Visual Slope User's Guide

Version 3

2010

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QUICK OVERVIEW

The Visual Slope Series is a multi-function engineering computer program developed for:

1. Slope Stability Analysis
2. Reinforced Slope Design
3. MSE Wall Design
4. Soil Nailing Design
5. Shoring Design

All functions in the Visual Slope Series have been designed to share a common analogy. Therefore, they are very easy to learn and use. Visual Slope uses convenient drawing procedures similar to AutoCAD to help users establish input files, which allows a detailed and accurate modeling of a real situation to be achieved, and which greatly reduces chances of input errors.

To perform the above analyses with the Visual Slope Series, the following four simple steps are required:

1. Starting Project
2. Establishing Profile
3. Setting Up and Assigning Material Properties
4. Performing Analysis

This User's Guide will provide our users with tutoring on how to use Visual Slope. The following sections will describe each of the above four steps.

STARTING PROJECT

After Visual Slope starts, Visual Slope will prompt the following dialogue box (Figure 1) to let the user choose either an existing project or a new project.

If the *Existing Project* option is chosen, the user can select the file from the project list or browse the file by selecting <<*Other Files*>>.

If the *New Project* option is chosen, Visual Slope will prompt the user to follow the *General Setting* page (Figure 2) to start a new project.

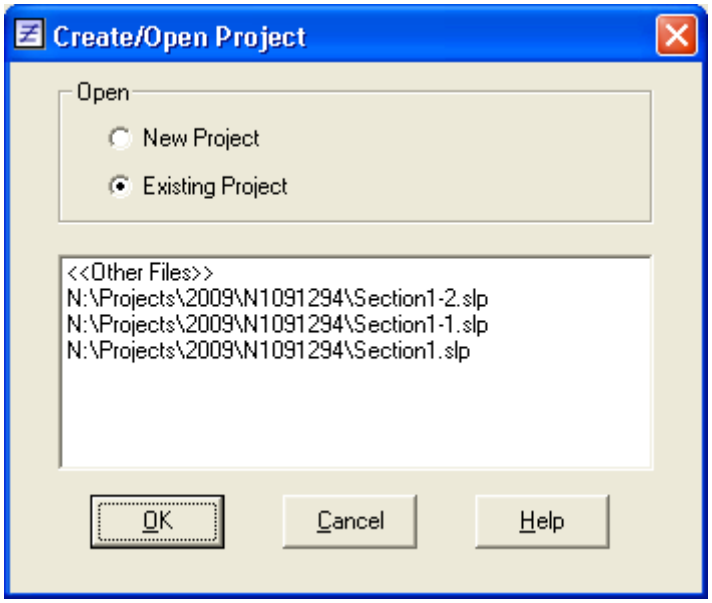

Figure 1 Create/Open Project

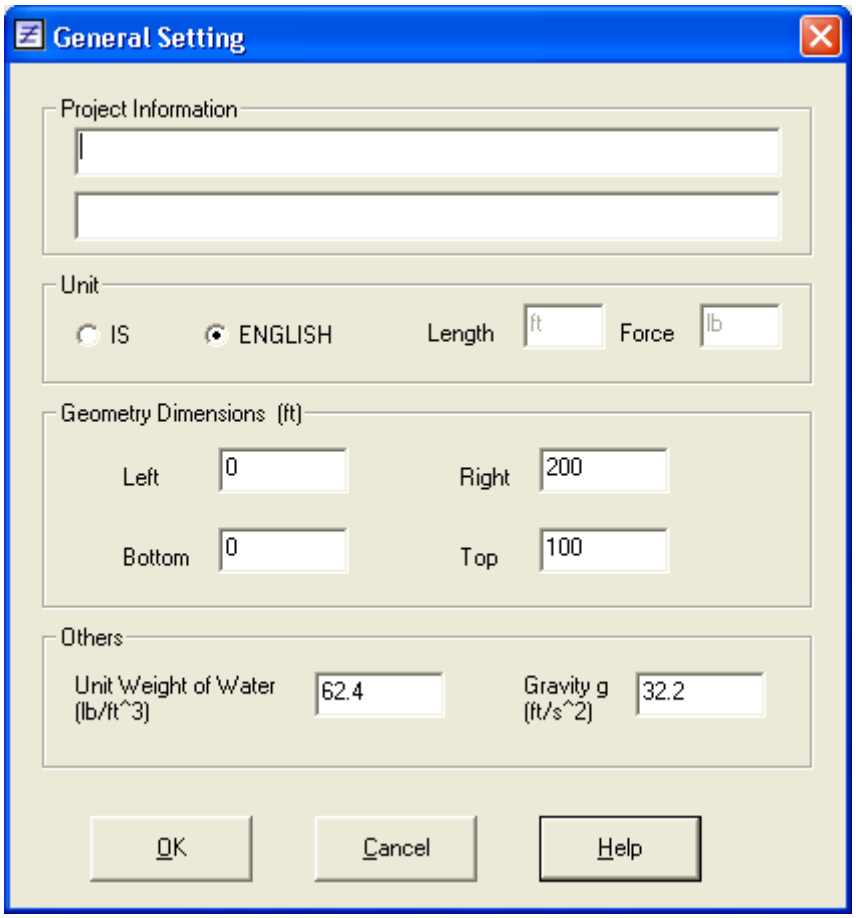

Figure 2 General Setting

On that page, the user can input the project information, select the unit, and define the dimensions that should cover the range of the profile. The general settings can always be modified later from the *File* menu, as shown in Figure 3.

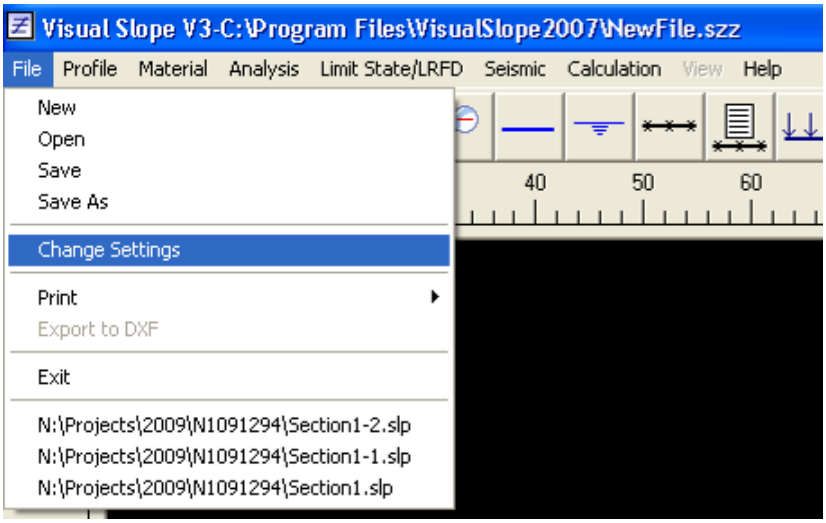

Figure 3 Change Settings

ESTABLISHING PROFILE

A Visual Slope profile (cross section) consists of lines – soil lines, geogrid lines, soil nail/tieback lines, water table lines, etc., similar to those shown in Figure 4. To draw different lines, the user must first click the corresponding line buttons on the *Toolbar*. Figure 5 shows the line buttons on the *Toolbar*.

After choosing the correct line type, the user can begin to draw a profile. There are two ways to draw a line: the direct drawing method or the coordinate input method. The following sections describe how to draw lines, edit lines, and delete lines.

START LINE DRAWING

After a line button is clicked, the program is in the drawing mode and the cursor becomes a cross hair. The user can move the cursor to the position at which the line will begin by referencing either the coordinates shown on the horizontal scale located immediately below the *Toolbar* and the vertical scale located on the left side of the screen, or the coordinates displayed at the lower left corner of the screen, as shown in Figure 6. Left click the mouse button to begin a line. Move the cursor to the end point of the line, following the same process mentioned above.

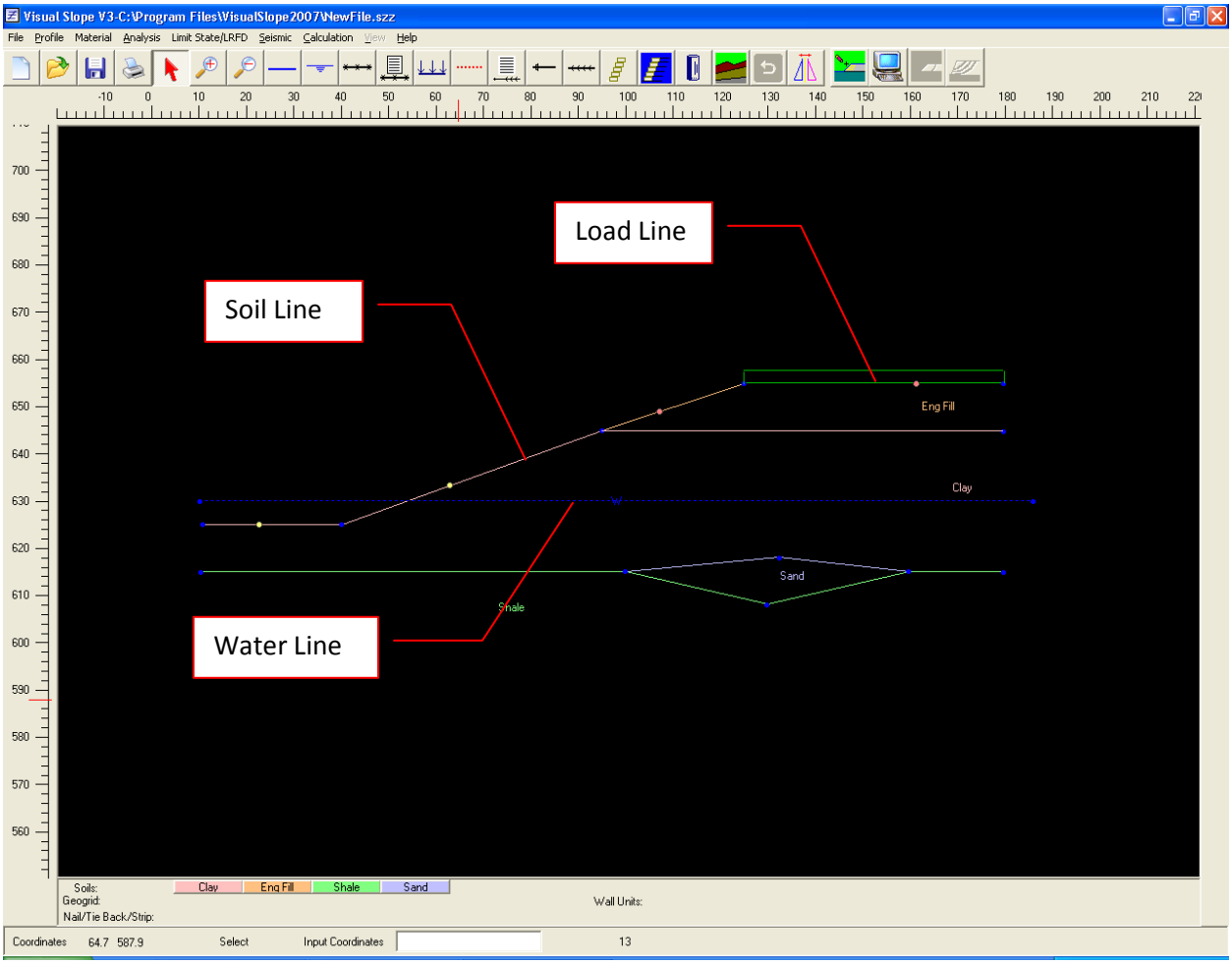

Figure 4 Typical Visual Slope Profile

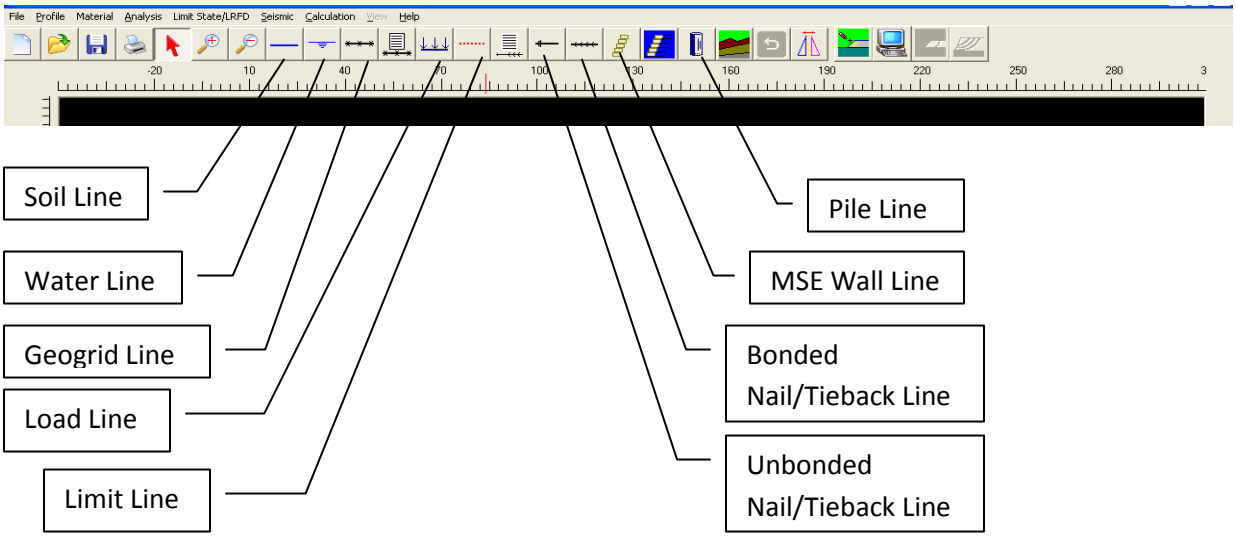

Figure 5 Line Buttons

Repeat the above procedure for the following lines. Visual Slope will automatically start the next line at the end point of the previous line.

STOP LINE DRAWING

To stop drawing or to start a line from a different position, right click the mouse button or press the *Esc* key on the keyboard.

DATA ENTERING METHOD

Besides referencing the coordinates from the scales or from the coordinates display, the user can also type the horizontal and vertical coordinates into the *Coordinate Entry* box at the bottom of the screen. Both the horizontal and vertical coordinates should be separated by a space. For example, if the horizontal coordinate is 50.1 and the vertical coordinate is 635.4, the user can type 50.1 635.4 into the *Coordinate* box (Figure 7) and press the *Enter* key on the keyboard. The line will start at that point. The same method can be used for the end point.

Besides using vertical and horizontal coordinates, the user can also use length and angle for the end point input. For example, if the line length is 10.3 and the slope is 20 degrees above the horizontal line, the user can type 10.3 <20 into the coordinate box (Figure 8) and press the *Enter* key on the keyboard. The length and the angle must be separated by a space.

RULES OF LINE DRAWING

1. A line must be drawn from left to right. Otherwise Visual Slope will ask the user to re-draw.

2. For soil lines, if they are connected, they must connect at their end points and cannot connect at the middle point of the line.

3. Visual Slope does not require the lines to be drawn in a specific sequence. Lines can be drawn in any order. Lines can also be added or deleted anywhere as desired.

SNAP ON FEATURE

If a new line point is very close to an existing line point, the new line point will automatically snap on to the existing line point.

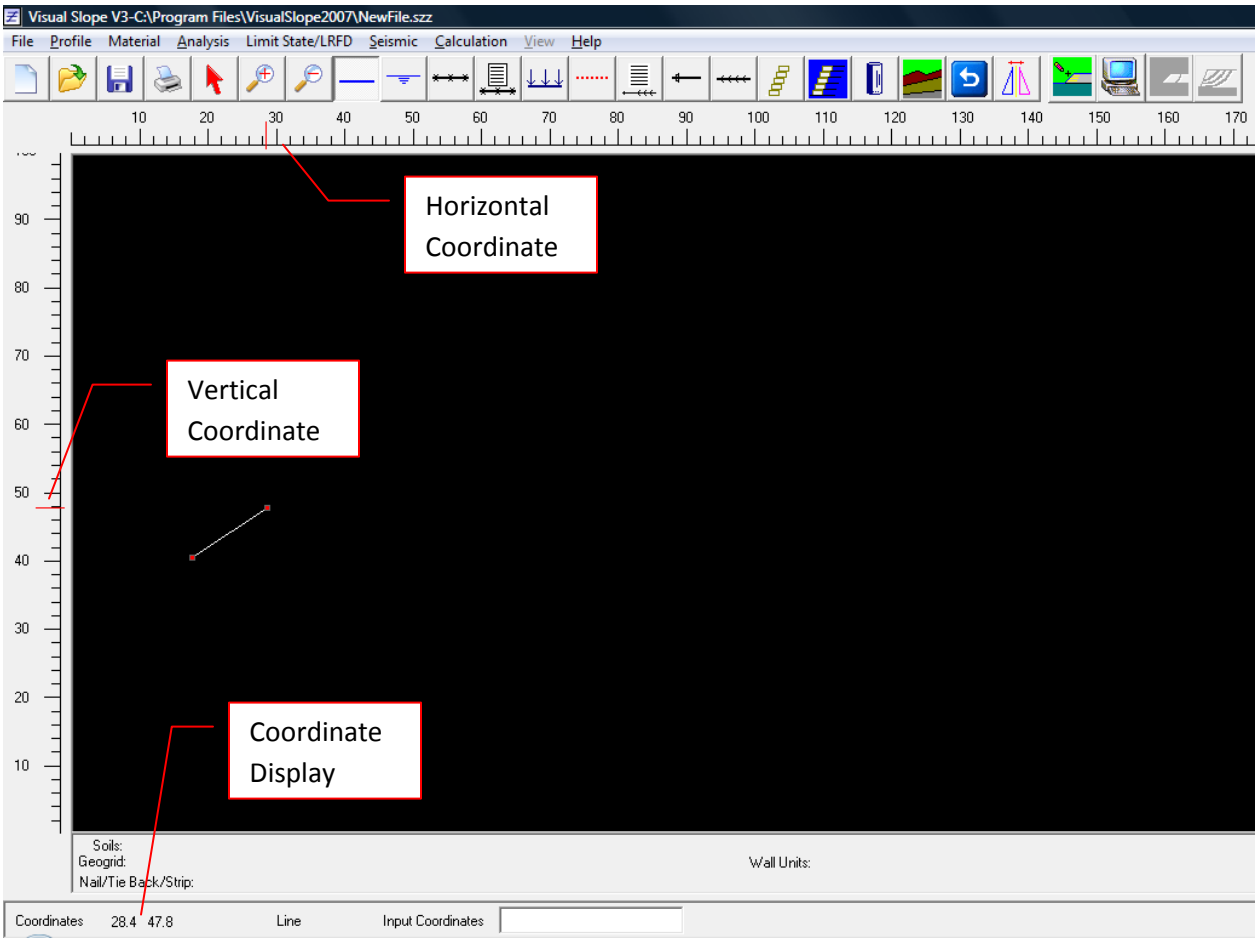

Figure 6 Coordinate Indicators

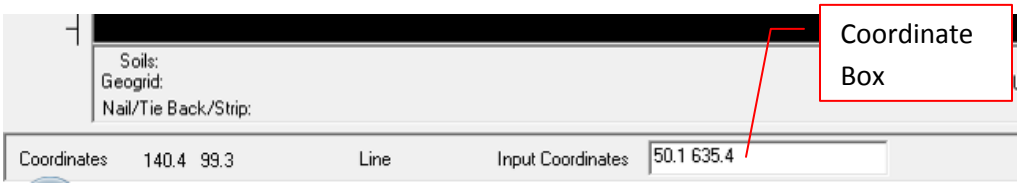

Figure 7 Coordinate Input

Figure 8 Length-Angle Input

EDIT OR DELETE LINE

To edit or delete a line, click the *Select* button on the *Toolbar*, and then move the cursor to the line to be edited or deleted and click the line. The *Select Dialog Box* will appear (Figure 9). Select the line in the dialog box and click the *Delete* button. The selected line will be deleted.

