate numerical values for cohesion (c vs. c') and friction angle (ϕ vs. ϕ'), and the specification of pore water pressure information when effective stresses are being used. Regardless of the values that are entered, the shear strength is always computed from an equation of the form:

$$s = c + (\sigma - u) \tan\phi \tag{2.1}$$

where c and ϕ represent the total stress or effective stress values of cohesion and friction angle, respectively, that are entered as input data, and u is the pore water pressure. For total stresses no (zero) pore water pressure must be specified, and Eq. 2.1 becomes identical to the equation for total stresses.

Linear Increase in Undrained Strength with Depth

The second shear strength option allows you to specify the shear strength at the elevation of an arbitrary horizontal, reference datum and the rate of increase in shear strength below the datum (Figure 2.3). This option is restricted to describing undrained shear strengths of saturated clays, i. e. where $\phi = 0$. Input data consist of (1) the elevation of the "datum", expressed as a y coordinate, $y_o$, (2) the value of shear strength at the elevation of the datum, $s_o$, and (3) the rate of increase in shear strength with depth, $\Delta s/\Delta y$. The shear strength is computed and assigned for each slice as a cohesion value (c) and $\phi$ is assumed to be zero. No (zero) pore water pressures are specified.

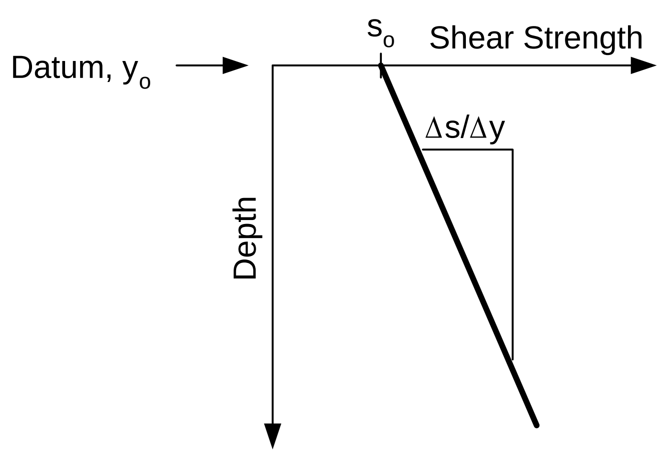



**Figure 2.3 - Representation of linear increase in strength with depth.**

Nonlinear (Curved) Mohr-Coulomb Envelope

The third shear strength option allows a nonlinear ("curved") Mohr failure envelope to be specified (Figure 2.4). The envelope is defined by entering values of the normal stress and shear stress that define a series of points (in the order of increasing normal stress) along the shear strength envelope. The envelope is formed by connecting the specified points by straight lines, i. e. the envelope is piecewise linear. The envelope may be specified using either effective normal stresses or total normal stresses, depending on what is appropriate. When effective stresses are used appropriate pore water pressures must be specified.

For the maximum number of points allowed for defining a nonlinear Mohr failure envelope see the discussion of **Limitations** at the end of this section (Section 2).

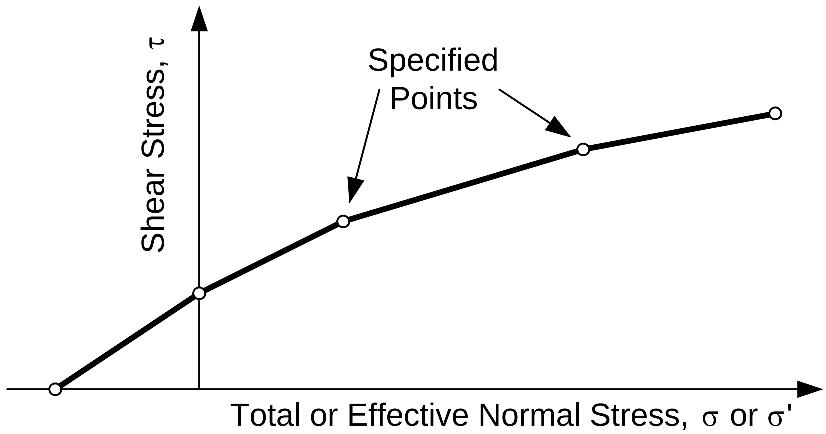



**Figure 2.4 - Nonlinear (curved) Mohr failure envelope.**

Pore Water Pressure Information

When shear strengths are expressed as a function of effective stresses pore water pressure information must also be specified. If the shear strength is specified in terms of total stresses, pore water pressures should be specified as zero. For strengths expressed in terms of effective stresses non-zero pore water pressures may be specified either by a constant pore water pressure coefficient, $r_u$, or by a piezometric line. The pore water pressure coefficient, $r_u$, is the ratio of the pore water pressure (u) to the corresponding total vertical overburden pressure ($\gamma z$) at any point, i. e.

$$r_u = \frac{u}{\gamma z} \tag{2.2}$$

where $\gamma$ is the total unit weight of soil and z is the vertical depth below the surface of the slope to the point where the pore water pressure is defined. When the pore water pressures are defined by a value of $r_u$, the value of $r_u$ is entered with the material property data.

When a piezometric line is used to define pore water pressures the actual data defining the location of the piezometric line are entered separately (See the next section on Piezometric Line).

Piezometric Line

A piezometric line is one way that pore water pressures may be defined when the shear strength is expressed using effective stresses. When a piezometric line is used, pore water pressures are computed by multiplying the vertical distance between the piezometric line and the center of the base of each slice by the unit weight of water. Pore water pressures are positive below the piezometric line and negative above the piezometric line. However, negative pore water pressures are ignored (set to zero) when the slope stability computations are performed.

A piezometric line is defined by specifying the coordinates of a set of points along the piezometric line from left to right. Straight lines are assumed to connect the points that define the piezometric line.

Only a single piezometric line may be used; however the single line may define pore water pressures in more than one material. For the maximum number of points allowed on the piezometric line see the discussion of **Limitations** at the end of this section (Section 2).

### Distributed Loads

Distributed load data are used to represent pressures acting on the surface of the slope. Distributed loads are used to represent the water on or adjacent to the slope as well as loads due to footings or similar structural loads (Figure 2.5). Because a two-dimensional planar cross-section is analyzed, distributed loads represent strip loads that extend to infinity in the direction perpendicular to the plane of the two-dimensional cross-section.

Distributed loads are entered by specifying a series of points along the surface of the slope. At each point the x-y coordinates of the point and the corresponding value of pressure (normal stress) are specified. Pressures are assumed to vary linearly between points and are zero to the left of the first point and to the right of the last point. If the distributed load changes abruptly, i. e. a “step” load exists, the point where the load changes is entered twice - once with the value of the pressure to the left of the point and, the second time, with the value of the pressure to the right of the point (See Figure 2.5).

For the maximum number of points allowed for defining distributed loads see the discussion of **Limitations** at the end of this section (Section 2).

### Reinforcement Lines

Reinforcement lines are used to describe internal soil reinforcement. Each line of reinforcement is defined by a series of points along the length of the reinforcement and the value of longitudinal (axial) and transverse (shear) force at each point. Longitudinal and transverse forces are assumed to vary linearly between the points where they are specified. Reinforcement may be vertical, horizontal or inclined (Figure 2.6).

Longitudinal reinforcement forces that are tensile are considered to be positive; compressive reinforcement forces are negative. The sign convention for shear forces is shown in Figure 2.7. For the maximum number of reinforcement lines and the maximum number of points allowed per line see the discussion of **Limitations** at the end of this section (Section 2).

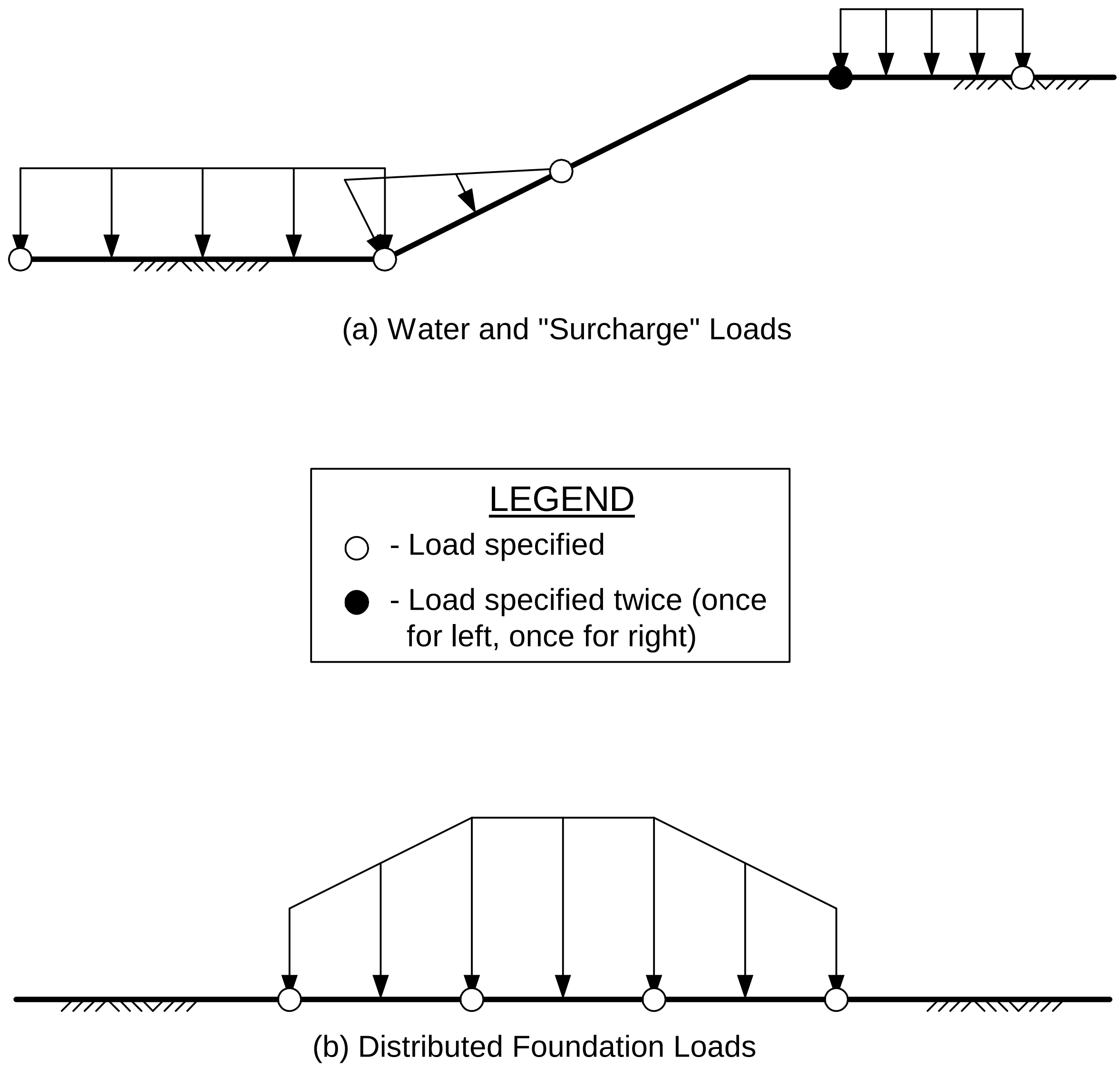
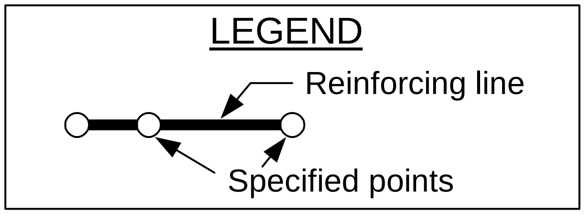
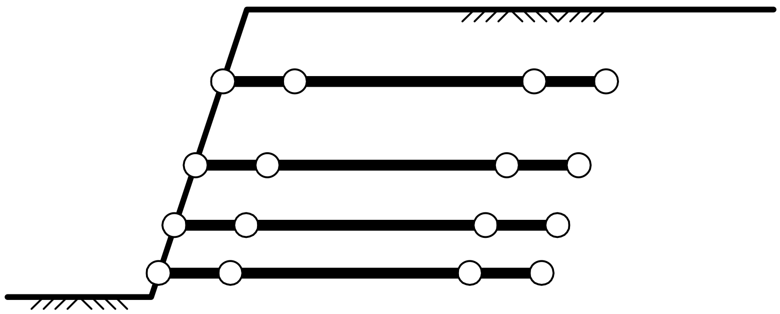