SURCHARGE LOAD

Surcharge loads can be added by using a drawing method similar to drawing other lines. Click the *Load* button on the *Toolbar* or choose *Load* from the *Profile* menu. Then, draw the surcharge load from left to right. The initial load intensity is 1. To specify the load intensity, the user can use the *Line Edit* method, referring to the last section. The user should also specify the load as "live" or "dead." This process is shown in Figure 10.

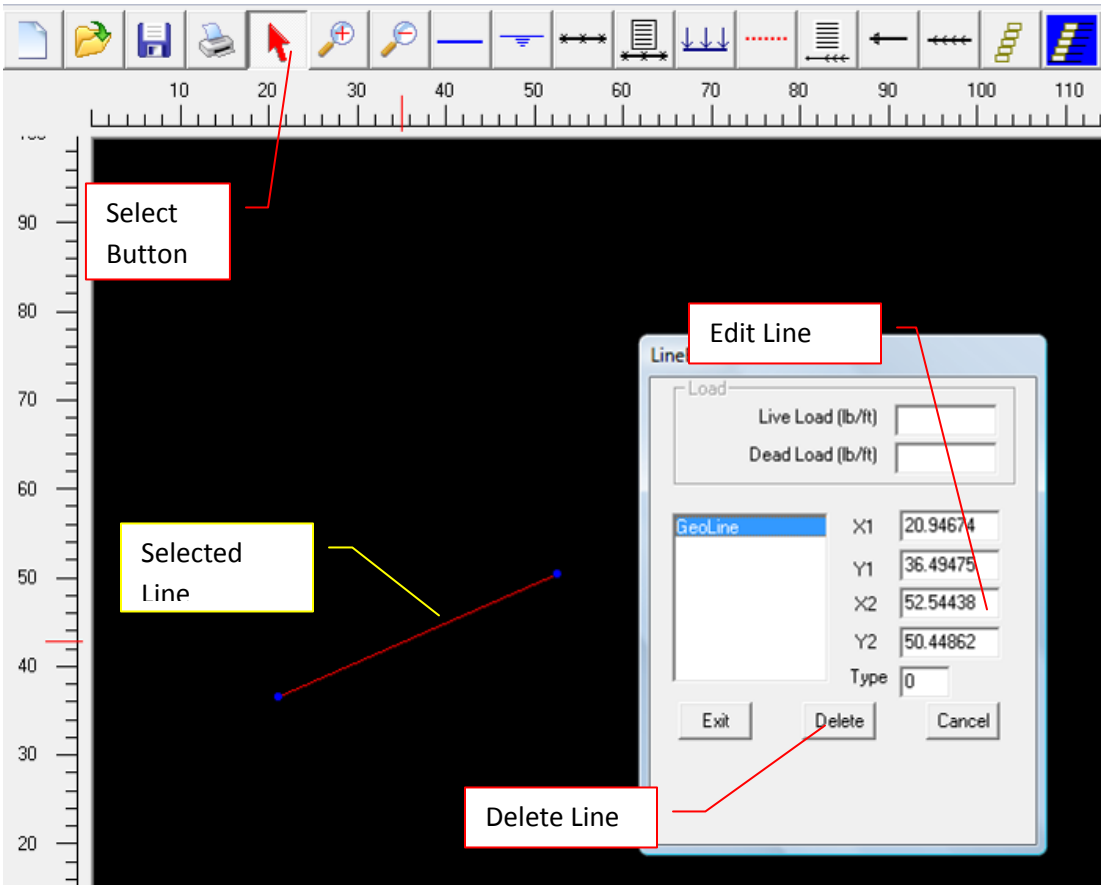

Figure 9 Edit or Delete a Line

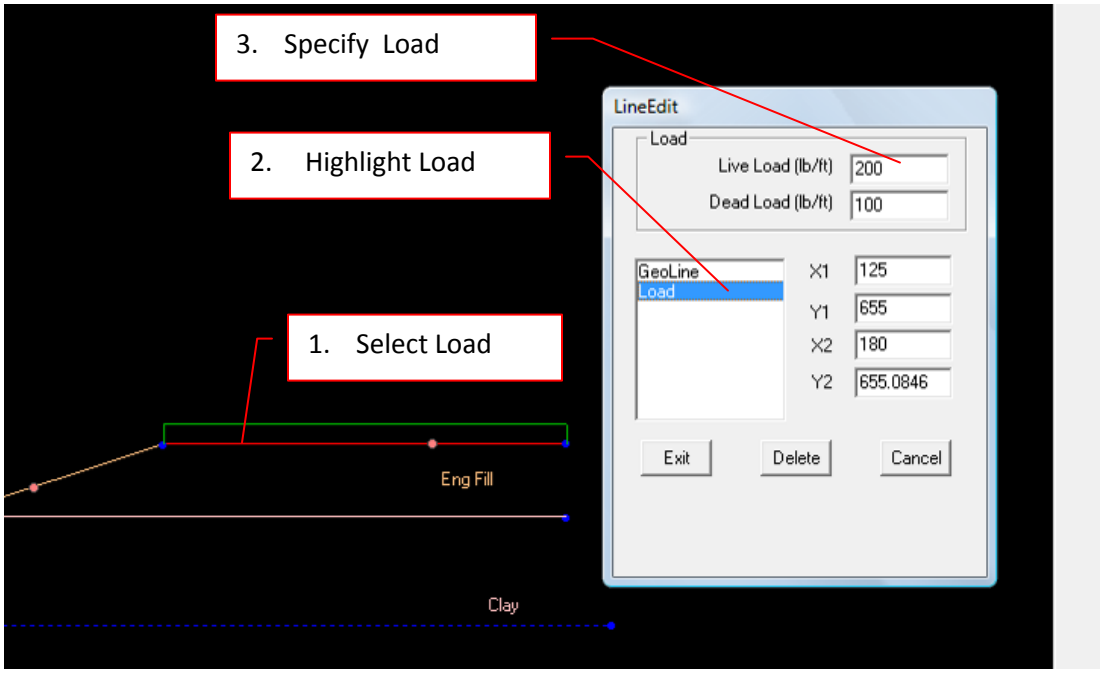

Figure 10 Specify Load Intensity

OTHER FEATURES

To help users establish profiles, Visual Slope provides many other features, such as *Zoom In*, *Zoom Out*, *Undo,* and *Flip*.

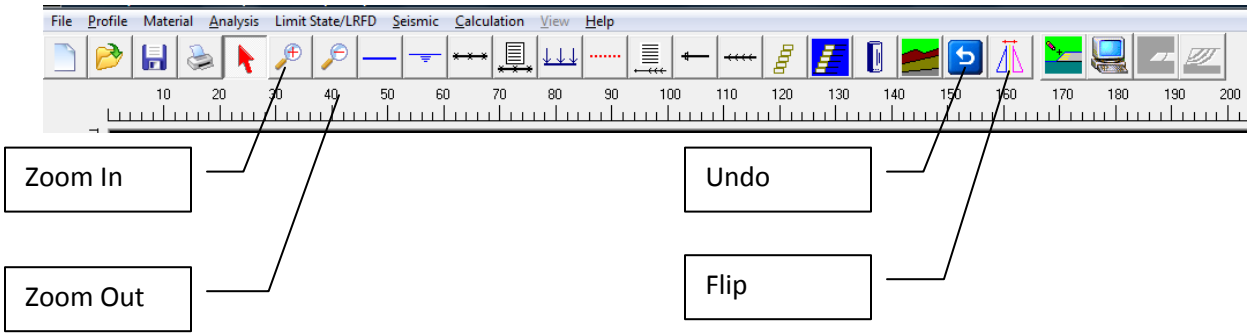

Figure 11 Other Features

Zoom In and Zoom Out

The *Zoom In* and *Zoom Out* features help users:

1. Draw details in a small area
2. Perform an analysis focused on a specific area

To zoom in an area, click the *Zoom In* button, hold the left mouse button down, drag diagonally across the area to be zoomed in, and then release the button.

To zoom out, click the *Zoom Out* button.

Undo

To undo, click the *Undo* Button. The user can undo up to 5 steps back.

Flip

A slope, MSE wall, or shoring system to be analyzed must face left. However, in some cases the original slope may face right or have slopes on both sides that need to be analyzed, such as a dam. The *Flip* feature can be used to flip the slope from right to left for the analysis.

MATERIAL PROPERTIES

Material properties in Visual Slope include:

1. Soil Properties
2. Geogrid Properties
3. Soil Nail/Tieback/Metal Strip Properties
4. MSE Wall Unit Properties
5. Wall Unit and Geogrid Connection Properties.

The user must set up the material properties before running an analysis. The type of materials needed depends on the type of analysis to be performed. In an MSE wall analysis, for example, soil, geogrid, and wall unit, as well as connection properties, are required. Visual Slope provides the most commonly used material properties in its material banks for users to employ. Users can also save their own material properties into the bank for future use.

The following sections describe how to:

1. Set up material properties
2. Use the material properties saved in the material banks
3. Save material properties into the material banks for future use

4. Assign the material properties to the profile

SET UP MATERIAL PROPERTIES

To set up material properties, the user must first click the *Material* button (Figure 12) on the *Toolbar*. The *Material Input* page (Figure 13) will appear.

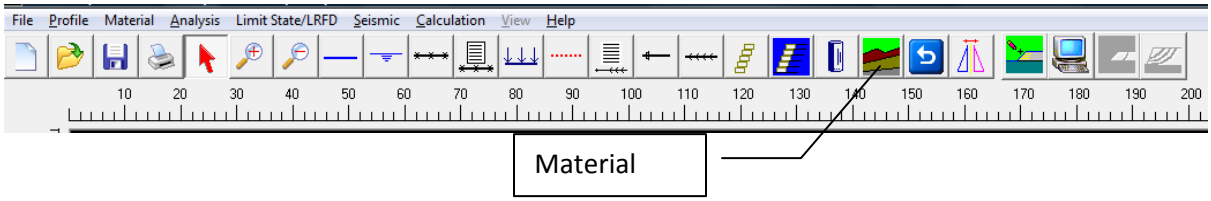

Figure 12 Material Button

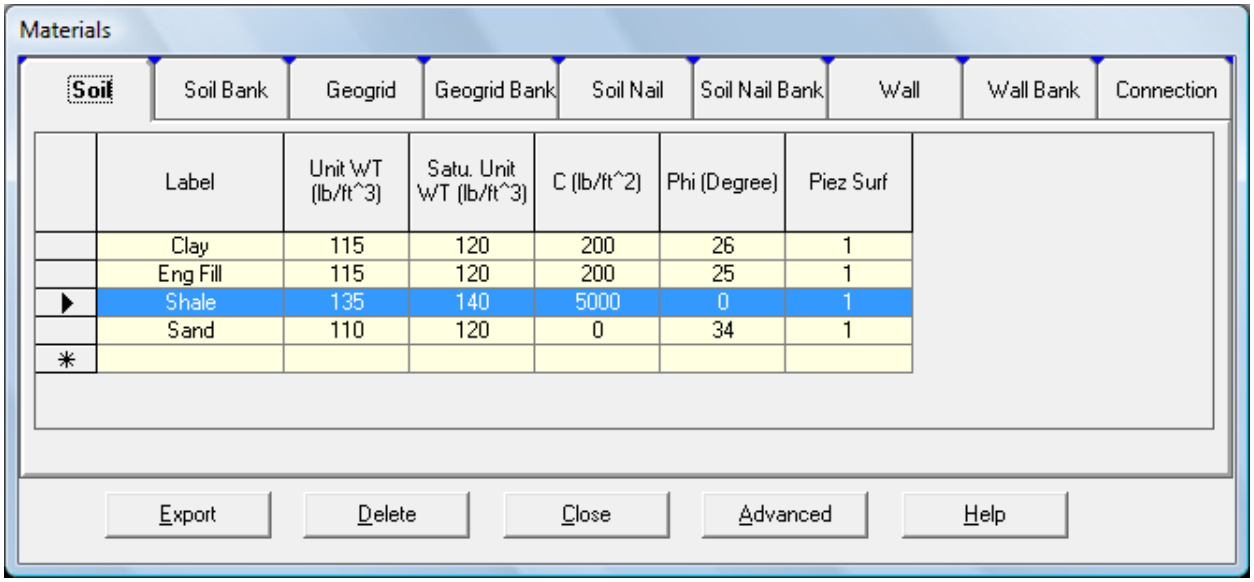

Figure 13 Material-Input Page

At the *Material Property* page, the user can select different types of materials by clicking the corresponding tabs and typing in the parameters.

To delete a material, select the row to be deleted and then click the *Delete* button.

After finishing, click the *Close* button.

SAVE TO MATERIAL BANKS

To save a material to the corresponding bank, select the row to be saved and click the *Export* button. This material is saved to the database and can be used for different projects.

USE SAVED MATERIALS

To use the materials saved in the material bank, click the corresponding *Material Bank* tab first. From the *Material Bank* (Figure 14), select the row to be used and click the *Export* button. The material is exported to the current project.

SET UP CONNECTION DATA

The connection data are only used for MSE wall design. Once the data are set up, they can be used by all projects. Visual Slope will search the database for the connection data during an MSE wall analysis. To set up connection data, in the first column of the *Connection* page (Figure 15), select the wall unit that has been saved in the *Wall Bank*, and select the geogrid that has been saved in the *Geogrid Bank* from the second column. After selection of the wall unit and geogrid, type in the remaining connection data. The connection data should be from the wall unit manufacturer.

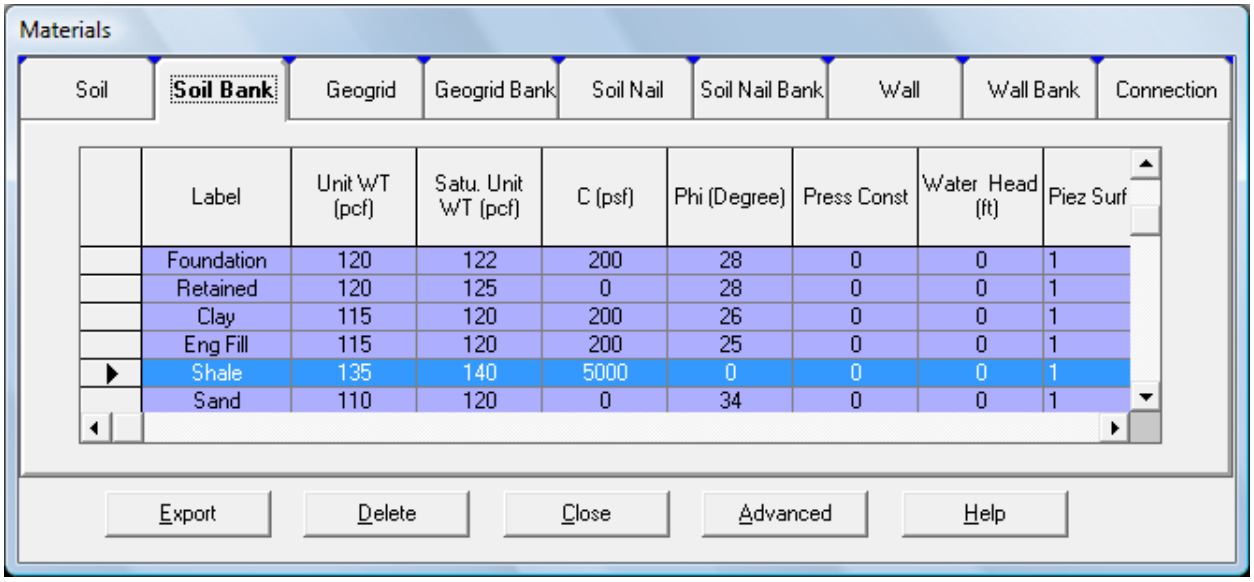

Figure 14 Material Bank

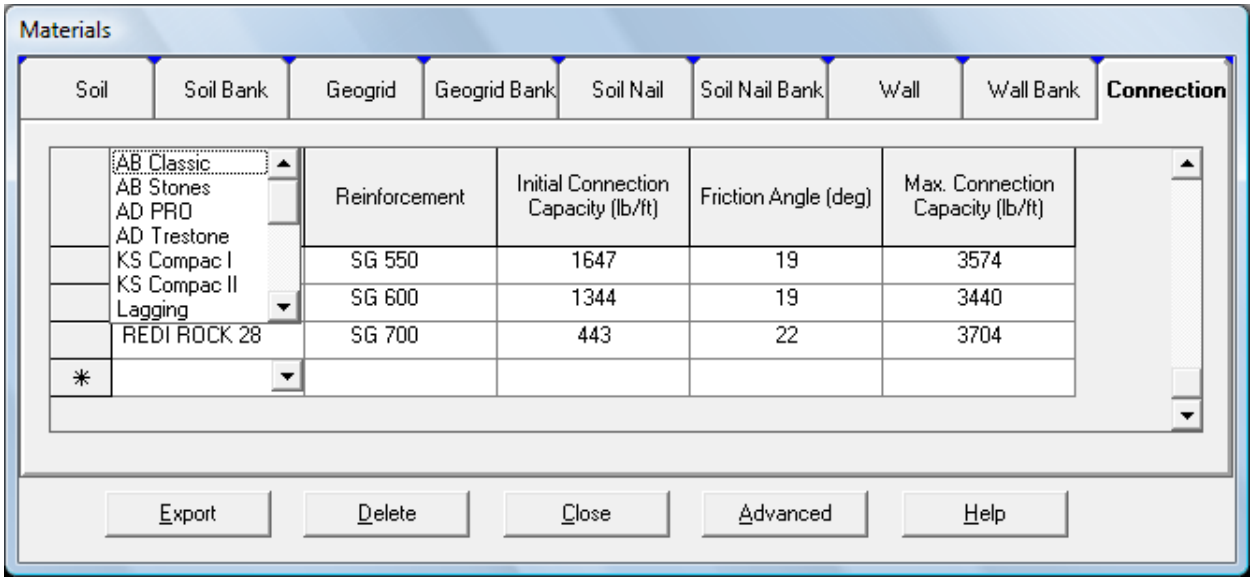

Figure 15 Set up Connection Data

MATERIAL PROPERTY ASSIGNMENT

Once the *Material* page is closed, material buttons will appear on the *Material Bar* at the bottom of the screen. The user can assign the materials to the profile.

Soil Property Assignment

To assign soil properties to soil layers, click the *Soil* button first and then click the zone to which the soil properties should be assigned. The color of the soil lines above the zone will change to the same color as that of the button. The soil name will appear on the zone. This process is shown in Figure 16. To remove the soil name label, double click it.

Material Properties Assignment to Other Objects

To assign material properties to other objects, such as soil nail, geogrid, or MSE wall, click the *Material* button first and then click the corresponding object, as shown in Figure 17. The color of the object line becomes the same color as that of the button.

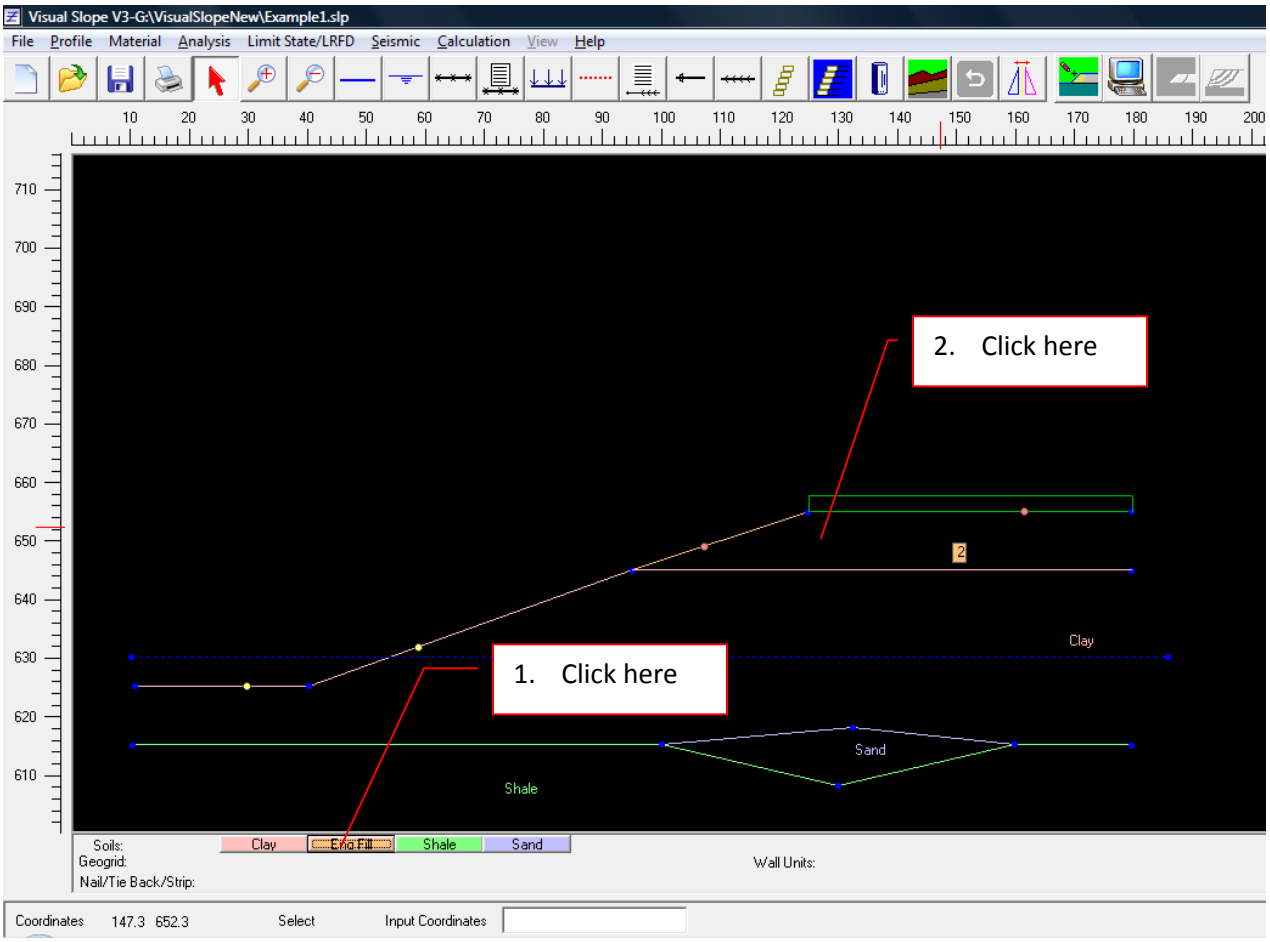

Figure 16 Assign Material

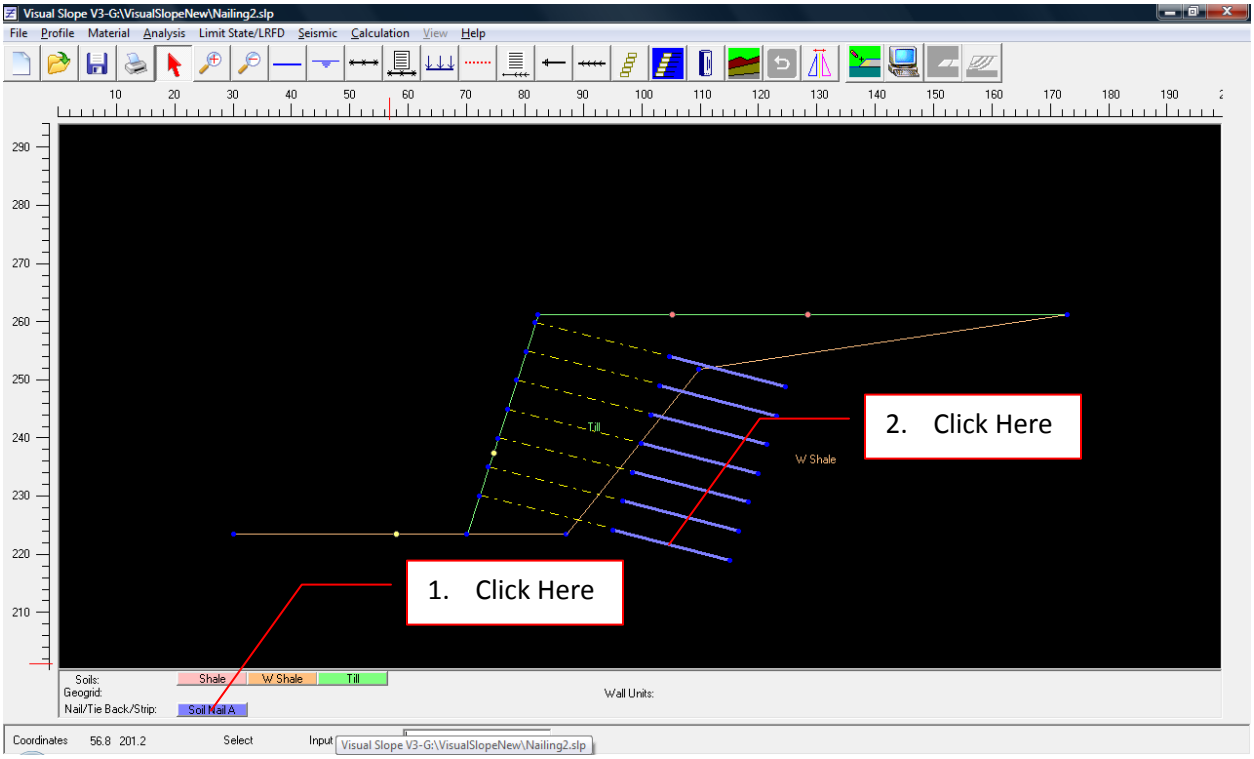

Figure 17 Material Assignment to Other Objects

ANALYSES

SLOPE STABILITY ANALYSES

Visual Slope can perform three types of slope analyses:

1. Circular Failure Surface with Modified Bishop Method
2. Translational Failure Surface with Janbu Method
3. User Specified Failure Surface with either Modified Bishop Method or Janbu Method depending on the shape of the specified failure surface

These three types of failure surfaces can also be analyzed with the Spencer Method, if that is chosen. The following sections describe how to perform these three types of analyses with Visual Slope.

Circular Failure Analysis

To perform circular failure analysis, click *Circular Failure* from the *Analysis* menu, as shown in Figure 18. The *Circular Failure Input* box will appear (Figure 19). A circular failure analysis is specified by five numbers: 1) X-coordinate of leftmost initiation point; 2) X-coordinate of left termination point; 3) X-coordinate of rightmost initiation point; 4) X-coordinate of right termination point; and 5) Number of failure surfaces.

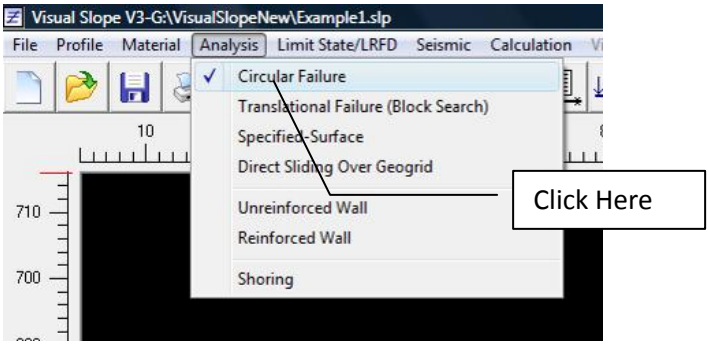

Figure 18 Circular Failure Analysis

The user can type X-coordinates into the corresponding data boxes. More conveniently, the user can click the button next to the data box and then move the cursor to the position where the user wants the X-coordinate to be and click. The X-coordinate of this position will be input into the data box and a dot will appear on the top boundary with that X-coordinate. Those steps are shown in Figure 19.

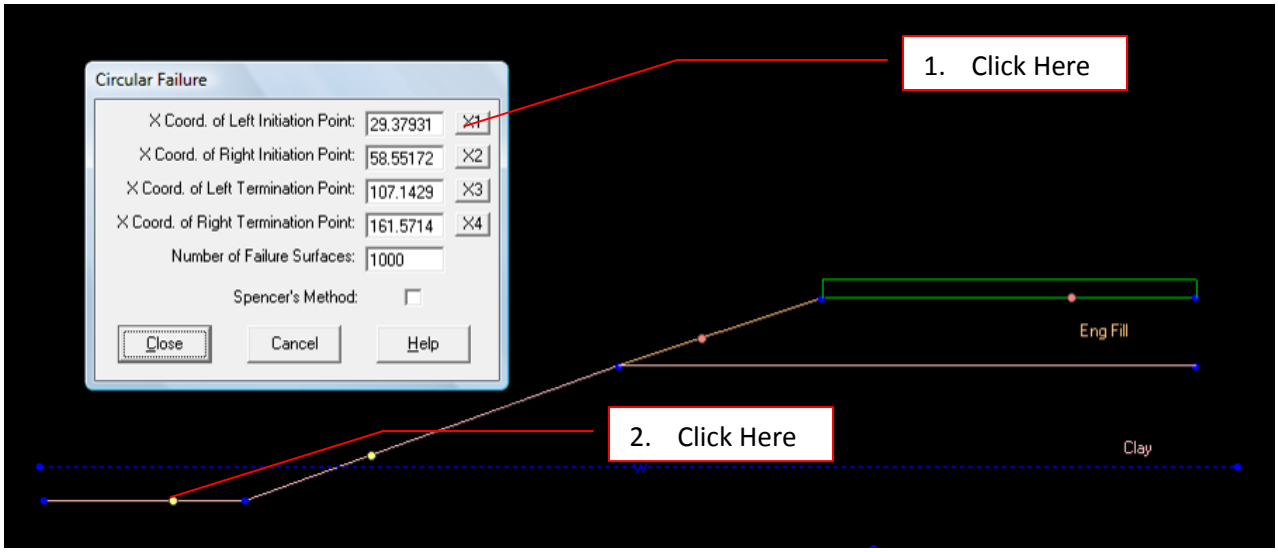

Figure 19 Set up Circular Failure Analysis

The number of failure surfaces should be an integer. It is recommended that this number be at least 500.

If the user wants to use the Spencer Method for the analysis, the *Spencer Method* check box should be checked.

For the analysis, click the *Calculation* button. After the analysis is completed, click the *Curve* button to see the failure surfaces (Figure 20).

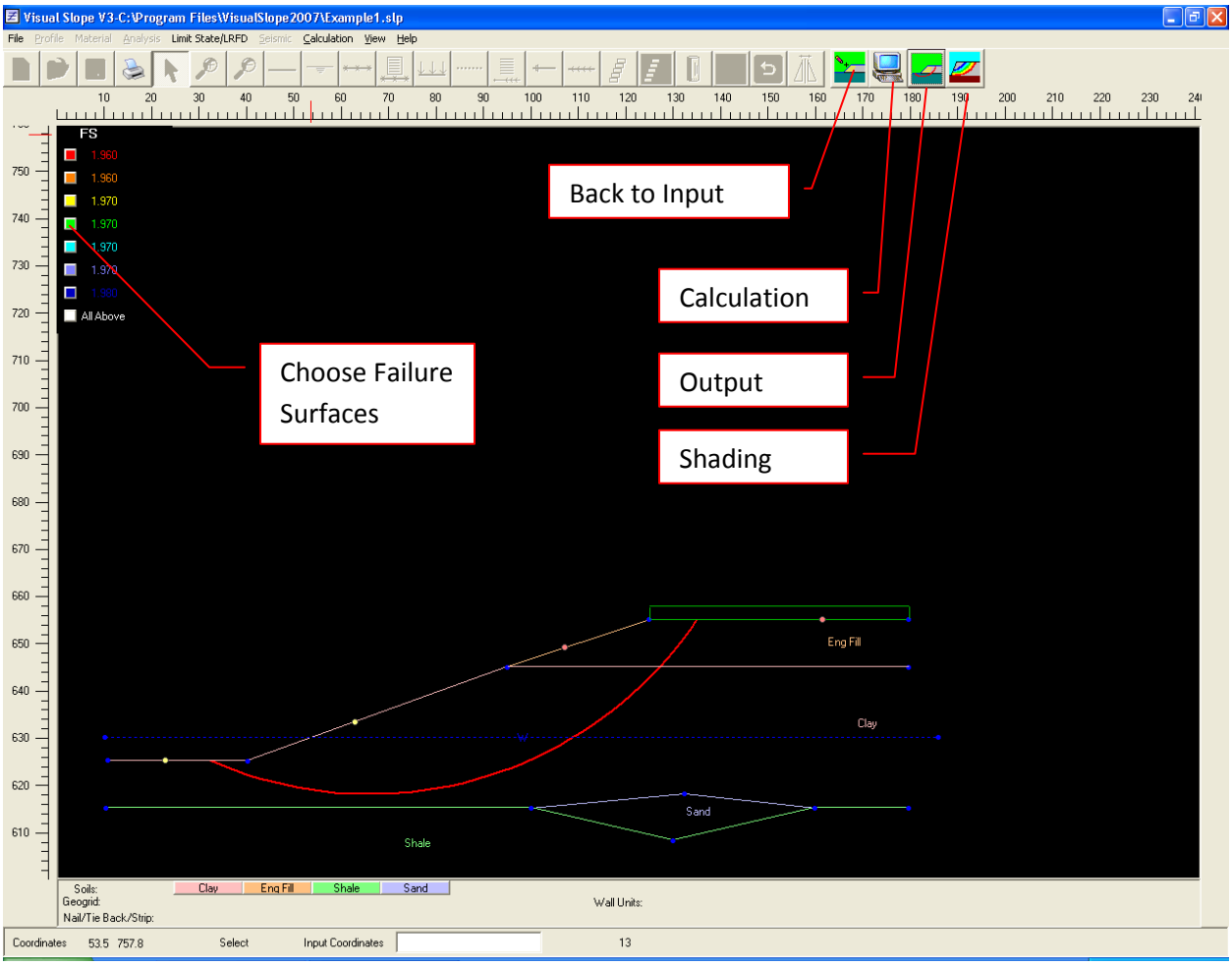

Figure 20 Result of Analysis

Translational Failure Surface Analysis

Translational Failure Surfaces are defined by a group of sliding blocks from left to right. Each block is specified by five numbers: 1) X-coordinate of the left end of the center line defining the block; 2) Y-coordinate of the left end of the center line defining the block; 3) X-coordinate of the right end of the center line defining the block; 4) Y-coordinate of the right end of the center line defining the block; and 5) Height of the block.