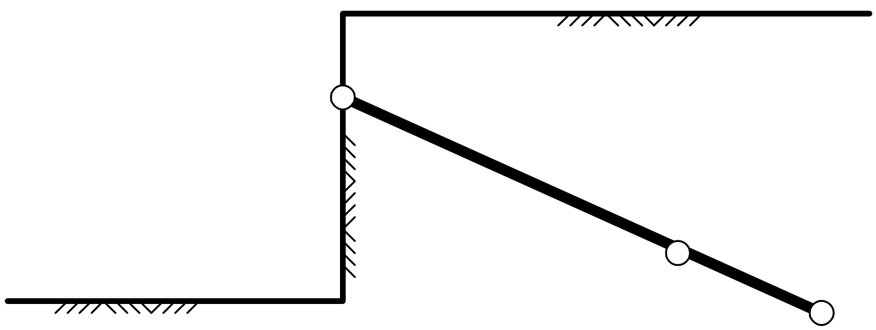

**Figure 2.5 – Example distributed loads on “slope”.**




(a) Slope reinforced with Geosynthetics



(b) Anchored (tie-back) wall



(c) Pile-reinforced slope

**Figure 2.6 – Example reinforcement "lines" in slopes.**

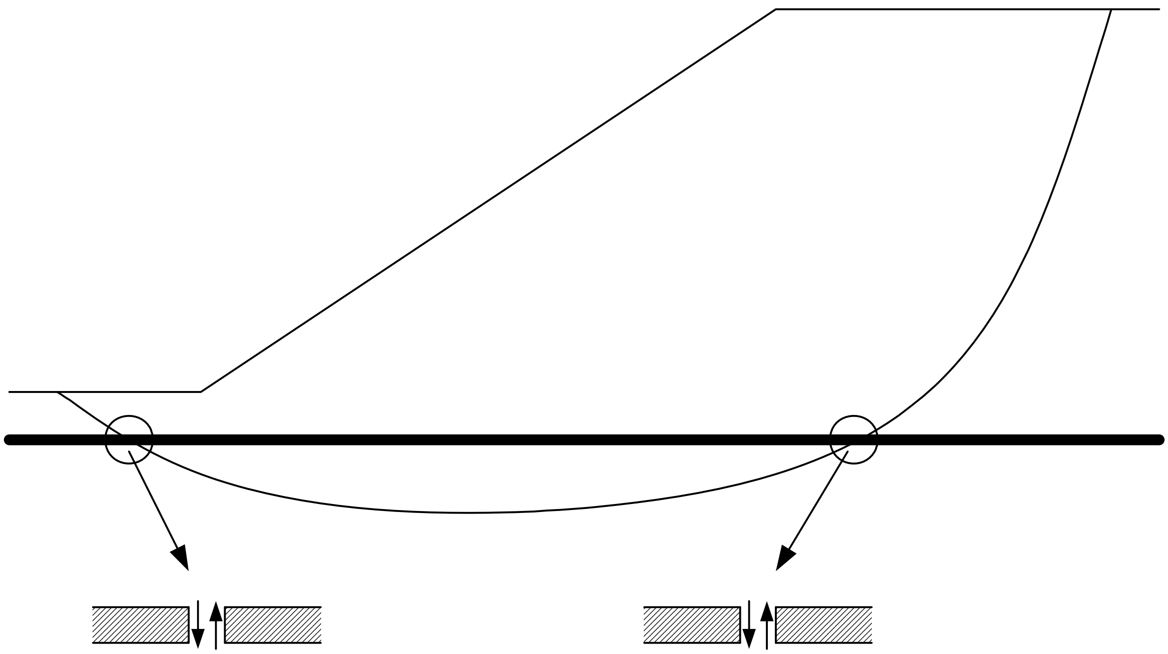


**Figure 2.7 – Sign convention for positive shear forces in reinforcement; negative forces act in opposite directions.**

## Analysis/Computation Data

The Analysis/Computation data are used to define the type of computations that are to be performed. These data include the shape of the slip surface and information pertaining to whether a single slip surface is to be analyzed or an automatic search is to be conducted to locate a "critical" slip surface with the lowest factor of safety. Four different types of computations can be performed as described below.

### Automatic Search with Circular Slip Surfaces

An automatic search can be performed to locate a “critical” circle that produces a minimum factor of safety. For the search the location of the center point and radius of circles are systematically varied until a minimum factor of safety is found. Care must be exercised because the factor of safety found by an automatic search may only represent a “local” minimum. It may be necessary to initiate searches with several different starting conditions (initial trial center point and radius) to be sure that the overall minimum factor of safety is found.

For the automatic search you must enter a starting point for the center of the circle and the initial elevation for the bottom of trial circles. The center point and depth of circles will be varied from the starting point to find the most critical circle. A maximum depth, expressed as limiting elevation, y, is also specified. Circles are not allowed to pass below the limiting depth.

The automatic search is conducted by first finding the most critical circle passing to the starting depth (y elevation) indicated. The centers of circles are varied using a 9-point (3 x 3) grid, which is moved repeatedly. The grid is moved until the circle whose center is at the center of the grid has the lowest factor of safety relative to the circles with centers at the eight points on the perimeter of the grid. Also, as the grid is moved, the size of the grid is varied until the final, smallest spacing between adjacent center points is 2.5 percent (0.025) of the slope height. The initial grid spacing is chosen to be 40 times the final spacing, i. e. the initial grid spacing is equal to the slope height.

### Interactive, “Manual” Search with Circular Slip Surfaces

Instead of having the search performed automatically, you can conduct a search manually by selecting each trial center point by clicking in the main display window with the mouse. For each center point selected the radius of the circle is varied to find the radius producing the lowest factor of safety. Radii are varied automatically between maximum and minimum values that are designated as part of the input data. The increment used to vary the radii between the maximum and minimum values is also designated by input data.

Once at least three center points have been entered interactively and the factor of safety has been successfully computed for each center point, contours of factor of safety are drawn. The contours are based on the lowest factor of safety calculated for each center point. The contours can be used to judge where the next center point should be located and in this way a "search" can be conducted to find a minimum. This search can also be used to find multiple, local minimums if they exist.

#### Individual Noncircular Slip Surface

The third analysis option allows you to perform computations for a single, selected noncircular slip surface. The Analysis/Computation data consist of the coordinates of points along the selected slip surface from left to right. Straight lines are assumed to connect the points to form a continuous, piecewise linear slip surface. The first and last points on the slip surface must be located on the surface of the slope.

#### Automatic Search with Noncircular Slip Surfaces

The fourth and final analysis option allows an automatic search to be conducted to find a noncircular slip surface with a minimum factor of safety. The search is conducted using a procedure similar to the one developed by Celestino and Duncan (1981). The search is started with an initial, assumed trial slip surface, which is defined by the coordinates of a set of points along the slip surface from left to right. Each point on the initial slip surface is then moved some distance in two directions, e.g. up and down, and the factor of safety is computed for each of the two moves. After all points on the initial trial slip surface have been moved, the location of the slip surface is adjusted and the process is repeated. The amount each point is moved is reduced as the search progresses. The direction that each point is moved and the initial and final distances that points are moved are entered as part of the input data for the search.

#### "Tension" Crack

The depth of a vertical "tension" crack and the depth of water in the crack may also be entered as part of the input data for either circular or noncircular slip surfaces. When a tension crack is specified, the slip surface is automatically terminated at a depth corresponding to the bottom of the crack, near the upslope end of the slip surface.

### Limitations on Problem Size

The educational version of the UTEXAS4 software limits the size of the problem that you can run by limiting the number of Profile Lines, piezometric lines and reinforcement lines that can be entered. The maximum number of points that can be entered on any one line as well as the maximum number of points allowed for noncircular slip surfaces is also limited. To determine the current limitations for the version of UTEXASED4 that you are using, start the program and choose the ***Limitations*** command from the ***Data*** menu. A Dialog box like the one shown in Figure 2.8 is then displayed showing the limitations.

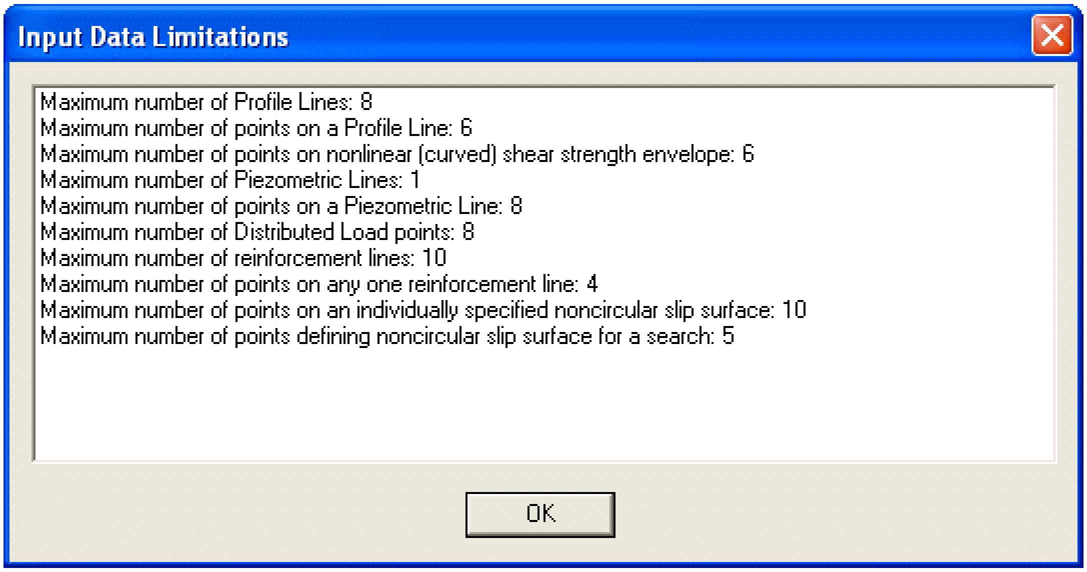



**Figure 2.8 – Dialog box used to display limitations on problem data size for UTEXASED4.**

## Section 3 - Preparing Your Data

Prior to running UTEXASED4 you should prepare the data for your problem for input. Make a scale drawing of the slope and determine the coordinates of points defining each of the Profile Lines that you will be using. Also determine what unit weight and shear strength properties will be assigned to each material. If shear strengths are expressed using effective stresses, determine how the pore water pressures will be defined for each material. If a piezometric line will be used to define pore water pressures, determine the coordinates of the points that will be used to define the piezometric line.

If there are external, distributed loads on the slope, determine the appropriate locations of the points that will be used to define the loads. In general, points will need to be defined where the distributed load starts and ends as well as where the rate of change in distributed load changes significantly.

If a slope has reinforcement, e. g geogrids, piers or tie-back anchors, you need to determine the coordinates of points that define each line of reinforcement and the values of longitudinal (axial) and transverse (shear) force at each point.

You will also need to decide whether to perform computations using circular or noncircular slip surfaces. For an automatic search with circles you will need to select a reasonable center point for starting the search as well as an initial depth (y elevation) for the bottom of the circles. For an interactive, manual “search” with circles the radii will be varied for each trial center point. You will need to determine the minimum and maximum radii to be used. For computations with noncircular slip surfaces determine the coordinates of points along either the single noncircular slip surface to be analyzed or, in the case of a search, the initial trial noncircular slip surface.

## Section 4 - Entering and Checking Input Data

To run UTEXASED4 follow the instructions you should have been given for starting UTEXASED4 on the computer system you are using. Once UTEXASED4 is running you should see the main display window with a menu bar at the top. You are then ready to begin entering your input data.

Data are entered into UTEXASED4 using commands in the ***Data*** menu and dialog boxes. At any time while you are entering data, you can save the data using the ***Save*** command in the ***File*** menu. Entry of each group of data is described in the sections below. In general you should enter data in the order the data are described below, but once data are entered you can always go back and correct or modify your input in any sequence.

When you enter data such as Profile Lines that can be represented graphically the data are displayed in the main display window of UTEXASED4. As each group of data (Profile Lines, piezometric line, slip surface, etc.) is entered, it is displayed in the main window. However, the display is not immediately updated as the data are entered and changed in a dialog box. You must first dismiss the dialog box by clicking on the **OK** button before the display reflects the changes.

### Units

Before entering input data for the problem, you should select the type of units you will be using. Choose the ***Units*** command from the ***Settings*** menu. A dialog box like the one shown in Figure 4.1 then appears. Use the dropdown list labeled **Type of Units** to select one of the following:

- Feet and Pounds
- SI – Meters and Newtons
- Meters and Kilonewtons

Depending on the type of units selected the units that will be assumed for length, force, stress, etc. will be shown in the lower part of the dialog box. The default value for the unit weight of water (or other fluid) is also shown.

The default value for the unit weight of water is assigned to data provided that you have not specifically entered a value for the unit weight of water separately. The unit weight of water is entered by choosing the ***Unit Weight of Water*** command from the ***Data*** menu. Once you enter a value for the unit weight of water, the default value for the unit weight of water is no longer used. The default value is only used when you first start UTEXASED4. Also, once you have entered a value for the unit weight of water, changing the type of units using the ***Units*** item in the ***Data*** menu will not reset the default value for the unit weight of water. However, if you change the units using the ***Units*** command, the change will affect the numbers of decimals that are used to display data.