The user can type the coordinates and height of the block into the input data cells. More conveniently, the user can single click the X-coordinate data cell, at which point a button will appear. The user can click the button and move the cursor to the position of the left or right center of the block and click. The X and Y coordinates will automatically be input into the data cells and the side of the block will appear on the computer screen. Using a similar approach, the user can specify the height of the block. This process is illustrated in Figures 21 through 23.

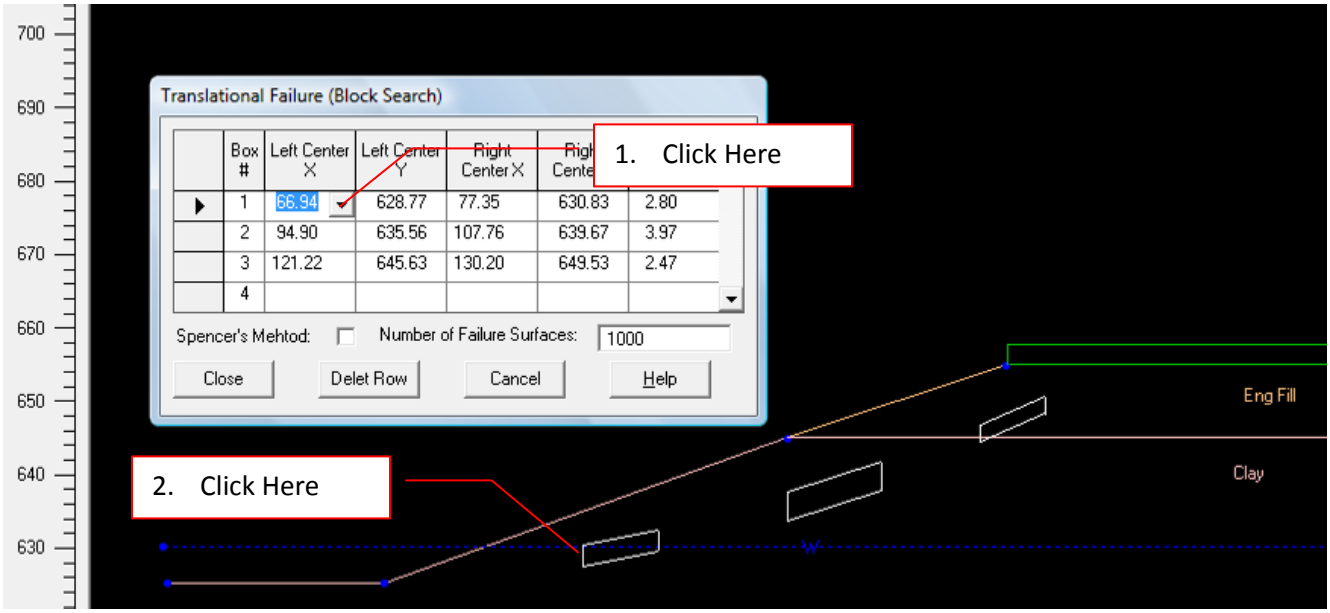

Figure 21 Coordinates for Left Side

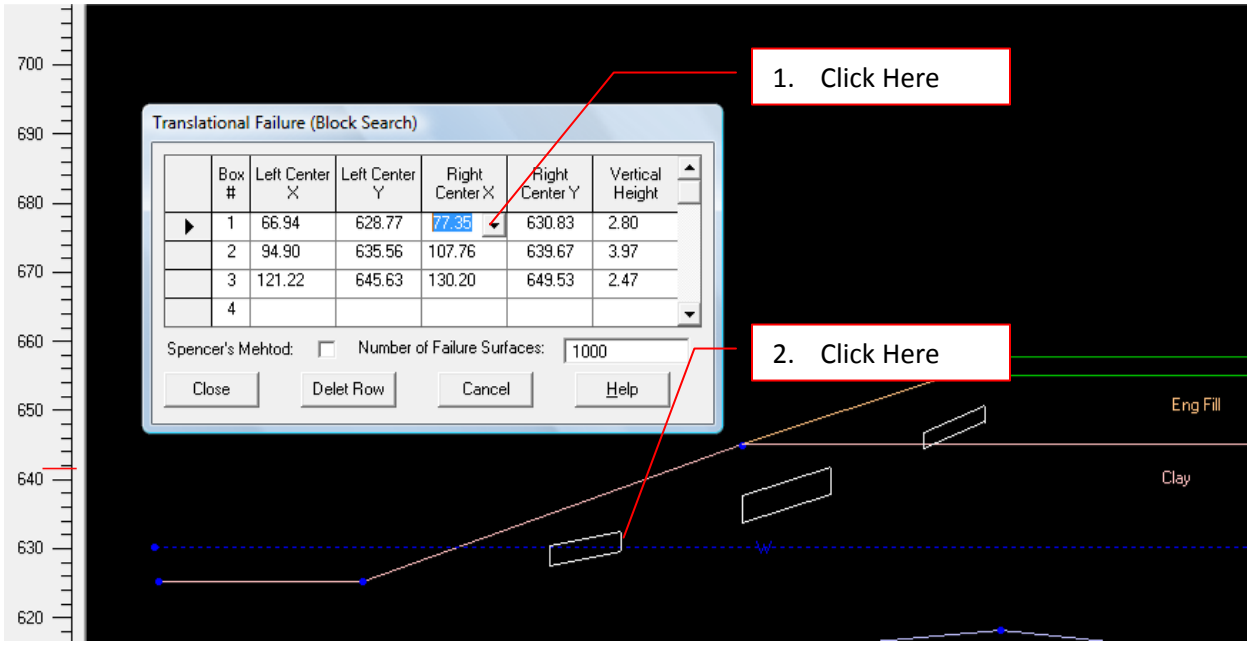

Figure 22 Coordinates for Right Side

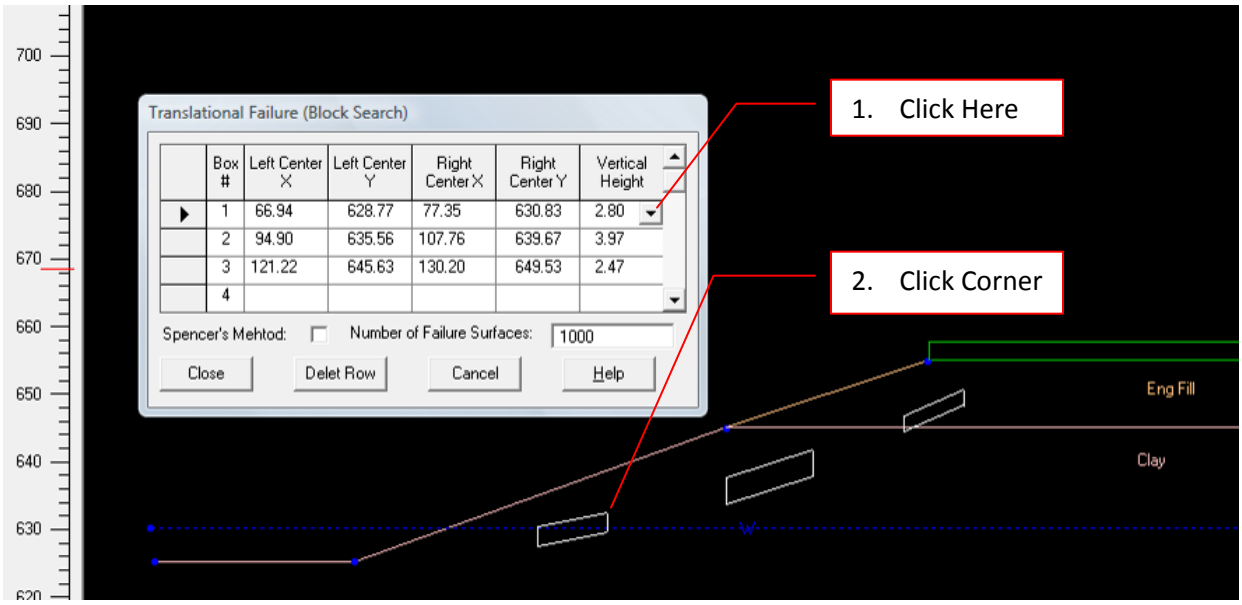

Figure 23 Height of Block

User Specified Single Failure Surface

Visual Slope allows the user to specify a potential failure surface for an analysis. The method for the analysis will depend on the shape of the failure surface. The failure surface is defined by a series of X and Y coordinates. The user can type the coordinates into the data cells manually,

or use the drawing method. To use the drawing method, the user can single click the X-coordinate cell. A button will appear, as shown in Figure 24. The user can then click the button and move the cursor to the point on the failure surface and click at that point. The X and Y coordinates of that point will be input into the data cells. A failure surface line will appear on the screen after the second point is defined (Figure 25).

Repeating the above process, the user can draw a complete failure surface (Figure 26). The failure surface should be specified consecutively from left to right. The start point and end point of the failure surface should be slightly beyond the ground surface of the slope.

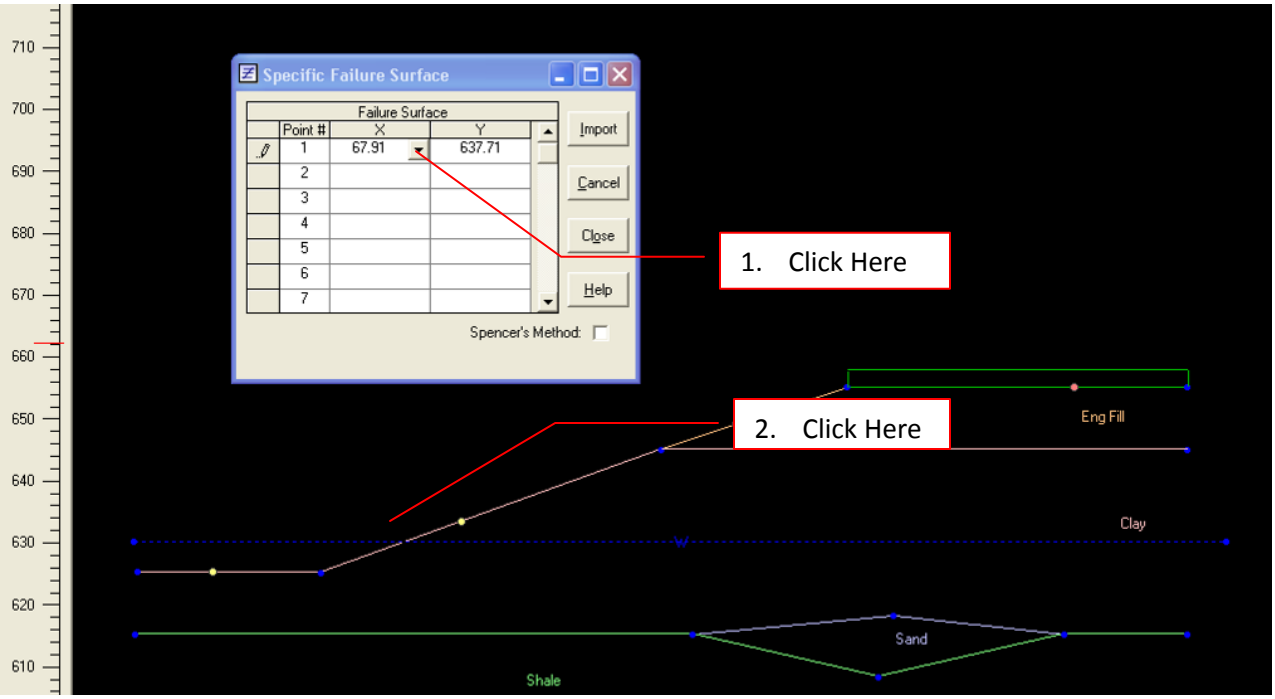

Figure 24 Draw Failure Surface

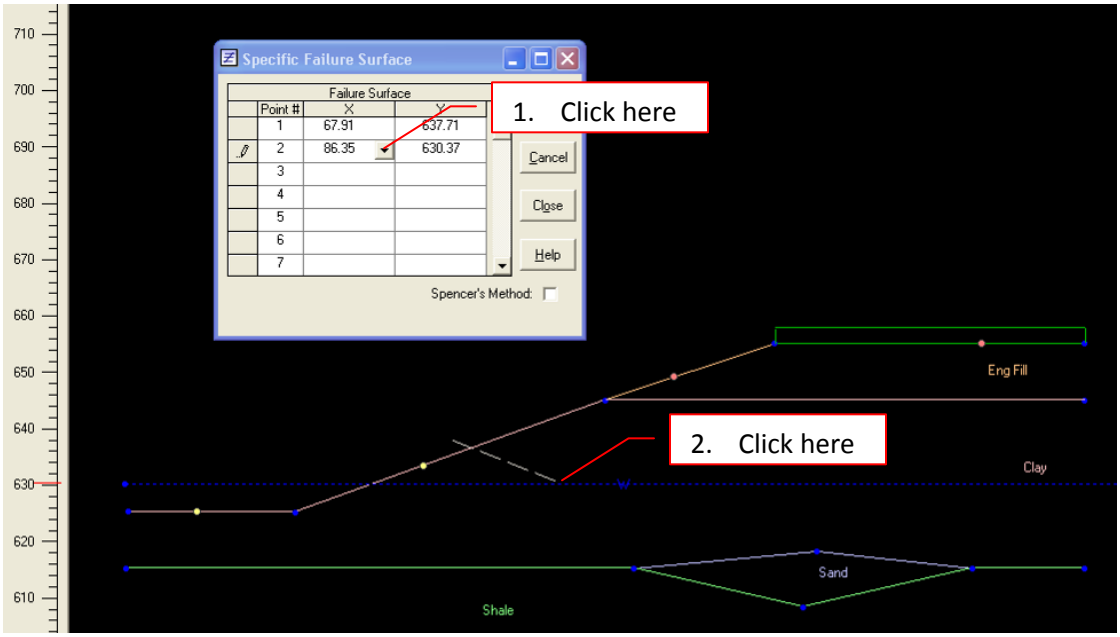

Figure 25 Continue to Draw

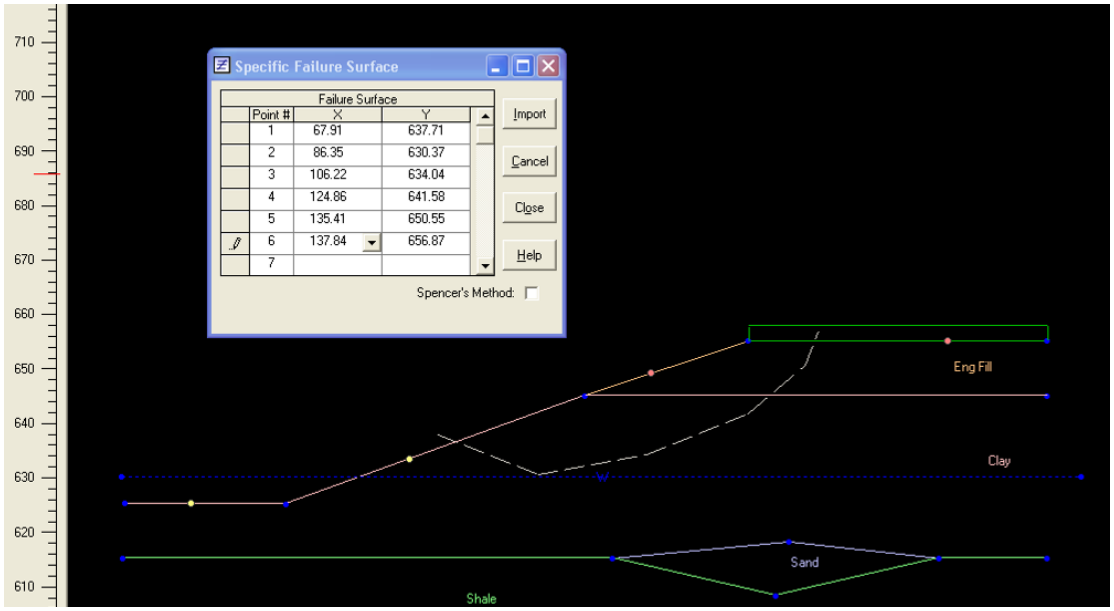

Figure 26 User-Defined Failure Surface

REINFORCED SLOPE DESIGN

If a soil fill slope is too steep, it may not meet the slope stability requirement. To increase slope stability, geogrid or geotextile can be used as reinforcement for the slope. A reinforced slope must meet the minimum factors of safety for circular failure and direct sliding over

geosynthetics. The following sections describe how to use Visual Slope to design a reinforced slope.

Adding Geogrid to Slope

Drawing Method

To add geogrid layers to a slope, the user can draw in the geogrid layer by layer, similar to drawing soil lines. After drawing, the user can assign the material to the geogrid (Figure 27).

Grid Array

The grid array method is easier than the drawing method to generate geogrid layers with the same type and same length at one time. To use the grid array method, the user must set up the geogrid properties first, using the *Material Set Up* dialog box. After materials have been set up, the user can click the *Grid Array* button on the *Toolbar*. The *Grid Array* dialog box will appear (Figure 28). The user must select the geogrid type from the pull down list, and then provide the start elevation, end elevation, vertical spacing, and geogrid length for the corresponding data cells. Once the user clicks the *Close* button, geogrid layers will appear on the profile.