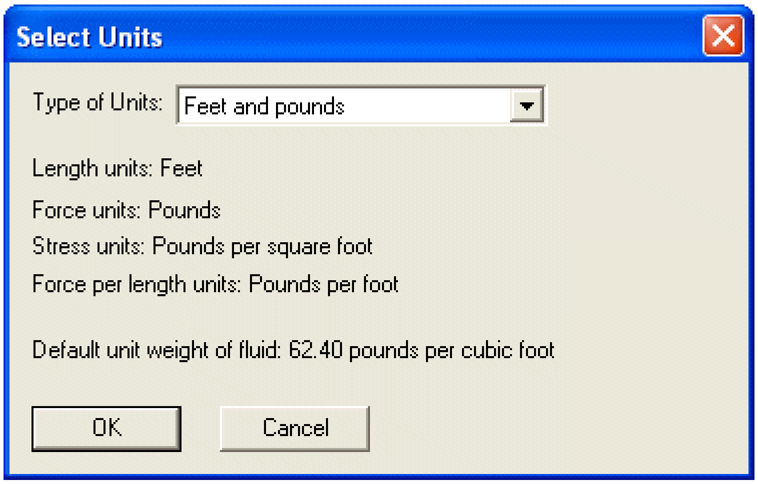



**Figure 4.1 – Dialog box for selecting type of units for problem.**

Profile Lines

To enter data for the Profile Lines choose the ***Profile Lines*** command from the ***Data*** menu. When you do, a dialog box similar to the one shown in Figure 4.2 is displayed for you to enter data. The tabs at the top of the dialog box are used to select individual Profile Lines for data entry. The numbering of lines and order of data entry for lines does not matter. You may enter data in any order and for any line numbers. Only lines for which coordinates of two or more points have been entered are used. To enter data for a particular line, first select the line number by clicking on the appropriate tab at the top of the dialog box. Enter x-y coordinates of points along the line by typing them in the cells provided in the data grid. You can change values at any time by typing new values in the text boxes. Points that you enter will eventually be sorted so that they are in a left-to-right order.

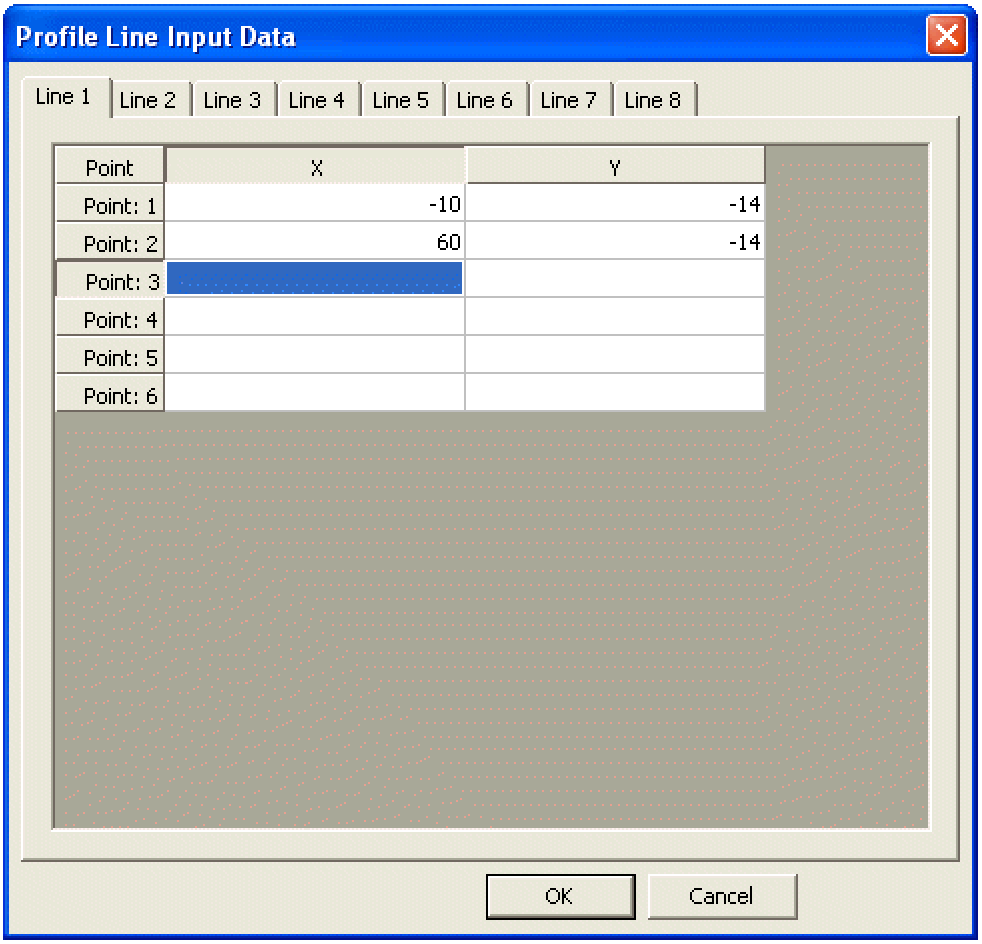



**Figure 4.2 - Dialog box for entering Profile Line data.**

To enter data for another Profile Line, click on the appropriate tab at the top of the dialog box and enter data in the same way that you entered data for the first line. Repeat this process until data for all lines have been entered. Profile lines may be entered and numbered in any order. In fact numbers do not need to be in continuous sequence, e.g. Profile Lines 1, 2, and 4 may be entered, while Profile Line number 3 is omitted (not used).

When you have finished entering the Profile Line data, click on the **OK** button. Clicking on the **Cancel** button will cause any data that you have entered or changed to be ignored.

Once you have entered the Profile Line data it is a good idea to save your data before proceeding to enter data for the material properties. Use the ***Save*** command in the ***Data*** menu to save your data. You can return to the Profile Line dialog box at any time later. When you do, the data that you have entered will be displayed in the dialog box.

## Material Properties

To enter material properties choose the ***Material Properties*** command from the ***Data*** menu. A dialog box similar to the one shown in Figure 4.3 is displayed for you to enter data. Tabs at the top of the dialog box correspond to the materials for each Profile Line that was entered. If you have not entered any Profile Line data, when you choose the ***Material Properties*** command from the ***Data*** menu, a warning message is displayed instead of the dialog box. You must enter Profile Line data before you can enter material properties.

Enter the data for material properties in the dialog box. Option lists are shown for both the shear strength and pore water pressures. The available required data and options are described below.

### Unit Weight

Enter the total unit weight in the text box provided for each material.

### Shear Strength Data

Three options are available in the **Shear Strength Option** list: (1) ***Conventional: cohesion, friction angle***, (2) ***Linear increase in undrained strength below horiz. datum***, and (3) ***Nonlinear (curved) Mohr failure envelope***. To select a strength option click on the drop-down list labeled **Shear strength option**. A list of the available shear strength options will appear for you to choose an option. Depending on the option you choose, the dialog box and information entered will change. If you choose ***Conventional: cohesion, friction angle*** as the strength option, the area for entering shear strength properties should look like the one shown in Figure 4.3. If you choose ***Linear increase in undrained strength below horiz. datum***, the area for entering strength properties in the dialog box will change to look like the one shown in Figure 4.4. You will then enter the elevation (y) of the horizontal datum, the value of the shear strength at the datum elevation and the rate of strength increase below the datum.

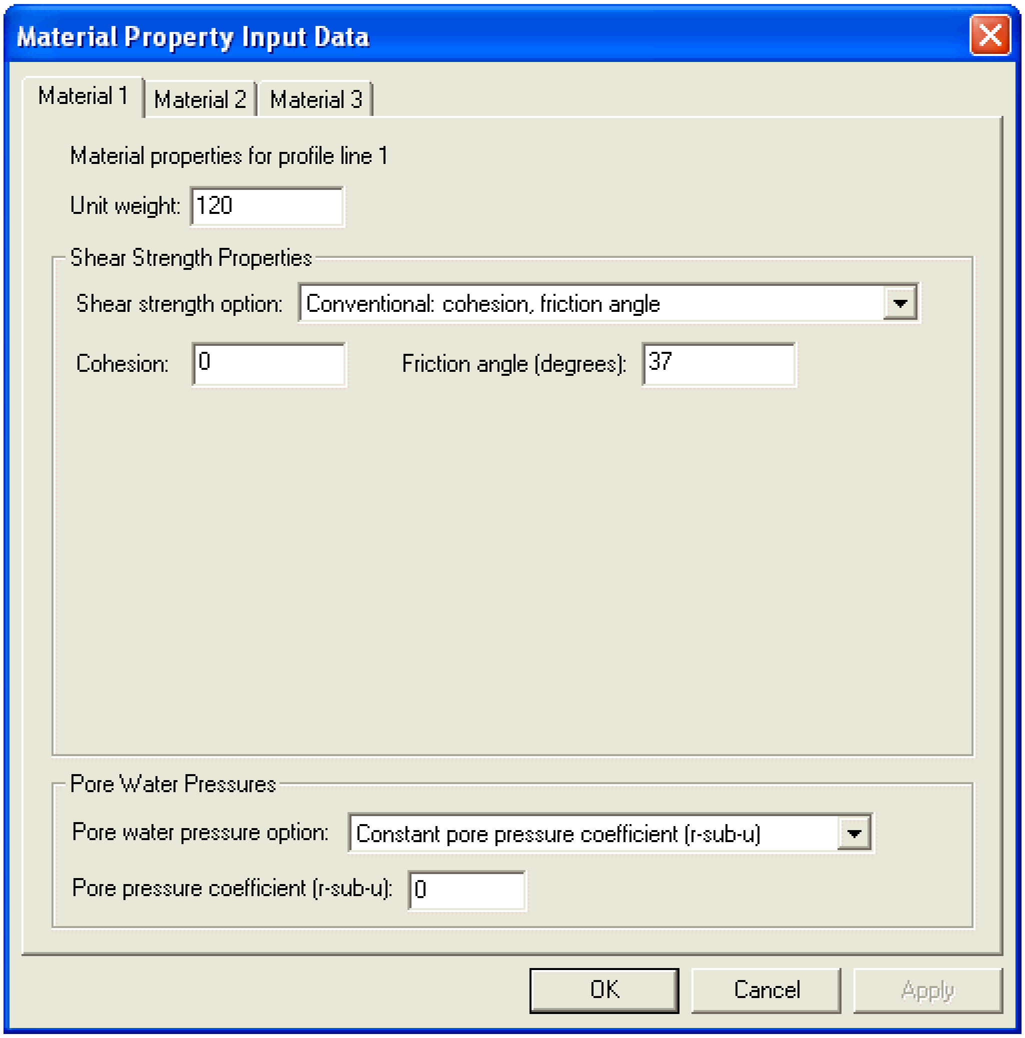



**Figure 4.3 - Dialog box for entering material properties.**

If you choose ***Nonlinear (curved) Mohr failure envelope*** as the strength option, the area of the dialog box for entering shear strength properties will look similar to the one shown in Figure 4.5. To enter data for a nonlinear Mohr failure envelope type values for the normal stress and shear stress in the cells of the data grid. Points should be arranged in the order of increasing normal stress and no two points may have the same value of normal stress. However, if you do not enter points in the proper order they will eventually be sorted automatically.

At least two points are required to define a nonlinear Mohr failure envelope. To change the value of normal or shear stress for a point, simply type new values in the appropriate cells of the data grid.

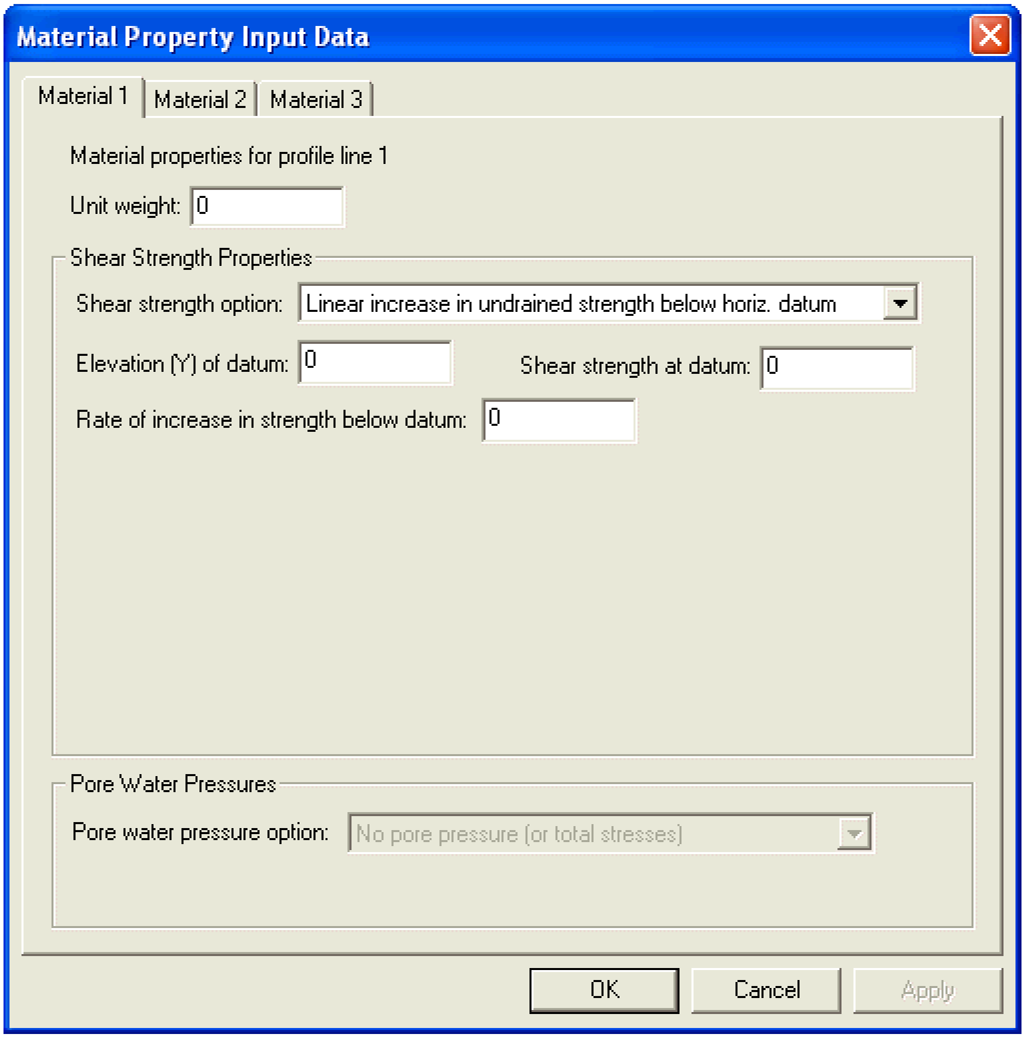



**Figure 4.4 - Dialog box for entering material properties when the undrained shear strength increases linearly with depth.**

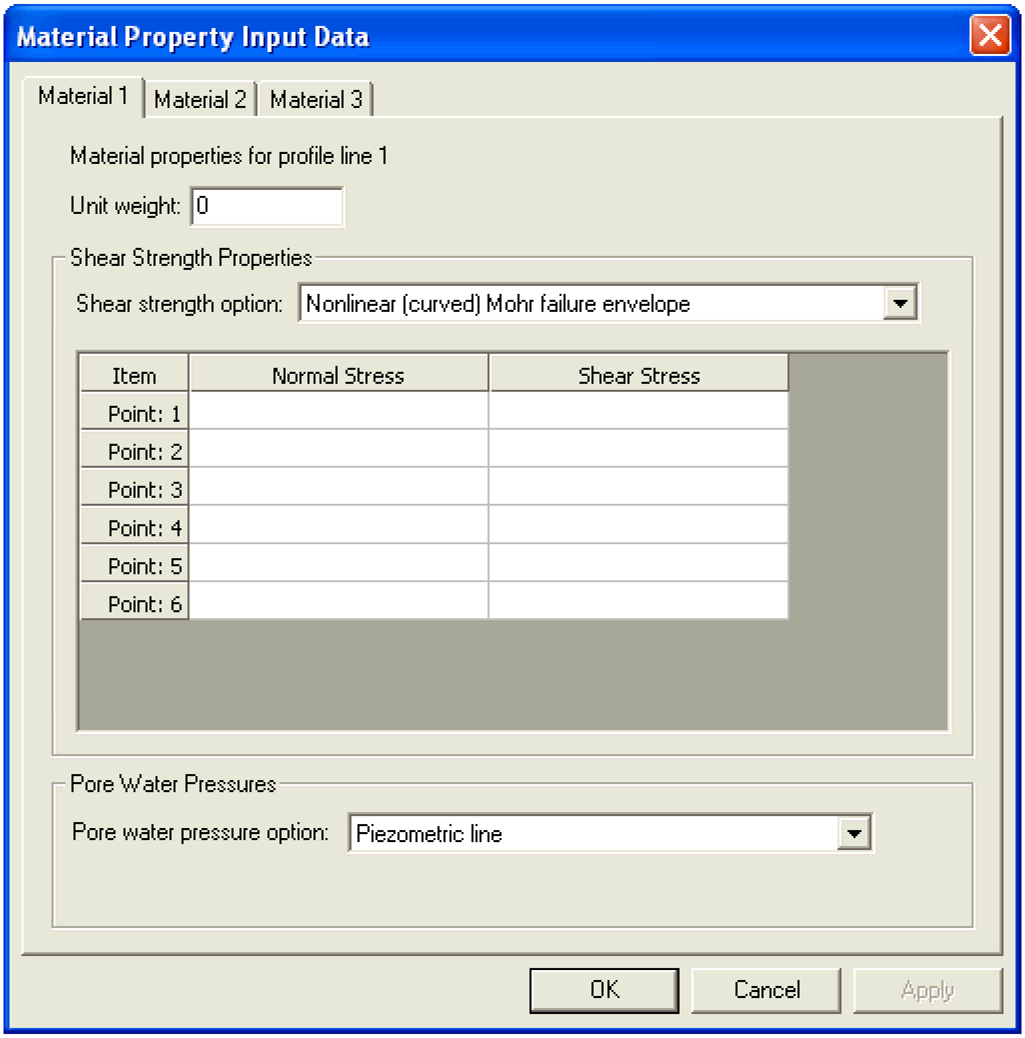



**Figure 4.5 - Dialog box for entering material properties when a nonlinear (curved) Mohr failure envelope is used**

Pore Water Pressures

A dropdown list labeled **Pore water pressure option** is used to select how the pore water pressures are defined for each material. The list presents three options: (1) ***No pore pressure (or total stresses)***, (2) ***Constant pore pressure coefficient (r-sub-u)***, and (3) ***Piezometric line***. To select a pore water pressure option click on the dropdown list labeled **Pore water pressure option**. The list of three available pore water pressure options is then displayed for you to select an option. Depending on the option you choose the dialog box and information entered will change. If you choose ***No Pore Pressure (or Total Stresses)***, no additional information is required to define the pore water pressures. If you choose ***Constant pore pressure coefficient (r-sub-u)*** as the option, the area for entering pore water pressures in the dialog box will change to look like the one shown in Figure 4.3. You should then type the value of the pore water pressure coefficient, $r_u$, in the text box provided. If you choose ***Piezometric line*** as the pore water pressure option, the area for entering the pore water pressure information will look like the one illustrated in Figure 4.5. Note that if you choose to define the shear strength by a linear increase with depth, total stresses are assumed and you will not be able to select a pore pressure option (See Figure 4.4).

Unit Weight of Water

The unit weight of water is used to compute pore water pressures from a piezometric line and to compute the force due to water in an assumed "tension" crack. To enter a unit weight for water, choose ***Unit Weight of Water*** from the ***Data*** menu. When you do a dialog box like the one shown in Figure 4.6 is displayed. Type a value in the text box provided and, press the **OK** button to change the unit weight of water.

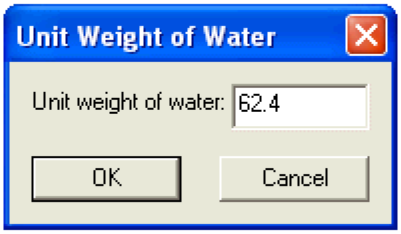



**Figure 4.6 - Dialog box for entering the unit weight of water.**

Initially a default value is assumed for the unit weight of water. The default value is determined according to the type of units, which is set using the ***Units*** command in the ***Settings*** menu. However, once you enter a unit weight of water using the ***Unit Weight of Water*** menu item and the dialog box shown in Figure 4.6, the default value is no longer applicable. Even if you change the type of units, the unit weight of water will remain the value set using the ***Unit Weight of Water*** menu item.

Piezometric Line

To enter data for the piezometric line choose the ***Piezometric Line*** command from the ***Data*** menu. A dialog box similar to the one shown in Figure 4.7 is then displayed. If none of the materials entered use a piezometric line to define pore water pressures, a warning message instead of the dialog box is displayed when you choose the ***Piezometric Line*** command. You can only enter data for a piezometric line when the piezometric line is being used to define pore water pressures for at least one material. Thus, material properties must always be entered before entering piezometric line data.

Data for the piezometric line are entered in almost the same way that you enter data for Profile Lines. Values are entered by typing them in the cells of the data grid.

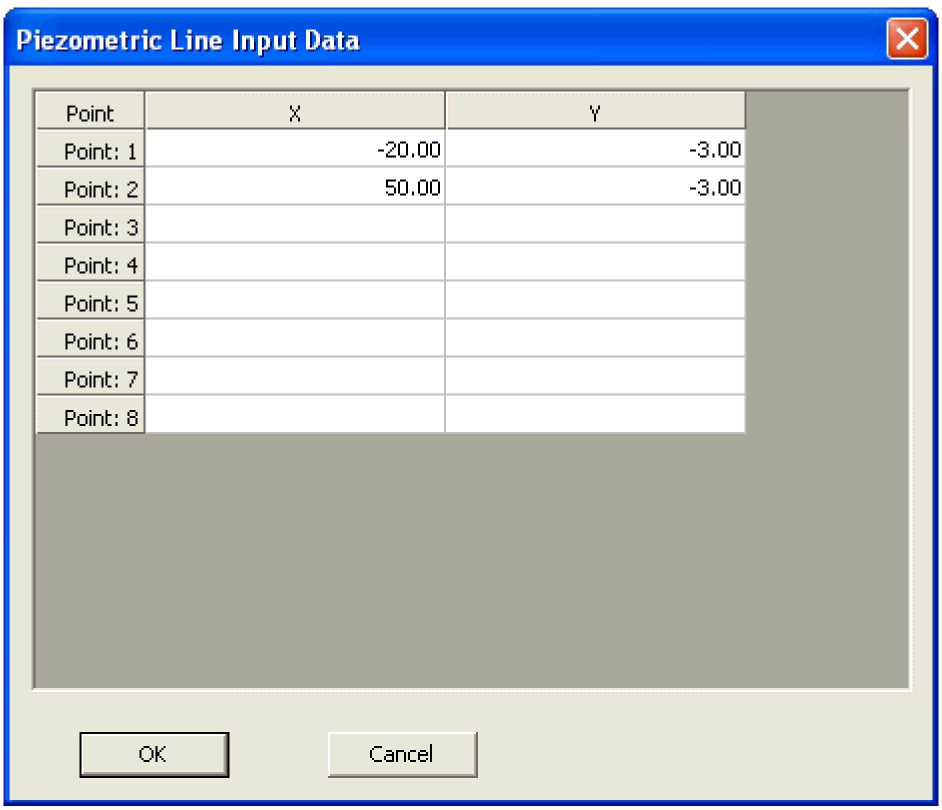



**Figure 4.7 - Dialog box for entering data for the Piezometric Line.**

Distributed Load Data

To enter data for distributed loads (pressures) on the surface of the slope choose the ***Distributed Loads*** command from the ***Data*** menu. A dialog box like the one shown in Figure 4.8 is then displayed for you to enter data. Enter the x-y coordinates and the value of pressure (normal stress) for each point where the distributed load is to be defined by typing the values in the cells of the data grid.

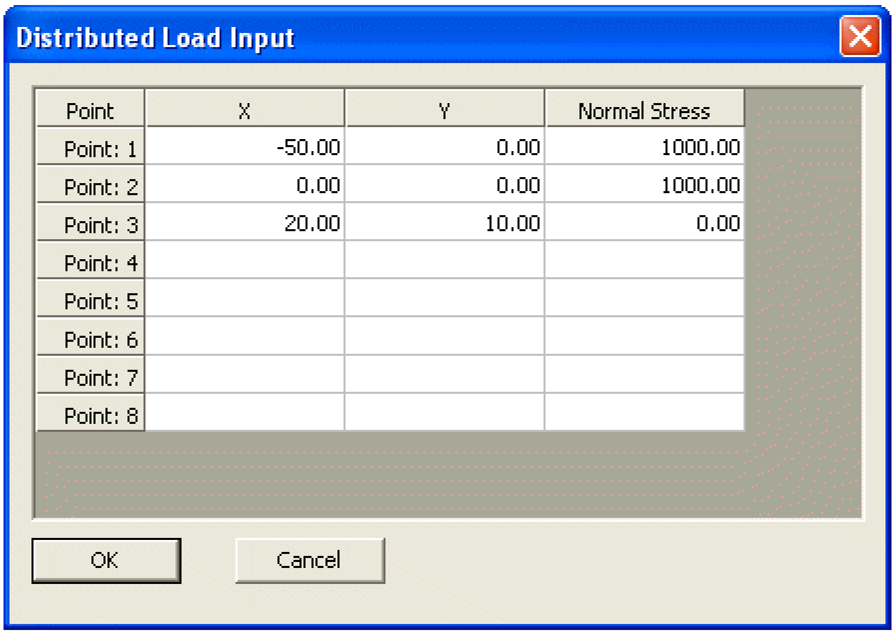



**Figure 4.8 – Dialog box for entering data for distributed loads**

<u>Reinforcement Data</u>

To enter data for internal reinforcing lines choose the ***Reinforcement Lines*** command from the ***Data*** menu. A dialog box like the one shown in Figure 4.9 is then displayed for you to enter data. The tabs at the top of the dialog box are used to select individual reinforcement lines for data entry. The numbering of lines and order of data entry for lines does not matter. You may enter data for lines in any order and for any line numbers. Only lines for which data have been entered are used.

To enter data for a particular line, first select the line number by clicking on the appropriate tab at the top of the dialog box. Enter x-y coordinates of points along the line and the corresponding values of the longitudinal and transverse force by typing them in the cells of the data grid. UTEXAS requires that the points be ordered from left-to-right; however, if you enter the points in another order, they will be automatically sorted once you dismiss the data entry dialog box by clicking on the **OK** button.