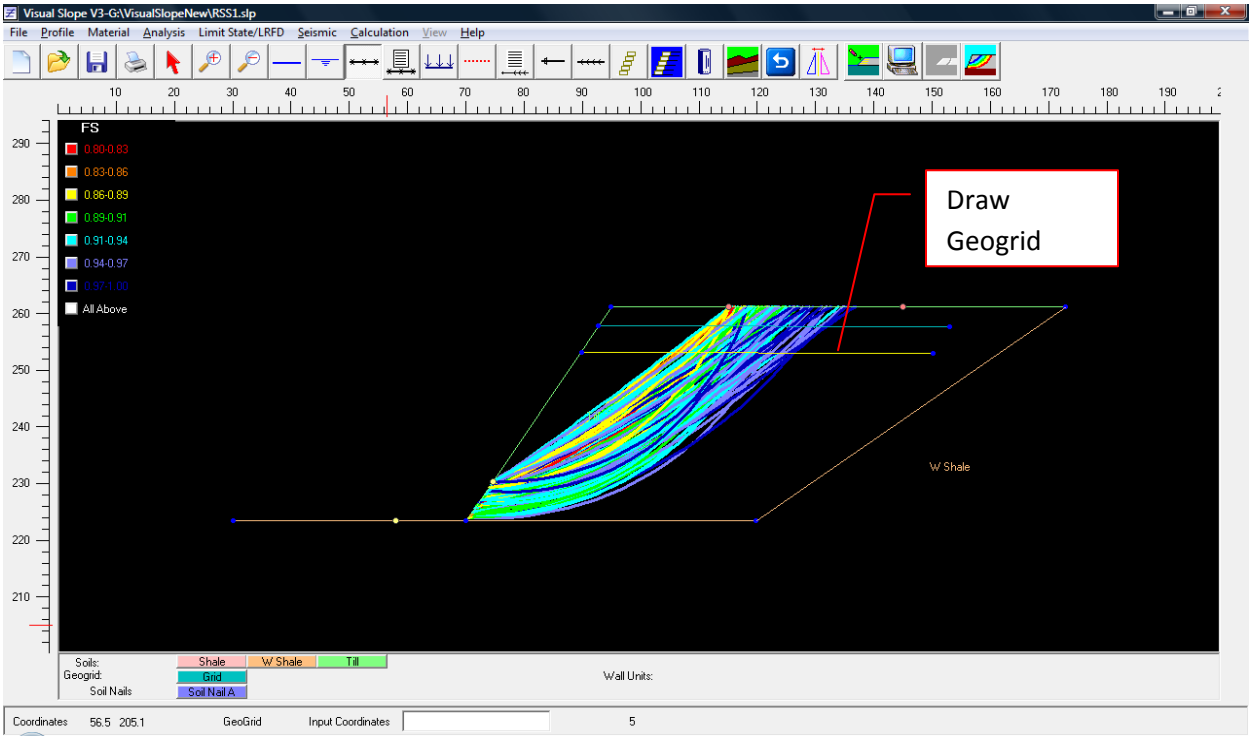

Figure 27 Draw Geogrid

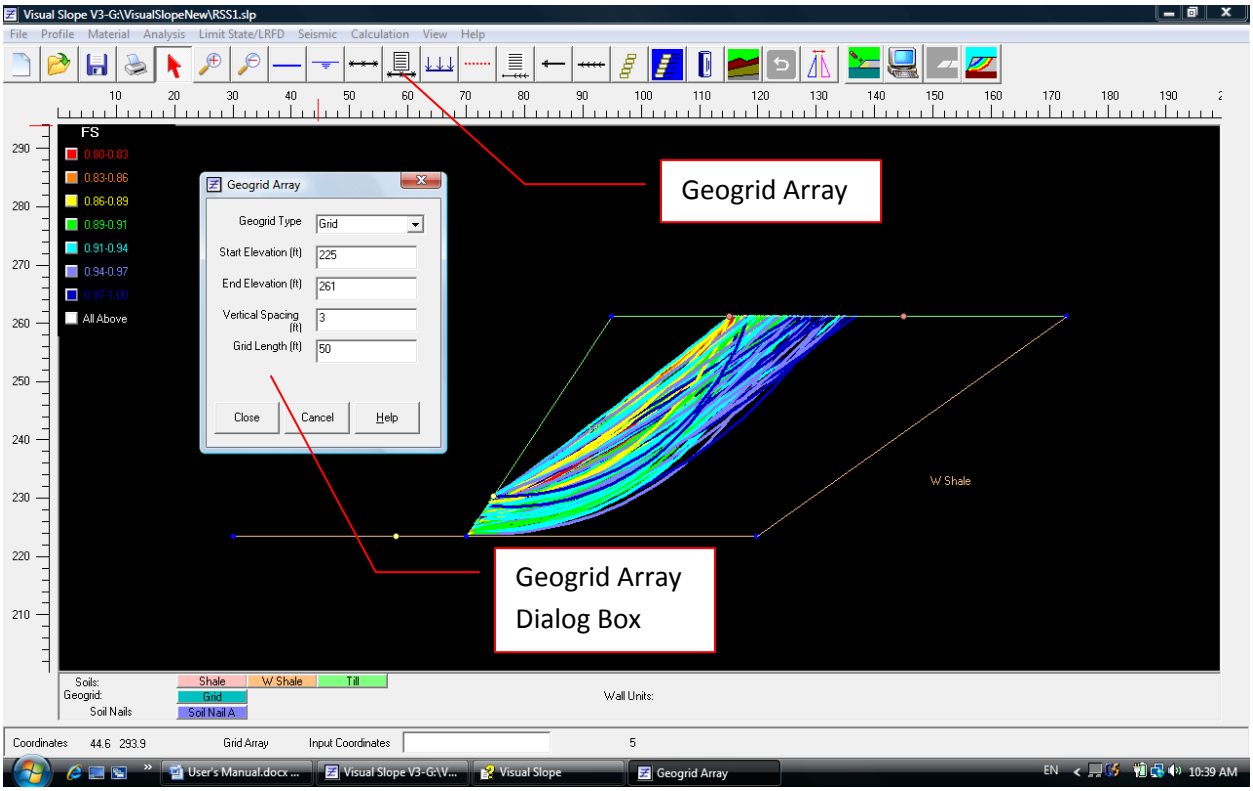

Figure 28 Geogrid Array

The user can use the grid array method repeatedly to generate different types or different lengths of geogrid layers.

The maximum layers of geogrid should not exceed 100.

Circular Failure Analysis

Please refer to the Circular Failure Analysis of Slope Stability Analyses for performance of a circular failure analysis for a reinforced slope. An example of circular failure is show in Figure 29.

Direct Sliding Analysis

To perform an analysis for direct sliding over the geogrid in reinforced slope design, the user can select *Direct Sliding Over Geogrid* from the *Analysis* menu. On the resulting page, the user can see seven of the most critical failure surfaces by clicking the *Failure Surface* buttons. The user can also see the most critical failure surface of each geogrid layer, as shown in Figure 30.

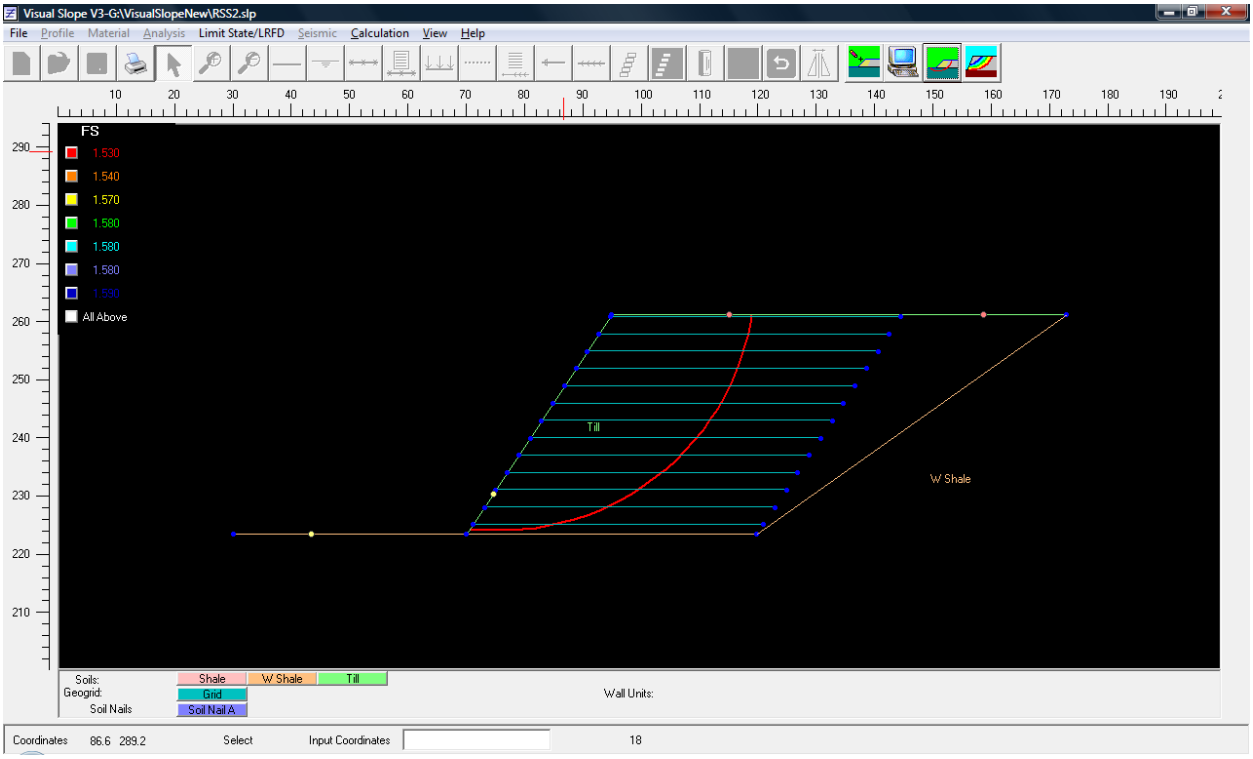

Figure 29 Circular Failure

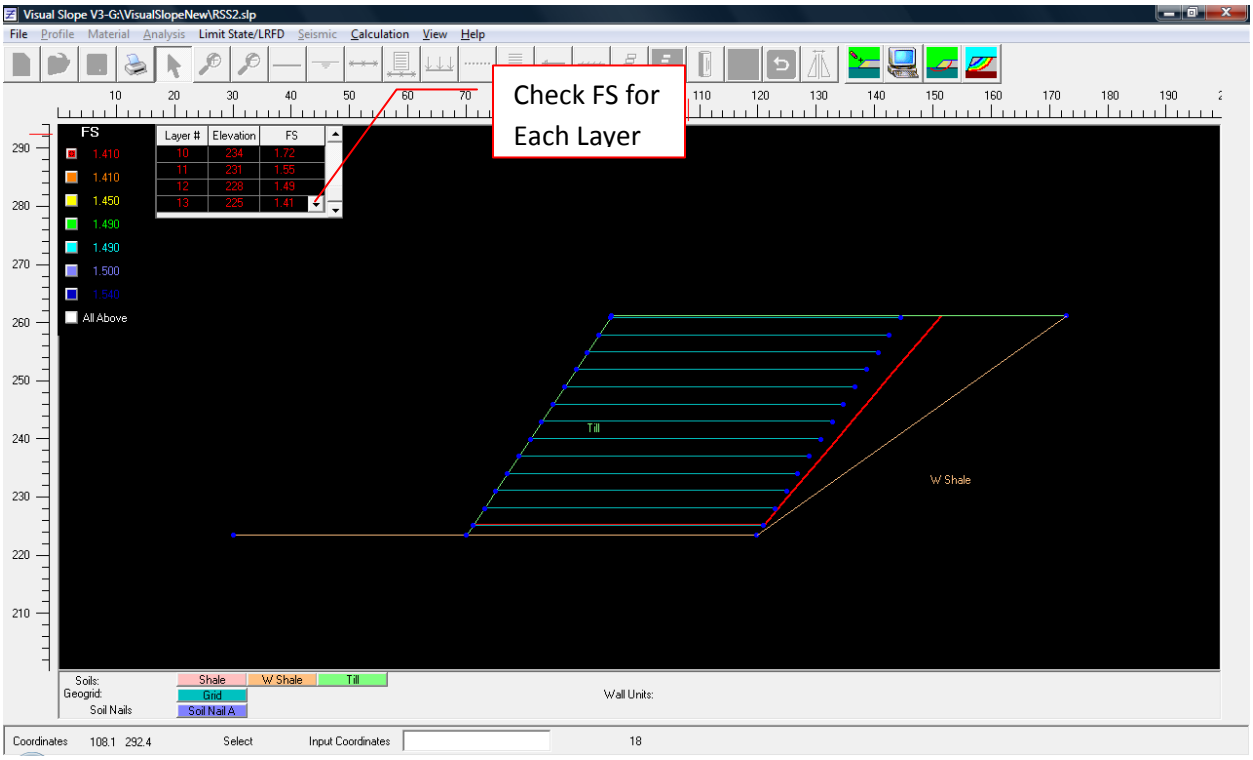

Figure 30 Direct Sliding

MSE WALL DESIGN

Both the NCMA method and the AASHTO method can be used in Visual Slope to perform an MSE wall design. The NCMA method used in Visual Slope is based on the third edition of the *NCMA Segmental Retaining Wall Design Manual*; while the AASHTO method in Visual Slope is, in general, in accordance with the AASHTO 2002 MSE Wall Design Guideline. Visual Slope is also capable of performing LRFD analyses incorporated with the AASHTO method.

An MSE wall is commonly constructed from dry-stacked units that are usually connected through concrete shear keys or mechanical connectors. An MSE wall can be constructed as an unreinforced gravity retaining wall or as a retaining wall with reinforcement, such as a geogrid, geotextile, metal grid, or metal strips. The soils in a reinforced MSE wall analysis can be divided into three zones. The soil within the reinforcement zone is called “reinforced soil.” The reinforced soil and reinforcement (such as geogrid), as well as dry-stacked units, work together and act as a compound gravity wall. The soil behind the reinforced zone is called “retained soil.” The soil that the MSE wall, which includes the dry-stacked column and the reinforced zone, bears on is called “foundation soil.”

An MSE wall analysis includes:

1. Internal Stability
2. External Stability
3. Global Stability
4. Compound Stability
5. Settlement

Visual Slope is capable of providing all those analyses with one simple input file. The following sections describe how to perform an MSE wall analysis with Visual Slope. The process is very similar to performing a slope stability analysis with Visual Slope.

Wall Geometry

Similar to a slope stability analysis, the user should use the *Line Tool* to draw the retaining wall cross section to scale as a design drawing, which includes:

1. The reinforced zone, retained zone, and foundation zone
2. The back slope, a broken back slope, or a front slope, if they exist

Soil strata in the foundation zone are for global stability and settlement analyses. All lines must be drawn from left to right! Do not draw wall units in detail!

To simplify the process, the user can use the *MSE Wall Profile Generator* and *Geogrid Array* together to develop an MSE profile. From the *Toolbar*, click the *Wall Profile* button (Figure 31). Fill out the *Wall Profile* dialog box (Figure 32). The wall profile will appear (Figure 33). Then use Geogrid Array to establish the geogrid layers (Figure 34).