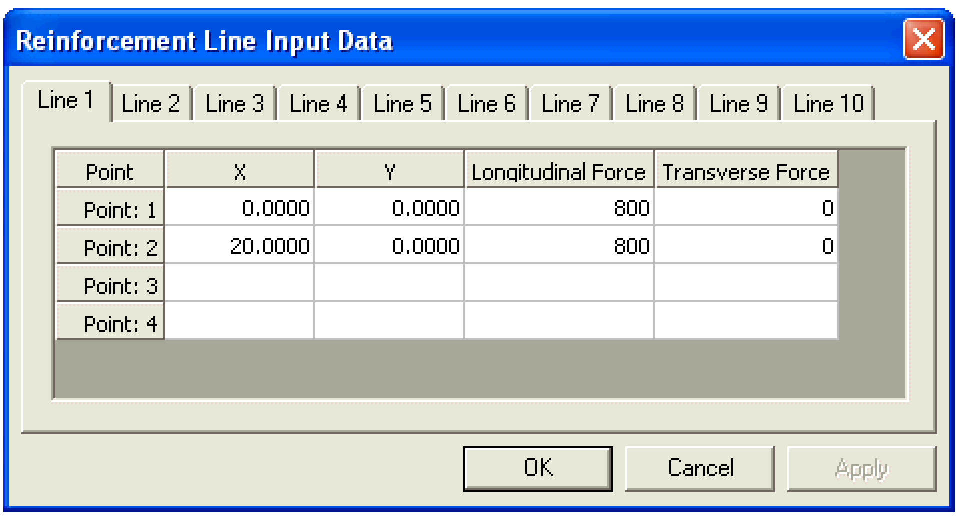



**Figure 4.9 – Dialog box for entering data for reinforcement lines**

Analysis/Computation Data

Enter "Analysis/Computation" data by choosing the ***Analysis Computation*** command from the ***Data*** menu. A dialog box like the one shown in Figure 4.10 is then displayed for you to select the type of analysis. You can select from four choices:

- ***Automatic search with circles*** - an automatic search is performed using circular slip surfaces to locate a "critical" circle with a minimum factor of safety.

- ***Interactive, manual search with circles*** - an interactive search, where each trial circle is selected manually, is performed.

- ***Individual noncircular slip surface*** - a single, selected noncircular slip surface is analyzed.

- ***Automatic search with noncircular slip surfaces*** - an automatic search is performed to locate a "critical" noncircular slip surface with a minimum factor of safety.

Choose one of the four options by clicking on the appropriate radio button and then click on the **OK** button to dismiss the dialog box. A second dialog box is then displayed for you to enter the additional data needed for the type of analysis you have chosen. Each analysis option and the data required are described further below.

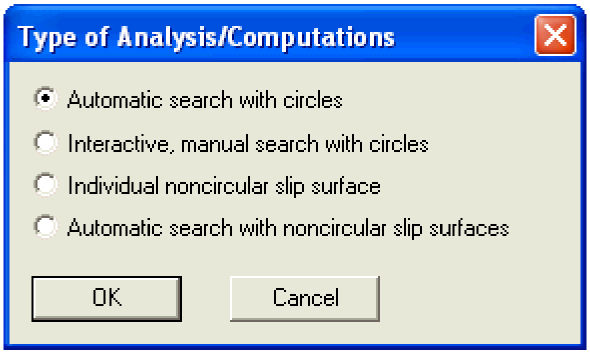



**Figure 4.10 – Dialog box for selecting the type of analysis to be performed.**

Automatic Search with Circles

If you choose to perform an automatic search with circular slip surfaces, a dialog box like the one shown in Figure 4.11 is displayed. Enter the x-y coordinates of the center point where the automatic search is to start as well as the elevation of the bottom of the initial trial circle. Also enter a maximum depth (minimum elevation) allowed for circles; the maximum depth is expressed as an elevation (y) of the bottom of circles. Type each of these values in the appropriate text boxes shown in Figure 4.11.

For circles you can choose either the ***Simplified Bishop*** or ***Spencer*** procedure for the analysis. Use the dropdown list labeled **Procedure of analysis** to choose the procedure to be used.

You can also specify a vertical "tension" crack and a depth (height) for the water in the tension crack. Enter values for the depth of crack and the depth of water in the crack by typing them in the boxes at the bottom of the dialog box. When you have finished entering all the data in the dialog box, click on the **OK** button to return to the main display window.

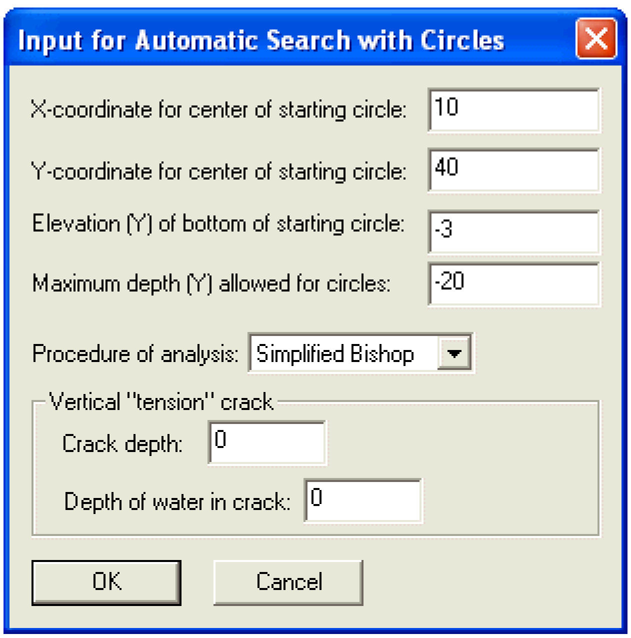



**Figure 4.11 – Dialog box for entering data for an automatic search with circles**

Interactive (Manual) "Search" with Circles

If you choose an interactive search with circles, a dialog box like the one shown in Figure 4.12 is displayed. This dialog box is used to enter information needed for the interactive search. The upper approximately two-thirds of the dialog box (labeled **Maximum and Minimum Radius Limits**) is used to enter information that defines the range of radii that will be tried for each trial center point, i. e. the information defines the maximum and minimum radii that will be tried. The radii may be defined by (1) a value of radius, (2) a point through which the circles pass, or (3) a line to which the circles are tangent. To enter information that defines the maximum and minimum radii:

1. Click on the **New** button to enter a new criterion for defining radii (you will first create a new criterion and then enter the specific data that define the criterion).

2. Use the drop-down list labeled **Maximum or minimum radius defined by** to choose how the radius is defined. You can choose one of the following: ***Value of radius***, ***Point through which circle passes***, or ***Tangent line***. If you choose ***Value of radius***, a text box becomes active for you to enter a value for the radius. If you choose ***Point through which circle passes***, two text boxes become active for you to enter the x-y coordinates for the point. Finally, if you choose ***Tangent line***, a text box becomes active for you to enter the elevation of the horizontal line to which circles are tangent.

   The description of the criterion you have just entered will initially be shown as Criterion number 1 in the list of criteria at the top of the dialog box. This description will only be updated either when you add a new criterion (by clicking on the **New** button again) or when you click on one of the criteria listed in the criteria list. Don't be concerned that the description does not immediately reflect the values you have typed in the various text boxes.

3. To enter another criterion click on the **New** button again and repeat Step 2.

A minimum of two criteria must be entered to define the range of trial radii for each center point. However, you may enter any number of criteria in excess of two to specify the range of radii to be used. Regardless of the number of criteria entered the range for radii is determined for each center point by the maximum and minimum radii that result when all the criteria are applied for the particular center point. If more than two criteria are chosen, different pairs of criteria may govern the maximum and minimum radius depending on the particular location of the center point.

Radii are varied beginning with a coarse increment and then reducing the size of the increment. The initial increment is determined by dividing the difference between the maximum and minimum radii by a number. This number is entered as an integer in the text box labeled **Number of radius increments** in the dialog box shown in Figure 4.12. Radii are varied in successively smaller increments until a minimum value of the increment is reached. The minimum value of the radius increment is entered as a distance/length value in the text box labeled **Minimum radius increment** in the dialog box shown in Figure 4.12.

The procedure of analysis (Simplified Bishop or Spencer) is chosen using the dropdown list in the dialog box labeled **Procedure of analysis**. You can choose either the ***Simplified Bishop*** or ***Spencer*** procedure.

The depth of a vertical crack and the depth of any water in the crack are the final (optional) data that are entered in the dialog box shown in Figure 4.12. After entering all the necessary data in the dialog box, click on the **OK** button to continue.

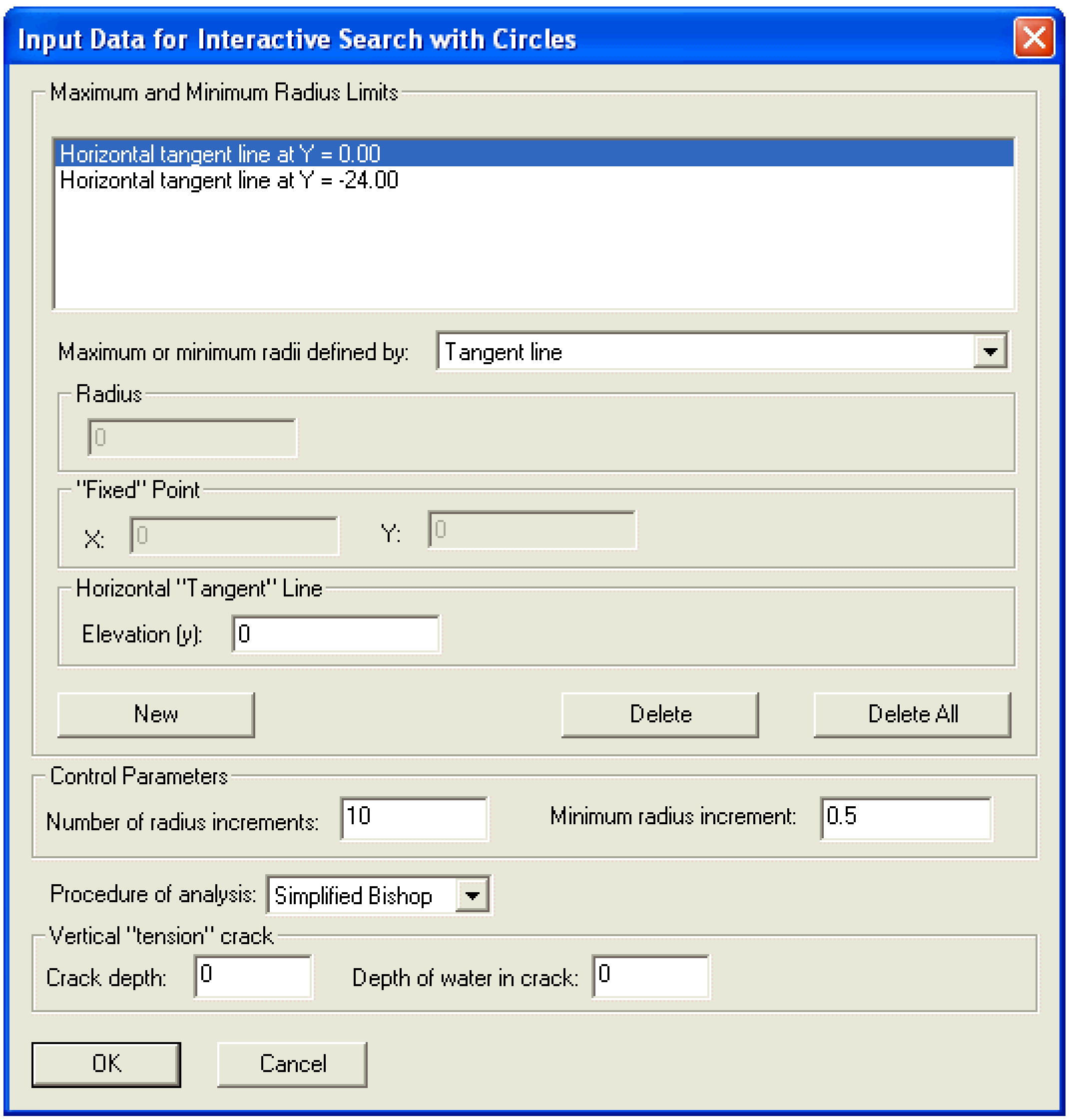



**Figure 4.12 – Dialog box for entering data for interactive (manual) search with circles**

Single Noncircular Slip Surface

If you have chosen to perform computations for a single noncircular slip surface, a dialog box like the one shown in Figure 4.13 is displayed. You will need to enter the coordinates of points defining the noncircular slip surface. Type each pair of x-y values in the appropriate cells of the data grid.

You can also specify a vertical "tension" crack and a depth for the water in the crack. Enter values for the depth of crack and the depth of water in the crack by typing them in the boxes at the bottom of the dialog box. When you have finished entering all the data in the dialog box, click on the **OK** button to return to the main display window.

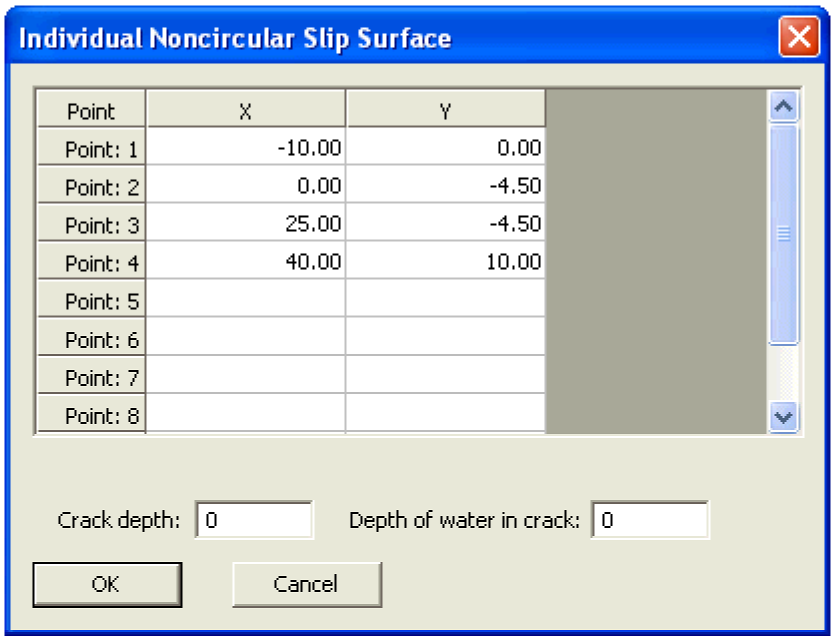



**Figure 4.13 – Dialog box for entering data for a single noncircular slip surface.**

Automatic Search with Noncircular Slip Surfaces

If you chose to perform an automatic search with noncircular slip surfaces, a dialog box like the one shown in Figure 4.14 is displayed. You will need to enter the coordinates of points that define the initial trial noncircular slip surface. Also, for each point you must designate whether the point is to be fixed during the search or moveable, and if moveable, the direction (horizontal or vertical) for shifting the point. Coordinates of points are entered by typing the values in the appropriate cells of the data grid. Information for shifting each point is entered using the drop-down list to the right of where the coordinates are entered. Click on the drop-down list to choose how the point is to be shifted from one of the following four options:

- ***Moveable – direction computed*** - point will be shifted approximately perpendicular to the slip surface.
- ***Moveable - moved horizontally***
- ***Moveable - moved vertically***
- ***Fixed***

Shifting of the two end points of the slip surface is constrained to the slope and any direction that you stipulate for the end points will be ignored.

You must also enter an initial and final distance for shifting points on the noncircular slip surface during the automatic search. The search will begin by shifting points by the "initial distance" that you specify. The distance will then be progressively reduced as the search proceeds until the distance is less than the "final distance" specified, at which point the search is stopped. Enter the distances for shifting points in the boxes labeled **Initial distance for shifting points** and **Final distance for shifting points**.

You can also specify a vertical "tension" crack and a depth for the water in the tension crack. Enter values for the depth of crack and the depth of water by typing them in the boxes at the bottom of the dialog box. When you have finished entering all the data in the dialog box, click on the **OK** button to return to the main display window.

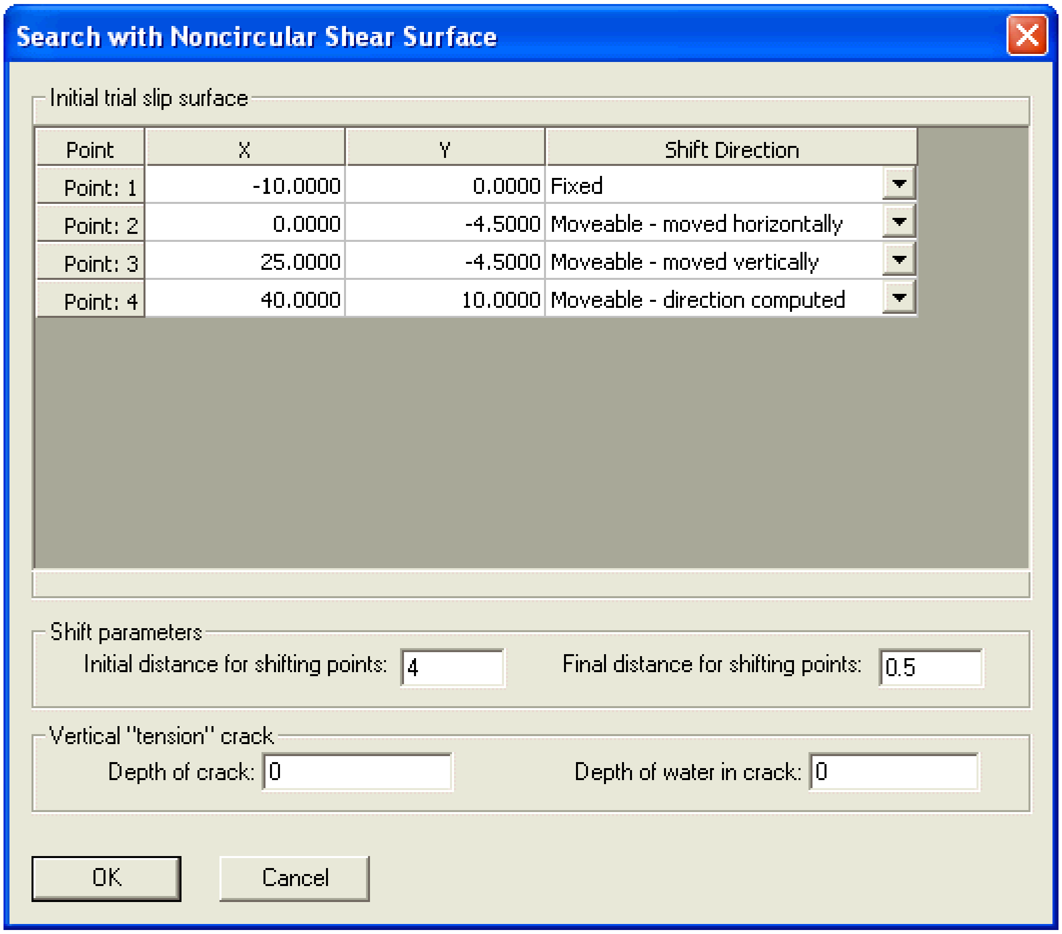



**Figure 4.14 – Dialog box for entering data for an automatic search with noncircular slip surfaces.**

<u>Crack Information</u>

When a vertical "tension" crack is introduced the slip surface (slices) are terminated and a vertical boundary is added at the point where the slip surface reaches the depth of the crack, near the upslope end of the slip surface. Be careful that the crack depth does not exceed the depth of slip surfaces that may be of interest. If the crack depth exceeds the depth of a slip surface, no computations are performed for that slip surface.

## Checking Input Data

Once you have created your input data, the data should be checked before attempting to run UTEXASED4. To check the data choose the ***Check Data*** command from the ***Data*** menu.

If errors are detected in your input data when the ***Check Data*** command is chosen, a dialog box similar to the one shown in Figure 4.15 is displayed. This dialog box can be used to view all of the errors detected. Click on the **Next Error** button to advance to the next error. Similarly use the **First Error**, **Previous Error** and **Last Error** buttons to move to the first, previous and last errors, respectively. Some buttons may be dimmed when you are at either the start or end of the errors list: The **First Error** and **Previous Error** buttons are dimmed when the first error is displayed; the **Next Error** and **Last Error** buttons are dimmed when the last error is displayed.

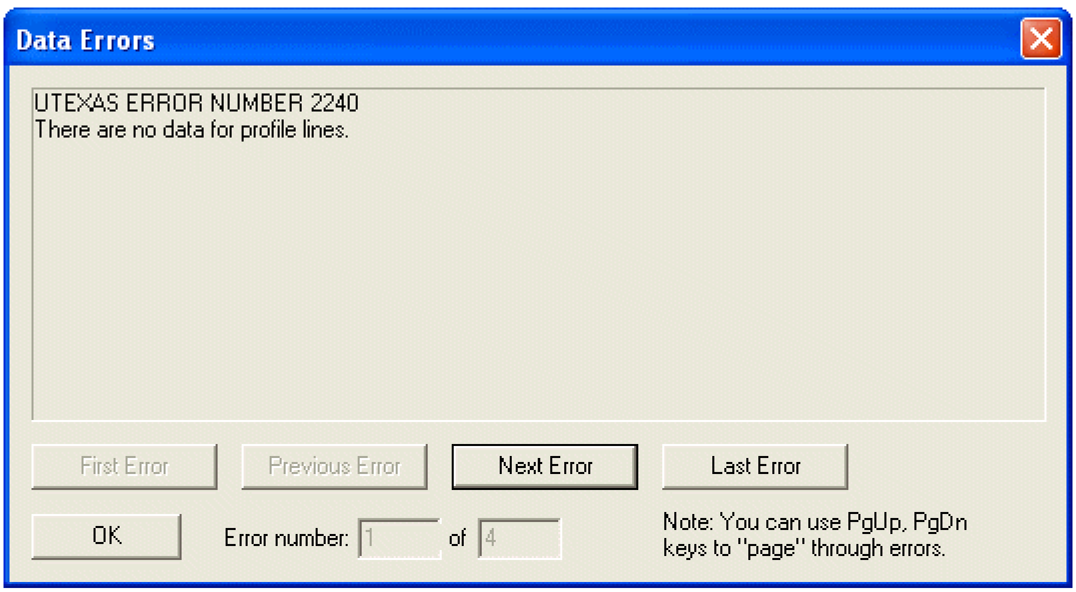



**Figure 4.15 - Dialog box used to display error messages**

If your input data contain errors, correct them before proceeding with the computations. Errors displayed in the dialog box are not automatically removed from the dialog box when you correct your data. The errors displayed are only removed from the dialog box and updated when you check your data again. To re-check your data and confirm your corrections, choose the ***Check Data*** command. If there are still errors, the dialog box will be updated to show the errors that still exist.

# Section 5 - Performing the Computations

After you have created your input data and corrected any errors you are ready to perform the stability computations. To start the computations choose ***Do Computations*** from the ***Computations*** menu. Depending on the type of computations you chose the response will differ as described further below:

## Automatic Search with Circles

If you chose to perform an automatic search with circular slip surfaces, the various trial circles and factors of safety are displayed as the computations are performed. However, before the computations begin a dialog box like the one shown in Figure 5.1 is displayed for you to enter additional information related to what is displayed as follows:

> Search Delay: The search delay area allows you to choose a delay between computation of the factor of safety for each trial circle. With faster computers the computations may be performed so rapidly that it is difficult to see the sequence of circles tried. By choosing a delay, you can slow down the computations and the display to make it easier to follow the search.
>
> Circles to Save: Once computations have been completed and the results are displayed, you can choose to display a selected number of the trial circles that had the lowest factors of safety. The selected number of circles to be displayed, e.g. ten, is chosen using the radio buttons on the right-hand side of the dialog box.

After you have made appropriate selections in the dialog box, click on the **OK** button to dismiss the dialog box and the computations will begin. During the computations each trial circle is drawn in the main display window and the corresponding factor of safety for each circle is displayed in the next to last panel of the **Status Bar** at the bottom of the display window. The last panel in the **Status Bar** displays the lowest value calculated for the factor of safety to that point. Trial circles are displayed in gray; while the circle having the lowest factor of safety is displayed in red.

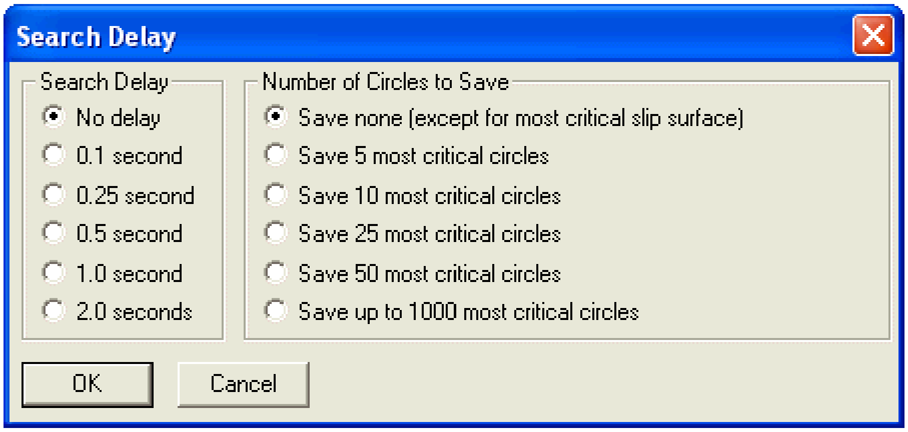



**Figure 5.1 - Dialog box for selecting delays between successive trial circles and the number of circles to save for an automatic search with circular slip surfaces.**

Once the automatic search is completed, you can display the most critical circle, including the individual slices and the distribution of stresses along the circle by clicking once in the main display window. This will cause the display to change from showing all the trial circles to showing the critical circle. Also, if you indicated that some trial circles were to be saved (See Figure 5.1), the circles that were saved are also displayed.