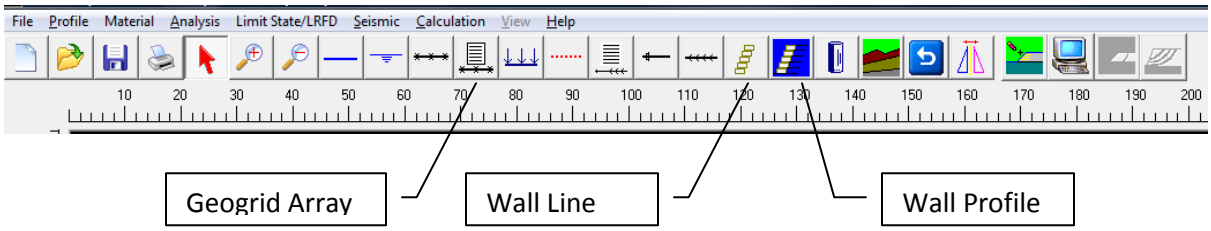

Figure 31 Buttons for MSE Wall

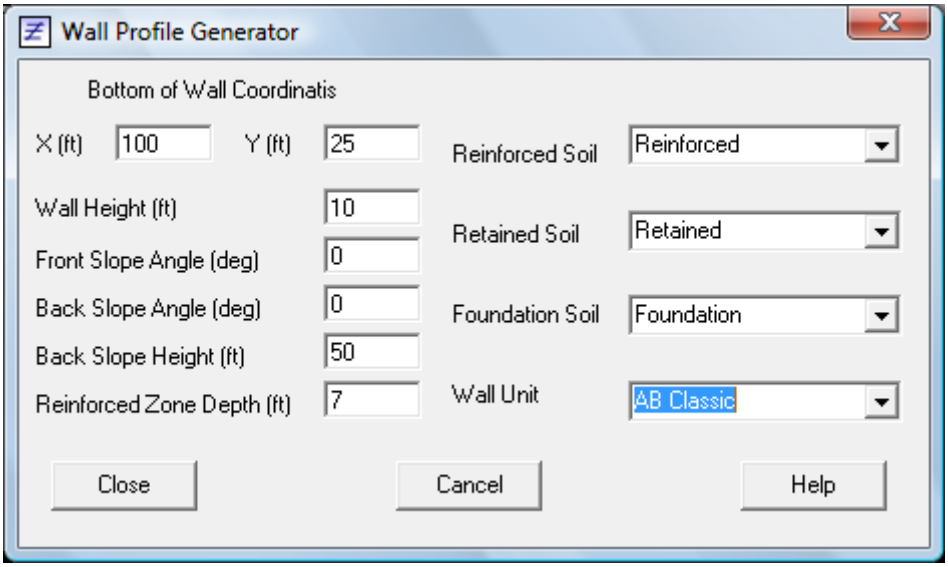

Figure 32 Wall Profile Generator

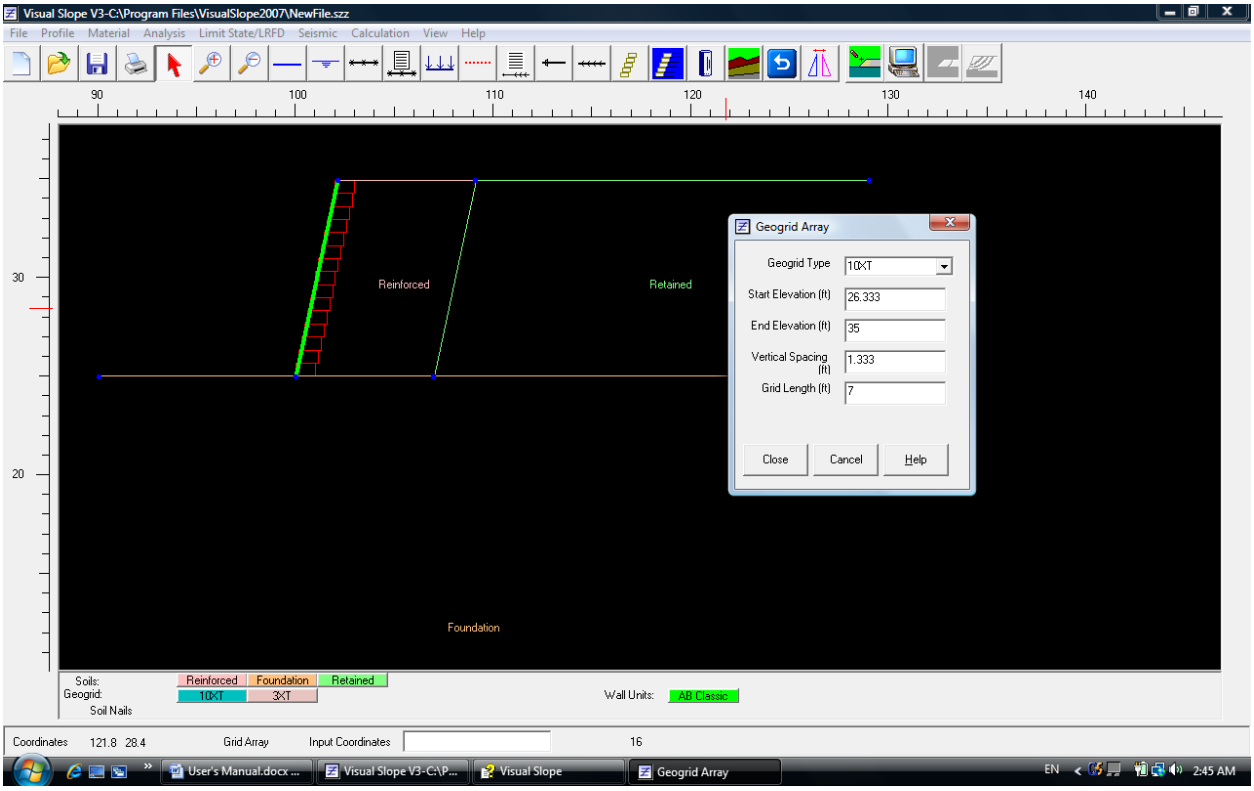

Figure 33 Geogrid Array

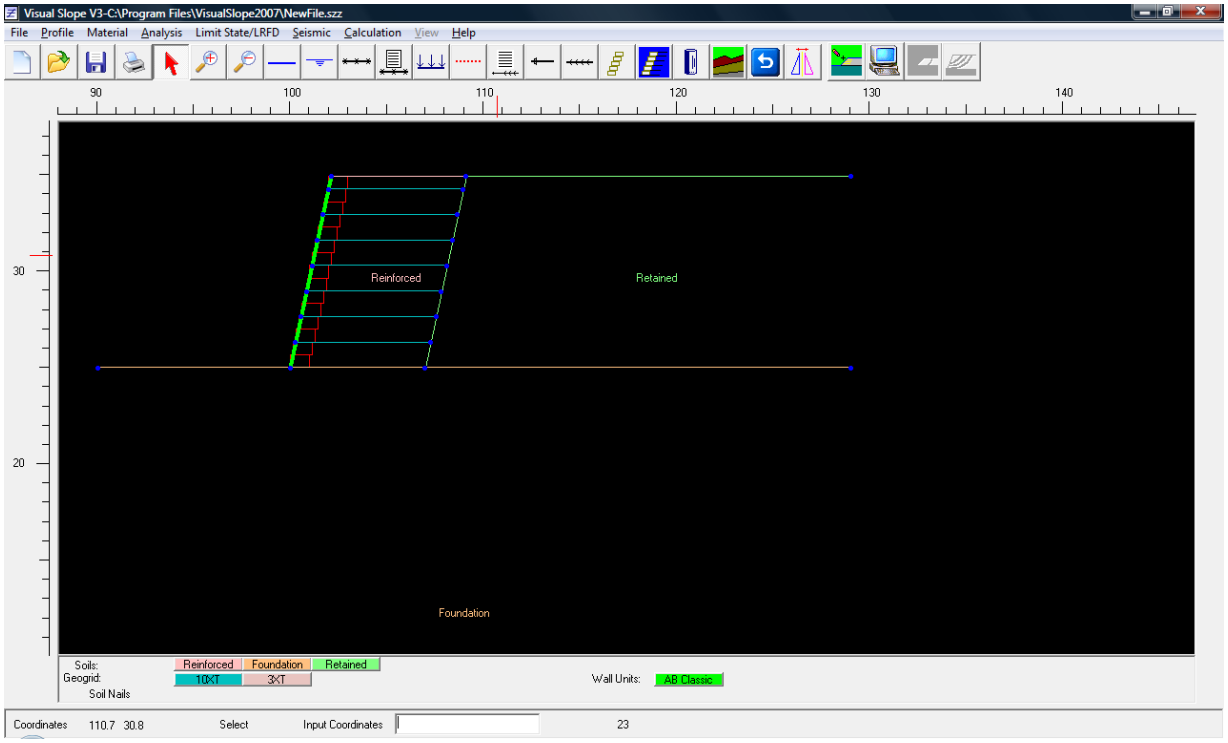

Figure 34 MSE Wall Profile

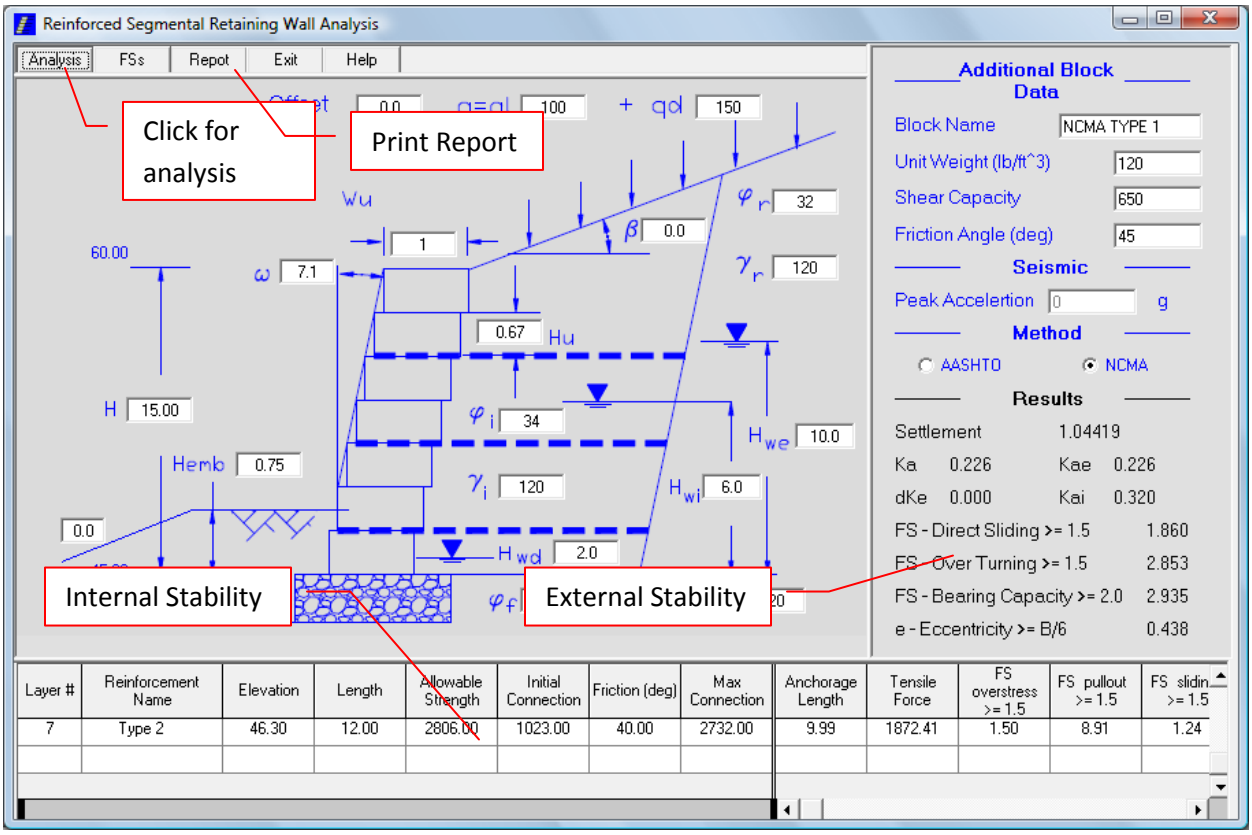

Figure 35 Internal and External Stabilities

Internal and External Stability

To perform internal and external stability analyses, click *Reinforced Wall* or *Unreinforced Wall* from the *Analysis* menu, depending on the wall type. The *MSE Wall Analysis* page (Figure 35) will appear. The *MSE Wall* page should include all the information necessary for the analysis from the provided profile. Click the *Analysis* button on that page for analysis.

Global and Compound Stability

The global and compound stabilities are similar to the regular slope stability analysis with circular failure surfaces. For the global stability analysis, the area to be analyzed should generally be out of the reinforced zone. In contrast, the compound stability analysis should focus on the reinforced zone. Figure 36 shows a compound stability result.

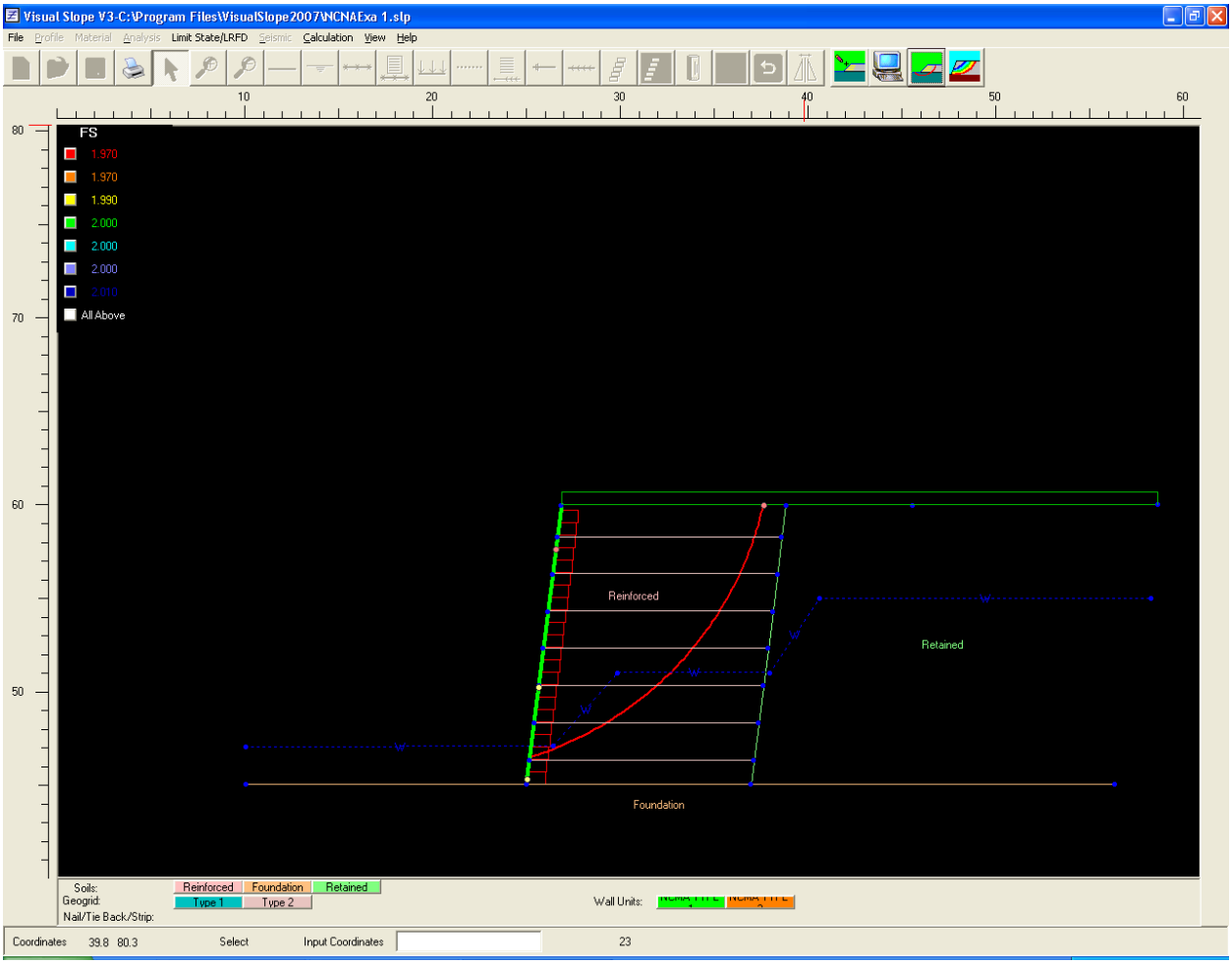

Figure 36 Compound Stability Analysis

SOIL/ROCK NAILING DESIGN

If a soil or rock cut is not stable, nails can be used to stabilize the cut. Visual Slope is capable of soil or rock nailing design. A nail-reinforced excavation must meet the minimum factors of safety for different failure conditions. The following sections describe how to use Visual Slope for soil/rock nailing design.

Adding Nails to Slope

Drawing Method

To add nails to a profile, the user can simply draw nails one by one, similar to drawing soil lines. After drawing, the user can assign the material to the nails. Using length and angle input, such as 10 <-20, will be more convenient for drawing nails. The potential failure surfaces with factor safety less than 1 can be overlain by the profile to assist drawing (Figure 37).

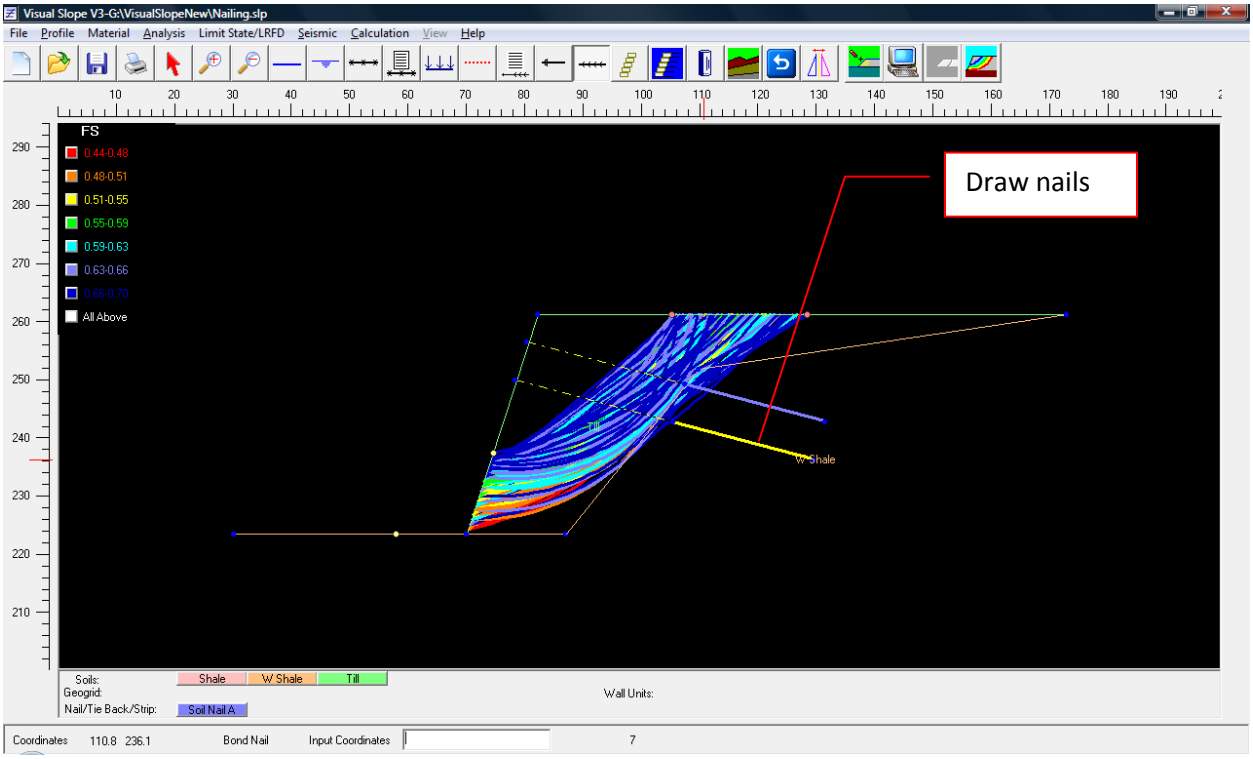

Figure 37 Adding Nails

Nail Array

The nail array method is easier than the drawing method to generate nails with the same type and same length at one time. To use the nail array method, the user must set up the nail properties first using the *Material Set Up* dialog box. After material set up, the user can click the *Nail Array* button on the *Toolbar*. The *Grid Array* dialog box will appear (Figure 38). The user must select the nail type from the pull down list and then provide the start elevation, end elevation, vertical spacing, angle of inclination, unbounded length, and bonded length for the corresponding data boxes. Once the user clicks the *Close* button, nails will appear on the profile (Figure 39).

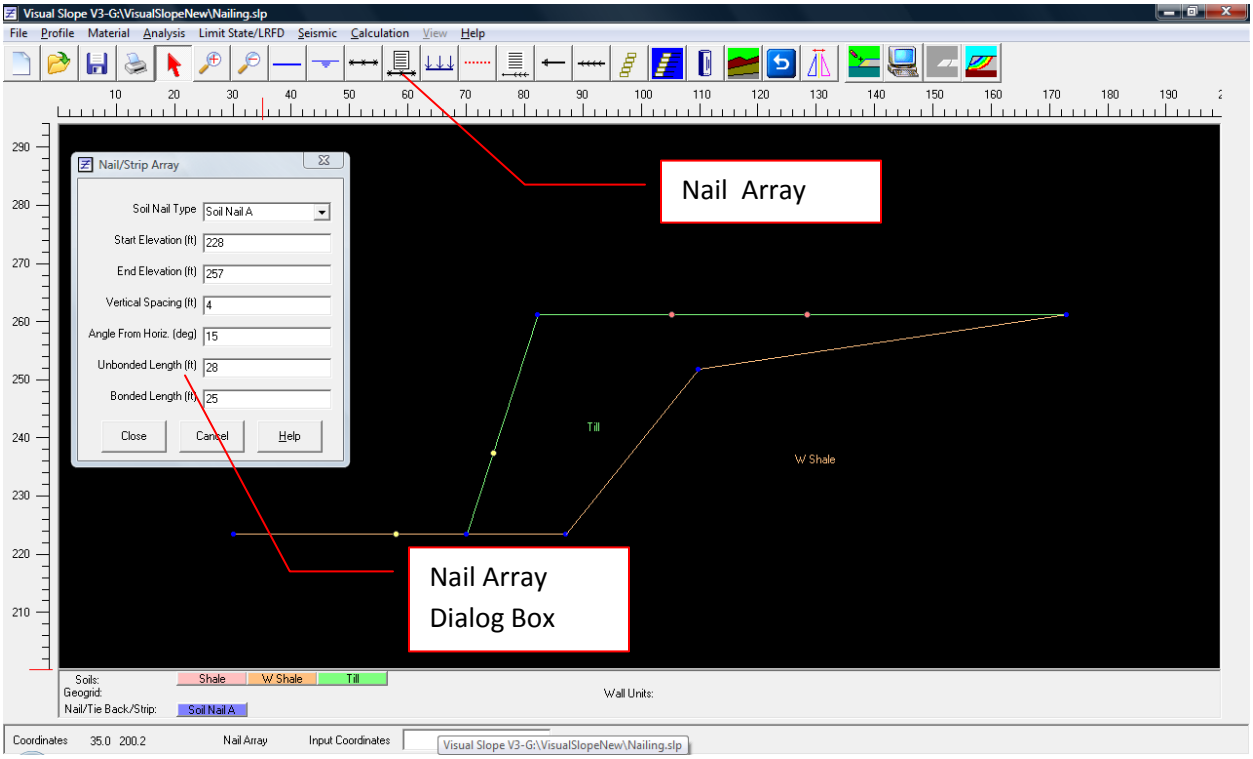

Figure 38 Nail Array

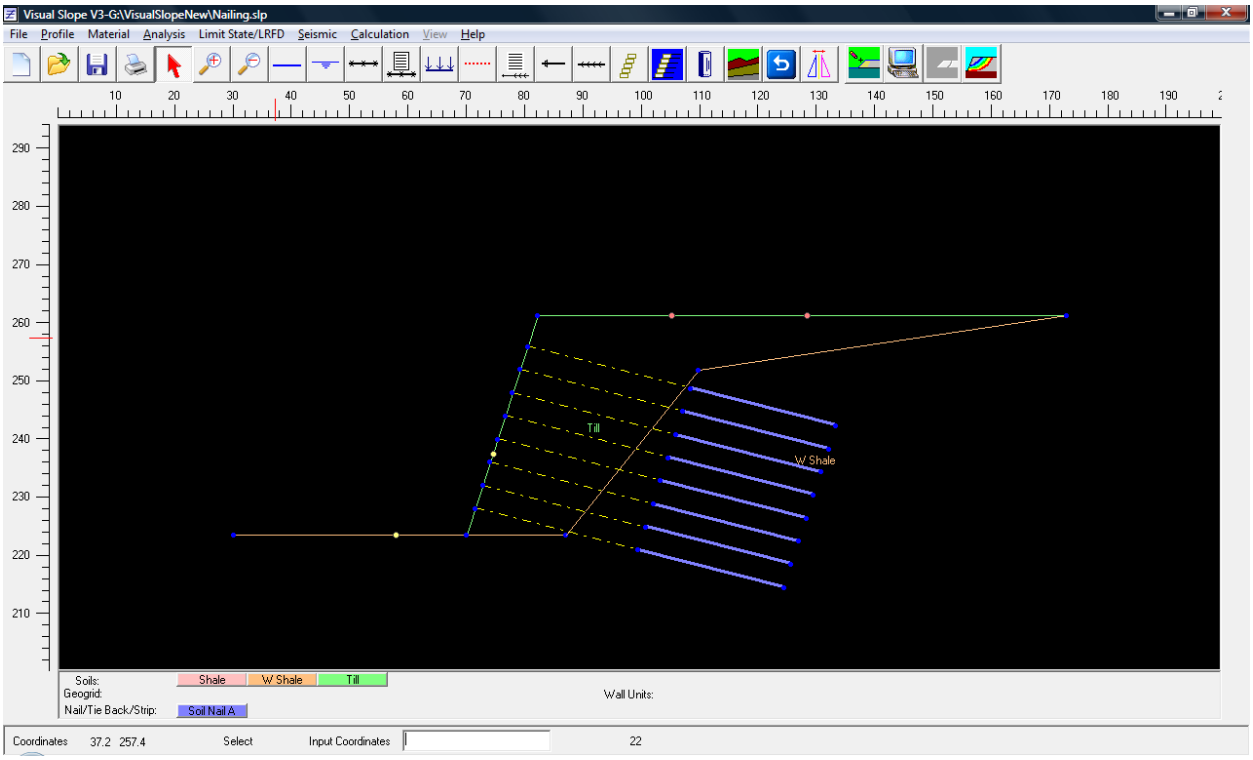

Figure 39 Profile

Analysis

The nailing design must satisfy the factor of safety for all potential failure conditions. The circular failure model is always a good one with which to begin.

SHORING DESIGN

Shoring systems commonly consist of sheet piles, diaphragm walls, soldier pile walls with lagging, etc. A shoring system can be cantilevered, single braced, or multi-level braced, depending the height of the wall. Visual Slope is capable of designing all those types of retaining walls. Similar to that of designing an MSE wall, the process of designing a shoring system includes the following three steps:

1. Establishing soil profile (cross section), similar to that for a Slope Stability Analysis
2. Adding wall and braces (if needed)
3. Performing analysis

The following sections describe those three steps.

Establishing Soil Profile

To design a shoring system, the user must create the soil profile (cross section) first. If you are not familiar with creating a profile, please read the *Establishing Profile* section. The dredge side must be on the left. The wall face should still be a slope facing the left (x1<x2), even though it is near vertical. The profile can include different soil strata, surcharges and water table. Similar to performing a slope stability analysis, the soil properties must be assigned to each soil stratum. Figure 40 shows a profile for shoring analysis.

Drawing Wall and Brace

To draw a wall, click the *Shoring Pile* button on the *Toolbar* first. The wall line must be drawn from the dredge line to the top. The user does not have to draw the embedment. The program will adjust the embedment length automatically after calculation. Figure 41 shows the retaining wall.

Once the retaining wall is in place, braces can be drawn in to their locations. Drawing braces is similar to drawing nails. If you are not familiar with drawing nails, please read the Soil/rock nailing Design sections. If regular braces are used, click the *Unbond Nail Button* first. The braces can then be drawn in. Figure 42 shows a retaining wall with regular braces.

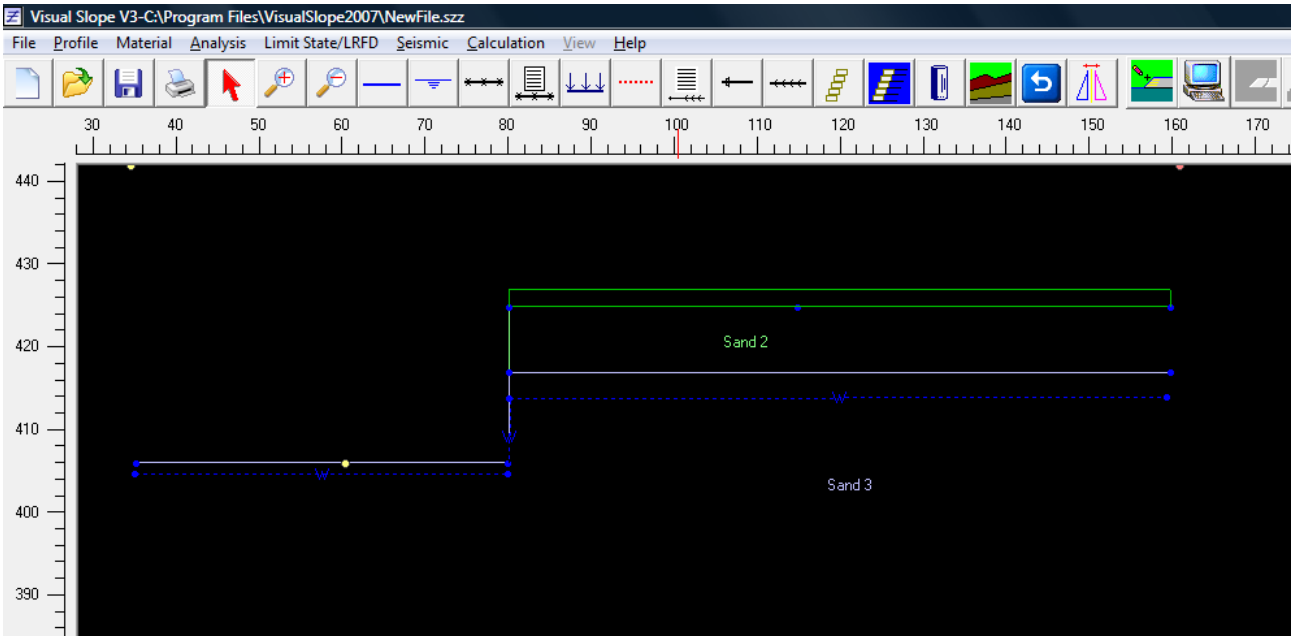

Figure 40 Soil Profile for Shoring System

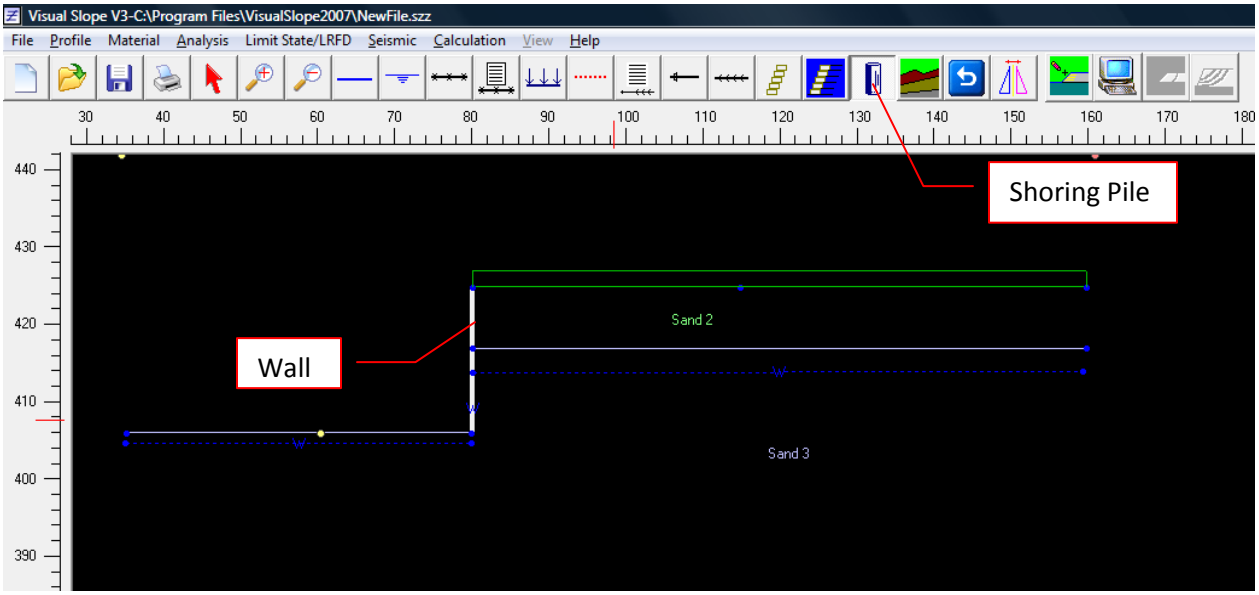

Figure 41 Retaining Wall

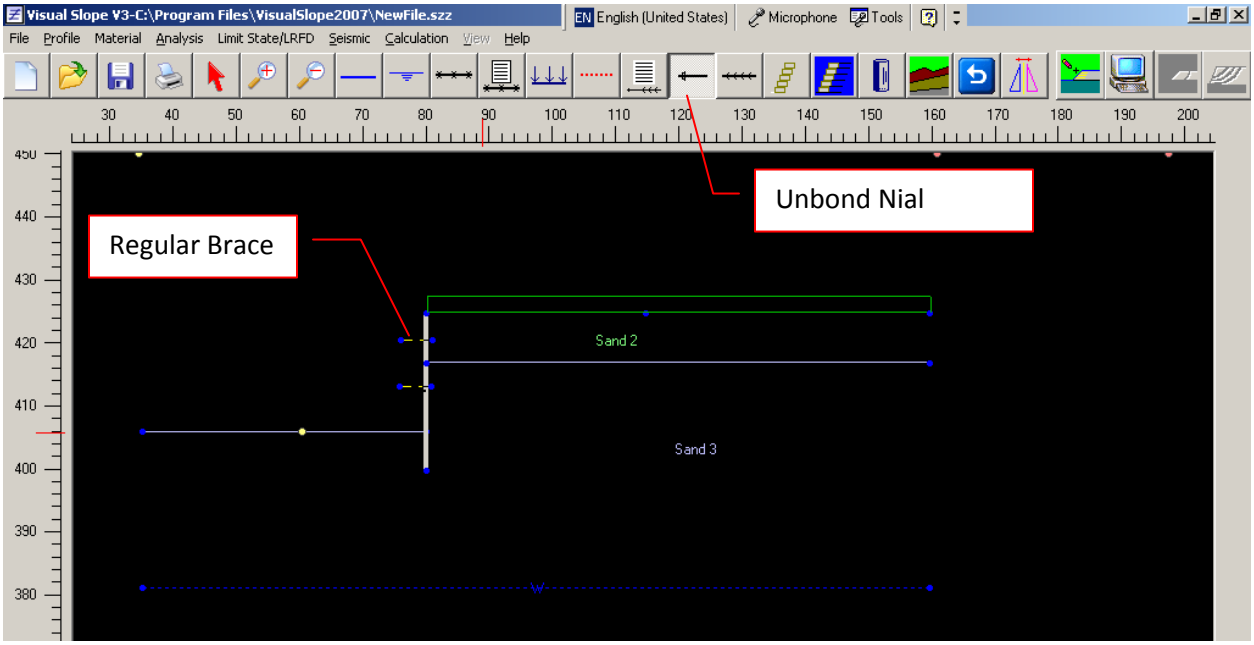

Figure 42 Retaining Wall with Regular Braces

If tiebacks are used, the tiebacks can be drawn in as drawing bond and undone nails. Nail array can also be used to generate a series of tiebacks. Figure 43 shows a tieback wall.

After completing the profile, the user can perform the analysis. To perform a shoring analysis, choose *Shoring* from the *Analysis* menu. Visual Slope is able to detect what type of retaining system the user is working on based on the provided profile. The following sections describe how to perform an analysis for a cantilevered, braced, or tieback shoring system.

Cantilevered Wall

If the profile is a cantilevered wall, after the user clicks *Shoring* from the *Analysis* menu, the shoring analysis page (Figure 44) will appear:

Retaining Width

For a continuous wall, such as a sheet pile wall or a diaphragm wall, a unit width of 1 ft or 1 m can be used for analysis. For a soldier pile wall, the retaining width should be the spacing of the soldier piles.

Embedment Width

For a continuous wall, the embedment width should be the same as the retaining width. For a soldier pile wall, the embedment width should be the width of the soldier pile.

Factor of Safety

The user should provide a proper factor of safety for analysis.

After filling out the page, click the *Analysis* button for an analysis. After the analysis is completed, the *Moment Diagram* will appear (Figure 45). The user can use the diagram buttons to display the moment, shear, earth pressure, and failure surface diagrams. The detailed results are tabulated in the results table.