### Interactive (Manual) "Search" with Circles

If you chose to perform an interactive "search", the dialog box shown in Figure 5.2 is displayed. During the interactive search the main display window and a separate "Graph Window" are displayed. The Graph Window shows how the factor of safety varies with the radius of the circle for the most recent center point entered. The dialog box shown in Figure 5.2 is displayed to allow you to choose to have the windows arranged automatically so that they do not overlap (you can later rearrange the windows differently if you wish). It is generally recommended that you allow the windows to be arraigned automatically by clicking on the **Yes** button. Choose **No** if you do not want the windows automatically arranged; choose **Cancel** if you do not want the interactive search to start.

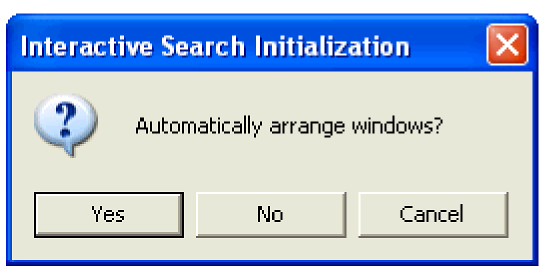
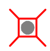



**Figure 5.2 – Dialog box displayed at start of interactive search.**

If you clicked on either the **Yes** or **No** button, you are now ready to start the interactive search. Begin by selecting a center point for a trial circle by clicking in the main display window at the location of the center point. If the computations are successful the trial circles are displayed in the main display window and the variation in factor of safety with radius is displayed in the Graph Window. Also as each trial circle (radius) is attempted the factor of safety is displayed in the **Status Bar** at the bottom of the main display window in the box labeled **F**. The lowest factor of safety calculated for the trial center point is also displayed on the far right in the **Status Bar** in the box labeled **F-min**.

If the factor of safety can be successfully computed, the center point is displayed as a gray dot (●). The center point that produced the lowest factor of safety at any stage in the "search" also has a small, red square and "X" displayed at the location, similar to what is shown below:



If the factor of safety cannot be computed for a center point for any of the trial radii, the trial center point is displayed with a red "X" as follows:

Continue to enter trial center points until you are satisfied that you have located the most critical circle. Use the contours and the marked location of the most critical center point to guide your search.

You can halt the search at any time and display the circle that currently has the minimum factor of safety. To do so, choose the ***Suspend Interactive Search*** command from the ***Computations*** menu. The display then changes to show the most critical circle found to that point along with the individual slices and the distribution of stresses along the circle. The factor of safety is also shown as text in the area above the slope.

To resume the interactive search once it has been suspended, choose the ***Resume Interactive Search*** command from the ***Computations*** menu. The contours of factor of safety are again displayed and you can continue to select center points for trial circles by clicking in the main display window.

When you have completed selecting center points for the interactive search choose the ***Finish Interactive Search*** command from the ***Computations*** menu. This will end the search and write the final output tables to the text output file. The ***Finish Interactive Search*** command is identical to the ***Suspend Interactive Search*** command except it completes writing the final information to the text output file and the search cannot be resumed using the ***Resume Interactive Search*** command.

### Individual Noncircular Slip Surface

If you chose to analyze an individual noncircular slip surface, the computations are immediately performed and the slip surface is displayed along with the individual slices and the distribution of effective normal stress and pore water pressure along the slip surface.

### Automatic Search with Noncircular Shear Surfaces

If you chose to perform an automatic search with noncircular slip surfaces, as soon as you choose the ***Do Computations*** command, a dialog box like the one shown in Figure 5.3 is displayed for you to enter additional information related to what is displayed as follows:

> Search Delay: The search delay area allows you to choose a delay between computations for the factor of safety for successive shifts of points on the noncircular slip surface. With faster computers the computations may be performed so rapidly that it is difficult to see the sequence of shifts. By choosing a delay, you can slow down the computations and the display to make it easier to follow the search.
>
> Number of Slip Surfaces to Save: Once computations have been completed and the results are displayed, you can choose how many of the most critical (lowest factor of safety) trial noncircular slip surfaces will be displayed. UTEXASED4 allows you to save a selected number of slip surfaces, e.g. ten, to be displayed with the final results. Use the radio buttons on the right-hand side of the dialog box to choose the number of noncircular slip surfaces to be saved.

After you have made appropriate selections in the dialog box, click on the **OK** button and the computations will begin. The shifted position of individual points on the slip surface will be drawn along with the current position of the most critical slip surface. The factor of safety for each trial shift is displayed in the next to last panel of the **Status Bar** at the bottom of the display window. The last panel in the **Status Bar** displays the lowest value calculated for the factor of safety at the current stage of the computations. The slip surface geometry resulting from each trial shift is displayed in light gray, while the position of the slip surface with the lowest factor of safety is shown in red.

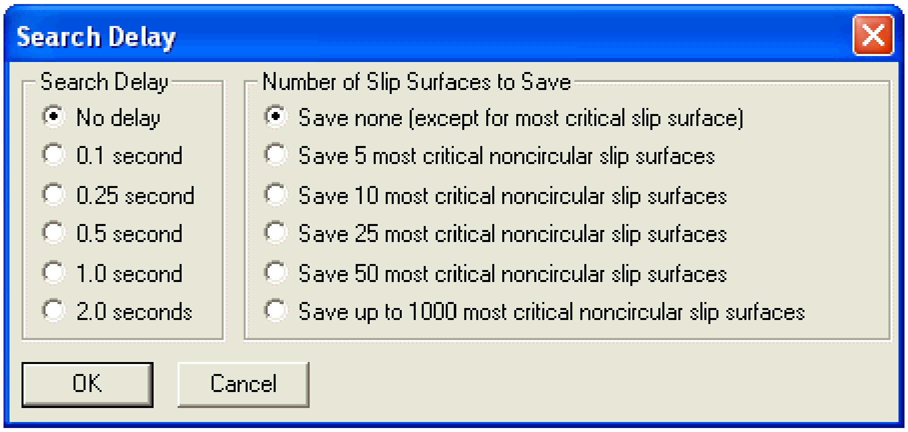



**Figure 5.3 - Dialog box for selecting delays between successive shifts of points and the number of slip surfaces to save for an automatic search using noncircular slip surfaces.**

# Section 6 - Graphical Display

Input data, including the Profile Lines, piezometric line and circular and noncircular slip surfaces that are entered as input data are displayed in the main display window. Also, once the computations are completed, additional information is displayed. The display of both the input data and the results of the computations are described separately below.

## Input Data

The input data that are displayed and the colors used for display are summarized in Table 6.1. In addition to the items listed in Table 6.1 the numbers assigned to the Profile Lines are displayed on the Profile Lines surrounded by a rectangular frame. The slope line may coincide with one or more Profile Lines and may actually obscure the Profile Line(s) when displayed. All information pertaining to the input data is displayed before any computations are performed as well as after the computations are completed.

**Table 6.1 - Input data displayed and colors used**

| Item | Color |
|---|---|
| Profile Lines (numbers shown in rectangles) | Dark green |
| Slope Line (may obscure upper-most Profile Line or Lines) | Brown w/ surface hatching |
| Piezometric Line | Blue |
| Distributed Loads | Navy (dark) blue |
| Reinforcement Lines | Magenta |
| Initial Trial /or/ Designated Slip Surface (Circular or Noncircular) | Gray |

### Distributed Load Scaling

Distributed loads are displayed as a series of vectors representing the direction and magnitude of the distributed stress. The loads (stresses) are scaled based on the current type of units. Loads are scaled such that the length of the vectors representing the stress at each point corresponds approximately to an equivalent height of water. This is particularly useful for checking the validity of data when the distributed loads are produced by water adjacent to the slope. The scale factors expressed as pressure per unit distance are shown in Table 6.2.

**Table 6.2 - Scale factors for distributed loads**

| Units | Scale Factor |
|---|---|
| Feet and pounds. | 62.4 pounds/square foot/ foot |
| SI - Meters and newtons. | 9800 newtons/square meter/meter<br>9800 pascals/meter |
| Meters and kilonewtons. | 9.8 kilonewtons/square meter/meter<br>9.8 kilopascals/meter |

### Reinforcement Force Scaling

Longitudinal and transverse forces in the reinforcement are represented by a shaded trapezoidal area representing the magnitude of the force. The forces are scaled based on the current type of units. The forces are scaled such that the distance representing the maximum force in the reinforcement is a prescribed length. The lengths representing the maximum force in the reinforcement are shown in Table 6.3. These lengths are actual lengths on the display (computer screen or printed page).

**Table 6.3 - Lengths used to represent maximum reinforcement force**

| Units | Maximum Length |
|---|---|
| Feet and pounds. | 0.5 inch |
| SI - Meters and newtons. | 1 centimeter |
| Meters and kilonewtons. | 1 centimeter |

## Display During Computations

When an automatic search is performed using circles each trial circle is displayed in gray. As the search progresses the most critical (lowest factor of safety) circle is always displayed in red; the circle displayed in red will change as the location of the circle with the lowest factor of safety changes. As soon as the computations are completed the final results are shown. Display of the final results is described in the next section.

When an interactive, manual search is performed the trial center points and contours of factor of safety are displayed as soon as the factor of safety has been calculated for at least three center points. The contours are constantly updated as each new trial center point is selected and the factor of safety is calculated. At any stage of the interactive search you can display the final results (described in the next section) by choosing the ***Suspend Interactive Search*** command from the ***Computations*** menu. To return to the interactive search and the display of contours of factor of safety, choose the ***Resume Interactive Search*** command from the ***Computations*** menu.

When an automatic search is performed using noncircular slip surfaces the various trial positions of the noncircular slip surface are displayed as the search is in progress. Immediately upon completion of the search the display is updated to show the final results as described below.

### Display of Final Results

The final results that are displayed are summarized in Table 6.4 and described in more detail below. The colors used to display each item are also shown in Table 6.4.

**Table 6.4 - Computation results displayed and colors used**

| Item | Color |
|---|---|
| Critical (Lowest F) Slip Surface | Red |
| Slice vertical boundaries | Gray |
| Factor of Safety and Side Force Inclination (text) | Red |
| Line of Thrust (Spencer's procedure only) | Orange |
| Pore Water Pressures | Blue |
| Normal Stresses (Total or Effective) | Light Green (Compression)<br>Red (Tension) |
| All trial slip surfaces (Automatic search with circles or noncircular slip surfaces only) | Gray |
| Factor of safety contours (Interactive search only). | Red |
| Triangulation of center points (Used to draw contours of factor of safety - interactive search only). | Gray |

#### Critical (Lowest F) Slip Surface

The slip surface with the lowest factor of safety found from a search is displayed, or if a single noncircular slip surface is analyzed, the single slip surface is displayed[1]. When an automatic search is performed with circles the center point of the critical circle is also displayed (as a cross +) with two lines extending from the center of the circle to the two ends of the circular arc.

[1] If a single slip surface is analyzed, the "final" slip surface will coincide with and overlie the "initial" slip surface.

### Slices

Vertical lines are drawn to represent the boundaries between individual slices. Slices are shown for either the slip surface with the lowest factor of safety (when a search is performed) or the designated, single slip surface (when a single slip surface is analyzed).

### Factor of Safety/Side Force Inclination

The computed factor of safety for either the most critical slip surface (when a search is performed) or the designated slip surface (when a single slip surface is analyzed) is shown as text near the center of the display, above the slope. The interslice (side) force inclination is also displayed when Spencer's procedure is used to compute the factor of safety.

### Line of Thrust

When Spencer's procedure is used to compute the factor of safety the "line of thrust", representing the locations of the interslice forces on slice boundaries, is displayed. The line is drawn as a piecewise linear continuous line joining the points of action of the interslice force on each slice boundary.

### Pore Water Pressures

Pore water pressures for effective stress analyses are plotted as a distribution of stresses along the slip surface. The pressure on the base of each slice is represented as a trapezoidal outline with the interior of the trapezoid cross-hatched. The pore water pressures are scaled so that the length of the distribution measured perpendicular to the base of the slice is roughly equal to an equivalent height of soil. The resulting factors (unit weights of equivalent soil) used for scaling are shown in Table 6.5. Once the pressure is converted to an equivalent length (height of soil) in feet or meters, the length is further scaled for display in the same way that other lengths and coordinates representing the Profile Lines, etc are scaled.

**Table 6.5 - Scaling values used for pore water pressures and normal stresses**

| Units | Scaling Value |
|---|---|
| Feet and pounds. | 125 pounds/square foot/ foot |
| SI - Meters and newtons. | 20,000 newtons/square meter/meter<br>20,000 pascals/meter |
| Meters and kilonewtons. | 20 kilonewtons/square meter/meter<br>20 kilopascals/meter |

### Normal Stresses

Normal stresses on the slip surface are displayed in a way similar to the way that pore water pressures are displayed. The normal stresses represent the total stress minus any pore water pressure that has been specified for the analysis. Thus, for analyses where no pore water pressures are specified the normal stresses are the total stresses. For analyses where pore water pressures are specified the normal stresses are the effective stresses. The type of normal stress displayed - total or effective - may vary from soil-to-soil depending on how the material properties are defined for each soil.

Positive normal stresses (compression) are represented in light green color; negative stresses, representing tension in the soil, are displayed in red.

### All Trial Slip Surfaces

When an automatic search is performed with either circular or noncircular slip surfaces all trial circles can be displayed. In the case of a search with noncircular slip surfaces the slip surfaces that results in the individual, point-by-point shifts of each point along a trial surface are not displayed; instead only the trial slip surfaces after the entire slip surface has been shifted are displayed.