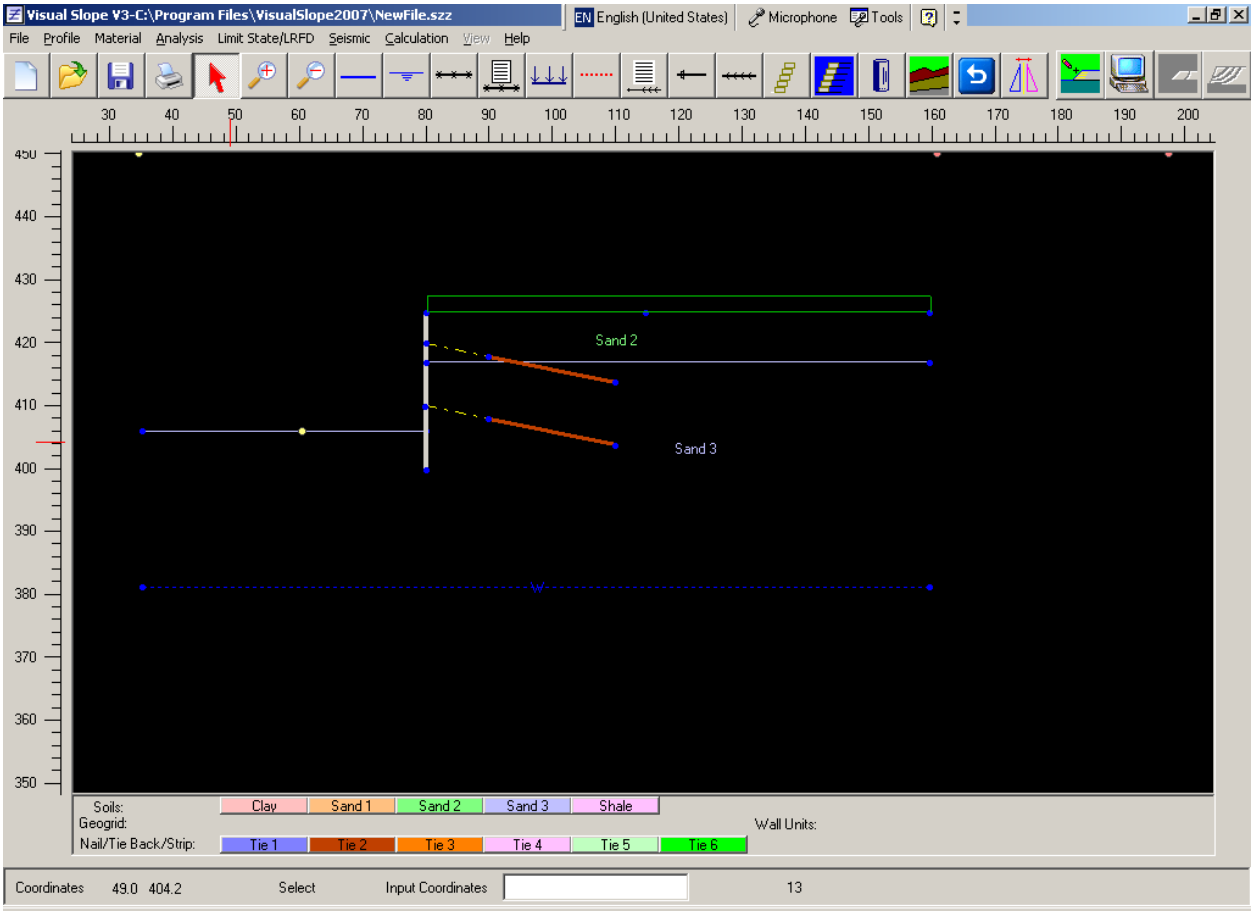

Figure 43 Tieback Wall

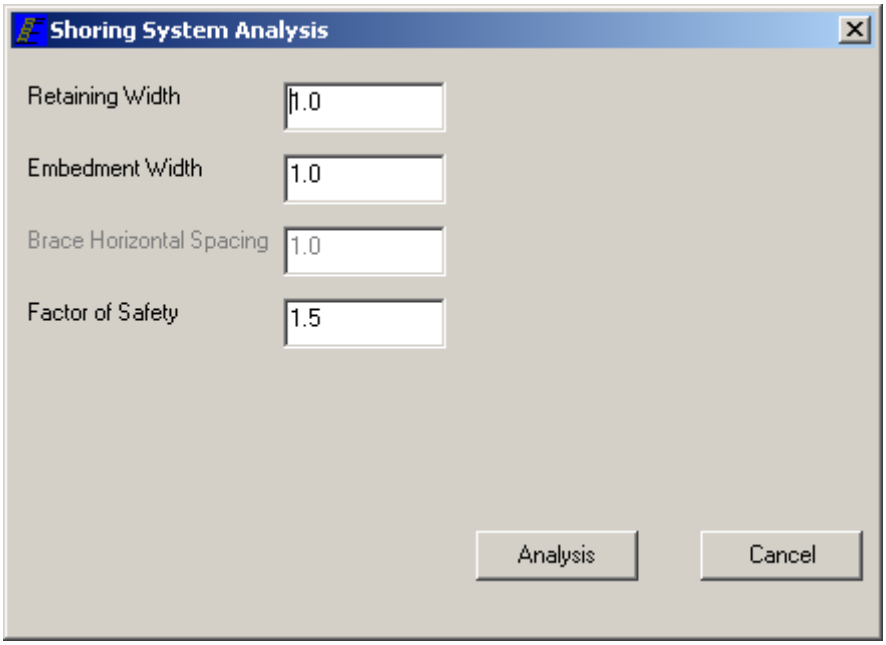

Figure 44 Cantilevered Wall Analysis

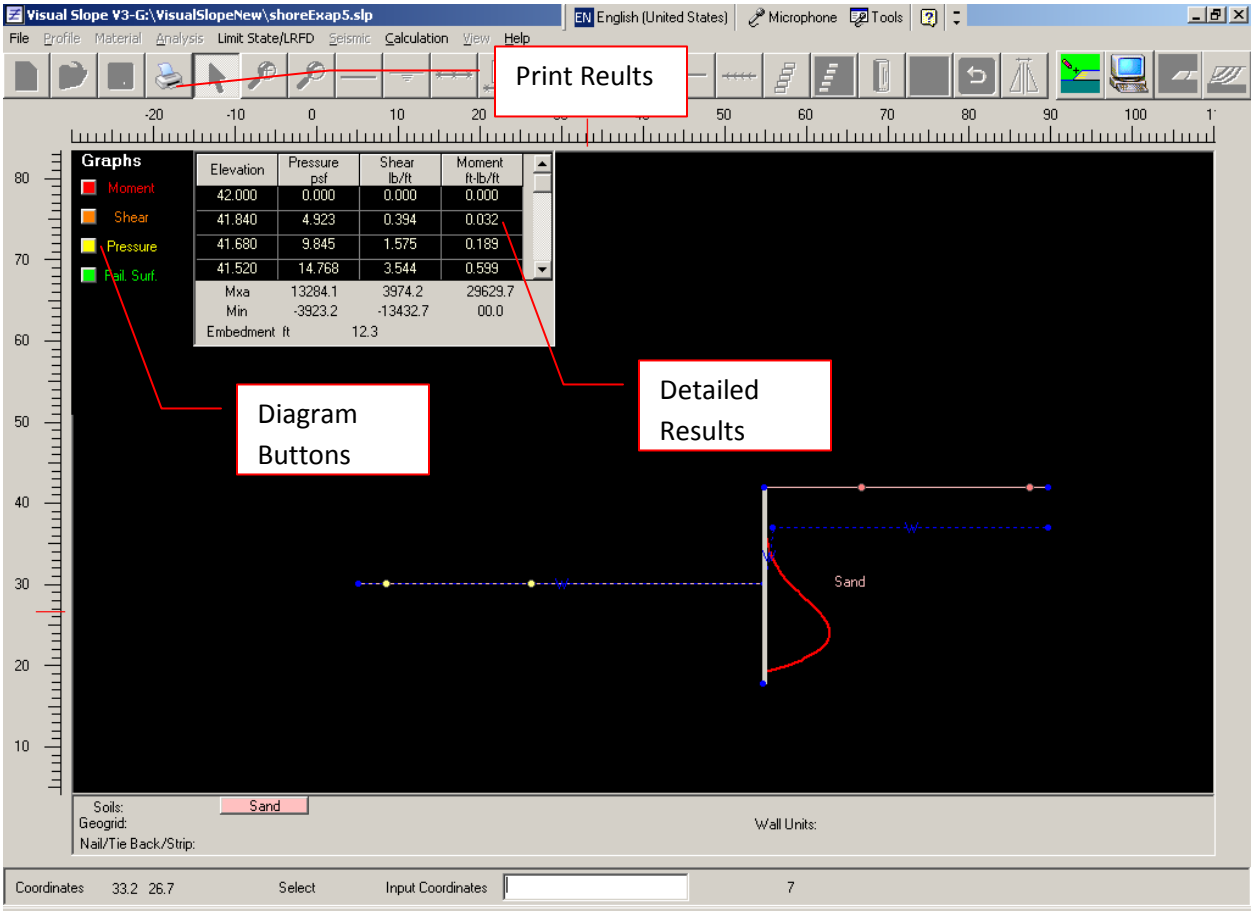

Figure 45 Results of Analysis

Braced Retaining Wall

The example in Figure 43 is used to explain how to perform a braced retaining wall analysis. After completion of the profile, the user can choose *Shoring* from the *Analysis* menu. The *Shoring Analysis* page (Figure 46) will appear.

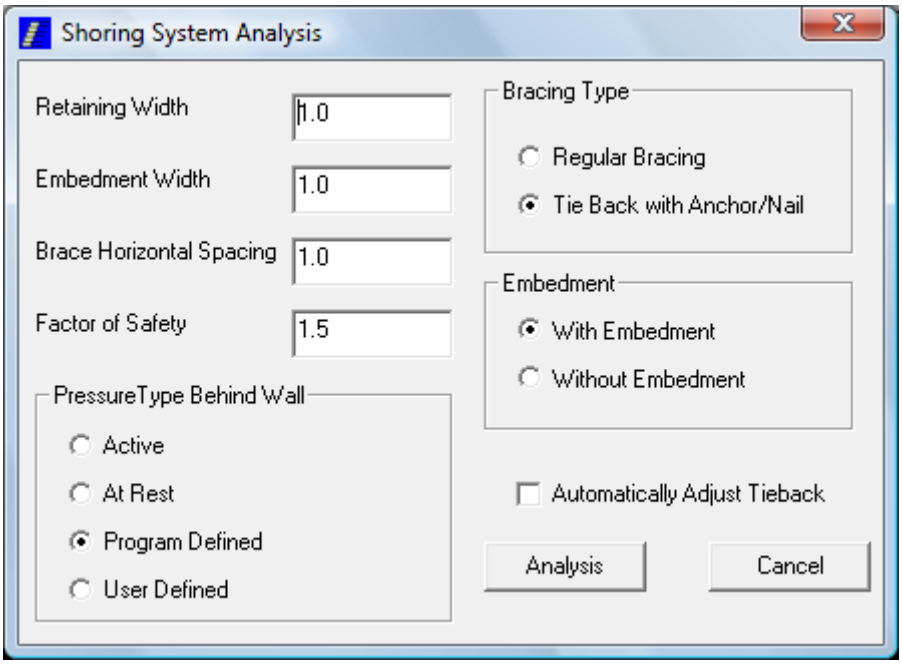

Figure 46 Shoring System Analysis

Visual Slope can detect what type of brace it is. If it is a multi-braced retaining wall, Visual Slope will allow the user to select the different types of earth pressure — active, at rest, program-defined, and user defined.

The program defined earth pressure is based on:

$$P = 0.65\gamma HK_a$$

The shapes of the earth pressure are:

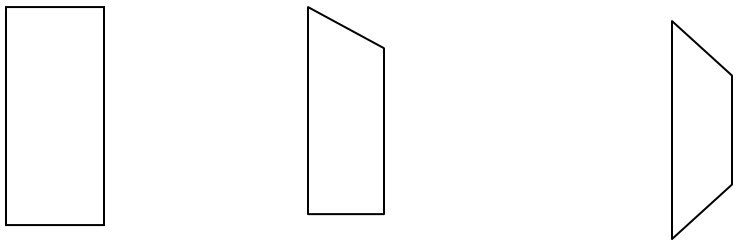

Figure 47 Earth Pressure Diagrams

The user can also use the user defined earth pressure. The user can type elevations and earth pressure values into the input box (Figure 48). The pressure value is positive if the pressure is acting on the back of the wall, and is negative if the pressure is acting on the front of the wall.

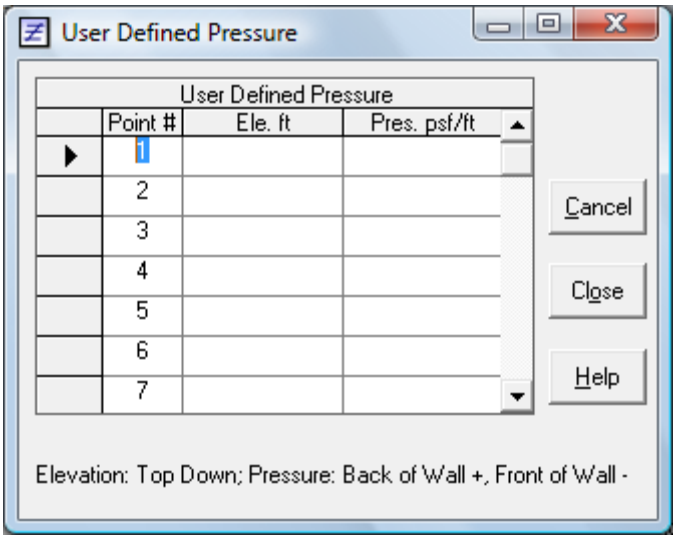

Figure 48 User-Defined Pressure

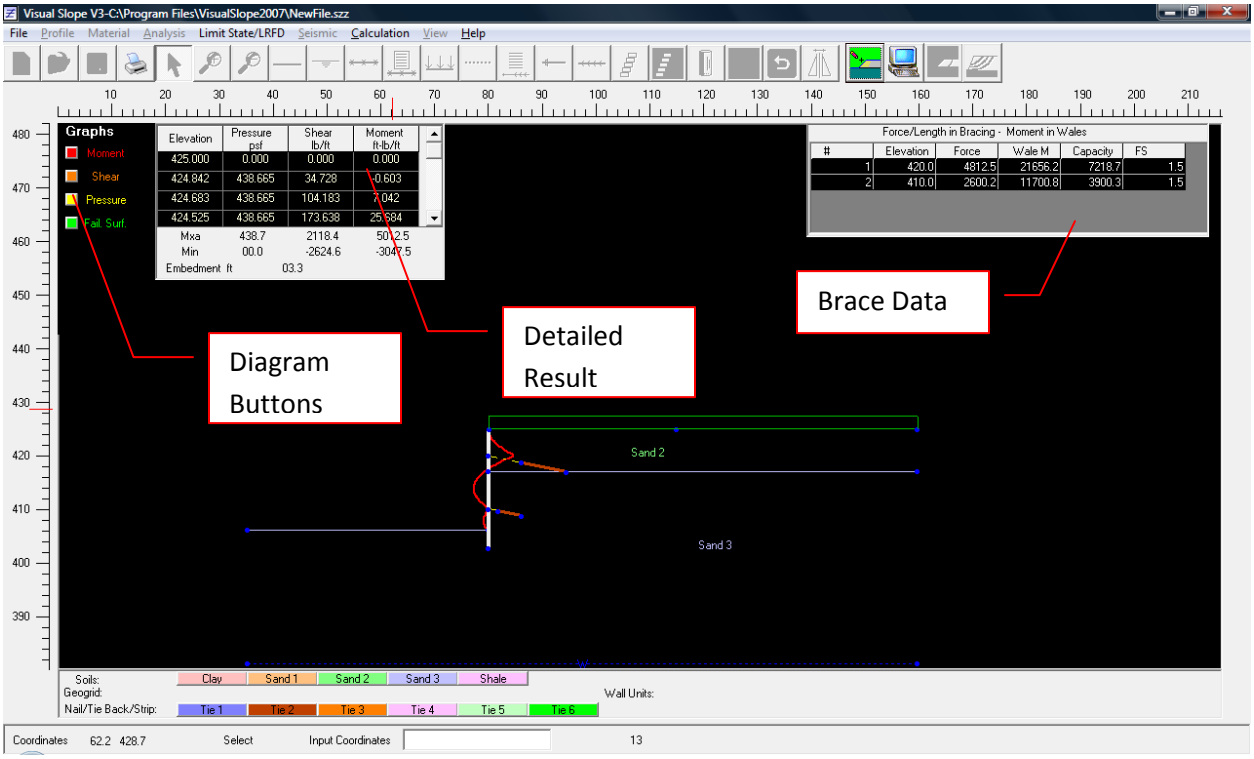

Figure 49 Result of Tieback Retaining Wall

If a user defined pressure is used, all other pressures, such as surcharge pressure and water pressure, will be ignored.

For a multi-braced retaining wall, the user can select *With or Without Embedment*. If the *Automatically-Adjust-Tieback* option is selected, Visual Slope will adjust the tieback free length so that the bonded zone will be beyond the failure zone and it will adjust the bonded length to meet the factor of safety requirement.

Bottom Heave

Visual Slope also adjusts the embedment so that the retaining wall will have an adequate factor of safety against the bottom heave.

OTHER FEATURES

Visual Slope includes many other features. This section briefly describes those features.

SEISMIC ANALYSIS

The seismic effect can be included in slope stability analysis, reinforced slope design, soil/rock nailing design, and MSE wall design. To include the seismic effect in the analysis, click the *Seismic Menu* and choose the *Seismic On* option.

LRFD/LIMIT STATE ANALYSIS

LRFD/Limit State analysis can be used in slope stability analysis, reinforced slope design, and MSE wall design. To use the LRFD method, click the *LRDF/Limit State Menu* and choose the *LRDF/Limit State On* option.

ONLINE TUTORIAL VIDEOS

The tutorial videos at www.visualslope.com can help users learn how to use Visual Slope. Users are encouraged to watch those movies.