### "N-most" Critical Slip Surfaces

When you have directed that the "n" slip surfaces with the lowest factors of safety be saved (See Figures 5.1 and 5.3), the "n" surfaces that were saved are displayed.

### Factor of Safety Contours

When an interactive search is performed contours of factor of safety are displayed. While the search is being conducted (not suspended) the contours are drawn, but not labeled. As soon as the search is suspended the contours are redrawn and labeled. Contours are initially drawn using a contour interval of 0.1 for the factor of safety.

The contouring interval can be changed by choosing the ***Interactive Search Contouring*** command in the ***Settings*** menu[2]. A dialog box like the one shown in Figure 6.1 is then displayed for you to choose a scheme for specifying the contour interval. You can choose from one of the following schemes:

- ***Contour interval specified*** - you will specify the actual interval in factor of safety to be used for contours.

[2] This command is only active in the ***Settings*** menu when data have been entered for an interactive search.

- ***Nominal number of contours specified*** - you will specify the approximate number of contours to be drawn and a suitable "nice" interval will be chosen to give approximately this number of contours.

- ***Exact number of contours specified*** - you will specify the exact number of contours to be drawn. This may result in an "odd" value for the contour interval to achieve the designated number of contours.

- ***Individual contour values specified*** - you will specify the specific values of factor of safety for which contours are to be drawn.

Once you choose a contouring scheme and click on the **OK** button another dialog box is displayed for you to enter the required data for contouring. After you have entered the revised contouring data the contours will be drawn accordingly.

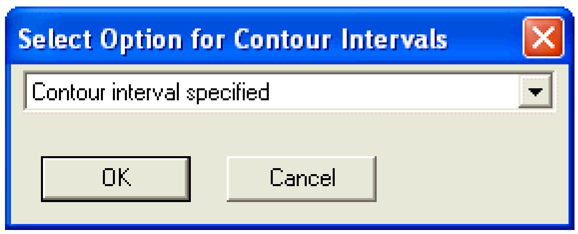



**Figure 6.1 - Dialog box for selecting scheme for contouring factors of safety**

### Selecting Information to be displayed

Normally all of the information described above is displayed on the computer screen. To select only a portion of the information for display choose the ***Display Selections*** command from the ***Settings*** menu. A dialog box like the one shown in Figure 6.2 is then displayed for you to select what items will be displayed.

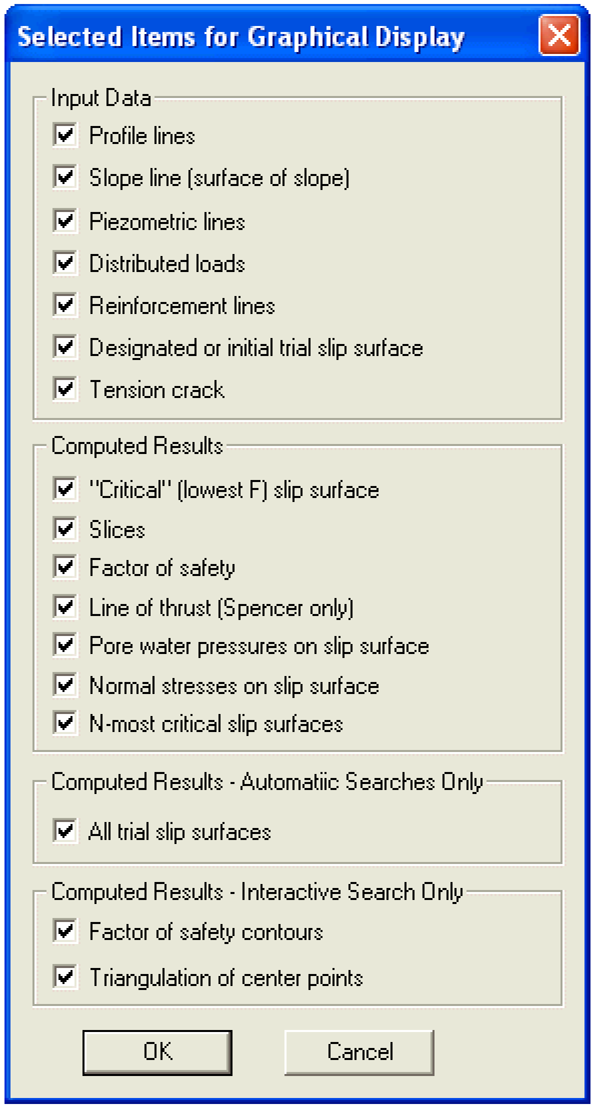



**Figure 6.2 - Dialog box for selecting items to be displayed**

# Section 7 - Text Output File

Most of the important details of the slope stability calculations are reported in a text output file. The output file contains the input data and results of the computations in a series of "tables". The various tables and the information they contain are summarized in Table 7.1.

## Viewing the Output File

To view the output file choose the ***Show Output File*** command from the ***View*** menu. A dialog window like the one shown in Figure 7.1 will then be displayed. You can "page" through the output file using the **First Page**, **Next Page**, **Previous Page** and **Last Page** buttons. Alternatively you can use the **Home**, **PageUp**, **End** and **PageDown** keys with the **Shift** key depressed to "page" through the output file. For some of the longer "pages" a scroll bar is used to scroll vertically through the page. The dialog window can also be resized as necessary to change the amount of the page that is visible.

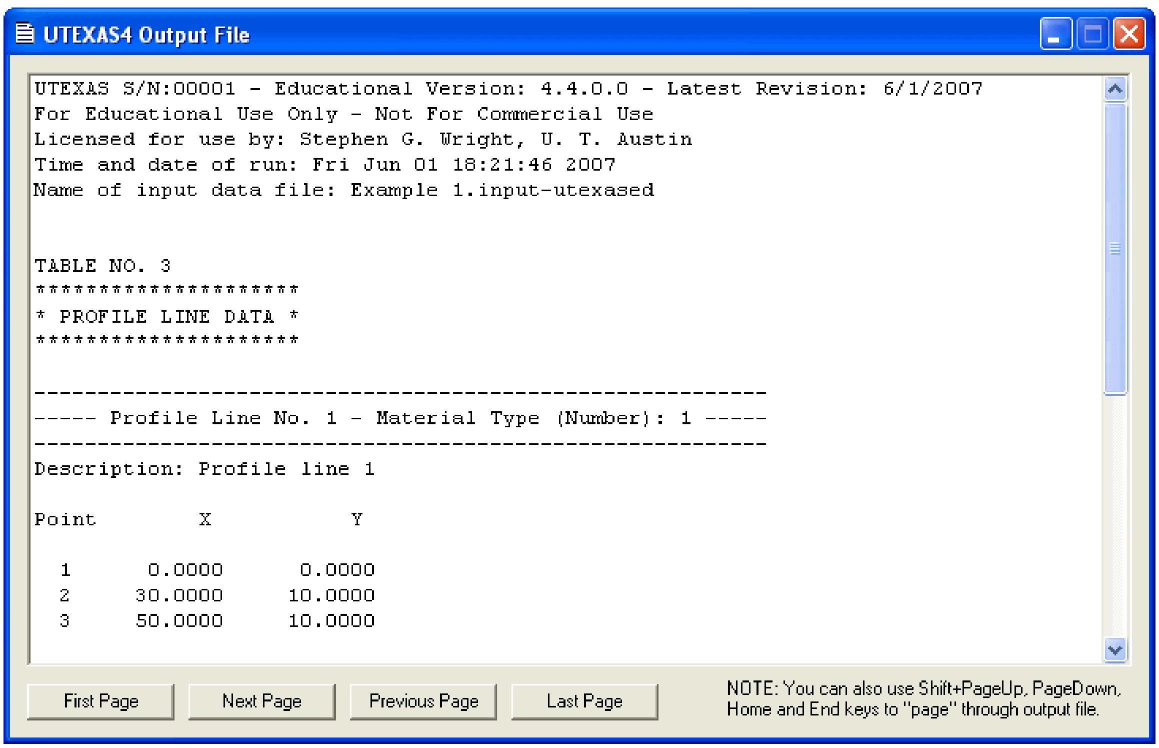



**Figure 7.1 - Dialog window used to view the text output file**

## Printing the Output File

Each time you read an input file or perform a set of computations with UTEXASED4 a text output file is created in the same directory as the input data file. The name of the output file is the same as the name of your input data file, except with the file name extension *out-utexased*. To print the output file choose the ***Print Output File*** command from the ***File*** menu. A standard File Open dialog box is displayed with the name of the current output file shown as a default. To print the current output file, simply click on the **Open** button. Next, a standard Print dialog box is displayed for you to choose print options. After selecting the desired printer and associated print options, click on the **OK** button to print the output file. You can also print any output file created by a previous set of data and computations using the ***Print Output File*** command. To print an output file other than the current one just select the appropriate output file when the File Open dialog box is displayed.

**Table 7.1 - Contents of Text Output Tables**

| Table No. | Contents |
|---|---|
| 1 | UTEXASED4 header message containing program name, version number, copyright notice, usage restrictions, and disclaimer and warning message. Printed only once at start of execution. |
| 2 | Information pertaining to the units selected for the problem. |
| 3 | Profile line input data. |
| 4 | Material property input data. |
| 5 | Piezometric line input data. |
| 6 | Distributed loads input data. |
| 7 | Reinforcement line input data. |
| 8 | Analysis/computation input data. |
| 9 | Slope geometry (coordinates) created from Profile Line data. |
| 10 | Output of factor of safety for each trial center during automatic search with circles tangent to a prescribed horizontal line. |
| 11 | Output of factor of safety for each trial center during automatic search with circles with a constant, prescribed radius. |
| 12 | Summary of final critical circle location and factor of safety for automatic search with circles. |
| 13 | Summary listing of information for "n" slip surfaces with the lowest factor of safety when more than the most critical (lowest F) slip surface is to be saved. |
| 14 | Output table for interactive search. For each trial center point the various radii and factors of safety are summarized. |
| 15 | Summary of center point coordinate and radius for the circle with the lowest factor of safety from the "interactive" search. |
| 16 | This table is output during a search with noncircular slip surfaces. The table is output once for each trial "pass"/position of the noncircular slip surface and shows the shifted coordinates of each point and the computed factor of safety for the shift. |

| Table No. | Contents |
|---|---|
| 17 | This table is output at the conclusion of a search with noncircular slip surfaces. The table summarizes the trail passes and lists the coordinates and factor of safety for the critical noncircular slip surface. |
| 18 | This table is output at the conclusion of a search with noncircular slip surfaces when more than the slip surface with the lowest factor of safety are to be saved. The table summarizes the coordinates and factor of safety for the "n" noncircular slip surfaces with the lowest factors of safety. |
| 19 | Summary of properties for individual slices for either the slip surface with the lowest factor of safety (for a search) or the single specified slip surface. |
| 20 | Summary of forces due to distributed loads for individual slices for either the slip surface with the lowest factor of safety (for a search) or the single specified slip surface. A companion to Table 19. |
| 21 | First summary table of reinforcement forces for individual slices for either the slip surface with the lowest factor of safety (for a search) or the single specified slip surface. This table is only output when reinforcement exists. A companion to Table 19. |
| 22 | Second summary table reinforcement forces for individual slices for either the most critical (lowest factor of safety) slip surface or an individually specified slip surface. This table is only output when reinforcement exists. A companion to Table 19. |
| 23 | Summary of trial and error calculations for the normal stress-shear strength when a nonlinear Mohr failure envelope is used to describe the strength of any material. |
| 24 | Summary of iterations for computing the factor of safety for either the most critical (lowest factor of safety) slip surface or an individually specified slip surface. A companion to Table 19. |
| 25 | Summary of equilibrium checks of solution for factor of safety for either the most critical (lowest factor of safety) slip surface or an individually specified slip surface for Spencer's procedure. A companion to Table 19. |
| 26 | Summary of equilibrium checks of solution for factor of safety for either the most critical (lowest factor of safety) slip surface or an individually specified slip surface for the Simplified Bishop procedure. A companion to Table 19. |
| 27 | Summary of stresses on the slip surface for individual slices. A companion to Table 19. |
| 28 | Summary of interslice forces, including the position of the line of thrust, for individual slices. A companion to Table 19. This table is only printed when Spencer's procedure is used to compute the factor of safety. |

Tables 19 - 28 are output for either the most critical (lowest factor of safety) slip surface in the case of a search or the individually specified slip surface when only one slip surface is analyzed.

## References

Bishop, A.W. (1955) "The use of the slip circle in the stability analysis of slopes," *Geotechnique*, Institution of Civil Engineers, Great Britain, Vol. 5, No. 1, Mar., pp. 7-17.

Celestino, T. B., and J. M. Duncan (1981), "Simplified search for noncircular slip surfaces," *Proceedings*, Tenth International Conference on Soil Mechanics and Foundation Engineering, Stockholm, June 15-19, Vol. 3, pp. 391-394.

Spencer, E. (1967) "A method of analysis of the stability of embankments assuming parallel inter-slice forces," *Geotechnique*, Institution of Civil Engineers, Great Britain, Vol. 17, No. 1, March, pp. 11-26.